Saralyn Stewart

BULLETIN

OF THE AMERICAN PHYSICAL SOCIETY

APRIL MEETING 2006
JOINTLY WITH THE
SHERWOOD FUSION THEORY CONFERENCE

April 22–25, 2006
Dallas, Texas



April 2006

Volume 51, No. 2

APS

BULLETIN
OF THE AMERICAN PHYSICAL SOCIETY

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One Physics Ellipse
College Park, MD 20740-3844
Telephone: (301) 209-3286
FAX: (301) 209-0866
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BULLETIN
OF THE AMERICAN PHYSICAL SOCIETY

Vol. 51, No. 2, April 2006

April Meeting 2006
jointly with the
Sherwood Fusion Theory Conference

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APS APRIL MEETING 2006

Jointly with the Sherwood Fusion Theory Conference

April 22-25, 2006
Hyatt Regency Hotel
Dallas, TX

General Information

Welcome to the 2006 April Meeting of the American Physical Society. We hope you benefit from attending the fine program organized by the 2006 April Meeting Program Committee, and enjoy your stay in Dallas.

About the Program

The April Meeting will offer an outstanding scientific program consisting of three plenary sessions, approximately 75 invited sessions, more than 100 contributed, and posters sessions.

Participating APS Units

Divisions: Astrophysics, Nuclear Physics, Particles and Fields, Physics of Beams, Plasma Physics, Computational Physics

Forums: Education, Physics and Society, International Affairs, History of Physics, and Graduate Student Affairs

Topical Groups: Few-Body Systems, Precision Measurement and Fundamental Constants, Gravitation, Plasma Astrophysics, and Hadronic Physics

Americans with Disabilities Act Statement

The APS wishes to take any steps required to ensure that no individual with a disability is excluded, denied services, segregated or otherwise treated differently due to the absence of auxiliary aids and services identified in the Americans with Disabilities Act. If any such services are necessary in order for you to participate in the April Meeting, please communicate your needs in advance to the APS Meetings Department.

Registration Location/Hours

On-site registration will take place in the Pullman A in Union Station attached by walkway to the Hyatt Hotel as follows:

Friday, April 21	1:00pm — 6:00pm
Saturday, April 22	7:00am — 5:00pm
Sunday, April 23	7:00am — 4:00pm
Monday, April 24	7:00am — 3:00pm
Tuesday, April 25	7:00am — 1:00pm

Badge Checking

You must register for the meeting in order to attend. Please wear your badge at all times during the meeting. There will be security personnel on-site checking for badges. Attendees without badges will not be allowed into the sessions.

E-mail Service

Pullman B, Union Station (attached by walkway to the Hyatt Hotel).

E-mail service will be available for April Meeting attendees to retrieve and send e-mail messages according to the schedule below:

E-mail Service Hours:

Friday, April 21	1:00pm — 6:00pm
Saturday, April 22	7:00am — 6:00pm
Sunday, April 23	7:00am — 6:00pm
Monday, April 24	7:00am — 6:00pm
Tuesday, April 25	7:00am — 2:00pm

Wireless Access

Wireless internet access is available in the Hyatt Hotel in all the meeting rooms, public space and the lobby. Individuals must pay for access to this service.

Audio-Visual Equipment

All rooms will be equipped with an LCD projector, overhead projector, screen, lavalier microphone, and pointer. If you plan on doing a PowerPoint presentation, please bring your program on your own laptop computer, and be sure to visit the Speaker—Ready Room to run through your presentation to ensure that it goes smoothly during the session. (We recommend that you also bring your presentation on vugraphs as a back-up to your computer presentation.) When you arrive at the session in which you are speaking, if you are using the LCD projector, please have your laptop turned on and ready to go. If you require additional equipment it can be rented by ordering directly through APS's contracted A-V company servicing the meeting in Cumberland H. Note: you are not allowed to bring/use your own projectors at the meeting.

Speaker-Ready Room

Cumberland H

You are strongly encouraged to visit the Speaker-Ready Room to run through your presentation. A-V technicians will be on-hand to assist you with any problems you might have according to the following schedule:

Friday, April 21	3:00pm — 7:00pm
Saturday, April 22	7:00am — 5:00pm
Sunday, April 23	7:00am — 5:00pm
Monday, April 24	7:00am — 5:00pm
Tuesday, April 25	7:00am —12:00noon

Press Room

Cherokee Room

Saturday, April 22	8:00am–5:00pm
Sunday, April 23	8:00am–5:00pm
Monday, April 24	8:00am–5:00pm
Tuesday, April 25	8:00am–12noon

Press Conference Room

Baker Room

A schedule of news conferences can be obtained from the Press Room—Cherokee Room.

APS Membership Desk

Landmark Concourse

Stop by the APS Membership Desk if you have questions about APS membership or journal subscriptions. The APS Membership Booth will be in operation throughout the meeting.

APS Souvenir Store

Landmark Concourse

Come browse our t-shirts, bumper stickers, and more.

Contact Congress

Saturday - Monday

Landmark Concourse

Worried about the slashing of NSF, DOE and NASA funding? Concerned about the dearth of science literacy in our high-schoolers? Anxious about where the country's security is heading? YOU can have an impact on national science policy! Come write your representatives in Congress to let them know how you feel about science issues of interest to you. The most important letters that a Member of Congress receives are the ones from his or her constituents – you elect them, and you matter. The American Physical Society feels that it is incumbent on all of us to interact with the government, to offer technical assistance where we can, and to remind our Members of Congress that scientists have much to offer the country, in areas of basic science R&D funding, education, and energy policy. We have set up computers in the entrance area where you can send a letter to your Senators and Representatives - you can use our template or write your own letter on issues that matter to you. If the state of affairs in Washington, DC, interests you, we have another way for you to get involved: the APS "Physics and Government Network," a group of APS members who volunteer to contact their representatives in Congress a few times a year at critical junctures. PGNet signup fliers will be available at the "Contact Congress" registration desk. Come help make science more visible in Congress!

Exhibits

The following companies will have table top displays available for you to visit. Stop by the exhibits in the Landmark Concourse during the meeting.

- CAEN Technologies
- Cambridge University Press
- CTNS — STARS
- IOP Publishing
- Oxford University Press
- Springer-Verlag
- Struck Innovative Systeme GmbH
- University of Texas/Dallas
- Wiener, Plein & Baus, Ltd.

APS Job Fair

Sunday, April 23 – Monday, April 24

Important Dates:

April 3	Post/view jobs and resumes
April 7	Pre-registration deadline
April 22	Recruiter booth set-up Employer/Job Seeker onsite pre-registration and check-in *1:00pm–3:00pm*
April 23	Job Fair hours of operation *9:00am–5:00pm*
April 24	Job Fair hours of operation *9:00am–5:00pm* Recruiter booth tear down *5:00pm*
May 3	*Last day to view/search jobs and resumes online*

Whether you are looking for a job or recruiting, the American Physical Society April Meeting Job Fair is the place to be! The Job Fair will provide job seekers and hiring managers with recruitment and networking opportunities.

Job Seekers

You can utilize the Job Fair services to:

- Network with technical staff and human resource recruiters
- Post your resume and search open positions
- Interview for positions

Job Seeker/Candidate Registration

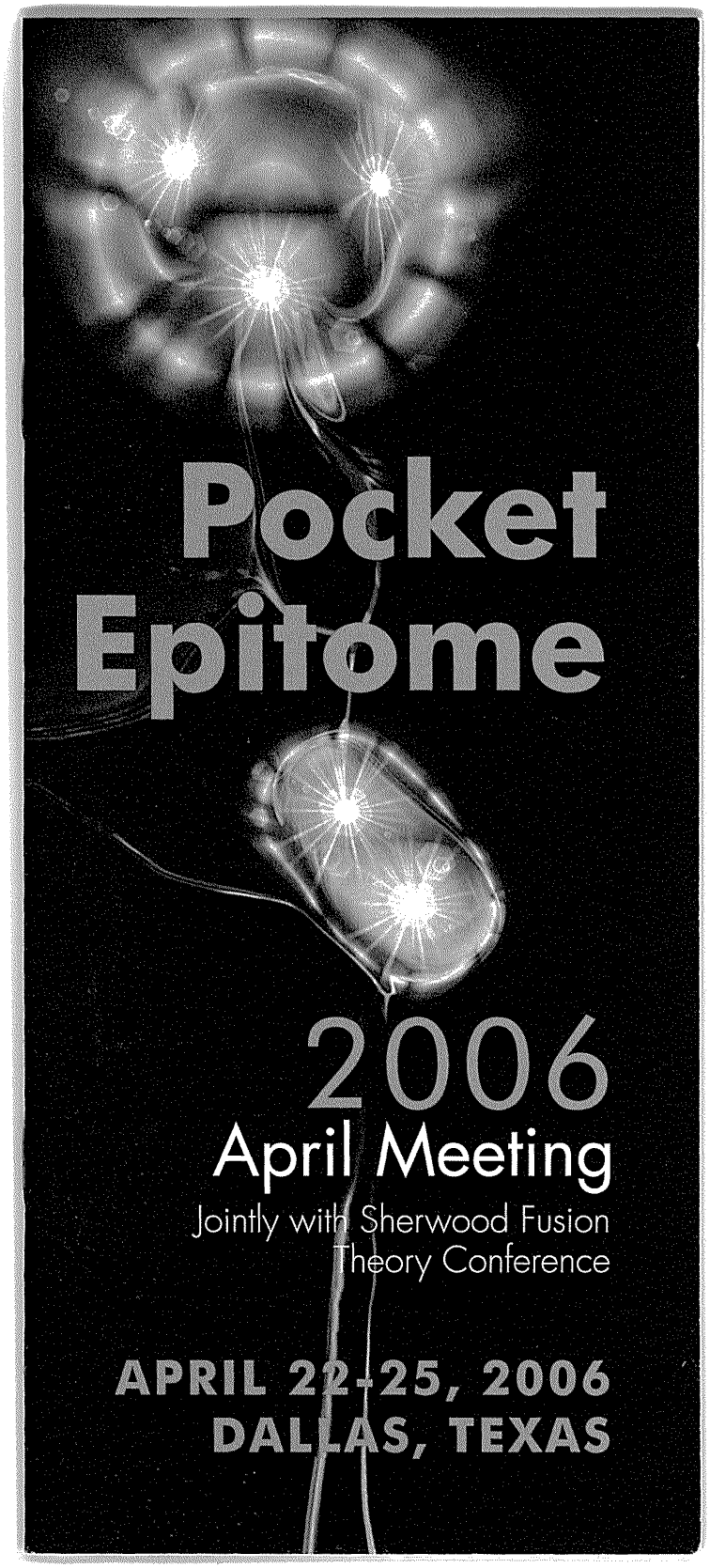
(https://www.aip.org/forms/candreg_apsapril06.html)

Post Early! Employers have access to the online resume database two weeks before the Job Fair. Posting your resume early increases your chances of on-site interviewing. The Job Fair is free of charge to all job seekers.

Employers

You can utilize the Job Fair services to:

- Showcase your company or organization with a Recruitment Booth
- Advertise open positions
- Interview qualified job seekers
- Search resumes specific to this meeting


Pocket
Epitome
2006
April Meeting
Jointly with Sherwood Fusion
Theory Conference
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- Search resumes specific to this meeting

Employer/Recruiter Registration
(https://www.aip.org/forms/reg_apsapril06.html)

The pre-registration deadline for both employers and job seekers is April 7, 2006.
Note: Jobs and resumes will be available online from April 3 – May 3, 2006.

Questions
For more information about the Job Fair, please contact:
American Institute of Physics
Career Services Division
One Physics Ellipse
College Park, MD 20740
tel: 301-209-3187; fax: 301-209-0841
email: abrice@aip.org
website: www.aip.org/careers

PRE-MEETING PROGRAMS

High School Physics Teachers' Day

Friday, April 21
8:00am to 2:45pm
Cumberland J

In conjunction with the 2006 April Meeting, the APS Department of Education & Outreach is sponsoring a High School Physics Teachers' Day for teachers in the Dallas region. The day includes:

- Hands-on workshops presenting innovative, classroom-ready activities
- Research talks on cutting-edge physics
- A welcoming breakfast, and a chance to network with fellow teachers
- Lunch with a physicist

If you would like to join the teachers for lunch (11:45am-12:45pm) contact Ed Lee.

Professional Skills Development Workshop for Women Physicists

Sponsored by the Committee on the Status of Women in Physics (CSWP)

Friday, April 21
Workshop: 8:00am – 5:00pm
Workshop: Cumberland F
Reception: 5:00pm – 6:30pm
Reception: Cumberland A

This one day workshop will offer training on persuasive negotiation and communication skills for tenure-track and newly-tenured women physicists. Workshop will be led by professional facilitators using an interactive format that encourages highly personal learning. Lunch will be provided and a reception for participants will follow the workshop. Limited to 30 participants. Information can be found at http://www.aps.org/educ/cswp/skills/. There is no on-site registration for this activity - you must pre-register to attend the workshop.

APS MEETINGS / EVENTS

(In chronological order)

Plenary Talks

Saturday, April 22
8:30am-10:30am
Landmark A

- *Exploring the Final Frontier of the Solar System*
  Edward Stone, CalTech
- *Liquid Phase Quark-Gluon Plasma*
  Barbara Jacak, SUNY, Stony Brook
- *Recent Results from MiniBoone*
  Hira Tanaka, Princeton

Monday, April 24
8:30am-10:30am
Landmark A

- *Neutrinos and Cosmology*
  Nicole Bell, CalTech
- *Plasma Turbulance in Astrophysics and in the Laboratory*
  William Dorland, University of Maryland
- *Cochlear Implants and the Physics of Hearing*
  Ian Shipsey, Purdue University

Tuesday, April 25
8:30am-10:30am
Landmark A

- *The Science of Nanotubes*
  Alex Zettl, UC, Berkeley
- *Searching for Gravitational Waves with LIGO*
  Gabriella Gonzalez, Louisiana State University
- *Physics Prospects and International Aspects of ILC*
  Albrecht Wagner, DESY

APS Welcome Reception

Saturday, April 22
5:30pm-7:00pm
Grand Hall, Union Station (attached by walkway to the Hyatt)
All April Meeting attendees are invited to attend and join your colleagues for refreshments.

Scientific Professionalism and the Physicist: The Skills You Need to Succeed in Physics-based Careers

Saturday, April 22
7:00pm–9:00pm
Club Car, Union Station (connected by walkway to the Hyatt Hotel)
Workshop Facilitator: Alaina G. Levine, Director of Special Projects
College of Science, University of Arizona; President, Quantum Success Solutions

This interactive and humor-filled workshop will address key professional skills which will help both physicists and physics students succeed in whatever scientific career they choose. Too often, physics students enter the job market with little knowledge of the skills needed to advance and succeed in any professional arena. Participants in this workshop will learn and practice strategic skills such as communication, networking, contact management, and partnering with a mentor, which are crucial to advancing in the job market and beyond.

You will discover how to empower yourself, and the strategy and importance of getting noticed for your physics talents by not only your boss and colleagues, but others as well, especially your boss's boss and other VIPs. We will also discuss the concept of a brand (which is simply a promise), and how to build and promote the brand that is YOU by establishing yourself as a leader and an expert in your area of knowledge and ability.

Participants will also learn about the vast array of resources available to assist them with their career exploration and will learn how to apply the skills developed in the workshop to take the fullest advantage of these opportunities, resources, and contacts.

The workshop will be educational, stimulating, fast-paced, informative, and will not only introduce concepts but teach participants to apply them that very day, giving them the edge they need to succeed in a very competitive job market.

Special Symposium:

New Reports from Major National Studies (Session G1)
Saturday, April 22
7:15pm–9:00pm
Landmark A
Chair: John Hopfield, Princeton University, APS President
Speakers:

- Harold Shapiro, President Emeritus Princeton University
  Elementary Particle Physics in the 21st Century: Explorations of the Terascale
- Andreas Albrecht, Department of Physics, UC Davis
  Report from the Dark Energy Task Force

APS Journal Editors Panel Discussion (Session K15)

Sunday, April 23
2:00pm-3:00pm
Cumberland K
All are invited to a panel discussion with the Editors of the American Physical Society journals. The panel will include Editors from Physical Review and Physical Review Letters. They will briefly discuss some current issues facing the journals such as how to express appreciation for good refereeing, possible inclusion of popular abstracts in PRL to make Letters accessible to physicists in all fields, the challenge posed by open access, etc. The Editors look forward to hearing opinions on these and other issues, and will respond to questions and comments. The Panel Discussion will be followed by the Meet the Editors Reception.

Meet the Editors of Physical Review and Physical Review Letters

Sunday, April 23
3:00pm-5:00pm
Pre-Function Area, Marsalis Hall
The editors of Physical Review and Physical Review Letters cordially invite you to join them for conversation and refreshments. Your questions, suggestions, compliments and complaints about the journals are welcome. We hope you will be able to join us.

Awards Session (Session M1)

Sunday, April 23
5:15pm-6:45pm
Landmark A

- Prizes and awards will be bestowed on individuals for outstanding contributions to physics. Please plan on attending the Awards Program and join us in honoring these individuals. See page 10 of the bulletin for a list of award and prize winners.
- Marvin Cohen, APS Past President, will give the retiring presidential address entitled, *Looking Back on the World Year of Physics 2005.*

• Lilienfeld Prize Talk, *Persistent Challenges of Quantum Chromodynamics,* Mikhail Shifman, University of Minnesota

Special Lunchtime Talk

Monday, April 24
12:45pm–1:25pm
Landmark A

Norman Augustine, CEO Lockheed Martin, Retired,
Rising Above the Gathering Storm: Addressing America's Competitiveness Challenges. Bring a lunch to eat during the talk.

An Evening with Lisa Randall

Monday, April 24
6:30pm–8:00pm
Landmark A

Warped Passages: Unraveling the Mysteries of the Universe's Hidden Dimensions
Hosted by Victoria Smith Downing, Kilby Foundation. A question period and book signing will follow.

APS EVENTS FOR SPECIAL GROUPS

(In chronological order)

Student Reception

Friday, April 21
8:00pm–9:00pm
Pegasus B

All students are cordially invited to an informal reception hosted by the APS and the Forum on Graduate Student Affairs. This is your chance to meet your fellow students, enjoy refreshments, and show off your physics trivia knowledge in our quiz.
(There will be prizes of course!)

Companion's Breakfast

Saturday, April 22
9:00am–10:00am
Club Car, Union Station (attached by a walkway to the Hyatt Hotel)

All companions of April Meeting attendees are invited to attend. A presentation about the city of Dallas will be given by the Dallas Convention and Visitors Bureau.

CSWP/DPF Lunch for Women in Physics

Monday, April 24
12:00pm–1:30pm
Club Car, Union Station (attached by walkway to Hyatt Hotel)

Enjoy a full buffet lunch and network with colleagues! Natalie Roe (LBNL), Marcela Carena (Fermilab) and Ann Heinson (University of California Riverside) will speak informally, followed by an opportunity for questions. Open to all with an interest in women in physics. Cost $20 ($5 for students). Space is limited. Pre-registration at http://www.aps.org/educ/cswp/index.cfm.

Students Lunch with the Experts

Monday, April 24
12:30pm-2:00pm
Station Master, Union Station
(attached by walkway to Hyatt Hotel)

Students can sign up on-site to enjoy complimentary box-lunch while participating in an informal discussion with an expert on a topic of interest to them. Sign-up will take place beginning on Saturday, April 22 at 1:00pm at the APS registration desk, and will be on a first-come, first-served basis. Attendance is limited to eight students per topic.
List of Topics and Experts

1. Nuclear Structure Physics
   Expert: Richard Casten, Yale University
2. Fundamental Physics with Ultra Cold Neutrons (DNP)
   Expert: Alexander Saunders, LANL
3. Relativistic Heavy Ion Physics (DNP)
   Expert: Gerd Kunde, LANL
4. Physics of Particle Accelerators (DPB)
   Expert: Thomas Roser, BNL
5. Working in Collaborations: It's More than Just Physics
   Expert: Katherine Frame, LANL
6. General Relativity and Gravitational Waves (GGR)
   Expert: Gabriela Gonzalez, LSU
7. Fusion Energy (DPP)
   Experts: Ron Stambaugh, General Atomics & Cris Barnes, LANL

COM/CSWP Reception

Monday, April 24
5:30pm–7:00pm
Sanger AB

The APS Committee on Minorities in Physics (COM) will co-sponsor a reception with the Committee on the Status of Women in Physics (CSWP). This is a wonderful opportunity to learn about the work of these Committees, to network with colleagues, and to unwind after a long day of sessions. All are welcome to join us.

Sherwood/DPP Reception

(By Invitation Only)
Monday, April 24
5:30pm-7:30pm
Cumberland K

BUSINESS MEETINGS

Monday, April 24
5:30pm–6:30pm

GFB Business Meeting
Cumberland E

FPS Business Meeting
Marsalis A

DPB Business Meeting
Reverchon AB
5:30pm-8:30pm

FHP Business Meeting
Cumberland I

DNP Business Meeting
Landmark B

DAP Business Meeting
Pegasus A

GGR Business Meeting
Cumberland F

SATELITE MEETINGS

Workshop on Long Time Simulations of Kinetic Plasmas
Friday, April 2
9:00am – 5:00pm
Pegasus A

PAC 07 Program Committee
Saturday, April 22
1:00pm – 10:00pm
Cumberland C

Jefferson Lab Users Group
Monday, April 24
11:30am – 1:00pm
Dealey

RHIC & AGS Users' Group
Monday, April 24
2:00pm – 3:00pm
McMillan

Theory Coordinating Committee
Monday, April 24
7:30pm – 9:30pm
Cumberland E

CEMM Meeting
Tuesday, April 25
1:00pm – 6:00pm
Station Master, Union Station
(attached by walkway to Hyatt Hotel)

PROGRAM FORMAT

Program Time-Blocks

Saturday: A-G
Sunday: H-M
Monday: O-T
Tuesday: V-X

There are four time blocks for each day of the meeting. (Saturday, Monday and Tuesday: 8:30am, 10:45am, 1:30pm and 3:30pm; Sunday: 8:30am, 10:30am; 1:15pm and 3:15pm.) The time blocks are designated in alphabetical order beginning with time block "A" on Saturday at 8:30am, and ending with time block "X" designating the 1:30pm session on Tuesday. See the Program Schedule for details.

Session Codes

Each session within a time block is numbered sequentially, as well as the papers within a session. For example, session code B4.3 = time block B at 10:45am on Saturday; session #4 within the B time block, and paper #3 to be presented in session B4.

Poster Codes

Posters are numbered sequentially.

Poster Presentations

If you are presenting a poster, please be sure to have your poster up prior to the start of the session to which you have been assigned, and taken down immediately at the end of the session. APS will not be responsible for posters left up after the end of each poster session. No A-V is allowed in the poster sessions. Consult the Poster Session Schedule for exact times and a breakdown of poster topics.

Poster Session Schedule

Poster Session I (Session D1)
Saturday, April 22, 2:00pm-5:00pm

Posters 1-12:	Gravitation
Posters 13-15:	Undergraduate Research
Posters 16-24:	Plasma Physics: Basic, Laser and Non-Neutral Plasma
Posters 25-44:	Plasma Physics: Space and Astrophysical Plasma
Posters 45-49:	Computatonal Physics
Posters 50-51:	Accelerator Systems
Posters 52-53:	Beam Physics
Posters 54-70:	Tests of Physics Laws
Posters 71-76:	Particles and Fields
Posters 77-80:	New Precision Measurement Methods
Posters 81-82:	Few-Body Systems
Posters 83-84:	History of Physics
Posters 85-102:	Astrophysics

Poster Session II (Session K1)
Sunday, April 23, 2:00pm-5:00pm

Poster 1-60:	Magnetically Confined Plasma I

Poster Session III (R1)
Monday, April 24, 2:00pm-5:00pm

Posters 1-60:	Magnetically Confined Plasma II: 1-60
Posters 61-62:	Astrophysics

Poster Session IV (W15)
Tuesday, April 25, 10:30am-2:00pm

Post-deadline Posters

A-V Policy at the April Meeting

In the interest of ensuring a professional and smooth-running meeting, the American Physical Society's A-V policy is as follows:

General A-V Policy
In keeping with our legally binding contract with our A-V vendor, speakers are not permitted to bring their own projection equipment for use at the meeting.

Standard A-V in all Sessions
The standard A-V package consists of an LCD projector, overhead projector, screen, laser pointer and lapel microphone. Any additional A-V equipment must be rented by the speaker directly through APS's designated A-V provider. The speaker is responsible for the cost of renting any additional equipment.

Policy and Guidelines on Use of LCD Projectors
The responsibility for a smooth, technically trouble-free presentation ultimately rests with the presenter. Speakers who plan to use LCDs must do the following:

- Bring your own laptop computer, power cord, and any proprietary cords required for your computer.
- Visit the Speaker-Ready room (Cumberland H) provided by APS to run through the presentation to ensure a smooth and technically trouble-free presentation. Testing your presentation in the Speaker-Ready room prior to your presentation is strongly recommended to minimize equipment compat ibility difficulties. If you encounter difficulties, consult with the A-V technicians.
- Bring a back-up vu-graph presentation in case there are set-up difficulties with the LCD equipment.

NOTE: The APS is not responsible for the security of personal laptop computers. The APS strongly recommends that LCD projectors not be used for contributed talks (12 minute talks). The presentation schedule must be maintained, and as is too often the case, the set-up of the laptop/projector can be problematic, using up valuable presentation time.

Guidelines for Speakers

Oral Presentations
Please arrive at least 15 minutes prior to the scheduled time of your talk. Contributed papers are allocated 12 minutes each - 10 minutes for presentation and 2 minutes for questions from the audience, unless otherwise specified. Invited papers are allocated 36 minutes - 30 minutes for presentation and 6 minutes for questions from the audience.

NOTE: Occasionally (and unfortunately) the chair for a session may not appear, in which case we ask that the first presenter serve as chair of the session.

Guidelines for Session Chairs

1. Please check the Bulletin to determine if any supplementary papers have been assigned to the session you are chairing. Prior to the session, check the Corrigenda distributed with the Bulletin, as well as the Program-Changes Board in the registration area to see if any papers have been withdrawn.

2. Arrive at the meeting room about 15 minutes prior to the start of the session and familiarize yourself with the controls for lights, microphones, A-V equipment and the timer. If you encounter problems, you should immediately alert the Meetings Manager and/or the A-V specialist.

3. Start the session on time. Briefly introduce yourself, announce the first paper and author, and start the timer.

4. Please adhere to the time schedule listed in the Bulletin, so that simultaneous sessions are as closely synchronized as possible. Many attendees move from session to session in order to hear specific papers.

5. The allotted time for contributed papers is 12 minutes; for invited papers—36 minutes. If you are chairing a session that includes both contributed and invited papers please be aware of the different times allocated for each and set the timer as follows:
   • Contributed papers—set timer for 8 minutes to give initial warning, then set the final bell to go off 2 minutes later. When this time is up, allow 2 additional minutes for questions relating to the paper, thank the speaker and promptly introduce the next paper and speaker.
   • Invited papers—set timer for 25 minutes for initial warning, and the final bell to ring 5 minutes later. Then set the timer for 6 additional minutes for questions from the audience. Explain the timing system to the audience prior to the start of the session, and as often during the session as you think necessary.

6. The By-Laws of the Society request that speakers be asked to stop when their allotted time is up in a courteous but firm manner. Keep in mind that the session must end on time, and that the last speaker has just as much right to an audience as does the first speaker.

7. Should a speaker fail to appear, call the author of the first supplementary paper assigned to the session, if any. If that author is not in attendance, call the author of the following supplementary paper, and so on. If there are no supplementary papers assigned to your session, allow the preceding discussion to continue, or recess the session until it is time for the next scheduled paper. At the end of the session, call again for the regularly scheduled paper, if time allows.

8. When two or more papers are submitted by an author, only one of these will be assigned a scheduled presentation time within that session. It is assumed that the first author listed in the abstract is the person who will present the paper at the meeting. Other papers with the same first author will be assigned as supplementary papers, to be called for if time permits. If you notice that an author who has already presented a paper rises to present another paper, you should request that this paper be presented at the end of the regular program as a supplementary paper, if time allows.

9. If any problems arise that you are unable to handle relative to successfully chairing the session, please inform the A-V tech in the room, or go immediately to the APS registration desk to alert the APS staff. Any time used by the speaker and/or technicians to set up laptops for LCD (Powerpoint) presentations is deducted from the time allocated for the talk.

Please Note:

The APS has made every effort to provide accurate and complete information in this ***Bulletin***. However, changes or corrections may occasionally be necessary and may be made without notice after the date of publication. To ensure that you receive the most up-to-date information, please check the meeting ***Corrigenda*** distributed with this ***Bulletin***.

ANNUAL APS APRIL MEETING 2006 EPITOME

April 22, 2006, 8:30AM, Saturday

Session A1 Plenary Session I Sponsor: APS Chair: John Hopfield, APS President, Princeton University. Room: Hyatt Regency Dallas Landmark A. Invited Speakers: Stone, Jacak, Tanaka

April 22, 2006, 10:45AM, Saturday

Session B1 Underground Labs: Plans and Progress Sponsor: DNP DPF Chair: Hamish Robertson, University of Washington. Room: Hyatt Regency Dallas Landmark A. Invited Speakers: Scholberg, Beier, Sinclair

Session B2 Light Exotic Nuclei Sponsor: DNP Chair: Michael Thoenessen, Michigan State University. Room: Hyatt Regency Dallas Landmark B Invited Speakers: DeYoung, Wuosmaa, Rogachev

Session B3 Laboratory Astrophysics: Supernovae and Jets Sponsor: DPP GPAP Chair: Paul Bellan, California Institute of Technology. Room: Hyatt Regency Dallas Landmark C Invited Speakers: Raymond, Blue, Lebedev

Session B4 Research Talks at the Undergraduate Level Sponsor: FEd Chair: David Ehrenstein, APS. Room: Hyatt Regency Dallas Marsalis A. Invited Speakers: Canelli, Chaikin, Carroll

Session B5 Cosmology I Sponsor: DAP FHP Chair: James Ryan, University of New Hampshire. Room: Hyatt Regency Dallas Pegasus B. Invited Speakers: Danielson, Barton, Carlstrom

Session B7 Gamma-Ray Bursts and GLAST Sponsor: DAP Chair: Julie McEnery, Goddard Space Flight Center. Room: Hyatt Regency Dallas Pegasus A

Session B8 Nuclear Instrumentation and Applications Sponsor: DNP Chair: Gary Westfall, Michigan State University. Room: Hyatt Regency Dallas Cumberland A

Session B9 Hadronic Physics I Sponsor: DNP Chair: Paul Reimer, Argonne National Laboratory. Room: Hyatt Regency Dallas Cumberland B

Session B11 Focus Session: Recent Results in Quantum Gravity Sponsor: GGR Chair: William Hiscock, Montana State University. Room: Hyatt Regency Dallas Cumberland E Invited Speakers: Smolin

Session B12 B Meson Decays Sponsor: DPF Chair: James Olsen, Princeton University. Room: Hyatt Regency Dallas Cumberland F

Session B13 W and Z Bosons I Sponsor: DPF Chair: Peter Nemethy, New York University. Room: Hyatt Regency Dallas Cumberland G

Session B14 Particle Beam Physics and Technologies Sponsor: DPB Chair: Joseph Bisognano, University of Wisconsin. Room: Hyatt Regency Dallas Cumberland I

April 22, 2006, 1:30PM, Saturday

Session C1 Novel Detector Technologies Sponsor: DPF Chair: John Jaros, Stanford Linear Accelerator Center. Room: Hyatt Regency Dallas Landmark A. Invited Speakers: Kagan, Dobbs, Magill

Session C2 Hadronic Physics II Sponsor: GHP Chair: Peter Tandy, Kent State University. Room: Hyatt Regency Dallas Landmark B Invited Speakers: Braaten, Pitt, Mueller

Session C3 Very High Energy Cosmic Gamma Rays Sponsor: DAP DPF Chair: Reshmi Mukherjee, Barnard College. Room: Hyatt Regency Dallas Landmark C. Invited Speakers: Aharonian, Nemethy, Ritz

Session C4 Public and Private Funding for International Research Sponsor: FIP Chair: Arthur Bienenstock, Stanford University. Room: Hyatt Regency Dallas Marsalis A. Invited Speakers: Owens, Bement, Schleich

Session C5 Cosmology II Sponsor: DAP FHP Chair: Virginia Trimble, University of California, Irvine. Room: Hyatt Regency Dallas Pegasus B Invited Speakers: Kragh, Spergel, Carroll

Session C6 Ground-Based Gravitational Wave Detection Sponsor: GGR GPMFC Chair: Benjamin Owen, The Pennsylvania State University. Room: Hyatt Regency Dallas Cumberland J. Invited Speakers: Zucker, Brady, Sutton

Session C7 Gravitational Wave Astronomy Sponsor: DAP Chair: TBD. Room: Hyatt Regency Dallas Pegasus A

Session C8 Nuclear Theory I Sponsor: DNP Chair: TBD. Room: Hyatt Regency Dallas Cumberland A

Session C9 Minisymposium: Toward a Universal Density Functional Theory for Nuclei I Sponsor: DNP Chair: David Dean, Oak Ridge National Laboratory. Room: Hyatt Regency Dallas Cumberland B Invited Speakers: Duguet

Session C10 Nuclear Science Education for the Nation Sponsor: FEd DNP Chair: Jolie Cizewski, Rutgers University. Room: Hyatt Regency Dallas Cumberland C. Invited Speakers: McMahan, Peaslee, Hartouni

Session C11 SPS Undergraduate Research Sponsor: SPS Chair: Gary White, Society of Physics Students. Room: Hyatt Regency Dallas Cumberland E

Session C12 Accelerator-Based Neutrino Experiments Sponsor: DPF Chair: Hugh Gallagher, Tufts University. Room: Hyatt Regency Dallas Cumberland F

Session C13 W and Z Bosons II Sponsor: DPF Chair: Sarah Eno, University of Maryland. Room: Hyatt Regency Dallas Cumberland G

Session C14 Physics of Muon and Polarized Beams Sponsor: DPB Chair: Mike Syphers, Fermi National Accelerator Laboratory. Room: Hyatt Regency Dallas Cumberland I

Session C16 DPP Contributed Orals I Sponsor: DPP Chair: Benjamin Chandran, University of New Hampshire. Room: Hyatt Regency Dallas Landmark D

April 22, 2006, 2:00PM, Saturday

Session D1 Poster. Room: Hyatt Regency Dallas Landmark Circle, 2:00pm - 5:00pm

April 22, 2006, 3:30PM, Saturday

Session E1 Accelerator and Detector R&D for the International Linear Collider Sponsor: DPB DPF Chair: Shekhar Mishra, Fermi National Accelerator Laboratory. Room: Hyatt Regency Dallas Landmark A Invited Speakers: Phinney, Padamsee, Weerts

Session E2 Primordial Nucleosynthesis Sponsor: DNP Chair: Carl R. Brune, Ohio University. Room: Hyatt Regency Dallas Landmark B Invited Speakers: Smith, Tytler, Wandelt

Session E3 Laboratory Astrophysics: Magnetic Reconnection Sponsor: DPP DAP GPAP Chair: Vincent Chan, General Atomics. Room: Hyatt Regency Dallas Landmark C. Invited Speakers: Antiochos, Ji, Strait

Session E4 Science and Development: Innovation Systems for Fighting Poverty Sponsor: FIP FPS Chair: Albrecht Wagner, Deutsches Elektronen-Synchrotron. Room: Hyatt Regency Dallas Marsalis A Invited Speakers: Marjoram, Lederman, Weber

Session E5a 50 Years Since the Discovery of Parity Nonconservation in the Weak Interactions I Sponsor: FHP DPF Chair: Natalie Roe, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Pegasus B. Invited Speakers: Lee, Lederman, Conrad

Session E6 Experimental Tests of General Relativity Sponsor: GGR Chair: Marc Favata, Cornell University. Room: Hyatt Regency Dallas Cumberland J. Invited Speakers: Adelberger, Turyshev, Anderson

Session E7 Cosmology III Sponsor: DAP Chair: TBD. Room: Hyatt Regency Dallas Pegasus A

Session E8 Minisymposium: the Spin Structure of the Nucleon Sponsor: DNP Chair: Ernst Sichtermann, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Cumberland A. Invited Speakers: Vogelsang

Session E9 Minisymposium: Toward a Universal Density Functional Theory for Nuclei II Sponsor: DNP Chair: Scott Bogner, Ohio State University. Room: Hyatt Regency Dallas Cumberland B Invited Speakers: Furnstahl

Session E10 Focus Session: K-12 Education Sponsor: FEd Chair: Peggy McMahan, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Cumberland C. Invited Speakers: Steiner

Session E11 Quantum and Classical Gravity Sponsor: GGR Chair TBD. Room: Hyatt Regency Dallas Cumberland E

Session E12 Neutrino Cross Sections Sponsor: DPF Chair: Petr Vogel, California Institute of Technology. Room: Hyatt Regency Dallas Cumberland F. Invited Speakers: Marino

Session E13 Jet and Fragmentation Studies Sponsor: DPF Chair: Andreas Kronfeld, Fermilab. Room: Hyatt Regency Dallas Cumberland G

Session E14 Few Body Problems Chair TBD. Room: Hyatt Regency Dallas Cumberland I

April 22, 2006, 5:00PM, Saturday

Session E5b 50 Years Since the Discovery of Parity Nonconservation in the Weak Interactions II Sponsor: FHP DPF Chair: Noemie Koller, Rutgers University. Room: Hyatt Regency Dallas Pegasus B Invited Speakers: Yang

April 22, 2006, 5:30PM, Saturday

Session F1 APS Welcome Reception Sponsor: APS. Room: Hyatt Regency Dallas Union Station, Grand Hall

April 22, 2006, 7:15PM, Saturday

Session G1 New Reports from Major National Studies Chair: John Hopfield, APS President, Princeton University. Room: Hyatt Regency Dallas Landmark A. Invited Speakers: Shapiro, Albrecht

April 23, 2006, 8:30AM, Sunday

Session H1 Recent Results in Flavor Physics Sponsor: DPF Chair: Jack Ritchie, University of Texas, Austin. Room: Hyatt Regency Dallas Landmark A Invited Speakers: Olsen, Casey, Morii

Session H2 Topics in Nuclear Physics Sponsor: DNP Chair: Donald Geesaman, Argonne National Laboratory. Room: Hyatt Regency Dallas Landmark B. Invited Speakers: Dean, Zegers, Thomas

Session H3 Ultra-high Energy Cosmic Rays: Experiment and Theory Sponsor: DPF DAP Chair: Sean Carroll, University of Chicago. Room: Hyatt Regency Dallas Landmark C. Invited Speakers: Westerhoff, Olinto, Saltzberg

Session H4 New Models for Graduate Education Sponsor: FEd Chair: Gay Stewart, University of Arkansas. Room: Hyatt Regency Dallas Marsalis A Invited Speakers: Vickers, Lopez, Campbell

Session H5 Discovery Prospects at the Energy Frontier Sponsor: COM Chair: Harrison Prosper, Florida State University. Room: Hyatt Regency Dallas Pegasus B. Invited Speakers: Baker, Assamagan, Holloway

Session H6 Applications of Free Electron Lasers I Sponsor: DPB FIAP Chair: Alan Todd, Advanced Energy Systems. Room: Hyatt Regency Dallas Cumberland J. Invited Speakers: Kelley, Haglund, Helvajian

Session H7 Astrobiology and Planetary Effects Sponsor: DAP Chair: James Ryan, University of New Hampshire. Room: Hyatt Regency Dallas Pegasus A

Session H8 Nuclear Reactions Sponsor: DNP Chair: Peggy McMahan, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Cumberland A

Session H9 Underground Neutrino Experiments and Proton Decay Sponsor: DNP Chair: Hamish Robertson, University of Washington. Room: Hyatt Regency Dallas Cumberland B

Session H10 Production Studies in e+e- Collisions Sponsor: DPF Chair: Bruce Berger, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Cumberland C

Session H11 Relativistic Simulations of Neutron Stars, Black Holes, and Plasmas Sponsor: GGR Chair: Harald Pfeiffer, California Institute of Technology. Room: Hyatt Regency Dallas Cumberland E

Session H12 New Directions in Particle Theory Sponsor: DPF Chair: Abdulmajeed Abdurrahman, Shippensburg University. Room: Hyatt Regency Dallas Cumberland F

Session H13 Top Quark Properties I Sponsor: DPF Chair: Reinhard Schwienhorst, Michigan State University. Room: Hyatt Regency Dallas Cumberland G

Session H14 Novel Techniques Chair: TBD. Room: Hyatt Regency Dallas Cumberland I

Session H16 Sherwood I Sponsor: DPP Chair: John M. Finn, Los Alamos National Laboratory. Room: Hyatt Regency Dallas Landmark D
Invited Speakers: Stambaugh, Berk, Hallatschek

April 23, 2006, 10:30AM, Sunday

Session I1 QCD: the Lattice Meets Data Sponsor: DPF Chair: Sally Dawson, Brookhaven National Laboratory. Room: Hyatt Regency Dallas Landmark A. Invited Speakers: Kronfeld, Cahn, Pedlar

Session I2 Applications of Nuclear Science Sponsor: DNP Chair: TBD. Room: Hyatt Regency Dallas Landmark B. Invited Speakers: Wang, Kouzes, Majewski

Session I5 Theories of Gravity, Dark Energy, and Cosmology Sponsor: GGR DPF Chair: Joseph Lykken, Fermilab. Room: Hyatt Regency Dallas Pegasus B. Invited Speakers: Kachru, Arkani-Hamed, Scoccimarro

Session I6 Applications of Free Electron Lasers II Sponsor: DPB FIAP Chair: Alan Todd, Advanced Energy Systems. Room: Hyatt Regency Dallas Cumberland J. Invited Speakers: Schaaf, Smith, Hastings

Session I7 Astroparticle Physics I Sponsor: DAP Chair: TBD. Room: Hyatt Regency Dallas Pegasus A

Session I8 Minisymposium: Nuclei and Nuclear Matter at Non-Normal Density I Sponsor: DNP Chair: Sherry J Yennello Texas A&M University. Room: Hyatt Regency Dallas Cumberland A
Invited Speakers: Natowitz

Session I9 Minisymposium: Electro-Weak Interactions Sponsor: DNP Chair: Krishna Kumar, University of Massachusetts. Room: Hyatt Regency Dallas Cumberland B. Invited Speakers: Souder

Session I10 Charm Production, Decay, and Excited States Sponsor: DPF Chair: Gregory Dubois-Felsmann, California Institute of Technology. Room: Hyatt Regency Dallas Cumberland C

Session I11 Focus Session: Initial Data Sets for Numerical Relativity Sponsor: GGR Chair: Larry Kidder, Cornell University. Room: Hyatt Regency Dallas Cumberland E
Invited Speakers: Cook

Session I12 Higgs Physics I Sponsor: DPF Chair: Thomas Junk, University of Illinois at Urbana-Champaign. Room: Hyatt Regency Dallas Cumberland F

Session I13 Top Quark Properties II Sponsor: DPF Chair: Ann Heinson, University of California, Riverside. Room: Hyatt Regency Dallas Cumberland G

Session I16 Sherwood II Sponsor: DPP Chair: Zhi Hong Lin, U.C. Irvine. Room: Hyatt Regency Dallas Landmark D. Invited Speakers: Sanchez, Kinsey, Lee

April 23, 2006, 1:15PM, Sunday

Session J1 Top is Ten Sponsor: DPF Chair: Harry Weerts, Argonne National Laboratory. Room: Hyatt Regency Dallas Landmark A
Invited Speakers: Halkiadakis, Schwienhorst, Orr

Session J2 A High Luminosity Lepton Ion Collider to Study QCD Sponsor: DPB DNP Chair: Richard G. Milner, Massachusetts Institute of Technology. Room: Hyatt Regency Dallas Landmark B
Invited Speakers: Farkhondeh, Deshpande, Venugopalan

Session J4 Precision Cosmology Sponsor: DAP GGR Chair: John Beacom, Ohio State University. Room: Hyatt Regency Dallas Marsalis A
Invited Speakers: Page, Frieman, Eisenstein

Session J5 Pioneering Women Astronomers Sponsor: CSWP FHP Chair: Marc Sher, William and Mary. Room: Hyatt Regency Dallas Pegasus B
Invited Speakers: Turner, Haramundanis, Tarter

Session J6 Laboratory Astrophysics: Dynamo and the Magnetorotational Instability Sponsor: DPP DAP Chair: Steven Cowley, University of California, Los Angeles. Room: Hyatt Regency Dallas Cumberland J. Invited Speakers: Goodman, Forest, Lathrop

Session J7 Astroparticle Physics II Sponsor: DAP Chair: TBD. Room: Hyatt Regency Dallas Pegasus A

Session J8 Minisymposium: Nuclei and Nuclear Matter at Non-Normal Density II Sponsor: DNP Chair: William Lynch, Michigan State University. Room: Hyatt Regency Dallas Cumberland A
Invited Speakers: Zielinska-Pfabe

Session J9 Double Beta Decay Sponsor: DNP Chair: Andrew Hime, Los Alamos National Laboratory. Room: Hyatt Regency Dallas Cumberland B

Session J10 Charm Mixing, Rare D and K Decays Sponsor: DPF Chair: Ian Shipsey, Purdue University. Room: Hyatt Regency Dallas Cumberland C

Session J11 Advances in Numerical Relativity I Sponsor: GGR Chair: Bernard Kelly, The University of Texas at Brownsville. Room: Hyatt Regency Dallas Cumberland E

Session J12 Higgs Physics II Sponsor: DPF Chair: Dan Amidei, University of Michigan. Room: Hyatt Regency Dallas Cumberland F

Session J13 Particle Theory Sponsor: DPF Chair: Joseph Lykken, Fermilab. Room: Hyatt Regency Dallas Cumberland G

April 23, 2006, 2:00PM, Sunday

Session K1 Poster Session: Magnetically Confined Plasma I Room: Hyatt Regency Dallas Landmark Circle, 2:00pm - 5:00pm

Session K15 Panel Discussion with PR/PRL Editors Sponsor: APS. Room: Hyatt Regency Dallas Cumberland K

Apr 23, 2006, 3:15PM, Sunday

Session L1 Physics at the Energy Frontier Sponsor: DPF Chair: Robert Cahn, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Landmark A. Invited Speakers: Heineman, Junk, Feng

Session L2 Study of Hadron Structure using Spin Polarized Beams Sponsor: DPB DNP Chair: Fulvia Pilat, Brookhaven National Laboratory. Room: Hyatt Regency Dallas Landmark B. Invited Speakers: Bai, Poelker, Howell

Session L3 Advances in Numerical Relativity II Sponsor: GGR COM Chair: Deirdre Shoemaker, The Pennsylvania State University. Room: Hyatt Regency Dallas Landmark C. Invited Speakers: Pretorius, Kidder, Baumgarte, Garfinkle

Session L4 Women in Science Policy Sponsor: CSWP FPS Chair: Marc Sher, William and Mary. Room: Hyatt Regency Dallas Marsalis A Invited Speakers: Flatten, Clay, Wiseman

Session L6 Scholars at Risk Sponsor: FIP Chair: Andrew Sessler, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Cumberland J. Invited Speakers: Quinn, Orlov, Hadizadeh

Session L7 Galaxies, AGNs and Galactic Gamma-Ray Sources Sponsor: DAP Chair: TBD. Room: Hyatt Regency Dallas Pegasus A

Session L8 Nuclear Astrophysics Sponsor: DNP Chair: Betty Tsang Michigan State University. Room: Hyatt Regency Dallas Cumberland A

Session L9 Ultrarelativistic Heavy Ions Sponsor: DNP Chair: Brant Johnson, Brookhaven National Laboratory. Room: Hyatt Regency Dallas Cumberland B

Session L10 B Meson Branching Fractions Sponsor: DPF Chair: Masahiro Morii, Harvard University. Room: Hyatt Regency Dallas Cumberland C

Session L11 Experimental Gravitation Sponsor: GGR Chair: Duncan Brown, California Institute of Technology. Room: Hyatt Regency Dallas Cumberland E

Session L12 Exclusive D Meson Decays Sponsor: DPF Chair: Todd Pedlar, Luther College. Room: Hyatt Regency Dallas Cumberland F

Session L13 Top Quark Mass Measurements Sponsor: DPF Chair: Eva Halkiadakis, Rutgers University. Room: Hyatt Regency Dallas Cumberland G

Session L16 Laboratory Astrophysics I Sponsor: DPP Chair: Hantao Ji, Princeton Plasma Physics Laboratory. Room: Hyatt Regency Dallas Landmark D Invited Speakers: Egedal, Intrator, Stenzel, Brown, Bellan, Colgate

April 23, 2006, 5:15PM, Sunday

Session M1 APS Award Presentations, Past President's Address and Lilienfeld Prize Talk Sponsor: APS Chair: John Hopfield, APS President, Princeton University. Room: Hyatt Regency Dallas Landmark A Invited Speakers: Cohen, Shifman

April 24, 2006, 8:30AM, Monday

Session O1 Plenary Session II Sponsor: APS Chair: William Carithers, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Landmark A. Invited Speakers: Bell, Dorland, Shipsey

April 24, 2006, 10:45AM, Monday

Session P1 DPF and DPB Prize Session Sponsor: DPB DPF Chair: Gerald Dugan, Cornell University. Room: Hyatt Regency Dallas Landmark A Invited Speakers: Dimopoulos, Smirnova, Miller

Session P2 Neutrinos II Sponsor: DNP DPF Chair: Rabi Mohapatra, University of Maryland. Room: Hyatt Regency Dallas Landmark B Invited Speakers: Vogel, Gallagher, Berger

Session P3 Innovative Programs in K-12 Teacher Preparation Sponsor: FEd Chair: Ramon Lopez, Florida Institute of Technology. Room: Hyatt Regency Dallas Landmark C. Invited Speakers: Grosnick, Novodvorsky, Otero

Session P4 Gravitational Wave Sources and Phenomenology Sponsor: GGR DAP Chair: Gabriela Gonzalez, Louisianna State University. Room: Hyatt Regency Dallas Marsalis A. Invited Speakers: Cutler, Buonanno, Miller

Session P6 The Postdoctoral Experience Sponsor: FGSA Chair: Minesh Bacrania, APS FGSA Chair. Room: Hyatt Regency Dallas Cumberland J Invited Speakers: Balantekin, Frame, Hogstrom, Horton-Smith

Session P7 Cosmic Rays and Solar Physics I Sponsor: DAP Chair: TBD. Room: Hyatt Regency Dallas Pegasus A

Session P8 Minisymposium: Parton Distributions at Larger X : Data and Challenges Sponsor: DNP Chair: Cynthia Keppel, Hampton University/Jefferson Lab. Room: Hyatt Regency Dallas Cumberland A Invited Speakers: Owens

Session P9 Minisymposium: Advances in Zero- and Finite-Temperature Lattice QCD Sponsor: DNP Chair: Ron Soltz, Lawrence Livermore National Laboratory. Room: Hyatt Regency Dallas Cumberland B Invited Speakers: Petreczky, Savage

Session P10 50 Years Since the Discovery of Parity Nonconservation in the Weak Interactions III Sponsor: FHP DNP Chair: Susan Seestrom, Los Alamos National Laboratory. Room: Hyatt Regency Dallas Cumberland C. Invited Speakers: Hudson, Yuan, Ramsey-Musolf

Session P11 Focus Session: Space-Based Gravitational Wave Detection Sponsor: GGR Chair: Curt Culter, Jet Propulsion Laboratory. Room: Hyatt Regency Dallas Cumberland E Invited Speakers: Cornish

Session P12 Bs, Bc Lifetimes and Mixing Sponsor: DPF Chair: Nigel Lockyer, University of Pennsylvania. Room: Hyatt Regency Dallas Cumberland F

Session P13 Particle Searches I Sponsor: DPF Chair: Vladimir Litvin, California Institute of Technology. Room: Hyatt Regency Dallas Cumberland G

Session P16 Sherwood III Sponsor: DPP Chair: Linda Sugiyama, PSFC, Massachusetts Institute of Technology. Room: Hyatt Regency Dallas Landmark D. Invited Speakers: Ebrahimi, Dewar, Pedersen, Ji

April 24, 2006, 12:45PM, Monday

Session 1A Rising Above the Gathering Storm. Room: Hyatt Regency Dallas Landmark D. Invited Speakers: Augustine

April 24, 2006, 1:30PM, Monday

Session Q1 Neutrinos I Sponsor: DAP DPF Chair: George Fuller, University of California, San Diego. Room: Hyatt Regency Dallas Landmark A Invited Speakers: Abazajian, Mezzacappa, Kayser

Session Q2 Implications of QCD Phase Transitions Sponsor: DNP Chair: TBD. Room: Hyatt Regency Dallas Landmark B. Invited Speakers: Zahed, Stankus, Rajagopal

Session Q3 Particle Acceleration Sponsor: DAP DPP Chair: James Drake, University of Maryland. Room: Hyatt Regency Dallas Landmark C Invited Speakers: Smith, Drury, Giacalone

Session Q4 Three-Body Systems Sponsor: GFB Chair: Werner Tornow, Duke University. Room: Hyatt Regency Dallas Marsalis A Invited Speakers: Ilieva, Sargsian, Epelbaum

Session Q5 Evolution: From the Big Bang to Us Sponsor: FPS FEd Chair: Barbara Levi, Physics Today. Room: Hyatt Regency Dallas Pegasus B Invited Speakers: Primack, Kasting, Jeffery

Session Q6 Advanced Acceleration Techniques for Future Energy Frontier Accelerators Sponsor: DPB Chair: James Rosenzweig, University of California, Los Angeles. Room: Hyatt Regency Dallas Cumberland J Invited Speakers: Muggli, Mori, Rosenzweig

Session Q8 Electromagnetic Interactions Sponsor: DNP Chair: Ioana Niculescu, James Madison University. Room: Hyatt Regency Dallas Cumberland A

Session Q9 Nuclear Structure Sponsor: DNP Chair: Carlos Bertulani, University of Arizona. Room: Hyatt Regency Dallas Cumberland B

Session Q10 Rare B Decays Sponsor: DPF Chair: Brendan Casey, Brown University. Room: Hyatt Regency Dallas Cumberland C

Session Q11 Simulations of Binary Black Hole Mergers Sponsor: GGR Chair: Carlos Lousto, The University of Texas at Brownsville. Room: Hyatt Regency Dallas Cumberland E

Session Q12 Baryons and B Lifetime Studies Sponsor: DPF Chair: William T. Ford, University of Colorado. Room: Hyatt Regency Dallas Cumberland F

Session Q13 Particle Searches II Sponsor: DPF Chair: Beate Heinemann, University of Liverpool. Room: Hyatt Regency Dallas Cumberland G

Session Q14 History of Physics Sponsor: FHP Chair: Robert H. Romer, Amherst College. Room: Hyatt Regency Dallas Cumberland I

April 24, 2006, 2:00PM, Monday

Session R1 Poster Session: Magnetically Confined Plasma II Room: Hyatt Regency Dallas Landmark Circle, 2:00pm - 5:00pm

April 24, 2006, 3:30PM, Monday

Session S1 High Power Proton Drivers for Accelerator-based Neutrino Physics Sponsor: DPB DPF Chair: Thomas Roser, Brookhaven National Laboratory. Room: Hyatt Regency Dallas Landmark A Invited Speakers: Diwan, Apollinari, Nagamiya

Session S2 DNP Prize Session Sponsor: DNP Chair: Bradley Sherrill, Michigan State University. Room: Hyatt Regency Dallas Landmark B Invited Speakers: Towner, Hardy, Truran

Session S3 The Heliospheric Termination Shock Sponsor: DAP Chair: Martin Lee, University of New Hampshire. Room: Hyatt Regency Dallas Landmark C. Invited Speakers: Decker, Moebius, Fisk

Session S4 FHP/FPS Award Session Sponsor: FHP FPS Chair: George Lewis, Peace Studies Program, Cornell University. Room: Hyatt Regency Dallas Marsalis A. Invited Speakers: Heilbron, Richards, Albright, Orlov

Session S6 Panofsky Prize Session Sponsor: DPF Chair: Bill Carithers, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Cumberland J. Invited Speakers: Jaros, Ford, Lockyer

Session S10 Focus Session: Undergraduate and Graduate Education Sponsor: FEd Chair: Bruce Ackerson, Oklahoma State University. Room: Hyatt Regency Dallas Cumberland C. Invited Speakers: Hasty

Session S11 Sources of Gravitational Waves Sponsor: GGR Chair: John Baker, Goddard Space Flight. Room: Hyatt Regency Dallas Cumberland E

Session S12 CP Violation in B Meson Decays Sponsor: DPF Chair: Masahiro Morii, Harvard University. Room: Hyatt Regency Dallas Cumberland F

Session S13 Top Quark Production Sponsor: DPF Chair: David Cline, University of California, Los Angeles. Room: Hyatt Regency Dallas Cumberland G

Session S16 Laboratory Astrophysics II Chair: Parvez Guzdar, University of Maryland. Room: Hyatt Regency Dallas Landmark D Invited Speakers: Craig, Fredrickson, Goree, Sun, Vincena, Carter

April 24, 2006, 5:30PM, Monday

Session T2 DNP Business Meeting Sponsor: DNP. Room: Hyatt Regency Dallas Landmark B

Session T4 FPS Business Meeting Sponsor: FPS. Room: Hyatt Regency Dallas Marsalis A

Session T5 DPB Business Meeting and Reception Sponsor: DPB. Room: Hyatt Regency Dallas Reverchon AB

Session T7 DAP Business Meeting Sponsor: DAP. Room: Hyatt Regency Dallas Pegasus A

Session T11 GFB Business Meeting Room: Hyatt Regency Dallas Cumberland E

Session T12 GGR Business Meeting Sponsor: GGR. Room: Hyatt Regency Dallas Cumberland F

Session T14 FHP Business Meeting Sponsor: FHP. Room: Hyatt Regency Dallas Cumberland I

April 25, 2006, 8:30AM, Tuesday

Session V1 Plenary Session III Sponsor: APS Chair: Brad Sherrill, Michigan State University. Room: Hyatt Regency Dallas Landmark A Invited Speakers: Zettl, Gonzalez, Wagner

April 25, 2006, 10:30AM, Tuesday

Session W5 Abrupt Climate Change Scenario Sponsor: FPS Chair: Tina Kaarsberg, U.S. Department of Energy. Room: Hyatt Regency Dallas Pegasus B. Invited Speakers: Day, Rosenfeld, Galloway

Session W15 Poster Session IV: Post-deadline Posters. Room: Hyatt Regency Dallas Landmark Circle, 10:30am-2:00pm

April 25, 2006, 10:45AM, Tuesday

Session W1 Shedding Light on Dark Energy Sponsor: DPF DAP Chair: Natalie Roe, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Landmark A. Invited Speakers: Howell, Linder, Bernstein

Session W2 Notes from Underground Sponsor: DNP DPF Chair: George Fuller, University of California, San Diego. Room: Hyatt Regency Dallas Landmark B. Invited Speakers: Gratta, Vagins, Goldschmidt

Session W3 Cosmic Gamma-Ray Bursts Sponsor: DAP Chair: Charles Meegan, National Space Science and Technology Center. Room: Hyatt Regency Dallas Landmark C. Invited Speakers: Gehrels, Hartmann, Reichart

Session W6 Research on Teaching Thermal Physics and Quantum Mechanics Sponsor: FEd Chair: Paula Heron, University of Washington. Room: Hyatt Regency Dallas Cumberland J
Invited Speakers: Thompson, Singh, Meltzer

Session W7 Cosmic Rays and Solar Physics II Sponsor: DAP Chair: TBD. Room: Hyatt Regency Dallas Pegasus A

Session W8 Minisymposium: Heavy Quark Energy Loss & Flow Sponsor: DNP Chair: Peter Jacobs, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Cumberland A. Invited Speakers: Liu

Session W9 Nuclear Theory II Sponsor: DNP Chair: Vladimir Zelevinsky, Michigan State University. Room: Hyatt Regency Dallas Cumberland B

Session W10 Heineman Prize Session Sponsor: GGR DPF Chair: Pierre Sikivie, University of Florida. Room: Hyatt Regency Dallas Cumberland C
Invited Speakers: Ferrara, Freedman, van Nieuwenhuizen

Session W11 Gravitational Wave Searches Sponsor: GGR Chair: Lior Burko, The University of Alabama, Huntsville. Room: Hyatt Regency Dallas Cumberland E

Session W12 Bs, B*, eta-B decays Sponsor: DPF Chair: Robert Cahn, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Cumberland F

Session W13 Particle Physics Instrumentation Sponsor: DPF Chair: Stephen Magill, Argonne National Laboratory. Room: Hyatt Regency Dallas Cumberland G

Session W16 Sherwood IV Sponsor: DPP Chair: Eric Held, Utah State University. Room: Hyatt Regency Dallas Landmark D
Invited Speakers: Bonoli, Chang, Arefiev, Dodin

April 25, 2006, 12:15PM, Tuesday

Session X5 Elements of a Real Energy Strategy Sponsor: FPS Chair: Anthony Nero, Lawrence Berkeley National Laboratory. Room: Hyatt Regency Dallas Pegasus B. Invited Speakers: Lewis, German, Burchill

April 25, 2006, 1:30PM, Tuesday

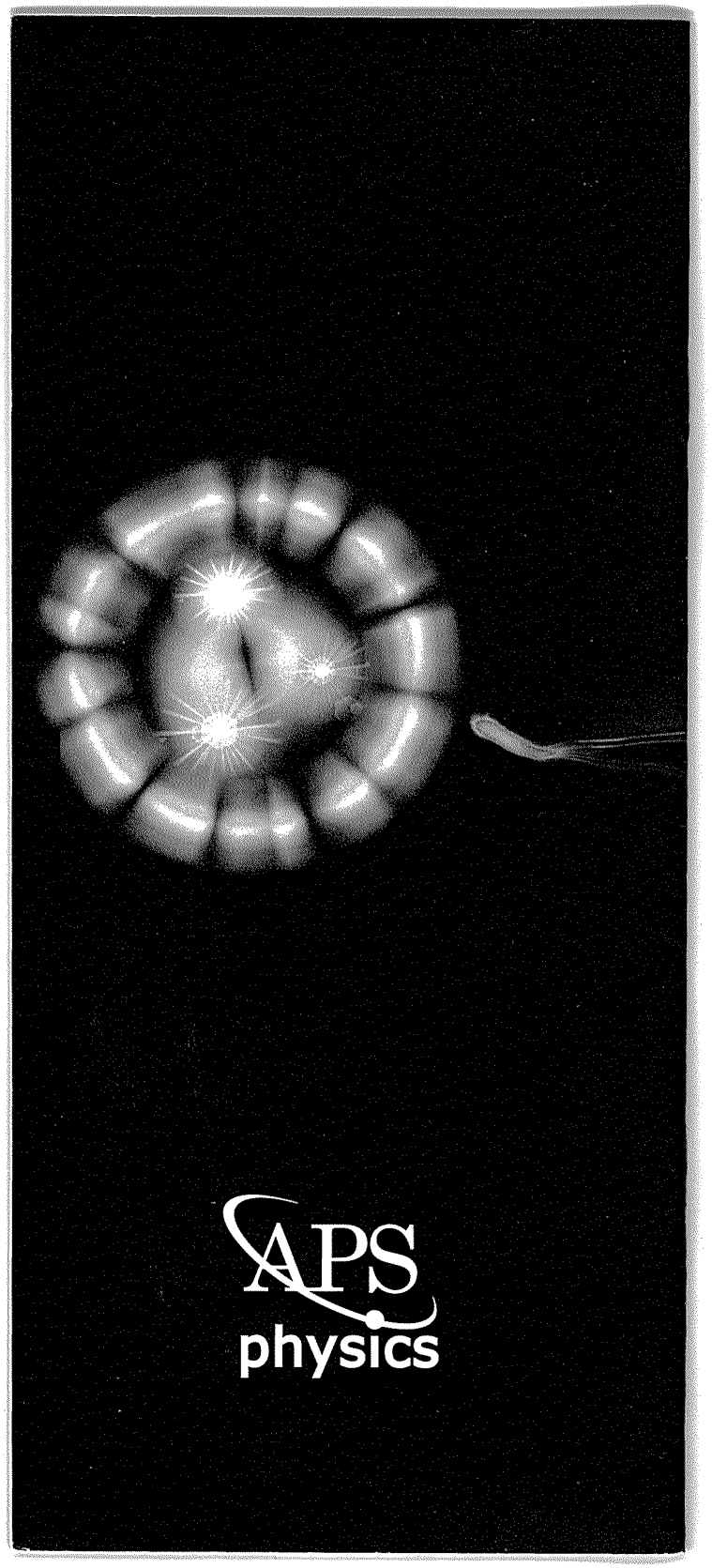
Session X1 Dark Matter Sponsor: DNP DPF Chair: Elena Aprile, Columbia University. Room: Hyatt Regency Dallas Landmark A
Invited Speakers: Hinchliffe, Shutt, Sikivie

Session X2 Physical Properties of Partonic Matter Sponsor: DNP Chair: TBD. Room: Hyatt Regency Dallas Landmark B. Invited Speakers: Teaney, Bathe, Jacobs

Session X3 Magnetars Sponsor: DAP Chair: David Palmer, Los Alamos National Laboratory. Room: Hyatt Regency Dallas Landmark C
Invited Speakers: Hurley, Strohmayer, Lyutikov

Session X16 Research on Teaching Large Enrollment Classes Sponsor: FEd Chair: David Meltzer, University of Washington. Room: Hyatt Regency Dallas Landmark D. Invited Speakers: Kanim, Stelzer, Pollock

NOTES


APS
physics

CORRIGENDA

Bulletin of the American Physical Society, Vol. 51, No. 2

April Meeting 2006 • Hyatt Regency Dallas

The Corrigenda is designed to complement the *Bulletin of the American Physical Society*. This list incorporates changes, additions and withdrawals that were received after the *Bulletin* was printed.* The most up-to-date changes will be displayed on the Changes Board located in the Landmark Concourse of the Hyatt Regency Dallas. Please inquire at registration or the information booth as to the location of this board.

LOCATION CHANGE

SESSION/ACTIVITY	NEW LOCATION
Email Stations	Marsalis Hall B
ALL Posters Sessions	Marsalis Hall B

SESSION CHAIR CHANGES

SESSION	NEW CHAIR
Session C7: Gravitational Wave Astronomy	Charles Dermer, Naval Research Laboratory
Session E14 Few Body Problems	Charlotte Elster, Ohio University
Session E11: Quantum and Classical Gravity	Kevin Vandersloot, Pennsylvania State Univ.
Session H14: Novel Techniques	Ron Mickens, Clark Atlanta University
Session I1: QCD: the Lattice Meets Data	Marcela Carena, Fermilab
Session I7: Astroparticle Physics I	Ulisse Bravar, University of New Hampshire
Session J7: Astroparticle Physics II	Martin Pohl, Iowa State University
Session L7: Galaxies, AGNs and Galactic Gamma-Ray Sources	Charles Dermer, Naval Research Laboratory
Session P11: Space-Based Gravitational Wave Detection	John Friedman, Univ. of Wisconsin at Madison
Session P7: Cosmic Rays and Solar Physics I	Stefan Westerhoff, Columbia University
Session X1: Dark Matter	Uwe Oberlack, Rice University

TITLE CHANGE

SESSION	TITLE CHANGE	AUTHOR
A1.3	Accelerator-based Neutrino Oscillation Studies: Present and Future	Hirohisa Tanaka

AFFILIATION CHANGE

SESSION	AUTHOR	NEW AFFILIATION
J2.1	M. Farkhondeh	Office of Nuclear Physics, Office of Science, U.S. Department of Energy

*Changes as of April 18, 2006

SPEAKER CHANGES

If available, complete abstracts for the new speakers appear online at: http://www.aps.org/meet/APR06/baps

SESSION	TITLE	NEW SPEAKER	ORIGINAL SPEAKER
C12.6	A Detector 2 km Away from the T2K Neutrino Source	Kate Scholberg	Edward Kearns
G1.1	Discovering the Quantum University	Joseph Lykken	Harold Shapiro
L4.2	A Capitol Hill Perspective	Christal Sheppard	Kathryn Clay
W11.9	Search for gravitational wave bursts associated with gamma-ray bursts using LIGO detectors	Isabel Leonor	Virginio Sannibale

SPEAKER ASSIGNMENT CHANGE

ORIGINAL PLACEMENT	NEW PLACEMENT	TITLE	SPEAKER
C1.2	C1.1	Bolometer Array System for Detection of the Cosmic Microwave Background	Matt Dobbs
C1.1	C1.2	Diamond Detectors	Harris Kagan

ABSTRACT REPLACEMENT

SESSION	REPLACEMENT ABSTRACT (REPLACES ABSTRACT IN PRINTED BULLETIN.)
L6.2 **Yuri Orlov,** **Cornell University**	**Title: Scholars at Risk in Russia** Abstract: I will share my general thoughts on safe haven for scholars at risk, based on my own experience, and will discuss scholars at risk in Russia. At the present time, these are mostly scientists falsely accused of espionage. I will highlight the special issues this fact raises for providing support or safe haven for such scientists.

ABSTRACT WITHDRAWALS

SESSION	TITLE	AUTHOR
C3.1	TeV Astrophysics and Cosmology	F. Aharonian
I9.6	Muon Decay Parameters from Majorana Neutrino Masses	Rebecca Erwin
I12.1	Search for Higgs Boson Production via the Process pp –> ZH –> l^+l^-bb at CDF	B. Kilminster
I12.2	CMS Detector Sensitivity to the Standard Model Higgs Boson in H –> ZZ –> 4: Decay Channel	A. Drozdetski
J7.10	An Origin for Gravity and Electromagnetism when Mass and Specific Density are Statistical Intensive Parameters	G. Holstrom
L8.1	Equation of State for low density nuclear matter	J. Taruna
P9.5	Lattice QCD calculations of B meson properties and consequences for quark flavor phenomenology	M. Wingate

Employer/Recruiter Registration
(https://www.aip.org/forms/reg_apsapril06.html)

The pre-registration deadline for both employers and job seekers is April 7, 2006.
Note: Jobs and resumes will be available online from April 3 – May 3, 2006.

Questions
For more information about the Job Fair, please contact:
American Institute of Physics
Career Services Division
One Physics Ellipse
College Park, MD 20740
tel: 301-209-3187; fax: 301-209-0841
email: abrice@aip.org
website: www.aip.org/careers

PRE-MEETING PROGRAMS

High School Physics Teachers' Day

Friday, April 21
8:00am to 2:45pm
Cumberland J

In conjunction with the 2006 April Meeting, the APS Department of Education & Outreach is sponsoring a High School Physics Teachers' Day for teachers in the Dallas region. The day includes:

- Hands-on workshops presenting innovative, classroom-ready activities
- Research talks on cutting-edge physics
- A welcoming breakfast, and a chance to network with fellow teachers
- Lunch with a physicist

If you would like to join the teachers for lunch (11:45am-12:45pm) contact Ed Lee.

Professional Skills Development Workshop for Women Physicists

Sponsored by the Committee on the Status of Women in Physics (CSWP)

Friday, April 21
Workshop: 8:00am – 5:00pm
Workshop: Cumberland F
Reception: 5:00pm – 6:30pm
Reception: Cumberland A

This one day workshop will offer training on persuasive negotiation and communication skills for tenure-track and newly-tenured women physicists. Workshop will be led by professional facilitators using an interactive format that encourages highly personal learning. Lunch will be provided and a reception for participants will follow the workshop. Limited to 30 participants. Information can be found at http://www.aps.org/educ/cswp/skills/. There is no on-site registration for this activity - you must pre-register to attend the workshop.

APS MEETINGS / EVENTS
(In chronological order)

Plenary Talks
Saturday, April 22
8:30am-10:30am
Landmark A
- *Exploring the Final Frontier of the Solar System*
Edward Stone, CalTech
- *Liquid Phase Quark-Gluon Plasma*
Barbara Jacak, SUNY, Stony Brook
- *Recent Results from MiniBoone*
Hira Tanaka, Princeton

Monday, April 24
8:30am-10:30am
Landmark A
- *Neutrinos and Cosmology*
Nicole Bell, CalTech
- *Plasma Turbulance in Astrophysics and in the Laboratory*
William Dorland, University of Maryland
- *Cochlear Implants and the Physics of Hearing*
Ian Shipsey, Purdue University

Tuesday, April 25
8:30am-10:30am
Landmark A
- *The Science of Nanotubes*
Alex Zettl, UC, Berkeley
- *Searching for Gravitational Waves with LIGO*
Gabriella Gonzalez, Louisiana State University
- *Physics Prospects and International Aspects of ILC*
Albrecht Wagner, DESY

APS Welcome Reception
Saturday, April 22
5:30pm-7:00pm
Grand Hall, Union Station (attached by walkway to the Hyatt)
All April Meeting attendees are invited to attend and join your colleagues for refreshments.

Scientific Professionalism and the Physicist: The Skills You Need to Succeed in Physics-based Careers
Saturday, April 22
7:00pm–9:00pm
Club Car, Union Station (connected by walkway to the Hyatt Hotel)
Workshop Facilitator: Alaina G. Levine, Director of Special Projects
College of Science, University of Arizona; President, Quantum Success Solutions

This interactive and humor-filled workshop will address key professional skills which will help both physicists and physics students succeed in whatever scientific career they choose. Too often, physics students enter the job market with little knowledge of the skills needed to advance and succeed in any professional arena. Participants in this workshop will learn and practice strategic skills such as communication, networking, contact management, and partnering with a mentor, which are crucial to advancing in the job market and beyond.

You will discover how to empower yourself, and the strategy and importance of getting noticed for your physics talents by not only your boss and colleagues, but others as well, especially your boss's boss and other VIPs. We will also discuss the concept of a brand (which is simply a promise), and how to build and promote the brand that is YOU by establishing yourself as a leader and an expert in your area of knowledge and ability.

Participants will also learn about the vast array of resources available to assist them with their career exploration and will learn how to apply the skills developed in the workshop to take the fullest advantage of these opportunities, resources, and contacts.

The workshop will be educational, stimulating, fast-paced, informative, and will not only introduce concepts but teach participants to apply them that very day, giving them the edge they need to succeed in a very competitive job market.

Special Symposium:
New Reports from Major National Studies (Session G1)
Saturday, April 22
7:15pm–9:00pm
Landmark A
Chair: John Hopfield, Princeton University, APS President
Speakers:
- Harold Shapiro, President Emeritus Princeton University
Elementary Particle Physics in the 21st Century: Explorations of the Terascale
- Andreas Albrecht, Department of Physics, UC Davis
Report from the Dark Energy Task Force

APS Journal Editors Panel Discussion (Session K15)
Sunday, April 23
2:00pm-3:00pm
Cumberland K
All are invited to a panel discussion with the Editors of the American Physical Society journals. The panel will include Editors from Physical Review and Physical Review Letters. They will briefly discuss some current issues facing the journals such as how to express appreciation for good refereeing, possible inclusion of popular abstracts in PRL to make Letters accessible to physicists in all fields, the challenge posed by open access, etc. The Editors look forward to hearing opinions on these and other issues, and will respond to questions and comments. The Panel Discussion will be followed by the Meet the Editors Reception.

Meet the Editors of Physical Review and Physical Review Letters
Sunday, April 23
3:00pm-5:00pm
Pre-Function Area, Marsalis Hall
The editors of Physical Review and Physical Review Letters cordially invite you to join them for conversation and refreshments. Your questions, suggestions, compliments and complaints about the journals are welcome. We hope you will be able to join us.

APS MEETINGS / EVENTS
(In chronological order)

Awards Session (Session M1)
Sunday, April 23
5:15pm-6:45pm
Landmark A

- Prizes and awards will be bestowed on individuals for outstanding contributions to physics. Please plan on attending the Awards Program and join us in honoring these individuals. See page 10 for a list of award and prize winners.
- Marvin Cohen, APS Past President, will give the retiring presidential address entitled, *Looking Back on the World Year of Physics 2005*
- Lilienfeld Prize Talk, *Persistent Challenges of Quantum Chromodynamics,* Mikhail Shifman, University of Minnesota

Special Lunchtime Talk
Monday, April 24
12:45pm–1:25pm
Landmark A

Norman Augustine, CEO Lockheed Martin, Retired, *Rising Above the Gathering Storm: Addressing America's Competitiveness Challenges.* Bring a lunch to eat during the talk.

An Evening with Lisa Randall
Monday, April 24
6:30pm–8:00pm
Landmark A

Warped Passages: Unraveling the Mysteries of the Universe's Hidden Dimensions

APS EVENTS FOR SPECIAL GROUPS

(In chronological order)

Student Reception

Friday, April 21
8:00pm–9:00pm
Pegasus B

All students are cordially invited to an informal reception hosted by the APS and the Forum on Graduate Student Affairs. This is your chance to meet your fellow students, enjoy refreshments, and show off your physics trivia knowledge in our quiz. (There will be prizes of course!)

Companion's Breakfast

Saturday, April 22
9:00am–10:00am
Club Car, Union Station
(attached by a walkway to the Hyatt Hotel)

All companions of April Meeting attendees are invited to attend. A presentation about the city of Dallas will be given by the Dallas Convention and Visitors Bureau.

CSWP/DPF Lunch for Women in Physics

Monday, April 24
12:00pm–1:30pm
Club Car, Union Station (attached by walkway to Hyatt Hotel)

Enjoy a full buffet lunch and network with colleagues! Natalie Roe (LBNL), Marcela Carena (Fermilab) and Ann Heinson (University of California Riverside) will speak informally, followed by an opportunity for questions. Open to all with an interest in women in physics. Cost $20 ($5 for students). Space is limited. Pre-registration at http://www.aps.org/educ/cswp/index.cfm.

Students Lunch with the Experts

Monday, April 24
12:30pm-2:00pm
Station Master, Union Station
(attached by walkway to Hyatt Hotel)

Students can sign up on-site to enjoy complimentary box-lunch while participating in an informal discussion with an expert on a topic of interest to them. Sign-up will take place beginning on Saturday, April 22 at 1:00pm at the APS registration desk, and will be on a first-come, first-served basis. Attendance is limited to eight students per topic.

List of Topics and Experts

1. Nuclear Structure Physics
   Expert: Richard Casten, Yale University
2. Fundamental Physics with Ultra Cold Neutrons (DNP)
   Expert: Alexander Saunders, LANL
3. Relativistic Heavy Ion Physics (DNP)
   Expert: Gerd Kunde, LANL
4. Physics of Particle Accelerators (DPB)
   Expert: Thomas Roser, BNL
5. Working in Collaborations: It's More than Just Physics
   Expert: Katherine Frame, LANL
6. General Relativity and Gravitational Waves (GGR)
   Expert: Gabriela Gonzalez, LSU
7. Fusion Energy (DPP)
   Experts: Ron Stambaugh, General Atomics & Cris Barnes, LANL

COM/CSWP Reception

Monday, April 24
5:30pm–7:00pm
Sanger AB

The APS Committee on Minorities in Physics (COM) will co-sponsor a reception with the Committee on the Status of Women in Physics (CSWP). This is a wonderful opportunity to learn about the work of these Committees, to network with colleagues, and to unwind after a long day of sessions. All are welcome to join us.

Sherwood/DPP Reception

(By Invitation Only)
Monday, April 24
5:30pm-7:30pm
Cumberland K

BUSINESS MEETINGS

Monday, April 24
5:30pm–6:30pm

GFB Business Meeting
Cumberland E

FPS Business Meeting
Marsalis A

DPB Business Meeting
Reverchon AB
5:30pm-8:30pm

FHP Business Meeting
Cumberland I

DNP Business Meeting
Landmark B

DAP Business Meeting
Pegasus A

2006 PRIZES AND AWARDS

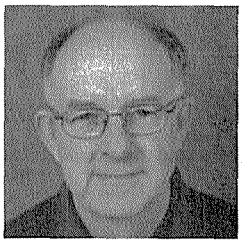


Hans A. Bethe Prize

Alastair G.W. Cameron
Harvard University

Session S2

"For his pioneering work in developing the fundamental concepts of nuclear astrophysics. These basic ideas, laid out almost 50 years ago, are still the basis of current research in this field."

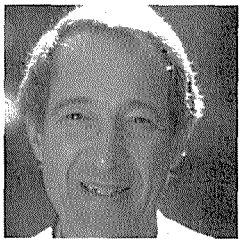


Tom W. Bonner Prize

Ian S. Towner
Queen's University

Session S2

"In recognition of ultra-high precision measurements and extraordinarily detailed analyses of $0^+ \rightarrow 0^+$ nuclear beta decay rates to explore the unitarity of the Cabibbo-Kobayashi-Maskawa quark mixing matrix as a test of the electroweak Standard Model."



Dannie Heineman Prize

Daniel Freedman,
Massachusetts Institute of Technology

Session W10

"For constructing supergravity, the first supersymmetric extension of Einstein's theory of general relativity, and for their central role in its subsequent development."



Julius E. Lilienfeld Prize

Mikhail Shifman,
University of Minnesota

Session M1

"For contributions to theoretical high energy physics, in particular for the understanding of strong interactions and dynamics of supersymmetric gauge theories, and for communicating the excitement of science to the public."



Tom W. Bonner Prize

John C. Hardy
Texas A&M University

Session S2

"In recognition of ultra-high precision measurements and extraordinarily detailed analyses of $0^+ \rightarrow 0^+$ nuclear beta decay rates to explore the unitarity of the Cabibbo-Kobayashi-Maskawa quark mixing matrix as a test of the electroweak Standard Model."

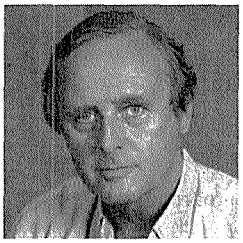


Dannie Heineman Prize

Sergio Ferrara
CERN

Session W10

"For constructing supergravity, the first supersymmetric extension of Einstein's theory of general relativity, and for their central role in its subsequent development."



Dannie Heineman Prize

Peter van Nieuwenhuizen,
SUNY, Stony Brook

Session W10

"For constructing supergravity, the first supersymmetric extension of Einstein's theory of general relativity, and for their central role in its subsequent development."



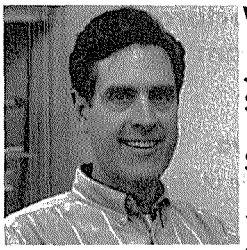
W.K.H. Panofsky Prize

William Ford
University of Colorado

Session S6

"For leading contributions to the discovery of the long b-quark lifetime with the MAC and Mark II experiments at SLAC. The unexpectedly large value of the b-quark lifetime revealed the hierarchy of the Cabibbo-Kobayashi-Maskawa quark mixing matrix."

2006 PRIZES AND AWARDS



W.K.H. Panofsky Prize

John Jaros
SLAC

Session S6

"For leading contributions to the discovery of the long b-quark lifetime with the MAC and Mark II experiments at SLAC. The unexpectedly large value of the b-quark lifetime revealed the hierarchy of the Cabibbo-Kobayashi-Maskawa quark mixing matrix."



W.K.H. Panofsky Prize

Nigel Lockyer
University of Pennsylvania

Session S6

"For leading contributions to the discovery of the long b-quark lifetime with the MAC and Mark II experiments at SLAC. The unexpectedly large value of the b-quark lifetime revealed the hierarchy of the Cabibbo-Kobayashi-Maskawa quark mixing matrix."



Andrei Sakharov Prize

Yuri Orlov
Cornell University

Session L6 and Session S4

"For his distinction as a creative physicist and as a life-long, ardent leader in the defense and development of international human rights, justice and the freedom of expression for scientists."



J.J. Sakurai Prize

Savas Dimopoulos
Stanford University

Session P1

"For his creative ideas on dynamical symmetry breaking, supersymmetry, and extra spatial dimensions, which have shaped theoretical research on TeV-scale physics, thereby inspiring a wide range of experiments."



Robert R. Wilson

Glen Lambertson
Lawrence Berkeley National Laboratory

"For fundamental contributions to accelerator science and technology, particularly in the area of beam electrodynamics, including the development of beam instrumentation for the feedback systems that are essential for the operation of high luminosity electron and hadron colliders."

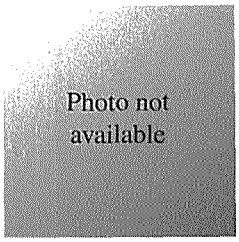


LeRoy Apker Award, PhD

David Wilkins Miller
University of Chicago

Session P1

"Search for high-energy axions with the CAST calorimeter"



Joseph A. Burton Forum Award

David Albright
Institute for Science and International Security

Session S4

"For his tireless and productive efforts to slow the transfer of nuclear weapons technology. He brings a unique combination of deep understanding, objectivity, and effectiveness to this vexed area."



Abraham Pais Prize for History of Physics

John Lewis Heilbron
Oxford University

Session S4

"For his groundbreaking and broad historical studies, ranging from the use of Renaissance churches for astronomy, through 17th and 18th-century electrical science, to modern physics."

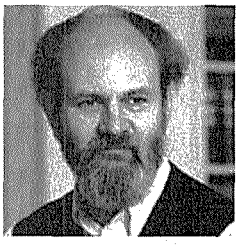
2006 PRIZES AND AWARDS



Nicholson Medal For Human Outreach

Padma Kant Shukla
Ruhr-Universität Bochum

"For his prodigious and successful efforts in encouraging young scientists from under-represented countries throughout the world, by his regular visits to their universities and by facilitating their participation in international meetings and workshops."



Leo Szilard Lectureship Award

Paul G. Richards
Columbia University

Session S4

"For work applying his expertise in geophysics to seismic detection of nuclear explosions. His developments in "forensic seismology" are at the heart of the verification required for a test ban."



Mitsuyoshi Tanaka Dissertation Award

Maria Florencia Canelli
Fermilab

Session B4

"For developing a new technique for extracting the maximum information in top decay events in order to measure the W boson helicity."



Outstanding Doctoral Thesis Research In Beam Physics Award

Evgenya I. Smirnova
Massachusetts Institute of Technology

Session P1

"For the design, fabrication and successful testing of a 17 GHz electron accelerator utilizing a photonic crystal structure."



Dissertation Award in Nuclear Physics

Li-Bang Wang
University of Illinois, Urbana-Champaign

Session I2

"For his outstanding and innovative experimental work to precisely measure the charge radius of the exotic and short-lived isotope ^{6}He by laser spectroscopic studies of single atoms stored in a magneto-optical trap. The result helps to reveal the nature of weakly bound nuclei and serves as a key benchmark for nuclear models."



Mitsuyoshi Tanaka Dissertation Award

Alysia D. Marino
Fermilab

Session E12

"For her contributions to the measurement of neutrino fluxes which conclusively support the hypothesis of flavor oscillation of neutrinos produced in the sun as they travel toward the earth. The results further suggest the most likely cause of the flavor change to be matter-induced oscillation."

PROGRAM FORMAT

Program Time-Blocks

Saturday: A-G
Sunday: H-M
Monday: O-T
Tuesday: V-X

There are four time blocks for each day of the meeting. (Saturday, Monday and Tuesday: 8:30am, 10:45am, 1:30pm and 3:30pm; Sunday: 8:30am, 10:30am; 1:15pm and 3:15pm.) The time blocks are designated in alphabetical order beginning with time block "A" on Saturday at 8:30am, and ending with time block "X" designating the 1:30pm session on Tuesday. See the Program Schedule for details.

Session Codes

Each session within a time block is numbered sequentially, as well as the papers within a session. For example, session code B4.3 = time block B at 10:45am on Saturday; session #4 within the B time block, and paper #3 to be presented in session B4.

Poster Codes

Posters are numbered sequentially.

Poster Presentations

If you are presenting a poster, please be sure to have your poster up prior to the start of the session to which you have been assigned, and taken down immediately at the end of the session. APS will not be responsible for posters left up after the end of each poster session. No A-V is allowed in the poster sessions. Posters will be on display between the hours of 10:00am to 5:00pm Saturday and Sunday. Consult the Poster Session Schedule for exact times and a breakdown of poster topics.

Poster Session Schedule

Poster Session I (Session D1)
Saturday, April 22, 2:00pm-5:00pm

Posters 1-12:	Gravitation
Posters 13-15:	Undergraduate Research
Posters 16-24:	Plasma Physics: Basic, Laser and Non-Neutral Plasma
Posters 25-44:	Plasma Physics: Space and Astrophysical Plasma
Posters 45-49:	Computatonal Physics
Posters 50-51:	Accelerator Systems
Posters 52-53:	Beam Physics
Posters 54-70:	Tests of Physics Laws
Posters 71-76:	Particles and Fields
Posters 77-80:	New Precision Measurement Methods
Posters 81-82:	Few-Body Systems
Posters 83-84:	History of Physics
Posters 85-102:	Astrophysics

Poster Session II (Session K1)
Sunday, April 23, 2:00pm-5:00pm

Poster 1-60:	Magnetically Confined Plasma I

Poster Session III (R1)
Monday, April 24, 2:00pm-5:00pm

Posters 1-60:	Magnetically Confined Plasma II: 1-60
Posters 61-62:	Astrophysics

Poster Session IV (W15)
Tuesday, April 25, 10:30am-2:00pm

Post-deadline Posters

A-V Policy at the April Meeting

In the interest of ensuring a professional and smooth-running meeting, the American Physical Society's A-V policy is as follows:

General A-V Policy

In keeping with our legally binding contract with our A-V vendor, speakers are not permitted to bring their own projection equipment for use at the meeting.

Standard A-V in all Sessions

The standard A-V package consists of an LCD projector, overhead projector, screen, laser pointer and lapel microphone. Any additional A-V equipment must be rented by the speaker directly through APS's designated A-V provider. The speaker is responsible for the cost of renting any additional equipment.

Policy and Guidelines on Use of LCD Projectors

The responsibility for a smooth, technically trouble-free presentation ultimately rests with the presenter. Speakers who plan to use LCDs must do the following:

- Bring your own laptop computer, power cord, and any proprietary cords required for your computer.
- Visit the Speaker-Ready room (Cumberland H) provided by APS to run through the presentation to ensure a smooth and technically trouble-free presentation. Testing your presentation in the Speaker-Ready room prior to your presentation is strongly recommended to minimize equipment compat ibility difficulties. If you encounter difficulties, consult with the A-V technicians.
- Bring a back-up vu-graph presentation in case there are set-up difficulties with the LCD equipment.

NOTE: The APS is not responsible for the security of personal laptop computers. The APS strongly recommends that LCD projectors not be used for contributed talks (12 minute talks). The presentation schedule must be maintained, and as is too often the case, the set-up of the laptop/projector can be problematic, using up valuable presentation time.

Guidelines for Speakers

Oral Presentations

Please arrive at least 15 minutes prior to the scheduled time of your talk. Contributed papers are allocated 12 minutes each - 10 minutes for presentation and 2 minutes for questions from the audience, unless otherwise specified. Invited papers are allocated 36 minutes - 30 minutes for presentation and 6 minutes for questions from the audience.

PROGRAM FORMAT

NOTE: Occasionally (and unfortunately) the chair for a session may not appear, in which case we ask that the first presenter serve as chair of the session.

Guidelines for Session Chairs

1. Please check the Bulletin to determine if any supplementary papers have been assigned to the session you are chairing. Prior to the session, check the Corrigenda distributed with the Bulletin, as well as the Program-Changes Board in the registration area to see if any papers have been withdrawn.

2. Arrive at the meeting room about 15 minutes prior to the start of the session and familiarize yourself with the controls for lights, microphones, A-V equipment and the timer. If you encounter problems, you should immediately alert the Meetings Manager and/or the A-V specialist.

3. Start the session on time. Briefly introduce yourself, announce the first paper and author, and start the timer.

4. Please adhere to the time schedule listed in the Bulletin, so that simultaneous sessions are as closely synchronized as possible. Many attendees move from session to session in order to hear specific papers.

5. The allotted time for contributed papers is 12 minutes; for invited papers—36 minutes. If you are chairing a session that includes both contributed and invited papers please be aware of the different times allocated for each and set the timer as follows:
   • Contributed papers—set timer for 8 minutes to give initial warning, then set the final bell to go off 2 minutes later. When this time is up, allow 2 additional minutes for questions relating to the paper, thank the speaker and promptly introduce the next paper and speaker.
   • Invited papers—set timer for 25 minutes for initial warning, and the final bell to ring 5 minutes later. Then set the timer for 6 additional minutes for questions from the audience. Explain the timing system to the audience prior to the start of the session, and as often during the session as you think necessary.

6. The By-Laws of the Society request that speakers be asked to stop when their allotted time is up in a courteous but firm manner. Keep in mind that the session must end on time, and that the last speaker has just as much right to an audience as does the first speaker.

7. Should a speaker fail to appear, call the author of the first supplementary paper assigned to the session, if any. If that author is not in attendance, call the author of the following supplementary paper, and so on. If there are no supplementary papers assigned to your session, allow the preceding discussion to continue, or recess the session until it is time for the next scheduled paper. At the end of the session, call again for the regularly scheduled paper, if time allows.

8. When two or more papers are submitted by an author, only one of these will be assigned a scheduled presentation time within that session. It is assumed that the first author listed in the abstract is the person who will present the paper at the meeting. Other papers with the same first author will be assigned as supplementary papers, to be called for if time permits. If you notice that an author who has already presented a paper rises to present another paper, you should request that this paper be presented at the end of the regular program as a supplementary paper, if time allows.

9. If any problems arise that you are unable to handle relative to successfully chairing the session, please inform the A-V tech in the room, or go immediately to the APS registration desk to alert the APS staff. Any time used by the speaker and/or technicians to set up laptops for LCD (Powerpoint) presentations is deducted from the time allocated for the talk.

Please Note:

The APS has made every effort to provide accurate and complete information in this *Bulletin*. However, changes or corrections may occasionally be necessary and may be made without notice after the date of publication. To ensure that you receive the most up-to-date information, please check the meeting *Corrigenda* distributed with this *Bulletin*.

Epitome of the April Meeting 2006

8:30 SATURDAY MORNING 22 APRIL 2006

A1 APS: **Plenary Session I**
Stone, Jacak, Tanaka
Landmark A, Hyatt Regency Dallas

10:45 SATURDAY MORNING 22 APRIL 2006

B1 DNP/DPF: **Underground Labs: Plans and Progress**
Scholberg, Beier, Sinclair
Landmark A, Hyatt Regency Dallas

B2 DNP: **Light Exotic Nuclei**
DeYoung, Wuosmaa, Rogachev
Landmark B, Hyatt Regency Dallas

B3 DPP/GPAP: **Laboratory Astrophysics: Supernovae and Jets**
Raymond, Blue, Lebedev
Landmark C, Hyatt Regency Dallas

B4 FEd: **Research Talks at the Undergraduate Level**
Canelli, Chaikin, Carroll
Marsalis A, Hyatt Regency Dallas

B5 DAP/FHP: **Cosmology I**
Danielson, Barton, Carlstrom
Pegasus B, Hyatt Regency Dallas

B7 DAP: **Gamma-Ray Bursts and GLAST**
Pegasus A, Hyatt Regency Dallas

B8 DNP: **Nuclear Instrumentation and Applications**
Cumberland A, Hyatt Regency Dallas

B9 DNP: **Hadronic Physics I**
Cumberland B, Hyatt Regency Dallas

B11 GGR: **Focus Session: Recent Results in Quantum Gravity**
Smolin
Cumberland E, Hyatt Regency Dallas

B12 DPF: **B Meson Decays**
Cumberland F, Hyatt Regency Dallas

B13 DPF: **W and Z Bosons I**
Cumberland G, Hyatt Regency Dallas

B14 DPB: **Particle Beam Physics and Technologies**
Cumberland I, Hyatt Regency Dallas

13:30 SATURDAY AFTERNOON 22 APRIL 2006

C1 DPF: **Novel Detector Technologies**
Kagan, Dobbs, Magill
Landmark A, Hyatt Regency Dallas

C2 GHP: **Hadronic Physics II**
Braaten, Pitt, Mueller
Landmark B, Hyatt Regency Dallas

C3 DAP/DPF: **Very High Energy Cosmic Gamma Rays**
Aharonian, Nemethy, Ritz
Landmark C, Hyatt Regency Dallas

C4 FIP: **Public and Private Funding for International Research**
Owens, Bement, Schleich
Marsalis A, Hyatt Regency Dallas

C5 DAP/FHP: **Cosmology II**
Kragh, Spergel, Carroll
Pegasus B, Hyatt Regency Dallas

C6 GGR/GPMFC: **Ground-Based Gravitational Wave Detection**
Zucker, Brady, Sutton
Cumberland J, Hyatt Regency Dallas

C7 DAP: **Gravitational Wave Astronomy**
Pegasus A, Hyatt Regency Dallas

C8 DNP: **Nuclear Theory I**
Cumberland A, Hyatt Regency Dallas

C9 DNP: **Minisymposium: Toward a Universal Density Functional Theory for Nuclei I**
Duguet
Cumberland B, Hyatt Regency Dallas

C10 FEd/ DNP: **Nuclear Science Education for the Nation**
McMahan, Peaslee, Hartouni
Cumberland C, Hyatt Regency Dallas

C11 SPS: **SPS Undergraduate Research**
Cumberland E, Hyatt Regency Dallas

C12 DPF: **Accelerator-Based Neutrino Experiments**
Cumberland F, Hyatt Regency Dallas

C13 DPF: **W and Z Bosons II**
Cumberland G, Hyatt Regency Dallas

C14 DPB: **Physics of Muon and Polarized Beams**
Cumberland I, Hyatt Regency Dallas

C16 DPP: **DPP Contributed Orals I**
Landmark D, Hyatt Regency Dallas

14:00 SATURDAY AFTERNOON 22 APRIL 2006

D1 **Poster Session**
Landmark Circle, 2:00pm–5:00pm, Hyatt Regency Dallas

15:30 SATURDAY AFTERNOON 22 APRIL 2006

E1 DPB/ DPF: **Accelerator and Detector R&D for the International Linear Collider**
Phinney, Padamsee, Weerts
Landmark A, Hyatt Regency Dallas

E2 DNP: **Primordial Nucleosynthesis**
Smith, Tytler, Wandelt
Landmark B, Hyatt Regency Dallas

E3 DPP/ DAP/ GPAP: **Laboratory Astrophysics: Magnetic Reconnection**
Antiochos, Ji, Strait
Landmark C, Hyatt Regency Dallas

E4 FIP/ FPS: **Science and Development: Innovation Systems for Fighting Poverty**
Marjoram, Weber, Lederman, Mansouri
Marsalis A, Hyatt Regency Dallas

E5a FHP/ DPF: **50 Years Since the Discovery of Parity Nonconservation in the Weak Interactions I**
Lee, Lederman, Conrad
Pegasus B, Hyatt Regency Dallas

E5b FHP/ DPF: **50 Years Since the Discovery of Parity Nonconservation in the Weak Interactions II**
Yang
Pegasus B, Hyatt Regency Dallas

E6 GGR: **Experimental Tests of General Relativity**
Adelberger, Turyshev, Anderson
Cumberland J, Hyatt Regency Dallas

E7 DAP: **Cosmology III**
Pegasus A, Hyatt Regency Dallas

E8 DNP: **Minisymposium: The Spin Structure of the Nucleon**
Vogelsang
Cumberland A, Hyatt Regency Dallas

E9 DNP: **Minisymposium: Toward a Universal Density Functional Theory for Nuclei II**
Furnstahl
Cumberland B, Hyatt Regency Dallas

E10 FEd: **Focus Session: K-12 Education**
Steiner
Cumberland C, Hyatt Regency Dallas

E11 GGR: **Quantum and Classical Gravity**
Cumberland E, Hyatt Regency Dallas

E12 DPF: **Neutrino Cross Sections**
Cumberland F, Hyatt Regency Dallas

E13 DPF: **Jet and Fragmentation Studies**
Cumberland G, Hyatt Regency Dallas

E14 **Few Body Problems**
Cumberland I, Hyatt Regency Dallas

17:30 SATURDAY EVENING 22 APRIL 2006

F1 APS: **APS Welcome Reception**
Union Station, Grand Hall, Hyatt Regency Dallas

19:15 SATURDAY EVENING 22 APRIL 2006

G1 **New Reports from Major National Studies**
Shapiro, Albrecht
Landmark A, Hyatt Regency Dallas

8:30 SUNDAY MORNING 23 APRIL 2006

H1 DPF: **Recent Results in Flavor Physics**
Olsen, Casey, Morii
Landmark A, Hyatt Regency Dallas

H2 DNP: **Topics in Nuclear Physics**
Dean, Zegers, Thomas
Landmark B, Hyatt Regency Dallas

H3 DPF/DAP: **Ultra-high Energy Cosmic Rays: Experiment and Theory**
Westerhoff, Olinto, Saltzberg
Landmark C, Hyatt Regency Dallas

H4 FEd: **New Models for Graduate Education**
Vickers, Lopez, Campbell
Marsalis A, Hyatt Regency Dallas

H5 COM: **Discovery Prospects at the Energy Frontier**
Baker, Assamagan, Holloway
Pegasus B, Hyatt Regency Dallas

H6 DPB/FIAP: **Applications of Free Electron Lasers I**
Kelley, Haglund, Helvajian
Cumberland J, Hyatt Regency Dallas

H7 DAP: **Astrobiology and Planetary Effects**
Pegasus A, Hyatt Regency Dallas

H8 DNP: **Nuclear Reactions**
Cumberland A, Hyatt Regency Dallas

H9 DNP: **Underground Neutrino Experiments and Proton Decay**
Cumberland B, Hyatt Regency Dallas

H10 DPF: **Production Studies in e^+e^- Collisions**
Cumberland C, Hyatt Regency Dallas

H11 GGR: **Relativistic Simulations of Neutron Stars, Black Holes, and Plasmas**
Cumberland E, Hyatt Regency Dallas

H12 DPF: **New Directions in Particle Theory**
Cumberland F, Hyatt Regency Dallas

H13 DPF: **Top Quark Properties I**
Cumberland G, Hyatt Regency Dallas

H14 **Novel Techniques**
Cumberland I, Hyatt Regency Dallas

H16 DPP: **Sherwood I**
Stambaugh, Berk, Hallatschek
Landmark D, Hyatt Regency Dallas

10:30 SUNDAY MORNING 23 APRIL 2006

I1 DPF: **QCD: The Lattice Meets Data**
Kronfeld, Cahn, Pedlar
Landmark A, Hyatt Regency Dallas

I2 DNP: **Applications of Nuclear Science**
Wang, Kouzes, Majewski
Landmark B, Hyatt Regency Dallas

I5 GGR/DPF: **Theories of Gravity, Dark Energy, and Cosmology**
Kachru, Arkani-Hamed, Scoccimarro
Pegasus B, Hyatt Regency Dallas

I6 DPB/FIAP: **Applications of Free Electron Lasers II**
Schaaf, Smith, Hastings
Cumberland J, Hyatt Regency Dallas

I7 DAP: **Astroparticle Physics I**
Pegasus A, Hyatt Regency Dallas

I8 DNP: **Minisymposium: Nuclei and Nuclear Matter at Non-Normal Density I**
Natowitz
Cumberland A, Hyatt Regency Dallas

I9 DNP: **Minisymposium: Electro-Weak Interactions**
Souder
Cumberland B, Hyatt Regency Dallas

I10 DPF: **Charm Production, Decay, and Excited States**
Cumberland C, Hyatt Regency Dallas

I11 GGR: **Focus Session: Initial Data Sets for Numerical Relativity**
Cook
Cumberland E, Hyatt Regency Dallas

I12 DPF: **Higgs Physics I**
Cumberland F, Hyatt Regency Dallas

I13 DPF: **Top Quark Properties II**
Cumberland G, Hyatt Regency Dallas

I16 DPP: **Sherwood II**
Sanchez, Kinsey, Lee
Landmark D, Hyatt Regency Dallas

13:15 SUNDAY AFTERNOON 23 APRIL 2006

J1 DPF: **Top is Ten**
Halkiadakis, Schwienhorst, Orr
Landmark A, Hyatt Regency Dallas

J2 DPB/ DNP: **A High Luminosity Lepton Ion Collider to Study QCD**
Farkhondeh, Deshpande, Venugopalan
Landmark B, Hyatt Regency Dallas

J4 DAP/ GGR: **Precision Cosmology**
Page, Frieman, Eisenstein
Marsalis A, Hyatt Regency Dallas

J5 CSWP/ FHP: **Pioneering Women Astronomers**
Turner, Haramundanis, Tarter
Pegasus B, Hyatt Regency Dallas

J6 DPP/ DAP: **Laboratory Astrophysics: Dynamo and the Magnetorotational Instability**
Goodman, Forest, Lathrop
Cumberland J, Hyatt Regency Dallas

J7 DAP: **Astroparticle Physics II**
Pegasus A, Hyatt Regency Dallas

J8 DNP: **Minisymposium: Nuclei and Nuclear Matter at Non-Normal Density II**
Zielinska-Pfabe
Cumberland A, Hyatt Regency Dallas

J9 DNP: **Double Beta Decay**
Cumberland B, Hyatt Regency Dallas

J10 DPF: **Charm Mixing, Rare D and K Decays**
Cumberland C, Hyatt Regency Dallas

J11 GGR: **Advances in Numerical Relativity I**
Cumberland E, Hyatt Regency Dallas

J12 DPF: **Higgs Physics II**
Cumberland F, Hyatt Regency Dallas

J13 DPF: **Particle Theory**
Cumberland G, Hyatt Regency Dallas

14:00 SUNDAY AFTERNOON 23 APRIL 2006

K1 **Poster Session: Magnetically Confined Plasma I**
Landmark Circle, 2:00pm–5:00pm, Hyatt Regency Dallas

K15 APS: **APS Journal Editors Panel Discussion**
Cumberland K, Hyatt Regency Dallas

15:15 SUNDAY AFTERNOON 23 APRIL 2006

L1 DPF: **Physics at the Energy Frontier**
Heineman, Junk, Feng
Landmark A, Hyatt Regency Dallas

L2 DPB/DNP: **Study of Hadron Structure Using Spin Polarized Beams**
Bai, Poelker, Howell
Landmark B, Hyatt Regency Dallas

L3 GGR/COM: **Advances in Numerical Relativity II**
Pretorius, Kidder, Baumgarte, Garfinkle
Landmark C, Hyatt Regency Dallas

L4 CSWP/FPS: **Women in Science Policy**
Flatten, Clay, Wiseman
Marsalis A, Hyatt Regency Dallas

L6 FIP: **Scholars at Risk**
Quinn, Orlov, Hadizadeh
Cumberland J, Hyatt Regency Dallas

L7 DAP: **Galaxies, AGNs and Galactic Gamma-Ray Sources**
Pegasus A, Hyatt Regency Dallas

L8 DNP: **Nuclear Astrophysics**
Cumberland A, Hyatt Regency Dallas

L9 DNP: **Ultrarelativistic Heavy Ions**
Cumberland B, Hyatt Regency Dallas

L10 DPF: **B Meson Branching Fractions**
Cumberland C, Hyatt Regency Dallas

L11 GGR: **Experimental Gravitation**
Cumberland E, Hyatt Regency Dallas

L12 DPF: **Exclusive D Meson Decays**
Cumberland F, Hyatt Regency Dallas

L13 DPF: **Top Quark Mass Measurements**
Cumberland G, Hyatt Regency Dallas

L16 DPP: **Laboratory Astrophysics I**
Egedal, Intrator, Stenzel, Brown, Bellan, Colgate
Landmark D, Hyatt Regency Dallas

17:15 SUNDAY EVENING 23 APRIL 2006

M1 APS: **APS Award Presentations, Past President's Address and Lilienfeld Prize Talk**
Cohen, Shifman
Landmark A, Hyatt Regency Dallas

8:30 MONDAY MORNING 24 APRIL 2006

O1 APS: **Plenary Session II**
Bell, Dorland, Shipsey
Landmark A, Hyatt Regency Dallas

10:45 MONDAY MORNING 24 APRIL 2006

P1 DPB/DPF: **DPF and DPB Prize Session**
Dimopoulos, Smirnova, Miller
Landmark A, Hyatt Regency Dallas

P2 DNP/DPF: **Neutrinos II**
Vogel, Gallagher, Berger
Landmark B, Hyatt Regency Dallas

P3 FEd: **Innovative Programs in K-12 Teacher Preparation**
Grosnick, Novodvorsky, Otero
Landmark C, Hyatt Regency Dallas

P4 GGR/DAP: **Gravitational Wave Sources and Phenomenology**
Cutler, Buonanno, Miller
Marsalis A, Hyatt Regency Dallas

P6 FGSA: **The Postdoctoral Experience**
Balantekin, Frame, Hogstrom, Horton-Smith
Cumberland J, Hyatt Regency Dallas

P7 DAP: **Cosmic Rays and Solar Physics I**
Pegasus A, Hyatt Regency Dallas

P8 DNP: **Minisymposium: Parton Distributions at Larger X: Data and Challenges**
Owens
Cumberland A, Hyatt Regency Dallas

P9 DNP: **Minisymposium: Advances in Zero- and Finite-Temperature Lattice QCD**
Petreczky, Savage
Cumberland B, Hyatt Regency Dallas

P10 FHP/DNP: **50 Years Since the Discovery of Parity Nonconservation in the Weak Interactions III**
Hudson, Yuan, Ramsey-Musolf
Cumberland C, Hyatt Regency Dallas

P11 GGR: **Focus Session: Space-Based Gravitational Wave Detection**
Cornish
Cumberland E, Hyatt Regency Dallas

P12 DPF: **Bs, Bc Lifetimes and Mixing**
Cumberland F, Hyatt Regency Dallas

P13 DPF: **Particle Searches I**
Cumberland G, Hyatt Regency Dallas

P16 DPP: **Sherwood III**
Ebrahimi, Dewar, Pedersen, Ji
Landmark D, Hyatt Regency Dallas

12:45 MONDAY AFTERNOON 24 APRIL 2006

1A **Rising Above the Gathering Storm**
Augustine
Landmark D, Hyatt Regency Dallas

13:30 MONDAY AFTERNOON 24 APRIL 2006

Q1 DAP/DPF: **Neutrinos I**
Abazajian, Mezzacappa, Kayser
Landmark A, Hyatt Regency Dallas

Q2 DNP: **Implications of QCD Phase Transitions**
Zahed, Stankus, Rajagopal
Landmark B, Hyatt Regency Dallas

Q3 DAP/DPP: **Particle Acceleration**
Smith, Drury, Giacalone
Landmark C, Hyatt Regency Dallas

Q4 GFB: **Three-Body Systems**
Ilieva, Sargsian, Epelbaum
Marsalis A, Hyatt Regency Dallas

Q5 FPS/FEd: **Evolution: From the Big Bang to Us**
Primack, Kasting, Jeffery
Pegasus B, Hyatt Regency Dallas

Q6 DPB: **Advanced Acceleration Techniques for Future Energy Frontier Accelerators**
Muggli, Mori, Rosenzweig
Cumberland J, Hyatt Regency Dallas

Q8 DNP: **Electromagnetic Interactions**
Cumberland A, Hyatt Regency Dallas

Q9 DNP: **Nuclear Structure**
Cumberland B, Hyatt Regency Dallas

Q10 DPF: **Rare B Decays**
Cumberland C, Hyatt Regency Dallas

Q11 GGR: **Simulations of Binary Black Hole Mergers**
Cumberland E, Hyatt Regency Dallas

Q12 DPF: **Baryons and B Lifetime Studies**
Cumberland F, Hyatt Regency Dallas

Q13 DPF: **Particle Searches II**
Cumberland G, Hyatt Regency Dallas

Q14 FHP: **History of Physics**
Cumberland I, Hyatt Regency Dallas

14:00 MONDAY AFTERNOON 24 APRIL 2006

R1 **Poster Session: Magnetically Confined Plasma II**
Landmark Circle, 2:00pm–5:00pm, Hyatt Regency Dallas

15:30 MONDAY AFTERNOON 24 APRIL 2006

S1 DPB/DPF: **High Power Proton Drivers for Accelerator-based Neutrino Physics**
Diwan, Apollinari, Nagamiya
Landmark A, Hyatt Regency Dallas

S2 DNP: **DNP Prize Session**
Towner, Hardy, Truran
Landmark B, Hyatt Regency Dallas

S3 DAP: **The Heliospheric Termination Shock**
Decker, Möbius, Fisk
Landmark C, Hyatt Regency Dallas

S4 FHP/FPS: **FHP/FPS Award Session**
Heilbron, Richards, Albright, Orlov
Marsalis A, Hyatt Regency Dallas

S6 DPF: **Panofsky Prize Session**
Jaros, Ford, Lockyer
Cumberland J, Hyatt Regency Dallas

S10 FEd: **Focus Session: Undergraduate and Graduate Education**
Hasty
Cumberland C, Hyatt Regency Dallas

S11 GGR: **Sources of Gravitational Waves**
Cumberland E, Hyatt Regency Dallas

S12 DPF: **CP Violation in B Meson Decays**
Cumberland F, Hyatt Regency Dallas

S13 DPF: **Top Quark Production**
Cumberland G, Hyatt Regency Dallas

S16 **Laboratory Astrophysics II**
Craig, Fredrickson, Goree, Sun, Vincena, Carter
Landmark D, Hyatt Regency Dallas

17:30 MONDAY EVENING 24 APRIL 2006

T2 DNP: **DNP Business Meeting**
Landmark B, Hyatt Regency Dallas

T4 FPS: **FPS Business Meeting**
Marsalis A, Hyatt Regency Dallas

T5 DPB: **DPB Business Meeting and Reception**
Station Master, Hyatt Regency Dallas

T7 **DAP Business Meeting**
Pegasus A, Hyatt Regency Dallas

T11 **GFB Business Meeting**
Cumberland E, Hyatt Regency Dallas

T12 **GGR Business Meeting**
Cumberland F, Hyatt Regency Dallas

T14 FHP: **FHP Business Meeting**
Cumberland I, Hyatt Regency Dallas

8:30 TUESDAY MORNING 25 APRIL 2006

V1 APS: **Plenary Session III**
Zettl, Gonzalez, Wagner
Landmark A, Hyatt Regency Dallas

10:30 TUESDAY MORNING 25 APRIL 2006

W5 FPS: **Abrupt Climate Change Scenario**
Day, Rosenfeld, Galloway
Pegasus B, Hyatt Regency Dallas

W15 **Poster Session IV: Post-deadline Posters**
Landmark Circle, 10:30am–2:00pm, Hyatt Regency Dallas

10:45 TUESDAY MORNING 25 APRIL 2006

W1 DPF/DAP: **Shedding Light on Dark Energy D**
Howell, Linder, Bernstein
Landmark A, Hyatt Regency Dallas

W2 DNP/DPF: **Notes from Underground**
Gratta, Vagins, Goldschmidt
Landmark B, Hyatt Regency Dallas

W3 DAP: **Cosmic Gamma-Ray Bursts**
Gehrels, Hartmann, Reichart
Landmark C, Hyatt Regency Dallas

W6 FEd: **Research on Teaching Thermal Physics and Quantum Mechanics**
Thompson, Singh, Meltzer
Cumberland J, Hyatt Regency Dallas

W7 DAP: **Cosmic Rays and Solar Physics II**
Pegasus A, Hyatt Regency Dallas

W8 DNP: **Minisymposium: Heavy Quark Energy Loss & Flow**
Liu
Cumberland A, Hyatt Regency Dallas

W9 DNP: **Nuclear Theory II**
Cumberland B, Hyatt Regency Dallas

W10 GGR/DPF: **Heineman Prize Session**
Ferrara, Freedman, van Nieuwenhuizen
Cumberland C, Hyatt Regency Dallas

W11 GGR: **Gravitational Wave Searches**
Cumberland E, Hyatt Regency Dallas

W12 DPF: **Bs, B*, eta-B decays**
Cumberland F, Hyatt Regency Dallas

W13 DPF: **Particle Physics Instrumentation**
Cumberland G, Hyatt Regency Dallas

W16 DPP: **Sherwood IV**
Bonoli, Chang, Arefiev, Dodin
Landmark D, Hyatt Regency Dallas

12:15 TUESDAY AFTERNOON 25 APRIL 2006

X5 FPS: **Elements of a Real Energy Strategy**
Lewis, German, Burchill
Pegasus B, Hyatt Regency Dallas

13:30 TUESDAY AFTERNOON 25 APRIL 2006

X1 DNP/DPF: **Dark Matter**
Hinchliffe, Shutt, Sikivie
Landmark A, Hyatt Regency Dallas

X2 DNP: **Physical Properties of Partonic Matter**
Teaney, Bathe, Jacobs
Landmark B, Hyatt Regency Dallas

X3 DAP: **Magnetars**
Hurley, Strohmayer, Lyutikov
Landmark C, Hyatt Regency Dallas

X16 FEd: **Research on Teaching Large Enrollment Classes**
Kanim, Stelzer, Pollock
Landmark D, Hyatt Regency Dallas

MAIN TEXT

SESSION A1: PLENARY SESSION I
Saturday Morning, 22 April 2006; Landmark A, Hyatt Regency Dallas at 8:30
John Hopfield, Princeton University, presiding

8:30
A1 1 Exploring the Final Frontier of the Solar System.
EDWARD STONE, *California Institute of Technology*

In December 2004 at 94 AU, Voyager 1 crossed the termination shock marking the abrupt slowing of the supersonic solar wind and began exploring the region where the solar plasma presses outward against the local interstellar medium. The flow in this region is much slower than expected and the turbulence is different than in the supersonic solar wind. In contradiction to many predictions that the shock was the source of medium energy anomalous cosmic rays, their intensity did not peak at the shock, indicating their origin remains to be discovered. However, the shock is the source of low energy ions that reveal new aspects of the acceleration process. Recent results from Voyager 2 at southern solar latitudes suggest that the shock may be 7 to 10 AU closer than at Voyager 1 in the north, consistent with an asymmetric distortion of the heliosphere by a local interstellar magnetic field. The Voyagers will provide more insight into this outermost region of the heliosphere and what lies beyond as they continue their journeys to interstellar space.

9:06
A1 2 Nature's First Liquid: The Quark Gluon Plasma.
BARBARA JACAK, *SUNY, Stony Brook*

High energy collisions of nuclei recreate the high energy densities that existed a few microseconds after the Big Bang. Matter under such conditions is expected to be a plasma of quarks and gluons not confined inside hadrons. The Relativistic Heavy Ion Collider (RHIC) produces such matter in the laboratory, and its behavior has proven to be quite surprising. Examination of thousands of particles in the final state yields evidence for very rapid thermalization leading to a dense, opaque, collectively flowing system. The degrees of freedom cannot be hadrons and the interactions are not those expected for asymptotically free quarks. Rather, the matter behaves like a liquid with low viscosity, as may be expected for some plasmas. I will review experimental results and discuss insights into the properties of the produced matter.

9:42
A1 3 MiniBoone: Why We Love Neutrinos. Why We Might Need More.
HIROHISA TANAKA, *Princeton University*

The study of neutrino oscillations using accelerator-based beams is entering a renaissance. Experiments on three continents aim to elucidate the nature of this phenomenon in its entirety as part of a world-wide program involving both accelerator and non-accelerator techniques. Neutrino oscillations represent the first evidence of physics beyond the Standard Model; the results will have profound implications for not only particle physics, but our understanding of how the universe evolved to its current state. The MINOS and upcoming OPERA and ICARUS experiments aim to confirm our understanding of the atmospheric neutrino phenomenon via oscillations and precisely measure its parameters. These experiments will be followed by the T2K and proposed NOvA experiments, which will search for a third, as-yet unobserved mode of oscillation that may hold the key towards understanding how antineutrinos differ from neutrinos and the hierarchy of their masses. Meanwhile, MiniBooNE at Fermilab is searching for oscillations indicated by the LSND experiment that would indicate a complete break from the Standard Model. Such new physics could take the form of heretofore unseen sterile neutrinos or exotic forms of symmetry breaking that would dramatically change the landscape of particle physics.

SESSION B1: UNDERGROUND LABS: PLANS AND PROGRESS
Saturday Morning, 22 April 2006; Landmark A, Hyatt Regency Dallas at 10:45
Hamish Robertson, University of Washington, presiding

10:45
B1 1 Particle and Nuclear Physics at a Deep Underground Laboratory.
KATE SCHOLBERG, *Duke University*

A new underground laboratory will provide numerous opportunities for experiments exploring new physics. This talk will broadly survey the goals of the next-generation suite of experiments, including dark matter detection, searches for baryon number violation, and neutrino mass and oscillation studies.

11:21
B1 2 A Deep Underground Science and Engineering Laboratory in the United States.*
EUGENE BEIER, *University of Pennsylvania*

United States scientists carry out important research projects in physics, earth sciences, biology, and engineering in many underground sites around the world. Increasing opportunities in these sciences require a dedicated laboratory in the United States to support this research. A plan leading to the creation of a Deep Underground Science and Engineering Laboratory (DUSEL) in the United States was announced by the National Science Foundation early in 2004. Two sites, the Henderson Mine in Colorado and the Homestake mine in South Dakota, have received awards to develop proposals to host DUSEL. This talk will discuss the status of the effort to create an underground laboratory for science and engineering research in the United States.

*Work supported by the National Science Foundation.

11:57
B1 3 SNOLAB Status, Prospects.
DAVID SINCLAIR, *Carleton University and TRIUMF*

SNOLAB is a new underground facility being developed adjacent to the SNO experiment. The new facility will provide twice the space available for deep underground experiments over the existing SNO installation. In contrast to other underground facilities, the entire space will be maintained in a clean room condition and much of the design has focused on establishing clean interfaces between the laboratory and the mine environment. All of the space will be under a flat overburden of 6000 mwe. Letters of Interest have been received from about 20 projects interested in locating at the new laboratory and these have helped to define the design criteria for the facility. This talk will outline the progress in constructing the laboratory and discuss the developing scientific programme.

SESSION B2: LIGHT EXOTIC NUCLEI
Saturday Morning, 22 April 2006; Landmark B, Hyatt Regency Dallas at 10:45
Michael Thoenessen, Michigan State University, presiding

10:45
B2 1 Studies of Neutron-Rich Nuclei with the MoNA/Sweeper System at the NSCL.*
P.A. DEYOUNG,† *Hope College, Department of Physics*

Binding energies and excitation spectra of nuclei are important benchmarks for nuclear structure calculations. In the case of very neutron-rich or neutron-unbound nuclei, changes of the shell structure and the effects from the continuum have to be taken into account in theoretical calculations. The Modular Neutron Array (MoNA) was completed in late 2003 and was commissioned in 2004 along with the 4 T sweeper magnet. The measurements done with the system have focused on the structure of very neutron-rich p-shell nuclei near where the magic N = 8 or N = 20 numbers may disappear. To date, measurements of ^{25}O (ground state energy), ^{24}O* (neutron-unbound excited state), ^{13}Li (two-neutron decay), and ^{12}Be (spectroscopic factor) have been completed. A summary of the state of theses experiments will be given. The results of a more global study of nuclei at the neutron dripline using fragmentation will also be shown. In addition to a discussion of the physics being studied, the current role of undergraduate students in experiments and analysis will be discussed. An update on how the widely-separated members of the collaboration interact in between experiments will be presented.

*Funded by the National Science Foundation.
†MoNA Collaboration.

11:21
B2 2 Nucleon transfer reactions with exotic light nuclei.
ALAN H. WUOSMAA, *Western Michigan University*

There has been considerable renewed interest in the structure of light nuclei, especially away from stability, in recent years. Modern theoretical techniques for calculating nuclear structure, often referred to as "*ab-initio*" methods, have been extremely successful in predicting a variety of properties for systems with 10 or fewer nucleons. These include excitation energies, transition matrix elements and charge radii. The possibility to use simple direct transfer reactions such as *(d,p)* to study the properties of exotic light nuclei extends our ability to test these models at the extremes of neutron number where data were not previously available. Of particular interest are very loosely or even unbound systems where questions may remain about the applicability of these theoretical approaches. I will discuss some of the opportunities and challenges presented in this new domain, and present two recent examples of neutron transfer measurements to study the nuclei ^{9}Li and ^{7}He. This work supported by the U. S. Department of Energy, Office of Nuclear Physics under contract DE-FG02-04R41320.

11:57
B2 3 The Structure of ^{9}C and ^{7}He.
GRIGORY ROGACHEV, *Department of Physics, Florida State University, Tallahassee, FL 32306*

Light exotic nuclei provide important insights into the understanding of nuclear forces at large neutron to proton ratios, unreachable for heavier nuclei. The progress in development of modern theoretical approaches such as quantum Monte-Carlo calculations (QMC) and no-core shell model (NCSM) allows for predictions of properties of light nuclei (A<12) from the basic principles, starting from bare nucleon-nucleon interaction. Unfortunately, experimental information on the structure of many light exotic isotopes is very incomplete making it difficult to judge the accuracy of the *itabinitio* models in case of large excess of neutrons or protons. Scarcity of spectroscopic information for many exotic isotopes is mostly related to the experimental difficulties one has to overcome to populate these isotopes and extract useful information. Development of Radioactive Nuclear Beams allowed application of simple resonance reactions, such as elastic scattering or resonance charge exchange reaction for spectroscopy studies of exotic nuclei. The advantage of this approach is mainly related to the fact that resonance reactions have high cross section and provide direct way to extract spectroscopic information. Application of resonance reactions for spectroscopy of exotic nuclei will be considered in two examples: ^{9}C and ^{7}He. The proton rich nucleus ^{9}C was studied via resonance elastic scattering of protons on ^{8}B. Only one excited state was known in ^{9}C before this study. Method of inverse geometry and very thick target was used to obtain the excitation function of p +^{8}B elastic scattering up to the excitation energy of 4.5 MeV. The neutron rich nucleus ^{7}He was studied through the T=3/2 Isobaric Analog States in ^{7}Li. These states were populated in resonance charge exchange reaction ^{6}He(p,n)^{6}Li*(0^{+}). Two complimentary experimental techniques were developed to measure the excitation function of this process. In one, neutrons are measured in coincidence with γ rays from the decay of 0^{+} excited state of ^{6}Li [1] and in the other Doppler shift of these γ rays is used to extract information on the total cross section and angular distribution of ^{6}He(p,n)^{6}Li(0^{+}) process [2]. [1] G.V. Rogachev, et al., Phys. Rev. Lett. 92, 232502 (2004). [2] P. Boutachkov, et al., Phys. Rev. Lett. 95, 132502 (2005).

SESSION B3: LABORATORY ASTROPHYSICS: SUPERNOVAE AND JETS
Saturday Morning, 22 April 2006: Landmark C, Hyatt Regency Dallas at 10:45
Paul Bellan, California Institute of Technology, presiding

10:45
B3 1 Structure of Supernova Remnant Shock Waves.
JOHN RAYMOND, *Center for Astrophysics*

The traditional model of supernova remnants as spherical blast waves works in few cases, but not many. In young SNRs, the asymmetry of the supernova explosion itself is important, as jets, dense clumps and large rings of material interact with the interstellar gas or with shocked ejecta. In older remnants, the inhomogeneous density distribution of the ambient gas dominates the structure, and both dynamical (Rayleigh-Taylor, thin shell, Kelvin-Helmholtz) and thermal instabilities can become important. This talk gives an overview of the processes and the parameter ranges important for supernova remnant studies.

11:21
B3 2 Modeling Supernova Shocks with Intense Lasers.
BRENT BLUE, *Lawrence Livermore National Laboratory*

Large-scale directional outflows of supersonic plasma are ubiquitous phenomena in astrophysics, with specific application to supernovae. The traditional approach to understanding such phenomena is through theoretical analysis and numerical simulations. However, theoretical analysis might not capture all the relevant physics and numerical simulations have limited resolution and fail to scale correctly in Reynolds number and perhaps other key dimensionless parameters. Recent advances in high energy density physics using large inertial confinement fusion devices now allow controlled laboratory experiments on macroscopic volumes of plasma of direct relevance to astrophysics. This talk will present an overview of these facilities as well as results from current laboratory astrophysics experiments designed to study hydrodynamic jets and Rayleigh-Taylor mixing. This work is performed under the auspices of the U. S. DOE by Lawrence Livermore National Laboratory under Contract No. W-7405-ENG-48, Los Alamos National Laboratory under Contract No. W-7405-ENG-36, and the Laboratory for Laser Energetics under Contract No. DE-FC03-92SF19460.

11:57
B3 3 Modeling Astrophysical Jets in a Laboratory Experiment.
SERGEY LEBEDEV, *Imperial College London*

We will present experimental results on formation of supersonic radiatively cooled plasma jets with dimensionless parameters (Mach number $\sim$ 20, cooling parameter $\sim$ 1 and density contrast $\rho j/\rho a \sim 10$) similar to those in proto-stellar jets. Two different experimental configurations are used. In the first the produced jets are purely hydrodynamic and are used to study deflection of the jets by the cross-wind. The ''cross wind'' leads to deflection of the jet through formation of internal oblique shocks in the jet and we will discuss the relevance of these observations to the astrophysical systems. In the second configuration the jets have toroidal magnetic field and the plasma beta in these jets is of the order of unity. We will present experimental data on the dynamics of ''magnetic bubble'' surrounding the jet and on the development of m=0,1 instabilities in the jet. Although at later times the jet column is observed to go unstable, we observe that the jet retains its collimation. Modifications of the experimental configuration allowing addition of the poloidal magnetic field and angular momentum to the jet will be also discussed. The experiments are scalable to astrophysical flows in that critical dimensionless numbers such as the plasma collisionality, the plasma beta and the magnetic Reynolds number are all in the astrophysically appropriate ranges. In collaboration with A. Ciardi, D. Ampleford, S.N. Bland, S.C. Bott, J.P. Chittenden, G. Hall, C. Jennings, J. Rapley A. Frank, E. G. Blackman, and T. Lery.

SESSION B4: RESEARCH TALKS AT THE UNDERGRADUATE LEVEL
Saturday Morning, 22 April 2006; Marsalis A, Hyatt Regency Dallas at 10:45
David Ehrenstein, APS, presiding

10:45
B4 1 Top Quarks and the High Energy Frontier.
FLORENCIA CANELLI, *Fermi National Accelerator Laboratory*

One of the still missing pieces of the Standard Model of particle physics is the Higgs boson, providing a mechanism to generate the masses of the particles. Furthermore, there is strong indication that the Standard Model is merely the low energy limit of a more fundamental theory which could manifest itself near the TeV scale. This talk will explore aspects of experimentation at the High Energy frontier, starting from experience at the Tevatron accelerator currently providing the world's highest energy particle collisions. In particular, a precision measurement of the top quark mass using the Collider Detector at Fermilab (CDF) will be presented. An outlook will be given towards a direct search for the Higgs boson and New Physics at the LHC and beyond, concluding with a historic perspective.

11:21
B4 2 Ellipsoids Beat Spheres: Experiments with Candies, Colloids and Crystals.
PAUL CHAIKIN, *Princeton University*

How many gumballs fit in the glass sphere of a gumball machine? Scientists have been puzzling over problems like this since the Ancient Greeks. Yet it was only recently proven that the standard way of stacking oranges at a grocery store—with one orange on top of each set of three below—is the densist packing for spheres, with a packing fraction $\phi \sim$ 0.74. Random (amorphous) packings of spheres have a lower density, with $\phi \sim 0.64$. The density of crystalline and random packings of atoms is intimately related to the melting transition in matter. We have studied the crystal-liquid transition in spherical colloidal systems on earth and in microgravity. The simplest objects to study after spheres are

squashed spheres – ellipsoids. Surprisingly we find that ellipsoids can randomly pack more densely than spheres, up to $\phi \sim 0.68 - 0.71$ for a shape close to that of M&M's® Candies, and even approach $\phi \sim 0.75$ for general ellipsoids. The higher density relates directly to the higher number of neighbors needed to prevent the more asymetric ellipsoid from rotating. We have also found the ellipsoids can be packed in a crystalline array to a density, $\phi \sim 0.7707$ which exceeds the highest previous packing. Our findings provide insights into granular materials, rigidity, crystals and glasses, and they may lead to higher quality ceramic materials.

11:57
B4 3 Why Is the Universe Accelerating?
SEAN CARROLL, *University of Chicago*

Our universe is accelerating, a phenomenon that cannot be accounted for by ordinary matter and conventional gravity. The simplest explanation is to invoke a vacuum energy of 120 orders of magnitude less than the expected amount. Alternatively, there could be a smoothly-distributed, slowly-varying dynamical component, or a breakdown of general relativity on cosmological scales. All of the possibilities are very exciting, and future observations have promise for distinguishing between them. I will give an overview of the theoretical proposals for explaining the acceleration of the universe and the observational constraints which any model must satisfy.

SESSION B5: COSMOLOGY I
Saturday Morning, 22 April 2006; Pegasus B, Hyatt Regency Dallas at 10:45
James Ryan, University of New Hampshire, presiding

10:45
B5 1 Why Aristotle took so long to die.
DENNIS DANIELSON, *Univ. of British Columbia*

Like young people looking askance at their parents, we often have trouble taking seriously the interests or even the intellects of ''scientists'' from centuries gone by (an attitude already betrayed by the urge to use quotation marks). After all, their theories were wrong. But the greatest wrong physicist of them all was Aristotle. The earliest thinkers we today classify as scientists (Bacon, Galileo, Newton) cut their teeth trying to show how he was wrong–but it wasn't easy. In order to see why it was so hard, we need to transport ourselves mentally back to the period between ancient Greece and seventeenth-century Europe and try to think like Aristotelians. That way we can catch a taste of the intellectual pleasures of Aristotelian physics and cosmology–including Aristotle's concepts of elements, cause, natural motion, and the ''two-storey'' universe. By becoming (temporary) Aristotelians, we'll be able to see better, for example, why Copernicanism took a hundred years to catch on. For the heliocentric ''celestial machine'' demanded a new physics that nobody had yet provided. Finally, to examine Aristotle's long monopoly on physics–based on what had grown to look like simple common sense–is also to stir up questions about how we might gain enough perspective on our present habits of thought to avoid getting stuck in our own orthodoxies. We may even find that those habits, as exemplified by modern astrophysics, still conceal unpurged remnants of Aristotle.

11:21
B5 2 The New Mysteries of the Cosmos.
ELIZABETH BARTON, *Center for Cosmology, University of California, Irvine*

From WMAP's precise measurements of the Cosmic Microwave Background, to evidence for dark energy, to the ever-accelerating search for the early galaxies responsible for the reionization of neutral intergalactic hydrogen in the early universe and first light, the recent advances in observational cosmology present a number of serious challenges to our understanding of the physical universe. I will describe some of the leading puzzles posed by recent and ongoing observations.

11:57
B5 3 The Future of Cosmic Microwave Background Observations.
JOHN CARLSTROM, *University of Chicago*

Measurements of the cosmic microwave background radiation (CMB) have led to a remarkable picture of the origin, make-up and evolution of the universe. The measurements provide support for the inflation theory of the big bang. In the broadest sense, the measurements have allowed a full accounting of the stuff that makes up the universe, although we know few details beyond the few percent contributed by ordinary matter. Future measurements will focus on characterizing the temperature anisotropy on finer angular scales and the polarization anisotropy on all angular scales. These

measurements can be used to constrain the neutrino mass and the equation of state of the Dark Energy. The most exciting future prospect, and by far the most challenging experiment, is the possibility of detecting the signature of inflationary gravitational waves generated in the first instants of time imprinted on the CMB polarization. After a brief review of the current status and ongoing experiments, this talk will focus on the expectations and challenges for future CMB observations.

SESSION B7: GAMMA-RAY BURSTS AND GLAST
Saturday Morning, 22 April 2006
Pegasus A, Hyatt Regency Dallas at 10:45
Julie McEnery, Goddard Space Flight Center, presiding

10:45
B7 1 Gamma-Ray Bursts Observations with GLAST NICOLA OMODEI, *INFN, Pisa* CHARLES MEEGAN, VALERIE CONNAUGHTON, *MSFC, NASA* NEIL GEHRELS, JAY NORRIS, *GSFC, NASA* GLAST LAT AND GBM COLLABORATION, The Gamma-Ray Large Area Space Telescope (GLAST), scheduled to be launched in 2007, is the next generation satellite for high-energy gamma-ray astronomy. The Large Area Telescope, the heart of GLAST, is a pair conversion telescope built with a plastic anticoincidence shield, a segmented CsI electromagnetic calorimeter, and the largest silicon strip tracker ever built. LAT will survey the sky in the energy range between 30 MeV to greater than 300 GeV, exploring the high energy gamma-ray sky, shedding light on many issues left open by its ancestor EGRET. The LATs wide field of view ($>$ 2 sr), large effective area and low deadtime combine to provide excellent high-energy gamma-ray observations of GRB. To tie these frontier high-energy observations to the better-known properties at lower energies, a second instrument, the GLAST Burst Monitor (GBM) will provide important spectra and timing in the 10 keV to 25 MeV range. We briefly present the instruments onboard the GLAST satellite, their synergy in the GRB observation and the work done so far by the collaboration in simulation, analysis, and GRB sensitivity estimation.

10:57
B7 2 Rapid Spectral Variability of GRBs. A Puzzle Solved?* MIKHAIL MEDVEDEV, *University of Kansas* Millisecond spectral variability of prompt GRBs, such as the so-called ''tracking behavior'' and correlation of the soft photon index α and the observed flux, does not have a satisfactory explanation for some fifteen years. We demonstrate that the spectral variability of GRBs is an inherent property of radiation emitted by electrons from highly anisotropic small- scale magnetic fields, generated at internal shocks. We interpret the flux-α correlation and the tracking pattern as a combined effect of temporal variation of the shock viewing angle and relativistic aberration of an instantaneously illuminated, thin shell. The model predicts that hard (e.g., synchrotron violating, with $\alpha > -2/3$) spectra result from a shock patch close to the line of sight and that they are associated with the onset of a sub-pulse. The spectral softening occurs on the $R/c\Gamma^2$ timescale. The model also naturally explains why the peak of the distribution of α is at $\alpha \sim -1$. The presence of a low-energy break in the jitter spectrum at oblique angles also explains the appearance of a soft X-ray component in some GRBs. We emphasize that our theory is based solely on the first principles and contains no ad hoc assumptions.

*This work is supported by NASA and DOE grants.

11:09
B7 3 TeV Gamma Ray Astronomy and GLAST* ELLIOTT BLOOM,† LESTER MILLER,‡ *KIPAC-SLAC, Stanford University* GLAST LAT COLLABORATION, The Large Area Telescope (LAT) on the Gamma-ray Large Area Space Telescope (GLAST) will have sensitivity to gamma rays beyond 100 GeV, for the first time providing a data set overlapping with the energy range of ground based gamma ray instruments. The next generation of Imaging Atmospheric Cherenkov Telescopes (IACTs), including MAGIC, HESS, and VERITAS, will therefore be complemented by the GLAST survey dataset. The GLAST large field of view will provide a survey of the high energy sky, providing the IACTs with a large number of potential sources to observe. In addition, GLAST observations can be used to cross-calibrate the IACT energy scale and flux measurements, potentially reducing their systematic uncertainty. Together GLAST and IACTs will be able to probe gamma ray spectra from 20 MeV to the multi - TeV regime.

*Work supported by DoE Contract DE-AC02-76SF00515.
†APS Member Sponsor.
‡Speaker.

11:21
B7 4 Overview of the Gamma-ray Large Area Space Telescope (GLAST) Large Area Telescope (LAT): Description and Performance Goals* TRACY USHER, *Stanford Linear Accelerator Center* GLAST-LAT COLLABORATION, The Gamma-ray Large Area Space Telescope, GLAST, is an orbital mission in the final stages of construction designed to measure the cosmic gamma-ray flux in the energy range 20 MeV to $>$ 300 GeV, with supporting measurements for gamma-ray bursts from 10 keV to 25 MeV. With its launch in 2007, GLAST will open a new and important window on a wide variety of high energy phenomena. This talk will present an overview of the GLAST LAT instrument design and construction, including estimates of the performance that demonstrate the power of this new high-energy gamma-ray physics tool.

*Tracy Usher (SLAC) Representing the GLAST LAT collaboration.

11:33
B7 5 Onboard filtering and science processing in GLAST FREDERICK KUEHN, *The Ohio State University* GLAST LAT COLLABORATION, Launching in 2007, the Gamma-ray Large Area Space Telescope (GLAST), will measure the spectrum of gamma-rays from 20 MeV to $>$ 300 GeV using the Large Area Telescope (LAT). As photons enter the LAT, they produce electron-positron pairs that traverse a tracker consisting of planes of silicon strip detectors and a segmented CsI calorimeter. Charged Cosmic Rays (CR's) are vetoed by an Anti-Coincidence Detector. CR backgrounds are far larger than the gamma-ray flux. Onboard, the LAT uses hardware triggers that are efficient for determining gamma-ray candidate events, along with subsequent software filters that reduce the data volume by an additional factor of $\sim$ 10 to meet the downlink requirements. Incorporated in the

onboard software are algorithms for identifying transients such as Gamma Ray Bursts and flaring states of Active Galactic Nuclei. I will describe the hardware and software trigger algorithms and their impact on event selection and onboard science.

SESSION B8: NUCLEAR INSTRUMENTATION AND APPLICATIONS
Saturday Morning, 22 April 2006
Cumberland A, Hyatt Regency Dallas at 10:45
Gary Westfall, Michigan State University, presiding

10:45
B8 1 Neutron capture cross sections for AFCI at DANCE RENE REIFARTH, *Los Alamos National Laboratory* DANCE COLLABORATION, The Detector for Advanced Neutron Capture Experiments (DANCE) is a 160-element 4π barium fluoride array designed to study neutron capture on small quantities of radioactive material. It is located on a 20 meter neutron flight path, which views an ''upper tier'' water moderator at the Manuel J. Lujan Jr. Neutron Scattering Center at the Los Alamos Neutron Science Center (LANSCE). A number of radioactive isotopes under investigation were motivated by the Advanced Fuel Cycle Initiative (AFCI). During the talk the detector will be described, and first results for the neutron capture cross section experiment on ^{240,242}Pu will be presented.

10:57
B8 2 Muon Flux at Proposed US Sites for Underground Labs* KREGG PHILPOTT, *Department of Physics and INT, University of Washington* Because the next generation of solar neutrino, dark matter, and double beta decay experiments will require sites with extremely low cosmic-ray muon backgrounds, the establishment of a US deep underground laboratory has been under discussion. As some of the proposed sites involve irregular mountain topographies, a detailed calculation of muon production and penetration can be important both in properly positioning a laboratory and in assessing the potential cleanliness of that laboratory. Such calculations can influence engineering decisions, such as the tradeoffs between depth and rock quality and tunneling costs. Following Gaisser's semi-analytic formulation of atmospheric muon production and muon energy loss in rock and employing available Digital Elevation Models, we have evaluated several proposed sites and made comparisons to the existing laboratories at Kamioka and Gran Sasso. Results will be presented for the Henderson (CO), Homestake (SD), and Kimballton (VA) mines, for San Jacinto Peak (CA) and for the Mt. Stuart batholith (Cowboy and Cashmere Mts, WA).

*Work supported by the US Department of Energy and in collaboration with W. Haxton.

11:09
B8 3 Reactor Safeguards using Compact Antineutrino Detectors NATHANIEL BOWDEN, MATTHEW ALLEN, JAMES LUND, *Sandia National Laboratories, CA* ADAM BERNSTEIN, CELSETE WINANT, *Lawrence Livermore National Laboratory* Fission reactors emit large numbers of antineutrinos and this flux may be useful for the measurement of two quantities of interest for reactor safeguards: the reactor's power and plutonium inventory throughout its cycle. The high antineutrino flux and relatively low background rates means that simple cubic meter scale detectors at tens of meters standoff can record hundreds or thousands of antineutrino events per day. To estimate plutonium content, we exploit the fact that the ingrowth of $\sim$ 250 kilograms of plutonium in the core during a typical 1.5 year fuel cycle induces a predictable fall-off in the antineutrino rate in that time. Such antineutrino detectors would add online, quasi-real-time bulk material accountancy to the set of reactor monitoring tools available to the IAEA and other safeguards agencies with minimal impact on reactor operations. Our SNL/LLNL collaboration has deployed a prototype safeguards detector at a reactor in Southern California in order to test both the method and the practicality of its implementation in the field. Here I present results from this prototype detector, discuss further steps needed for practical implementation of this technique, and discuss overlap between these measurements and planned experiments to measure theta13.

11:21
B8 4 Measurement and modeling of dissolved radon as a tracer of ground water flow in a well VINCENTE GUISEPPE, *University of Maine* C.T. HESS, *University of Maine* ^{222}Rn, a naturally occurring radioactive gas produced in the ^{238}U decay series, can build-up in rock and dissolve in ground water. Although ^{238}U and ^{226}Ra dictate the presence of radon in the rock, the dynamics of ground water systems control dissolved radon in a well. We have measured variation of radon concentrations (up to a factor of 5) while drawing water from a well over 2 hours. We have measured the vertical distributions of radon in nine wells and identified the sources of dissolved radon. We designed and built a discrete interval thief sampler, lowered it desired depths and collected a volume of water to be later analyzed for radon using liquid scintillation. Using borehole geophysical instruments, we determined the location of fractures and the flow in the well as a function of depth. We observed higher radon values at both the locations of fractures as well as where flow is high. The core fragments removed during well-drilling were counted using gamma spectroscopy to determine the concentrations of radionuclides in the ^{238}U decay series surrounding the well. A mathematical model of the water mixing and flow out of the well predicts the variation of radon measured over time using the measured vertical radon profiles.

11:33
B8 5 Multigap Resistive Plate Chamber (MRPC) cosmic ray test system for the STAR Time-of-Flight detector* KOHEI KAJIMOTO, *The University of Texas at Austin* STAR COLLABORATION, Research and development for a time-of-flight (TOF) subsystem for the STAR detector at RHIC has been underway for the past several years. The TOF system will utilize multigap resistive plate chambers (MRPC) whose excellent time resolution (velocity determination), together with STARs Time Projection Chamber (TPC) track information (momentum determination), will considerably extend the particle identification capability of STAR to higher momentum over large angular acceptance. We have constructed a cosmic ray test system comprised of three plastic scintillators, 4 MRPC modules, and TOF prototype electronics in order to investigate the timing resolution that will be characteristic of the entire TOF system. The test setup will be discussed, test data will be described, and the timing analysis technique will be presented. Overall timing resolution of $\sim$ 90–100 ps for cosmic ray events has been achieved.

*Supported in part by the U. S. Dept. of Energy.

11:45

B8 6 Proposed STAR Time of Flight Readout Electronics and DAQ* JOACHIM SCHAMBACH, *The University of Texas at Austin* STAR COLLABORATION, A novel Time-of-Flight (TOF) subsystem is under design for the STAR detector at RHIC. A total of 3840 Multi-gap Resistive Plate Chambers (MRPC) of 6 pads each are distributed over 120 trays. The total number of channels is 23040. Each TOF tray consists of 192 detector channels and three different types of electronic circuit cards, called TINO, TDIG, and TCPU, listed in order of the data flow. Every 30 trays send their data to a THUB card that interfaces to the STAR trigger and transmits the data over a fiber to a fiber receiver which is part of STAR DAQ. The TINO contains the analog front end electronics based on a custom IC called NINO. The output of TINO is passed to the TDIG, where the data are digitized (using the CERN HPTDC ASIC). The TCPU formats and buffers the digital detector information. This formatted data is passed to THUB, which transmits it over an optical fiber to a data receiver in the STAR DAQ room. The architecture of this readout chain and DAQ will be described, and first results from prototypes of the component boards will be discussed.

*Supported in part by The U. S. Dept. of Energy.

11:57

B8 7 Front-End Electronics for a Zero Degree Calorimeter BRENNAN METZLER, *University of Kansas* The Zero Degree Calorimeter for the CMS experiment at the LHC is designed to measure the geometry of Pb-Pb collisions and to detect photons from proton-proton collisions. It is a high frequency device that will be run with a 40MHz beam in a high radiation environment with significant electronic noise. An overview of the design of the front-end electronics system for the ZDC will be presented, including descriptions of how PMT signals will be transmitted from the calorimeter to the counting house, how we plan to split the signals and how Charge Integrating and Encoding Analog to Digital Converting (QIE ADC) chips will be utilized to digitize the signals. We will also discuss the high voltage system for the ZDC.

12:09

B8 8 Development of Multiplexed Analog Shaper Electronics for use with Highly Segmented Silicon Arrays* CARL METELKO, SYLVIE HUDAN, ROMUALDO DESOUZA, *Dept. of Chemistry, Indiana University/IUCF* ANDREW ALEXANDER, JOHN POEHLMAN, *Dept. of Chemistry, Indiana University* MATTHEW HODEK, *Bowling Green State Univ.* We report on an electronic system, MASE (Multiplexed Analog Shaper Electronics), designed to simplify the analog processing and readout from a highly segmented silicon detector array. This system focuses on providing good energy resolution and adequate timing information for up to 1024 channels. It consists of 16-channel boards which can be either used independently or as part of a larger system. The analog portion of each channel has low and high gain shapers with associated leading edge discriminators and peak hold circuits. The logic for readout of the analog signals is performed by two FPGA chips located on each board. Readout of MASE channels is multiplexed. Logical signals are transferred via LVDS while the analog signals are sequenced into a multisampling ADC. Signals are also multiplexed for inspection purposes. Shaper gains and discriminator thresholds are adjustable through DACs via a USB interface. Performance characteristics of the prototype module will be described.

*Supported by the U.S Dept. of Energy Grant No. DE.FG02-88ER.40404.

12:21

B8 9 Investigation of Limitations on the Photon Tagging Technique at High Energies* MARIANNA GABRIELYAN, *University of Kentucky* PRIMEX COLLABORATION, The Hall B Jefferson Lab *PrimEx* Collaboration is using tagged photons to perform a 1.5% level measurement of the absolute cross section for the photoproduction of neutral pions in the Coulomb field of a nucleus. In view of the high precision necessary for this experiment, we are investigating the extent of possible limitations on the tagging technique for photon energies of about 5 GeV. These effects arise from two sources–radiative Møller scattering in the bremsstrahlung radiator, and incoherent bremsstrahlung, where the recoiling nucleus is left in an excited state or undergoes nucleon knockout. Both of these processes limit the correlation between the energy of the bremsstrahlung photon and the post-bremsstrahlung electron. These studies use the *PrimEx* Hall B pair spectrometer, which consists of a pair converter, a dipole magnet, and a segmented array of plastic scintillator telescopes to detect the electron-positron pair. This enables a comparison between the bremsstrahlung photon energy as determined by the pair spectrometer, and that given by the photon tagger. We will present results from the Fall 2004 *PrimEx* run and compare to GEANT simulations of the setup.

*This work is supported by NSF Grant No. PHY-0079840 and DOE Grant Number DE-FG02-99ER41101.

SESSION B9: HADRONIC PHYSICS I
Saturday Morning, 22 April 2006
Cumberland B, Hyatt Regency Dallas at 10:45
Paul Reimer, Argonne National Laboratory, presiding

10:45

B9 1 Bethe-Salpeter Study of Heavy-light Pseudoscalar and Vector Meson Masses* NICHOLAS SOUCHLAS, *Kent State University* PIETER MARIS, *University of Pittsburgh* PETER TANDY, *Kent State University* A model based on the ladder-rainbow truncation of the Dyson-Schwinger equations of QCD is extended to heavy-light ground state mesons in the charm and bottom quark regions. The approach is fully covariant. Consistent dressing of the light quark propagator is included in the calculations. Results presented will include the B, $B^\star$, D and $D^\star$ mesons.

*Work supported in part by NSF grant No. PHY-0301190 and DOE contract No. DE-FG02-00ER41135.

10:57

B9 2 Thermal Time Scales in a Color Glass Condensate VIVEK PARIHAR, ALLAN WIDOM,* *Northeastern University* YOGI SRIVASTAVA, *NEU, Physics Dept, Univ. of Perugia & INFN* In a model of relativistic heavy ion collisions wherein the unconfined quark-gluon plasma is condensed into glass, we derive the Vogel-Fulcher-Tammann cooling law. This law is well known to hold true in condensed matter glasses. The high energy plasma is initially created in a very hot negative temperature state and

cools down to the Hagedorn glass temperature at an ever decreasing rate. The cooling rate is largely determined by the QCD stringtension derived from hadronic Regge trajectories. The ultimately slow relaxation time is characteristic of a color glass condensate.

*Pls. CC all correspondence to Prof. Widom.

11:09

B9 3 Coherent ϕ-meson photoproduction on deuteron TSUTOMU MIBE, *Department of Physics and Astronomy, Ohio University* DAVID TEDESCHI, STEPAN STEPANYAN, CLAS COLLABORATION, Coherent ϕ-meson photoproduction on deuteron is studied in a high-statistics photo-deuteron experiment at CLAS with a tagged photon beam (E_γ = 0.8 – 3.6 GeV). The reaction $\gamma d \rightarrow \phi d$ is identified in the $K\bar{K}d$ final state. Because of the iso-scalar target, exchange of iso-vector mesons (e.g. π exchange) are not allowed. A comparison of cross sections with proton results would reveal the iso-spin structure of the production amplitudes. The high luminosity and a wide acceptance of CLAS enable one to measure the coherent ϕ photoproduction reaction at large angles for the first time. At large angles, the ϕ-nucleon cross section ($\sigma_{\phi N}$) can be investigated via a double scattering diagram. Recently, LEPS measured $\sigma_{\phi N}$ from nuclear A-dependence. The $\sigma_{\phi N}$ is large compared to the quark model prediction. A comparison of $\sigma_{\phi N}$ with the one from the A-dependence is of great interest in connection with possible medium effect. Current status of analysis will be reported.

11:21

B9 4 Measurement of the Pion's Electric Form Factor Via Pion Electroproduction TANJA HORN, *University of Maryland* FPI-2 COLLABORATION, A fundamental challenge in nuclear physics is the description of hadrons in terms of the constituents of the underlying theory of strong interactions. The simplest hadronic system is the pion, whose electromagnetic structure is determined by a single form factor (F_π). While F_π can be calculated using perturbative QCD in the limit of very large values of four momentum transfer (Q^2), its calculation in the transition region from moderate to asymptotic values of Q^2 is model dependent. Assuming dominance of the pion exchange process, the value of F_π can be extracted from the separated longitudinal response function. The F_π2-Collaboration measured the $^1H(e,e'\pi^+)n$ reaction for two values of Q^2 (1.6 and 2.5 (GeV/c)^2) in Hall C at Jefferson Lab. This experiment will increase the dynamic range of precision data for which F_π has been extracted to Q^2=2.5 (GeV/c)^2. The data may give an indication on the transition to the perturbative regime and will also help to constrain non-perturbative calculations of F_π in a region where model predictions begin to diverge.

11:33

B9 5 Overview of the Hypernuclear Spectroscopy Experiment E01-011 at Jefferson Lab VICTOR M. RODRIGUEZ, *University of Houston* HKS COLLABORATION, Experiment E01-011, ''Spectroscopic Study of Λ Hypernuclei up to Medium-Heavy Mass Region Through the (e, e' K$^+$) Reaction,'' (HKS), was successfully completed during a 2005 summer run in Hall C at the Jefferson Laboratory. Data were taken using C12, Si28, Li6, Li7, and Be9 targets. The experimental geometry included a new High Resolution Kaon Spectrometer (HKS), and implemented a ''Tilt Method'' for the electron spectrometer in order to increase the yield and the signal to accidental ratio. The experiment was designed to achieve a hypernuclear energy resolution of $\sim$ 400 KeV with rates that match or exceed those obtained using mesonic reactions. These studies will help define the hyperon-nucleon interaction, and the Λ effective mass in nuclear media.

11:45

B9 6 Excitation Spectra of Λ Hypernuclei using the (e,e'K$^+$) Reaction LEON COLE, *Hampton University* TOHOKU UNIVERSITY COLLABORATION, FLORIDA INTERNATIONAL UNIVERSITY COLLABORATION, UNIVERSITY OF HOUSTON COLLABORATION, UNIVERSITY OF ZAGREB COLLABORATION, The JLAB HKS experiment was designed to take full advantage of the (e,e'K$^+$) reaction and the new High Resolution Kaon Spectrometer. The expected results will provide Λ hypernuclear spectra with the best energy resolution ever achieved. This energy resolution of $\sim$ 400 keV (FWHM) will yield knowledge on the single-particle behavior of Λ hyperon in a nuclear medium and allow precise studies of the effective Λ -N interaction. This presentation will showcase the preliminary results of the excitation spectra from the ^{28}Si, ^{7}Li, and ^{12}C targets.

11:57

B9 7 Optical Calibration For Jefferson Lab HKS Spectrometer LULLIN YUAN, *Hampton University* Jefferson Lab HKS experiment aims at obtaining high resolution hypernuclear spectroscopy by $(e,e'K)$ reaction. The calibration of the HKS spectrometer is crucial in order to obtain the proposed missing mass resolution. This calibration procedure is complicated due to the use of a zero degree on-target splitter magnet. We have developed a high precision optical calibration method, making use of the known masses of Λ, Σ^0 hyperons produced from hydrogen in CH_2 target and the narrow width of $^{12}_{\Lambda}$B hypernuclear ground state from ^{12}C target. To deal with the high accidental background, we have implemented the Expectation-Maximization parameter estimation method. In this talk, the procedure of the calibration will be described and the preliminary results of the calibration will be presented.

12:09

B9 8 Searching for $\Phi(1860)^{--}$ pentaquark state in photo-induced reactions using the CLAS detector JÖRN LANGHEINRICH, *University of South Carolina* HOVANES EGIYAN, *University of New Hampshire* CLAS COLLABORATION, By launching the eg3 experiment the CLAS collaboration joined the worldwide efforts to search the $\Phi(1860)^{--}$ state, which is predicted to be one of the S=-2 states in the pentaquark anti-decuplet. Evidence for this state has been found by the NA49 experiment but couldn't be confirmed by any other group so far. The eg3 experiment exploits the fact that the state - if present - decays by two subsequent weak interactions which allows us to cut on the extremely narrow invariant masses of the intermediate states as well as on the well separated decay vertices. The reconstruction of $S=-2$ states from its decay products is a new analysis technique for CLAS, thus pushing the hardware and software to their limits. Data taking and calibration are now completed and the intermediate states Λ and Ξ^- have been identified. The focus of the ongoing analysis is the search for the $\Phi(1860)^{--}$ as well as for excited Ξ states.

12:21
B9 9 Search for the Θ^+ Pentaquark with Photoproduction off Deuterium at CLAS* KEN HICKS, *Ohio University* CLAS COLLABORATION, The g10 experiment at Jefferson Lab is a high-statistics measurement of photoproduction from a deuterium target with photon energies between 1.0-3.0 GeV. Two independent data sets were obtained, one at 80% of the maximum magnetic field of the CLAS detector and one at 60% of the maxiumum, each with a luminosity of order 30 pb^{-1}. For the final state pK^-K^+n the upper limit for the elementary production of the Θ^+ from the neutron is estimated using a model for final state interactions (FSI). This model and the estimated upper limit of the elementary cross section will be presented. In addition, production into the $\Lambda\Theta^+$ final has been investigated, and cross section upper limits will be presented. The high statistics of the g10 experiment are placing significant constraints on the question of whether narrow pentaquark resonances can exist.

*Supported in part by NSF grant PHY-0244999.

SESSION B11: FOCUS SESSION: RECENT RESULTS IN QUANTUM GRAVITY
Saturday Morning, 22 April 2006; Cumberland E, Hyatt Regency Dallas at 10:45
William Hiscock, Montana State University, presiding

Invited Papers

10:45
B11 1 Emergence of the standard model from quantum gravity.
LEE SMOLIN, *Perimeter Institute for Theoretical Physics*

Recent developments in loop quantum gravity (LQG) are presented which have implications for experiment. First a review is given of the basic ideas and principles which underlie loop quantum gravity which is a non-perturbative approach to unifying gravity and relativity with quantum theory. The main results are then reviewed, with emphasis on those that establish the finiteness of the theory and the discreteness of quantum geometry. A brief survey is then given of recent applications to black holes, the very early universe and high energy astrophys experiments such as AUGER and GLAST. The last part of the talk will then introduce recent results which show that, given certain assumptions, the low energy excitations of the quantum gravity theory have fermionic states which coincide with the fermions of the standard model.

Contributed Papers

11:21
B11 2 Black hole peregrinations EANNA FLANAGAN, *Cornell University* We consider the evaporation of a black hole of initial mass M_i, as monitored by observers who measure its position, mass, and momentum from its asymptotic gravitational field at a distance of order $\sim M_i^2$ in Planck units. As the black hole evaporates, each quanta of Hawking radiation will carry away some spatial momentum and will cause a slight recoil of the black hole. The net effect of this is a spreading of the black hole's wavefunction, first analyzed by Don Page in 1980. There are corresponding fluctuations in the asymptotically measured mass. We argue based on simple models that at the end of the evaporation process the black hole is spread out over a region of size $\sim M_i^2$ in both space and time. This effect complicates the usual sharp arguments for the information loss paradox, and seems to lead to a slight easing of the paradox.

11:33
B11 3 Holography and entropy bounds in the plane wave matrix model* ALEKSEY MINTS, RAPHAEL BOUSSO, *University of California, Berkeley* As a quantum theory of gravity, Matrix theory should provide a realization of the holographic principle, in the sense that a holographic theory should contain one binary degree of freedom per Planck area. We present evidence that Bekenstein's entropy bound, which is related to area differences, is manifest in the plane wave matrix model. If holography is implemented in this way, we predict crossover behavior at strong coupling when the energy exceeds N**2 in units of the mass scale.

*Research supported by the Berkeley Center for Theoretical Physics.

11:45
B11 4 Consistent discretization of classical and quantum Regge Calculus JORGE PULLIN, *Louisiana State University* RODOLFO GAMBINI, *University of the Republic of Uruguay* We apply the ''consistent discretization'' approach to Regge Calculus. As a consequence, one can construct a consistent well defined canonical theory for it. This would, in particular, allow the introduction of a natural measure in the path integral quite different from the usual ones. We apply the technique to a concrete example in 2+1 dimensional gravity.

11:57
B11 5 Horizon Constraints and Stringy Black Holes* STEVEN CARLIP, *University of California at Davis* To ask a question about a black hole in quantum gravity, one must constrain initial or boundary data to ensure that a suitable black hole is actually present. In a canonical formalism, such a new constraint can alter the algebra of diffeomorphisms, leading to the appearance of ''Goldstone boson-like'' physical degrees of freedom. I show that this modified algebra can be matched to known properties of a large class of string theoretical black holes, allowing a simple picture of their thermodynamics.

*Supported by DOE grant DE-FG03-91ER40674.

12:09
B11 6 Loop quantum cosmology in the Schwarzschild interior DANIEL CARTIN, *Naval Academy Preparatory School* GAURAV KHANNA, *University of Massachusetts, Dartmouth* In this work, we solve the discrete Hamiltonian constraint for the interior of the Schwarzschild black hole, recently derived by Ashtekar and Bojowald. Both analytic results and numerical simulations are presented here, characterizing the range of wave function solutions and putting a limitation on the quantum ambiguities appearing in the problem.

12:21
B11 7 Non-singular cosmological dynamics in Bianchi models of Loop Quantum Cosmology* KEVIN VANDERSLOOT, *Penn State* ABHAY ASHTEKAR COLLABORATION, PARAMPREET SINGH COLLABORATION, TOMASZ PAWLOWSKI COLLABORATION, Loop quantum cosmolgy predicts modifications to the standard Friedmann dynamics of cosmological models in the high energy regime. We show the ramefications of this in the Bianchi I and IX models and how it resolves the classical Big-Bang singularity and replaces it with a bounce for generic forms of matter.

*Eberly research funds of Penn State, NSF grants PHY-0090091, PHY-0354932.

12:33
B11 8 Introducing a Unifying Theory of Relativity and Quantum Mechanics N. GLENN GRATKE, The essence of this proposition of Unified Quantum Relativity lies in the realization that the energy of rest-rest quanta vary due to motion and gravity and that this variation produces the effects of Relativity. This talk will reinterpret gravitational redshift as a basis for assessing the variation of quanta due to gravity.

SESSION B12: B MESON DECAYS
Saturday Morning, 22 April 2006
Cumberland F, Hyatt Regency Dallas at 10:45
James Olsen, Princeton University, presiding

10:45
B12 1 Measurement of branching fractions of B-meson decays to final states containing an η' and a vector meson ALAN ROBERTSON, *University of Edinburgh* BABAR COLLABORATION, We present branching fraction results for charged and neutral B decay modes to charmless, quasi-two body, final states containing $\eta' K^*$ and $\eta' \rho$. The results are compared to theoretical predictions and provide information on the suppressed magnitude of $\eta' K^*$ with respect to enhanced $\eta' K^*$ decay channel. The results are derived using a multivariate maximum likelihood fit using data recorded by the BaBar detector, which comprise an integrated luminosity of 210.5fb^{-1} corresponding to 232 million $B\bar{B}$ pairs.

10:57
B12 2 $\Upsilon(1S) \rightarrow \eta' + X$ decays KOLOINA RANDRIANARIVONY, *Syracuse University* CLEO COLLABORATION, We present an improved measurement of the η' spectra in $\Upsilon(1S)$ decays, performed using 1.2 fb^{-1} of data taken at the $\Upsilon(1S)$ center-of-mass energy with the CLEO-III detector at CESR. The improved measurement of the end point of the η' spectrum from the $\Upsilon(1S) \rightarrow ggg$ decay will allow a more precise parametrization of the η' vertex function and will have implications for our understanding of the inclusive $B \rightarrow \eta' X_s$ decay.

11:09
B12 3 Searches for radiative B meson decays to $\eta(')K\gamma$ ALFIO LAZZARO, *University of Milano* BABAR COLLABORATION, We present preliminary results of a search of radiative B meson decays to $\eta(')K\gamma$. The data set consists of approximately 232 million $B\bar{B}$ pairs produced in electron-positron annihilations at the PEP II collider and recorded by the BaBar detector.

11:21
B12 4 Search for B^0 meson decay to $\eta'\eta' K^0_S$ RICCARDO PELLEGRINI, *INFN Sezione di Milano* BABAR COLLABORATION, We present preliminary results of a search for B^0 meson decay to $\eta'\eta' K^0_S$. The data set consists of approximately 232 million $B\bar{B}$ pairs produced in electron- positron annihilation at the PEP-II collider and recorded by the BaBar detector.

11:33
B12 5 Ratios of Branching Fractions for Hadronic b Meson Decays BORIS IYUTIN, *MIT* CDF COLLABORATION, The addition of the displaced track trigger at the second trigger level has enabled CDF in Run II to study purely hadronic b hadron decays. We present ratio of branching fractions for $B^0 \rightarrow D^-\pi^+(\pi^+\pi^-)$, $B_s \rightarrow D_s^-\pi^+(\pi^+\pi^-)$ and $B^0 \rightarrow D_s^+ D^-$, $B_s \rightarrow D_s^+ D_s^-$. The latter provides a good handle to estimate $\Delta\Gamma/\Gamma$.

11:45
B12 6 Study of CP violation in mixing with partially reconstructed $D^{*-}\ell^+\nu$ events ELISA MANONI, *University of Perugia and INFN Sezione di Perugia* BABAR COLLABORATION, We present a simultaneous measurement of the neutral B-meson lifetime difference $\Delta\Gamma$ and of the parameter $|q/p|$, relative to the CP violation in B mixing, using $D^{*-}\ell^+\nu$ events. The semileptonic final state is partially reconstructed, i.e. only the slow pion from D^{*-} decay and the lepton are used. The flavour of the other B is determined by means of lepton tagging. The measurement is performed using a fit to the proper time difference distribution of the two mesons on a sample of 240 million $\Upsilon(4S) \rightarrow B\bar{B}$ events, collected by the BaBar detector at the PEP-II asymmetric-energy B factory.

11:57
B12 7 Study of the $B^\pm \rightarrow (K\pi\pi^0)_{D^0/\overline{D^0}}K^\pm$ through the ADS method VIOLA SORDINI, *LAL-Orsay and University of Roma, La Sapienza* BABAR COLLABORATION, We report on our study of $B^\pm$ mesons decaying into the final states $K^+\pi^-\pi^0 K^\pm$ and $K^-\pi^+\pi^0 K^\pm$, where $K\pi\pi^0$ come from a D^0 or $\overline{D^0}$ meson, using 205fb^{-1} of data collected by the BaBar detector at the PEP-II asymmetric-energy e^+e^- B Factory at SLAC. We aim to measure the ratio $R_{ADS} = \mathcal{BR}(B^+ \rightarrow K^-\pi^+\pi^0 K^+)$

$+\mathcal{BR}(B^- \to K^+\pi^-\pi^0 K^-)/\mathcal{BR}(B^+ \to K^+\pi^-\pi^0 K^+)$ $+\mathcal{BR}(B^- \to K^-\pi^+\pi^0 K^-)$, from which we can extract information on the parameter $r_B = A(B^+ \to D^0 K^+)/A(B^+ \to \overline{D^0} K^+)$. Since r_B is the ratio between a V_{ub} and the V_{cb} decay amplitude, it's knowledge corresponds to a constraint on $\rho-\eta$ plane in the γ sector.

SESSION B13: W AND Z BOSONS I
Saturday Morning, 22 April 2006
Cumberland G, Hyatt Regency Dallas at 10:45
Peter Nemethy, New York University, presiding

10:45
B13 1 W/Z/Higgs Production at LHC and PDF Uncertainties* FREDRICK OLNESS, *SMU* At the LHC, W and Z boson production will be used as ''benchmark'' processes to calibrate various searches for the Higgs boson, SUSY, and other ''new physics'' processes. In the context of the PDF global analysis, we examine current data from HERA, Tevatron, and fixed-targets to properly quantify the PDF uncertainties. This helps us distinguish ''new physics'' from ''old physics,'' and thereby maximize the discovery potential of the LHC.

*This work is supported the U.S. Department of Energy and the Lightner-Sams Foundation.

10:57
B13 2 Study of Inclusive WZ Events in Trilepton Final States at Dzero JAMES DEGENHARDT, *University of Michigan* DZERO COLLABORATION, Presented is a study of the WZ di-boson events using data with integrated luminosity of about 1/fb collected by Dzero at the Fermilab Tevatron with a center-of-mass energy of 1.96 TeV. The signal from process of WZ to tri-leptons and associated background are studied in detail, which has resulted the first measurement of the WZ production cross-section in a hadron collider experiment. The most restrictive anomalous coupling limits using WZ production from a hadron collider are also set.

11:09
B13 3 Search for *WZ* Production at the Tevatron KEVIN McCARTHY, SHIH-CHIEH HSU, ELLIOT LIPELES, MARK NEUBAUER, FRANK WÜRTHWEIN, *University of California, San Diego* CDF COLLABORATION, We present a search for *WZ* production using $\approx$ 800 pb^{-1} of data accumulated with the CDF II detector. Our event selection criteria of three charged leptons and missing transverse energy is sensitive to $p\bar{p} \to WZ \to \ell\nu\ell\ell$ production. The main background sources to this channel are dilepton final states from Drell-Yan and top quark production with a hadronic jet misidentified as a lepton.

11:21
B13 4 Search for *WZ* and *ZZ* Production in the Dilepton Plus Dijet Final State at the Tevatron JONATHAN EFRON, *Ohio State University* BEATE HEINEMANN, *University of Liverpool* RICHARD HUGHES, BEN KILMINSTER, *Ohio State University* ANDY MEHTA, *University of Liverpool* BRIAN WINER, *Ohio State University* CDF COLLABORATION, We present a search for diboson production using $\approx$ 700 pb^{-1} of CDF II dilepton plus dijet data. This final state is sensitive to both $ZZ \to \ell\ell q\bar{q}$ and $ZW \to \ell\ell q\bar{q}'$ production. The signal can be discriminated from the main background of Z bosons produced in association with jets using the dijet mass distribution. Observation of diboson production in this final state is an important step in the search for Higgs boson production in association with a Z boson.

11:33
B13 5 Measurement of *b* jet Production in Events with a *Z* Boson in $p\bar{p}$ Collisions at $\sqrt{s}$ = 1.96 TeV JONATHAN WILSON, *Baylor University* CDF COLLABORATION, A measurement of the single inclusive bottom jet cross section is presented for events containing a Z boson in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV with the Collider Detector at Fermilab. Z bosons are identified in their electron and muon decay modes, and b jets with $E_T > 20$ GeV and $|\eta| < 1.5$ are identified by reconstructing a secondary decay vertex. The measurement is based on an integrated luminosity of 337 pb^{-1} for the electron decay mode and 324 pb^{-1} for the muon decay mode. We find a cross section of $\sigma(Z + b \text{ jet}, Z \to l^+l^-) = 0.96 \pm 0.35$ pb and the fraction of b-jets to the total number of jets in this sample is $(2.39 \pm 0.86)\%$. This measurement is in agreement with NLO QCD predictions.

11:45
B13 6 Search for New Physics in the DiElectron Channel at CDF SAM HARPER, *Oxford University* CDF COLLABORATION, We present a measurement of the Drell-Yan mass spectrum at high energies in the electron channel using 820 inverse picobarns of proton-antiproton collision data taken with the CDF II detector at a centre of mass energy of 1.96 GeV. We examine this mass spectrum for any excesses over Standard Model predictions and also interpret the mass spectrum to provide limits on new neutral massive bosons decaying to two electrons. Examples of such particles include Z' bosons resulting from various new physics models and the Randal-Sundrum Graviton.

11:57
B13 7 Search for Narrow di-Muon Resonances in a Wide Mass Range MICHAEL SCHMITT, *Northwestern University* JANE NACHTMAN, *FNAL* CDF COLLABORATION, A search for narrow di-muon resonances has been conducted with data collected by the CDF Collaboration. A very wide mass range is examined, extending from the J/ψ resonance to the highest reach of the Tevatron. An innovative statistical treatment is employed allowing a minimal reliance on simulations. Results are interpreted in a model-independent framework allowing limits to be placed on the production of Z' resonances of almost any mass.

12:09

B13 8 Study of Hadronic Final States in Z Production in Searches for Monojet Signatures at the Tevatron MONICA D'ONOFRIO, ORIOL SALTO, *IFAE Barcelona* CDF COLLABORATION, We present a comprehensive review of hadronic final states in Z boson production in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV. The analysis is performed in the context of preliminary studies on irreducible backgrounds in searches for monojet signatures, based on $\sim 1 fb^{-1}$ of data collected by the CDF experiment in Run 2.

12:21

B13 9 A Study of Anomalous Production of Z-Bosons with High Transverse Momentum at the Tevatron ALEXANDER PARAMONOV, *The University of Chicago* CDF COLLABORATION, As part of a broad search for new heavy particles decaying into W and Z bosons, we have measured an upper limit on the anomalous production of Z-bosons with large transverse momentum. The Z bosons, which are produced in $p\bar{p}$ collisions at 1.96 TeV at the Fermilab Tevatron, are studied in the e^+e^- and $\mu^+\mu^-$ final states using the CDF detector. The integrated luminosity of the data samples is 305 pb^{-1}. In addition to the comparison with the Standard Model, we have compared the results with the predictions of a specific model, proposed by Bjorken, Pakvasa, and Tuan, of heavy right-handed quarks that decay into the W, Z, and Higgs bosons.

SESSION B14: PARTICLE BEAM PHYSICS AND TECHNOLOGIES
Saturday Morning, 22 April 2006
Cumberland I, Hyatt Regency Dallas at 10:45
Joseph Bisognano, University of Wisconsin, presiding

10:45

B14 1 Experimental Investigation of Beam Breakup in the Jefferson Laboratory 10 kW FEL Upgrade Driver* CHRISTOPHER TENNANT, DAVID DOUGLAS, KEVIN JORDAN, LIA MERMINGA, EDUARD POZDEYEV, HAIPENG WANG, In energy recovery linacs the maximum average current can be limited by the multipass beam breakup (BBU) instability, which occurs when the electron beam interacts with the higher-order modes (HOMs) of an accelerating cavity on the accelerating pass and again on the energy recovered pass. Experimental characterization and observations of the instability at the Jefferson Laboratory 10 kW Free Electron Laser (FEL) Driver are presented. Methods to measure the threshold current for the instability were developed and the results were used to compare with the predictions of several BBU simulation codes. This represents the first time in which the codes have been definitively benchmarked. With BBU posing a threat to high current beam operation in the FEL Driver, several suppression schemes were successfully developed. These include direct damping of the dangerous HOM and appropriately modifying the electron beam optics so as to reduce the coupling between the beam and mode.

*Supported by the Office of Naval Research, the Joint Technology Office, the Commonwealth of Virginia, the Air Force Research Laboratory, and by DOE Contract DE-AC05-84ER40150.

10:57

B14 2 Controlling wiggler harmonic radiation to minimize FEL cavity mirror damage* S.L. HUANG, Y.K. WU, *Duke University* Wigglers emit both fundamental and harmonic radiation. In UV-VUV oscillator FELs, harmonic radiation can cause serious damage to the downstream mirror of the FEL cavity. This work reports our studies of wiggler radiation loading on the FEL cavity mirror. A mechanism to control and reduce mirror damage using a set of controllable in-vacuum apertures is being developed for the Duke storage ring FELs. Two optical klystron FELs, one with a pair of horizontally polarized wigglers, the other with a pair of circularly polarized wigglers, will be studied in detail. We will report the effectiveness of the apertures in reducing the wiggler harmonic radiation loading on the FEL cavity mirror for both optical klystron FELs under various operation conditions and for different lasing wavelengths.

*This work is supported by the U.S. AFOSR MFEL grant F49620-001-0370.

11:09

B14 3 Recent Studies of Coherent Bremsstrahlung HERBERT UBERALL, *Catholic University* The concept of coherent bremsstrahlung (CB), i.e., of X-rays generated by electrons in single crystals that exhibit monochromatic spikes was brought to light by Dyson and Uberall (Phys. Rev. 99, 1955, p. 604). Experimental studies were first carried out by Diambrini et al. (Rev. Mod. Phys. 40, 1968, p. 611) and repeated world-wide afterwards. These spikes are almost 100% linearly polarized, such that CB is now being developed into a source of monochromatic polarized radiation in a way where no other method could accomplish that, and where many scientific investigations are now becoming possible due to its use, e.g. at Jefferson Lab., Newport News, VA. 5.7 GeV electrons produce 2-GeV photons with 84% polarization at the peak energy. Experiments carried out with them involve production of ρ, ζ and ω mesons. Electrons of 189 GeV at CERN yield CB photons at 170 GeV. Studies are being carried out at 855-MeV Mainz electron accelerator MAMI, of the Mozley-de Wire effect, which, by collimating the emitted radiation, narrows the width of the CB peaks and enhances the CB linear polarization.

11:21

B14 4 Injection, focusing, and acceleration of electrons in the nonlinear 3D laser wakefield* SERGUEI KALMYKOV, *The Department of Physics and Institute for Fusion Studies, The University of Texas at Austin* LEONID GOBUNOV, *P. N. Lebedev Physics Institute, Russian Academy of Sciences, Moscow, Russian Federation* PATRICK MORA, *Centre de Physique Theorique (UMR 7644 du CNRS), Ecole Polytechnique, Palaiseau, France* GENNADY SHVETS, *The Department of Physics and Institute for Fusion Studies, The University of Texas at Austin* Accelerating and focusing phases of the nonlinear three-dimensional axisymmetric laser wakefield can almost entirely overlap at some distance back from the laser pulse in homogeneous plasma. Field structure of this kind results from the curvature of phase fronts due to the radially inhomogeneous relativistic plasma frequency shift. Consequently, the number of trapped low-energy electrons can be much greater than that predicted by the linear wake theory. This effect is favorable for trapping and monoenergetic acceleration of considerable charge (several hundreds of pC) to about 1 GeV per electron in the plasma wakefield driven by the ultrashort (of order

30 fs) loosely focused (focal spot radius about 100 microns) petawatt laser pulse.

*Supported by the Russian Fund for Basic Research (Grant No. 02-02-1611), by the U.S. DoE under Contracts #DE-FG02-04ER54763 and DE-FG02-04ER41321, and by the NSF grant PHY-0114336 administered by the FOCUS Center at the University of Michigan, Ann Arbor.

11:33

B14 5 Acceleration of a Train of Micro-Bunches Moving in a Dilute Resonant Active Medium* LEVI SCHACHTER, *Technion – IIT* Adapting the frequency of a train of micro-bunches, injected into a resonant medium to the resonance of the latter, leads to an effective interaction between the electrons and the medium. Of particular interest is the case when the medium is active, i.e., it stores energy since the train of micro-bunches may be accelerated. If the bandwidth of the resonant line is much narrower than that associated with the interference pattern of electromagnetic field of the *M* micro-bunches, then the energy transferred is independent of the number of micro-bunches. Implying that all the bunches are uniformly accelerated.

*This study was supported by the Israel Science Foundation and the US DoE.

11:45

B14 6 Electron Cloud Investigations in the Fermilab Main Injector ROBERT ZWASKA, WEIREN CHOU, IOANIS KOURBANIS, ALBERTO MARCHIONNI, VLADIMIR SHILTSEV, XIAOLONG ZHANG, *Fermilab* The Fermilab Main Injector currently accelerates 300 kW of 120 GeV protons for antiproton and neutrino production. We report on searches for the formation of an electron cloud within the Main Injector, and possible associated proton beam instabilities. Current capabilities and instrumentation upgrades will be discussed. These studies are performed with the anticipation that future plans could lead to a fourfold increase of the proton charge in the Main Injector.

11:57

B14 7 Characterization of Quasi-monoenergetic Neutron Beams from Deuteron Breakup at the 88-Inch Cyclotron* DARREN BLEUEL, MARGARET MCMAHAN, *Lawrence Berkeley National Laboratory* LARRY AHLE, LEE BERNSTEIN, *Lawrence Livermore National Laboratory* LAWRENCE HEILBRONN, *Lawrence Berkeley National Laboratory* A neutron irradiation facility is being developed at Lawrence Berkeley National Laboratory's (LBNL's) 88-inch cyclotron to measure neutron cross sections on radioactive targets important to nuclear astrophysics and stockpile stewardship. Quasi-monoenergetic neutron beams are produced in the 10–32 MeV range using the deuteron breakup reaction on various thin targets. Accurate characterization of these beams is needed before cross section measurements may be performed. To determine the neutron spectra produced by the breakup reaction on thin targets, three methods have been used, including activation foil measurements, direct neutron measurement using the time-of-flight technique with a Stilbene detector, and complimentary measurements of the associated protons using STARS, a silicon telescope array. Preliminary results indicate a good outlook for producing quasi-monoenergetic neutron beams with fluxes in the 10^{6-8} n/cm^2/s range.

*Supported by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231 and SSNA Grant No. NA00078.

12:09

B14 8 Spatially resolved X-ray emission of heavy ion beam interaction with solid matter SERGEY PIKUZ JR., OLGA ROSMEJ, ANATOLY FAENOV, VLADIMIR P. EFREMOV, SVITLANA KOROSTIY, ABEL BLAZEVIC, ALEXANDER FERTMAN, IGOR SKOBELEV, HENRY E. NORMAN, DIETER H.H. HOFFMANN, We have been investigated K-shell radiation of projectile ions and solid media during its interaction. The main advantage of the method consists in that the media is transparent for radiation applied for diagnostics, which provides the data acquisition directly from the interaction volume. The projectile and target spectra in the energy range of 1.5 – 8 keV were registered by means of spherically bend crystal spectrometers (FSSR) with a high spatial resolution along the beam propagation. The Ni, Ca and Mg ions accelerated in GSI UNILAC facility to the energies of 11.4 and 5.9 MeV/u were slowed down in solid quartz, quartz aerogels and aluminum media. Low-density (up to 0.02 g/cc) aerogel targets allowed expanding the interaction volume up to 100 times and, accordingly, to resolve the evolution of ion beam velocity and charge states inside the media. Simultaneously, the wavelengths and relative intensities of K_α satellite lines radiated by Si and Al target ions with different charges were measured. This has been provided us to investigate the excited media of the heavy ion track on a timescale of radiation transitions lifetimes (~ 20 fs after excitation). Low beam current of 1 uA allowed us to consider the excitation process as a number of statistically independent acts of single heavy ion energy deposition to the media.

12:21

B14 9 An Active X-Band High Power RF Compression System Using an Ultrafast Silicon Switch JIQUAN GUO, SAMI TANTAWI, *Stanford Linear Accelerator Center/ Stanford University* In this paper, we present the recent results of our research on the ultra-high power fast silicon RF switch and its application on active X-Band RF pulse compression systems. This switch is composed of a group of PIN diodes on a high purity silicon wafer. The wafer is inserted into a cylindrical waveguide operating in the TE01 mode. Switching is performed by injecting carriers into the bulk silicon through a high current pulse. Our current design uses a CMOS compatible process and the fabrication is accomplished at SNF (Stanford Nanofabrication Facility). The RF energy is stored in a room-temperature, high-Q 400 ns delay line; it is then extracted out of the line in a short time using the switch. The pulse compression system has achieved a gain of 11, which is the ratio between output and input power. Power handling capability of the switch is estimated at the level of 10MW.

SESSION C1: NOVEL DETECTOR TECHNOLOGIES
Saturday Afternoon, 22 April 2006; Landmark A, Hyatt Regency Dallas at 13:30
John Jaros, Stanford Linear Accelerator Center, presiding

13:30
C1 1 Diamond Detectors.
HARRIS KAGAN, *Ohio State University*

Progress in experimental particle physics in the coming decade depends crucially upon the ability to carry out experiments at high energies and high luminosities. These two conditions imply that future experiments will take place in very high radiation areas. In order to perform these complex and perhaps expensive experiments new radiation hard technologies will have to be developed. Chemical Vapor Deposition (CVD) diamond detectors are being developed as a radiation tolerant alternative for use very close to the interaction region where detectors may have to operate in extreme radiation conditions. During the past few years many CVD diamond devices have been manufactured and tested. As a detector for high radiation environments CVD diamond benefits substantially from its radiation hardness, very low leakage current, low dielectric constant, fast signal collection and ability to operate at room temperature. We will present the present state-of-the-art of polycrystalline CVD diamond and the latest results obtained from detectors constructed with this material. Recently a new type of diamond has been developed: single crystal CVD diamond which resolves many of the issues associated with polycrystalline material. We will also present recent results obtained from devices constructed from this new diamond material. Finally, we will discuss the use of diamond detectors in future applications and their survivability in the highest radiation environments.

14:06
C1 2 Bolometer Array Systems for Detection of the Cosmic Microwave Background.
MATT DOBBS, *McGill University*

The next generation of Cosmic Microwave Background (CMB) experiments will open a new window on the universe. By making precision measurements of the CMB polarization on large angular scales, we may see the signature of inflation carried by gravity waves. Through measurements of temperature anisotropy on small angular scales, we can discover distant galaxy clusters, constraining dark energy by providing a measurement of the universe's expansion history. These advances are made possible by new technology. I'll discuss recent advances in detector, readout, and cryogenic technology which are reaching the field now.

14:42
C1 3 Particle Flow Calorimetry for the ILC.
STEPHEN MAGILL, *Argonne National Laboratory*

The Particle Flow approach to detector design is seen as the best way to achieve dijet mass resolutions suitable for the precision measurements anticipated at a future e^+e^- Linear Collider (LC). Particle Flow Algorithms (PFAs) affect not only the way data is analyzed, but are necessary and crucial elements used even in initial stages of detector design. In particular, the Calorimeter design parameters are almost entirely dependent on the optimized performance of the PFA. Use of PFAs imposes constraints on the granularity and segmentation of the readout cells, the choices of absorber and active media, and overall detector parameters such as the strength of the B-field, magnet bore, hermeticity, etc. PFAs must be flexible and modular in order to evaluate many detector models in simulation. The influence of PFA development on calorimetry is presented here with particular emphasis on results from the use of PFAs on several LC detector models.

SESSION C2: HADRONIC PHYSICS II
Saturday Afternoon, 22 April 2006; Landmark B, Hyatt Regency Dallas at 13:30
Peter Tandy, Kent State University, presiding

13:30
C2 1 The New Exotic Heavy Mesons.*
ERIC BRAATEN, *Ohio State University*

Several new hadrons whose constituents include a charm quark and antiquark have recently been discovered, beginning with the X(3872) in 2003. Some of them do not fit naturally into the charmonium spectrum and they are therefore

candidates for exotic mesons. The exotic possibilities include hybrid mesons, tetraquark mesons, and mesonic molecules. The large mass of the charm quark provides a handle that can help discriminate between charmonium states and exotic mesons. The remarkable proximity of the mass of the X(3872) to a charm meson theshold provides an additional handle that establishes this state definitively as a charm meson molecule. The interpretation of several of the other exotic candidates remains a mystery.

*supported in part by Department of Energy under grant DE-FG02-91-ER4069.

14:06
C2 2 Strange Quarks in the Nucleon.
MARK PITT, *Virginia Tech*

Strange quarks contribute to the ground state structure of protons and neutrons through their presence in the virtual ''sea'' of quark – antiquark pairs. This talk will present the current status of the value of the strange quark contributions to scalar, axial-vector, and vector nucleon ground state matrix elements. Particular emphasis will be placed on the vector observables, which are parameterized by the strange electric and magnetic form factors. These quantities are measured experimentally using the technique of parity-violating electron scattering. Several new measurements of this type have been reported in the last two years, and there is consistency among the various measurements. For example, the combined results of five experiments at low four-momentum transfer are consistent with the strange quark sea contributing 10% to the magnetic moment of the proton. This result and the other physics implications of the recent measurements will be discussed.

14:42
C2 3 Jet Interactions with Dense Matter at RHIC.*
BERNDT MUELLER, *Duke University*

The emission of hadrons with high transverse momentum is found to be suppressed in Au+Au collisions at RHIC compared with the emission in proton-proton collisions. This suppression is understood to be a final-state effect caused by the energy loss of energetic precursor partons during their propagation in the hot medium created in the nuclear collisions. The energy loss process is an important tool for probing the properties of the medium. In my talk, I will review our current quantitative understanding of the energy loss process and discuss possible observable effects of the energy deposition on the medium

*Supported in part by DOE grant DE-FG02-05ER41367.

SESSION C3: VERY HIGH ENERGY COSMIC GAMMA RAYS
Saturday Afternoon, 22 April 2006; Landmark C, Hyatt Regency Dallas at 13:30
Reshmi Mukherjee, Barnard College, presiding

13:30
C3 1 TeV Astrophysics and Cosmology.
FELIX AHARONIAN, *MPIK, Heidelberg*

The stereoscopic arrays of imaging atmospheric Cherenkov telescopes are powerful multi-functional tools for spectrometric, morphological and temporal studies of nonthermal phenomena and objects representing different Galactic and Extragalactic source populations. I will overview the status of the field with emphasis on the recent exciting results obtained with HESS. I will highlight the most important observations and discuss the astrophysical and cosmological implications of these results.

14:06
C3 2 Recent Results from Milagro.*
PETER NEMETHY, *New York University*

The Milagro Gamma Ray Observatory, a large field-of-view Water Cerenkov Air Shower Array designed to detect gamma rays near 1 TeV, is particularly suited for studying emission from extended gamma sources or broad structures in cosmic rays. Gamma rays are the best direct probe of cosmic rays outside our solar neighborhood. Gamma-ray emission up to 30 GeV from a narrow band along the galactic equator has previously been detected by space-based instruments, notably EGRET. Results will be presented from a completed Milagro analysis giving evidence for TeV gamma ray emission from a mid-longitude region of the Galactic Plane. In a three-year data set with fixed region-of-

interest a Milagro signal with a significance of 4.5 standard deviations has been detected above the cosmic ray background. This is interpreted as gamma rays from the interaction of cosmic rays with the interstellar medium at the Galactic equator. New developments from this work, ongoing investigations with a larger data set and different methodologies, will be described. Another study concentrates on the dominant charged cosmic-ray-initiated showers. Cosmic rays impinging on earth are expected to be nearly isotropic in celestial coordinates. Milagro's large aperture makes it an ideal instrument to detect small deviations from isotropy, such as predicted by Compton and Geller in 1935. Preliminary results on an observed anisotropy at levels of order 10^{-3} will be presented.

*Supported by NSF Grants PHY-0206656 and PHY-0504201.

14:42
C3 3 GLAST and the Future of High Energy Gamma-ray Astrophysics.
STEVEN RITZ, *Goddard Space Flight Center*

The Gamma-ray Large Area Space Telescope, GLAST, is a mission to measure the cosmic gamma-ray flux in the energy range 20 MeV to > 300 GeV, with supporting measurements for gamma-ray bursts from 10 keV to 25 MeV. With its launch in 2007, GLAST will open a new and important window on a wide variety of high energy phenomena, including black holes and active galactic nuclei; gamma-ray bursts; the origin of cosmic rays and supernova remnants; and searches for hypothetical new phenomena such as supersymmetric dark matter annihilations, Lorentz invariance violation, and exotic relics from the Big Bang. In addition to the science opportunities, this talk will include a description of the instruments and the mission status. These topics will be discussed in the context of anticipated breakthrough measurements from other gamma-ray facilities in the future.

SESSION C4: PUBLIC AND PRIVATE FUNDING FOR INTERNATIONAL RESEARCH
Saturday Afternoon, 22 April 2006; Marsalis A, Hyatt Regency Dallas at 13:30
Arthur Bienenstock, Stanford University,presiding

13:30
C4 1 Forging Partnership: CRDF in the FSU and the World.
TOM OWENS, *U.S. Civilian Research & Development Foundation*

The founding legislation[1] for CRDF clearly intended the organization to combine public and private purposes, and that it could and should receive funding from both public and private sources. It also gave CRDF specific formal Purposes that included building international partnerships for supporting high-quality research, helping weapons scientists find another line of work, and helping American industry and foreign scientists to work together for mutual benefit and economic progress. CRDF was expected to "promote and support joint research and development projects for peaceful purposes between scientists and engineers in the United States and independent states of the former Soviet Union on subjects of mutual interest." CRDF has operated as a private foundation funding international research collaborations through peer-reviewed competitions, making more than 2,000 awards in ten years. It has carried out this work with resources provided largely by the U.S. government to facilitate non-proliferation, and to advance U.S. scientific, technical and human health objectives as well as U.S. foreign policy generally – but also from private sources, to advance primarily humanitarian and educational goals. CRDF's experience melding public and private support for international scientific cooperation has yielded a unique set of procedures and programs that it seeks now to apply in new geographic arenas.

[1]Public Law 102-511 "Freedom Support Act," Section 511, October 24, 1992.

14:06
C4 2 Crossing Borders to Advance the Frontier: NSF's Role in International Outreach.
ARDEN BEMENT, *Director, National Science Foundation*

The globalization of today's science and engineering is unprecedented. Ideas and discoveries emerge around the world and are transmitted instantaneously. Skills and capabilities are moving to new venues. We can view this free flow of investment and intellectual capital not only as a challenge, but also as an opportunity to form partnerships that integrate our strengths with those of other cultures and economies. As a nation, we can seek additional ways to become a valued partner in the global arena. We can train scientists and engineers that are not only technically competent but also skilled in cross-disciplinary, multi-cultural collaborations. NSF is committed to building bridges across borders to pursue these goals and collaboratively advance the frontiers of science and engineering.

14:42
C4 3 The Alexander von Humboldt-Foundation.
WOLFGANG SCHLEICH, *Alexander Von Humboldt Foundation and the University of Ulm*

The Alexander von Humboldt-Foundation promotes international cooperation between scholars from abroad and specialist collegues in Germany. The foundation has built up an international network of more than 23,000 individuals in approximately 130 countries who maintain active academic, cultural, political, and economic contacts with Germany. Under various sponsorship programs new members are accepted into the network every year. At the same time contacts already established on a long term basis are matured by means of specific sponsorship. In the present talk we briefly review the history of this foundation and given an overview over its various programs.

SESSION C5: COSMOLOGY II
Saturday Afternoon, 22 April 2006; Pegasus B, Hyatt Regency Dallas at 13:30
Virginia Trimble, University of California, Irvine, presiding

13:30
C5 1 Before the Microwave Background: Early Big Bang Cosmology (The J. Robert Oppenheimer Lecture).
HELGE KRAGH

Finite-age (or big-bang) cosmological models can be traced back to G. Lemaître's relativistic model of 1931 (or even earlier, to A. Friedmann in 1922). However, the big bang concept does not exclusively belong to the class of relativistic models, and in the 1930s it was often associated with E.A. Milne's very different, so-called kinematic cosmology. But it was only with G. Gamow's research program in the late 1940s that the big-bang scenario became widely known and turned into a nuclear-physical theory of the early universe. How does the theory of Gamow and his collaborators R. Alpher and R. Herman compare with Lemaître's earlier ideas of a ''primeval atom''? And with the post-1965 version of big bang cosmology? The strange fate of the Gamow-Alpher-Herman hot big bang theory can only be understood if taking into account that relativistic evolution cosmology faced stiff competition throughout the 1950s from the steady-state theory of F. Hoyle and others.

14:06
C5 2 The New Standard Cosmology.
DAVID SPERGEL, *Princeton University*

Cosmology now has a standard model. A relatively simple cosmological model describes the large-scale distribution of galaxies, detailed observations of the microwave background, observations of supernovae, and the abundances of light elements as well as a host of astronomical observations. In this model, the universe is spatially flat, homogeneous and isotropic on large scales. It is composed of ordinary matter, radiation, and dark matter and has a cosmological constant. The primordial fluctuations in this model are nearly scale-invariant Gaussian random fluctuations. I will highlight the key tests of the model and focus on the new results from the Wilkinson Microwave Anisotropy Probe. While this simple model has many successes, many key cosmological questions remain unanswered: what happened during the first moments of the big bang? What is the dark energy? What were the properties of the first stars? I will discuss the role of on-going and future CMB observations in addressing these key cosmological questions and describe how the combination of large-scale structure, supernova and CMB data can be used to address these questions.

14:42
C5 3 The Future of Theoretical Cosmology.
SEAN CARROLL, *University of Chicago*

Over the course of the twentieth century, we went from knowing essentially nothing about the large-scale structure of the universe to knowing quite a bit: that it is expanding from a Big Bang, that it is approximately 14 billion years old, that there are perhaps 100 billion galaxies spread uniformly throughout the observable universe. Theory has progressed along with observation: general relativity now forms the basis for all our discussions about cosmology, and advances in quantum field theory and particle physics have allowed us to talk sensibly about nucleosynthesis, dark matter, and primordial inflation. In the twenty-first century, two obvious candidates stand out: the nature of the dark sector, and the beginning of time. With 95% of the energy density of the universe apparently residing in dark matter and dark energy, the issues to be addressed by theorists span a wide range: What are these substances? Do they interact, with each other or with ordinary matter? Can they be detected in the lab? Why do they have the abundances we observe? Do they really exist, or are we being fooled by the behavior of gravity on large scales? Meanwhile, we will continue to stretch our theoretical models further into the past. Did the dark matter decouple from thermal equilibrium at early times? Do phase

transitions in the early universe produce observable gravitational-wave backgrounds? Did inflation occur, and if so what were the dynamics of the inflaton field? Why did inflation start? Are there distinct domains within the universe, possibly with different properties? Can quantum gravity resolve the initial singularity, and connect us with a pre-Big-Bang phase? Why is the early universe different from the late universe – what is the origin of time asymmetry? It is impossible to predict what the answers to any of these issues will turn out to be, but we can be confident that we would not be running out of interesting questions.

SESSION C6: GROUND-BASED GRAVITATIONAL WAVE DETECTION
Saturday Afternoon, 22 April 2006; Cumberland J, Hyatt Regency Dallas at 13:30
Benjamin Owen, The Pennsylvania State University, presiding

13:30
C6 1 Status of LIGO Interferometers.
MICHAEL ZUCKER, *California Institute of Technology*

LIGO interferometers are now collecting data full time, having reached design sensitivity in the last year. This achievement required an understanding of subtle unforeseen effects and some innovative design solutions to overcome them. The journey sets the stage for still better performance, as advanced detector technologies reach maturity in laboratories around the world.

14:06
C6 2 Results from LIGO observations I.
PATRICK BRADY,* *University of Wisconsin-Milwaukee*

The Laser Interferometer Gravitational-wave Observatory (LIGO) detectors have reached their design sensitivity, and searches for gravitational waves are ongoing. Gravitational waves from isolated neutron stars and from the inspiral/merger of compact binary systems carry significant information about the bulk properties of of black holes and neutron stars. We discuss current attempts to detect gravitational waves from these sources and comment on future prospects for these searches.

*For the LIGO Scientific Collaboration.

14:42
C6 3 Results from LIGO observations II.
PATRICK SUTTON,* *California Institute of Technology*

The Laser Interferometer Gravitational-wave Observatory (LIGO) detectors have reached their design sensitivity, and searches for gravitational waves are ongoing. We highlight current attempts to detect two classes of target signals. One class is unmodeled sub-second bursts of gravitational radiation, such as from core-collapse supernovae, the merger phase of coalescing binaries, and gamma-ray bursters. The second class is a stochastic background of gravitational waves of cosmological origin, which would provide a unique view of conditions in the very early universe. We summarize the current status of efforts to detect such signals, and comment briefly on the future prospects for these searches.

*For the LIGO Scientific Collaboration.

SESSION C7: GRAVITATIONAL WAVE ASTRONOMY
Saturday Afternoon, 22 April 2006
Pegasus A, Hyatt Regency Dallas at 13:30

13:30
C7 1 Search for gravitational waves from neutron stars: first results from Einstein@Home REINHARD PRIX, *Albert-Einstein Institut* FOR THE LIGO SCIENTIFIC COLLABORATION, The sensitivity of a search for unknown sources of continuous gravitational waves (such as could be emitted from rotating neutron stars) is limited to a large degree by the necessary computational power. In order to optimize the probability of detection, one has to use the most efficient search algorithm and maximize the available computing power. Einstein@Home is a large-scale public computing framework that allows one to achieve both of these goals by distributing the search to a large number of participating computers on the internet. In this talk we present results from the Einstein@Home search using data from the third scientific LIGO run (S3).

13:42
C7 2 A Search for gravitational wave signals from known pulsars using early data from the LIGO S5 run MATTHEW

PITKIN, *University of Glasgow* THE LIGO SCIENTIFIC COLLABORATION, We have analysed the first months of data collected in the fifth science run of LIGO to look for gravitational wave signals from known radio pulsars. The S5 run promises unprecedented sensitivities for these targets. We present a status report from this investigation, using pulsar timing data taken prior to S5, and consider the implication for a search based on a full year of S5 data.

13:54

C7 3 A coherent consistency test for gravitational-wave bursts PATRICK SUTTON, SHOUROV CHATTERJI, ALBERT LAZZARINI, *California Institute of Technology* ANTONY SEARLE, *Australian National University* LEO STEIN, *California Institute of Technology* MASSIMO TINTO, *Jet Propulsion Laboratory* A common feature of gravitational-wave bursts is that their waveforms are unknown or poorly modelled. This lack of knowledge could make it difficult to distinguish between real signals and coincidental noise fluctuations in gravitational-wave detectors. We present a multi-detector coherent analysis test that can distinguish unmodelled gravitational-wave bursts from interferometer ''glitches,'' without requiring any a priori knowledge of the gravitational-wave signal. We demonstrate this algorithm using a population of simulated core-collapse supernova waveforms and simulated noise glitches.

SESSION C8: NUCLEAR THEORY I
Saturday Afternoon, 22 April 2006
Cumberland A, Hyatt Regency Dallas at 13:30

13:30

C8 1 Pygmy-Resonance as a Manifestation of Strong Coupling to Continuum* ALEXANDER VOLYA, *Florida State University* VLADIMIR ZELEVINSKY, *NSCL and Michigan State University* The collective strength of giant resonances is built on coherent interaction of many simple particle-hole type excitations with specific quantum numbers. For isovector modes, and for the giant dipole resonance in particular, the collective strength forms a main peak shifted up in energy. The remaining unshifted low-energy strength becomes more pronounced in neutron-rich nuclei giving rise to the pygmy-branch of the giant resonance. Microscopically it can be presented as a vibration of the neutron skin against the core. Standard RPA calculations do not reveal an important role played by the continuum coupling. The particle-hole excitations, especially in loosely bound nuclei, are quasistationary states in the continuum. In such cases, the interaction through decay channels competes with a conventional shell model interaction and, for sufficiently large decay widths and overlapping resonances, leads to the collectivization of the widths (the phenomenon of ''super-radiation''). The interplay of two collectivities was originally considered in [1], where the enhancement of the pygmy-branch was predicted on the base of schematic models. We present the first results of microscopic calculations in the framework of the recently advanced version of the continuum shell model [2]. 1. V.V. Sokolov and V.G. Zelevinsky, Fizika (Zagreb) **22**, 303 (1990). 2. A. Volya and V. Zelevinsky, Phys. Rev. Lett. **94** (2005) 052501.

*Supported by DOE grant DE-FG02-92ER40750 and NSF grants PHY-0070911 and PHY-0244453.

13:42

C8 2 Structure of Light Nuclei Using Chiral Three-Nucleon Interaction* V.G. GUEORGUIEV, P. NAVRATIL, *Lawrence Livermore National Laboratory* J.P. VARY, *Iowa State University* W.E. ORMAND, *Lawrence Livermore National Laboratory* Modern high-precision nucleon-nucleon (NN) interactions adjusted to reproduce the phase shifts in the two nucleon system need to be augmented by three-nucleon interactions (TNI) in order to reproduce properties of multi nucleon systems. Chiral perturbation theory (χPT) at next-to-next-to-leading order (N^2LO) predicts three types of TNI terms. A two-pion exchange term, which is frequently used, has parameters determined from the two-nucleon χPT-potential and/or pion-nucleon scattering data. The other two terms, the one-pion exchange with NN-contact term and the NNN-contact term, are accompanied by undetermined low-energy constants. We include all three TNI terms in *ab initio* no-core shell model (NCSM) calculations. The two undetermined TNI constants are fit to binding energies of *s*-shell nuclei. The effect on the nuclear structure of adding N^2LO TNI is then studied in NCSM calculations for p-shell nuclei, such as $^{10,11}B$ and $^{12,13}C$ that are particularly sensitive to the presence of and the form of the TNI.

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13:54

C8 3 Structure of *p*-shell Nuclei with Interactions Derived from Chiral Effective-Field Theory* W. E. ORMAND, V. G. GUEORGUIEV, P. NAVRATIL, *Lawrence Livermore National Laboratory* J. P. VARY, *Iowa State University* Traditional realistic nucleon-nucleon (NN) interactions based on precision fits to 2-body data have not produced high-quality descriptions of light nuclei. Effective-Field theories (EFT) based on chiral-perturbation theory provide a natural scheme to derive inter-nucleon interactions and predict a three-nucleon interaction at next-to-next-to-leading order (N2LO). A key feature of these EFT potentials is a set of parameters; some of which are determined by the EFT NN couplings, while others are chosen to reproduce the binding energies of A=3 and 4 nuclei. We have developed the tools to utilize EFT-based potentials, including the NNN terms, in the ab initio no-core shell model (NCSM). We have also improved our shell-model codes to increase the scope of our calculations with three-nucleon interactions to the point where model spaces up to $6\hbar\Omega$ are accessible for all *p*-shell nuclei. We will show results of large-basis NCSM calculations for light p-shell nuclei, especially masses A = 10,11,12,13 and highlight the impact the N2LO TNI and its parameters on their structure. Support from LDRD contract No. 04-ERD-058 and DOE grant SCW0498 is acknowledged.

*This work was performed in part under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

14:06

C8 4 Possible Collective Effects of Residual Three-Body Forces* VLADIMIR ZELEVINSKY, *NSCL and Michigan State University* TONY SUMARYADA, ALEXANDER VOLYA, *Florida State University* The *ab-initio* calculations for light nuclei show the influence of three-body forces. Here we discuss possible effects of residual three-body forces added to the effective two-body interaction. The well known monopole corrections determined by the single-particle occupation numbers can be interpreted as a result of the mean-field averaging over the third particle. A classification of three-body effective interactions according to angular momentum of participating pairs shows a possibility of less trivial collective effects. The monopole renormalization of pairing can be considered exactly. We give an example of predictions that works for the xenon isotopes and allows one to estimate the typical strength of the effect. We also discuss cubic interactions of collective phonons which may be enhanced due to the three-body contribution. The octupole-quadrupole-octupole vertex is especially interesting leading to strong phonon coupling in agreement with the recent experiments for xenon isotopes [W.F. Mueller *et al.*, in press]. This can also be important for the enhancement of the nuclear Schiff moment in nuclei with soft octupole and quadrupole modes.

*Supported by DOE grant DE-FG02-92ER40750 and NSF grants PHY-0070911 and PHY-0244453.

14:18

C8 5 Benchmark result on the ^{4}He photoabsorbtion cross section SOFIA QUAGLIONI, IONEL STETCU, BRUCE R. BARRETT, *Univ. of Arizona* SONIA BACCA, *Gesellschaft für Schwerionenforschung* PETR NAVRÁTIL, *LLNL* WINFRIED LEIDEMANN, GIUSEPPINA ORLANDINI, *Univ. of Trento* NIR BARNEA, *Racah Institute of Physics* CALVIN W. JOHNSON, *SDSU* We present the results of a benchmark calculation of the ^{4}He photoabsorbtion cross section via the Lorentz integral transform approach, using both the no-core shell model (NCSM) and the effective interaction hyperspherical harmonic (EIHH) expansion methods. The present study, which is fully microscopic in the treatment of the dynamics in both the initial and final states, uses a semirealistic nucleon-nucleon potential, with the goal to test the reliability of the NCSM for the description of such processes. We find that the results of both EIHH and NCSM agree, which opens the the way for the use of two- and three-body forces obtained from EFT, and for applications to heavier nuclei by means of the NCSM. S.Q., I.S., and B.R.B acknowledge partial support by NFS grants PHY0070858 and PHY0244389. The work was performed in part under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48. P.N. received support from LDRD contract 04-ERD-058. W.L. and G.O. acknowledge support by the grant COFIN03 of the Italian Ministry of University and Research. N.B. acknowledges support by the Israel Science Foundation (Grant No. 202/02). C.W.J. acknowledges USDOE grant No. DE-FG02-03ER41272.

14:30

C8 6 A cluster model of ^{6}He JEREMY ARMSTRONG, *NSCL and Department of Physics and Astronomy, Michigan State University* ALEXANDER SAKHARUK, *NSCL, Michigan State University* VLADIMIR ZELEVINSKY, *NSCL and Department of Physics and Astronomy, Michigan State University* Small nuclei provide an ideal testing ground of few-body theories. ^{6}He is particularly interesting in that it shows an extended particle distribution similar to a halo nucleus, is loosely bound, and is a Borromean system. We apply the Brink Formalism in secondary quantization to study the structure of ^{6}He. This formalism allows for the proper treatment of Fermi statistics and correct projection into eigenstates of angular momentum. The alpha plus dineutron configuration and "cigar" (neutron, alpha, neutron chain) configuration were studied to obtain binding energies, charge radii, matter radii, and B(E2) for ^{6}He. We discuss the relative weight of both configurations as well as the size of the interference term between them in the overall ^{6}He wavefunction.

14:42

C8 7 Precision extraction of a_{nn} from $\pi^- d \to nn\gamma$ using χPT* ANDERS GÅRDESTIG, *University of South Carolina* DANIEL PHILLIPS, *Ohio University* We present an updated chiral perturbation theory calculation of the $\pi^- d \to nn\gamma$ reaction. By using other observables to constrain the unknown short-distance physics, we can drastically reduce the theoretical error in the extracted neutron-neutron scattering length. Further consequences of the results will be discussed.

*Supported in part by the Institute of Nuclear and Particle Physics at Ohio University and the DOE grant DE-FG02-93ER40756.

14:54

C8 8 Pionic Color Transparency ARNOLD LARSON, GERALD MILLER, *University of Washington* MARK STRIKMAN, *Pennsylvania State University* A search for pionic color transparency effects in nuclear reactions is currently under experimental investigation. However, it is unclear if the transparency effect is greater than the effect of the momentum dependence of the nuclear pion content. We review the use of a semi-classical formula to compute pion transparency and discuss the use of pionic response in determining the relative importance of these two effects.

15:06

C8 9 Pionic Contributions in a Quark Model of Nucleons and Nuclei* T. GOLDMAN, RICHARD R. SILBAR, *Los Alamos National Laboratory* A successful relativistic quark model of small nuclei[1] did not include long-range effects of pion exchanges between quarks. We add these contributions to themodel with a short-range cutoff (to avoid double counting). We report on the changes induced in model parameters and binding energies. [1]T. Goldman, K.R. Maltman, G.J. Stephenson, Jr., and K.E. Schmidt, itNucl. Phys. **A481**, 621 (1988).

*Work supported by the U.S. Department of Energy under contract W-7405-ENG-36.

SESSION C9: MINISYMPOSIUM: TOWARD A UNIVERSAL DENSITY FUNCTIONAL THEORY FOR NUCLEI I
Saturday Afternoon, 22 April 2006; Cumberland B, Hyatt Regency Dallas at 13:30
David Dean, Oak Ridge National Laboratory, presiding

Invited Papers

13:30
C9 1 Towards a Universal Density Functional Theory for Nuclei: Challenges to Overcome.*
THOMAS DUGUET, *NSCL/Michigan State University*

In the study of medium to heavy mass nuclei, nuclear Density Functional Theory (DFT), based on the self-consistent Hartree-Fock-Bogoliubov (HFB) method and its extensions, is the theoretical tool of choice. As more exotic beams facilities are being built or proposed to be built around the world, DFT is on the edge of becoming a predictive theory for all nuclei but the lightest. This is not only true for ground state properties, such as binding energies, radii or multipoles of the density, but also for low energy excited states of different types and for the calculation of their decay probabilities. These decisive advances are coming to life thanks to the development of better energy functionals and thanks to the increase of computer resources. However, the needed accuracy and predictive power still leaves much to be desired and DFT is facing important challenges in its quest for the truly universal energy density functional which should be able to describe properties of finite nuclei in all possible exotic modes as well as extended asymmetric nucleonic matter. In this talk, I will elaborate on those challenges before discussing the results of two ongoing studies aiming at tackling some of them. The first one is an attempt to construct the pairing part of the nuclear functional starting from the bare nucleon-nucleon interaction. Indeed, and despite its major role, the nature of pairing correlations in nuclei is largely unknown and has mostly relied on pure phenomenology so far. The long-term goal is to identify the in-medium effects at play in the pairing channel and model them via isoscalar and isovector density-dependences and/or gradient corrections. I will describe a way to realize the first step of such a program, that is, to set up a functional which is able to reproduce the pairing properties generated by the full realistic $AV18$ bare nucleon-nucleon force in finite nuclei. The second study deals with the conceptual problem one faces when defining the Particle Number Projected (PNP) HFB method within the context of DFT. Indeed, one manipulates in this case an ill-defined functional presenting divergences and jumps whenever a single particle state crosses the Fermi surface. I will discuss how those divergences and jumps are related to a spurious "self-pairing" interaction between paired nucleons and how one can identify and remove the corresponding spurious contributions to the projected energy.

*This work was supported by the U.S. National Science Foundation under Grant No. PHY-0456903.

Contributed Papers

14:06
C9 2 Density Functional Theory for Fermions close to the Unitary Regime ANIRBAN BHATTACHARYYA, THOMAS PAPENBROCK, *Univ. of Tennessee Knoxville/ORNL* We consider interacting Fermi systems close to the unitary regime and compute the corrections to the energy density that are due to a large scattering length and a small effective range. Our approach exploits the universality of the density functional and determines the corrections from the analyical results for the harmonically trapped two-body system. The corrections due to the finite scattering length compare well with the result of Monte Carlo simulations. We also apply our results to symmetric neutron matter.

14:18
C9 3 Energy Functionals from Low-Momentum Potentials*
S.K. BOGNER, *Ohio State University* The nonperturbative nature of conventional inter-nucleon interactions is strongly scale or resolution dependent, and can be radically modified by using the renormalization group to lower the momentum cutoff of the two-nucleon potential. Recent calculations demonstrate that using low-momentum potentials ("$V_{low k}$") with consistent three-body forces leads to saturating nuclear matter at the Hartree-Fock level, with rapidly converging perturbative corrections in the particle-particle channel.[a] With these interactions, the density matrix expansion (DME) becomes a natural tool for the microscopic construction of a universal energy functional for nuclei.[b] By varying the cutoff, the resolution dependence of the functional can be studied. The use of sharp momentum cutoffs in $V_{low k}$ complicates the application of the DME in coordinate space. This problem is resolved with the recent generalization of $V_{low k}$ to smooth cutoff regulators. [a]S. K. Bogner, A. Schwenk, R. J. Furnstahl and A. Nogga, Nucl. Phys. A **763**, 59 (2005). [b]J. W. Negele and D. Vautherin, Phys. Rev. C **5**, 1472 (1972).

*Supported by NSF Grant PHY-0354916.

14:30
C9 4 The Nuclear Equation of State and Its Applications to Neutron Stars* PLAMEN KRASTEV, FRANCESCA SAMMARRUCA, *University of Idaho* One of the most challenging problems in both theoretical and experimental nuclear physics is to understand the nature of matter under extreme conditions of density and pressure. Observations of neutron star properties impose important constraints on the equation of state of dense matter, as the latter is the basic input quantity that enters the structure

equations of these compact objects. Continuing with our systematic study of the effective nucleon-nucleon interactions in dense and isospin-asymmetric hadronic environment, we will present predictions of neutron star masses and radii obtained from our relativistic equation of state. We use realistic nucleon-nucleon potentials defined in the framework of the meson-exchange potential model and the Dirac-Brueckner approach. We will provide an overview of theoretical predictions and recent observational data. This broad outlook will help us gauge the quality of our tools and determine the importance of mechanisms beyond the present model.

*The authors acknowledge financial support from the U.S. Department of Energy under grant DE-FG02-03ER41270.

SESSION C10: NUCLEAR SCIENCE EDUCATION FOR THE NATION
Saturday Afternoon, 22 April 2006; Cumberland C, Hyatt Regency Dallas at 13:30
Jolie Cizewski, Rutgers University, presiding

13:30
C10 1 Nuclear Science Outreach in the World Year of Physics.*
MARGARET MCMAHAN, *Lawrence Berkeley National Lab*

The ability of scientists to articulate the importance and value of their research has become increasingly important in the present climate of declining budgets, and this is most critical in the field of nuclear science ,where researchers must fight an uphill battle against negative public perception. Yet nuclear science encompasses important technical and societal issues that should be of primary interest to informed citizens, and the need for scientists trained in nuclear techniques are important for many applications in nuclear medicine, national security and future energy sources. The NSAC Education Subcommittee Report [1] identified the need for a nationally coordinated effort in nuclear science outreach, naming as its first recommendation that it'the highest priority for new investment in education be the creation by the DOE and NSF of a Center for Nuclear Science Outreach'. This talk will review the present status of public outreach in nuclear science and highlight some specific efforts that have taken place during the World Year of Physics. [1] Education in Nuclear Science: A Status Report and Recommendations for the Beginning of the 21st Century, A Report of the DOE/NSF Nuclear Science Advisory Committee Subcommittee on Education, November 2004, http://www.sc.doe.gov/henp/np/nsac/docs/NSAC_CR_education_report_final.pdf.

*Supported by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

14:06
C10 2 Bringing Nuclear Science into the Undergraduate Curriculum.*
GRAHAM PEASLEE, *Hope College*

Think about the first time you encountered nuclear science in your formal curriculum. For most nuclear scientists this experience occurred as an undergraduate in an upper-level course in a traditional four-year institution. Because of changing student demographics, an explosion of interest in the life sciences, the end of the cold war and a variety of other factors, fewer undergraduates are encountering a traditional nuclear science course at all. For the field to remain vital, we suggest that educators in nuclear science will have to adapt to the changes in student populations and interests. To this end we now offer a variety of experiences to our undergraduate students that incorporate fundamental nuclear science. One component to our approach is to create exciting opportunities in undergraduate research, and another component involves creation of nuclear science modules that can fit within other courses. In recent years both of these components have evolved with an interdisciplinary flavor, but continue to yield students that become interested in pursuing nuclear science careers. We will discuss research opportunities offered to undergraduates at Hope College, and our success with collaborative research opportunities at a variety of extramural laboratories, as well as with our in-house research program with a low-energy accelerator. An overview of several pedagogical approaches we have adopted will also be presented, and there is clearly opportunity to pursue this approach much further. Although the examples are specific to Hope College, both components can clearly be adopted at a variety of other institutions.

*Funding from NSF-RUI #0354920 and NSF-MRI #0319523 is gratefully acknowledged.

14:42
C10 3 Science and National and International Security: the role of Physics in Non-proliferation and counter-terroism.
EDWARD P. HARTOUNI, *University of California, Lawrence Livermore National Laboratory*

Compliance with international agreements as well as detecting clandestine activities are often limited by the technical capabilities of those enforcing the agreements and national and international law. Further, some technological solutions may violate personal liberties, offend local cultural sensibilities or fail to have the desired detection specificity. Many of these solutions exploit fundamental physical properties to provide specific ''signatures.'' The ability to implement these ''signatures'' into effective monitoring schemes is one role science plays on the scene of national and international security.

SESSION C11: SPS UNDERGRADUATE RESEARCH
Saturday Afternoon, 22 April 2006
Cumberland E, Hyatt Regency Dallas at 13:30
Gary White, Society of Physics Students, presiding

13:30

C11 1 Lorentz-Violating Electrodynamics and the Hydrogen Spectrum ADAM HINKLE, MATTHEW MEWES, *Marquette University* Atomic spectra have provided sensitive tests of Lorentz symmetry. The hydrogen spectrum from the fermion sector of the Lorentz-violating Standard-Model Extension (SME) has been well studied. Here we present an analysis of the spectrum from the less studied photon sector.

13:42

C11 2 Debye Model of Steps on Vicinal Crystal Surfaces* CLINT A. GREENE, HOWARD L. RICHARDS, *Texas A & M University-Commerce* The steps on a vicinal crystal surface can be mapped onto the world lines of spinless fermions, with the average direction of the steps (the y-direction) being mapped to time. If the interaction energy per unit length between neighboring steps is given by $V(L) = A/L^2$ (as is common), this resulting quantum system is integrable for only three values of $\tilde{A} \equiv \tilde{\beta}A/(k_B T)^2$. For other values of $\tilde{A}$, the Pairwise Einstein Model gives an excellent approximation for the Terrace Width Distribution [TWD, the histogram of $x_{i+1}(y) - x_i(y)$] but is severely limited in describing $g_x(\Delta y) \equiv \langle [x_i(y + \Delta y) - x_i(y)]^2 \rangle$, particularly for $\Delta y > \xi$, the correlation length. Here we show how the one- dimensional Debye model correctly gives $g_x(\Delta y)$ even for large Δy. The Pairwise Einstein Model also suggests a relationship between the compressibility of the steps and the tails of the TWD, a relationship we clarify using the Debye model.

*Supported by TAMU-Commerce and Research Corporation.

13:54

C11 3 Hardware Controls System Upgrade for the STAR Experiment* MATTHEW BRNICKY, *Creighton University* STAR COLLABORATION, The hardware controls system for the STAR (Solenoidal Tracker At RHIC) experiment is being upgraded to accommodate new detectors. The number of items monitored and controlled will increase from 25000 to 40000. While reliable, the current system uses processors designed when the first system tests were carried out in the mid-1990's. Such computing hardware is not appropriate for the new front end electronics. Specialized workstations are being replaced by new personal computers. Additionally, many aging processors housed in electronics crates will be replaced by PC's. A prototype upgrade is being tested during the Spring 2006 run. Software systems are currently being redesigned to require less operator intervention while maintaining backward compatibility. A stand-alone distribution kit has been developed to make the controls tools available to the new subsystems. Implementation and aspects of the new control hardware and software will be presented.

*Supported by the Office of Science, US Department of Energy.

14:06

C11 4 Analyzing Orbits of Bodies Accreting into Schwarzschild and Kerr Black Holes JAFET MORALES, RICHARD CARDENAS, *St. Mary's University* The purpose of this report is to use Maple to study the orbits of bodies accreting into Schwarzschild and Kerr black holes. A Schwarzschild black hole is a spherically symmetric black hole with no charge and no angular momentum, while a Kerr black hole has charge and angular momentum. In this study, I wrote Maple programs to look at these types of black holes under a variety of initial conditions. In addition, I compared these general relativistic solutions to a classical model. My research was focused mainly on studying general relativity and black holes. I studied geodesics near both Schwarzschild and Kerr black holes with the use of computer algorithms in Maple. I also designed an algorithm that will help understand null geodesics coming from the accretion disk of Kerr black holes, and how they can be affected by several factors, such as the torus around the BH, and ionized gas.

14:18

C11 5 Singularity formation with the harmonic map and a distributed data analysis tool. JASON WILLIAMS, STEVE LIEBLING, I have developed a new tool which can analyze data from numerical relativity. It runs in parallel and is easily extensible. With help from this tool I have implemented a model to find solutions to the harmonic map ($M^{\{3+1\}} \rightarrow S^2$) within a distributed adaptive mesh refinement (AMR) code in order to study the formation of singularities in flat space.

14:30

C11 6 Development of a Low-Cost Spectrophotometric Sensor for ClO_2 Gas JESSICA CONRY, *Henderson State University* DANE SCOTT, ALLEN APBLETT, NICHOLAS MATERER, *Oklahoma State University* ClO_2 is of interest because of it's capability to kill biological hazards such as E. coli and mold. However, ClO_2 is a toxic, reactive gas that must be generated at the point-of-use. Gas storage is not possible due to the possibility of an explosion. The need to detect the amount of ClO_2 at the point-of-use necessitates a low cost sensor. A low-cost spectrophotometric sensor based on a broad-band light source, a photodiode detector and a band-pass filter is proposed. To verify the design, precise determinations of the gas-phase cross-section and characterization of the optical components are necessary. Known concentrations of ClO_2(g) are prepared using the equilibrium relationship between an aqueous solution and the gas phase. The aqueous solutions are obtained by generating the gas via a chemical reaction and passing it through water. The concentrations of the aqueous solutions are then determined by chemical titration and UV-visible absorption measurements. For the solutions, a maximum absorption is observed at 359 nm, and the cross section at this wavelength is determined to be $4.79 \times 10^{-18} cm^2$, in agreement with previous observations. Using a broad-band source, the absorption of ClO_2 gas is successfully analyzed and concentrations are determined as low as 100 ppm. A more recent prototype based on an UV LED can measure down to concentrations as low as one ppm.

SESSION C12: ACCELERATOR-BASED NEUTRINO EXPERIMENTS
Saturday Afternoon, 22 April 2006
Cumberland F, Hyatt Regency Dallas at 13:30
Hugh Gallagher, Tufts University, presiding

13:30
C12 1 The Neutrino Beam for the MINOS (Main Injector Neutrino Oscillation Search) Experiment at Fermilab MARY BISHAI, *Brookhaven National Laboratory* MINOS COLLABORATION, On January 21st, 2005 the NuMI (Neutrinos at the Main Injector) neutrino beamline delivered its first neutrino beam to the MINOS experiment. During its first year of operation the NuMI beamline has delivered over 1×10^{20} protons-on-target to the MINOS experiment. The NuMI proton beamline is one of the most heavily instrumented beamlines in high energy physics. This has enabled the MINOS experiment to characterize and study the primary proton beam characteristics as well as the secondary neutrino beam. We present a review of the NuMI beamline performance in 2005 and discuss the implications of beam performance on the MINOS experiment's neutrino physics program.

13:42
C12 2 Deep Inelastic Scattering Cross Section in MINOS* DEBDATTA BHATTACHARYA, *University of Pittsburgh* MINOS COLLABORATION, The MINOS experiment, using the high-intensity NUMI beam, has been recording beam neutrino interactions in the near and the far detector since March 2005. The near detector data sample will have high statistics in the 1-30 GeV range. A measurement of charged-current neutrino deep inelastic scattering cross section using this sample will be discussed. The deep inelastic scattering cross section will allow a first measurement of the neutrino-iron structure functions in the low-Q2, high-x region. Understanding the neutrino cross section in the given energy range will be important both for MINOS and for the next generation neutrino oscillation experiments (T2K, Nova).

*For the MINOS collaboration.

13:54
C12 3 $\nu_\mu \rightarrow \nu_e$ oscillation study in MINOS TINGJUN YANG, MINOS COLLABORATION, The MINOS (Main Injector Neutrino Oscillation Search) is a long baseline neutrino experiment using the NuMI neutrino beam to study neutrino oscillations. MINOS will be able to improve the limit on the neutrino mixing angle θ_{13} by searching for an electron neutrino appearance signal in the far detector from ν_μ beams. We may make the first measuremeant of θ_{13} with improved proton intensity if θ_{13} is found to be sufficiently large. I will present the method to identify electron neutrinos and show the systematics analysis using the MINOS near detector data.

14:06
C12 4 Sterile Neutrino Analysis in MINOS THOMAS OSIECKI, *University of Texas At Austin* MINOS COLLABORATION, MINOS is a long baseline neutrino oscillation experiment based at Fermilab with an intense neutrino beam at its disposal. MINOS will produce the best measurement to date of Δm^2 using $\nu_\mu \rightarrow \nu_\tau$ oscillations and also has sensitivity to a sterile admixture from $\nu_\mu \rightarrow \nu_{sterile}$ oscillations using Neutral Current interactions. The basic sterile neurino analysis will be discussed and results from the Near Detector at Fermilab will also be presented.

14:18
C12 5 Latest Atmospheric Neutrino Results from MINOS PEDRO OCHOA, *CalTech* MINOS COLLABORATION, The latest atmospheric neutrino results based on 418 days of exposure of the MINOS Far Detector in Soudan, MN are presented. A fit to the observed L/E distribution excludes the null oscillation hypothesis at the 98% level, and a charge ratio measurement for atmospheric neutrinos is obtained. These results constitute the first observation of atmospheric neutrino interactions for neutrinos and antineutrinos separately.

14:30
C12 6 A Detector 2 km Away from the T2K Neutrino Source EDWARD KEARNS, *Boston University* T2K 2KM COLLABORATION, We describe a detector array 2 km from the neutrino production target of the T2K experiment. At this distance, almost the same neutrino flux is measured as that seen at Super-Kamiokande, 295 km away. The detector consists of a 1 kton water Cherenkov detector, a muon range detector, and a 100 ton liquid argon TPC. We show how this detector may be used to study neutrino oscillations with the T2K beam and Super-Kamiokande.

14:42
C12 7 Liquid Argon Detectors for Long Baseline Neutrino Oscillation Physics BONNIE FLEMING, *Yale University* Long baseline, off-axis ν_e appearance programs are sensitive to the final unknowns in the MNS neutrino mixing matrix, θ_{13}, a possible CP violating phase, δ, and with sufficient baseline, the mass hierarchy. These experiments are difficult, though, and require the best detectors to do the physics. Liquid Argon Time Projection Chambers (LArTPC) are the best way to take advantage of new high intensity neutrino beams, such as the NuMI neutrino beamline at Fermilab, to do these experiments. The sensitivity of these detectors for this physics, their feasibility, as well as a program to utilize these detectors on the NuMI beamline at Fermilab will be presented.

14:54
C12 8 Liquid argon R & D at Yale MATTHEW HARRISON, ALESSANDRO CURIONI, *Yale University* BONNIE FLEMING, *Yale University Physics* Liquid argon detectors are at the cutting edge of several present and/or proposed experimental activities in particle and astroparticle physics: neutrinos, Dark Matter, proton decay etc. Recently a great deal of attention has been paid to the scintillation light from liquid Ar. The Yale group is among the leaders of the US-based effort toward a multi-kiloton liquid argon time projection chamber for neutrino physics. Here we present results from the laboratory activities at Yale, in particular studies of light detection in liquid Ar.

SESSION C13: W AND Z BOSONS II
Saturday Afternoon, 22 April 2006
Cumberland G, Hyatt Regency Dallas at 13:30
Sarah Eno, University of Maryland, presiding

13:30

C13 1 Measurement of the Drell-Yan Cross Section in $p\bar{p}$ Collisions at the Tevatron JANE NACHTMAN, *Fermi National Accelerator Laboratory* MICHAEL SCHMITT, *Northwestern University* CDF COLLABORATION, A preliminary measurement of the Drell-Yan cross section $\sigma(p\bar{p} \rightarrow \mu^+\mu^-)$ for dimuon masses in the range 30–200 GeV/c^2 is presented. The data were taken by the CDF Collaboration, and correspond to an integrated luminosity of $\approx$ 340 pb^{-1} for $p\bar{p}$ collisions at an energy of 1.96 TeV/c. NLO calculations of this cross section are compared to the data.

13:42

C13 2 Measurement of the $p\bar{p} \rightarrow W$ Cross Section using Forward Electrons JOSE ENRIQUE GARCIA, GIORGIO CHIARELLI, MARTIN CILJAK, IVAN FEDORKO, SANDRA LEONE, ANTONIO SIDOTI, ATHANASIOS STAVERIS, *University of Pisa* CDF COLLABORATION, We present an updated measurement of the W boson production cross section using electrons identified in the rapidity region $1.2>|\eta|<2.8$ in 223 pb^{-1} of CDF II data collected from 2002 to 2004. $W \rightarrow e\nu$ events are selected using the combined information from the forward calorimeter and silicon tracking detectors. The result agrees with NLO theoretical predictions and with previous measurements using reconstructed central leptons ($|\eta| < 1$).

13:54

C13 3 A New Method to Measure the Ratio of W and Z Cross Sections KATHERINE COPIC, *University of Michigan* VICTORIA MARTIN, *University of Edinburgh* MICHAEL SCHMITT, *Northwestern University* CDF COLLABORATION, We present a new method for measuring the ratio, R, of the cross sections for W and Z production in $p\bar{p}$ collisions at the Fermilab Tevatron. A combined sample of W and Z boson candidates is selected by requiring at least one charged lepton and low net hadronic activity. The p_T spectrum of the leptons is used to infer the relative rate of W and Z production. We obtain a preliminary measurement of R using data collected with the CDF II detector corresponding to an integrated luminosity of approximately 350 pb^{-1} and extract an indirect value for the width of the W boson.

14:06

C13 4 Measurement of differential cross section for Z boson production at Dzero LEI WANG, *University of Maryland* DZERO COLLABORATION, The Tevatron has delivered more than 1/fb of proton-antiproton data with a center of mass energy of 1.96 TeV to the collider experiments. Using events containing two high p_T electrons with $|\eta| < 1$, we show results of a preliminary measurement of the Z boson cross section and the differential distribution $d\sigma(Z \rightarrow e^+e^-)/dp_T$ using the full data sample taken by the Dzero experiment before December 2005.

14:18

C13 5 Measurement of the Transverse Momentum Distribution for Z Boson Production at the Tevatron W. DAVID DAGENHART, *Brandeis University* CDF COLLABORATION, We present a measurement of the transverse momentum distribution for $\sigma(p\bar{p} \rightarrow Z/\gamma^*) \cdot Br(Z/\gamma^* \rightarrow \mu\mu)$ in the 66 GeV/c^2 to 116 GeV/c^2 Z/γ^* mass range using CDF Run II data corresponding to an integrated luminosity of 337 pb^{-1}. In the low p_T region this distribution is determined by soft gluon radiation and experimental measurements constrain models of this process. These constraints reduce the systematic uncertainty associated with the W boson p_T spectrum in Tevatron measurements of the W boson mass.

14:30

C13 6 Study of Z+Photon production and limits on anomalous couplings at Dzero ALEXEI FERAPONTOV, *IHEP, Protvino, Russia* DZERO COLLABORATION, We present a measurement of Z+Photon production cross section and limits on anomalous Z Z Photon and Z Photon Photon couplings for form-factor scales of Lambda = 750 and 1000 GeV. The measurement is based on approximately 1/fb of integrated luminosity collected by Dzero detector at a center-of-mass energy of1.96 TeV.

14:42

C13 7 Measurement of W+Photon events at Dzero GREGORY PAWLOSKI, *Rice University* DZERO COLLABORATION, The coupling parameters for the W W Photon vertex are studied by using final state lepton (electron or muon), neutrino, and photon events that were collected at the D0 detector and delivered by the Fermilab Tevatron Collider at a center-of-mass energy of 1.96 TeV. Physical features of the W W Photon gauge coupling are discussed. The importance of the Standard Model radiation amplitude zero in the photon-lepton charge signed rapidity difference is detailed.

14:54

C13 8 QCD inputs to W Mass Measurement TIMOTHY ANDEEN, *Northwestern University* DZERO COLLABORATION, We present a study of the sensitivity of W boson mass measurement to various QCD input parameters. In high statistics measurements at the Tevatron these parameters will be a significant source of the uncertainty. In particular, we have investigated how the concurrent measurements of the Z boson transverse momentum distribution and the W boson charge asymmetry during Run II of the Tevatron can help to constrain these inputs.

15:06

C13 9 A Direct Measurement of the W Boson Width EMILY NURSE, VALERIA BARTSCH, DANIEL BEECHER, MARK LANCASTER, SARAH MALIK, TROY VINE, DAVID WATERS, *University College London* CDF COLLABORATION, We present a direct measurement of the W boson width using CDF II electron and muon decay channel data with respective integrated luminosities of 377 pb^{-1} and 330 pb^{-1}. The measurement is made by fitting the W boson transverse mass distribution, and the result provides a constraint on potential exotic decay modes of the W boson.

SESSION C14: PHYSICS OF MUON AND POLARIZED BEAMS
Saturday Afternoon, 22 April 2006
Cumberland I, Hyatt Regency Dallas at 13:30
Mike Syphers, Fermi National Accelerator Laboratory, presiding

13:30
C14 1 A Muon Collider as a SUSY Higgs Factory DAVID CLINE, *University of California, Los Angeles* GAIL HANSON, *University of California, Riverside* NEUTRINO FACTORY AND MUON COLLIDER COLLABORATION, In the Minimal Supersymmetric (SUSY) Standard Model (MSSM) there are five Higgs bosons, the lightest of which h^0 will most likely be discovered at the Large Hadron Collider (LHC). However, for moderately large $tan\beta$ the heavier Higgs bosons A^0 and H^0 may have greatly suppressed couplings to gauge bosons. Discovery of these heavier Higgs bosons may not be possible at the LHC or at an e^+e^- linear collider. In a muon collider Higgs bosons are produced through the s-channel, and even in the decoupling limit the couplings of the A^0 and H^0 to $\mu^+\mu^-$ are not suppressed. In this case a muon collider will be needed to discover the A^0 and H^0. In addition, these heavy Higgs bosons can be largely degenerate, and the very small center-of-mass energy spread of a muon collider will be necessary to separate them. A muon collider as a SUSY Higgs factory will be discussed.

13:42
C14 2 The Muon Ionization Cooling Experiment TERRY HART, MUON IONIZATION COOLING EXPERIMENT (MICE) COLLABORATION, Muon storage rings have been proposed for use as sources of intense high-energy neutrino beams and as the basis for multi-TeV lepton-antilepton colliding-beam facilities. Optimizing the performance of such facilities is likely to require the phase-space compression (cooling) of the muon beam prior to acceleration and storage. The short muon lifetime makes traditional beam-cooling techniques ineffective. Ionization cooling, a process in which the muon beam is passed through a series of energy absorbers followed by accelerating RF cavities, is thus the technique of choice. The international Muon Ionization Cooling Experiment (MICE) collaboration has been formed to carry out a muon-cooling demonstration experiment, and its proposal to Rutherford Appleton Laboratory has been approved. The MICE cooling channel, its instrumentation, and its implementation at the Rutherford Appleton Laboratory are described together with the predicted performance of the channel and the measurements that will be made.

13:54
C14 3 Studies of Six-Dimensional Cooling of a Muon Beam AMIT KLIER, GAIL HANSON, *University of California Riverside* The reduction of the phase-space volume (emittance), also known as "beam cooling," is an essential ingredient in muon colliders and is also very useful in neutrino factories. In a muon collider, in particular, the six-dimensional emittance must be reduced by about six orders of magnitude. Ionization cooling is used for transverse emittance reduction. In this process, the beam loses energy through ionizations in an absorber and then regains only longitudinal momentum in RF cavities. Cooling the beam longitudinally is achieved through the process of emittance exchange, in which the beam loses energy by passing through wedge-shaped absorbers in a dispersive magnetic field, designed in such a way that fast muons travel through more absorber material than slow ones and thus lose more energy. Six-dimensional cooling is done by combining the two processes. We simulate cooling channels, in which a muon beam is cooled in all six phase space dimensions while rotating several times in a ring or ring-like cooling channel. Some ring designs and cooling simulation results are presented and discussed.

14:06
C14 4 The MuCool RF Program ALAN BROSS, *Fermilab* DERUN LI, *LBNL* AL MORETTI, *Fermilab* JIM NOREM, *Argonne National Lab* ZUBAO QIAN, *Fermilab* ROBERT RIMMER, *JLAB* YAGMUR TORUN, *Illinois Institute of Technology* MICHAEL ZISMAN, *LBLN* MUCOOL COLLABORATION, Cooling muon beams in flight requires absorbers to reduce the muon momentum, accelerating fields to replace the lost momentum, and static solenoidal magnetic fields to focus the muon beams. The process is most efficient if both the magnetic fields and accelerating fields are high and the rf frequency is low. In order to study the interactions of a static magnetic field with the operation of high gradient accelerating fields we have conducted tests to determine the operating envelope of accelerating cavities in high magnetic fields. These studies have already produced useful information on dark currents, magnetic fields and breakdown in cavities. In addition to continuing our program at 805 MHz, we are starting to test a 201 MHz cavity and are planning to look at a variety of appropriate geometries and materials. In parallel with these activities, we are pursuing supporting R&D on models and surface structure.

14:18
C14 5 Exploration of Horizontal Intrinsic Spin Resonances in the AGS* FANGLEI LIN, S.Y. LEE, *Indiana University, USA* LEIF A. AHRENS, MEI BAI, KEVIN BROWN, ERNEST D. COURANT, JOSEPH W. GLENN, HAIXIN HUANG, ALFREDO LUCCIO, WILLIAM W. MacKAY, VADIM PTITSYN, THOMAS ROSER, STEVEN TEPIKIAN, NICHOLAOS TSOUPAS, JEFF WOOD, YIN YIP, *Brookhaven National Lab, USA* MASAHIRO OKAMURA, JUNPEI TAKANO, *RIKEN, Japen* INDIANA UNIVERSITY, USA COLLABORATION, BROOKHAVEN NATIONAL LAB, USA COLLABORATION, RIKEN, JAPAN COLLABORATION, Siberian snakes have been employed to overcome spin resonances during polarized proton acceleration. Considering limited space in the AGS, strong partial snakes that rotate the spin by less than 180 degrees can be used to avoid the spin imperfection and intrinsic resonances in low energy accelerators. However, the tilt of spin away from the vertical direction may become sensitive to horizontal betatron motion which can also cause spin depolarization. These resonances, called horizontal intrinsic spin resonances, have been observed in simulations. Preliminary measurements with beam were also carried out in AGS 2005 polarized proton run. During the AGS 2006 run, we plan to explore the details about the horizontal intrinsics

resonances further. This paper describes the experimental methods and the latest results.

*This work was performed under the auspices of the US Department of Energy and RIKEN Japan.

14:30

C14 6 Spin manipulating vector & tensor polarized deuterons stored in COSY V.S. MOROZOV, A.D. KRISCH, M.A. LEONOVA, R.S. RAYMOND, D.W. SIVERS, V.K. WONG, *Univ. of Michigan, Ann Arbor, MI 48109-1120* K. YONEHARA, *IIT, Chicago, IL 60616* R. GEBEL, A. LEHRACH, B. LORENTZ, R. MAIER, D. PRASUHN, A. SCHNASE, H. STOCKHORST, *Forschungszentrum Juelich, IKP, D-52425 Juelich* D. EVERSHEIM, F. HINTERBERGER, H. ROHDJESS, K. ULBRICH, *Helmholtz Inst., Univ. Bonn, D-53115 Bonn* We recently studied the spin manipulation of a simultaneously vector and tensor polarized deuteron beam stored at 1.85 GeV/c in the COSY Cooler Synchrotron. Using the EDDA detector, we first calibrated the vector and tensor analyzing powers, which were earlier unmeasured at 1.85 GeV/c; this allowed us to measure the absolute values of both the vector and tensor polarizations. Then we manipulated the deuteron's polarization by sweeping the frequency of a ferrite rf dipole through an rf-induced spin resonance. We first experimentally determined the resonance's frequency and then varied the rf dipole's frequency sweep range Δf and frequency ramp time Δt to maximize the spin-flip efficiency. We then obtained a measured vector spin-flip efficiency of 98.5 $\pm$ 0.3% [1]. We also studied, in detail, the behavior of the tensor polarization during spin manipulation; these new data may allow a better understanding of the interesting quantum behavior of spin-1 bosons. This research was supported by the German BMBF Science Ministry. [1] V.S. Morozov et al., Phys. Rev. ST Accel. Beams 8, 061001 (2005).

14:42

C14 7 Spin manipulating 2.1 GeV/c polarized protons stored in COSY M.A. LEONOVA, A.D. KRISCH, V.S. MOROZOV, R.S. RAYMOND, D.W. SIVERS, V.K. WONG, *University of Michigan, Ann Arbor, MI 48109-1120* R. GEBEL, A. LEHRACH, B. LORENTZ, R. MAIER, D. PRASUHN, A. SCHNASE, H. STOCKHORST, *Forschungszentrum Juelich, IKP, D-52425 Juelich* D. EVERSHEIM, F. HINTERBERGER, K. ULBRICH, *Helmholtz Inst., Universitaet Bonn, D-53115 Bonn* We studied spin flipping of a 2.1 GeV/c vertically polarized proton beam stored in COSY. We swept the frequency of a strong ferrite rf-dipole, with $\int Bdl = 0.46$ T $\cdot$ mm, through an rf-induced spin resonance to flip the beam's polarization direction. After determining the resonance's frequency, we varied the frequency ramp time Δt and frequency range Δf to maximize the spin-flip efficiency. At the rf-dipole's maximum strength and optimum Δf and Δt, we used the multiple spin flip technique to measure a spin-flip efficiency of 99.92 $\pm$ 0.04% [1]. Comparison of the theoretically predicted and experimentally measured rf-induced spin resonance strengths showed that experimentally it was about 10 times stronger than predicted. We then studied this discrepancy by varying the beam size and vertical betatron tune while measuring the strength of the rf-induced spin resonance. We observed a hyperbolic dependence on the distance from an intrinsic spin resonance and no significant dependence on the beam size. This research was supported by the German BMBF Ministry. [1] M.A. Leonova et al., Phys. Rev. Lett. 93, 224801 (2004).

SESSION C16: DPP CONTRIBUTED ORALS I
Saturday Afternoon, 22 April 2006
Landmark D, Hyatt Regency Dallas at 13:30
Benjamin Chandran, University of New Hampshire, presiding

13:30

C16 1 Weak compressible MHD turbulence in the solar corona* BENJAMIN CHANDRAN, *University of New Hampshire* This presentation describes a weak-turbulence calculation for fast waves and Alfven waves in low-beta plasmas. Numerical and analytic results are presented for the anisotropic power spectra and nonlinear time scales for energy transfer to small scales and high frequencies. It is argued that high-frequency waves produced by MHD turbulence in the solar corona are a promising mechanism for explaining the observed anisotropic heating of minor ions in the corona.

*This work was supported by NASA grant NNG 05GH39G and NSF grant AST 05-49577.

13:42

C16 2 Spectrum of MHD Turbulence* STANISLAV BOLDYREV, *University of Chicago* We propose a phenomenological theory of strong incompressible magnetohydrodynamic turbulence in the presence of a large-scale external magnetic field. We argue that in the inertial range of scales, magnetic-field and velocity-field fluctuations tend to align the directions of their polarizations. However, in driven turbulence the perfect alignment cannot be reached, it is precluded by the presence of a constant energy flux over scales. As a consequence, the directions of fluid and magnetic-field fluctuations at each scale λ become aligned within the angle $\phi_\lambda \propto \lambda^{1/4}$, which leads to scale-dependent depletion of nonlinear interaction and to the field-perpendicular energy spectrum $E(k_\perp) \propto k_\perp^{-3/2}$. Our results may be universal, i.e., independent of the external magnetic field, since small-scale fluctuations locally experience a strong field produced by large-scale eddies. The application of the results to diffractive interstellar scintillation is discussed.

*Supported by the NSF Center for magnetic self-organization in Laboratory and Astrophysical Plasmas, U. Chicago; REF: astro-ph/0511290.

13:54

C16 3 Charged Grains and the Dynamics of Saturn's F Ring LORIN MATTHEWS, TRUELL HYDE, *Baylor University* The dynamics of Saturn's F Ring have been a matter of curiosity ever since the probes Pioneer 11 and Voyagers 1 and 2 sent back data revealing the ring's unusual features. Once again this dynamic ring is in the spotlight with Cassini now at Saturn sending back high-resolution images of its rapidly evolving features. The F Ring displays clumps, kinks, waves and braids, structures which evolve on the time scale of months, and has recently been described as a spiral ring. Several models have been proposed to explain these features; most of these invoke perturbations caused by the shepherding moons or km sized moonlets imbedded in the ring and are purely gravitational in nature. These models assume that both the plasma densities at the F Ring and the charges on the grains are small enough that electromagnetic forces can be ignored. Most models also assume that the effects of solar radiation pressure and solar gravity act on a timescale of thousands of years and thus do

not contribute to the evolving features. This study shows that electromagnetic and radiation forces can lead to significant perturbations of the orbits of micron sized grains, even for very small grain charges, and may have implications for the steep size-distribution seen in the F Ring.

14:06

C16 4 Structural Phases in Complex Plasmas TRUELL HYDE, KE QIAO, JIE KONG, LORIN MATTHEWS, JORGE CARMONA, JERRY REAY, MIKE COOK, JIMMY SCHMOKE, *CASPER - Baylor University* Dust particles imbedded within plasma acquire a charge from collisions with free electrons and ions in the plasma. If the ratio of the inter-particle potential energy to the average kinetic energy is sufficient, the particles form a ''liquid'' structure with short range ordering or a crystalline structure with longer range ordering. When the dust particles form a crystalline structure and reside within two-dimensionally extended lattice planes, different stable crystalline phases have been observed experimentally. Recently, it has been found that energetically favored structures can be formed employing various external DC biases. Additionally, dust free region formation employing this form of external DC bias will also be discussed. Experimental results will be shown to be in good agreement with current theoretical predictions for a strongly coupled complex plasma system.

14:18

C16 5 MHD Turbulence in the Madison Dynamo Experiment MARK NORNBERG, *University of Wisconsin-Madison* CARY FOREST, ROCH KENDRICK, ERIK SPENCE, ADAM BAYLISS, CRAIG JACOBSON, CARLOS PARADA, Initial results from the Madison Dynamo Experiment provide details of the inductive response of a turbulent flow of liquid sodium to an applied magnetic field. The magnetic field structure is reconstructed from both internal and external measurements. A mean toroidal magnetic field is induced by the flow when an axial field is applied, thereby demonstrating the Omega Effect. Poloidal magnetic flux is expelled from the fluid by the poloidal flow. Small-scale magnetic field structures are generated by turbulence in the flow. The resulting magnetic power spectrum exhibits a power-law scaling consistent with the equipartition of the magnetic field with a turbulent velocity field. The magnetic power spectrum has an apparent knee at the resistive dissipation scale. Large-scale eddies in the flow cause significant changes to the instantaneous flow profile resulting in intermittent bursts of non-axisymmetric magnetic fields, demonstrating that the transition to a dynamo is not smooth for a turbulent flow.

14:30

C16 6 Measurements of the two-point correlation function in the ion phase-space FRED SKIFF, AHMED DIALLO, ILKER UZUN, *University of Iowa* We report measurements of the ion two-point correlation function in a magnetized plasma cylinder. Using a single frequency laser and two movable light-collection systems we measure the space, time, and particle velocity dependence of the two-point correlation function on the axis of a weakly- collisional magnetized plasma in a plasma cylinder where the main source of fluctuations is dissipative drift instability. Due to convection of waves out of the plasma volume, the collective fluctuations remain at low amplitude. In addition to the well known drift instability, we observe other collective effects in the two-point correlation that are anomalous. A kinetic component to the fluctuations, which exhibits a particle velocity dependent phase velocity, suggests plasma nonlinearity at low amplitude. Very quiet plasma discharges are made using a customized inductively coupled plasma source that operates continuously at low power (5W). Singly ionized Argon plasmas are produced with Te$\approx$ 2eV and Ti$\approx$ 0.1eV at a density near $10^9 cm^{-3}$. Each particle species exhibits a nearly Maxwellian velocity distribution function and the drift instabilities are at a relative density fluctuation of near 10%. The plasma discharge is stabilized and large data sets are taken to obtain 58 db of dynamic range on the correlation measurement.

14:42

C16 7 Search for Zonal Flow Associated with ITG Modes in CLM* AMIYA SEN, VLADIMIR SOKOLOV, XIAO WEI, *Columbia University* The basic physics transport experiments in the Columbia Linear Machine (CLM) have indicated inverse gyro-Bohm dependence of the ion thermal conductivity on the isotope mass. This paradox was explained by an unique 3-wave coupling of two ITG modes and an ion acoustic wave [1]. However, the competitive process of transport regulation via zonal flow [2] was not investigated. A series of basic experiments to detect any generation of zonal flow is now reported. Towards this end we have carefully examined the fine structure of the power spectrum and found two side bands with a shifts of about 3 kHz. An interpretation of this in terms of frequency modulation (FM) of ITG mode by a zonal flow appears plausible. Detailed cross correlation studies of two axially separated probes (one capacitive probe, the other ring probe) reveal two distinct modes (both m=0): one with $k_{//} \neq 0$, $\omega/2\pi \sim$ 2 to 10 kHz ion acoustic wave, and the other with $k_{//} = 0$, $\omega/2\pi \leqslant$ 5 kHz, possibly a zonal flow. A theory using reductive perturbation method has been developed for self coupling of ITG mode in conjunction with the 3- wave coupling of two ITG radial harmonics and an ion acoustic mode. The results agree with the experimental values within a factor of 2. [1] V. Sokolov and A. K. Sen, Phys. Rev. Lett, **92**, 165002 (2004). [2] P.H.Dimond, S.Champeaux, M.Malkov et al., Nucl. Fusion **41**, 1067 (2001).

*The research was supported by U.S. DOE Grant DE-FG02-98ER-54464.

14:54

C16 8 Linear Stability Analysis of Self-Similar Ablation Flows of ICF SERGE GAUTHIER, JEAN-MARIE CLARISSE, CARINE BOUDESOCQUE-DUBOIS, VIRGINIE LOMBARD, *CEA/ Bruyères-le-Châtel* The stability of an ablative flow is of crucial importance in inertial confinement fusion (ICF). In particular, laser imprinting on accelerated target determines the seeds for the acceleration phase Rayleigh-Taylor instability. We present the first analysis of the imprinting problem using a dynamic solution. We first exhibit a family of exact self-similar solutions of the gas dynamics equations with nonlinear heat conduction. Such self-similar solutions are representative of the early stage of the pellet ablation by a laser. A wide variety of ablation configurations may thus be obtained. Linear stability analyses of such time-dependent solutions are then performed by solving an initial and boundary value problem. These similar solutions and their 3D perturbations are computed using a highly accurate numerical method, namely an auto-adaptive multidomain Chebyshev spectral method.Various solutions may be studied, depending on the choice of initial conditions. Generally and by contrast with steady low Mach number models for ablation front, we obtain that: (a) maximum perturba-

tion amplitudes in the thin ablation layer are reached for transverse wavenumber k=0; (b) the growth and damping of ablation front perturbations are clearly related to thermal diffusion; (c) ablation front perturbations seem to persist although the transverse wave number increases.

SESSION D1: POSTER SESSION
Saturday Afternoon, 22 April 2006
Landmark Circle, 2:00pm–5:00pm, Hyatt Regency Dallas at 14:00

D1 1 GRAVITATION POSTERS

D1 2 Abstract Withdrawn.

D1 3 Unifying Gravity and EM in Detail DOUGLAS SWEETSER, Unify gravity and EM with the simplest asymmetric field strength tensor:

$$S_{GEM}=\int \sqrt{-g}d^4x\left(-(J_q^\nu-J_m^\nu)A_\nu-1/4c^2\nabla^\mu A^\nu\nabla_\mu A_\nu\right)$$

Particles with equal charges but different masses move differently, so mass charge breaks EM gauge symmetry. The field equations arise by varying the action with respect to the 4-potential, the metric is fixed up to a diffeomorphism

$$J_q^\nu-J_m^\nu=\nabla_\mu\nabla^\mu A^\nu$$

With a constant potential, the exponential Rosen metric solves the field equations consistent with current tests of gravity, but predicts 0.7 μarcseconds more bending around the Sun than the Schwarzschild metric of GR. All supporting calculations are done in detail.

D1 4 Nuclear Quantum Gravitation and General Relativity Compared RONALD KOTAS, *Grand Quantum Research* Nuclear Quantum Gravitation has 18 proofs and indications with a reasonable, non-fallacious explanation stating Gravity and Gravitation are electromagnetic and alternating, functioning in nuclei and alternating electromagnetic coupling between nuclei and other nuclei in other masses. This is according to Maxwell, Quantum, and Newtonian Laws. Nuclear Quantum Gravitation passes the Cavendish test. With the 18 proofs and indications of NQG it is clear that Gravity and Gravitation are electromagnetic and thoroughly explained by the Nuclear Quantum Gravitation theory. In comparison, General Relativity pictures mass somehow effects ''Time-Space'' about the mass, producing gravity about that mass. This is not described as an electromagnetic effect, but as a geometric function; the changing of geometry about mass. GR lists as a proof the bending of light in the area near the Sun. However, recently it was observed that the temperature of the Sun's corona is in the millions of degrees, and thus the bending of light and other electromagnetic radiation is caused by the refraction effects of the corona and heliosphere; NOT GR. The other ''proofs'' of GR are not definitive, and no one has yet explained the ''somehow'' of GR. General Relativity fails the Cavendish experiment and cannot account for the attractions between masses. It should be realized that Nuclear Quantum Gravitation provides a coherent, factual, scientific and direct physical explanation of Gravity and Gravitation thus Unifying the Physical Forces.

D1 5 A Model for an Object Created HYEOK-JE JEONG, *Hynix Semiconductor Inc.* Before going into the model treated here, it is need to know the nature of energy. Energy itself is active and constantly move. This fact results in the phenomenon of energy spread. The phenomenon of energy spread is under the law of energy conservation. For confining energy, additional energy is required. Suppose there were gathered energies for some reason. Creation of some objects is the result of the gathered energy and energy spread. In the case where a new object is more stable, after some fluctuation, energy from the object goes away so that a new object remains behind. For this, the enegy, E, larger than the sum of energy barrier, Eb, and the difference between the energy state of the object and initial energy state, dE, is required. E > Eb+dE Thus, a new object is created. It is an irreversable process. Adaptation is a sort of creation with no energy barrier. In the case where there is no energy source near the object. The created object is relatively inactive one. This is matter. To reduce the increased energy state due to gravitation, matters gather. In the case where there is an energy source near matters. A new object can be created around or within the matters. The created object will be active. This is life.

D1 6 Indirect determination of conservative self forces and orbital evolution LIOR M. BURKO, *University of Alabama in Huntsville* We compare the corrections to Kepler's law with orbital evolution under a self force, and find the finite, already regularized part of the latter in a specific gauge. We apply this method to a quasi-circular orbit around a Schwarzchild black hole for an extreme mass ratio binary, and determine the first- and second-order gravitational self force in a post Newtonian expansion. Specifically, we find the part of the self-force that is quadratic in the mass ratio to 2PN order, and the part that is cubic in the mass ratio to 1PN (including the Newtonian self force for either order of the self force). Next, we use these results to compute the orbital evolution including both dissipation and the PN conservative self force, and find the gravitational wave forms. Finally, we include spin-orbit coupling, and find that the orbit-integrated conservative spin effects are comparable in magnitude to the conservative self force effects on the waveforms, even though the leading post Newtonian order of the former (1.5PN) is higher than that of the latter.

D1 7 A Newtonian Description of the Time Delay of Radar Echoes from Venus ALAN MARTINEZ, GARY HUNTER, JAMES ESPINOSA, *University of West Georgia* After World War II, the advent of powerful radar transmitters made possible a fourth test of Einstein's General Theory of Relativity. I. Shapiro and his research group bounced radar waves off Venus when it was located at its superior conjunction; they found a time delay of 240 μsec compared to the expected Newtonian result. We have developed a modified Newtonian law of gravity that correctly ac-

counts for the classical tests of GR, as well as the time delay. We will show how our result should be interpreted as the bending of the light ray in Euclidean space and the slowing down of the speed of light near the surface of the Sun.

D1 8 Newtonian Radiation GARY HUNTER, ALAN MARTINEZ, JAMES ESPINOSA, *University of West Georgia* Einstein suggested three possible tests of his Theory of General Relativity: 1) bending of starlight by the Sun, 2) precession of Mercury's orbit, and 3) gravitational redshift of spectra. Experimental and observational results of these tests are in excellent agreement with GR. With the advent of alternative gravitational theories such as the Brans-Dicke model, other tests have been suggested including the Nordtvedt effect. We reinterpreted the three classical tests of Einstein and the Nordtvedt effect completely within the framework of Newtonian physics. We formulated a law of gravity that assumes this force travels at the speed of light and, when combined with Newton's second law, arrived at results identical to those of Einstein's theory: an angle of precession of 43.1 ''for the orbit of Mercury, a deflection angle of 1.75'' arc seconds for light passing near the Sun, a gravitational redshift of 2.5×10^{-15} for the Pound-Rebka experiment, and a null result for the Nordtvedt effect. We apply this modified law of gravity to a binary system and compare our results to those of General Relativity. The amount of radiation predicted by our theory agrees with GR but differs in its polarization.

D1 9 Order in Gravitation Potentially Linked to Evolution SHANTILAL GORADIA, *Gravity Research Institute, Inc.* Darwin, in the concluding remark of his text, On the Origin of Species (1859), referred to ''the fixed law of gravity,'' which implies an assumption that the gravitational constant and the Newtonian the inverse square logic are potentially fixed. Therefore, they cannot influence evolution. My substantiation of the Dirac's Large Number Hypothesis (LNH) (In version 1 of http://www.arXiv.org/pdf/physics/0210040) predicting the decreasing value of gravitational constant theorizes that all coupling constants are increasing with time. This is also backed by the recent observations. Consequently, it is logical that the orderly increase of coupling constants imparts an orderly influence on mutations assumed uninfluenced otherwise. This orderly influence is unidirectional, clearly in the direction of increasing intelligence, looking at the evolutionary history, whether or not in the sense of a religion. On the horizon, I see that the order in gravitation is linked to the order in entropy as well.

D1 10 General Relativistic Aspects of the Electron JOSEPH D. RUDMIN, *James Madison University* Some thoughts and calculations are presented involving the Gravitational Stress Energy Tensor, with implications for black holes, electromagnetic fields, and unification theories.

D1 11 Abstract not Available.

D1 12 Derivation of the cosmological constant from the physics of neutrino oscillations ERVIN GOLDFAIN, *OptiSolve Consulting* Neutrinos are the lightest known leptons in the Universe. We start from the hypothesis that neutrinos are the predominant contributor to the cosmological vacuum and their oscillations are the sole detectable evidence for vacuum fluctuations on the cosmic scale. Let $\Delta m_{12}^2 = m_1^2 - m_2^2$ represent the difference in mass squares for two consecutive neutrino mass eigenstates. Considering that there is roughly one quasi-particle of mass Δm_{12} per each Compton wavelength cubed ($\lambda_c^3 \sim \Delta m_{12}^{-3}$), the quantum expectation value of the vacuum density is given by

$$\rho_{vac} \approx 10^{13} ({}^{0.7}\Delta m_{12} / {}_{0.7} m_{proton})^4 (g/cc)$$

Inserting the upper bounds on Δm_{12} from neutrino physics experiments ($\Delta m_{12,sol}^2 < 9.5 \times 10^{-5} eV^2$, $\Delta m_{12,atm}^2 < 4.8 \times 10^{-3} eV^2$), we derive

$$\rho_{vac,sol} < 1.165 \times 10^{-31} (g/cc)$$

$$\rho_{vac,atm} < 2.973 \times 10^{-28} (g/cc)$$

These predictions agree well with recent supernova results [$\rho_{vac} < 6 \times 10^{-30} (g/cc)$] and latest astrophysical data that place the ''observed'' cosmological constant at ${}^{0.7}\Lambda / {}_{0.7} 8\pi G \approx (2 \times 10^{-3} eV)^4$.

D1 13 UNDERGRADUATE RESEARCH POSTERS

D1 14 Chaotic Ionization of Excited Hydrogen Atoms Near a Metal Surface* CHRIS CROWE,† ROBERT HAUSSMAN,‡ SHAYNE JOHNSTON, *Oklahoma School of Science and Mathematics* A previously published analysis of classical chaos in hydrogen atoms located near a conducting wall [N.S. Simonovic, At. Mol. Opt. Phys. 30, L613 (1997)] is extended in two directions. First, a more realistic model for the metal surface potential is used, the potential being finite rather than infinite at the wall. Second, the presence of chaos is investigated by direct numerical evaluation of the electron trajectories rather than indirectly through interpretation of the electron Hamiltonian. A chaotic dependence of the wall capture time on the initial ejection angle from the nucleus is demonstrated under certain conditions, and the critical atom-surface distance for such chaotic ionization to occur is derived.

*Work supported by Research Corporation.
†Present address: University of Oklahoma.
‡Present address: MIT.

D1 15 Denoising of Nondestructive Examination Data Using Wavelet, Maximum Entropy, and Limited Differential Methods* NICK ECKENSTEIN,† JORDAN JOHNSTON,‡ SHAYNE JOHNSTON, *Oklahoma School of Science and Mathematics* AARON DIAZ, *Pacific Northwest National Laboratory* A simple and original denoising method, the ''limited differential method,'' has been developed. The algorithm is based on iterated local-pixel-averaging, and is very effective for large-amplitude speckled noise on a smoother background signal. For noise of this type, tests on both noisy two- dimensional images and noisy ultrasonic-scattering data volumes clearly demonstrate the superiority of the method relative to three more complicated standard methods: Fourier processing, wavelet denoising, and maximum-entropy reconstruction.

*Work supported by Research Corporation.
†Present address: Rice University.
‡Present address: University of Oklahoma.

D1 16 PLASMA PHYSICS: BASIC, LASER AND NON-NEUTRAL PLASMA POSTERS

D1 17 Undulator Induced Transparency in Magnetized Plasma: Microwave pulse compression and power switching MIKHAIL TUSHENTSOV, GENNADY SHVETS, *The University of Texas at Austin* Numerical modeling of a plasma-microwave interaction in the Undulator Induced Transparency (UIT) regime is presented. UIT is a phenomenon originating from the coupling between the transverse and the longitudinal electromagnetic waves (EM) in a magnetized plasma in the presence of a static helical magnetic undulator, which eliminates the absorption of an EM wave at the cyclotron frequency. This coupling yields ultra-slow hybrid EM waves with a group velocity substantially less than the speed of light in vacuum, causing extreme compression of the wave energy in the UIT plasma. Direct application of UIT to electron and ion acceleration is suitable because the polarization of the compressed waves is primarily longitudinal and their phase velocity is controllable by the undulator period. We are also envisioning a microwave pulse compressor in the plasma based on rapid change of plasma or undulator parameters. In the specific range of parameters the UIT medium exhibits a peculiar phenomenon where the wave with the slow group velocity is accompanied by the one with negative group velocity. The analytical model of the EM wave propagation in the inhomogeneous UIT medium (plasma column in the combined axial and undulator magnetic field) based on the vector WKB theory and amplitude scattering matrix description is developed and agrees well with the numerical modeling results.

D1 18 Results of magnetoactive laser produced plasma investigations VADIM BELYAEV, *CRIMB RFSA* Lifetime of the magnetic field generated in laser plasma is demonstrated to far exceed the laser-producing pulse duration. The theory of the pinch effect in laser plasma gains its development. The increase in density and temperature at pinching, as well as the long life of the magnetic field confining the hot plasma, are demonstrated to provide a possibility for the Lowson criterion of Break-even thermonuclear reaction to be realized in laser plasma. Here we offer our explanation of the dependence of the neutron yield from D-D fusion reactions on the laser radiation intensity and energy for the pico- and femtosecond laser pulse. With our laser plant, up to 2×10^{18} W/cm^2 intensity, we investigated the D-D fusion reaction neutron yield (up to 10^6 per a pulse). We also implemented $p + {}^{11}B \rightarrow 3\alpha + 8.7$ MeV reaction to investigate the α-particle yield (up to 10^3 per a pulse) and spectral response. Further, we measured the plasma ion energy (temperature) distribution and noted the presence of a small group within the energy range of $\sim$ 1 MeV. We also noted a high-energy ion stream directed inward the target and here we suggest the mechanism of the movement of the sort. When investigating $\gamma + {}^{9}Be \rightarrow 2\alpha + n$ reaction, we registered neutron yield of $\sim 3 \div 7$ per a pulse, estimated the share of the electrons and γ-quanta which occur in laser plasma with the energy of $\geqslant$ 2 MeV and are responsible for the implementation of this reaction.

D1 19 Partially Neutralized Plasmas in Penning Traps* CARLOS ORDONEZ, *University of North Texas* Plasma confinement configurations involving partially neutralized plasmas in Penning traps have been identified recently [C. A. Ordonez, Phys. Rev. E **67**, 046401 (2003); C. A. Ordonez, J. Appl. Phys. **94**, 3732 (2003)]. The configurations are intriguing in that a plasma species is confined electrostatically as one component of a partially neutralized plasma. For example, an ion plasma can be confined within a three-dimensional electric potential well. As a result, the ion density is not limited by the severe ion density limit that normally occurs in Penning traps. For confinement of low-charge-state ions, the ion temperature must be smaller than the electron temperature. However, relatively long ion confinement times have been found to be possible because the equilibration of the ion temperature and the electron temperature is a slow collisional process due to the disparate masses involved. An overview of recent progress in developing an understanding of the confinement physics associated with the configurations is presented.

*This material is based upon work supported by the National Science Foundation.

D1 20 Cross-Magnetic-Field Diffusion Due To Quasibound State Formation* YASIN AHAT, CARLOS ORDONEZ, *University of North Texas* Classical trajectory simulations indicate that quasibound states of hydrogen (or antihydrogen) can form in low density magnetized plasmas [C. E. Correa, J. R. Correa, and C. A. Ordonez, Phys. Rev. E **72**, 046406 (2003)]. Such quasibound states form at positive energies, where the energy of the two-particle system is defined to be zero when the electron and proton are at rest with infinite separation. The formation of quasibound states may affect the rate of diffusion of electrons across a magnetic field. Electron diffusion transverse to a magnetic field occurs, in part, because the guiding center position of an electron shifts with each binary interaction between an electron and a proton. The shift associated with a single binary interaction is normally not larger than a typical cyclotron radius. However, simulations indicate that a binary interaction that results in the formation of a quasibound state can cause a shift of the electron guiding center that is much larger than the cyclotron radius before the interaction. An assessment of the effect that the formation of quasibound states may have on electron cross-field diffusion is presented.

*This material is based upon work supported by the National Science Foundation.

D1 21 Multicomponent WKB and Path Integrals A. S. RICHARDSON, E. R. TRACY, *Physics Dept, College of William and Mary* N. ZOBIN, *Dept of Mathematics, College of William and Mary* A. N. KAUFMAN, *Physics Dept, UC Berkeley and LBNL* By examining path integral methods for multicomponent wave equations in the presence of localized resonances, we are led to a new approach to multicomponent WKB. We are pursuing a new formalism, developed by N. Zobin, which should make it easier to identify uncoupled dispersion functions and polarizations, even in complicated geometry. As an example, a toroidally symmetric plasma is studied using a cold plasma model similar to that used in [1]. [1] A. N. Kaufman, E. R. Tracy, and A. J. Brizard, "Helical rays in two-dimensional resonant wave conversion," Phys. Plasma **12**, 022101 (2005).

D1 22 Hamiltonian Closure and Symmetry P.J. MORRISON,* *Physics Department and IFS, University of Texas at Austin* C.S. JONES, *Los Alamos National Laboratory* To obtain fluid theories from kinetic theories requires some kind of closure. Closure can be approximate, as is the case for asymptotic expansions of kinetic

theories with collision operators, or can be exact, as is the case for water bags and its generalizations. Collisionless kinetic theories are Hamiltonian and, consequently, this must also be the case for fluid equations obtained by exact closure. A procedure for obtaining exact Hamiltonian closure to all orders will be presented. Also, the manner in which symmetries of kinetic theory induce symmetries of fluid theory will be discussed, in both the exact and approximated contexts.

*Supported by the U.S. Department of Energy under contract no. DE-FG03-96ER-54346.

D1 23 Nonlinear Wave-Wave Interactions in Ion Density Fluctuations Spectrum ILKER UZUN-KAYMAK, FRED SKIFF, *University of Iowa* For the phase-space resolved measurements of ion density fluctuations obtained by using Laser Induced Flouresecence (LIF) diagnostics, nonlinear three-wave interactions are investigated via bispectrum and higher order spectral analysis methods. Previously, it has been observed that the fluctuation spectrum has a distinctive broad peak near the drift wave frequency (ω^*) that can be dissected into two components in terms of their wavelength and ion particle velocity dependence.[1] Even though, one of these components is consistent with drift wave theory, the other has a short correlation length and ion particle velocity dependence, thereby, it is called "kinetic component." Opposed to what would be expected for a single broad spectrum, in higher order spectral calculations, nonlinear three wave interactions are observed for these spectral components satisfying resonance conditions. As the neutral pressure thus the ion-neutral collision frequency increase, we observe a certain threshold where the kinetic component vanishes from the cross power spectrum, in return, a new peak arises at the vicinity of second harmonic of ω^*. Meanwhile, the bispectrum analysis proves us that the bispectral signature for these components also changes accordingly. One explanation for these spectral changes can be given in terms of modulation instability. This work is supported by U.S. DOE Grant No. DEFG02-99ER54543. [1] A. Diallo, F. Skiff, Phys. Plasmas, **12**(11), 110701 (2005).

D1 24 Investigation of nonlinear kinetic effects induced by weak turbulencein Vlasov-Maxwell simulations of Backward Stimulated Raman Scattering A. GHIZZO, *LPMIA UMR 7040 UHP Nancy France* M. ALBRECHT-MARC, *LPMIA* T. W. JOHNSTON, *INRS Energie et Materiaux Quebec* T. REVEILLE, *LPMIA* P. BERTRAND, *LPMIA* B. AFEYAN, *Polymath Research Inc, Pleasanton CA* We report here our recent results from semi-lagrangian Vlasov-Maxwell simulations which have been performed for homogeneous or inhomogeneous (parabolic) profiles over a long time. A major role is played by the conventional Backward Stimulated Raman Scattering (B-SRS) for only a short time, after what trapping effects induce a new kinetic regime dominated by self-organized and self-sustained phase space holes induced by EPW vortex merging and similar to Bernstein-Greene-Kruskal (BGK) equilibria. Optical mixing was considered in simulations that means the start of the instability (B-SRS) was controlled by the injection of a low-amplitude electromagnetic probe allowing by the noiseless character of the Vlasov code. A new parametric interaction mechanism was observed involving the scattering off of the probe light by BGK-like structures. These results shows also that the fluid-like behavior at early times of simulation becomes afterwards fully kinetic, invalidating a fluid approach based on a usual three-wave model in this regime.

D1 25 PLASMA PHYSICS: SPACE AND ASTROPHYSICAL PLASMA POSTERS

D1 26 Origin of Rotating Ring Structures in the Strong Gravity of a Central Object* B. COPPI, *MIT* The origin of plasma rotating ring structures forming around a central object whose gravity is prevalent has been identified [1] through the analysis of thin equilibrium configurations that are immersed in a relatively weak external magnetic field and can carry internal toroidal currents. Unlike the case of the "classical" gaseous disk, in which the vertical equilibrium is maintained only by gravity, rings are maintained vertically by the Lorentz force and radially by gravity. The differential rotation is the sustaining factor of these ring structures and of the jets that may emerge from them. The rings are connected with the formation of a periodic sequence [2] of Field Reverse Configurations of the poloidal magnetic field, consisting of pairs of counter-streaming toroidal current channels. In magnetic field configurations that have been considered previously for accretion disks the magnetic field diffusion was assumed to be such that the Ferraro isorotation condition was not valid, while in our case it has a primary role. The relevant equilibria are not described by the Grad-Shafranov equation but by two non-linear coupled equations that have been solved analytically. These provide both the plasma pressure function and the magnetic surface function once a consistent plasma density function is chosen within a relatively narrow class. A two-fluid description of the same equilibria is given differentiating the relative roles of electrons and ions. [1] B. Coppi and F. Rousseau, to appear in Ap. J., April (2006). [2] B. Coppi, Phys. of Plasmas, **12**, 057302 (2005).

*Sponsored in part by the U.S.D.O.E.

D1 27 Bifurcation Model for the Onset of Fast Magnetic Reconnection PAUL CASSAK, JAMES DRAKE, *University of Maryland-College Park* MICHAEL SHAY, *University of Delaware* BRUNO ECKHARDT, *Phillipps-Universität Marburg* The mechanism triggering the onset of fast magnetic reconnection, the driver of solar eruptions and fusion device disruptions, has long been elusive. A catastrophe model for the explosive onset of fast magnetic reconnection has been proposed[1]. The crux of the model is that both the Sweet-Parker and Hall reconnection solutions are valid when the Sweet-Parker current sheet is thicker than the ion inertial length d_i, but the Sweet-Parker solution disappears catastrophically when the layer thins below d_i. Simulations confirm that the thinning of the current sheet occurs naturally during reconnection as convection increases the magnetic field just upstream of the dissipation region, eventually leading to explosive onset. We interpret the disappearance of the Sweet-Parker solution as a saddle-node bifurcation and confirm its signatures with simulations. Earlier numerical results have been extended to include a guide field. We explore the model's potential impact on the explosive onset of magnetic reconnection in solar eruptions and sawtooth crashes.

[1]P. A. Cassak, M. A. Shay, and J. F. Drake, Phys. Rev. Lett., 95, 235002 (2005).

D1 28 The Vlasov-Einstein System* T. OKABE, P.J. MORRISON, *Physics Department and IFS, University of Texas at Austin* It is well-known that the Vlasov-Poisson system describes Newtonian self-gravitating matter, a usage that predates that of plasma physics. For strong interaction, general relativistic effects

become important, and thus it is natural to consider the Vlasov-Einstein system, which is of interest because the matter field is more realistic than commonly used dust or perfect fluid models. New results on equilibria, stability, and nonlinear reductions will be discussed for this model in spherical symmetry, both with and without the cosmological constant.

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D1 29 Non-axisymmetric three-dimensional modes in differentially rotating thin disks and rings* CHRIS CRABTREE, BRUNO COPPI, *MIT* In the literature of the theory of differentially rotating magnetized plasmas around celestial objects whose gravity is prevalent, there are several approximations that are often invoked. Namely, 1) that the perturbation is symmetric about the axis of rotation, 2) that the plasma beta (the ratio of thermal energy density to magnetic energy density) is very high, and 3) that the fluid motion is incompressible. When axisymmetry is abandoned there are singularities where: 1) the Doppler shifted frequency of the mode corresponds to the frequency of the ''slow'' magnetosonic mode [1], which would be eliminated by the third assumption above, and 2) where the Doppler shifted mode frequency corresponds to the shear Alfven frequency. Because of several arguments including Cowling's theorem [2], which states that magnetic field dynamo generation cannot occur in two-dimensional motions, the non-axisymmetric three-dimensional modes [1] must be confronted. In addition, it is also reasonable to assume that the plasma beta cannot be large in disks from which jets emerge. In this work an attempt is made to consider three-dimensional modes (as were considered in Ref. [1]) for equilibrium configurations that have substantial toroidal currents. [1] B. Coppi & P. S. Coppi, Ann. of Phys. **291**, 134 (2001). [2] T. G. Cowling, MNRAS **94**, 39 (1933).

*Supported in part by U.S.D.O.E.

D1 30 Global Magneto-Rotational Instability (MRI) in Hall MHD JESSE PINO,* SWADESH MAHAJAN, *IFS, U. Texas at Austin* VINOD KRISHAN, *Graduate School of Frontier Sciences, The University of Tokyo* PARVEZ GUZDAR, *U. Maryland* We derive the radial eigenmode equation for the linear (thin accretion disk) MRI within the framework of Hall Magnetohydrodynamics (HMHD). Eigenmodes are computed with a finite-differencing method, and the stability of these are compared to global MHD modes as well as the local approximation. In both MHD and HMHD the local analysis can give misleading conditions for instability as well as for the scaling of the frequency. In general the Hall current is stabilizing, however, parameter regimes exist where the Hall current can have a destabilizing effect.

*USDOE/ORISE FES Fellow.

D1 31 Plasma (Accretion) Disks with High Magnetic Energy Densities* F. ROUSSEAU, *E.N.S., Paris* B. COPPI, ''Corrugated'' plasma disks[1] can form in the dominant gravity of a central object when the peak plasma pressure in the disk is of the same order as that of the pressure of the ''external'' magnetic field, while the magnetic field resulting from internal plasma currents is of the same order as the external field. The corrugation refers to a periodic variation of the plasma density in a region around the equatorial plane. The considered structure represents a transition between a ''classical'' accretion disk and a ''rings sequence'' configuration.[2] The common feature of the ''corrugated'' and the ''rings sequence'' configurations is the ''crystal'' structure[2] of the magnetic surfaces that consist of a sequence of pairs of oppositely directed toroidal current density filaments. The connection between the characteristics of these configurations and those of the marginally stable ballooning modes that can be found in a model accretion disk[3] is pointed out and analyzed.

*Sponsored in part by the U.S. D.O.E.

[1]B. Coppi and F. Rousseau, to be published in Astroph. J., April 2006.
[2]B. Coppi, Phys. Plasmas **12**, 057302 (2005).
[3]B. Coppi and P.S. Coppi, Phys. Rev. Letters **87**, 051101 (2001).

D1 32 Magnetic reconnection in nontoroidal plasmas* ALLEN BOOZER, *Columbia University* Magnetic reconnection in solar and astrophysical plasmas differs fundamentally from the formation of magnetic islands that is characteristic of reconnection in toroidal plasmas. At any instant a generic magnetic field has only point nulls, which can be shown to imply that the evolution of a generic field is consistent, near each spatial point, with being embedded in a perfectly conducting fluid [Phys. Rev. Lett. **88**, 215005 (2002)]. This result implies, in doubly periodic systems, that the nonideal evolution of the magnetic field lines is localized to surfaces on which the magnetic field lines close on themselves, the rational surfaces. That is, the rational surfaces split to form magnetic islands. Rational surfaces are not a credible explanation for reconnection in non-laboratory plasmas-different mechanisms are required. We have shown [Phys. Plasmas **12**, 070706, (2005)] that the exponentially increasing separation of neighboring magnetic field lines, which is generic, tends to produce rapid magnetic reconnection if the length of the field lines is greater than about 20 times the exponentiation, or Lyapunov, length. This derivation and the importance of this result will be discussed.

*Work supported by Grant No. DE-FG02-95ER54333.

D1 33 Kink Stability of MHD Equilibria with Line Tying EVSTATI EVSTATIEV, GIAN LUCA DELZANNO, JOHN FINN, GIOVANNI LAPENTA, *LANL* We have studied the line-tied kink stability of cylindrical equilibria for applications to solar loops and flux core spheromak formation. Our semi-analytic formulation allows in principle for plasmas or arbitrary length and arbitrary current density profiles; it involves expansion in a series of basis function which are radial eigenfunctions, some with real k_z and some for which k_z is complex. The boundary conditions are applied on a set of radial grid points at the ends, or alternatively integrating over selected distributed basis functions. The dispersion relation is found from the determinant of the resulting matrix. For most cases, the matrix becomes prohibitively stiff for even a moderate number of basis functions. We have modified the process so that the boundary conditions at the ends overdetermine the basis function coefcients, and we therefore satisfy the boundary conditions in a least squares sense. The effectiveness of this approach will be discussed. We also show nonlinear simulations, leading to a nonlinearly saturated kink with topological changes due to magnetic reconnection. Results with stabilization due to hollow pressure profile, possibly related to collimation of astrophysical jets, will be shown.

D1 34 Shearing Box Simulations of the MRI in a Collisionless Plasma P. SHARMA, G.W. HAMMETT, *Princeton Plasma*

Physics Lab E. QUATAERT, *Berkeley* J.M. STONE, *Princeton University* We describe local shearing box simulations of turbulence driven by the magnetorotational instability (MRI) in a collisionless plasma. Collisionless effects may be important in radiatively inefficient accretion flows, such as near the black hole in the Galactic Center. The MHD version of ZEUS is modified to evolve an anisotropic pressure tensor. A fluid closure approximation is used to calculate heat conduction along magnetic field lines. The anisotropic pressure tensor provides a qualitatively new mechanism for transporting angular momentum in accretion flows (in addition to the Maxwell and Reynolds stresses). We estimate limits on the pressure anisotropy due to pitch angle scattering by kinetic instabilities. Such instabilities provide an effective ''collision'' rate in a collisionless plasma and lead to more MHD-like dynamics. We find that the MRI leads to efficient growth of the magnetic field in a collisionless plasma, with saturation amplitudes comparable to those in MHD. In the saturated state, the anisotropic stress is comparable to the Maxwell stress, implying that the rate of angular momentum transport may be moderately enhanced in a collisionless plasma.

D1 35 A Fermi mechanism for the production of energetic electrons during magnetic reconnection J.F. DRAKE, *University of Maryland* M. SWISDAK, *Naval Research Laboratory* H. CHE, *University of Maryland* M.A. SHAY, *University of Delaware* The production of energetic electrons has been documented in observations of solar flares, magnetic reconnection in the Earth's magnetosphere and in laboratory fusion experiments yet the understanding of these widespread observations remains poor. Simulations reveal that magnetic reconnection with a guide field leads to the growth and dynamics of multiple magnetic islands rather than a single large x-line. Above a critical energy electron acceleration is dominated by the Fermi-like reflection of electrons within the resulting magnetic islands rather than by the parallel electric fields. Particles trapped within islands gain energy as they reflect from ends of contracting magnetic islands. A Fokker-Planck equation for the distribution of energetic particles similar to that developed in shock accelertion theory is obtained by averaging over the particle interaction with many islands. Steady state solutions in reconnection geometry result from convective losses balancing the Fermi drive. Distribution functions take the form of a powerlaw whose spectral index depends on the mean aspect-ratio of the islands. We show that the energy transfered to energetic electrons is linked to the magnetic energy released during reconnection. The model is consistent with several key solar and magnetospheric observations: the production of large numbers of energetic electrons and powerlaw distributions.

D1 36 Physics Modeling of Storms and Substorms with Solar Wind Data* M. LEILA MAYS, EDMUND SPENCER, WENDELL HORTON, ISIDOROS DOXAS, We construct analytic solar wind signals using data from ACE for the Wang et al. Oct. 3–6 2000 event in which a fast forward shock advanced into a preceding magnetic cloud. We examine the response of the WINDMI model, an eight dimensional model of the solar wind driven magnetosphere-ionosphere system, to our analytic signals for this event. The auroral magnetometer AL signal result from the model driven by the analytic solar wind dynamo voltage captures the 8 substorms in the main phase of the storm. The model mid-latitude magnetometer D_{st} signal used to quantify magnetospheric storms has the correct qualitative feature of a sharp rise for the expansion phase and a slower decay for the recovery phase. The role of the shock can be examined by using analytic signals in which the shock feature in the density, solar wind velocity, and magnetic field are tested individually. The shock near the end of the 42 hr magnetic cloud is shown to be largely responsible for the very large region 1 field aligned current surges associated with the $-AL > 1300$nT peaks at the end of the main phase of the storm. We are performing similar analysis to study the role of three fast forward shock events associated with halo CMEs during the April 15-24 2002 geomagnetic storm.

*The work is supported by NSF-ATM grant 0539099.

D1 37 Ideal $m = 1$ internal kink mode in line-tied screw pinch YI-MIN HUANG, *CMSO, University of Wisconsin, Madison* ELLEN G. ZWEIBEL, CARL R. SOVINEC, *University of Wisconsin, Madison* It is well known that the radial displacement of the $m = 1$ internal kink mode in a periodic screw pinch has a steep jump at the resonant surface where $\mathbf{k} \cdot \mathbf{B} = 0$. In a line-tied system, relevant to solar and astrophysical plasmas, the resonant surface is no longer a valid concept. It is then of interest to see how line-tying alters the result for a periodic system. If the line-tied kink also produces a steep gradient, it may lead to strong heating even with weak dissipation. Numerical solution of the eigenmode equations finds that the fastest growing kink mode in a line-tied system still possesses a jump in the radial displacement at the location coincident with the resonant surface of the fastest growing mode in the periodic counterpart. However, line-tying thickens the inner layer and reduces the growth rate. As the system length L approaches infinity, both the inner layer thickness and the growth rate approach the periodic values. In the limit of small $\epsilon \sim B_\phi/B_z$, the critical length for instability $L_c \sim 1/\epsilon^3$. The relative increase in the inner layer thickness due to line-tying scales as $(1/\epsilon)(L_c/L)^{2.5}$. The nonlinear equilibrium after the onset of the kink instability is of greater interest. Work is in progress to solve the new equilibrium by a magnetofrictional relaxation method. To avoid reconnection due to numerical resistivity, we take a Lagrangian approach formulated in Clebsch coordinates.

D1 38 Ideal and resistive Suydam-like modes driven by axial and poloidal flows in a cylinder* V.I. PARIEV, V.V. MIRNOV, S.C. PRAGER, *University of Wisconsin-Madison, Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas* Experimental observation of magnetorotational instability (MRI) in high temperature lab plasmas is difficult because the strong magnetic field suppresses the MRI. However, in the vicinity of rational surfaces with $k_\parallel = 0$ magnetic perturbations are small, allowing for excitation of the modes similar to MRI. They are driven by the flow shear and stabilized by the magnetic shear that determines strong radial localization of perturbations. We consider a plasma cylinder with helical magnetic field and two different flows: pure axial flow $u_z(r)$ and pure poloidal (rotational) flow $u_\theta(r) = r\Omega(r)$. We reduce marginal stability criteria [1] for the case of the large flow gradient and find that $u_\theta(r)$ can drive both a resonant compressible mode, if $r^2|d\Omega/dr| \simeq c_s$, and an MRI-like mode, if $r^2|d\Omega/dr| \simeq v_A$, while axial flow can generate only compressible instability, when $r|du_z/dr| \simeq c_s$ (the unstable band is very narrow). These results suggest that the instability from axial flow can possibly be observed in the Madison Symmetric Torus (MST) experiment if flow is driven (for example by biased electrodes). We also report results on resistive analog of this instability that becomes important if the flow is ideally stable. [1] A. Bondeson, R. Iacono, and A. Bhattacharjee, Phys. Fluids **30**(7), 2167 (1987).

*This work is supported by NSF and DOE.

D1 39 Ion heating and velocity fluctuation measurements in a high-temperature laboratory plasma D.A. ENNIS, D. CRAIG, D.J. DEN HARTOG, G. FIKSEL, S. GANGADHARA, S.C. PRAGER, *University of Wisconsin-Madison and the Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas* In many astrophysical and laboratory plasmas the magnetic field and plasma temperature are affected by magnetic fluctuations. In the Madison Symmetric Torus we study the redistribution of magnetic field by correlated velocity and magnetic field fluctuations (the MHD dynamo, $\langle v \times b \rangle$) and ion heating during magnetic reconnection. Emission from neutral beam-induced charge exchange recombination is collected by a high-throughput spectrometer yielding localized measurements of impurity ion temperature and velocity with high time resolution. We find poloidal velocity fluctuations correlated with magnetic fluctuations for a range of wavenumbers and the phase implies a contribution to the MHD dynamo. The correlation is greatest near resonant surfaces, where the wavenumber parallel to the magnetic field vanishes. During reconnection events, fluctuation amplitudes increase, the stored magnetic energy decreases, and strong ion heating is observed. The heating mechanism is unclear, but the increase in ion energy is comparable to the decrease in stored magnetic energy. Measurements of both bulk and impurity ions suggest the impurities are more strongly heated than the bulk and the heating source is global. Work supported by U.S.D.O.E. and N.S.F.

D1 40 Effects of line-tied boundary conditions on internal current-driven kink mode* V.V. MIRNOV, C.B. FOREST, C.C. HEGNA, *University of Wisconsin and Center for Magnetic Self-Organization in Lab and Astrophysical Plasmas* MHD kink instabilities caused by current passing though high temperature plasma in magnetic field is a topic of importance to astrophysical and lab plasmas. Recent theoretical study of external kink mode stability in line-tied geometry [1] has shown the existence of complex axial wave numbers k_z in spatial spectrum of the system. Similar to the external kink mode complex k_z were found in numerical calculations performed at LANL for line-tied internal kink instability. We are developing an analytical model for internal mode in line-tied cylindrical geometry to follow transition from the case of periodic cylinder where all axial wave numbers are real to line-tied boundary conditions (BC). The model allows us to determine whether line-tying BC change axial modes globally or their effect is ''shielded'' in long systems in the vicinity of the end-plates. This is important for mode structure and, specifically, for perturbed current profile (''current sheet'') which is localized on the resonance surface in periodic case and is broadened due to superposition of ''quasi-resonances'' in line-tied geometry. [1] V.V. Mirnov et al., Bull. of the APS, **50**(8), p. 238, DPP Meeting, Oct. 24–28, 2005.

*The work is supported by NSF and DOE.

D1 41 NIMROD Simulations of Reconnection in MRX and SSX NICHOLAS MURPHY, CARL SOVINEC, *University of Wisconsin* Two-fluid effects are known to influence magnetic reconnection rates through non-MHD communication between the reconnection layer and surrounding magnetic field topology [1]. To examine the interrelationship between the local reconnection physics and the global magnetic field arrangement, we perform simulations of the Magnetic Reconnection Experiment (MRX) and the Swarthmore Spheromak Experiment (SSX) using the NIMROD extended MHD code. The presence of dual flux cores makes the grid of MRX nontrivial, and the steps to account for a logically non-rectangular grid in NIMROD are outlined. For MRX, we show simulations of co- and counter-helicity push and pull reconnection and discuss the characteristics of the reconnection sheet. For SSX, we show simulations of reconnection during counter-helicity spheromak merging. We compare single-fluid and two-fluid simulations to gauge the importance of two-fluid effects. These results are compared to the recent detection of the quadrupole field resulting from two-fluid collisionless reconnection in both SSX [2] and MRX [3]. 1. Biskamp, Schwarz, and Drake, Phys. Plasmas 4, 1002 (1997). 2. Matthaeus, Cothran, Landreman, and Brown, Geophys. Rev. Lett. **32** (2005). 3. Ren, Yamada, Gerhardt, Ji, Kulsrud, and Kuritsyn, Phys. Rev. Lett. **95** (2005).

D1 42 Study of Magnetorotational Instability and Hydrodynamic Stability at Large Reynolds Numbers in a Short Couette Flow* HANTAO JI, *Princeton University* MICHAEL BURIN, ETHAN SCHARTMAN, JEREMY GOODMAN, WEI LIU, Rapid angular momentum transport in accretion disks has been a longstanding astrophysical puzzle. Molecular viscosity is inadequate to explain observationally inferred accretion rates. Since Keplerian flow profiles are linearly stable in hydrodynamics, there exist only two viable mechanisms for the required turbulence: nonlinear hydrodynamic instability or magnetorotational instability (MRI). The latter is regarded as a dominant mechanism for rapid angular momentum transport in hot accretion disks ranging from quasars and X-ray binaries to cataclysmic variables. The former has been proposed mainly for colder protoplanetary disks, whose Reynolds numbers are typically large. Despite their popularity, however, both candidate mechanisms have been rarely demonstrated and studied in the laboratory. In this paper, I will describe a laboratory experiment in a short Taylor-Couette flow geometry intended for such purposes. Based on the results from prototype experiments and simulations, the apparatus containing novel features for better controls of the boundary-driven secondary flows has been constructed. Initial results on hydrodynamic stability have shown, somewhat surprisingly, robust quiescence of the Keplerian-like flows with million Reynolds numbers, casting questions on viability of the nonlinear hydrodynamic instability.

*This project is supported by DoE, NSF, and NASA.

D1 43 Diagnostics of Weibel Turbulence by Anisotropic Radiation Spectra* SARAH REYNOLDS, MIKHAIL MEDVEDEV, *University of Kansas* It has recently been realized that the Weibel instability plays a major role in the formation and dynamics of astrophysical shocks of gamma-ray bursts and supernovae. Thanks to technological advances in the recent years, experimental studies of the Weibel instability are now possible in laser-plasma interaction devices. We, thus, have a unique opportunity to model and study astrophysical conditions in laboratory experiments – a key goal of the Laboratory Astrophysics program. At this stage, accurate diagnostic techniques are of great demand. In this presentation, we will discuss the properties of radiation emitted by electrons (e.g., an electron beam) moving through the Weibel-generated magnetic fields, referred to as the jitter radiation. We'll demonstrate that the jitter radiation field is anisotropic with respect to the direction of the Weibel current filaments and

that its spectral and polarization characteristics are determined by microphysical plasma parameters. We stress that the spectral analysis will provide accurate diagnostics of the plasma conditions in laboratory experiments and in astrophysical shocks.

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D1 44 Current Sheet Formation Near a Hyperbolic Magnetic Neutral Line in a Variable Density Plasma BHIMSEN SHIVAMOGGI, DAVID ROLLINS, *University of Central Florida* itCurrent-sheet formation near a ithyperbolic magnetic neutral line has been investigated by including the effects of sweeping and shearing of the magnetic field lines by the plasma flow and itexact solutions of the MHD equations appropriate for these situations were given by Shivamoggi [1], [2]. The itcurrent-sheet evolution described by this solution is in agreement with laboratory experiments (Kirii *et al.* [3]). For the case with no itshearing of the field lines, this solution exhibits a itfinite-time singularity. The itshearing of the magnetic field lines tends to itimpede the itcurrent-sheet formation. Investigation of the itintegrability aspects of the system of nonlinearly-coupled differential equations governing these dynamics has been made (Rollins and Shivamoggi [4]) which indicated the possibility of shear-induced chaotic evolution in the dynamical system in question. The investigation is extended to include the effects of density variation of the plasma (Shivamoggi and Rollins [5]). The itcurrent-sheet formation process is found to itspeed up in the presence of a plasma density itbuild-up near the current sheet in agreement with the numerical simulation of Brunnel et al. [6] which described an enhanced reconnected magnetic flux when there is plasma density build up near the magnetic neutral point. This plasma density itbuild-up produces a new itfinite-time singularity in the itvariable-density MHD solution.

D1 45 COMPUTATIONAL PHYSICS POSTERS

D1 46 Mapping Phase Boundaries of 3-Component Model Membrane by Monte Carlo Simulation M.R. ALI, J. HUANG, *Physics Department, Texas Tech University* Three-component model membrane constituted of two phospholipids and cholesterol is a useful system to study many cell membrane phenomena, such as lipid raft formation and phase separation. Extracting the molecular interactions from the existing experimental membrane data or to extend further to predict new phenomena poses lot of challenges. The problem demands correct computational methodologies along with relevant thermodynamics of model system. In this work, we will present Monte Carlo simulation results of three-component model membranes. The detailed computational methodologies to simulate phase separations in the ternary system will be presented.

D1 47 Unconditionally Stable Lattice Boltzmann Schemes for 3D MHD BRIAN KEATING, GEORGE VAHALA, *William & Mary* JONATHAN CARTER, *NERSC, LBL* MIN SOE, *Rogers State University* LINDA VAHALA, *Old Dominion University* JEFFREY YEPEZ, *AFRL, Hanscom Field* Thus, there are several fundamental advantages to using a kinetic representation (like the Lattice Boltzmann scheme) over the standard coarse-grained macroscopic representation. First, simple trajectories in a high-dimensional space can be accurately followed in time, and yet these trajectories can appear chaotic and space-filling when projected onto a lower dimensional space. Second, at the kinetic level, one is treating turbulent and thermodynamic fluctuations concurrently, leading to a more systematic coarse-graining procedure. Moreover, in LB research (A) we have an extremely powerful yet simple simulation code for turbulence that scales almost ideally with the number of PEs, and (B) we have a kinetic model that can yield conceptually better turbulence closure models when DNS cannot be used due to the limitations on PE memory due to the exceptationally large grids required. Here we extend our 3D MHD-LB code, that ran over 26 TFlops on 4800 PEs on the Earth Simulator, to handle significantly lower transport coefficients using the renormalized relaxation parameter technique of Li et al. [1]. We then discuss how to incorporate boundary conditions into the model. [1] Y. Li, et al., J. Fluid Mech **519**, 273 (2004).

D1 48 Discrete Particle Noise and Its Effects on Particle-in-Cell Simulations of Plasma Turbulence* G. HAMMETT, *PPPL* W. NEVINS, A. DIMITS, D. SHUMAKER, *LLNL* W. DORLAND, *U. of Maryland* In order to understand the differences between gyrokinetic particle simulations and gyrokinetic continuum simulations of Electron Temperature Gradient (ETG) turbulence, we have investigated the role of discrete particle noise. A detailed theory of the spectrum of noise fluctuations in a gyrokinetic particle simulation has been developed. With no free parameters, this theory agrees very well both with the fluctuation spectrum and the transport levels observed at late times in gyrokinetic particle simulations when noise dominates. The theory also matches the simulations well as the average squared weight (and thus the fluctuation energy) is varied by a factor of 500 in noise restart tests. The theory is based on Krommes' calculation of the gyrokinetic noise spectrum[1], extended to include the effects of numerical filtering, finite-size particles, and a resonance-broadening type of renormalization of the dielectric shielding and of the test particle trajectories. The noise builds up in time in present δf algorithms and eventually becomes large enough in typical particle simulations to suppress ETG turbulence, thus explaining why they give lower transport levels at late times than observed in continuum simulations.

*This work performed for USDOE by PPPL under contract DE-AC02-76CH03073 and UC-LLNL under contract W-7405-ENG-48.

[1]J.A. Krommes, Phys. Fluids B **5**, 1066 (1993).

D1 49 Molecular potential energy surfaces for interstellar chemistry and fusion applications* BASTIAAN J. BRAAMS,[†] XINCHUAN HUANG, ZHONG JIN, ZHEN XIE, XIUBIN ZHANG, JOEL M. BOWMAN,[‡] *Emory University* AMIT RAJ SHARMA, RALF SCHEIDER, *MPI for Plasma Physics, Greifswald, Germany* In the Born-Oppenheimer approximation the electronic Schrödinger equation is solved given the nuclear positions as parameters, and this defines the potential energy surface. We have used computational invariant theory and the MAGMA computer algebra system as an aid to develop representations for the potential energy and dipole moment surfaces that are fully invariant under permutations of like nuclei, extending an approach that for 3-body and 4-body systems has a long history, e.g. [J. N. Murrell et al. Molecular Potential Energy Functions, Wiley, 1984]. A many-body (cluster) expansion is used to describe reaction com-

plexes. The methods have been applied in an almost routine way for systems of up to 7 nuclei, including several molecules that are of interest for interstellar chemistry and for the issue of hydrocarbon breakdown in fusion edge plasma: H_5^+, CH_5, CH_5^+, $C_2H_3^+$, and their fragments, with $C_2H_5^+$ on the way. The mathematical and computional methods and the hydrocarbon applications will be presented.

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†Department of Mathematics and Computer Science.
‡Chemistry Department.

D1 50 ACCELERATOR SYSTEMS POSTERS

D1 51 Two methods of injection/matching at the University of Maryland Electron Ring (UMER)* J. TOBIN,* S. BERNAL, R. KISHEK, M. WALTER, B. QUINN, G. BAI,* D. STRATAKIS,* C. PAPADOPOULOS,* M. HOLLOWAY,* T. GODLOVE, M. REISER,* P.G. O'SHEA,*† *Institute for Research in Electronics and Applied Physics, Univ. of Maryland, College Park, MD 20742* Intense charged particle beams are of great interest to many wide areas of applications ranging from high-energy physics to free-electron lasers. The University of Maryland Electron Ring (UMER) is a scaled model to investigate the physics of such intense beams. It uses a 10-keV electron beam along with other scaled beam parameters that model the larger machines but at a lower cost. In order to have full current transport of the electron beam, and to increase the number of turns of the beam around the ring, injection of the beam from the straight section into the ring becomes crucial. Careful injection of a matched beam will also minimize emittance growth and halo formation around the ring. In this work, we describe and analyze two methods of injection of the electron beam from the straight section into the ring. In one of the methods, the two injection quads are fixed to a preset value, while in the other both the injection quads are switched off. The injection and matching of a space charge dominated beam by these two methods is analyzed and the same is repeated with an emittance dominated beam.

*Work supported by US Department of Energy.

†*Also at Dept. of ECE Univ. of Maryland College Park, MD 20742 USA.

D1 52 BEAM PHYSICS POSTERS

D1 53 Computation of Transfer Maps from Surface Data with Applications to Wigglers CHAD MITCHELL, ALEX DRAGT, *University of Maryland, College Park* Simulations indicate that the dynamic aperture of the proposed ILC Damping Rings is dictated primarily by the nonlinear properties of their wiggler transfer maps. Wiggler transfer maps in turn depend sensitively on fringe-field and high-multipole effects. Therefore it is important to have a detailed and realistic model of the interior magnetic field, including knowledge of high spatial derivatives. Modeling of these derivatives is made difficult by the presence of numerical noise. We describe how such information can be extracted reliably from 3-dimensional field data on a grid as provided, for example, by various 3-dimensional finite element field codes (OPERA-3d) available from Vector Fields. The key ingredients are the use of surface data and the smoothing property of the inverse Laplacian operator. We describe the advantages of fitting on an elliptic cylindrical surface surrounding the beam.

D1 54 TESTS OF PHYSICS LAWS POSTERS

D1 55 On the Correct Formulation of the First Law of Thermodynamics TEMUR Z. KALANOV, *Home of Physical Problems, Pisatelskaya 6a, 700200 Tashkent, Uzbekistan* The critical analysis of the generally accepted formulation of the first law of thermodynamics is proposed. The purpose of the analysis is to prove that the standard formulation contains a mathematical error and to offer the correct formulation. The correct formulation is based on the concepts of function and differential of function. Really, if internal energy U of a system is a function of two independent variables $Q = Q(t)$ (describing of the thermal form of energy) and $R = R(t)$ (describing non-thermal form of energy), then the correct formulation of the first law of thermodynamics is: $dU(Q,R)/dt = (\partial U/\partial Q)_R dQ/dt + (\partial U/\partial R)_Q dR/dt$, where t and $-(\partial U/\partial R)_Q/(\partial U/\partial Q)_R$ are time and measure of mutual transformation of forms of energy, correspondingly. General conclusion: standard thermodynamics is incorrect.

D1 56 The Second Law of Thermodynamics: Mathematical Error TEMUR Z. KALANOV, *Home of Physical Problems, Pisatelskaya 6a, 700200 Tashkent, Uzbekistan* The critical analysis of the generally accepted foundations of thermodynamics is proposed. Within the framework of the work [1], the following statement is proved: Gibbs's quantum canonical distribution $f_n = f_0 \exp(-E_n/T)$ (where E_n, $n = 0, 1, \ldots, f_n$, T are the energy of the subsystem, probability, and temperature, respectively) defines the correct relation of the thermal energy Q of the subsystem to the entropy S of the subsystem and the temperature T. This relation has the form: $S = Q/T$ and $\lim_{T\to 0} S = 0$ (where $Q \equiv \Sigma_{n=0}^{\infty} E_n f_n$, $S \equiv \Sigma_{n=0}^{\infty} S_n f_n$, $S_n \equiv E_n/)T = -\ln(f_n/f_0)$). Consequence: the second law (i.e. $dS = dQ/T$) of thermodynamics represents mathematical error. Ref.: [1] T.Z. Kalanov, "On the main errors underlying statistical physics." Bulletin of the APS, Vol. 47, No. 2 (2005), p. 164.

D1 57 The Problem of the SETI: A Methodological Error in Cosmology and Astrophysics TEMUR Z. KALANOV, *Home of Physical Problems, Pisatelskaya 6a, 700200 Tashkent, Uzbekistan* As is known, the problem of the Search for Extra Terrestrial Intelligence (SETI) is not solved till now. The fact is that "Cosmos keeps silence." In this connection, within the framework of the approach [1], a new analysis of the problem of the SETI is proposed. The new theoretical results are as follows. (1) The problem of the SETI cannot be solved within the framework of the special

sciences (physics, astrophysics, biology, etc.), since this problem is a philosophical problem [1]. (2) The philosophical problem of the SETI is formulated as follows: What is essence of the Universe? This problem can be solved only within the framework of the new philosophy and gnosiology [1] based on formal logic, dialectics, system approach, and information theory. (3) The main statement of the new philosophy and gnosiology is that information is essence of the Universe, and material objects and processes are manifestation of essence. (4) The Universe is controlled by means of information. (5) Human Reason and development of Mankind is consequence of existence of Supreme Reason (in other words, existence and development of Mankind is the main proof of existence of Supreme Reason). Consequence: the generally accepted idea of the SETI is a methodological error in cosmology and astrophysics. Ref.: [1] T.Z. Kalanov, Bull. APS, Vol. 48, No. 2 (2003), pp. 154–155.

D1 58 On the Hypothesis of Universe's "System Block" TEMUR Z. KALANOV, *Home of Physical Problems, Pisatelskaya 6a, 700200 Tashkent, Uzbekistan* The hypothesis of Universe's "system block" is proposed. The hypothesis is based on the new philosophy and gnosiology [1–3] according to which information is essence of the Universe, and material objects are manifestation of the essence. The hypothesis is formulated as follows: (1) the Universe represents the unity of opposites: essence and phenomenon (i.e. manifestation of essence). This unity exists as unity of matter states (i.e. as Universe structure); (2) "physical vacuum" is the lowest state defined by absolute zero of information and, consequently, energy; (3) "material objects" are the highest state defined by nonzero information and, consequently, energy; (4) there exist intermediate state between the lowest and highest states. It is called "dark matter"; (5) there is no physical interaction between the "material objects" and the "dark matter"; (6) interaction between the "material objects" and the "dark matter" represents informational interaction; (7) "material objects" is controlled by the "dark matter," i.e. the "dark matter" is Universe's "system block" (i.e. Supreme Reason). This hypothesis explains correctly the phenomena occurring in the Universe and shows that the generally accepted idea of the SETI is a methodological error in cosmology and astrophysics. [1] T.Z. Kalanov, Bull. APS, Vol. 48, No. 2 (2003), pp. 154–155; [2] T.Z. Kalanov, Bull. APS, Vol. 50, No. 2 (2005); [3] T.Z. Kalanov, http: // www.wbabin.net.

D1 59 Bose's Method: A Logical Error TEMUR Z. KALANOV, *Home of Physical Problems, Pisatelskaya 6a, 700200 Tashkent, Uzbekistan* The critical analysis of Bose's method—starting-point of Dirac's method of secondary quantization—is proposed. It is proved that Bose's method for derivation of Planck's formula stated by S.N. Bose in the article "Planck's law and light quanta hypothesis" (1924) contains logical errors (i.e. errors in definition of concepts). The main logical error is as follows [1]: the method does not take into explicit consideration an interaction between radiation and substance, i.e. the subsystem "photon gas" (radiation) is defined as the isolated subsystem which does not interact with the subsystem "molecule gas" (substance). (Such definition of concept "photon gas" represents a logic error because presence of radiating substance is an essential condition of existence of temperature and thermal radiation). Conclusions: firstly, this error leads to the incorrect statement that photon gas (quantum gas) is characterized by temperature; secondly, this error puts obstacles in the way of correct definition of the important concepts "phase cell" and "empty phase cell" which concern substance; thirdly, this error enters into the starting-point of Dirac's method of secondary quantization and, hence, into the standard theory of physical vacuum (i.e. the theory of "empty phase cell"). [1] T.Z. Kalanov, "On statistics of photon gas," Doklady Akademii Nauk SSSR (Russia), Vol. 316, No. 1 (1991), p. 100.

D1 60 Dirac's Theory of Physical Vacuum: Continuation of Bose's Logical Errors TEMUZ Z. KALANOV, *Home of Physical Problems, Pisatelskaya 6a, 700200 Tashkent, Uzbekistan* The critical analysis of Dirac's theory of physical vacuum is proposed. The purpose of the analysis is to prove that the foundations of Dirac's theory include Bose's logical errors. The proof is based on the following statements: (a) a material object has physical states, and physical states are the inseparable characteristics of a material object and belong only to a material object; (b) the problem of physical meaning of the formalism of secondary quantization can be solved only by means of the correct quantum-statistical description of the subsystem "photon gas" representing the inseparable part of the system "molecule + photon gas + thermostat." The main result of the analysis is as follows: both the "phase cell" and the "state of photon gas" are defined by not photons with energy $h\nu_{nm}$, but substance: namely, the expression $|E_n - E_m|$, $n \neq m$ where E_n and E_m are the energy levels of the molecule emitting and absorbing photons. The general conclusion: since it is supposed in Bose's method and Dirac's theory that both the "phase cell" and the "state of photon gas" are defined by photons with energy $h\nu_{nm}$, both Bose "empty phase cell" and Dirac "vacuum state of photon gas" are not a characteristic of material object, have no physical meaning and, hence, represent logical error.

D1 61 Bose-Einstein Statistics and Fermi-Dirac Statistics: A Logical Error TEMUR Z. KALANOV, *Home of Physical Problems, Pisatelskaya 6a, 700200 Tashkent, Uzbekistan* The critical analysis of Bose-Einstein statistics and Fermi-Dirac statistics—consequence of Bose's method—is proposed. The main result of the analysis is as follows. (1) In accordance with the definition, Bose-Einstein (B-E) and Fermi-Dirac (F-D) distribution functions $f^s_{(B-E)}$, $f^s_{(F-D)}$ are the average values of the random quantity: $f^s \equiv \varepsilon^s/\varepsilon^s_1$, $\varepsilon^s \equiv \Sigma_r \varepsilon^s_r p^s_r$, $p^s_r = p^s_0 \exp[-(\alpha + \beta\varepsilon^s_1)r]$, $r = 0, 1, \ldots(B - E)$, $r = 0, 1(F - D)$ where f^s is the average number of the noninteracting monoenergetic identical quantum particles in the s-layer cell; ε^s_1 is energy of one particle of kind s; p^s_r is the probability that energy takes on the value $\varepsilon^s_r = \varepsilon^s_1 r \equiv (\alpha + \beta\varepsilon^s_1)r/\beta$; $1/\beta \equiv T$ is temperature; $\alpha \equiv -\beta\mu$ is degeneration parameter; μ is chemical potential. (2) In accordance with the logic law of identity, $p^s_r \equiv p^s_r$, $\varepsilon^s_r = \varepsilon^s_1 r \equiv (\alpha + \beta\varepsilon^s_1)r/\beta$. Hence, $\alpha \equiv 0$. Thus, $\mu \equiv 0$ and, consequently, Bose-Einstein statistics and Fermi-Dirac statistics represent logical error.

D1 62 On the Correct Analysis of the Maxwell Distribution TEMUR Z. KALANOV, *Home of Physical Problems, Pisatelskaya 6a, 700200 Tashkent, Uzbekistan* The critical analysis of the Maxwell distribution is proposed. The main results of the analysis are as follows. (1) As is known, an experimental device for studying the Maxwell distribution consists of the following basic physical subsystems: (a) ideal molecular gas enclosed in a vessel (gas is in the equilibrium state); (b) molecule beam which is emitted from the small aperture of the vessel (the small aperture is a stochastic

source of quantum particles). (2) The energy of the molecule of the beam does not represent random quantity, since molecules does not collide with each other. In this case, only the set of the monoenergetic molecules emitted by the stochastic source is a random quantity. This set is called a quantum gas. The probability p_k that the quantum gas has the energy E_nk is given by the Gibbs quantum canonical distribution: $p_k = p_0 \exp(-E_nk/T)$, $k = 0, 1, \ldots$ where k is the number of molecules with energy E_n; T is temperature of the molecule in the vessel. (3) The average number of the molecules with energy E_n represents the Planck distribution function: $f = \Sigma_{k=0}^{\infty} k p_k \equiv f_{(Planck)}$. (4) In classical case, the expression $E_n f_{(Planck)}$ represents the Maxwell distribution function: $f_{(Maxwell)} \sim E_n f_{(Planck)} \sim v^2 \exp(-mv^2/2T)$. Consequently, the generally accepted statement that the Maxwell distribution function describes gas enclosed in a vessel is a logical error.

D1 63 "Hidden Kinetic Energy" and "Mass-Electric" Principle PHILIP CHU, *Avery Dennison* A hypothesis is proposed which suggests another fundamental energy equation of Special Relativity. Another relativistic variance is described which gives self-consistent definition of Lagrange Function for both classical and relativistic dynamics. This hypothesis leads to a new "Hidden Kinetic Energy" concept as well as a new "Mass-Electric" Principle.

D1 64 On a New Theory of the Black Hole TEMUR Z. KALANOV, *Home of Physical Problems, Pisatelskaya 6a, 700200 Tashkent, Uzbekistan* In connection with the fact that the special theory of relativity and, hence, the general theory of relativity is incorrect [1], a new theory of black hole is proposed. This theory is methodologically connected with the new theory of physical vacuum [2] and based on the following philosophical statements: (1) information is essence of the Universe, and material objects are manifestation of essence; (2) extermination of essence leads to extermination of manifestation of essence; (3) material object cannot be exterminated without extermination of its essence. Consequently, black hole is an exterminated object (in other words, black hole and exterminating object is one and the same). The theory based on these statements explains correctly the processes occurring in the Universe. [1] T.Z. Kalanov, "On logical errors underlying the special theory of relativity," Journal of Theoretics (USA), Vol. 6-1, 2004 (http://www.journaloftheoretics.com); [2] T.Z. Kalanov, "On a new theory of physical vacuum," Bulletin of the APS, Vol. 50, No. 2 (2005).

D1 65 Lorentzian geometry in four extended spatial dimensions DAVID BIRRELL, *Windsor Bush Consulting* A vector space defined as inertial 4 space (I^4) is described as an extension of Minkowski four dimensional spacetime (M^4). I^4 shares metric signature $(- + + +)$ with M^4 and is also shown as a subspace of a non-temporal symmetrical vector space defined as primary 4-space (P^4) where the momentum of mass is manifested as a wave. The collective 4-space geometry where $\exists P^4 : P^4 \rightarrow I^4 \rightarrow M^4$ is shown to be compatible with special relativity. In the 4-space system, the three spatial dimensions in an M^4 subspace can be considered a modified 3-brane embedded in a 4 dimensional bulk. The 4^{th} special dimensions is occupied by the wave property of mass resulting in the creation of a time dimension and the suppression of a space dimension.

D1 66 On a New Approach to the Solution of the Problem of Quantization of Energy TEMUR Z. KALANOV, *Home of Physical Problems, Pisatelskaya 6a, 700200 Tashkent, Uzbekistan* In connection with the fact that foundations of quantum mechanics contain logical errors [1], the correct approach to the solution of the problem of quantization of energy is proposed. The correct approach is based on the following key idea: (1) properties of a particle do not exist separately of a particle; (2) energy is inalienable property of a particle; (3) energy levels of an object arise and disappear only as a result of absorption and emission of a particle, correspondingly. Hence, quantization of energy of an object is not the Shroendinger problem of eigenvalues and is the problem of absorption and emission of particles. Within the framework of work [2], this idea opens a way to new understanding of the problem of quantization of the energy of an object as the unified problem of quantization, of elementary particles, and of gravitation. [1] T.Z. Kalanov, "On the correct theoretical analysis of the foundations of quantum mechanics," Bulletin of the APS, Vol. 50, No. 2 (2005); [2] T.Z. Kalanov, "On a new basis of quantum theory," Bulletin of the APS, Vol. 47, No. 2 (2002).

D1 67 Time-dependent solutions to the Dirac equation KHIN LAY WIN, ATHANASIOS PETRIDIS, *Drake University* The time-evolution of Dirac spinors is studied using the numerical staggered-leap-frog method. This technique is shown to be very precise, stable, and fast. Numerical results regarding the zitterbewegung of the expectation values and standard deviations of the spin and the position are obtained and found to be in agreement with analytical calculations whenever those are possible. The time-development of the decay of near-resonance spinors initially set inside a potential well is studied and compared to non-relativistic results. The decay of states away from resonance is also examined. All the calculations are performed using an average personal computer.

D1 68 Mirror Numbers and Wigner's "Unreasonable Effectiveness" ALEXANDER BEREZIN, *McMaster University* Wigner's "unreasonable effectiveness of mathematics in physics" can be augmented by concept of mirror number (MN). It is defined as digital string infinite in both directions. Example is $(\ldots)51413271820(\ldots)$ where first 5 digits is Pi "spelled" backward ("mirrored") and last 5 digits is the beginning of decimal expl string. Let MN be constructed from two different transcendental (or algebraically irrational) numbers, set of such MNs is Cantor-uncountable. Most MNs have contain any finite digital sequence repeated infinitely many times. In spirit of "Contact" (C. Sagan) each normal MN contains "Library of Babel" of all possible texts and patterns (J.L. Borges). Infinite at both ends, MN do not have any numerical values and, contrary to numbers written in positional systems, all digits in MNs have equal weight – sort of "numerological democracy." In Pythagorean-Platonic models (space-time and physical world originating from pure numbers) idea of MN resolves paradox of "beginning" (or "end") of time. Because in MNs all digits have equal status, (quantum) randomness leads to more uniform and fully ergodic phase trajectories (cf. F. Dyson, Infinite in All Directions).

D1 69 Exposing the Fallacy of Bell's Inequality N. GLENN GRATKE, The essential flaw of Bell's Inequality involves the mischaracterization of classical spin and classical polarization, the correction of which reveals that EPR experiments have been systematically misinterpreted. This poster session will show the specific mathematical details that expose the error of Bell's Inequality.

D1 70 Measurement Can't Influence the Nature PANKAJ SINHA, *Indra Gandhi National Open University* Science does not govern the nature rather it has been laid to describe the various facts of the nature. This straightly leads us to state some ''categorical'' facts/clarification about the nature. 1) The speed of light (even in vacuum) has not the same constant value in each frame of reference. It encourages us to think uniformity of physical laws in all inertial frames, constancy of speed of light and/or Maxwellian laws of electromagnetism are incoherent. 2) All natural processes do have same consequences in all inertial frames of reference. It's only law of Physics which may have different-different forms depending on frames of reference. 3) Measurement cannot influence the natural processes . . . ! Different measurements after all can be considered only as different rates of the happening of the nature. 4) Kinetic Energy of a particle is same in each inertial frame of reference and is ''truly'' defined by classical mechanics. The total energy of a particle is defined as $\mathbf{E}_i$ **= K.E. + P.E. + Work done** 5) Energy and entity of a particle are equivalent, i.e., they are just two modes of existence - in a particular sort of conditions we see a particle existing in forms of energy or with entity-features or in both. We strongly feel that the postulates of 'Special Theory of Relativity' are totally wrong and only ''willful'' assumptions.

D1 71 PARTICLES AND FIELDS POSTERS

D1 72 Search for the B^0 meson decay to $a_1\rho$ KATHERINE GEORGE, *University of Liverpool* BABAR COLLABORATION, We present a search for the decay $B^0 \to a_1^+\rho^-$. The data set analyzed consists of approximately 110 million $B\bar{B}$ pairs produced in electron-positron annihilation at the PEP-II collider and recorded by the BaBar detector.

D1 73 Family Structure of Leptons and Their Currents of An Axial - Vector Nature RASULKHOZHA S. SHARAFIDDINOV, *Institute of Nuclear Physics, Uzbekistan Academy of Sciences* Each of neutrinos has a non - zero mass and regardless of whether it is a Dirac or a Majorana mass, can possess both anapole and electric dipole moments. Between their form factors appears a connection, for example, at the longitudinal neutrinos scattering on spinless nuclei. We discuss a theory, in which a Dirac mass consists of vector and axial - vector components responsible for separateness of leptonic current into the vector and axial - vector parts of the same charge or dipole moment. Such a model can explain the absence of truly neutral neutrinos vector interactions and the availability of an axial - vector structure of a Majorana mass. Thereby it relates the two neutrinos of a different nature. We derive an equation which unites the masses to a ratio of the anapole and electric dipole form factors of any lepton and its neutrino as a consequence of their unification in families of doublets and singlets. This testifies in favor of the existence of the right - left dileptons and paradileptons of the axial - vector currents. Each of them together with formation of a kind of system of the vector nature answers to conservation of charge and any lepton flavor. Therefore, an axial - vector mass, anapole and electric dipole moment of the neutrino become proportional respectively to an axial - vector mass, anapole and electric dipole moment of a particle of the same families.

D1 74 SLHC Detector Upgrade R&D Studies for the CMS Hadron Calorimeter FIRDEVS DURU, U. AKGUN, A.S. AYAN, Y. ONEL, *University of Iowa* CMS COLLABORATION, The Large Hadron Collider (LHC) is designed to provide a beam energy of 7 TeV and a luminosity of $\mathcal{L} = 10^{34}\ cm^{-2}s^{-1}$. Future LHC upgrade scenarios include increasing the luminosity to $\mathcal{L} = 10^{35}\ cm^{-2}s^{-1}$. We refer to this upgraded LHC as the SuperLHC (SLHC). An increase in luminosity would require some upgrades to the CMS detector as well because of the very high radiation environment that would be created. In this report we summarize an ongoing $R\&D$ effort to upgrade the CMS Endcap Hadronic Calorimeter by replacing the scintillator tiles with quartz.

D1 75 GEANT4 Simulations for a Quartz Plate Calorimeter Prototype UGUR AKGUN, A.S. AYAN, E.A. ALBAYRAK, F. DURU, Y. ONEL, *University of Iowa* CMS COLLABORATION, Cerenkov calorimeters are effective solutions to the high radiation environments typical of future hadron colliders. The University of Iowa HEP group has designed a prototype Cerenkov calorimeter that consists of 20 layers of quartz plates separated by iron absorber. In this report we present the details of the design and a GEANT4 simulation of this prototype. The energy resolution, signal collection uniformity, and linearity of the calorimeter are simulated for electron and pion beams.

D1 76 On the Operator connecting the Witten 3-Vertex and the CSV 3-Vertex A ABDURRAHMAN, *Shippensburg University* The half-string approach to string field theory is used to construct the ghost conformal operator connecting the ghost part of the Witten interaction three vertex and the standard ghost vertex due to Caneschi, Schwimmer and Venziano.

D1 77 NEW PRECISION MEASUREMENT METHODS POSTERS

D1 78 Demonstration Cold Atom Fountain Electron Electric Dipole Moment (EDM) Experiment* HARVEY GOULD, JASON M. AMINI,† CHARLES T. MUNGER,‡ *LBNL* A demonstration cold-atom-fountain electron EDM experiment has been operated at LBNL. The apparatus is free of static magnetic fields ($B < 1$ nT) which reduces sensitivity to motional magnetic field effects. Electric-field quantization, state preparation and detection in field-free regions, fractional-cycle pulses, active motional magnetic field nulling, multiple-quantum transitions, and web based, unattended operation of the experiment will be discussed. Our results support the premise that a fountain experiment can detect (or rule out) an electron EDM far smaller than the present experimental limits.

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†Also U.C. Berkeley.

‡Also SLAC.

D1 79 NMR and ICR for precision measurements XIANG FEI, *Central Institute for Precision Study* High-precision comparison of the NMR signals of macroscopic samples and the ion cyclotron resonance (ICR) of charged particles in the Penning traps could yield important information on the fundamental properties of matter. For example, the magnetic moment ratio of the shielded helion to the nuclear magneton could be measured by comparing the helium-3 NMR frequencies with the proton cyclotron frequencies in the ion cyclotron nuclear magnetic resonance (IC-NMR) scheme.[1] Cylindrical ion traps (or orthorhombic ion traps) with compensation electrodes[2] may be used to contain the NMR measurement probe structure. Vertical and radial asymmetric electrical potentials in longitudinally and azimuthally segmented electrodes can move a charged particle (e.g. a proton) away from the center of a Penning trap for 3D magnetic field gradient measurements approximately over the volume of the NMR probe. Magnetic perturbations due to the experimental setup and environment should be carefully studied.[3] The magnetic effect of the NMR probe structure to its sample inside may be measured by a smaller NMR probe that can be readily inserted into and extracted from the measurement probe. [1]X. Fei, Bull. Am. Phys. Soc. **50**, No. 2, L1 2 (2005). [2]X. Fei, W.M. Snow, Nucl. Instr. and Meth. A **425**, 431 (1999). [3]X. Fei, V.W. Hughes, R. Prigl, Nucl. Instr. and Meth. A **394**, 349 (1997).

D1 80 Coherent population trapping with a train of pulses via the continuum and its application to excited-state suppression of pumping radiation in laser crystals* ELENA KUZNETSOVA, ROMAN KOLESOV, OLGA KOCHAROVSKAYA, *Department of Physics, Texas A&M University* Coherent population trapping via the continuum using a train of ultrashort pulses is considered theoretically. It is shown that it can result in complete suppression of population transfer to the continuum. This technique can be applied to suppression of excited-state absorption of pumping radiation in laser crystals. As an example, a Ti3+:YAlO3 is considered, which has a fluorescence band in the 550 – 750 nm range and thus can be a solid-state analog of dye laser if the excited-state absorption of pump radiation is reduced.

*The work was supported by NSF and AFOSR

D1 81 FEW-BODY SYSTEMS POSTERS

D1 82 Quantum Energy Level Calculations of Molecules Using Weyl-Heisenberg Wavelets and Classical Phase Space RICHARD LOMBARDINI, BILL POIRIER, *Texas Tech University* New methods are examined regarding the quantum-mechanical calculations of the nuclear dynamics of polyatomic systems. The first of these, introduced earlier in a series of articles, involves compact orthogonal wavelets as the basis set which is subsequently truncated using the guidance of a classical phase space picture of the system. This poster presents the first application of this technique to real molecular systems, more specifically, the calculation of the rovibrational energy levels of the neon dimer. The second technique involves further optimizations of the latter method using phase space region operators which improve the efficiency K/N of the basis set where N represents the number of basis functions needed to calculate K eigenvalues at a desired accuracy. Finally, for systems that produce sparse Hamiltonian matrices in the wavelet basis, a new parallel algorithm for matrix diagonalization is introduced which uses the subspace iteration method.

D1 83 HISTORY OF PHYSICS POSTERS

D1 84 Ideas of Flat and Curved Space in History of Physics ALEXANDER A. BEREZIN, *McMaster University* Since ''everything which is not prohibited is compulsory'' (assigned to Gell-Mann) we can postulate infinite flat Cartesian N-dimensional (N: any integer) space-time (ST) as embedding for any curved ST. Ergodicity raises quest of whether total number of inflationary and/or Everett bubbles (mini-verses) is finite, countably infinite (aleph-zero) or uncountably infinite (aleph-one). Are these bubbles form Gaussian distribution or form some non-random subsetting? Perhaps, communication between mini-verses (idea of D.Deutsch) can be facilitated by a kind of minimax non-local dynamics akin to Fermat principle? (Minimax Principle in Bubble Cosmology). Even such classical effects as magnetism and polarization have some non-local features. Can we go below the Planck length to perhaps Compton wavelength of our ''Hubble's bubble'' (h/Mc = 10 to minus 95 m, if M = 10 to 54 kg)? When talking about time loops and ergodicity (eternal return paradigm) is there some hysterisis in the way quantum states are accessed in ''forward'' or ''reverse'' direction? (reverse direction implies backward causality of J. Wheeler and/or Aristotelian final causation).

D1 85 ASTROPHYSICS POSTERS

D1 86 Prediction of electric and magnetic anomalies in gaseous planets, stars, galaxies, galactic groupings and universe STEWART BREKKE, *Northeastern Illinois University* Due to the dynamic nature of interiors of gaseous planets, anomalous electric fields are created in various places. Moving electric fields create magnetic fields as well. Therefore, gaseous planets probably have electric and magnetic anomalies thoughout the layers of the planetary gaseous mass. Stars are gaseous bodies with dynamic layers of gaseous mass and have magnetic and electric anomalies such as sunspots. The moving charged gaseous material prabably creates sunspots which are anomalous magnetic masses. Galaxies have been found to have electric fields associated with them. Since Galaxies are irregular collections of stars in motion, galaxies will have anomalous electric and magnetic fields as well. Since galactic groups are collections of moving electric and magnetic fields ssociated with individual galaxies, each galactic grouping will have magnetic and electric anomalies associated with them. Therefore, the universe itself will have magnetic and electric anomalies resulting from the different groups of galaxies having magnetic and electric fields associated with them.

D1 87 Solving the Transfer Equation for Arbitrary Flows in Static Spacetimes BIN CHEN, R. KANTOWSKI, E. BARON, *University of Oklahoma* SEBASTIAN KNOP, *Hamburger Sternwarte* We describe the derivation of the radiative transfer equation for arbitrary stationary relativistic flows in static spacetimes. We show that the standard characteristics method of solution developed by Mihalas and used throughout the radiative transfer community can be significantly simplified in that the characteristics always coincide with geodesics and can always be specified by constants. Thus, the direct integration of the characteristics is not required, since they are (in principle) known for a specified metric. We give details for both flat and static spherically symmetric spacetimes. This work has direct application in 3-dimensional simulations of supernovae, gamma-ray bursts, and AGN, as well as in modeling neutron star atmospheres.

D1 88 The GLAST Science Support Center's Role in Supporting the User Community TOM STEPHENS, *GSFC/L-3 GSI* DAVID DAVIS, *UMBC/GSFC* GLAST SCIENCE SUPPORT CENTER TEAM, The GLAST Science Support Center (GSSC) is GLAST's interface with the scientific community and is responsible for scheduling the science observations to be performed by the GLAST mission. The GSSC will provide GLAST mission data, analysis software and documentation to the general community. In addition, the GSSC will administer the guest investigator program for NASA HQ and will provide proposal preparation tools to assist proposers in assessing the feasibility of observing sources of interest. Here we present an overview of the GSSC responsibilities and services to be provided to the users.

D1 89 The Auger Star Monitor JOHANA DIAZ, DAVID NITZ, BRIAN FICK, *MTU* The Auger Star Monitor (ASM) is designed to automatically measure the total vertical atmospheric extinction above the Auger Observatory. The system continually takes wide-field CCD images of the night sky through a Johnson U-Band filter. Photometry is performed on the star images. The change in recorded star brightness as a function of zenith angle is used to obtain values for the integrated density of atmospheric scattering components. The MTU group has installed two ASMs; one at the Southern Observatory atop the Los Leones Fluorescence Detector building and one at the future site of the Northern Observatory in Colorado. Both of these units have been routinely operating during the past year. Much of our effort has turned to developing better data-reduction algorithms and automated software. Significant work has done to perfect the algorithms for image processing, star identification and photometry. Partial results of extinction coefficients obtained by the ASM will be presented.

D1 90 Three-dimensional Particle Acceleration in Electromagnetic Dominated Outflows with Background Plasma and Clump KOICHI NOGUCHI, EDISON LIANG, *Rice University* The effect of background plasma on particle acceleration via Poynting fluxes, which may explain the high-energy tail of γ-ray bursts and astronomical jets, is studied in 3D PIC simulation of electron-positron and ion-electron plasmas. When strongly magnetized plasma at the center expands to background low-temperature electron-positron plasma, EM wave front accelerates background plasma and a low-density clump, and captures them in the Ponderomotive potential well. In electron-positron case, we do not observe any instability, and the momentum distribution of background and clump forms a power law of slope close to -1 with a sharp peak in the middle. In the ion-electron background and clump case, strong charge separation decelerates the wave propagation.

D1 91 A variability and localization study of the Galactic Center gamma-ray source 3EG J1746-2851 MARTIN POHL, *Iowa State University* I have studied the variability properties and localization of 3EG J1746-2851 based on EGRET data of the observing periods 1–4. Using corrections for know systematic problems and performing various consistency checks I find no evidence of variability with an amplitude exceeding 30% with the possible exception of viewing period 429, for which a strong soft excess is observed. 3EG J1746-2851 is displaced from the exact Galactic Center towards positive Galactic longitudes. Sgr A*, the center of Sgr A East, the pulsar J1747-2958, and the TeV gamma-ray source observed with HESS seem to be excluded as possible counterparts at the $> 95\%$ level.

D1 92 3D MHD Simulations of Large-Scale Structures of Magnetic Jets HUI LI, MASANORI NAKAMURA, SHENGTAI LI, *LANL* Extragalactic radio jets represent a significant amount of magnetic energy (and perhaps magnetic flux) flow from supermassive black holes inside massive galaxies to the intergalactic medium (IGM). We will present 3D MHD simulations of the formation of large scale magnetic jets/''towers,'' evolved from an isolated and idealized initial state where magnetic fields are injected in a small volume. We will present a detailed analysis of the ''tower'' structure, collimation mechanisms, instabilities, and flux conversion processes. We will also compare our simulation results with astrophysical jet observations.

D1 93 Modeling the Rotational Dynamics of Spiral Galaxies with Plasmas, Molecular Hydrogen, and Numerical Mass Distributions (Elliptical plus Disk) C.F. GALLO, *Superconix Inc* The early evolution of Spiral Galaxies is modeled with electromagnetic plasma interactions which cause the initial coalescence, rotation, wispy spirals, filamentary structures and magnetic pinches to initiate clumps. As time progresses, the interstellar plasma density decreases, EM plasma effects become weaker and gravitational effects become stronger. Stars are gravitationally formed from the clumps initiated by magnetic pinches. Simultaneously, the galactic temperature decreases and molecular species form in the cooler regions. The model includes the presence of molecular hydrogen at a level similar to the densities observed by the European Space Agency's infrared space telescope, ISO. The mass distribution in the galaxy is modeled with the sum of ellipsoidal and thin disk distributions. The resulting dynamics compare favorably with the mass distribution required to produce the rotational characteristics encountered in mature Spiral Galaxies with low plasma density. (References: A. Peratt on Plasma Effects, and L. Marmet on Gravitational Models at http://www.marmet.ca/louis/galaxy/index.html).

D1 94 Effects of density fluctuations on supernova neutrinos TANVIR RAHMAN, *McGill, Long Island University* We have studied the effects of density fluctuations on supernova neutrinos by computing the expected neutrino flux from a future galactic supernova explosion. Our results show that for the most recent neutrino parameter space constraints, the expected neutrino flux is affected by possible stellar density fluctuations. Possible phenomenological implications are discussed.

D1 95 Expected Upper and Lower Limits on Pulsars Astrophysical Parameters from LIGO II data* G. SANTOSTASI, *McNeese State University* The current LIGO observatories are collecting data on the strength of possible gravitational waves from different sources in terms of the dimensional strain parameter h.

Among the possible sources there are rotating neutron stars. The strain h that can be converted in terms of fundamental parameters that are characteristics of the neutron stars physical properties. In particular the ellipticity of the neutron star can be derived from the strain when certain other parameters are know as the rotation frequency, spin-down and distance as in the case of known pulsars. At the moment the LIGO observatories are setting upper limits on ellipticity on few of the known pulsars. All these upper limits (with the exclusion of the limit on the Crab Pulsar) can be derived with more stringent way with other methods as for example the Energy Conservation method where the observed spin-down of the pulsar is attributed solely to the emission of gravitational waves and the strength of the wave is derived from calculating the resulting loss of energy due to this emission process. The situation is quite different when LIGO II data will be available in the future. In this case, the upper limit from direct observation will be better for a large number of know pulsars. Furthermore, once the Energy Conservation limit is beaten then other interesting lower and upper limits on astrophysical parameters can be derived from the data. The methods and results of the extraction of these parameters are discussed in this work. *Shearman Grant 2005.

D1 96 Using GEANT4 to model the photonic component of cosmic ray air showers. J. BENCH, S. NUTTER, *Northern Kentucky University* The CREST (Cosmic Ray Electron Synchrotron Telescope) project uses a high altitude balloon to carry a cosmic ray detector into Earth's upper atmosphere. The purpose of the project is to understand more about the local galactic sources that produce high-energy electron cosmic rays by detecting the linear pattern of synchrotron radiation emitted as the electrons are diverted by Earth's magnetic field. While this pattern is very distinct, there is a possibility that a similar pattern could be mimicked by cosmic ray air showers, which also produce temporally and spatially correlated photons. To estimate the background event rate due to air showers at balloon altitudes, GEANT4 is used to simulate cosmic ray air showers. The simulation entails modeling the composition and structure of earth's atmosphere by representing it as hundreds of variable density layers, along with reproducing the cosmic ray incident energy spectrum and composition. Information about photons is recorded as they pass through different depths in the atmosphere.

D1 97 Particle acceleration and magnetic field generation in SNR shocks M. SUSLOV, P.H. DIAMOND, M.A. MALKOV, *CASS and Physics Dept., UCSD* We discuss the diffusive acceleration mechanism in SNR shocks in terms of its potential to accelerate CRs to 10^{18} eV, as observations imply. One possibility, currently discussed in the literature, is to resonantly generate a turbulent magnetic field via accelerated particles in excess of the background field. We analyze some problems of this scenario and suggest a different mechanism, which is based on the generation of Alfven waves at the gyroradius scale at the background field level, with a subsequent transfer to longer scales via interaction with strong acoustic turbulence in the shock precursor. The acoustic turbulence in turn, may be generated by Drury instability or by parametric instability of the Alfven (A) waves. The essential idea is an A$\rightarrow$ A+S decay instability process, where one of the interacting scatterers (i.e. the sound, or S-waves) are driven by the Drury instability process. This rapidly generates longer wavelength Alfven waves, which in turn resonate with high energy CRs thus binding them to the shock and enabling their further acceleration.

D1 98 Nonlinear Diffusive Shock Acceleration in Fast Regime* M.A. MALKOV, P.H. DIAMOND, *CASS and Physics Dept., UCSD* We suggest a physical mechanism whereby the acceleration time of cosmic rays by shock waves can be significantly reduced. This creates the possibility of particle acceleration beyond the knee energy at 10^{15} eV. The acceleration results from a nonlinear modification of the flow ahead of the shock supported by particles already accelerated to the knee momentum. The particles gain energy by bouncing off converging magnetic irregularities frozen into the flow in the shock precursor and not so much by re-crossing the shock itself. The acceleration rate is thus determined by the gradient of the flow velocity and turns out to be formally independent of the particle mean free path. The velocity gradient is, in turn, set by the knee-particles. The acceleration rate of particles above the knee does not decrease with energy, unlike in the linear acceleration regime. The knee forms because particles above it are effectively confined to the shock while they are within limited domains in the momentum space, while other particles fall into ''loss-islands,'' similar to the ''loss-cone'' of magnetic traps. This also maintains the steep velocity gradient and high acceleration rate.

*Supported by NASA and DoE.

D1 99 MaxEnt Power Spectrum of the Solar Magnetic Cycle from a Wavelet Analysis of Sunspots R. W. JOHNSON, *Fusion Research Center, Georgia Institute of Technology* The power spectrum of the solar magnetic cycle is calculated from a wavelet analysis of the de-rectified yearly sunspot Wolf index for the years 1700–1995. Boundary edge effects in the cone-of-influence are treated via reflection of the data, with comment on such technique's validity. Broad peaks are sharpened using maximum entropy. The $\sim$ 22 year Hale cycle is shown to have variability in its period as a function of time. Evidence for the excitation of harmonics is seen during times of greater amplitude of the fundamental. The yearly solar magnetic power is compared with records of global temperature.

D1 100 Further Investigations Into the Formation Mechanisms for Kuiper Belt Binaries RAY NAZZARIO, TRUELL HYDE, *CASPER - Baylor University* Recent observations and theoretical studies show that multiple-member groupings of Kuiper Belt objects exist. Although their creation presents problems in current models, the inclusion of a massive third body (ex. one of the outer planets or a forming protoplanet) often provides the necessary conditions for the formation of such objects. The presence of a perturbing body can also provide clearing of the primordial Kuiper Belt while producing more stable, longer-lived multiple-member groupings of Kuiper belt objects. In this work, a fifth order Runge-Kutta algorithm is employed to numerically examine the situation described. It is shown that the interparticle gravitational interaction creates one of several effects; scattering into the Oort cloud, collisions with nearby growing protoplanets, formation of up to quartenary systems of Kuiper Belt objects, or creation of a single Kuiper belt object. Additionally, it is seen that the initial location of the precursors of the Kuiper belt objects can also have a significant effect on binary formation with objects near resonances tending not to form mutli-member groupings.

D1 101 Single-Sided Charge-Sharing CZT Strip Detectors for Gamma Ray Astronomy BURCIN DONMEZ, JAMES RYAN, JOHN MACRI, MARK McCONNELL, *University of New*

Hampshire TOMOHIKO NARITA, *College of the Holy Cross* LOUIS-ANDRE HAMEL, *University of Montreal* We report progress in the study of thick single-sided charge-sharing cadmium zinc telluride (CZT) strip detector modules designed to perform gamma-ray spectroscopy and 3-D imaging. We report laboratory and simulation measurements of prototype detectors with $11\times$ 11 unit cells ($15\times$ $15\times$ $7.5mm^3$). We report measurements of the 3-D spatial resolution. Our studies are aimed at developing compact, efficient, detector modules for 0.05 to 1 MeV gamma measurements while minimizing the number and complexity of the electronic readout channels. This is particularly important in space-based coded aperture and Compton telescope instruments that require large area, large volume detector arrays. Such arrays will be required for the NASA's Black Hole Finder Probe (BHFP) and Advanced Compton Telescope (ACT). This design requires an anode pattern with contacts whose dimensions and spacing are roughly the size of the ionization charge cloud. The first prototype devices have 125μm anode contacts on 225μm pitch. Our studies conclude that finer pitch contacts will be required to improve imaging efficiency.

D1 102 How S-S′ di quark pairs signify an Einstein constant dominated cosmology, and lead to new inflationary cosmology physics ANDREW BECKWITH, We review the results of a model of how nucleation of a new universe occurs, assuming a di quark identification for soliton-anti soliton constituent parts of a scalar field. Initially, we employ a false vacuum potential system; however, when cosmological expansion is dominated by the Einstein cosmological constant at the end of chaotic inflation, the initial di quark scalar field is not consistent w.r.t a semi classical consistency condition we analyze as the potential changes to the chaotic inflationary potential utilized by Guth. We use Scherrer's derivation of a sound speed being zero during initial inflationary cosmology, and obtain a sound speed approaching unity as the slope of the scalar field moves away from a thin wall approximation. All this is to aid in a data reconstruction problem of how to account for the initial origins of CMB due to dark matter since effective field theories as presently constructed require a cut off value for applicability of their potential structure. This is often at the cost of, especially in early universe theoretical models, clearly defined baryogenesis, and a well defined mechanism of phase transitions.

SESSION E1: ACCELERATOR AND DETECTOR R&D FOR THE INTERNATIONAL LINEAR COLLIDER
Saturday Afternoon, 22 April 2006; Landmark A, Hyatt Regency Dallas at 15:30
Shekhar Mishra, Fermi National Accelerator Laboratory, presiding

15:30
E1 1 Accelerator Design and R&D for the ILC.*
NAN PHINNEY, *SLAC*

Since the formation of the Global Design Effort in early 2005, substantial progress has been made on the ILC design and a coordinated international program of R&D has been launched. R&D projects address the entire accelerator from the electron and positron sources to the damping rings and bunch compressors, main linacs and beam delivery system. Test facilities at DESY, FNAL, KEK and SLAC support a wide variety of experiments and hardware development. New initiatives include the proposed final focus test facility at KEK (ATF2) and an instrumentation and IR test facility at SLAC (ESA) as well as experiments on existing machines around the world. The extensive R&D program on superconducting RF will be covered separately.

*Work supported by the Department of Energy contract DE-AC03-76SF00515.

16:06
E1 2
HASAN PADAMSEE, *Cornell University*

This abstract was not received electronically.

16:42
E1 3 ILC detector R&D and design studies.
HARRY WEERTS, *Argonne National Laboratory*

Starting from the precision physics program of the ILC, the talk will outline the corresponding necessary detector performance in order to do this physics. Based on this performance I will outline what detector R&D needs to be done to realize such a detector, give a status of the worldwide R&D activities, what still needs to be in the future and describe the status of the current detector concept studies that are being pursued worldwide.

SESSION E2: PRIMORDIAL NUCLEOSYNTHESIS
Saturday Afternoon, 22 April 2006; Landmark B, Hyatt Regency Dallas at 15:30
Carl R. Brune, Ohio University, presiding

15:30
E2 1 Light Elements on Fire: Nuclear Information for Big Bang Studies.*
MICHAEL S. SMITH, *ORNL Physics Division*

Within the last decade, our notions of the cosmos have been radically altered by precision observations of the light from distant Type Ia supernovae and, separately, the power spectrum of the cosmic microwave afterglow of the Big Bang. These show that the expansion of the universe is actually accelerating, and that the Universe is overwhelmingly composed of a mysterious dark energy (75%) and dark matter (21%), with only 4% of the total being baryonic ''normal'') matter. Determining the amount and characteristics of dark matter, dark energy, and normal matter is one of the most compelling problems in astrophysics today. A complementary and independent approach to determine the baryonic matter density is to compare the predictions of the abundances of ''primordial'' light elements (H, He, Li) formed three minutes after the Big Bang with observations of these elements in the interstellar medium and on the surface of very old stars. ''Big Bang Nucleosynthesis'' (BBN) calculations require, as input, thermonuclear reaction rates at the high temperatures characteristic of the early universe. BBN estimates of the ^{2}H, ^{4}He, and ^{7}Li abundances imply a baryonic density that, respectively, agrees, marginally agrees, and disagrees with the density from other approaches. This discordance, and the current status of nuclear physics information for BBN studies, will be reviewed, and reactions needing additional measurements will be discussed.

*ORNL is managed by UT-Battelle, LLC, for the U.S.D.O.E. under contract DE-AC05-00OR22725.

16:06
E2 2 Observations of the Light Element Abundances and the Cosmological Baryon Density.
DAVID TYTLER, *UCSD*

Three methods of measuring the mean cosmological density of baryons now agree within about 10 to 30%: the cosmic microwave background, the D/H ratio using Standard Big Bang Nucleosynthesis, and the Lyman-alpha absorption from neutral Hydrogen in the intergalactic medium. Using this baryon density, Standard Big Bang Nucleosynthesis predicts a factor 3 to 4 more ^{7}Li than is seen in halo stars. There are theoretical models that can allow halo stars to destroy ^{7}Li, but these models are challenged by both the amount of destruction and the lack of variation amongst stars with different mass. We do not know whether these stars did destroy their ^{7}Li. The baryon density also predicts systematically more 4He that most measurements over the last 20 years. We review the measurements and modifications to BBN that might explain the tension between D, He, and Li.

16:42
E2 3 CMB-BBN complementarity.
BENJAMIN WANDELT, *University of Illinois at Urbana-Champaign*

I will review the measurement of eta, the photon-to-baryon ratio, coming from observations of the cosmic microwave background. Eta is also obtained independently from the measurements of light element abundances. These two independent determinations of eta amount to a consistency check on (and hence a test of) the standard model of cosmology. If our standard model of cosmology passes this test we obtain constraints on non-standard features, such as decaying particles, or new particle interactions. If we are willing to assume the standard model, the measurement of eta from the cosmic microwave background can be taken as a starting point for standard BBN, which would give definite predictions for the primordial abundances of light elements, a key input for other areas of cosmology. I will discuss how this results in an additional consistency check due to the sensitivity of the CMB anisotropies to the Helium abundance.

SESSION E3: LABORATORY ASTROPHYSICS: MAGNETIC RECONNECTION
Saturday Afternoon, 22 April 2006; Landmark C, Hyatt Regency Dallas at 15:30
Vincent Chan, General Atomics, presiding

15:30
E3 1 The Dynamics of Magnetic Reconnection in the Solar Atmosphere.*
SPIRO ANTIOCHOS, *Naval Research Laboratory*

Magnetic reconnection is widely believed to play the central role in the interaction between matter and magnetic field in the Sun's corona and, therefore, to underlie most solar activity. Direct plasma heating due to reconnection has been proposed as the process that produces both the quasi-steady and the flare hot corona. Reconnection-driven flows have been proposed as the explanation for transient dynamic phenomena ranging from the smallest spicule to giant surges and sprays. Reconnection has also been proposed as the origin of the electron beams in flares, and numerous authors have argued that it is the mechanism responsible for the origin of coronal mass ejections and prominence/filament eruptions. In fact, it is difficult to find a solar phenomenon that has not been blamed on magnetic reconnection! On the other hand, there is surprisingly scarce direct evidence for reconnection in coronal observations. In this talk, I will present both the latest observations and 3D models for reconnection-driven dynamics in the corona and attempt to reconcile the data with theory.

*Work supported, in part, by ONR and NASA.

16:06
E3 2 Magnetic Reconnection in a Laboratory Plasma.*
HANTAO JI, *Princeton University*

Magnetic reconnection plays an important role in determining the evolution of magnetic topology in relaxation processes in laboratory plasmas, magnetospheric substorms, solar flares, and more distant astrophysical plasmas. Often, magnetic reconnection is invoked to explain the observed rapid release of magnetic energy. A central question concerns why the observed reconnection rates are much faster than predictions made by classical theories, such as the Sweet-Parker model based on MHD with classical Spitzer resistivity. In general, the reconnection process is determined by both local plasma dynamics in the diffusion region as well as by global boundary conditions. Presently, there are two prevailing theories to explain the mechanism of local dissipation enhancement and fast reconnection, based on the generalized Ohm's law. One is anomalous resistivity due to wave particle interactions and the other is the Hall effect originated from separation of electron motion from ions. In this talk, I would like to present recent results on these fundamental issues of reconnection from a well- controlled laboratory experiment, Magnetic Reconnection Experiment (MRX). Both electromagnetic turbulence and out-of- plane quadrupole magnetic field (a hallmark of the Hall effect) have been observed during fast reconnection process, which is also strongly affected by boundary conditions. Physics insights based on these observations as well as their comparisons and implications to space, solar and astrophysical plasmas will be discussed.

*This work is supported jointly by US DOE, NASA and NSF.

16:42
E3 3 Magnetic Reconnection in the DIII-D Tokamak.*
E.J. STRAIT, *General Atomics*

Magnetic reconnection is an important feature of tokamak plasmas, with the resulting changes in magnetic topology often leading to redistribution of the plasma's thermal and magnetic energy. Improved experimental diagnostics, including direct measurements of the internal magnetic field, and large nonlinear 3D numerical simulations have begun to offer new views of tokamak magnetohydrodynamic (MHD) instabilities. The full potential of these tools for investigation of reconnection physics and quantitative comparison of theory and experiment has yet to be exploited. This talk summarizes several areas of research related to reconnection in the DIII-D tokamak. The sawtooth is a periodic reconnection with poloidal and toroidal mode numbers $m=1$, $n=1$ that occurs in the core of a tokamak plasma. DIII-D results demonstrate a wide range of sawtooth behavior in different plasma regimes, ranging from fast, complete reconnection of the core region (similar to the classic Kadomtsev model) to a quasi-interchange-like instability with slower reconnection. Reconnection often leads to tearing modes and magnetic islands at flux surfaces with rational safety factors $q=m/n > 1$. At low plasma pressure, the onset and growth of tearing modes in DIII-D are in good agreement with the classic stability index Δ'. At higher pressure the evolution and saturation of ''neoclassical tearing modes'' agrees well with the Rutherford equation, modified to include the pressure-driven bootstrap current. Forced reconnection is also important in tokamak plasmas. Tearing modes may be driven by external magnetic field errors or by other MHD events. However, plasma rotation at the resonant surface can shield the driving perturbation and inhibit reconnection, leading to nonlinear threshold

behavior as observed in DIII-D and other experiments. The shielding becomes stronger as the Lundquist number increases, a possibly favorable result for larger, hotter, stronger-field fusion devices of the future.

*Work supported by US DOE under DE-FC02-04ER54698.

SESSION E4: SCIENCE AND DEVELOPMENT: INNOVATION SYSTEMS FOR FIGHTING POVERTY
Saturday Afternoon, 22 April 2006; Marsalis A, Hyatt Regency Dallas at 15:30
Albrecht Wagner, Deutsches Elektronen-Synchrotron, presiding

15:30
E4 1 UNESCO and the use of Science to Combat Poverty.
TONY MARJORAM, *UNESCO Senior Program Specialist*

This abstract was not received electronically.

16:00
E4 2 TBD.
DANIEL LEDERMAN, *Senior Economist, World Bank; Latin America & the Caribbean Under Secondment to the World Bank Development Research Group*

This abstract was not received electronically.

16:30
E4 3 TBD.
THOMAS A. WEBER, *International Science and Engineering National Science Foundation*

This abstract was not received electronically.

SESSION E5a: 50 YEARS SINCE THE DISCOVERY OF PARITY NONCONSERVATION IN THE WEAK INTERACTIONS I
Saturday Afternoon, 22 April 2006; Pegasus B, Hyatt Regency Dallas at 15:30
Natalie Roe, Lawrence Berkeley National Laboratory, presiding

15:30
E5a 1 New Insights to Old Problems.
TSUNG DAO LEE, *Columbia University*

From the history of the θ-τ puzzle and the discovery of parity non-conservation in 1956, we review the current status of discrete symmetry violations in the weak interaction. Possible origins of these symmetry violations are discussed.

15:57
E5a 2 Cracks in the Mirror: Saga of a 36 Hour Experiment.
LEON LEDERMAN, *Fermi National Accelerator Laboratory*

The history of the fall of parity, mirror symmetry, emerges from a puzzle in the behavior of particles (T-Θ puzzle). This stimulated the Lee-Yang paper of mid-1956 questioning the validity of parity in the weak interactions. They specifically raised the issue of the weak decays $\pi^{\pm} \rightarrow \mu^{\pm} + \nu$ and $\mu^{pm} \rightarrow e^{\pm} + 2\nu$. In subsequent detailed discussions between C.S. Wu and T.D. Lee, Wu designed a collaborative experiment with physicists from the Bureau of Standards in Washington D.C. which examined the decay of Co^{60}, an easily polarizable nucleus. Early positive results of the Wu experiment were discussed at a Friday lunch traditionally ''chaired'' by T.D. Lee. The precise date was the Friday of the first working week after the New Year, 1957. Here, for what was probably the first time, the possibility was raised that the failure of parity conservation could be a large effect. The conversation at the very traditional Chinese lunch was exciting. This new concept stirred me in my drive from Columbia to home in Irvington, actually a short walk to the

NEVIS laboratory where Columbia's 400 MeV synchrocyclotron lab was housed. The events of the next few days are the substance of my paper. By Tuesday noon, the word had spread around the world that parity conservation was dead. By that time we had a 20 σ effect and many of the essential tests of validity of our experiment were done. Some of the consequences important to that time, and some still relevant in 2006 will be presented.

16:24
E5a 3 Do left-handed neutrinos have rights too?
JANET CONRAD, *Columbia University*

As with any great discovery, the result of C.S. Wu's experiment on parity violation opened up many more questions. This talk explores these questions in light of recent discoveries about neutrino properties and the potential for new discoveries at the highest energy scales.

SESSION E5b: 50 YEARS SINCE THE DISCOVERY PARITY NONCONSERVATION IN THE WEAK INTERACTIONS II
Saturday Afternoon, 22 April 2006; Pegasus B, Hyatt Regency Dallas at 17:00
Noemi Koller, Rutgers University, presiding

17:00
E5b 1 In Which Direction is the Door?
C. N. YANG, *SUNY, Stony Brook, Emeritus*

This abstract was not received electronically.

SESSION E6: EXPERIMENTAL TESTS OF GENERAL RELATIVITY
Saturday Afternoon, 22 April 2006; Cumberland J, Hyatt Regency Dallas at 15:30
Marc Favata, Cornell University, presiding

15:30
E6 1 Tests of the Gravitational Inverse-Square Law at the Dark-Energy Length Scale.
ERIC ADELBERGER, *University of Washington*

This abstract was not received electronically.

16:06
E6 2 Science, Technology and Mission Design for the Laser Astrometric Test of Relativity.
SLAVA G. TURYSHEV, *NASA Jet Propulsion Laboratory, California Institute of Technology*

The Laser Astrometric Test of Relativity (LATOR) is a Michelson-Morley-type experiment designed to improve current tests of Einstein's general theory of relativity by more than four orders of magnitude. The space experiment uses laser interferometry between two laser sources placed on two small spacecraft separated by 1 degree (as seen from the Earth), whose lines of sight several times pass close by the Sun, to measure accurately the deflection of light by the solar gravitational field. The key element of the experimental design is a redundant geometry optical truss provided by a long-baseline ($\sim$ 100m) Michelson stellar optical interferometer that is used to measure the angle between the two spacecraft (with accuracy of 0.1 picoradian). The three arms of the light triangle formed by three space nodes are monitored with laser metrology (accurate to $\sim$ 1 cm). By using a combination of independent time-series of highly accurate measurements of gravitational deflection of light in the immediate proximity to the Sun, along with measurements of the Shapiro time delay on the interplanetary scales, LATOR will significantly improve our knowledge of relativistic gravity in the solar system. The experiment will measure the key post-Newtonian Eddington parameter γ with accuracy of 1 part in 10^9 and will also conduct a number of other unique measurements of the gravity effects on light propagation. This primary measurement pushes to unprecedented accuracy the search for cosmologically relevant scalar-tensor theories of gravity by looking for a remnant scalar field in today's solar system. LATOR will lead to very robust advances in the tests of fundamental physics: this mission could discover a violation or extension of general relativity and/or reveal the presence of an additional long range interaction in the physical law. In this talk we will discus the science, technology, and mission design for the LATOR experiment.

16:42
E6 3 Anomalous Acceleration of Pioneer 10 and 11.*
JOHN D. ANDERSON, *Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109*

Coherent radio Doppler data generated by the Deep Space Network with the Pioneer 10 and 11 spacecraft show an anomalous, constant, frequency drift that can be interpreted as an acceleration directed towards the Sun of magnitude $(8.74 \pm 1.33) \times 10^{-10}$ m s^{-2} at distances between 20 and 70 AU (Anderson et al., *Phys. Rev. Lett.* **81**, 2858; Anderson et al., *Phys. Rev. D* **65**, 082004). Launched in 1972 and 1973 on the first mission to Jupiter, these two relatively simple spinning spacecraft are exceptionally useful as probes of solar-system gravitation. Although it is suspected that there is a systematic origin to the anomalous acceleration, none has been unambiguously demonstrated. The observational basis for the measurement and its error budget are reviewed. Then recent and ongoing data analysis is discussed, including earlier data for both spacecraft, and some sparse later data generated for Pioneer 10 between July 1998 and March 2006 at distances between 70 and 90 AU.

*This work was performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA.

SESSION E7: COSMOLOGY III
Saturday Afternoon, 22 April 2006
Pegasus A, Hyatt Regency Dallas at 15:30

15:30
E7 1 Singular behavior in Lemaître-Tolman-Bondi cosmological models and the difficulties in using them as realistic models of the Universe ALI VANDERVELD, EANNA FLANAGAN, IRA WASSERMAN, *Cornell University* There has been much debate over whether or not one could explain the observed acceleration of the Universe with inhomogeneous cosmological models, such as the spherically-symmetric Lemaître-Tolman-Bondi (LTB) models. It has been claimed that the central observer in these models can observe a local acceleration, which would contradict general theorems. We resolve the contradiction by noting that many of the models that have been explored contain a weak singularity at the location of the observer, which makes them unphysical. In the absence of this singularity, we show that LTB models must have a positive central deceleration parameter q_0, in agreement with the general theorems. We also show that at nonzero redshifts the apparent deceleration parameter measured by the central observer can be negative. However, we find other singularities that tend to arise in LTB models when attempting to match luminosity distance data, and these generally limit the range of redshifts for which these models can mimic observations of an accelerating Universe.

15:42
E7 2 In Search of B-modes: Deconvolution Map-Making for CMB Polarization Observations CHARMAINE ARMITAGE, BENJAMIN WANDELT, *University of Illinois at Urbana-Champaign* The upcoming Planck satellite will provide new cosmological information contained in precision measurements of the polarization of the Cosmic Microwave Background (CMB) anisotropies. In particular, a measurement of the B-mode polarization would probe inflationary gravitational waves. Several challenges are faced in measuring this B-mode: the signal is tiny compared to the temperature anisotropies, and it is difficult to separate the E-mode from the B-mode. Thus, we expect that polarimetry experiments will be very sensitive to beam asymmetries and stray light. Deconvolution map-making (Armitage & Wandelt, 2004) removes systematic effects due to beam asymmetries by solving the maximum-likelihood map-making problem for arbitrary beams. We compare results from our method with a standard map-making method and demonstrate that the true sky is recovered with high accuracy via the deconvolution method. We also consider foregrounds and show the effects of ignoring beam asymmetries on the reconstruction of point sources.

15:54
E7 3 Black Hole Formation during a Cosmological QCD Phase Transition* TODD SPRINGER, JOSEPH KAPUSTA, *School of Physics and Astronomy, University of Minnesota, Minneapolis, MN 55455* The formation of primordial black holes from density fluctuations is usually thought to be relatively rare due to the large over-density required to overcome pressure forces and cause a collapse. In recent years, work has been done to examine whether the effect of a quark-hadron phase transition could reduce the necessary over-density due to a softening of the equation of state. Previous analyses have focused on a first order phase transition using a bag model equation of state. Using a combination of semi-analytic and numerical approaches, we examine this issue for equations of state that exhibit a first order phase transition, a second order phase transition, or just a rapid crossover. We find there is an enhanced production of sub-solar mass black holes even if the transition is not first order.

*This work was supported by the US Department of Energy under grant DE-FG02-87ER40328.

16:06
E7 4 Force-free Magnetosphere of a Kerr Black Hole and Energy Extraction* GOVIND MENON, *Troy University* CHARLES DERMER, *Naval Research Laboratory* TROY UNIVERSITY COLLABORATION, NAVAL RESEARCH LABORATORY COLLABORATION, Recent results on the electrodynamics of Black Holes will be discussed using the 3+1 (space and global time) formalism. This formalism has permitted the construction of an exact class of solutions to the Blandford-Znajek mechanism. Physical properties of the exact solution are analyzed following which the nature of jet formation and energy extraction from Kerr Black Holes will be presented.

*Troy University sabbatical, NASA GLAST Investigation No. DPR-S-1563-Y.

16:18
E7 5 CMB Tomography: Reconstruction of Adiabatic Primordial Scalar Potential Using Temperature and Polarization

Maps. AMIT P. S. YADAV, BENJAMIN D. WANDELT, *University of Illinois at Urbana-Champaign* Assuming linearity of the perturbations at the time of decoupling, we reconstruct the primordial scalar potential from the temperature and polarization anisotropies in the cosmic microwave background radiation. In doing so we derive an optimal linear filter which, when operated on the spherical harmonic coefficients of the anisotropy maps, returns an estimate of the primordial scalar potential fluctuations in a spherical slice. The reconstruction is best in a thick shell around the decoupling epoch; the quality of the reconstruction depends on the redshift of the slice within this shell. With high quality maps of the temperature and polarization anisotropies it will be possible to obtain a reconstruction of potential fluctuation on scales between $\ell = 2$ and $\ell \sim 300$ at the redshift of decoupling, with some information about the three-dimensional shapes of the perturbations in a shell of width 250Mpc. The main motivation for reconstructing primordial perturbations is to study the non-Gaussianities in the initial conditions. Reconstruction allows us to be more sensitive to the primordial perturbations, which is important because current detections of non-Gaussianity do not specifically select for the primordial perturbations.

16:30

E7 6 Gravitational lensing by 3-d matter distributions THOMAS KLING, *Bridgewater State College* Gravitational lensing studies have become an important tool for studying galactic structure and cluster morphology because the methods do not rely heavily on specific knowledge of cosmological parameters. To date, lensing studies use a weak- field, thin lens approximation where the lensing action is assumed to occur in a two-dimensional lens plane. We compare this approximation with the results of integrating the null geodesic equations for weak field metrics with ''standard'' three dimensional mass distributions.

16:42

E7 7 The Large Synoptic Survey Telescope Project DAVID GILMORE, *Stanford/SLAC/KIPAC* The prime goal of LSST is a precision measure of the nature of dark energy though a suite of techniques using a homogeneous imaging dataset. Central of these is weak lens shear of galaxy shapes to z=3 by mass at z< 3, giving a unique probe of dark energy. This will be done through a combination of deep-wide multi-band imaging data over 20,000 sq.deg. in a weak lensing survey of unprecedented sensitivity, volume and quality. LSST will be a large, wide-field groundbased telescope designed to obtain sequential images of the entire visible sky every few nights. The optical design involves a 3-mirror system with an 8.4 m primary, which feeds three refractive correcting elements inside a camera, providing a 10 square degree field of view sampled by a 3 Gpixel focal plane array. The total effective system throughput, $A\Omega$ = 318 m 2 deg2, is nearly two orders of magnitude larger than that of any existing facility. The survey will yield contiguous overlapping imaging of 20,000 – 23,000 square degrees of sky in 6 optical bands covering the wavelength regime 350–1100 nm.

16:54

E7 8 Magnitude-Redshift Relation for Supernovae Ia, Time Dilation, and Plasma Redshift. ARI BRYNJOLFSSON, *Appl. Rad. Ind.* Using conventional axioms of physics, the plasma redshift follows from exact evaluation of photons interaction with hot sparse electron plasma, as shown by Brynjolfsson in arXiv:astro-ph/0401420. We have previously used the supernovae data by Riess et al. to show that they match the prediction of the magnitude-redshift relation in plasma-redshift cosmology. In the present article, we use the most recent SNLS data, which have slightly narrower distribution, as reported by Astier et al. in 2005, to show that also these data match the predictions of the plasma redshift. The comparison indicates that consistent with plasma-redshift cosmology there is no cosmological time dilation and no Big Bang. There is no need for Dark Energy or Dark Matter. The plasma redshift predicts also significant intrinsic redshifts of stars, galaxies, and quasars consistent with that observed. Plasma redshift predicts well not only the observed magnitude-redshift relation for supernovae Ia, also the observed cosmic microwave background (CMB), and the cosmic X-ray background. The Hubble constant is about 62.6 km per sec per Mpc.

17:06

E7 9 The shrinking Hubble constant. RUSSELL COLLINS, *retired, U. T. Austin* The extraction of the Hubble constant from a plot of the measured distance of stellar objects vs. red shift Z is flawed in 3 ways. Distances must be extrapolated to present time. The Doppler portion of the red shift must be found. The gravitational changes of the metric through which the light passes must be accounted for. Using a model of the big bang as a sphere of radius R=cT, with uniform density and absent acceleration, extrapolation is had by multiplying distance by $1+\beta$. The red shift can be separated into Doppler and gravitational components, upon recognizing that the time of the event, T*, connects them. The gravitational potential decreases as the big bang expands, and this affects the measured optical distance. Correction is had using mass-metric relativity (arxiv physics/0012059), and fully accounts for curvature in high Z Hubble plots. Using a data set to Z=1.2 by Riess (AJ/journals/v116n3/980111), one finds T=23.5 billion years (Ho=41.6). This is older than the present consensus value, T=14 billion years (Ho=71). Plotted correctly as present distance vs. velocity, a linear Hubble plot is obtained. Full details at arxiv physics/0601013.

17:18

E7 10 Initial Conditions for Cosmic Evolution Using GRMHD Equations DAVID GARRISON, CINDI BALLARD, JOHN HAMILTON, *University of Houston Clear Lake* Numerically evolving the early universe after the inflationary expansion period requires a method of handling the Smoothness problem. Through the use of GRMHD turbulence it should be possible to show that structure formation can occur without violating the Smoothness condition or introducing concepts such as Imperceptibly Unsmooth Smoothness or Quantum Vacuum Energy Fluctuations. An attempt to solve Einstein's equations coupled with the equations of General Relativistic Magnetohydrodynamics for a smooth plasma is being made at the University of Houston Clear Lake. The challenge of this work is to identify the initial conditions for the standard model that lead to the development of the observed mass concentration in clusters and super clusters of galaxies. The initial conditions were selected so that alignment with observed values of the spectrum and isotropy of the cosmic background radiation are preserved as one evolves forward in time. This work presents the derivation of the initial conditions as well as the assumptions leading to them.

SESSION E8: MINISYMPOSIUM: THE SPIN STRUCTURE OF THE NUCLEON
Saturday Afternoon, 22 April 2006; Cumberland A, Hyatt Regency Dallas at 15:30
Ernst Sichtermann, Berkeley National Laboratory, presiding

Invited Papers

15:30
E8 1 The Spin Structure of the Nucleon – Present Knowledge and Open Questions.
WERNER VOGELSANG, *Brookhaven National Laboratory, Nuclear Theory Group and RBRC*

The talk gives an introduction to the spin structure of the nucleon. It describes our present knowledge and addresses the most compelling open questions and their theoretical background. It also gives an overview of the current activities in the field in both theory and experiment.

Contributed Papers

16:06
E8 2 Double Longitudal Spin Asymmetry Measurement and Cross-section for Inclusive Jets at $\sqrt{s}$=200 GeV in polarized p+p collisions JULIE MILLANE, *Massachusetts Institute of Technology* One of the STAR Spin Collabroation's goals is to determine the proton's polarized gluon distribution for $0.01 < x_g < 0.3$. The STAR Collaboration takes data at RHIC, which collides polarized protons. A time projection chamber and electromagnetic calorimeter allow pseudorapidity coverage from -1 to $+2$. A progress report on the 2005 double spin asymmetry measurement will be the focus of this contribution. This measurement has approximately 3 pb^{-1} of data at $\sqrt{s}$=200GeV. Jet transverse momentum coverage is $5 <$ pt $<$ 20 GeV. In 2005 there was increased luminosity, improved jet trigger rates and higher polarization over previous years. Comparisons of A_{LL} to various inclusive jets A_{LL} predictions based on several gluon polarization scenarios will be made. 2003/2004 cross-section and double spin asymmetry measurements will also be presented. These measurements have approximately 1 pb^{-1} of data. Jet transverse momentum for the cross-section measurement is $5 <$ pt $<$ 50 GeV. The cross-section will be compared to NLO pQCD calculations and to simulations.

16:18
E8 3 Spin Structure in the Resonance Region FRANK R. WESSELMANN, *Norfolk State University* JEFFERSON LAB RSS COLLABORATION, The RSS collaboration has measured the spin structure functions of the proton and the deuteron at Jefferson Lab using the lab's polarized electron beam, the Hall C HMS spectrometer and the UVa polarized solid target. The asymmetries $A_\parallel$ and $A_\perp$ were measured at the elastic peak and in the region of the nucleon resonances ($0.70\text{GeV} < W < 1.98\text{GeV}$) at an average four momentum transfer of $Q^2 = 1.3\text{GeV}^2$. The extracted spin structure functions and their kinematic dependence make a significant contribution in the study of higher-twist effects and polarized duality tests.

16:30
E8 4 Measurement of the double spin asymmetry A_{LL} from inclusive charged pion production in polarized p+p collisions at 200 GeV A. KOCOLOSKI, STAR COLLABORATION, A primary goal of the RHIC Spin program is the measurement of the polarized gluon distribution function Δg, which can be obtained from a global analysis incorporating measurements of the double spin asymmetry A_{LL} in various final state channels of polarized p+p collisions. Final states with large production cross sections such as inclusive jet and hadron production are analyzed as the program moves towards the measurement of A_{LL} in the theoretically clean channel of prompt photon production. The channels $\vec{p} + \vec{p} \rightarrow \pi^{+/-} + X$ are unique in that the ordering of the measurements of A_{LL} in these two channels is sensitive to the sign of Δg. Moreover, the STAR experiment has already established the procedure for the identification of charged pions and the calculation of their production cross-sections over a broad kinematic range. This contribution will present progress towards measurements of A_{LL} extracted from inclusive charged pion yields in the transverse momentum region $2 < p_T < 12$ GeV/c. These yields were obtained from $\sim$ 3 pb^{-1} of data taken by STAR at $\sqrt{s}$=200 GeV in 2005.

16:42
E8 5 Indirect Determination of the GDH Integrand on the Deuteron near Photodisintegration Threshold M.A. BLACKSTON, M.A. AHMED, *Duke University/TUNL* B.E. NORUM, *Physics Department, University of Virginia* B. SAWATZKY, *Temple University/JLAB* H.R. WELLER, *Duke University/TUNL* Data obtained from measurements[1] recently performed at the High Intensity $\vec{\gamma}$-ray Source (HI$\vec{\gamma}$S) are being analyzed to extract the Gerasimov-Drell-Hearn (GDH) integrand on the deuteron at γ-ray energies of 3.5, 4.0, 6.0, and 10.0 MeV. Linearly polarized γ-rays were used to extract the shape of the polarized differential cross section for the $d(\vec{\gamma},n)p$ reaction near breakup threshold using the 88 neutron detectors of the BLOWFISH array. The coefficients of a Legendre polynomial expansion of the data were extracted and written in terms of the amplitudes and phases of the transition matrix elements. A grid search was performed to determine the amplitudes of the T-matrix elements, using the phase shifts obtained from *n-p* scattering data[2] to fix the relative phases. The amplitudes are used in a low-energy expansion of the GDH integrand to determine the integrand values at each energy. This talk will provide a brief overview of the experiment, describe how the amplitudes were extracted, and compare the results obtained for the GDH integrand to theory.[3]

[1]B. Sawatzky, Ph.D. thesis, Univ. of Virginia, 2005.
[2]SAID Analysis, http://gwdac.phys.gwu.edu/.
[3]H. Arenhövel *et al.*, Nucl. Phys., **A631**, 612c (1998).

16:54
E8 6 The Generalized GDH Sum Rule: Measuring the Spin Structure of ^{3}He and the Neutron Using Nearly Real Photons

JAIDEEP SINGH, *University of Virginia* JEFFERSON LAB HALL A COLLABORATION, The Gerasimov-Drell-Hearn (GDH) sum rule is one of the most important tools available to study nucleon spin structure. Originally derived for real photon absorption ($Q^2 = 0$), the GDH sum rule has been generalized to finite Q^2. The goals of Jefferson Lab experiment E97-110 are to measure the Q^2 dependence of the GDH integral between 0.02 and 0.3 $(\mathrm{GeV}/c)^2$, to study the slope of the GDH integral at $Q^2 \approx 0$, and to extrapolate to the real photon point for ^{3}He and the neutron. In this domain, the measurement of the generalized GDH integral tests Chiral Perturbation Theory and probes its limits of applicability at low Q^2. The low Q^2 measurements from this experiment will provide new constraints on understanding the ^{3}He and neutron spin structure and a better understanding of the effect of nucleon resonances. Data collection was completed in August 2003 using the Jefferson Lab high polarization continuous electron beam and a polarized ^{3}He target. The status of the data analysis and future perpectives will be discussed.

SESSION E9: MINISYMPOSIUM: TOWARD A UNIVERSAL DENSITY FUNCTIONAL THEORY FOR NUCLEI II
Saturday Afternoon, 22 April 2006; Cumberland B, Hyatt Regency Dallas at 15:30
Scott Bogner, Ohio State University, presiding

Invited Papers

15:30
E9 1 Density Functional Theory from Effective Field Theory.*
RICHARD FURNSTAHL, *Ohio State University*

The combination of progress in chiral effective field theory (EFT) for inter-nucleon interactions, the application of renormalization group (RG) techniques to nuclear systems, and advances in many-body computational tools and methods opens the possibility of itconstructive density functional theory (DFT) for nuclei. Effective actions provide a natural framework for the development of EFT/DFT. One approach uses EFT power counting to define an order-by-order inversion of the generating functional in the presence of a source coupled to the density. This leads directly to Kohn-Sham DFT, which is widely used in condensed matter and quantum chemistry applications. Natural extensions lead to functionals of more general densities and the incorporation of pairing, consistent with phenomenological energy functionals for nuclei, which are themselves consistent with chiral EFT power counting. Chiral EFT offers a model-independent starting point, including a systematic approach to many-nucleon forces. The chiral inter-nucleon interactions are constructed with cutoffs in relative momentum much lower than those in conventional potentials, resulting in much softer interactions. If RG techniques are used to lower the cutoff further while preserving observables, Hartree-Fock plus second-order contributions (with three-body forces included) is found to be a good, possibly perturbative, first approximation for nuclear matter. The dominance of Hartree-Fock, in common with Coulomb DFT, raises hope for a quantitative microscopic construction. There are significant challenges to realizing this goal, both conceptual and technical, such as arise in extending DFT to self-bound systems. But the path is reasonably clear and meshes well with on-going efforts to develop, refine, and test phenomenological energy functionals for application across the mass table.

*Supported by NSF Grant #PHY–0354916.

Contributed Papers

16:06
E9 2 Isoscalar Giant Dipole Resonance within Fermi Liquid Drop Model OLEKSIY POCHIVALOV, SHALOM SHLOMO, *Cyclotron Institute, Texas A&M University, College Station, TX 77843, USA* Recent highly accurate experimental data on Isoscalar Giant Dipole (ISGDR) and Monopole (ISGMR) Resonances in nuclei renewed interest in correct microscopic description of collective excitations. Hartree-Fock based Random-Phase-Approximation (HF-RPA) is a successful method of describing collective excitations in nuclei. However, recent fully self-consistent HF-RPA calculations, which reproduce the centroid energies of the ISGMR, systematically overestimate by 1.5–2.5 MeV results for the ISGDR energy comparing with experimentally obtained data. Also, the HF-RPA model does not provide description of the widths of giant resonances. We consider these issues within the semi-classical generalization of the mean field theory, namely, Fermi-Liquid-Drop-Model (FLDM). In this presentation, we provide description of the FLDM formalism in its application to ISGDR and ISGMR calculations. We present results of FLDM calculations for centroid energy and widths of the ISGDR and ISGMR in the four nuclei, namely, 90Zr, 116Sn, 144Sm, and 208Pb and compare with available experimental data.

16:18
E9 3 Fully self-consistent Hartree-Fock RPA calculations for nuclear giant resonances TAPAS SIL, SHALOM SHLOMO, *Cyclotron Institute, Texas A & M University, College Station, TX 77843, USA* The basic theory for the microscopic description of giant resonances is the Hartree-Fock(HF) based random phase approximation (RPA). A very accurate calculation within HF+RPA demands a sufficiently complete basis and in particular self-consistency, i.e., using exactly the same terms in the residual interaction that have been used in the underlying HF calculation. Apart from some fully self-consistent calculations most existing HF+RPA calculations are contaminated by self-consistency violation. We have carried out highly accurate fully self-consistent HF+RPA calculations for the strength functions of various modes of giant resonances for a host of nuclei. We check the accuracy of our calculations of the strength functions of giant resonances by

comparing the RPA results with the corresponding ones of constrained HF for the case of isoscalar giant monopole (ISGMR) and the total energy weighted strengths with the corresponding energy weighted sum rule (EWSR). We have quantified very accurately the effects of self-consistency violation due to the omission of the spin-orbit (LS) and Coulomb (CO) particle-hole interaction on the centroid energy (E_C) which is commonly used to determine the nuclear matter incompressibility K. The effects of violations of self-consistency due to the ph LS or CO interactions are most significant for the ISGMR (3 to 5 times the experimental errors), leading to an uncertainty of around 20 MeV in K.

16:30
E9 4 New effective nucleon-nucleon interaction for mean-field approximation AU VUONG, SHALOM SHLOMO, *Cyclotron Institute, Texas A&M University, College Station, TX 77840, USA* The effective Skyrme interaction has been used in mean-field models for several decades and many different parameterizations of the interaction have been realized to better reproduce nuclear masses, radii, and various other data. Today, there are more experimental data of nuclei far from stability line. It is time to improve the parameters of Skyrme-type effective nucleon-nucleon interactions. In this presentation, we present the procedure of the fitting of the mean-field results to an extensive set of experimental data with some constraints on the Skyrme parameters and some approximations in the mean-fields to obtain the parameters of the Skyrme type effective interactions, namely, KDE0 and KDE. We present results of fully self-consistent Hartree-Fock based Random-Phase-Approximation (HF+RPA) calculations for the centroid energies of the breathing modes in the four nuclei, namely, 90Zr, 116Sn, 144Sm, and 208Pb and compare with available experimental data.

SESSION E10: FOCUS SESSION: K-12 EDUCATION
Saturday Afternoon, 22 April 2006; Cumberland C, Hyatt Regency Dallas at 15:30
Peggy McMahan, Lawrence Berkeley National Laboratory, presiding

Invited Papers

15:30
E10 1 Online Physics Education Resources from the American Museum of Natural History.
ROBERT STEINER, *American Museum of Natural History*

Through its National Center for Science Literacy, Education and Technology, the American Museum of Natural History has created a rich array of physics education resources for teachers, students and the general public. Many of these resources, which include essays, images, videos and interactive simulations, leverage ongoing research within the Division of Physical Sciences at the Museum as well as exhibitions and specimens from the Museum's collections. The online resources featured include Science Bulletins (current research and recent discoveries), Ology (a website for children), Resources for Learning (a searchable database of curricular resources) and Seminars on Science (online teacher professional development). The genesis of these projects, their underlying strategies and their implementation will be reviewed. Sample resources will be presented, including colliding galaxies, the tracking of near-Earth asteroids, Einstein's legacy and geophysics. A CD of physics resources from the Museum will be provided to attendees.

Contributed Papers

16:06
E10 2 A Traveling Physics Demonstration Show for Northern Kentucky* S. NUTTER, M. O. ZACATE, L. KINNE, *Northern Kentucky University* As a result of the 1990 Kentucky Education Reform Act, the Kentucky Department of Education has established a detailed grade-by-grade curriculum. This largely assures that students in a given grade level will have been exposed to the same Physics topics regardless of the school they attend. This allows one to design a Physics demonstration show that augments the Kentucky Program of Studies in Physical Science in addition to generating interest in Physics. In this presentation we shall discuss factors influencing the selection of demonstrations, including anecdotal evidence for which topics require special attention, and outline plans for evaluating whether or not the demonstrations improve student understanding through pre-demonstration and post-demonstration quizzes.

*Support from the World Year of Physics 2005 Physics on the Road Program and the Center for Integrative Natural Science and Mathematics at NKU.

16:30
E10 3 Improving High School Physics Through An Outreach Initiative* NOUREDINE ZETTILI, *Department of Physical & Earth Sciences, Jacksonville State University, Jacksonville, AL 36265* We want to discuss our outreach initiative at Jacksonville State University designed to help improve the teaching of physics at a number of high schools in Northeast Alabama. This initiative is part of Project IMPACTSEED (IMproving Physics And Chemistry Teaching in SEcondary Education), a No-Child Left Behind grant funded by the Alabama Commission on Higher Education. This project is motivated by a major pressing local need: A large number of high school physics teachers teach out of field. IMPACTSEED is designed to achieve a double aim: (a) to make physics and chemistry understandable and fun to learn within a hands-on, inquiry-based setting; (b) to overcome the fear-factor for physics and chemistry among students. Through a two-week long summer institute, a series of weekend workshops designed to help bring technology into physics classrooms, onsite support, and a hotline, we have been providing year-round support to the physics/chemistry teachers in this area. IMPACTSEED aims at providing our students with a physics/chemistry education that

enjoys a great deal of continuity and consistency from high school to college.

*Supported by the Alabama Commission on Higher Education.

16:54

E10 4 Japan Fulbright Memorial Fund Program Opens New Avenues for Effective Technology Integration into Education* FRANCO PAOLETTI, LISA MARIE CARLUCCI, *East Windsor Regional School District, Hightstown, NJ 08520, USA* Technology is increasingly playing a major role in today's education often integrated into instruction to become one of the teacher's most effective and often indispensable tools used in the classroom. It can be said that the use of technology at the beginning of this new millennium is affecting the instructional process and it is changing some of its basic connotations. The presented work analyzes the impact of various technologies on education emphasizing the advantages provided by a successful integration, the obstacles encountered along the way, and the methodologies currently used in the process. ''Educational exchange can turn nations into people, contributing as no other form of communication can to the humanizing of international relations'' (Senator J.M. Fulbright). Technology of this modern era is providing the indispensable tool to achieve this superior level of communication overcoming historical, cultural, and language barriers. In the context of the Japan Fulbright Memorial Fund (JFMF) Teacher Program, we analyze the impact of technology on educational cross-cultural exchanges to raise awareness and interest of the scientific/educational community on the need of establishing stronger international relations promoting world peace and global prosperity.

*Supported by the Government of Japan - JFMF Teacher Program.

SESSION E11: QUANTUM AND CLASSICAL GRAVITY
Saturday Afternoon, 22 April 2006
Cumberland E, Hyatt Regency Dallas at 15:30

15:30

E11 1 Effects of nonzero neutrino masses on black hole evaporation* WILLIAM HISCOCK, DANIEL BAMBECK, *Montana State University* We study the consequences of nonzero neutrino masses for black holes evaporating by the emission of Hawking radiation. We find that the evolution of small, hot, black holes may be unaffected (if neutrinos are Majorana particles), or may show an increase in neutrino luminosity and a decrease in lifetime by up to a factor of approximately 1.85 (if neutrinos are Dirac particles). However, for sufficiently large (*e.g.*, stellar mass) black holes, nonzero masses result in neutrino emission being largely or entirely suppressed, resulting in a decrease in emitted power and an increase in lifetime by up to a factor of about 7.5.

*Work supported in part by NSF Grant No. PHY-0098787.

15:42

E11 2 Quantum effects in Spherically Symmetric Traversable Wormhole Spacetimes WILLIAM HIRSCH, *Wake Forest University* The expectation value of the full renormalized stress-energy tensor operator, $\langle T_{\mu\nu} \rangle$, has been calculated for a number of spherically symmetric wormhole spacetimes for the massless fermion field. One metric describes a phantom energy wormhole. The wormholes are at zero temperature. The components of $\langle T_{\mu\nu} \rangle$ are then examined to determine if the wormhole geometries are stable for various values of the renormalization parameter μ.

15:54

E11 3 Back Reaction of the Hawking Radiation CECILE DEWITT-MORETTE, *University of Texas at Austin* Three fundamental papers by G.A. Vilkovisky: ''Kinematics of evaporating black holes,'' ''Radiation equations for black holes,'' and ''Back-reaction of the Hawking radiation'' (respectively available from arXiv:hep-th/0511182/3/4) present the calculation of the evolution of black holes driven by the Hawking radiation. The solution of the backreaction problem is a generalization of the Schwarzschild metric. Bryce DeWitt had been hoping that the solution of the backreaction problem would be obtained in time for him to include it in his book ''The Global Approach to Quantum Field Theory'' The Hawking radiation and its backreaction are semiclassical effects. According to Vilkovisky, blackloles create a ''vacuum matter charge'' to protect themselves from the quantum evaporation. A spherically symmetric black hole having initially no ''matter charges'' radiates away about 10% of the initial mass and comes to a state in which the vacuum-induced charge equals the remaining mass. The metric in the semiclassical region of the collapse spacetime is obtained and studied. I shall present and discuss Vilkovisky's work.

16:06

E11 4 Quantum Gravity Modulates Fermion Field Strength during Inflation* RICHARD WOODARD, SHUN-PEI MIAO, *University of Florida* Because gravitons are massless without being conformally invariant, they engender enormously enhanced effects during inflation. One such effect is to alter the wave function of massless fermions by a time dependent field strength renormalization which would, if unchecked at higher loops, eventually convert positive norm particles into ghosts! We prove this by solving the effective field equations for massless fermions using the recently computed one loop self-energy for Gravity + Dirac (gr-qc/0511140). The Schwinger-Keldysh formalism is used to keep the results real and causal. It is curious that our result agrees, up to a numerical factor, with the Hartree-Foch approximation of simply taking the expectation value of the Dirac Lagrangian in the graviton vacuum.

*Partially supported by NSF grant PHY-244714.

16:18

E11 5 Quantum mechanical healing of classical singularities DEBORAH A. KONKOWSKI, *U.S. Naval Academy* THOMAS M. HELLIWELL, *Harvey Mudd College* How effective is quantum mechanics at healing classical spacetime singularities? A maximal spacetime has a classical singularity if it contains incomplete geodesics, while it has a quantum singularity if the propagation of a quantum wave packet is ill posed (in particular, if the Klein-Gordon wave operator is not essentially self-adjoint). We consider a wide class of classically singular spacetimes whose metric coefficients, as the singularity is approached, become

power laws in one of the spatial coordinates. We then determine the range of exponents for which quantum-mechanical particles are unable to detect the classical singularity so that the corresponding spacetimes are quantum-mechanically nonsingular.

16:30
E11 6 Quantum Geometrodynamics of the Bianchi IX Cosmological Model RUSLAN VAULIN, *Florida Atlantic University* ARKADY KHEYFETS, *North Carolina State University* WARNER MILLER, *Florida Atlantic University* The canonical quantum theory of gravity – Quantum Geometrodynamics (QG) is applied to the homogeneous Bianchi type IX cosmological model. As a result, the framework for the quantum theory of homogeneous cosmologies is developed. We show that the theory is internally consistent, and prove that it possesses the correct classical limit (the theory of general relativity). We show that, unlike the traditional approaches, QG leads to a well-defined Schrodinger equation for the wave- function of the universe that is inherently coupled to the expectation value of the constraint equations. This coupling to the constraints is responsible for the appearance of a coherent spacetime picture. Thus, the physical meaning of the constraints of the theory is quite different from Dirac's interpretation. In light of this distinctive feature of the theory, we readdress the question of the dark energy effects in the Bianchi IX cosmological model for highly non-classical quantum states.

16:42
E11 7 Nambu-Goldstone Modes in Theories with Spontaneous Lorentz Violation ROBERT BLUHM, *Colby College* ALAN KOSTELECKY, *Indiana University* The fate of the Nambu-Goldstone (NG) modes is examined in gravitational theories with spontaneous Lorentz violation. It is shown that the NG modes due to spontaneous Lorentz and diffeomorphism breaking can be naturally incorporated into the theory using a vierbein approach. The question of whether a Higgs mechanism occurs is examined as well. Vector models with spontaneous Lorentz violation called bumblebee models are used as an example.

16:54
E11 8 Energy Localization and the Taub Solution PAUL HALPERN, *University of the Sciences in Philadelphia* In an attempt to define the localized distribution of energy, Einstein proposed the first energy-momentum complex, which would eventually be followed by other measures proposed by Tolman, Landau-Lifshitz and others. Recent years have brought a revival of interest in these methods, following Bondi's 1990 result that energy must in principle be localizable, and the 1996 finding by Aguirregabiria, Chamorro and Virbhadra that for any metric of the Kerr-Schild class, various prescriptions for the energy-momentum complex yield precisely the same distribution. This talk will focus on anisotropic cosmological solutions, particularly Taub's 1951 exact solution for a Bianchi type-IX geometry, and compare the results for several different energy-localization prescriptions, showing that these yield reasonable and well-defined results. We'll comment on how these findings bear on Cooperstock's hypothesis about gravitational radiation.

17:06
E11 9 Unifying Gravity and EM: A Riddle You Can Solve DOUGLAS SWEETSER, Apply three rules to this riddle: 1. Start from standard theory. 2. Work with quantum mechanics. 3. No new math. Start from the vacuum Hilbert-Maxwell action:

$$S_{H-M}=\int \sqrt{-g}d^4x\left(R-1/4c^2(\nabla^\mu A^\nu-\nabla^\nu A^\mu)(\nabla_\mu A_\nu-\nabla_\nu A_\mu)\right)$$

The Hilbert action cannot be quantized, so drop the Ricci scalar. To do more than EM, use an asymmetric tensor:

$$S_{GEM}=\int \sqrt{-g}d^4x\,1/4c^2\,\nabla^\mu A^\nu\nabla_\mu A_\nu$$

The metric is fixed up to a diffeomorphism. With a constant potential, the Rosen metric solves the field equations, is consistent with current tests, but predicts 0.7 μarcseconds more bending around the Sun than GR. Gauge symmetry is broken by the mass charge of particles.

SESSION E12: NEUTRINO CROSS SECTIONS
Saturday Afternoon, 22 April 2006
Cumberland F, Hyatt Regency Dallas at 15:30
Petr Vogel, California Institute of Technology, presiding

Contributed Papers

15:30
E12 1 The MIPP experiment and its application to neutrino beam simulations ANDREW GODLEY, *University of South Carolina* MIPP COLLABORATION, The Main Injector Particle Production experiment (E907) at Fermilab measures particle production from nuclear targets using a tagged secondary beam of p, K and π with momenta 5 to 80 GeV/c and a primary proton beam of 120 GeV/c. The experiment comprises a large acceptance spectrometer for tracking and a combination of dE/dx, ToF, threshold and ring-imaging Cerenkov techniques for particle identification over the full range of the final state parameters. The MIPP data has applications in Nuclear Physics, meson spectroscopy, and neutrino beam calculations for K2K, MINOS, miniBooNE, T2K and NOvA. This talk will describe MIPP, its dataset, which has just finished collection, and highlight its application to reducing the main source of neutrino beam systematic error: hadron production. A possible upgrade to MIPP by speeding up its electronics will be mentioned.

15:42
E12 2 Neutrino Neutral Current Cross Section Measurement in NOMAD QUN WU, *Univ. of South Carolina* USC-HEP/ NOMAD TEAM, Current and future neutrino oscillation experiments (eg NOvA) require a much better understanding of the neutrino neutral current cross section. NOMAD, a former neutrino oscillation experiment, has the largest high resolution neutrino nucleon scattering data sample available. The effort towards this cross section measurement will be presented, in particular the likelihood method used to select the neutral current events.

15:54
E12 3 Measurement of Neutrino Induced Quasi-Elastic Cross Section JAE KIM, *The University of South Carolina* The measurement of the weak mixing angle is the goal, using the data collected in the NOMAD experiment at CERN. Studying the neutrino induced Quasi-Elastic (QE) scattering, in which neutrino hits neutron and results in a muon and a proton, would enhance our understanding of the 'higher-twist effect' – an effect that parameterizes the weak mixing angle. Toward this, I developed a likelihood probability density function that enabled me to eliminate a significant portion of the background, resonance and deep inelastic scattering events. As the Monte Carlo (MC) is only reliable to a precision not better than 15 – 20 percent, I developed several techniques to make sure that MC and DATA agreed around 5 percent. The axial mass and QE cross section can then be calculated. Techniques and the preliminary results relevant to the calculation will be presented.

16:06
E12 4 Neutrino Cross Sections at MiniBooNE ZELIMIR DJURCIC,* *Columbia University* The MiniBooNE (Booster Neutrino Experiment) neutrino oscillation experiment collected the world's largest sample of charged current quasi-elastic, charged current π^+, and neutral current π^0 events in 0.1 to a few GeV region. The data are used to measure neutrino cross section on carbon. The results are important to understanding the event rates and backgrounds in the oscillation analysis. A summary of the cross section studies will be presented.

*For the MiniBooNE Collaboration.

16:18
E12 5 Constraining intrinsic ν_e events in the MiniBooNE beam* KENDALL MAHN, *Columbia University* MINIBOONE COLLABORATION, MiniBooNE is a short baseline neutrino experiment at Fermilab looking for $\nu_\mu \rightarrow \nu_e$ oscillations in the region of the LSND signal. The neutrino beam is 99% pure muon flavor neutrinos from pion and kaon decays, however, kaons in the beam also decay to produce electron neutrinos. These ''intrinsic'' electron neutrinos are an important background to the electron neutrino appearance search. This talk will present how MiniBooNE constrains the number of kaons in the beam, and the number of ''intrinsic'' electron neutrino events.

*MiniBooNE gratefully acknowledges the support from the Department of Energy and the National Science Foundation. The presenter was supported by NSF grant NSF PHY-98-13383.

16:30
E12 6 CCpi0 events at MiniBooNE LAURA JEANTY, *Yale University* MINIBOONE COLLABORATION, Charged current neutral pion events are the fourth largest exclusive sample of neutrino interactions at MiniBooNE, constituting about 4% of total neutrino interactions. The study of this sample is interesting in several respects. First, at MiniBooNE energies ($\sim$ 1GeV) the cross section is known with only modest precision. Second, there is no coherent cross- section in this channel, and therefore the low Q^2 behavior differs from that of the CCπ^+ channel. Finally, if one wants to use CCπ^+ events for ν_e appearance studies, CCπ^0 events are a large background. The study of this data sample in MiniBooNE is complicated by the fact that a full kinematic reconstruction requires simultaneously reconstructing three Cherenkov rings. We will report on the recent progress in the reconstruction and study of these events.

16:42
E12 7 MINERvA High-Statistics Neutrino-Nucleus Scattering using a Fine-grained Detector MINSUK KIM, *Pittsburgh University* MINERVA COLLABORATION, The extremely intense NuMI neutrino beam at Fermilab, constructed for the MINOS Neutrino Oscillation Experiment, is an ideal beam for a high-statistics, low-energy neutrino scattering experiment. The MINERvA Collaboration has been approved to put a fine-grained, fully-active scintillator detector directly upstream of the MINOS near detector to study topics of interest to both particle and nuclear physicists. The NuMI beam, proposed detector, and physics topics will be outlined.

Invited Papers

16:54
E12 8 Tanaka Dissertation Award Talk: Evidence for Neutrino Flavor Oscillations in the Sudbury Neutrino Observatory.
Speaker: ALYSIA MARINO, *Fermilab*

This talk will discuss the evidence for neutrino oscillations, with an emphasis on the results from the Sudbury Neutrino Observatory (SNO). With its unique heavy-water volume, SNO can simultaneously measure the electron neutrino flux and the total active neutrino flux coming from the Sun. The SNO results provide compelling model-independent evidence for neutrino flavor changes, providing a solution to the long-standing ''solar neutrino problem''. While these results solve one mystery, there are many remaining questions about neutrinos. This talk will conclude with a discussion of the potential of current and future neutrino experiments.

SESSION E13: JET AND FRAGMENTATION STUDIES
Saturday Afternoon, 22 April 2006
Cumberland G, Hyatt Regency Dallas at 15:30
Andreas Kronfeld, Fermilab, presiding

15:30
E13 1 Inclusive Jet Production using the Midpoint Algorithm in Run II at CDF* CRAIG GROUP, *University of Florida* We present a preliminary measurement of the inclusive jet cross section for jets with transverse momenta above 60 GeV/c and with rapidity up to $|Y|=2.1$. The analysis is performed with approximately 800 pb^{-1} of data taken in proton-antiproton collisions at $\sqrt{s}=1.96$ TeV using the upgraded Collider Detector at Fermilab in Run II. This luminosity is more than twice that of our previous measurement. In addition, the rapidity range has been expanded to include the forward region. The results are compared with next to leading order perturbative QCD predictions based on the CTEQ6.1 parton distribution functions.

*Presented on behalf of the CDF Collaboration.

15:42
E13 2 Study of $q\bar{q}\gamma$ and $gg\gamma$ Fragmentation Using Hadron Production In Radiative Υ Decays HANNAH SWIFT, *University of Kansas* CLEO COLLABORATION, Using data collected by the CLEO III detector at the Cornell Electron Storage Ring, we compare hadron production on the Υ resonances to that of the underlying continuum for the Λ, p, $\bar{p}$, ϕ and f_2. By examining radiative Υ decays versus photon tagged quark-antiquark events, we have a direct comparison of gluon versus quark fragmentation, allowing us to probe the differing manner in which gluons and quarks hadronize.

15:54
E13 3 Two-particle momentum correlations in jets at the Tevatron SERGO JINDARIANI, ANDREY KORYTOV, *University of Florida* ALEXANDRE PRONKO, *Fermilab* CDF COLLABORATION, Presented are the measurements of two-particle momentum correlations in jets produced in p-pbar collisions at center of mass frame energy 1.96 TeV. Studies were performed for charged particles within a restricted opening angle of 0.5 rad around the jet axis and for dijet events with masses ranging from about 60 to 600 GeV. Comparison of the experimental results to the theoretical predictions obtained for partons within the framework of the resummed perturbative QCD (Next-to-leading Log Approximation) shows that the parton momentum correlations do survive the hadronization stage of jet fragmentation, thus giving further support to the hypothesis of Local Parton-Hadron Duality.

16:06
E13 4 Study of Cell Energy Thresholds in CMS Calorimeters for Jet Reconstruction JAMES DOLEN, R. DEMINA, C. JUSTUS, P. TIPTON, M. ZIELINSKI, *University of Rochester* A. BHATTI, *Rockefeller University* CMS COLLABORATION, Noise in the calorimeter of the Compact Muon Solenoid (CMS) can have a significant impact on the reconstruction of low P_T jets. Since noise is associated with individual readouts of calorimeter channels, and the average noise levels vary significantly for different compartments, it is natural to suppress energies of individual hits when building towers for reconstruction of jets and MET. We have proposed new thresholds for calorimeter hits, which are effective in reducing noise contributions to jets, while removing less real jet energy than the often-used cuts on whole towers. The effect of these new thresholds on efficiency, resolution, and fake rate will be presented.

16:18
E13 5 Study on the Effects of Layered Threshold Cuts on Noise in the CMS Calorimeter DYLAN PREDERGAST, R. DEMINA, J. DOLEN, *University of Rochester* R. HARRIS, *FNAL* P. TIPTON, M. ZIELINSKI, *University of Rochester* CMS COLLABORATION, Low P_T jets are important for understanding new physics at the LHC. In this low P_T region, noise can play a substantial role. In order to optimize the energy cuts that best reduce this noise, a quantization of how much noise is in each section of the calorimeter was required. We were then able to compare different energy cuts on different sections of the calorimeter to see where harder or softer cuts needed to be placed. This study used single muon samples to simulate "noise-only" events. We found $\sim$ 8.5 GeV of noise in the calorimeter. We decided on a layered jet energy cut scheme that reduced this noise to $\sim$ 1.4 GeV.

16:30
E13 6 Forward Proton Detection at DØ MURILO RANGEL, *Centro Brasileiro de Pesquisas Fisicas* D0 COLLABORATION, Quantum Chromo-Dynamics (QCD) has been a very successful model describing the strong interaction, but its success has been limited primarily to the perturbative regime. About 40% of the total proton-antiproton cross section at the Tevatron consists of the non-perturbative processes of elastic and diffractive scattering. These processes are better described by the phenomenology of a color singlet exchange of a particle with quantum numbers of the vacuum called the pomeron (Regge theory). The D0 experiment (http://www-d0.fnal.gov) is currently taking data with a forward proton detector (FPD) to better study this process. The FPD data is being used to study the diffractive phenomenology, which has attracted both experimental and theoretical attention. This data provides a unique opportunity to study many topics in the diffractive regime, for instance events which contain a double pomeron exchange. This talk will present FPD data acquired during the last year, focusing on the methods for eliminating background and noise and emphasizing the detector capabilities to explore this interesting physics regime.

16:42
E13 7 Calibrating the CMS Electromagnetic Calorimeter using π^0's JINGZHI ZHANG, D. GONG, Y. KUBOTA, R. RUSACK, *University of Minnesota* Y. GERSTEIN, *Florida State University* CMS COLLABORATION, Calibration defines the ultimate performance of the CMS electromagnetic calorimeter (ECAL) at the LHC. The individual calibration of all 75848 crystal channels to the desired precision of 0.5% is a challenge. $\pi^0 \rightarrow \gamma\gamma$ has a very large production rate and a substantial sample can be accumulated relatively easily. Here we present a study on calibrating this detector in-situ using inclusive π^0's.

16:54
E13 8 QEDXQCD Exponentiation and Shower/ME Matching at High Energies* B.F.L. WARD, SCOTT A. YOST, *Baylor University* We present the theory of QEDXQCD exponentiation and how permits the proper shower/ME matching in precision

LHC physics scenarios. Applications to single heavy gauge boson production at hadron colliders are illustrated.

*Work supported by US DOE grant #DE-FG02-05ER41399 and NATO grant PST.CLG.980342.

SESSION E14: FEW BODY PROBLEMS
Saturday Afternoon, 22 April 2006
Cumberland I, Hyatt Regency Dallas at 15:30

15:30

E14 1 Influence of the N*1440 and N*1535 Resonances in Intermediate Energy pp and np Scattering* CH. ELSTER, *Ohio U.* A. SCHWICK, *U. Tübingen* A. GARDESTIG, *U. South Carolina* F. HINTERBERGER, *U. Bonn* EDDA COLLABORATION, Recent precision measurements of pp spin correlation observables up to 2.5 GeV projectile energy rekindled interest in comparing available models of the NN interaction to those data. It is well known that the Delta resonance plays a dominant role in the energy region between pion production threshold and roughly 1 GeV, and is incorporated in all models of the NN interaction defined in this energy regime. It is natural to assume that when going higher in energy and leaving the regime of the Delta dominance, other low lying, distinct nucleon resonances may be important for a description of the data. Here we study the influence of the N*1440 (decaying mostly to Nπ) and the N*1535 (decaying to Nπ and Nη) on pp and np observables. Though the overall contributions of both N* resonances is much smaller than those of the Delta, they are quite visible in in T=0 channels close to pion threshold. A model for the NN interaction respecting unitarity and based on meson exchange and including the Delta, N*1440, and N*1535 resonances will be compared to np and pp data as well as phase-shift analyses for laboratory energies up to 1.3 GeV.

*Supported in part by the U.S. Dept. of Energy.

15:42

E14 2 Microscopic approach to scattering states in ^{5}He* HARTMUT M. HOFMANN, *University of Erlangen* GERALD M. HALE, *Los Alamos National Laboratory* In the framework of the resonating group model we study scattering states in ^{5}He using realistic two- and three-nucleon forces. We allow for α - neutron and triton - deuteron channels with relative angular momenta up to L = 2. The coupling to the first excited state of the α particle is also taken into account. We compare the results of the calculations to those of a comprehensive R-matrix analysis partial wave by partial wave. The agreement for the S-waves is very good. The calculated P-wave phase shifts do not yet reach the data. Preliminary results indicate the importance of internal D-waves inside the deuteron. The D-wave results are still in progress. We discuss the effects of the NNN-force and the coupling to the α^* - neutron channel.

*Supported by DFG under HO 780/9 (hmh) and by DOE (gmh).

15:54

E14 3 Proton – ^{3}He Elastic Scattering at Low Energies* B. M. FISHER,† C. R. BRUNE,‡ H. J. KARWOWSKI, D. S. LEONARD,§ E. J. LUDWIG, *University of North Carolina at Chapel Hill and Triangle Universities Nuclear Laboratory* T. C. BLACK, *University of North Carolina at Wilmington* M. VIVIANI, A. KIEVSKY, S. ROSATI, *INFN Pisa and University of Pisa* We present new accurate measurements of the differential cross section $\sigma(\theta)$ and the proton analyzing power A_y for proton–^{3}He elastic scattering at various energies. The $\sigma(\theta)$ distributions have been measured at E_p = 0.99, 1.59, 2.24, 3.11, and 4.02 MeV. Full angular distributions of $A_y(\theta)$ have been measured at E_p = 1.60, 2.25, 3.13, and 4.05 MeV. This set of high-precision data is compared to four-body variational calculations employing realistic nucleon-nucleon (NN) and three-nucleon ($3N$) interactions. For the unpolarized cross section the agreement between the theoretical calculation and experimental data is good when a realistic $3N$ potential is included. However, the comparison between the calculated and measured proton analyzing powers reveals discrepancies of approximately 50% at the maximum of each distribution.

*This work was supported in part by the U.S. Department of Energy under Grant No. DE-FG02-97ER41041.
†Present Address: Tulane University, New Orleans, LA.
‡Present Address: Ohio University, Athens, OH.
§Present Address: University of Alabama, Tuscaloosa, AL.

16:06

E14 4 Comparison of results for $N + N$ scattering at low energies* G. M. HALE, C. P. LIU, *Theoretical Division, Los Alamos National Laboratory* We show comparisons of $N + N$ scattering observables calculated from the Nijmegen potential with those obtained from an R-matrix analysis of low-energy measurements for the $N + N$ system. Of particular interest are the spin-dependent S-wave scattering lengths for $n + p$ scattering, and selected observables (with their associated uncertainties) for $n + p$ capture. We will discuss implications of the comparisons for the nature of phenomenological $N - N$ interactions.

*Work supported by the US DoE/NNSA.

16:18

E14 5 Neutron-deuteron scattering in configuration space VLADIMIR SUSLOV, MIKHAIL BRAUN, BRANISLAV VLAHOVIC, *North Carolina Central University, Durham NC, 27707* A new computational method for solving the configuration-space Faddeev equations for the breakup scattering problem [1] has been applied to consider itnd scattering both below and above two-body threshold. To perform numeric calculations for arbitrary nuclear potential and with arbitrary number of partial waves retained, we use approach proposed in [2]. The calculations of the inelasticity and phase-shift, as well the breakup amplitudes for itnd scattering for various lab energies were performed with the charge independent AV14 potential. The results are compared with those of Bochum and Pisa group [3]. 1. V.M. Suslov and B. Vlahovic, Phys. Rev. C **69**, 044003 (2004). 2. S.P. Merkuriev, C. Gignoux and A. Laverne, Ann. Phys. **99**, 30 (1976). 3. W. Glöckle, H. Witala, D. Hüber, H. Kamada, J. Golak, Physics Report, **274**, 107 (1996).

16:30
E14 6 Novel approach to effective interactions for many-body calculations IONEL STETCU, BRUCE R. BARRETT, UBIRAJARA VAN KOLCK, *Univ. of Arizona* Even in the absence of exact solutions from QCD, effective field theories (EFT) provide a modern understanding of the nuclear forces at low energies. Based on a EFT which integrates out the pions as degrees of freedom (pionless theory), we present a new approach to the derivation of effective interactions suitable for many-body calculations by means of the no-core shell model. Such an approach can provide a consistent, order-by-order improvable method to obtain interactions tailored for the model spaces used in the many-body calculations, as well as the corresponding electromagnetic and weak operators. In this work, we concentrate on the description of two-body scattering observables in a restricted harmonic oscillator basis. I.S. and B.R.B. acknowledge partial support by NSF grant numbers PHY0070858 and PHY0244389. U.v.K. acknowledges partial support from DOE grant number DE-FG02-04ER41338 and from the Sloan Foundation.

16:42
E14 7 Calculation of the two-body scattering T-matrix in Configuration Space GEORGE RAWITSCHER, *University of Connecticut* Three-body Faddeev calculations require as input two-body T-matrices. For atomic physics applications configuration space is preferable over momentum space, since the potentials are given in the former. A recently developed solution of the Lippmann-Schwinger integral equation for the one-variable scattering wave function in configuration space [1] has now been extended to obtain the two variable scattering T-matrix, as will be shown. The method is based on spectral expansions into Chebyshev Polynomials of two auxiliary functions in each radial partition, in terms of which the T-matrix is obtained. The result is an important ingredient for the solution of the Faddeev integral equations in configuration space [2]. [1] G. Rawitscher and I. Koltracht, Computing in. Sc. and Eng. **7**, 58 (2005); [2] W. Glöckle and G. Rawitscher "Three-atom scattering via the Faddeev scheme in configuration space," submitted for publication, and physics/0512010 at arxiv.com.

SESSION F1: APS WELCOME RECEPTION
Saturday Evening, 22 April 2006
Union Station, Grand Hall, Hyatt Regency Dallas at 17:30

17:30
F1 1 APS Welcome Reception

SESSION G1: NEW REPORTS FROM MAJOR NATIONAL STUDIES
Saturday Evening, 22 April 2006; Landmark A, Hyatt Regency Dallas at 19:15

19:15
G1 1 Elementary Particle Physics in the 21st Century: Explorations of the Terascale.
HAROLD SHAPIRO, *President Emeritus, Princeton University*

In the 21st century, elementary particle physics is poised to address some of the most basic questions in science. Obtaining the answers to these questions will require a global effort of great scale and complexity. Convened by the National Academies at the request of NSF and DOE, the EPP2010 committee was charged to construct a plan for U.S. participation in this effort. With members drawn from both inside and outside the field, the EPP2010 committee identified the scientific questions that define the future of the field and is recommending a 15-year implementation plan with realistic, ordered priorities to realize these opportunities. The presentation will describe the committee's approach and final report.

20:00
G1 2 Report from the Dark Energy Task Force.
ANDREAS ALBRECHT, *Department of Physics, University of California, Davis*

Understanding the observed cosmic acceleration is widely ranked among the very most compelling of all outstanding problems in physical science. Many believe that nothing short of a revolution will be required in order to integrate the cosmic acceleration (often attributed to "dark energy") with our understanding of fundamental physics. The DETF was formed at the request of DOE, NASA and NSF as a joint subcommittee of the Astronomy and Astrophysics Advisory Committee (AAAC) and the High Energy Physics Advisory Panel (HEPAP) to give advice on optimizing our program of dark energy studies. To this end we have assessed a wide variety of possible techniques and strategies. I will present our main conclusions and discuss their implications.

SESSION H1: RECENT RESULTS IN FLAVOR PHYSICS
Sunday Morning, 23 April 2006; Landmark A, Hyatt Regency Dallas at 8:30
Jack Ritchie, University of Texas, Austin, presiding

8:30
H1 1 CP violation and the Unitarity Triangle.
JAMES OLSEN, *Princeton University*

In the Standard Model of particle physics, the Kobayashi-Maskawa mechanism explains CP violation as arising from a single phase in the weak-interaction Lagrangian describing transitions between different quark flavors. This phase information is conveniently parameterized in the complex plane through the Unitarity Triangle (UT), whose interior angles are CP-violating observables that are directly measurable in decays of the B meson. Although this picture has been dramatically confirmed by the B-Factory experiments through precision measurements of the UT angle $\beta(\phi_1)$, several theories of physics beyond the Standard Model predict additional CP-violating phases that could show observable effects in B decays. In this talk I will summarize recent progress in the understanding of CP violation, including recent measurements of the UT angles $\alpha(\phi_2)$ and $\gamma(\phi_3)$ that are beginning to provide non-trivial constraints on possible scenarios of physics beyond the Standard Model.

9:06
H1 2 Rare Decays.
BRENDAN CASEY, *Brown University*

In this talk we highlight recent results on measurements of, and searches for, rare and exotic decays of heavy hadrons. New world records in peak luminosity are constantly being set at the B-factories and the Tevatron where BaBar, Belle, CDF, and DØ have all accumulated unprecedented data samples. We discuss precision measurements that are now being performed using B decay channels with branching fractions on the order of 10^{-6} and searches for new modes that probe D meson decay near the 10^{-6} level and B meson decay near the 10^{-7} level. These studies are strongly motivated by new physics scenarios that predict large deviations from Standard Model expectations. Emphasis will also be placed on the complementary nature of flavor physics programs at low energy e^+e^- and high energy hadron colliders.

9:42
H1 3 Semileptonic B Decays.
MASAHIRO MORII, *Harvard University*

Semileptonic B decays provide the best experimental probes for the Cabibbo-Kobayashi-Maskawa matrix elements V_{ub} and V_{cb}. A precise determination of the ratio $|V_{ub}/V_{cb}|$ would significantly improve the constraints on the Unitarity Triangle and provide a stringent test of the Standard-Model mechanism for CP violation. In this talk, I will review recent experimental measurements of the inclusive and exclusive semileptonic B decays, and discuss their interpretations.

SESSION H2: TOPICS IN NUCLEAR PHYSICS
Sunday Morning, 23 April 2006; Landmark B, Hyatt Regency Dallas at 8:30
Donald Geesaman, Argonne National Laboratory, presiding

8:30
H2 1 Nuclear structure theory with coupled-cluster techniques.*
DAVID DEAN, *Oak Ridge National Laboratory*

Investigations of rare isotopes in the laboratory are opening the way to understand and clarify the properties of all nuclei and bulk nuclear matter. In this talk I will assess where we stand today in solving the nuclear problem and how future rare isotope facilities will impact our understanding of nuclei. One intriguing aspect of the nuclear problem concerns our ability to describe complex nuclei from the ground up using as input the basic interactions among protons and neutrons. These interactions have their roots in QCD. Success in light nuclear systems was recently demonstrated through quantum Monte Carlo and Hamiltonian diagonalization methods. Our community is also investigating various many-body tech-

niques that will enable descriptions of medium-mass nuclei based on these same interactions. I will describe this exciting frontier of research through illustrating recent progress in the nuclear implementation of coupled-cluster methods, a quantum many-body technique that enjoys great success in quantum chemistry. After describing the basic coupled-cluster ideas, I will illustrate their power by reporting on results of ground- and excited state calculations for Oxygen and Calcium nuclei.

*This research is supported by the Office of Nuclear Physics, Office of Science of the U.S. Department of Energy under Contract Number DE-AC05-00OR22725 with UT-Battelle, LLC (Oak Ridge National Laboratory).

9:06
H2 2 (t,^{3}He) and (^{3}He,t): complementary probes of spin strength for astrophysics and double beta decay.*
REMCO G.T. ZEGERS, *NSCL, The Department of Physics and Astronomy and The Joint Institute for Nuclear Astrophysics, Michigan State University*

Nuclear charge-exchange (CE) experiments at intermediate energies (E~ 100–400 MeV/nucleon) have long been recognized as tools to study the isovector (spin) response of nuclei. The importance of increasing our understanding of collective isovector giant resonances is manifold. Fundamental topics, such as the isovector part of the nucleon-nucleon force and the symmetry part of the nuclear equation of state can be addressed. At the same time, results from CE experiments (in particular the excitation of Gamow-Teller and dipole resonances) are vital for validating theoretical weak transition rates that are input for stellar evolution codes. Furthermore, the accurate knowledge of charge-exchange matrix elements plays an important role in understanding neutrinoless double-beta decay ($0\nu\beta\beta$) and with the current efforts devoted to the experimental search of signals of $0\nu\beta\beta$ there is a strong need to pursue the measurements and reduce the uncertainties in the extraction of these matrix elements. At the NSCL, the (t,^{3}He) charge-exchange reaction at 115 MeV/nucleon has been developed to address these physics issues. It provides an important addition to existing probes in the (n,p)-direction [mainly (n,p) and (d,^{2}He)] since its mirror [(^{3}He,t), i.e. (p,n)-type] can be studied at similar beam energies at RCNP, Japan and in both directions good energy resolutions can be achieved. Since the reaction mechanisms of (t,^{3}He) and (^{3}He,t) are similar, it is possible to understand and reduce uncertainties in the extraction of the structure information. In the presentation, the status of the (t,^{3}He) program and its connection to the (^{3}He,t) experiments will be given.

*Supported by National Science Foundation under Grant No. PHY-0110253 and PHY02-16783 (JINA).

9:42
H2 3 The Role of Strangeness in Nuclear Matter.
ANTHONY THOMAS, *Jefferson Lab*

No study of the properties of dense matter, especially in connection with neutron stars, can be complete without a deep understanding of how strangeness modifies the equation of state. In finite nuclei we have extensive experience of Lambda hyperons, with JLab and KEK, in particular, currently contributing important new data. In most models, the Lambda hyperons enter the baryon population at roughly twice nuclear matter density but beyond this point there is little consensus. Some models would see Sigma hyperons enter soon, while in others the Cascade would enter first. Whether what comes next is a kaon condensate, quark matter, superconducting quark matter or something else is extremely model dependent. We will review recent progress, starting from the quark level, which offers a unified approach to the in-medium effective interactions between hyperons and nucleons as well as nucleons, at densities up to several times nuclear matter density. This same approach also allows for a consistent theoretical treatment of the transition to quark matter.

SESSION H3: ULTRA-HIGH ENERGY COSMIC RAYS: EXPERIMENT AND THEORY
Sunday Morning, 23 April 2006; Landmark C, Hyatt Regency Dallas at 8:30
Sean Carroll, University of Chicago, presiding

8:30
H3 1 Ultra-High-Energy Cosmic Rays: Recent Results From Auger and HiRes.*
STEFAN WESTERHOFF, *Columbia University*

Cosmic ray particles were discovered almost one hundred years ago, but still very little is known about the origin of the most energetic particles, above and around 10^{18} eV. The existence of particles at these energies, the highest energies observed in the Universe, continues to challenge our imagination: where do they come from, how are they accelerated, and how can they travel astronomical distances without substantial loss of energy? We are currently in an exciting new

era in cosmic ray physics, with instruments now producing data of unprecedented quality and quantity to tackle the many open questions. Over the last 5 years, the High Resolution Fly's Eye (HiRes) air fluorescence stereo detector has accumulated data characterized by excellent angular resolution. The world's largest detector for cosmic radiation, the Pierre Auger Observatory in Argentina, is nearing completion, and first results have already been published. In this talk, I will review recent results from the Auger and HiRes experiments on the energy spectrum, composition, and arrival directions of ultra-high-energy cosmic rays.

*Supported by the National Science Foundation under contract NSF-PHY-0500492.

9:06
H3 2 When Particle Physics Confronts Cosmic Ray Data.
ANGELA OLINTO, *University of Chicago*

The origin of the highest energy particles ever to be observed is still a mystery. They are messengers of an extreme universe and they test the limits of physical laws. The largest cosmic ray experiments are starting to probe the extremely high-energy region where pointing to cosmic ray sources is feasible and a long awaited Greisen-Zatsepin- Kuzmin feature in the spectrum is expected. Past experiments have claimed opposing results. The mystery of ultra-high energy cosmic rays will be reviewed in light of the first results from the Pierre Auger Observatory. Auger is under construction, yet first results have already challenged previous views of the physics of ultra-high energy cosmic rays.

9:42
H3 3 Ultra-High Energy Cosmic Neutrinos.
DAVID SALTZBERG, *UCLA Dept. of Physics and Astronomy*

Astrophysical processes appear to produce particles with energies of at least 10^{19-20} eV. Yet extra-galactic astronomy appears to be limited for photons with energies above 10^{14} eV due to absorption. Neutrino astronomy offers the possibility to perform extra-galactic astronomy to these energies and beyond without an absorption cutoff. In addition, the interactions of ultra-high energy (UHE) neutrinos of cosmic origin with local matter may reveal exotic new physics processes that are unavailable to modern accelerators. UHE neutrino telescopes based on optical detection techniques that are currently operating and under construction will soon have apertures on the scale of 10 km^3-sr with excellent thresholds. Radio and acoustic detection techniques have been demonstrated in laboratory experiments and are being used to instrument apertures from 10 to to 10,000 km^3-sr for neutrinos with energies above 10^{16} eV. Neutrino telescopes based on radio detection include the RICE detectors placed on the Amanda strings at the South Pole. The GLUE antennas pointed at the Moon have set limits on the neutrino intensity at higher energies. The best sensitivity at the highest energies comes from the FORTE satellite which looked for interactions in Greenland ice. The upcoming ANITA long-duration balloon flights over Antarctica will be sensitive to neutrinos produced by the interactions of cosmic rays with the cosmic microwave background radiation. Using the acoustic technique, the SAUND collaboration recently performed a UHE neutrino search using hydrophones in the deep sea near the Bahamas. Investigations for even larger apertures include several other detection possibilities, including placing radio and acoustic sensors in large underground salt formations. The acoustic technique may find promise in solid media currently under investigation. The neutrino sensitivity of current and proposed telescopes based on optical, radio, acoustic techniques will be compared for both specific models and in a model-independent fashion.

SESSION H4: NEW MODELS FOR GRADUATE EDUCATION
Sunday Morning, 23 April 2006; Marsalis A, Hyatt Regency Dallas at 8:30
Gay Stewart, University of Arkansas, presiding

8:30
H4 1 Implementing an Industrial Approach into Physics Graduate Education.
KEN VICKERS, *University of Arkansas*

Physics graduate education has attracted a student population with a both high independence and interest in individual professional work. These personality tendencies have been validated in the students' eyes by both the observed professional behaviors of the majority of their faculty, and by the public acceptance of the persona of ''eccentric but brilliant'' physics students. This has resulted in a self-perpetuating cycle of professionals entering the academic workplace whose interest in whole-organization optimization, as well as the skills needed to optimize organizations, are low to non-existent. But at the same time the needs of the country's technical work force, as defined by national gatherings of prominent leaders from academic, industrial, and governmental communities, continue to list human interaction ''soft skills'' as one of the most important professional traits needed by professionals in their careers. This gap between the

physics graduate education and requirements needed by next generation physicists provided an opportunity for experimental approaches to graduate physics education. The University of Arkansas' Physics Department lead the formation of a new experimental approach to interdisciplinary education in the broad field of microelectronics and photonics (microEP) in 1998, resulting in the formation of a stand-alone MS/PhD microEP program. This program implemented an industrial work group approach to graduate education, and won several educational grants including a NSF IGERT and a Department of Education FIPSE. The FIPSE grant in 2001 supported the modification of the industrial work group approach for implementation by the UA physics graduate program to address the gap between national need and current education. This talk will address the key goals of this implementation, the tactics that were put in place to address the goals, and the results of this educational approach since its implementation with the Fall 2001 entering class.

9:06
H4 2 New Models fro Graduate Education.*
RAMON LOPEZ

Overall, graduate education in the United States is widely considered to be of the highest quality, and students from around the world flock to our programs. Nonetheless, there is always room for improvement. In particular, the National Science Foundation has encouraged the development of innovative efforts in graduate education, such as the GK-12 fellowship program and the requirement that large projects like Science and Technology Centers incorporate innovations into the education of graduate students. In this talk I will highlight some current innovations in graduate education, with special focus on programs conducted by the Center for Integrated Space Weather Modeling, a Science and Technology Center funded by the NSF.

*This presentation was supported by CISM, which is funded by the STC Program of the National Science Foundation under Agreement Number ATM-0120950.

9:42
H4 3
DAVID CAMPBELL, *Lawrence Livermore National Laboratory*

This abstract was not received electronically.

SESSION H5: DISCOVERY PROSPECTS AT THE ENERGY FRONTIER
Sunday Morning, 23 April 2006; Pegasus B, Hyatt Regency Dallas at 8:30
Harrison Prosper, Florida State University, presiding

8:30
H5 1 The Coming Revolution in Particle Physics.
OLIVER BAKER, *Hampton University and Jefferson Lab*

Mysteries about the composition of our universe at its most fundamental level are fueling a revolution in particle physics. The nature of dark matter and dark energy, the disparity in gauge boson masses, the absence of primordial antimatter, and other observations make for an exciting period of likely discovery in the field. The physics program at the Large Hadron Collider (LHC) is one of the most likely venues for new discoveries that may shed light on these and other phenomena. I will present an overview of the ATLAS experiment at the LHC and highlight a few examples of profoundly new views of the character of space and time that are predicted to reveal themselves in the early running period.

9:06
H5 2 Discovery prospects at the Large Hadron Collider.
KETEVI ASSAMAGAN, *Brookhaven National Laboratory*

The physics program at the LHC includes precision tests of the Standard Model (SM), the search for the SM Higgs boson, the search for the MSSM Higgs bosons, the search for Super Symmetry, sensitivity to alternative scenarios such as compositeness, large extra dimensions, etc. This requires general purpose detectors with excellent performance. ATLAS and CMS are general purpose detectors under construction for the Large Hadron Collider (LHC). Data taking is expected to start in April 2007. The detector performance and the prospects for discoveries are studied in various physics and detector performance working groups. In this talk, we will review the discovery prospects of the LHC.

9:42
H5 3 Testing the top quark lifetime.
AYANA HOLLOWAY, *Harvard University*

Experiments at the Fermilab Tevatron are collecting large and exceptionally pure samples of top quarks, and performing measurements to confirm that the particle discovered in $p\bar{p}$ collisions a decade ago is the anticipated sixth quark. One unambiguous test is a measurement of the top quark lifetime, which is constrained by the consistency of the Standard Model to be less than 10^{-24} s. I will describe a search for anomalous decay lengths in $t\bar{t}$-like events observed with the Collider Detector at Fermilab (CDF), and report a first direct limit on the t quark lifetime.

SESSION H6: APPLICATIONS OF FREE ELECTRON LASERS I
Sunday Morning, 23 April 2006; Cumberland J, Hyatt Regency Dallas at 8:30
Alan Todd, Advanced Energy Systems, presiding

8:30
H6 1 Materials Processing with FEL Radiation—An Overview.*
MICHAEL J. KELLEY, *Thomas Jefferson National Accelerator Facility*

A unique feature of FEL's is their enormously wide range of output parameters, enabling ''processing by design.'' The FEL's energy delivery can be matched to materials properties, accomplishing the intended transformation. The immediate beneficiary is materials R&D, where systematic experimental investigations can now truly dance with computational modeling to make unique materials. For example, depositing energy into specific organic molecular bonds in a time frame too brief for escape into the rest of the molecule, results in selective bond scission. Collecting the ablated fragments on a substrate affords a molecularly faithful coating. Solvent-related complications of conventional coating are avoided, a greater advantage the wider the range of organics to be explored. Sharply adapting the FEL's design to a specific parameter set and taking advantage of the fall of unit cost with increasing power holds promise for applications in manufacturing. Several potential applications in ablative materials synthesis, rapid thermal processing and surface photochemistry will be briefly discussed.

*Work supported by U.S.Dept.of Energy DEAC05-84-ER40150, Office of Naval Research, Joint Technology Office, Commonwealth of Virginia and Jefferson Lab Laser Processing Consortium.

9:06
H6 2 Infrared Pulsed Laser Deposition: Applications in Photonics and Biomedical Technologies.*
RICHARD HAGLUND, *Vanderbilt University*

Resonant infrared pulsed-laser deposition (RIR-PLD) shows significant promise for synthesizing thin films of small organic molecules, thermoplastic and thermosetting polymers and biopolymers, without compromising structure or functionality. This contrasts with most attempts at UV-PLD of organic materials, which have often been accompanied by severe photochemical or photothermal degradation of the ablated material. Representative recent successes in RIR-PLD include deposition of: polymers for light emission and hole transport; functionalized polymers and nanoparticles for chemical and biological sensing; and biocompatible polymers suitable for coating medical devices or drug-delivery vehicles. Plume imaging and various other optical- and mass-spectroscopy experiments appear to confirm that polymers or organic molecules ablated by resonant infrared laser irradiation experience a high spatial and temporal density of vibrational excitation, but tend to remain in the electronic ground state. The mechanism of RIR-PLD is observed to depend on the anharmonicity of the mid-infrared absorption modes, their finite relaxation time, mode-specific nonlinear absorption, and rapid changes in polymer viscosity as a function of temperature. Many of the RIR-PLD experiments to date were carried out using a tunable, mid-infrared, picosecond free-electron laser. However, if RIR-PLD is to become a practical tool for making organic thin films, it will be necessary to develop more conventional lasers that can achieve a similar combination of high pulse intensity, low pulse energy, high pulse-repetition frequency and moderate average power. In conclusion, the prospects for developing precisely such table-top RIR-PLD systems will be discussed.

*In collaboration with D. M. Bubb, N. L. Dygert, J. S. Horwitz, S. L. Johnson, M. R. Papantonakis and K. E. Schriver. Supported by the Naval Research Laboratory and the Medical Free-Electron Laser Program of the Department of Defense.

9:42
H6 3 Laser Microengineering and the Advances Gained by Use of a FEL.
HENRY HELVAJIAN, *The Aerospace Corporation*

This abstract was not received electronically.

SESSION H7: ASTROBIOLOGY AND PLANETARY EFFECTS
Sunday Morning, 23 April 2006
Pegasus A, Hyatt Regency Dallas at 8:30
James Ryan, University of New Hampshire, presiding

8:30
H7 1 Astrophysical radiation sources and terrestrial biodiversity* ADRIAN MELOTT, *University of Kansas* ASTROBIOLOGY WORKING GROUP, UNIVERSITY OF KANSAS COLLABORATION, Extrasolar events such as gamma-ray bursts and supernovae have long been recognized as threats to the terrestrial biosphere, and possibly a driver of the mutation rate. It has recently become possible to quantify the severity of some of these effects and their expected incidence rate, with the dominant stress likely to be increased UVB at the surface due to ozone depletion, leading to protein and DNA damage to exposed organisms. Substantial fluctuations in the cosmic ray rate are also likely, and supported by terrestrial data. I will summarize results to date, and argue that biodiversity oscillations evident in the fossil record may be understood as a consequence of solar motion within the galaxy.

*We acknowledge support from the NASA Astrobiology program.

8:42
H7 2 Cosmic Rays, CO_2 Runaway, Sea Level Rise and Severe Global Flooding JOHN T.A. ELY, *University of Washington* In CO_2 runaway, the ocean surface layers (which in 1999AD contain, in each 100 m of depth, more CO_2 than the entire atmosphere) can suddenly become a continuous strong source of CO_2 as surface temperatures rise, because the solubility of CO_2 decreases 3 percent per degree Celsius. The evolving CO_2 increases atmospheric greenhouse longwave opacity providing positive feedback accelerating the CO_2 release (without the long time scales of deep ocean processes). Because the present atmospheric CO_2 concentration, 380ppmv, is already so much higher than the 270 ppmv thought to be the preindustrial Pleistocene maximum, it now presents a climate warming forcing so strong that orbital and other climate forcings, which in the past have brought about periodic ice ages, are not able to restore the glaciating mode.

8:54
H7 3 The Cosmogenic Origin of the 62 Myr Biodiversity Oscillation* MIKHAIL MEDVEDEV, ADRIAN MELOTT, *University of Kansas* Temporal variation of the diversity of terrestrial organisms has recently been put on the firm statistical basis. Rohde and Muller (Nature, 434, 208, 2005) have shown, using the de-trended data from Sepkoskis compendium, that the number of marine genera varies periodically with time with approximately 62 $\pm$ 3-million-year period. No satisfactory explanation has been put forward so far. For instance, ''traditional'' explanations of the cycle by the Solar system passing through the galactic spiral arms or the galactic plane do not reproduce the correct phase and/or period. Here we argue that the modulated cosmic ray flux can naturally explain the observed periodicity in the fossil record. We present a physical theory, which based on the cosmic ray propagation in the galactic interstellar medium magnetic turbulence and the Sun's motion in the Milky Way.

*This work was supported by NASA grant NNG-04GM41G and DOE grant DE-FG02-04ER54790.

SESSION H8: NUCLEAR REACTIONS
Sunday Morning, 23 April 2006
Cumberland A, Hyatt Regency Dallas at 8:30
Peggy McMahan, Lawrence Berkeley National Laboratory, presiding

8:30
H8 1 Electron scattering on halo nuclei* CARLOS BERTULANI, *University of Arizona* The inelastic scattering of electrons on weakly-bound nuclei is studied with a model based on the long range of the bound state wavefunction and on the effective-range expansion for the continuum wavefunctions. Three mechanisms have been considered: (a) dissociation of halo nuclei by high energy electrons, (b) dissociation by electrons present target, and (c) Coulomb dissociation. It is shown that the properties of halo nuclei can be studied in electron-radioactive colliders using the electro-disintegration process. A comparison with fixed-target experiments is also performed.

*This research was supported in part by the Department of Energy under Grant No. DE-FG02-04ER41338.

8:42
H8 2 The Search for Target Structure Effects in Elastic Scattering K.W. KEMPER, O.A. MOMOTYUK, B.T. ROEDER, *Florida State University* N. KEELEY, *CEA-Saclay, DSM/DAPNIA/SPhn, France* K. RUSEK, *A. Soltan Institute for Nuclear Studies, Warsaw, Poland* In elastic scattering, the question occurs as to how to separate details of the target structure from those of the projectile when using both standard optical potentials and semi-microscopic potentials in detailed coupled channels calculations. We will show that by graphing the cross section and analyzing power data as a function of momentum transfer rather than scattering angle that it is possible see regions of momentum transfer where effects arise from the projectile alone and regions where the target contribution must be accounted for. For light mass systems, these effects are more easily observed in the data by plotting the scattering cross section with respect to momentum transfer rather than the normally used ratio to Rutherford. The analysis of data for the elastic scattering of polarized ^{7}Li from targets of ^{6}Li, ^{7}Li and ^{12}C will be presented. A similar analysis of previously published data for ^{6}He (1) and ^{6}Li (2) elastic scattering from ^{12}C

will also be presented. (1) V. Lapoux et al., Phys. Rev. C **66**, 034608 (2002). (2) A. Nadasen et al., Phys. Rev. C **47**, 674 (1993). This work was supported in part by the U.S. National Science Foundation and the State of Florida.

8:54

H8 3 Tidal Effects in the Resonance decay of light clusters* ROMUALDO DESOUZA, ALAN MCINTOSH, SYLVIE HUDAN, CARL METELKO, *Dept. of Chemistry, Indiana University/IUCF* An excited nucleus can decay by emission of clusters. These clusters may be excited and themselves subsequently undergo particle decay. Peaks in the relative energy spectrum of the secondary decay products indicate resonance reflecting the discrete internal structure of the primary emitted cluster. Resonance spectroscopy can be used, for example, to determine the temperature of the initial source within a statistical approach. To date however, the effect of the field of the emitting nucleus on the decay of the cluster has been largely neglected. Tidal effects result in the correlation of the relative energy with emission angle as a function of the decay time. We explore the influence of the external Coulomb field on the decay of the first excited state of ^{8}Be in the reaction ^{60}Ni + ^{100}Mo at E/A=11 MeV. Experimental results will be compared with the predictions of a simple Coulomb trajectory model.

*Support by the U.S. Department of Energy Grant No DE.FG02-88ER.40404.

9:06

H8 4 Surrogate Measurement of the ^{237}U(n, f) Reaction Cross Section H. AI, *Yale University* C.W. BEAUSANG, *University of Richmond* L. AHLE, L.A. BERNSTEIN, J.T. BURKE, J.A. CHURCH, K. MOODY, E.B. NORMAN, W. YOUNES, *LLNL* D. BLEUEL, R.M. CLARK, P. FALLON, I.Y. LEE, A.O. MACCHIAVELLI, M.A. MCMAHAN, L.W. PHAIR, E. RODRIGUEZ-VIEITEZ, S. SINHA, M. WIEDEKING, *LBL* The surrogate method of estimating reaction cross section, by inferring from the reaction probability of a different reaction that forms the same excited compound nucleus, has been established to be reliable by recent works. Using this method, the goal of this measurement is to estimate the (n, f) cross section on the short lived ^{237}U through the measurement of the (α, α'f) reaction probability of the long lived ^{238}U. The ^{238}U(α, α'f) experiment was performed at LBNL with the STARS detector (Silicon Telescope Array for Reaction Studies.) Preliminary analysis on the estimation of the ^{237}U(n, f) reaction cross section will be presented. This work was supported by U.S. DOE Grant No. DE-FG02-05ER41379, DE-FG-05NA25929, and Contract No. W-7405-Eng-48, DE-AC03-76SF0098.

9:18

H8 5 Statistical model calculations of heavy-ion induced fusion-fission reactions SCOTT MCCALLA, JOHN LESTONE, *Los Alamos National Laboratory* Statistical model calculations of heavy-ion induced fusion-fission reactions are performed with fission barrier heights, and potential curvatures, at both the equilibrium and saddle points, determined as a function of the total spin, J, the spin about the symmetry axis, K, and the nuclear temperature, T, in a self-consistent manner. The fission saddle points are correctly determined by finding the minimum in the system entropy as a function of deformation along the fission path. It is shown that if the saddle points are incorrectly determined using the turn points in the T=0 potential energy surfaces, that erroneous conclusions can be made regarding the viscosity of nuclear matter. When fission is modeled correctly, vast amounts of heavy-ion induced fission-probability and particle-emission data are consistent with the fission of fully equilibrated systems with the nuclear viscosity determined via the surface plus window dissipation model of Nix and Sierk.

9:30

H8 6 Characterizing deuteron breakup on thin targets at 20 MeV* KRISTEN BROWN, *Lamar High School, Arlington, TX and LBNL* M.A. MCMAHAN, DARREN BLEUEL, LAWRENCE HEILBRONN, LARRY PHAIR, *LBNL* JOHN KEITH III, *LBNL and UC Berkeley* L.A. BERNSTEIN, LARRY AHLE, JASON BURKE, JENNIFER CHURCH, *LLNL* BETHANY LYLES, *LLNL and UC Berkeley* IAN THOMPSON, *University of Surrey* The breakup of a deuteron in the Coulomb field of a larger nucleus is a well-known phenomenon that has been studied for many decades. Deuteron breakup also has the potential of generating a forward-focused, relatively monoenergetic neutron beam at fluxes which are useful for many applications, including reactions on radioactive targets. However, most previous studies of this process have taken place at higher energies (Ed $\geqslant$ 56 MeV) and using thick targets. In order to evaluate the efficacy of deuteron breakup as a neutron source, we have studied the break-up process by measuring proton energy spectra – with and without neutron coincidence – from 2 - 9° in the laboratory using STARS (Silicon Telescope Array for Reaction Studies), on thin targets of Ti and Ta. Proton energy spectra and cross sections will be presented.

*Supported by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

9:42

H8 7 Sub-threshold neutron-induced fission cross sections of ^{240,242}Pu FREDRIK TOVESSON, TONY HILL, *Los Alamos National Laboratory* The ^{240,242}Pu(n,f) cross sections have been measured with a moderated spallation target at the Lujan facility at Los Alamos Neutron Science Center (LANSCE). In this experiment the cross section was measured from thermal energies up to the onset of the fission threshold at a few hundred keV. There are plans to extend the investigated energy range by using the WNR facility, where an un-moderated spallation target produces neutrons up to hundreds of MeV. The capture and fission cross sections for ^{240,242}Pu are important for fast reactor applications and are being measured in support of the Advanced Fuel Cycle Initiative (AFCI). The feasibility of measuring fission cross sections over this large energy rang has already been shown for ^{237}Np, and the present work is the first step towards measuring more short-lived isotopes. These Pu-isotopes are alpha-emitters, and ^{240}Pu has a half-life of only 6560 years. It was shown that the present experimental technique was suitable for handling targets with this high activity.

9:54

H8 8 The Zero Degree Calorimeter for CMS JEFF WOOD, *University of Kansas* CMS COLLABORATION, The Zero Degree Calorimeter (ZDC) is a device currently in the construction stages for use in nuclear research at the Large Hadron Collider (LHC) which is expected to operate by 2007. The ZDC will be used for both particle physics and nuclear physics research is scheduled at LHC. The ZDC itself will consist of plates at 45 degree angles relative to the beam and will be made of tungsten. Between these plates, there are plates of fiber optics that collect

light. The events from colliding beams within the ZDC release Cherenkov light which the fibers then pick up. These many fibers will be fed into a photomultiplier tube with a time resolution of about 25 nanoseconds, the period at which events are expected. One of the problems discussed shall be the tendency of the quartz-based optical fibers to darken over time, so calibration is also necessary. The calibration mechanism will involve injecting a known amount of light into the ZDC itself so that a comparison can be made with the amount of light that is received by the photomultiplier tube. The challenge is creating an injection system resilient enough to withstand a highly radiative environment that will be also compatible with the resolution of the photomultiplier tube.

SESSION H9: UNDERGROUND NEUTRINO EXPERIMENTS AND PROTON DECAY

Sunday Morning, 23 April 2006
Cumberland B, Hyatt Regency Dallas at 8:30
Hamish Robertson, University of Washington, presiding

8:30

H9 1 Second-forbidden beta decay of ^{8}B MINESH BACRANIA, DEREK STORM, R.G. HAMISH ROBERTSON, *Center for Experimental Nuclear Physics and Astrophysics, University of Washington* The second-forbidden beta decay of ^{8}B to the ground state of ^{8}Be would result in the production of solar neutrinos with energies higher those currently expected. The presence of these neutrinos would be a background to a precise measurement of the ^{8}B neutrino spectral shape, and to the detection of solar *hep* neutrinos. We will present an experimental limit on the branching ratio of this transition, and compare these results to a shell-model rate calculation.

8:42

H9 2 Neutrino Mass Implications for Muon Decay Parameters JENNIFER KILE, REBECCA ERWIN, MICHAEL RAMSEY-MUSOLF, PENG WANG, *California Institute of Technology* We use the scale of neutrino mass to derive model-independent naturalness constraints on possible contributions to muon decay parameters from new physics above the electroweak symmetry-breaking scale. Focusing on Dirac neutrinos, we obtain a complete basis of dimension four and dimension six operators that are invariant under the gauge symmetry of the Standard Model and that contribute to both muon decay and neutrino mass. We show that–in the absence of fine-tuning–the most stringent bounds on chirality-changing operators relevant to muon decay arise from one-loop contributions to neutrino mass and obtain bounds on the operator coefficients that are approximately 100 times stronger than bounds previously obtained in the literature. We arrive at bounds on the corresponding contributions to the Michel parameters that are six or more orders of magnitude below present experimental limits.

8:54

H9 3 Periodicity studies of solar neutrino signals at the Sudbury Neutrino Observatory AUBRA ANTHONY, SUDBURY NEUTRINO OBSERVATORY COLLABORATION, The Sudbury Neutrino Observatory collaboration has performed a search for sinusoidal periodicity in the ^{8}B solar neutrino flux, and has found no evidence of variations for periods between 1 day and 10 years. I describe here an effort to use the Rayleigh Power Test to probe periodicities in the SNO data in a higher frequency range than has been previously sampled ($>$ 1 day^{-1}). This has the advantage of sensitivity to neutrino flux variations that might arise due to solar oscillatory activity, particularly gravitational mode oscillations (''g-mode'' oscillations), which are confined to the interior of the sun.

9:06

H9 4 SNO neutral current reaction detector array: sensitivity of the neutrons and alphas signal reconstuction to the electronics calibration GERSENDE PRIOR, *Lawrence Berkeley National Laboratory* SNO COLLABORATION, At the Sudbury Neutrino Observatory (SNO), in Ontario, Canada, an array of neutron detectors has been deployed recently to observe the neutral current reaction on deuterium. It consists of 36 $^3He - CF_4$ and 4 $^4He - CF_4$ vertical counters arranged symmetrically relative to the center of the heavy water target. With two years of data taking, enough statistics would provide an improved measurement of the total solar neutrino flux. In order to best understand data provided by this new set of detectors, electronics calibration are performed on a regular basis. Dedicated calibration campaigns were also performed to measure different electronics constants in the neutron detector electronics system. In this talk, a study of the impact of the electronics parameters on the signal reconstruction and pulse shape determination for neutrons and alphas will be presented.

9:18

H9 5 Measuring Cherenkov Backgrounds from Proportional Counters in SNO* STANLEY SEIBERT, *University of Texas at Austin* SUDBURY NEUTRINO OBSERVATORY COLLABORATION, In the current phase of operation of the Sudbury Neutrino Observatory, He-3 proportional counters have been deployed in the center of the detector to measure neutron production from neutral-current interactions between neutrinos and deuterons in the heavy water. Radioactive decays of Bi-214 and Tl-208 in the counters produce gammas of sufficient energy to photodisintegrate deuterons, which become a background to the neutral current measurement. We have measured the background rate in-situ using Cherenkov light detected with SNO's 9456 inward-looking photomultiplier tubes. A maximum likelihood method is used to separate backgrounds in the heavy water from backgrounds in the proportional counters based upon the spatial distribution of low energy Cherenkov event vertices. Uncertainties on the backgrounds have been estimated using calibration data taken with both a distributed Na-24 source, and a contained Th source deployed at various points in the detector.

*This project supported by Department of Energy grants DE-FG02-04ER41332 and DE-FG02-93ER40757.

9:30

H9 6 Alpha Backgrounds in the SNO ^{3}He Proportional Counter Array* LAURA STONEHILL, *Los Alamos National Laboratory* SNO COLLABORATION, The Sudbury Neutrino Observatory (SNO) has recently deployed an array of proportional counters known as Neutral Current Detectors (NCDs) to detect thermalized neutrons via the ^{3}He(n,p)^{3}H reaction. The primary physics background to the neutron-capture signal is alpha particle emission from uranium- and thorium-chain decays in the NCD walls. The expected capture rate of neutrons from the neutral-current neutrino reaction on deuterium is three per day and the intrinsic alpha background rate is approximately 250 alphas per day. Fewer than 10% of these alphas fall into the energy range where neutron-capture signals occur, and a substantial number of these can be eliminated by pulse-shape analysis. This talk will focus on measurements of the alpha backgrounds in the NCDs and the extent to which these alphas contaminate the neutron-capture signal region.

*This work was supported by the U. S. Department of Energy Office of Nuclear Physics.

9:42

H9 7 Muon Reconstruction in the Sudbury Neutrino Observatory CHRISTOPHER KYBA, *University of Pennsylvania* SUDBURY NEUTRINO OBSERVATORY COLLABORATION, The Sudbury Neutrino Observatory is a water Cerenkov detector located 2km under a flat rock overburden. At SNO's depth cosmic muons range out at a zenith angle of approximately 65 degrees, making it possible for SNO to measure the unoscillated atmospheric neutrino flux by observing neutrino induced muons. The approximate spherical symmetry of the detector results in a characteristic event topology for through-going muon events that depends very strongly on the muon track length but not on the direction or entrance point of the muon. An impact parameter based maximum likelihood reconstruction algorithm which incorporates both the phototube charge and time information will be discussed in this talk. The information contained in the hit pattern makes it possible to reconstruct through-going muons at very large radii, which will allow SNO to use a fiducial area which is close to the total cross sectional area of the detector.

9:54

H9 8 Searches for Proton Decay in Super-Kamiokande SCOTT CLARK, *Boston University* SUPER-KAMIOKANDE COLLABORATION, The results of searches for proton decay via the modes $p \rightarrow e^+\pi^0$ and p $\rightarrow \bar{\nu}K^+$ using the Super-Kamiokande detector will be presented. These represent updates to previous searches using the same detector.

10:06

H9 9 Study of a highly-segmented HPGe detector at the Oroville Low-Background counting facility* REYCO HENNING, *LBNL* DAVID CAMPBELL, *LLNL* YUEN-DAT CHAN, *LBNL* KEVIN LESKO, *LBNL* MICHELLE PERRY, *Florida State University* ALAN POON, *LBNL* KAI VETTER, *LLNL* We present initial results of a study of a 8×5 segmented HPGe detector at the Oroville low radioactive background counting facility. The goal is to field a highly-segmented detector at a remote, low-background facility for an extended period of time and to evaluate its efficiency of rejecting residual radioactive backgrounds at such a facility. Applications of this study to the proposed Majorana experiment that will search for the neutrinoless double-beta decay of ^{76}Ge will also be discussed.

*This work is supported by the DOE Office of Nuclear Science.

SESSION H10: PRODUCTION STUDIES IN E^+E^- COLLISIONS

Sunday Morning, 23 April 2006
Cumberland C, Hyatt Regency Dallas at 8:30
Bruce Berger, Lawrence Berkeley National Laboratory, presiding

8:30

H10 1 Dipion Transitions from $\Upsilon(3S)$ and $\Upsilon(2S)$ TODD PEDLAR, *Luther College* CLEO COLLABORATION, The CLEO experiment has collected 5.8 million $\Upsilon(3S)$ and 7.8 million $\Upsilon(2S)$ decays. We report recent results of measurements of both charged and neutral two-pion transitions: $\Upsilon(3S) \rightarrow \Upsilon(2S)\pi\pi$, $\Upsilon(3S) \rightarrow \Upsilon(1S)\pi\pi$ and $\Upsilon(2S) \rightarrow \Upsilon(1S)\pi\pi$. Branching ratios for these transitions, two-pion invariant mass distributions, and angular distributions of the pions will be presented.

8:42

H10 2 Exclusive χ_c decays to multibody final states RUKSHANA PATEL, *University of Florida* CLEO COLLABORATION, Using a 3.08 million data sample obtained at the $\psi(2S)$ resonance collected by the CLEO detector; we measure exclusive hadronic decays of the P-wave spin-triplet charmonium states χ_{cJ}, where $J = 0,1,2$, into multibody final states involving one or more neutral mesons. Such decay rates may provide some hint on the decay patterns of glueball states, and help to test perturbative QCD.

8:54

H10 3 Studies of e^+e^- annihilations into vector-vector final states KAI YI, *Stanford Linear Accelerator Center* BABAR COLLABORATION, The observation of the exclusive reaction $e^+e^- \rightarrow \phi\rho$ will be reported. The final state C-parity configuration and the production angle distribution suggest that this is produced through a two-virtual-photon annihilation process. The cross section for this process at $\sqrt{s} = 10.58GeV$ based on approximately 230fb^{-1} of BaBar data will be reported. We also report results of searches for other exclusive processes, such as $e^+e^- \rightarrow \phi\phi$, in the same data set.

9:06

H10 4 Measurement of Upper Limits for $\Upsilon \rightarrow \gamma + \mathcal{R}$ Decays SHAWN HENDERSON, *University of Kansas* CLEO COLLABORATION, Using data collected from the CLEO III detector at the Cornell Electron Storage Ring, we report on a new study of exclusive radiative decays of the Υ resonances into two-body final states $\mathcal{R}\gamma$, with $\mathcal{R}$ some resonant hadronic state. We present pre-

liminary upper limits for these $\Upsilon(1S)$, $\Upsilon(2S)$, and $\Upsilon(3S)$ two-body decays as a function of γ energy. Additionally, we place upper limits on two-body final states of continuum $q\bar{q}$ decays for center-of-mass energies just below the $\Upsilon(1S)$, $\Upsilon(2S)$, and $\Upsilon(3S)$ energies.

9:18

H10 5 Comparisons of Exact Results for the Virtual Photon Contribution to Single Hard Bremsstrahlung in Radiative Return for Electron-Positron Annihilation* SCOTT YOST, B.F.L. WARD, *Baylor University* STANISLAW JADACH, *CERN Theory Division, Cracow Institute of Nuclear Physics* We compare fully differential exact results for the virtual photon correction to single hard photon bremsstrahlung obtained using independent calculations, both for e^+e^- annihilation at high-energy colliders and for radiative returnapplications. The results are compared using Monte Carlo evaluations of the matrix elements as well as by direct analytical evaluation of certain critical limits. Special attention is given to the issues of numerical stability and the treatment of finite-mass corrections. It is found that agreement on the order of 10^{-5} or better is obtained over most of the range of hard photon energies, at CMS energies relevant to both high energy collisions and radiative return experiments.

*Work partly supported by Department of Energy grant DE-FG02-05ER41399 and NATO grant PST.CLG.980342.

SESSION H11: RELATIVISTIC SIMULATIONS OF NEUTRON STARS, BLACK HOLES, AND PLASMAS

Sunday Morning, 23 April 2006
Cumberland E, Hyatt Regency Dallas at 8:30
Harald Pfeiffer, California Institute of Technology, presiding

8:30

H11 1 Binary neutron stars: Equilibrium models beyond spatial conformal flatness* KOJI URYU, *UWM* FRANCOIS LIMOUSIN, *Paris-Meudon Observatory* JOHN FRIEDMAN, *UWM* ERIC GOURGOULHON, *Paris-Meudon observatory* MASARU SHIBATA, *University of Tokyo* Equilibria of binary neutron stars in close circular orbits are computed numerically in a waveless approximation to general relativity. The new formulation exactly solves the Einstein-Euler system written in 3+1 form on a spacelike hypersurface. All components of the field equation are written elliptic equations, and hence all metric components, including the spatial metric, have Coulomb-type fall off. We choose the time-derivative of conformal three-metric to vanish on a spacelike hypersurface for a waveless condition, and impose helical symmetry for the other quantities. Two independent numerical codes, one based on a finite difference method, the other on a spectral method, are developed, and solution sequences that model inspiraling binary neutron stars during the final several orbits are successfully computed. The binding energy of the system near its final orbit deviates from earlier results of third post-Newtonian and of spatially conformally flat calculations. The new solutions may serve as initial data for merger simulations and as members of quasiequilibrium sequences to generate gravitational wave templates, and may improve estimates of the gravitational-wave cutoff frequency set by the last inspiral orbit.

*This work was supported by NSF grant PHY 0071044 and Monbukagakusho Grant 17030004 and 17540232.

8:42

H11 2 Models of helically symmetric binary systems JOCELYN READ, SHIN'ICHIROU YOSHIDA, *Department of Physics, University of Wisconsin-Milwaukee* BENJAMIN BROMLEY, *Department of Physics, University of Utah* KOJI URYU, JOHN FRIEDMAN, *Department of Physics, University of Wisconsin-Milwaukee* We report results from helically symmetric scalar field models and first results from a convergent helically symmetric binary neutron star code; these are models stationary in the rotating frame of a source with constant angular velocity Ω. In the scalar field models and the neutron star code, helical symmetry leads to a system of mixed elliptic-hyperbolic character. The scalar field models involve nonlinear terms of the form ψ^3, $(\nabla\psi)^2$, and $\psi\Box\psi$ that mimic nonlinear terms of the Einstein equation. Convergence is strikingly different for different signs of each nonlinear term; it is typically insensitive to the iterative method used; and it improves with an outer boundary in the near zone. In the neutron star code, convergence has been achieved only for an outer boundary less than $\sim$ 1 wavelength from the source or for a code that imposes helical symmetry only inside a near zone of that size. The inaccuracy of helically symmetric solutions with appropriate boundary conditions should be comparable to the inaccuracy of a waveless approximation that neglects gravitational waves; and the (near zone) solutions we obtain for waveless and helically symmetric BNScodes with the same boundary conditions nearly coincide.

8:54

H11 3 Neutron Star—Black Hole Mergers: Gravitational waves and implications for short GRBs* PABLO LAGUNA, *Penn State* FRED RASIO, EMMANOUELA RANTSIOU, *Northwestern University* SHIHO KOBAYASHI, *Liverpool University* A promising source of gravitational radiation in LIGO's sensitivity window is the inspiral and coalescence of a binary system consisting of a BH and a NS. There is additional interest in BH-NS binaries because they could play a key role as the central engine for short GRBs. If this is indeed the scenario, BH-NS binaries will give us a unique opportunity for *multi-messenger* astronomy, namely mergers that would be able to be seen both in the electromagnetic and gravitational windows. We present results of general relativistic SPH simulations of BH-NS merger, including estimates of the gravitational waves emitted during these astronomical events.

*Supported in part by NSG grants PHY-0244788 and PHY-0114375.

9:06

H11 4 Simulations of magnetized, differentially rotating neutron stars in full general relativity BRANSON C. STEPHENS, *University of Illinois at Urbana-Champaign* MATTHEW D. DUEZ, *Cornell University* YUK TUNG LIU, STUART L. SHAPIRO, *University of Illinois at Urbana-Champaign* MASARU SHIBATA, *University of Tokyo* Many problems at the forefront of theoretical astrophysics require the treatment of magnetized fluids in dynamical, strongly curved spacetimes. In order

to tackle such problems, we have recently developed a code which evolves the full Einstein-Maxwell-MHD system of equations. We employ this code to track the evolution of magnetized hypermassive neutron stars (HMNSs), which are equilibrium configurations supported against collapse by rapid differential rotation. HMNSs may form as possible transient remnants of binary neutron star mergers or through core collapse. We find that secular angular momentum transport due to magnetic braking and the magnetorotational instability results in the collapse of the HMNSs to rotating black holes surrounded by massive accretion tori. For comparison, we also evolve non-hypermassive but differentially rotating neutron stars with magnetic fields. Though we do not find collapse, an extended, torus-like structure does form for stars with excessive spin.

9:18

H11 5 Relativistic magnetohydrodynamics with black hole excision: Application to short gamma-ray bursts YUK TUNG LIU, *University of Illinois at Urbana-Champaign* MATTHEW DUEZ, *Cornell University* STUART SHAPIRO, *University of Illinois at Urbana-Champaign* MASARU SHIBATA, *University of Tokyo* BRANSON STEPHENS, *University of Illinois at Urbana-Champaign* A hypermassive neutron star (HMNS) is a possible transient formed after the merger of a neutron star binary. In our latest magnetohydrodynamic simulations in full general relativity, we find that a magnetized HMNS undergoes ''delayed'' collapse to a rotating black hole (BH) as a result of angular momentum transport via magnetic braking and the magnetorotational instability. The outcome is a BH surrounded by a massive, hot torus with a collimated magnetic field. To follow the subsequent evolution of this system, we continue the evolution using a black hole excision technique. We find that the system quickly settles down to a quasi-stationary state. The torus is hot and accretes onto the BH quasi-steadily. This BH-torus system is a promising central engine for the short-duration gamma-ray bursts. This model predicts that a short gamma-ray burst formed in this scenario should accompany a burst of gravitational waves and neutrinos.

9:30

H11 6 MHD in general relativity DAVID NEILSEN, ERIC HIRSCHMANN, *Brigham Young University* MATTHEW ANDERSON, LUIS LEHNER, *Louisiana State University* STEVEN LIEBLING, *Long Island University* Magnetic fields play an important role in many astrophysical phenomena. In this talk we present our method for solving the ideal MHD equations in general relativity. We discuss black hole excision, AMR for both fluid and geometric variables, and evolutions with dynamic geometry. Preliminary results on a black hole spacetime will be presented.

9:42

H11 7 Relativistic MHD and black hole excision: Formulation and initial tests* ERIC HIRSCHMANN, DAVID NEILSEN, STEVEN MILLWARD, *Brigham Young University* It is widely expected that strong magnetic fields are an important factor in the dynamics of many relativistic and energetic astrophysical phenomena. As a consequence, several groups have begun work on developing approaches to simulating the equations of relativistic magnetohydrodynamics. We present one such approach, including our formalism, high resolution shock capturing method on multiple coordinate patches, primitive variable solver and solenoidal constraint solver. We present tests and results in flat space.

*Work supported by the National Science Foundation.

9:54

H11 8 Relativistic magnetohydrodynamics with adaptive mesh refinement MATTHEW ANDERSON, *Louisiana State University* ERIC HIRSCHMANN, *Brigham Young University* STEVE LIEBLING, *Long Island University* DAVID NEILSEN, *Brigham Young University* Simulations involving relativistic fluids frequently require the numerical treatment of a large range of time and length scales. Parallel adaptive mesh refinement (AMR) techniques can greatly reduce the computational expense of such simulations by adaptively placing greater mesh resolution where needed in order to control error size. We present several relativistic magnetohydrodynamic simulations in 3+1 dimensions using parallel, vertex centered AMR. We focus on several special relativistic tests: the relativistic rotor, spherical shock, and Komissarov shocktube. Performance measures and speedups are also presented.

10:06

H11 9 Introducing Flow-er: A Hydrodynamics Code for Relativistic and Newtonian Flows* PATRICK MOTL, IGNACIO OLABARRIETA, JOEL TOHLINE, *Louisiana State University* We present a new numerical code (Flow-er) for calculating astrophysical flows in 1, 2 or 3 dimensions. We have implemented equations appropriate for the treatment of Newtonian gravity as well as the general relativistic formalism to treat flows with either a static or dynamic metric. The heart of the code is the recent non-oscillatory central difference scheme by Kurganov and Tadmor (2000). With this technique, we do not require a characteristic decomposition or the solution of Riemann problems that are required by most other high resolution, shock capturing techniques. Furthermore, the KT scheme naturally incorporates the Method of Lines, allowing considerable flexibility in the choice of time integrators. We have implemented several interpolation kernels that allow us to choose the spatial accuracy of an evolution. Flow-er has been tested against an independent implementation of the KT scheme to solve the relativistic equations in 1d - which we also describe. Flow-er can serve as the driver for the hydrodynamical portion of a simulation utilizing adaptive mesh refinement or on a unigrid. In addition to describing Flow-er, we present results from several test problems.

*We are pleased to acknowledge support for this work from the National Science Foundation through grants PHY-0326311 and AST-0407070.

SESSION H12: NEW DIRECTIONS IN PARTICLE THEORY

Sunday Morning, 23 April 2006
Cumberland F, Hyatt Regency Dallas at 8:30
Abdulmajeed Abdurrahman, Shippensburg University, presiding

8:30

H12 1 Quantum mechanics using Fradkin's representation* K. V. SHAJESH, KIMBALL MILTON, *University of Oklahoma* Fradkin's representation is a general method of attacking problems in quantum field theory, having as its basis the functional approach of Schwinger. As a pedagogical illustration of that method, we explicitly formulate it for quantum mechanics (field theory in one

dimension) and apply it to the solution of Schrodinger's equation for the quantum harmonic oscillator.

*US Department of Energy.

8:42

H12 2 On the Origin of the Klein-Gordon-Dirac Expression, and its Implication in Particle Mass Ratios D.T. FROEDGE, *Formerly Auburn University* This paper puts fourth the proposition that Klein-Gordon-Dirac wave equation is descended from a more general expression, and the solutions of the more general expression illustrate known particle properties including potentials and mass ratios. The particle solutions of the general expression encompass the particles general properties as well as the electromagnetic interaction. A plausible derivation of the mass ratios for particles is shown to imply certain allowed internal modes, and allows separation of the general equation into periodic and non-periodic equations. The modes and mass ratios are shown for the leptons, the proton, the neutron and the W boson, to a reasonable degree of accuracy.

8:54

H12 3 Vacuum Structure and Dynamics: Particle Formation J.X. ZHENG-JOHANSSON, *IOFPR, SWE* P.-I. JOHANSSON, *Uppsala Univ, SWE* We model the vacuum as filled of neutral vacuuons, each consisting of a p- vaculeon of charge +e at the core and an n- vaculeon of -e on the envelope, mutually bound with a Coulomb energy $\sim 10^6$ J. The model is derived based on overall experimental observations. In particular, as shown in the pair annihilation $e^- + e^+ \rightarrow \gamma + \gamma$, the two emitted γ rays carry the energy ($2M_ec^2 = 1022$ keV) converted from the mass $2M_{e^-}$ of e^- and e^+ only, whilst the Coulomb potential energy $V = -e^2/4\pi\epsilon_0 r_0$ between their charges $+e$ and $-e$ separated at r_0, are not released. Energy conservation requires V and its certain carriers must remain in the vacuum after the annihilation. The afore-modeled vacuum will be polarized by the static field of an external charge, induced with a shear elasticity, and thereby able to propagate the disturbances of the charge's accelerating movements as transverse elastic waves—whence the electromagnetic waves. We have given a systematic representation of the statics and dynamics of this vacuum based on classical equations of motion and solutions (JXZJ & P-IJ, *Unification of Classical, Quantum and Relativistic Mechanics and the Four Forces*, Fwd Prof R Lundin, Nova Science, NY, 2005). The solutions in particular yield a basic material particle, like an electron, proton, etc, formed of a massless oscillatory charge and its resulting electromagnetic waves in the vacuum, having the overall observational properties of the basic material particles.

9:06

H12 4 Multidimensional cut-off technique for Casimir energy of massless scalar fields with applications to Bose-Einstein condensates* ARIEL EDERY, *Bishop's* Quantum fluctuations of massless scalar fields represented by quantum fluctuations of the quasiparticle vacuum in a zero-temperature weakly-interacting dilute Bose-Einstein condensate (BEC) may well provide the first experimental arena for measuring the Casimir force of a field other than the electromagnetic field. This would constitute a real Casimir force measurement–due to quantum fluctuations–in contrast to thermal fluctuation effects. We develop a multidimensional cut-off technique for calculating the Casimir energy of massless scalar fields in d-dimensional rectangular spaces with arbitrary lengths. We explicitly evaluate the multidimensional remainder and express it in a form that converges exponentially fast. Most importantly, we show that the division between analytical and remainder is not arbitrary but has a natural physical interpretation. The analytical part can be viewed as the sum of individual parallel plate energies and the remainder as an interaction energy. The results are applied to the Casimir force in a zero-temperature weakly-interacting dilute BEC.

*Work supported via NSERC's discovery grant.

9:18

H12 5 Superluminal Quantum Models of the Electron and the Photon RICHARD GAUTHIER, *Santa Rosa, CA* A spatial model of a free electron (or a positron) is formed by a proposed helically circulating point-like charged superluminal quantum. The model includes the Dirac equation's electron spin $1/2\,\hbar$ and magnetic moment $e\hbar/2m$ as well as three Dirac equation measures of the electron's Zitterbewegung (jittery motion): a speed of light velocity c, a frequency of $2mc^2/h = 2.5 \times 10^{20}$ hz, and a radius of $1/2\,\hbar/mc = 1.9 \times 10^{-13}$m. The electron's superluminal quantum has a closed double-looped helical trajectory whose circular axis' double-looped length is one Compton wavelength h/mc. The superluminal quantum's maximum speed in the electron model's rest frame is $2.797c$. In the electron model's rest frame, the equations for the superluminal quantum's position are:

$$x(t) = R_0(1 + \sqrt{2}\cos(\omega_0 t))\cos(2\omega_0 t)$$
$$y(t) = R_0(1 + \sqrt{2}\cos(\omega_0 t))\sin(2\omega_0 t)$$
$$z(t) = R_0\sqrt{2}\sin(\omega_0 t)$$

where $R_0 = 1/2\,\hbar/mc$ and $\omega_0 = mc^2/\hbar$. A photon is modeled by an uncharged superluminal quantum moving at $1.414c$ along an open 45-degree helical trajectory with radius $R = \lambda/2\pi$. http://www.superluminalquantum.org

9:30

H12 6 Nonlinear finite self-energy classical electron model BAXTER ARMSTRONG, A classical electron model is proposed having finite self-energy e^2/r_0, stability, and Lorentz invariance. The electrostatic field energy density provides a nonlinear spherically symmetric microscopic integrable charge and energy distribution of infinite extent in the rest frame. In motion a coupling equation required for Lorentz invariance is defined between the radius of a spherically symmetric core containing the charge e and rest mass m_0, and its linear velocity v. It separates the charge and rest mass from the exterior electromagnetic field kinetic energy, providing a proxy size, demonstrating point-particle behavior and displaying the Coulomb field. The core radius decreases with increasing v, approaching zero as v$\rightarrow$ c. Analogies to the uncertainty principle and Zitterbewegung appear. Results of current theory are unchanged. Although the classical self energy is finite, its Coulomb field will produce some of the divergences encountered in QED. This derivation shows that the theory expands the scope of special relativity beyond point particles to include this class of extended charged particles.

9:42

H12 7 Chaotic behavior of the renormalization group flow and standard model parameters ERVIN GOLDFAIN, *OptiSolve Consulting* Despite years of sustained research efforts, a consistent and comprehensive understanding of standard model parameters is missing. For example, models based on the Higgs doublet or supersymmetry, as well as leptogenesis, grand unification and see-

saw mechanisms offer at most an incomplete picture with little or no experimental evidence. Our work suggests that the spectrum of particle masses, gauge couplings and fermion mixing angles may be derived from the chaotic regime of the renormalization group flow. We find that the observed hierarchies of parameters amount to a series of scaling ratios depending on the Feigenbaum constant. Since fermion mass scaling ratios and mixing matrices can be parameterized in terms of the Cabibbo angle, this finding provides a natural connection between the Cabibbo angle and the Feigenbaum constant. Moreover, it is shown that the model can accommodate hypothetical generations of both heavy and ultra-light fermions that are expected to emerge beyond the energy range of the standard model. A representative example in this regard is the fourth family neutrino whose detection is anticipated at future linear colliders.

9:54

H12 8 Schwinger's Measurement Algebra, Preons and the Lepton Masses CARL BRANNEN, *Liquafaction Inc.* In the 1950s and 1960s, Julian Schwinger developed an elegant general scheme for quantum kinematics and dynamics appropriate to systems with a finite number of dynamical variables, now knowns as ''Schwinger's Measurement Algebra'' (SMA). The SMA has seen little use, largely because it is non relativistic in that it does not allow for particle creation. In this paper, we apply the SMA to the problem of modeling tightly bound subparticles (preons) of the leptons and quarks. We discuss the structure of the ideals of Clifford algebras and, applying this to the elementary fermions, derive a preon substructure for the quarks and leptons. We show that matrices of SMA type elements can be used to model the quarks and leptons under the assumption that the preons are of such high energy that they cannot be created in normal interactions. This gives a definition of the SMA for the composite particle in terms of the SMA of its constituents. We solve the resulting matrix equation for the quarks and leptons. We show that the mass operator for the charged leptons is related to the democratic mass matrix used in the Koide mass formula.

10:06

H12 9 On the Structure of Leptonic Families and Currents of the Vector Nature RASULKHOZHA S. SHARAFIDDINOV, *Institute of Nuclear Physics, Uzbekistan Academy of Sciences* Any of leptonic neutrino similarly to a kind of lepton has a Dirac mass responsible as well as for its Coulomb's behavior. Such a neutrino can possess both electric charge and vector dipole moment. Their form factor appears, for example, at the polarized neutrinos scattering in the field of a spinless nucleus. We derive an equation which relates the masses to a ratio of Dirac and Pauli form factors of each lepton and its neutrino. A new theory of fermions unification is suggested. In this theory, the leptons and their neutrinos are united in families not only of the left - handed $SU(2)_L$ - doublets but also of the right - handed $SU(2)_R$ - singlets. Thereby it predicts the existence in nature of the right - left dileptons and paradileptons. A formation of any of them is responsible for the legality of conservation of charge, lepton flavors and full lepton number. Therefore, each of earlier measured processes originated at the conservation both of summed electric charge and of any lepton number may serve as the first confirmation of a given theory, in which the mass, charge and vector moment of the neutrino proportionally respectively to the mass, charge and vector moment of lepton of the same family.

SESSION H13: TOP QUARK PROPERTIES I
Sunday Morning, 23 April 2006
Cumberland G, Hyatt Regency Dallas at 8:30
Reinhard Schwienhorst, Michigan State University, presiding

8:30

H13 1 Search for Single Top Quark Production at DØ LIANG LI, *University of California, Riverside* DZERO COLLABORATION, Protons and antiprotons are collided in Run II at the Fermilab Tevatron at a center of mass energy of 1.96 TeV. We present results of an improved search for single top quark production in these collisions using a dataset of approximately 360 pb^{-1} collected with the DØdetector. This analysis considers both production modes, s-channel tb and t-channel tqb, and makes use of secondary-vertex tagging to identify jets originating from b quarks as well as neural networks to separate the expected signals from backgrounds.

8:42

H13 2 Searches for Single Top Production at CDF* JASON SLAUNWHITE, *The Ohio State Univ.* CDF COLLABORATION, We present recent results from searches for single-top-quark production at CDF in p-pbar collisions at 1.96 TeV. Individual top quarks are expected to be produced in association with bottom quarks mainly through the exchange of an off-mass-shell W boson (s-channel), or the W-gluon fusion process (t-channel). We select events with one charged lepton, high missing transverse energy and at least 2 jets, one of which is identified as a b-quark using the CDF Silicon detector. It is a challenge to distinguish the single top signal from significant backgrounds from W+jets processes with heavy flavour, eg Wbb, Wcc, Wc. We perform a combined search for the s- and t-channels, along with individual searches for each channel.

*For the CDF Collaboration.

8:54

H13 3 Search for Single Top Quarks Produced via Flavor-Changing Neutral-Current Couplings at DØ SUPRIYA JAIN, *University of California, Riverside* DZERO COLLABORATION, The large mass of the top quark, close to the electroweak symmetry-breaking scale, makes it a good candidate for probing physics beyond the Standard Model, including possible anomalous couplings. One form these couplings can take is with flavor-changing neutral currents, which can give rise to a single top quark in the final state through gluon exchange, together with a c or u quark in the initial or final state. We search for single top quark production through both the t-c-g and t-u-g couplings, using the DØ detector at the Fermilab Tevatron collider, and present limits on the anomalous coupling parameters κ_c/Λ and κ_u/Λ, where Λ defines the scale of new physics and κ_c (κ_u) defines the strength of the t-c-g (t-u-g) couplings.

9:06

H13 4 A Search for Resonant $t\bar{t}$ Production at DØ AMNON HAREL, *University of Rochester* DZERO COLLABORATION, We report on a search for a massive particle that decays to $t\bar{t}$. The search is performed using $t\bar{t}$ candidates in the lepton+jets channel. A constrained kinematic fit, with top quark mass fixed, is used to evaluate the $t\bar{t}$ invariant mass for each candidate. We then search for deviations from the $t\bar{t}$ mass distribution predicted by QCD.

9:18

H13 5 Search for Dilepton Signatures Containing Tau Leptons in Top Events at CDF* STEPHANE TOURNEUR, *LPNHE - Univ. Paris 6* CDF COLLABORATION, We present a measurement of the branching ratio of the top quark decaying exclusively into third generation particles: into a b quark, a tau lepton and a tau neutrino. The analysis is performed on the data collected by CDF during the Tevatron run II. We use top pair events in which, each top decaying into Wb, one W produces an electron or a muon, and the other W gives a tau decaying into hadrons and a neutrino. The result constitutes a first test of the lepton universality in the realm of the top physics.

*For the CDF Collaboration.

9:30

H13 6 First Measurement of $\sigma(gg \rightarrow t\bar{t})/\sigma(q\bar{q} \rightarrow t\bar{t})$ in $p\bar{p}$ Collisions at $\sqrt{s} = 1.96$ TeV* SHABNAZ PASHAPOUR, *Univ. of Toronto* CDF COLLABORATION, Following the discovery of the top quark, various studies have been dedicated to understanding the properties of this heavy particle. We will present the first measurement of the relative rate of $t\bar{t}$ production through gluon-gluon fusion in quark-antiquark annihilation, $\sigma(gg \rightarrow t\bar{t})/\sigma(q\bar{q} \rightarrow t\bar{t})$. This measurement uses about 0.7 fb^{-1} of $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV collected by the Collider Detector at Fermilab (CDF). It provides a test of the QCD predictions for this pair-production mechanism, and a technique to test for unexpected sources of top quark production. The average number of gluons in the initial state of candidate $t\bar{t}$ events is measured using the low p_T charged particle multiplicity, and the charged particle multiplicity is determined using W+n jet(s) and dijet data calibration samples, verified using Standard Model calculations.

*For the CDF Collaboration. This work has been supported by Natural Sciences and Research Council of Canada.

SESSION H14: NOVEL TECHNIQUES
Sunday Morning, 23 April 2006
Cumberland I, Hyatt Regency Dallas at 8:30

8:30

H14 1 New CP-violation and preferred-frame tests with polarized electrons CLAIRE CRAMER, *University of Washington* BLAYNE HECKEL, TED COOK, ERIC ADELBERGER, We report new results from our torsion pendulum test for spin-coupled interactions. Our experiment uses the torque produced on a spin-polarized torsion pendulum containing 8×10^{22} polarized electrons as a sensitive measure of weak spin-coupled forces. Results can be interpreted as constraints on CP-violating interactions between the pendulum's polarized electrons and unpolarized matter in the surrounding environment, velocity-dependent interactions, and preferred-frame effects that would cause the electrons to precess about a direction fixed in inertial space. When interpreted in the context of Kostelecký's Standard Model Extension, limits on CPT and Lorentz violating parameters are at the level of 10^{-22} eV in the electron sector. These represent a factor of one hundred improvement over previously reported results, and should be compared to the benchmark value $m_e^2/M_P = 2 \times 10^{-17}$ eV.

8:42

H14 2 ^{3}He Relaxation Study at Low Temperature for the Neutron Electric Dipole Moment Experiment* QIANG YE, *Duke University/TUNL* The search for the existence of a nonzero neutron electric dipole moment (EDM) is a direct search of time reversal symmetry violation and has the potential to reveal new sources of CP violation beyond the Standard Model and may have a significant impact on our understanding of baryogenesis. A new experiment has been proposed to provide a new way to measure the neutron EDM with unprecedented sensitivity. The experiment requires that the ^{3}He polarization to have little or negligible loss during each measurement period. Therefore, understanding the relaxation mechanism of polarized ^{3}He and maintaining its polarization at the unique nEDM experimental conditions is essential. We have studied the longitudinal relaxation time of ^{3}He vapor for the first time from a deuterated tetraphenyl butadiene (d-TPB) coated acrylic cell in a diluted mixture of ^{3}He-^{4}He at a temperature of 1.9K and first set of results will be reported. A d-TPB coated acrylic cells will be used in the neutron EDM experiment. It is important to extend our current work down to $\sim$ 500mK and to a ^{3}He concentration closer to that of the nEDM experiment. Such measurements are being planned with the use of a dilution refrigerator and a SQUID setup for the monitoring of the ^{3}He polarization.

*This work is supported by the School of Arts and Science of the Duke University, the U.S. Department of Energy under contract number DE-FG02-03ER41231, and a subcontract through the University of California, Los Alamos National Laboratory.

8:54

H14 3 Calculating Periodic Solutions to "Truly Nonlinear" Oscillatory ODE's* RONALD MICKENS, *Clark Atlanta University* "Truly nonlinear" oscillators (in one dimension) are modeled by second-order, ordinary differential equations having the form

$$(*)\ddot{x}+f(x)=\epsilon g(x,\dot{x}),$$

where the elastic restoring force $f(x)$ does not contain a linear term, ϵ is a positive parameter (which may or may not be small), and $g(x,\dot{x})$ is a polynomial function of $(x,\dot{x})$. A particular example of $f(x)$ is

$$(**)f(x)=x^{p/q},\ p=(2n+1),\ q=(2m+1),$$

where (n,m) are non-negative integers. The significant issue for Eq. (*) is that analytical approximations to its periodic solutions can be calculated. In general, when ϵ is small, Eq. (*) does not have a mathematical structure such that the standard perturbation methods can be used. We demonstrate that an iteration procedure can be formulated such that excellent approximations to the periodic solutions are obtained for the ODE given by Eq. (*). The

method is illustrated by applying it to the case where $f(x) = x^3$ and $\epsilon = 0$.

*Research supported by a grant from DOE and Title III Funds at Clark Atlanta University.

9:06

H14 4 Analysis of the Lev Ginzburg Equation* MICHAEL BELLAMY, RONALD MICKENS, *Clark Atlanta University* A second-order differential equation taking the form

$$(*)\ddot{x}=f(x,\dot{x},p)$$

was derived by Ginzburg.[1] In this ODE, $\dot{x}$ and $\ddot{x}$ represent the first and second derivatives with respect to time; and p stands for four parameters, $p = (p_1,p_2,p_3,p_4)$, where (p_1,p_2,p_3) are non-negative and p_4 can be of either sign. The function f is linear in x, but quadratic in $\dot{x}$. Ginzburg's main purpose in constructing this equation was to take into consideration the ''inertial behavior of biological populations.'' However, this ODE can also be used to model a variety of physical dynamical systems.[2] With four parameters, there is a broad range of possible solution behaviors. Our present purpose is to prove that limit-cycle behavior can occur for Eq. (*) under the appropriate conditions on the parameters. We demonstrate this result by means of the Hopf bifurcation theory.[3] [1]L. Ginzburg and M. Colyvan, Ecological Orbits (Oxford, New York, 2004). [2]S. H. Strogatz, Nonlinear Dynamics and Chaos (Addison-Wesley, Reading, MA, 1994). [3]E. Beltrami, Mathematics for Dynamic Modeling (Academic Press, Boston, 1987).

*Research supported in part by grant from DOE and Title III Funds at Clark Atlanta University.

9:18

H14 5 An Approach to Modeling Extreme Loading of Structures using Peridynamics* PAUL DEMMIE, *Sandia National Laboratories* Peridynamics is a theory of continuum mechanics that is formulated in terms of integral equations rather than partial differential equations. It assumes that particles in a continuum interact across a finite distance as in molecular dynamics. The integral equations remain valid regardless of any fractures or other discontinuities that may emerge due to loading. In contrast, the differential equations of classical theory break down when a discontinuity appears. Peridynamics predicts the deformation and failure of structures under dynamic loading, especially failure due to fracture. Cracks emerge spontaneously as a result of the equations of motion and material model and grow in whatever direction is energetically favorable. The implementation does not require a separate law that tells cracks when and where to grow. We describe peridynamics theory and provide some examples of its application as implemented in the EMU computer code. EMU is mesh free. Therefore, it does not use elements, and there are no geometrical objects connecting the grid points. Hence, there is no need for a mesh generator when modeling complex structures. Only the generation of grid points is required.

*Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000.

9:30

H14 6 3D real holographic image movies are projected into a volumetric display using dynamic digital micromirror device (DMD) holograms. MICHAEL L. HUEBSCHMAN, JEREMY HUNT, HAROLD R. GARNER, *Eugene McDermott Center for Human Growth and Development, Center for Translational Research, University of Texas Southwestern Medical Center at Dallas* The Texas Instruments Digital Micromirror Device (DMD) is being used as the recording medium for display of pre-calculated digital holograms. The high intensity throughput of the reflected laser light from DMD holograms enables volumetric display of projected real images as well as virtual images. A single DMD and single laser projector system has been designed to reconstruct projected images in a 6''× 6''× 4.5'' volumetric display. The volumetric display is composed of twenty-four, 6''-square, PSCT liquid crystal plates which are each cycled on and off to reduce unnecessary scatter in the volume. The DMD is an XGA format array, 1024x768, with 13.6 micron pitch mirrors. This holographic projection system has been used in the assessment of hologram image resolution, maximum image size, optical focusing of the real image, image look-around, and physiological depth cues. Dynamic movement images are projected by transferring the appropriately sequenced holograms to the DMD at movie frame rates.

SESSION H16: SHERWOOD I
Sunday Morning, 23 April 2006; Landmark D, Hyatt Regency Dallas at 8:30
John M. Finn, Los Alamos National Laboratory, presiding

8:30

H16 1 Fusion Physics Toward ITER.*
R.D. STAMBAUGH, *General Atomics*

Stars are powered by fusion, the energy released by fusing together light nuclei, using gravitational confinement of plasma. Fusion on earth will be done in a 100 million degree plasma made of deuterium and tritium and confined by magnetic fields or inertia. The worldwide fusion research community will construct ITER, the first experiment that will burn a DT plasma by copious fusion reactions. ITER's nominal goal is to create 500 MW of fusion power. An energy gain of 10 will mean the plasma is dominantly self-heated by the fusion-produced alpha particles. ITER's all superconducting magnet technology and steady-state heat removal technology will enable nominal 400 s pulses to allow the study of burning plasmas on the longest intrinsic timescale of the confined plasma - diffusive redistribution of the electrical currents in the plasma. The advances in magnetic confinement physics that have led to this opportunity will be described,

as well as the research opportunities afforded by ITER. The physics of confining stable plasmas and heating them will produce the high gain state in ITER. Sustained burn will come from the physics of controlling currents in plasmas and how the hot plasma is interfaced to its room temperature surroundings. ITER will provide our first experience with how fusion plasma self-heating will profoundly affect the complex, interlinked physical processes that occur in confined plasmas.

*Work supported by US DOE under DE-FC02-04ER54698.

9:30
H16 2 Interpretation of frequency sweeping of $n = 0$ mode in JET.
H.L. BERK, *University of Texas at Austin*

Persistent rapid up and down frequency chirping modes with a toroidal mode number of zero ($n = 0$) are observed in the JET tokamak when energetic ions, in the range of several hundred keV, are created by high field side ion cyclotron resonance frequency heating. Fokker-Planck calculations demonstrate that the heating method enables the formation of an energetically inverted ion distribution which supplies the free energy for the ions to excite a global geodesic acoustic mode (GGAM). The large frequency shifts of this mode are attributed to the formation of phase space structures whose frequencies, which are locked to an ion orbit resonance frequency, are forced to continually shift so that energetic particle energy can be released to counterbalance the energy dissipation present in the background plasma. In collaboration with C.J. Boswell, MIT; D. Borba, A.C.A. Figueiredo, Center for Nuclear Fusion Association; T. Johnson, Alfven Laboratory, KTH; M.F.F. Nave, Center for Nuclear Fusion Association; S.D. Pinches, Max Planck Institute for Plasma Physics; S.E. Sharapov, UKEA Culham Science Centre; and T. Zhou, University of Texas at Austin.

10:00
H16 3 News from the Geodesic Acoustic Mode: Magnetic Shear-, q-, and Geometry Effect.
KLAUS HALLATSCHEK, *Max-Planck-Institute for Plasma Physics*

The generation of GAMs has been studied in greater depth by three-dimensional turbulence simulations. A change of the magnetic shear, in particular, a switch to negative shear profoundly affects the amplification mechanics of the GAMs. Essentially, negative shear flips the symmetry of the turbulence modes with respect to the shear flows, altering the sign of the Stringer-Winsor forces. The phenomenon readily suggests an experimental test, which would quantify the role of the Stringer-Winsor effect in comparison to the Reynolds stress in exciting the GAMs. The safety factor q controls the coupling of the GAMs to the parallel velocity, i.e., sound waves. Lowering q increases this coupling. Since the parallel sound waves in turn are heavily damped by the turbulence, they act as a loss channel. Thus sufficiently low q leads to a quench of the GAM activity, as has been found in recent experiments, too. Finally, the shape of the flux surfaces has great influence on the frequency of the modes and the relative strength of the Stringer-Winsor force. Again, the results suggest a relatively straightforward comparison with experiments. In all these cases one has to carefully differentiate between changes of the turbulence brought about by the parameters, and changed properties of the GAMs and their interaction with the turbulence.

SESSION I1: QCD: THE LATTICE MEETS DATA
Sunday Morning, 23 April 2006; Landmark A, Hyatt Regency Dallas at 10:30
Sally Dawson, Brookhaven National Laboratory, presiding

10:30
I1 1 Lattice QCD: A Tool for Flavor Physics.
ANDREAS KRONFELD, *Fermilab*

For many years, numerical lattice gauge theory has promised, some day, to provide a tool for calculating hadronic properties *ab initio* from QCD. This talk argues, in three parts, that that day is here. First, we recall recent success in lattice QCD, reproducing well-measured masses, mass splittings, and light-meson decay constants. Second, we present a handful of *pre*dictions, and their subsequent confirmation by experiment, designed to test our methods. Third, we survey the status and prospects of lattice-QCD calculations needed to understand flavor physics.

11:06
I1 2 The New Charmonium Resonances.
ROBERT CAHN, *Lawrence Berkeley National Laboratory*

The charmonium states - resonances made of a charmed quark and a charmed antiquark - have for thirty years represented the simplest strongly interacting system. To a good approximation these states could be understood as non-relativistic bound states with a static potential. The spin-dependent effects could be understood as simple perturbations. Coupling to the continuum of true charmed states provided a refinement. Discoveries at the B-factories and at the Tevatron collider have changed all this. I review these discoveries, the difficulties in describing them within the canonical picture, and possible non-canonical explanations.

11:42
I1 3 Recent Results from CLEO-c.
TODD PEDLAR, *Luther College*

The CLEO-c experiment at Cornell University has completed its second year of running. We report on recent results in QCD physics obtained by CLEO-c from data taken in the charmonium and charm meson regions, and by her predecessor experiment, CLEO-III, from data taken at the bottomonium resonances. Particular attention will be paid to comparisons with Lattice Gauge calculations of relevant quantities. Among the experimental results that will be presented are measurements of charm meson decay constants and semileptonic decays, non-$D\bar{D}$ decays of $\psi(3770)$, and heavy quarkonium leptonic widths, masses and hadronic decays.

SESSION I2: APPLICATIONS OF NUCLEAR SCIENCE
Sunday Morning, 23 April 2006; Landmark B, Hyatt Regency Dallas at 10:30

10:30
I2 1 Laser spectroscopic determination of the ^{6}He nuclear charge radius.*
LI-BANG WANG, *Los Alamos National Laboratory*

The weakly bound ^{6}He nucleus is an excellent testing ground for few-body nuclear calculations and is of great interest since its halo structure was suggested in the 80s. In this thesis work, we performed precision laser spectroscopy on individual metastable ^{6}He atoms confined and cooled in a magneto-optical trap (MOT). This technique enabled us to accurately measure the isotope shift between ^{6}He and ^{4}He to be 43194.772(56) MHz in the 2^3S_1–3^3P_2 transition at 389 nm. Based on this measurement and the atomic theory calculation, the root-mean-square charge radius of ^{6}He was determined to be 2.054(14) fm [1]. This result confirmed the neutron-halo structure of the ^{6}He nucleus model-independently for the first time and helps reveal the structure of the loosely bound system. This experiment also demonstrates a new technique for precision laser spectroscopy of short-lived radioactive atoms, and provides a unique atomic method for nuclear physics studies. [1] L.-B. Wang et al., Phys. Rev. Lett. **93**, 142501 (2004).

*Work performed at Argonne National Laboratory in collaboration with K. Bailey, G.W.F. Drake, J.P. Greene, D. Henderson, R.J. Holt, R.V.F. Janssens, C.L. Jiang, Z.-T. Lu, P. Mueller, T.P. OConnor, R.C. Pardo, K.E. Rehm, J.P. Schiffer, and X.D. Tang.

11:06
I2 2 The Task of Detecting Illicit Nuclear Material: Status and Challenges.
RICHARD KOUZES, *Pacific Northwest National Laboratory*

In August 1994, police at the Munich airport intercepted a suitcase from Moscow with half a kilogram of nuclear-reactor fuel, of which 363 grams was weapons- grade plutonium. A few months later police seized 2.7 kilograms of highly enriched uranium from a former worker at a Russian nuclear institute and his accomplices in Prague. These are just two of 18 incidents involving the smuggling of weapons grade nuclear materials between 1993 and 2004 reported by the International Atomic Energy Agency. The consequences of a stolen or improvised nuclear device being exploded in a U.S. city would be world changing. The concern over the possibility of a nuclear weapon, or the material for a weapon or a radiological dispersion device, being smuggled across U.S. borders has led to the deployment of radiation detection equipment at the borders. Related efforts are occurring around the world. Radiation portal monitors are used as the main screening tool, supplemented by handheld detectors, personal radiation detectors, and x-ray imaging systems. Passive

detection techniques combined with imaging, and possibly active techniques, are the current available tools for screening cargo for items of concern. There are a number of physics limitations to what is possible with each technology given the presence of naturally occurring radioactive materials, commercial sources, and medical radionuclides in the stream of commerce. There have been a number of lessons learned to date from the various efforts in the U.S. and internationally about the capability for interdicting illicit nuclear material.

11:42
I2 3 High Performance Organ-Specific Nuclear Medicine Imagers.
STAN MAJEWSKI

One of the exciting applications of nuclear science is nuclear medicine. Well-known diagnostic imaging tools such as PET and SPECT (as well as MRI) were developed as spin-offs of basic scientific research in atomic and nuclear physics. Development of modern instrumentation for applications in particle physics experiments offers an opportunity to contribute to development of improved nuclear medicine (gamma and positron) imagers, complementing the present set of standard imaging tools (PET, SPECT, MRI, ultrasound, fMRI, MEG, etc). Several examples of new high performance imagers developed in national laboratories in collaboration with academia will be given to demonstrate this spin-off activity. These imagers are designed to specifically image organs such as breast, heart, head (brain), or prostate. The remaining and potentially most important challenging application field for dedicated nuclear medicine imagers is to assist with cancer radiation treatments. Better control of radiation dose delivery requires development of new compact in-situ imagers becoming integral parts of the radiation delivery systems using either external beams or based on radiation delivery by inserting or injecting radioactive sources (gamma, beta or alpha emitters) into tumors.

SESSION I5: THEORIES OF GRAVITY, DARK ENERGY, AND COSMOLOGY
Sunday Morning, 23 April 2006; Pegasus B, Hyatt Regency Dallas at 10:30
Joseph Lykken, Fermilab, presiding

10:30
I5 1 String theory and cosmology.
SHAMIT KACHRU, *Stanford University*

There is increasing evidence for a period of accelerated expansion or inflation in the very early universe. Most inflationary models are sensitive to ultra-violet properties of the underlying fundamental theory, including quantum gravity effects, so it makes sense to explore inflationary model building in the context of a UV complete framework. I discuss recent ideas about inflation in string theory, and describe some striking consequences of the simplest models. I also outline how, with simple and conservative assumptions, one can argue that there is a ''landscape'' of string vacua which encompasses diverse possibilities for low-energy physics.

11:06
I5 2 Implications of the Accelerating Universe for Fundamental Physics.
NIMA ARKANI-HAMED, *Harvard University*

This abstract was not received electronically.

11:42
I5 3 Differentiating between Modified Gravity and Dark Energy.
ROMAN SCOCCIMARRO, *New York University*

I'll discuss current ideas on how to distinguish whether the acceleration of the universe is caused by dark energy or modifications of general relativity.

SESSION I6: APPLICATIONS OF FREE ELECTRON LASERS II
Sunday Morning, 23 April 2006; Cumberland J, Hyatt Regency Dallas at 10:30
Alan Todd, Advanced Energy Systems, presiding

10:30
I6 1 Free Electron Laser Nitriding of Metals: From basic physics to industrial applications.*
PETER SCHAAF,† *University of Goettingen, II. Institute of Physics, 37077 Goettingen, Germany*

Functional or smart surfaces and coatings play an increasingly decisive role for the applicability and performance of all modern materials, and numerous methods were developed for their fabrication, stretching from simple PVD and CVD processes to complicated plasma and hybrid methods. Recently, it was established that short laser pulses of high enough energy can induce a direct laser synthesis of functional coatings if the materials surface is irradiated in a reactive atmosphere. The process is based on complicated and combined laser plasma gas material interactions. The Free Electron Laser (FEL) can be just the right tool to drive the mentioned process into the direction of industrial applicability. The high power and the flexibility in its temporal shaping of the FEL at the Jefferson Lab was the drive to make first experiments on the direct laser synthesis of functional coatings. Titanium, aluminum, silicon and steel have been treated with the FEL in pure nitrogen atmosphere at 0.1 MPa pressure. The wavelength of the irradiation was 3.1 micron with a micropulse repetition rate of 37 MHz. The micropulses were shaped to macropulses with durations ranging from 50 to 1000 μs at 2 to 60 Hz. A meandering scanning technique was used to irradiate larger areas. The produced coatings were investigated by a number or methods (X-ray diffraction including stress and texture analysis, elemental depth profiling by resonant nuclear reaction analysis and Rutherford backscattering spectrometry, nanoindentation hardness, Scanning electron microscopy, EDX). The obtained results correlate to numerical simulations of the melt bath, diffusion and solidification dynamics. For titanium, it was found that TiN coatings of up to 100 micron thickness could be easily produced. Furthermore, (100) texturing of the TiN could be obtained for certain timings of the FEL, which could be explained by the numerical modeling and solidification behavior during the FEL irradiation. (1) E. Carpene, M. Shinn, and P. Schaaf, Synthesis of highly oriented TiNx coatings by free electron laser processing of Ti in nitrogen gas, Applied Physics A **80**, 1707–1710 (2005). (2) P. Schaaf, M. Kahle, and E. Carpene, Reactive Laser Plasma Coating Formation, Surface and Coatings Technology, **200**, 608–611 (2005).

*Supported by the Thomas Jefferson National Accelerator Facility, Free Electron Laser Department, Newport News, VA 23606, USA, and the German Research Foundation DFG.
†pschaaf@uni-goettingen.de

11:06
I6 2 Quality Carbon Nanotube Production in Quantity using FEL Radiation.
MICHAEL SMITH, *NASA*

This abstract was not received electronically.

11:42
I6 3
JEROME HASTINGS, *Stanford Linear Accelerator Center*

This abstract was not received electronically.

SESSION I7: ASTROPARTICLE PHYSICS I
Sunday Morning, 23 April 2006
Pegasus A, Hyatt Regency Dallas at 10:30, presiding

10:30
I7 1 Signals in the Co-annihilation Region of Supersymmetry
RICHARD ARNOWITT, ADAM AURISANO, BHASKAR DUTTA, TERUKI KAMON, PAUL SIMEON, DAVID TOBACK, PETER WAGNER, *Texas A&M University* NIKOLAY KOLEV, *University of Regina* TEXAS A&M UNIVERSITY COLLABORATION, UNIVERSITY OF REGINA COLLABORATION, An unanswered problem in physics is the identity of the cold dark matter (CDM) in the universe. One of the leading candidates is a supersymmetric (SUSY) particle, the lightest neutralino. Recent cosmological measurements by the WMAP experiment have tightly constrained the SUSY parameter space in the mSUGRA model to the so called ''co-annihilation'' region in which the lightest supersymmetric tau lepton and the lightest neutralino are nearly degenerate in mass. We examine the prospects of using LHC detectors to measure this mass difference and present preliminary results.

10:42
I7 2 A new procedure to distinguish between dark energy models and modified gravity models* MUSTAPHA ISHAK, *University of Texas at Dallas* AMOL UPADHYE, *Princeton University* DAVID SPERGEL, *Princeton University* The acceleration of the expansion of the universe is one of the most important and challenging problems in physics. It is important to determine if the cosmic acceleration is due to a dark energy component in the universe or if it is due to a modification in the gravity sector. We

report here results on a procedure that we proposed recently and that will allow one to make such a distinction. The procedure goes one important step further than constraining the equation of state. It uses different combinations of simulated data of CMB, Weak Gravitational Lensing, and Supernovae. We explored the fact that the effect of dark energy on the expansion history must be consistent with the effect of dark energy on the growth factor of large-scale structure. The procedure is able to detect inconsistencies in this relation and thus provides a test to detect signatures of modified gravity models.

*Work supported by NASA TA-NNG04GK55G, AST-0413793, NSERC-PDF, and NSF-GRF.

10:54

I7 3 Neutron background studies and results from the Cryogenic Dark Matter Search RAUL HENNINGS-YEOMANS, *Case Western Reserve University* THE CRYOGENIC DARK MATTER SEARCH (CDMS II) COLLABORATION, Nonbaryonic dark matter makes one quarter of the energy density of the Universe. The Weakly Interacting Massive Particle (WIMP) is a dark matter candidate with a scattering cross section with an atomic nucleus of the order of the weak interaction and a mass comparable to that of an atomic nucleus. Results of the two tower run from the Cryogenic Dark Matter Search (CDMS II), consisting of a total exposure of 34 kg-d for germanium and 12 kg-d for silicon, at the Soudan Underground Laboratory are presented. Also we present studies of the neutron background relevant for our upcoming 10-fold more sensitive 5-tower run, as well as for other experiments in search of dark matter. During the two-tower run, no nuclear-recoil events exceeding expected background were observed for a WIMP mass of 60 GeV/c^2. The limit from Ge (Si) is a factor of 2.5 (10) lower than previous results, allowing to set further constraints on the predictions of supersymetric models. Our further studies of the muon-induced neutron background based on Monte Carlo simulations show that by replacing part of the outer polyethylene of the CDMS II shield by a neutron multiplicity meter, for example by Gd-loaded liquid scintillator (0.5% gadolinium content) with a PMT read out would allow us to better predict the absolute number of unvetoed nuclear recoils compared with present methods which rely on multiple nuclear recoil events.

11:06

I7 4 Precision Studies of Dark Energy with the LSST* DAVID BURKE, *SLAC* LSST COLLABORATION, The proposed Large Synoptic Survey Telescope (LSST) will confront ''dark energy'' and ''dark matter'' with multiple precision probes of space and time, evolution of energy and matter, and the relation between cosmological kinematics and dynamics in a single deep survey of half the astronomical sky. The LSST optical throughput will be 100 times that of any existing facility. In the ten-year LSST mission the 2-D shapes and 3-D positions of over 3 billion galaxies will be measured ($z \leq 3$), and each year 250,000 Type Ia supernovae detected ($z \leq 1$). The LSST will enable studies of tomographic projections of shear correlations of weakly lensed galaxies, distributions of galaxies and clusters, and baryon acoustic oscillations. With LSST studies of supernova ''standard candles'' and ''synchronized clocks'' (time delays of multiply-lensed supernovae), these will precisely determine cosmological parameters. Six eigenmodes of the DE equation of state will be mapped by LSST data, and combined with CMB data, the lowest eigenvalues determined with percent-level accuracy.

*LSST R&D is funded through NSF AST-0132798, DOE laboratories, LSST Corporation members, and private donations.

11:18

I7 5 Long-wavelength perturbations as a test of dark energy EDMUND BERTSCHINGER, *MIT Department of Physics* Long-wavelength perturbations of a Robertson-Walker universe evolve like Robertson-Walker universes with perturbed spatial curvature or equation of state. This result, which is true in a much broader class of theories than general relativity, reduces the time-dependence of long-wavelength density perturbations to quadratures involving the Hubble expansion rate. Thus, measurements of the growth-rate of long-wavelength cosmological density perturbations, such as weak lensing or the abundance of galaxy clusters, should in principle provide no more information about dark energy than measurements of the expansion history made, e.g., by supernovae or baryon acoustic oscillations. Nevertheless, it is worthwhile to measure both the expansion history of the universe and the evolution of clustering because (1) the two methods have different systematic errors, (2) comparison of the two methods provides an independent test of the Cosmological Principle, and (3) comparison also provides information about long-wavelength entropy perturbations. A violation of the quadrature relation could signify the presence of new long-range forces.

11:30

I7 6 Dark matter detection with mini-CLEAN JAMES NIKKEL, M. HARRISON, B. JORNS, W. LIPPINCOTT, D. McKINSEY, *Yale University* A. HIME, D. MEI, K. RIELAGE, L. STONEHILL, *Los Alamos National Laboratory* K. COAKLEY, *National Institute for Standards and Technology* M. BOULAY, *Queen's University* D. GASTLER, E. KEARNS, *Boston University* CLEAN COLLABORATION, mini-CLEAN is a planned WIMP detector containing approximately 100 kg of liquid neon or liquid argon scintillator viewed by 32 photomultipliers. The cryogens will be cooled with a pulse-tube refrigerator, allowing either liquid to be used as the active detection medium. The ability to exchange the two scintillators, with different sensitivities to WIMPs and fast neutrons, will allow both of these event populations to be distinguished and characterized. New measurements of the scintillation yield and time dependence for both gamma ray Compton scattering events and low energy nuclear recoil events in liquid neon and liquid argon show highly effective pulse-shape discrimination at low energies. Recent tests of photomultipliers at liquid neon temperature, as well as measurements of neon purification will be presented. The predicted sensitivity of mini-CLEAN to WIMP dark matter will be discussed. Results from mini-CLEAN will also provide key parameters for the design of a future 100-ton CLEAN detector, with simultaneous sensitivity to pp solar neutrinos and WIMPs.

11:42

I7 7 Neutron Background in WIMP Dark Matter Detectors Using Liquid Argon and Liquid Neon* ANDREW HIME, DONGMING MEI, *Los Alamos National Laboratory* CLEAN COLLABORATION, Neutron-induced nuclear recoil represents an irreducible background in detectors aimed at the direct detection of WIMP dark matter. Muon-induced neutrons can be adequately suppressed by staging experiments sufficiently deep

underground, however, it is also critical to suppress neutron production via (α,n) interactions due to naturally occurring radioactivity in detector construction materials. We present the results of simulations for the mini-CLEAN detector under development to search for WIMP dark matter using 100 kg of liquid argon or liquid neon as the target material. We show that neutron backgrounds can be sufficiently suppressed in a conceptually simple detector using the coincidence between the prompt nuclear recoil signal and the delayed neutron capture gamma ray.

*This work is supported with funds from the Los Alamos Directed Research and Development program.

11:54
I7 8 Updated RICE Bounds on Ultrahigh Energy Neutrino fluxes and interactions SHAHID HUSSAIN, *Bartol Research Institute* DOUGLAS McKAY, *University of Kansas* We explore limits on low scale gravity models set by results from the Radio Ice Cherenkov Experiment's (RICE) ongoing search for cosmic ray neutrinos in the cosmogenic, or GZK, energy range. The bound on, M_D, the fundamental scale of gravity, depends upon cosmogenic flux model, black hole formation and decay treatments, inclusion of graviton mediated elastic neutrino processes, and the number of large extra dimensions, d. We find bounds in the interval 0.9 TeV $<$ M_D $<$ 10 TeV. Values d = 5, 6 and 7, for which laboratory and astrophysical bounds on LSG models are less restrictive, lead to essentially the same limits on M_D.

12:06
I7 9 The Search for Dark Matter Using the Gamma Ray Large Area Telescope (GLAST)* ELLIOTT BLOOM,† PING WANG,‡LAWERENCE WAI, *KIPAC-SLAC, Stanford University* GLAST LAT COLLABORATION, The GLAST Large Area Telescope (LAT) Collaboration is one among several experimental groups, covering a wide range of approaches, pursuing the search for the nature of dark matter. However, as compared to direct and accelerator searches, the GLAST LAT has a unique ability to observe high energy gamma radiation emanating directly from WIMP annihilations in situ in the universe covering an important and complementary energy range with the ground-based TeV gamma-ray experiments. We describe the current status of feasibility studies for GLAST WIMP annihilation searches.

*Work supported by DoE Contract DE-AC03-768SF00515.
†APS member sponsor.
‡Speaker.

SESSION I8: MINISYMPOSIUM: NUCLEI AND NUCLEAR MATTER AT NON-NORMAL DENSITY I
Sunday Morning, 23 April 2006; Cumberland A, Hyatt Regency Dallas at 10:30
Sherry J. Yennello, Texas A&M University, presiding

Invited Papers

10:30
I8 1 Low Density Clustering in Near Fermi-Energy Collisions.
JOSEPH NATOWITZ, *Texas A&M University*

The nucleon collisions and thermal shock which occurs during near Fermi-Energy heavy ion collisions leads naturally to the production of nucleonic matter at sub-normal densities. Experiments suggest that average nuclear densities as low as $\sim$ 0.4 times normal density are reached. However there are large density fluctuations throughout the collision. In the early stages of the reaction the fluctuations are dynamically induced and lead to a decoupling of the momentum sphere of the initial participant matter from that of the remaining nucleons. This important feature of the dynamically evolving system manifests itself as kinematic differences between the early emitted light (gas) ejectiles and the remaining (liquid) matter. As the system relaxes toward equilibrium the two momentum spheres become more and more similar. Eventually the distinction is lost. The original kinematic differences can be exploited to probe the size and properties of the initial interaction zone, Such analyses reveal a large degree of alpha particle clustering at low densities. For densities near 0.025 normal density, temperature and density dependent symmetry energy coefficients have been derived from isoscaling analyses of the yields of nuclei with A # 4 produced in the collisions of 35A MeV ^{64}Zn + ^{92}Mo and ^{197}Au. The symmetry energies are much larger than those obtained in mean field calculations. They are in much better agreement with results of a recently proposed Virial Equation of State calculation.

Contributed Papers

11:06
I8 2 Breakup Densities of Hot Nuclei* VIC VIOLA, *Indiana University* ISIS COLLABORATION, Breakup densities of hot ^{197}Au-like residues have been deduced from the systematic trends of Coulomb parameters required to fit intermediate-mass-fragment kinetic-energy spectra. The results indicate emission from nuclei near normal nuclear density below an excitation energy E*/A $\lesssim$2 MeV, followed by a gradual decrease to a near-constant value of $\rho/\rho_0 \sim$ 3 for E*/A $\lesssim$5 MeV. Temperatures derived from these data with a density-dependent Fermi-gas model yield a nuclear caloric curve that is generally consistent with those derived from isotope ratios.

*Research supported by the U.S. DOE.

11:18
I8 3 Constructing the Phase Diagram of Infinite Nuclear Matter LUCIANO MORETTO, LARRY PHAIR, JIM ELLIOTT, KYRILL BUGAEV, *Lawrence Berkeley National Laboratory* The low-energy portion of the phase diagram of finite nuclear matter has been obtained. This was achieved by analyzing the fragmentation yields of the EOS and ISiS collaborations using Fisher's

droplet formalism corrected for finite size effects. The critical exponents, the surface energy coefficient, and the critical temperature associated with the liquid-vapor phase transition have all been extracted from the data. Using the ideal gas law, one can construct pressure-temperature and temperature-density coexistence curves for infinite nuclear matter. At much lower energies, compound nucleus reactions are also described by the Fisher formalism when one considers the ensemble average of first-chance emission of rare particles. A pressure-temperature correlation inferred from the mean emission times (measured by the ISiS collaboration) agrees very well with the pressure-temperature correlation inferred from the fragment yields.

11:30

I8 4 Cooling Dynamics in Multi-fragmentation Processes* WILLIAM LYNCH, T.X. LIU, M.J. VAN GOETHEM, X.D. LIU, R. SHOMIN, W.P. TAN, M.B. TSANG, G. VERDE, A. WAGNER, H.F. XI, H.S. XU, *Michigan State University* W.A. FRIEDMAN, *University of Wisconsin* S.R. SOUZA, R. DONANGELO, *Universidade Federal do Rio de Janeiro* B. DAVIN, Y. LAROCHELLE, R.T. DE SOUZA, V.E. VIOLA, *Indiana University* R.J. CHARITY, L.G. SOBOTKA, *Washington University* LASSA COLLABORATION, The energy spectra of the isotopes from Z=1–8 have been measured in the multifragmentation of Sn+Sn isotopes at E/A=50 MeV. Fragment energy spectra of neutron deficient isotopes are significantly more energetic than those of neutron rich isotopes of the same element. This trend is well beyond what can be expected for the bulk multifragmentation of an equilibrated system. It can be explained, however, if many of these fragments are evaporated from the surface of the system while it is expanding and cooling.

*This work is supported by the National Science Foundation under Grant Number PHY-01-10253.

11:42

I8 5 Short timescale behavior of colliding heavy nuclei at intermediate energies* SYLVIE HUDAN, ROMUALDO DESOUZA, *Dept. of Chemistry, Indiana Univ./IUCF* AKIRA ONO, *Tohoku University* Mid-peripheral collisions of two heavy-ions at intermediate energy are used to study the short-time scale behavior of colliding nuclei. The characteristics of clusters emitted by the excited projectile-like fragment (PLF*) formed in such collisions allow the characterization of the system at relatively early times. In particular, alpha particles emitted from the PLF* exhibit a strong preference for emission towards the target-like fragment. The interplay of the initial deformation of the PLF* caused by the reaction, Coulomb proximity, and the rotation of the PLF* can result in the observed anisotropic angular distribution. A description of the collisions in the framework of antisymmetrized molecular dynamics calculations will be shown.

*Support by the US Dept of Energy under Grant No DE.FG02-88ER40404 and Shared University Research grants from IBM, Inc. to Indiana University.

11:54

I8 6 Isotopic composition of the residues produced in the fragmentation of ^{124}Xe and ^{136}Xe projectiles DANIELA HENZLOVA, *NSCL MSU, GSI Darmstadt* CHARMS COLLABORATION, The evolution of the N/Z degree of freedom in the fragmenting system has become an important observable in investigations of the properties of nuclear systems under extreme temperatures and densities. With the use of the high-resolution magnetic spectrometer, the FRagment Separator (FRS), at GSI Darmstadt, the residues up to the heavy projectile, produced in the fragmentation of ^{124}Xe and ^{136}Xe projectiles in a lead target at 1AGeV, were isotopically identified. The full isotopic distributions and mean N/Z ratios measured in these reactions will be presented. The isotopic composition of the final residues reveals a clear sensitivity to the N/Z ratio of the projectile. The sensitivity of the final isotopic composition of the measured residues to the competing emission of light particles and more complex clusters during evaporation and to the thermal conditions at the freeze-out of the break-up stage is investigated.

12:06

I8 7 Reacceleration of the fragmentation residues in the reactions ^{197}Au+^{197}Au/^{27}Al at 0.5 and 1 *A* GeV VLADIMIR HENZL, *NSCL-MSU, GSI-Darmstadt* CHARMS COLLABORATION, We present the results of the first experiments dedicated to the precise measurements of the longitudinal momenta of the projectile fragments in the reactions ^{197}Au+^{197}Au at 0.5 and 1 *A* GeV, and ^{197}Au+^{27}Al at 0.5 *A* GeV performed with the high-resolution magnetic spectrometer FRS at GSI-Darmstadt. It is observed, that projectile residues with masses above $A_{res} > 150$ produced in very peripheral collisions are decelerated in the reaction and follow the well established Morrissey systematic [1], however the mean velocities of the lighter residues level off, and progressively increase with decreasing mass and even reach a positive value with respect to the original projectile velocity (for $A_{res} < 85$). The observed reacceleration phenomenon and its behavior with respect to the different beam energy and/or different collision geometry thus significantly improves our understanding of the spectator response to the participant blast which has been just recently theoretically predicted [2] and experimentally observed [3]. [1] D.J. Morrissey, Phys. Rev. C **39**, 460 (1989). [2] L. Shi, P. Danielewicz, and R. Lacey, Phys. Rev. C **64**, 034601 (2001). [3] M.V. Ricciardi et al., Phys. Rev. Lett. **90**, 2123021 (2003).

SESSION I9: MINISYMPOSIUM: ELECTRO-WEAK INTERACTIONS
Sunday Morning, 23 April 2006; Cumberland B, Hyatt Regency Dallas at 10:30
Krishna Kumar, University of Massachusetts, presiding

Invited Papers

10:30
I9 1 Parity-violating electron scattering on hydrogen and helium and strangeness in the nucleon.
PAUL SOUDER, *Syracuse University*

Parity violation in elastic electron scattering is sensitive to possible strange quark contributions to the vector structure of the nucleon, and thus provides an opportunity to isolate effects of the $q\bar{q}$ sea. The small parity-violating asymmetry in the cross section for the scattering of polarized electrons, which arises from $\gamma - Z$ interference, when combined with the known electromagnetic form factors, provides access to strange quark matrix elements. The HAPPEX collaboration in Hall A at Jefferson Lab has measured the parity-violating asymmetry in the scattering of longitudinally-polarized 3 GeV electrons from both hydrogen and ^{4}He cryogenic targets, at a small scattering angle (6°) and low four-momentum transfer ($Q^2 = 0.1$ GeV^2). The asymmetry for hydrogen is a function of a linear combination of G_E^s and G_M^s, the strange quark contributions to the electric and magnetic form factors of the nucleon respectively, and that for ^{4}He is a function solely of G_E^s. The combination of the two measurements therefore allows G_M^s and G_E^s to be separately determined. Preliminary results will be presented from the complete data set, obtained in runs in 2004 and 2005, yielding results of unprecedented precision.

Contributed Papers

11:06
I9 2 Performance of the beta-spectrometer for a precision measurement of the neutron beta-decay asymmetry B. PLASTER, B.W. FILIPPONE, J. HSIAO, *California Institute of Technology* T.M. ITO, *Los Alamos National Laboratory* J.W. MARTIN, *University of Winnipeg* J. YUAN, *California Institute of Technology* UCNA COLLABORATION, A precise value for the neutron beta-decay asymmetry will be extracted from measurements of the angular correlation between the neutron spin and the direction of emission of the decay electron in polarized ultracold neutron decay. Ultracold neutrons polarized via transport through a 7.0 Tesla field will be directed into the center of our beta-spectrometer, consisting of a 10-cm diameter, 3-m long open-ended decay trap situated within a highly-uniform 1.0 Tesla solenoidal field. Spiraling decay electrons will be detected at both ends of the decay trap in identical detector arrays consisting of a multiwire proportional chamber backed by plastic scintillator. Initial results of various performance tests of our beta-spectrometer and electron detector system will be presented.

11:18
I9 3 Observation of the radiative decay mode of the neutron T.R. GENTILE, K.J. COAKLEY, M.S. DEWEY, H.P. MUMM, J.S. NICO, A.K. THOMPSON, *NIST* B.M. FISHER, I. KREMSKY, F.E. WIETFELDT, *Tulane U.* R.L. COOPER, T.E. CHUPP, *U. Michigan* E.J. BEISE, K.G. KIRILUK, *U. Maryland* J. BYRNE, *U. Sussex* We report observation of the radiative decay mode of the neutron, in which the usual decay products are accompanied by an inner-bremsstrahlung photon. The experiment was carried out at the fundamental physics beam line at the National Institute of Standards and Technology (NIST) Center for Neutron Research (NCNR) Photons with energies between 15 keV and 340 keV were detected by a scintillating crystal coupled to an avalanche photodiode and were distinguished from uncorrelated background photons by coincidence with both the decay electron and proton. Correlated background from prompt external bremsstrahlung generated in the electron detector is estimated to be a small effect. We have studied the predicted dependence of the radiative process on the available phase space of the decay, which provides a unique signature of radiative decay. We report our measurements of the branching ratio for this rare decay.

11:30
I9 4 Monte Carlo Simulation and Photon Detector Development for the Radiative Decay Experiment R.L. COOPER, T.E. CHUPP, *U. Michigan* K.J. COAKLEY, M.S. DEWEY, T.R. GENTILE, H.P. MUMM, J.S. NICO, A.K. THOMPSON, *NIST* B.M. FISHER, I. KREMSKY, F.E. WIETFELDT, *Tulane U.* E.J. BEISE, K.G. KIRILUK, *U. Maryland* J. BYRNE, *U. Sussex* We have recently observed the radiative decay mode of the neutron, where an electron and photon are observed in coincidence, followed by a delayed proton. A false signal can be obtained if bremsstrahlung from the electron detector reaches the photon detector. We estimate the contribution from this process to be small. The potential false signal was experimentally addressed by measuring the dependence of the radiative decay process on the available phase space of decay and comparing it to prediction. Phase space was controlled by varying the voltage on an electrostatic mirror to reflect decay protons. We discuss the simulation techniques used to study the systematic effects in the experiment. We also discuss the performance of the photon detector, which operates in a high magnetic field and at cryogenic temperatures. Additionally we present the design of a 12-element scintillation detector that will allow a precision measurement of the radiative decay spectrum.

11:42
I9 5 Measurement of the Beta Neutrino Correlation in Laser-Trapped 21Na* PAUL VETTER, JAMIL ABO-SHAEER, REINA MARUYAMA, STUART FREEDMAN, *Lawrence Berkeley National Laboratory* We have measured the beta neutrino correlation in the decay of radioactive ^{21}Na atoms confined in a magneto-optic trap using a technique which detects the low-energy electrons shaken off by the daughter recoil atom (^{21}Ne).

Using a time-of-flight momentum analysis technique, we measure the energy spectrum of the ionized recoil nuclei in coincidence with the shake-off electrons to determine the beta-neutrino correlation. A major source of systematic error in this type of experiment arises from photoassociative binding of the trapped atoms into cold, trapped dimer molecules, despite the small number of trapped atoms. When an atom bound in a molecule beta decays, the momentum of the recoil nucleus is strongly perturbed by scattering from its molecular partner. We have studied the formation rate of cold dimer molecules in our trap, and have implemented a dark trap. This trap suppresses the fraction of atoms which populate the atomic excited state (necessary for photoassociation) and suppresses the molecule formation rate by roughly three orders of magnitude. Current results will be presented.

*Supported by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

11:54

I9 6 Muon Decay Parameters from Majorana Neutrino Masses REBECCA ERWIN, MIKHAIL GORSHTEYN, MICHAEL RAMSEY-MUSOLF, *California Institute of Technology* The TWIST experiment at TRIUMF will probe the Michel parameters, which parameterize contributions to muon decay from beyond the Standard Model, to unprecedented precision. Because some of these parameters are sensitive to operators that also contribute to Majorana neutrino mass, limits on the mass can be used to put constraints on these operator coefficients. In this talk, we will discuss our analysis of these constraints and their subsequent implications for the Michel parameters.

12:06

I9 7 Precise Branching Ratio Measurement for the β Decay of ^{21}Na V.E. IACOB, J.C. HARDY, C.A. GAGLIARDI, J. GOODWIN, N. NICA, H.-I. PARK, G. TABACARU, L. TRACHE, R.E. TRIBBLE, Y.J. ZHAI, I.S. TOWNER, *Cyclotron Institute, Texas A&M University, College Station, TX 77843* A recent paper [1] reports a measurement of the $\beta - \nu$ correlation coefficient for the ground-state mirror β^+ transition $^{21}Na(3/2^+) \rightarrow {}^{21}Ne(3/2^+)$ of $a_{\beta\nu} = 0.5243(91)$, which is significantly different from the Standard Model prediction of 0.558. However, both these values depend on the transition branching ratio, the currently accepted value of which, 94.97(13) %, is an average over mutually inconsistent measurements (25 to 45 years old!). We set out to improve this value. We used a $28 \cdot A$ MeV ^{22}Ne beam from the Texas A&M cyclotron to initiate the ^{1}H(^{22}Ne, 2n)^{21}Na reaction. The recoils passed through the MARS recoil separator and, after being degraded, the ^{21}Na ions were implanted as a $> 99\%$ pure source in the tape of a fast transport system. After a few-second collection time, the beam was turned off and the implanted source moved in 175 ms to a shielded region where it stopped between a plastic scintillator and a HPGe detector that is efficiency calibrated with high precision (0.2% between 50 and 1400 keV [2]). Both β singles and $\beta - \gamma$ coincidences were then recorded for 60s, and the collect/move/detect cycle was repeated to achieve the desired statistical accuracy. Our result for the ground-state branching ratio is 95.27(5)%. [1] N.D. Scielzo et al., Phys. Rev. Lett. **93** 102501 (2004). [2] R.G. Helmer et al., Nucl. Instr. Meth. **A511**, 360 (2003).

12:18

I9 8 Prospects for Testing Standard Model (SM) Extensions with Electron Electric Dipole Moment (EDM) Experiments* HARVEY GOULD, JASON M. AMINI,† CHARLES T. MUNGER,‡ *LBNL* Split SUSY and other SM extensions with new sources of CP violation allow electron EDMs that approach the present experimental limits. A new generation of laboratory experiments using laser-cooled atoms is expected to push back those limits, further constraining theory or discovering new physics. A demonstration laser-cooled-atom fountain electron EDM experiment operating at LBNL will be described and the EDM sensitivity and immunity to systematics, of a full scale experiment, discussed.

*Supported by NASA and by a NIST Precision Measurements Grant.
†Also UC Berkeley.
‡Also SLAC.

SESSION I10: CHARM PRODUCTION, DECAY, AND EXCITED STATES
Sunday Morning, 23 April 2006
Cumberland C, Hyatt Regency Dallas at 10:30
Gregory Dubois-Felsmann, California Institute of Technology, presiding

10:30

I10 1 D hadronic branching fractions STEVEN STROINEY, *Cornell University* CLEO COLLABORATION, The CLEO-c experiment at the CESR e^+e^- collider has collected 281 pb^{-1} of data at the $\psi(3770)$ resonance, producing 1 million $D^0\bar{D}^0$ and 0.8 million D^+D^- events. By exploiting the pair production of these charmed mesons, we can determine their absolute hadronic branching fractions without using the luminosity of the sample. We have previously measured branching fractions for the D^0 and D^+ from 56 pb^{-1} of data; here we report preliminary updates to these measurements from the 281 pb^{-1} sample now available.

10:42

I10 2 D Meson Decays into ϕ, η and η' RADIA SIA, *Syracuse University* CLEO COLLABORATION, We report on inclusive and exclusive decays of charmed mesons into particles that have a large content of $s\bar{s}$ quarks, namely the ϕ, η and η'. Data taken with the CLEO detector in the energy region where correlated $D\bar{D}$ pairs are produced are used, where one D meson is fully reconstructed and then the properties of the other D are examined. These measurements are particularly useful for ascertaining the properties of B meson decays.

10:54
I10 3 Hadronic D_s decays PETER ONYISI, *Cornell University* CLEO COLLABORATION, The CLEO-c experiment at the CESR e^+e^- collider has collected a large sample of $D_s^{\pm}D_s^{\mp *}$ events at $E_{cm} \sim 4.17$ GeV. By exploiting the pair production of these charmed mesons, we can determine their absolute hadronic branching fractions without reference to the total luminosity of the sample. Here we report preliminary measurements of major D_s^+ hadronic branching fractions, in particular $\mathcal{B}(D_s^+ \to \phi\pi^+)$.

11:06
I10 4 Measurement of Charm-Production Cross Sections in e^+e^- Annihilations at Center-of-Mass Energies Between 3.97 and 4.26GeV BRIAN LANG, *University of Minnesota* CLEO COLLABORATION, Using the CLEO-c detector at the Cornell Electron Storage Ring, we have measured charmed-hadron production cross sections for e^+e^- annihilations at twelve center-of-mass energies between 3.97 and 4.26 GeV. Observed cross sections for the final states $D\bar{D}$, $D^*\bar{D}$, $D^*\bar{D}^*$, $D_s\bar{D}_s$, $D_s^*\bar{D}_s$, and $D_s^*\bar{D}_s^*$ are presented, as well as the total charm cross section. Observed cross sections have been radiatively corrected to obtain tree-level cross sections and R.

11:18
I10 5 Measurement of the Branching Fraction for Bs $\to Ds1\pm(2536)\,\mu\nu X$ at DØ JASON RIEGER, *Indiana University* DZERO COLLABORATION, The orbitally excited charm state $D_{s1}^{\pm}(2536)$ has been observed at DØ in the decay channel $B_s \to D_{s1}^{\pm}(2536)\mu\nu X$ with $D_{s1}^{\pm}(2536) \to D^{*\pm}K_S^0$. The $D_{s1}^{\pm}(2536)$ mass peak is presented with a signal significance of greater than 5.0σ and the branching fraction for the semileptonic decay to this state is measured in approximately 1 fb^{-1} of data.

11:30
I10 6 Studies of the X(3872) ALEXANDRE RAKITINE, *MIT* CDF COLLABORATION, We investigate the puzzling nature of the state $X(3872)$ using data obtained with the CDF II detector at the Fermilab Tevatron Collider. The shape of the dipion mass spectrum in $X(3872) \to J/\psi\,\pi^+\pi^-$ decay is compared to theoretical predictions for the dipion spin-parity 0^{++} and 1^{--}. For 0^{++} case, the QCD multipole expansion for charmonium is used, and only $^3S_1$ state is found to be compatible with data. There is, however, no $^3S_1$ charmonium state available for assignment to the $X(3872)$. For the 1^{--} case the hypothesis $X(3872) \to J/\psi\rho^0$ is tested and found to be compatible with the data.

SESSION I11: FOCUS SESSION: INITIAL DATA SETS FOR NUMERICAL RELATIVITY
Sunday Morning, 23 April 2006; Cumberland E, Hyatt Regency Dallas at 10:30
Larry Kidder, Cornell University, presiding

Invited Papers

10:30
I11 1 Status of Initial Data for Binary Black Hole Collisions.
GREGORY COOK, *Wake Forest University*

The first initial data for black-hole binaries were derived from analytic time-symmetric multi-hole solutions of Misner and Lindquist in the early 1960s. These served as a test-bed for all of the pioneering efforts to evolve black-hole binaries to collision. The first major revolution in this field was introduced by Bowen and York in 1980, allowed for time-asymmetric data representing boosted and spinning holes, and required the numerical solution of a single scalar boundary-value problem. Initial-data methods based on the Bowen-York extrinsic curvature were developed and explored over the last 25 years and initial data based on these methods are still widely used for black-hole binary evolutions. However, in the past 5 years, a second major revolution has taken place that promises to yield initial data that is much more astrophysically realistic. These new initial-data sets are more computationally expensive to construct and their full physical content is still being explored. In this talk, we will look at this new method for constructing black-hole binary initial data, see what it does well, and where it needs further improvement.

Contributed Papers

11:06
I11 2 Progress in Post-Newtonian Data for Numerical Relativity BERNARD KELLY, MANUELA CAMPANELLI, *University of Texas at Brownsville* BERNARD WHITING, *University of Florida* WOLFGANG TICHY, *Florida Atlantic University* Physically realistic initial data for the black-hole-binary problem is expected to accord with predictions from post-Newtonian theory at sufficiently large separations. Schemes for using this idea in obtaining 3+1 initial data for black-hole binaries have recently been proposed by Tichy et al and by Nissanke. However in numerical applications based on post-Newtonian results, some difficulties have been encountered in the far-field region. We report on progress in extending these schemes up to 2.5 pN order to obtain globally well-behaved data sets that reduce asymptotically to the Kerr solution.

11:18
I11 3 Perfecting the Frankenstein approach: Improved asymptotically matched initial data for non-spinning black hole binaries NICOLAS YUNES, *Penn State* WOLFGANG TICHY, *Florida Atlantic University* The accuracy of gravitational wave templates produced by numerical simulations is partially determined by the initial data chosen. A promising method to construct accurate data employs asymptotic matching to construct an approximate global 4-metric. In this talk, we will apply this method

to a binary system of non-spinning black holes and discuss improvements. A global metric can be constructed by asymptotically matching two tidally perturbed Schwarzschild metrics in isotropic coordinates valid near each hole to an ADMTT post-Newtonian metric valid far from them. As a result, adjacent metrics agree in the matching region up to uncontrolled remainders in the approximations. We build a smooth global 4-metric with transition functions, carefully constructed to avoid introducing errors larger than those in the approximations. The main improvement arises by using metrics in similar coordinates before performing the matching. This similarity leads to adjacent metrics that are similar even near the horizons, thus allowing for a smoother transition and constraint violations. We also construct a map that takes this metric to Kerr-Schild coordinates near each hole.

11:30

I11 4 Well-posed 3+1 representation of the Bondi-Sachs problem SIMONETTA FRITTELLI, *Duquesne University* Conventionally, in the case of the Einstein equations, characteristic problems have been stated in the Bondi-Sachs form, whereas Cauchy-problems have been formulated in the ADM form, and both problems have been pursued independently of each other. Yet characteristic and Cauchy problems are only two sides of the same differential equations. Under the restriction of spherical symmetry, we provide a 3+1 version of the Einstein equations that functions as the initial-value representation of the Bondi-Sachs equations. This is a well-posed ADM formulation that allows us to interpret the Bondi-Sachs variables precisely in terms of outgoing characteristic fields. The ADM form is automatically first-order in time, with no need for reduction. Both these features have relevance to numerical simulations. We indicate which of the features are maintained when the assumption of symmetry is removed.

11:42

I11 5 Spin Dependence in Computational Black-Hole Data SCOTT HAWLEY, RICHARD MATZNER, MICHAEL VITALO, *Center for Relativity, Department of Physics, University of Texas at Austin* We have implemented an parallel multigrid solver, to solve the initial data problem for 3 + 1 General Relativity. This involves solution of elliptic equations derived from the Hamiltonian and the momentum constraints. We use the conformal transverse-traceless method of York and collaborators, which consists of a conformal decomposition with a scalar ϕ that adjusts the metric, and a vector potential w^i that adjusts the longitudinal components of the extrinsic curvature. The constraint equations are then solved for these quantities ϕ, w^i such that the complete solution fully satisfies the constraints. We apply this technique to confirm theoretical expectations for the spin-orientation and -separation dependence in the case of spinning interacting black holes, and we investigate some of the nonlinear effects in initial data for binary black hole interactions.

SESSION I12: HIGGS PHYSICS I
Sunday Morning, 23 April 2006
Cumberland F, Hyatt Regency Dallas at 10:30
Thomas Junk, University of Illinois at Urbana-Champaign, presiding

10:30

I12 1 Search for Higgs Boson Production via the Process $p\bar{p} \rightarrow ZH \rightarrow l^+l^-b\bar{b}$ at CDF BEN KILMINSTER, JONATHAN EFRON, BRIAN WINER, RICHARD HUGHES, *Ohio State University* BEATE HEINEMANN, ANDREW MEHTA, *Liverpool* CDF COLLABORATION, We are conducting a search for the Higgs boson via the process $p\bar{p} \rightarrow ZH \rightarrow l^+l^-b\bar{b}$ using 700 pb^{-1} of data from CDF Run 2. The Higgs Boson is predicted by the Standard Model but has yet to be observed. The main background of this ZH signal is Z + jets, where the Z decays into two charged leptons. The signal is distinguished from the backgrounds using an artificial neural network. We will report on the status of the search and the future prospects using the anticipated large data samples from Run 2.

10:42

I12 2 CMS Detector Sensitivity to the Standard Model Higgs Boson in $H \rightarrow ZZ \rightarrow 4\mu$ Decay Channel ALEXEI DROZDETSKI, D. ACOSTA, P. BARTALINI, R. CAVANAUGH, A. KORYTOV, G. MITSELMAKHER, B. SCURLOCK, YU. PAKHOTIN, *University of Florida* M. ALDAYA, P. ARCE, J. CABALLERO, B. CRUZ, P. GARCIA, J. HERNANDEZ, I. JOSA, E.R. MORALES, *CIEMAT, Madrid, Spain* A. SHERSTNEV, *Cavendish Laboratory, University of Cambridge, UK* S. ABDULLIN, *FNAL* CMS COLLABORATION, Presented are the results of the analysis of the CMS detector sensitivity to the Standard Model Higgs boson in its 4-muon decay channel, $H \rightarrow ZZ \rightarrow 4\mu$, in the Higgs boson mass range from 115–600 GeV. The studies are based on the most recent full CMS detector simulation and mimic the real data analysis with the most critical calibrations extracted from "data" and all systematic uncertainties explicitly evaluated and taken into account.

10:54

I12 3 A Study of $H \rightarrow WW^* \rightarrow l\nu jj$ at CMS HEEJONG KIM, N. AKCHURIN, *Texas Tech University* J. DAMGOV, *INRNE-BAS/FNAL* S. KUNORI, *U. Maryland* H. PI, *University of Florida* E. YAZGAN, *Middle East Technical University/FNAL* CMS COLLABORATION, One of the most challenging channels for observing Higgs boson production at the Large Hadron Collider (LHC) is a Higgs which is produced via the Vector Boson Fusion process and which then decays $H \rightarrow WW^* \rightarrow \ell\nu jj$ (ℓ is an electron or muon, j is a jet). We present results of a study of the sensitivity of the CMS experiment for this process, assuming Higgs mass at 120 GeV/c^2.

11:06

I12 4 Search for Standard Model Higgs Boson Production in Association with $W^{\pm}$ Bosons at CDF YOSHIAKI KUSAKABE, *Waseda* CDF COLLABORATION, We present a search for the Standard Model Higgs boson decaying into $b\bar{b}$ after being produced in association with a $W^{\pm}$ boson in the $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. The search uses the data collected up to fall 2005 using the CDF detector, which corresponds to an integrated luminosity of about 700 pb^{-1}. Events with an electron or muon, large missing transverse energy and jets are selected using an advanced multivariate technique and at least one of the jets is required to be b-tagged for further reduction of the large $W^{\pm}$ + jet background. We set a limit on the $p\bar{p} \rightarrow W^{\pm}H$ production cross section.

11:18

I12 5 Search for Associated Production of W and Higgs Bosons at DØ VENKATESH KAUSHIK, *University of Texas, Arlington*

D0 COLLABORATION, We present preliminary results of $Wb\bar{b}$ production and a search for the Higgs boson through its associated production with W for masses between 105 and 150 GeV in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV. The search is performed in events containing one election, an imbalance in the transverse enegy (E_T) and two b-tagged jets in $\approx 1fb^{-1}$ of integrated luminosity accumulated by the DØ experiment at Fermilab.

11:30
I12 6 Search for Associated Production of Z and Higgs Bosons in $e^+e^-b\bar{b}$ Final States JAMES HEINMILLER, *University of Illinois, Chicago* D0 COLLABORATION, Studies are presented of the search for a light Standard Model Higgs boson produced in association with a Z boson in the $Z \to e^+e^-$ and $h \to b\bar{b}$ decay channel using Run II data collected by the DØ detector at the Fermilab $p\bar{p}$ collider at $\sqrt{s} = 1.96$ TeV. We also present our current understanding of the most significant background to this process, namely the QCD production of $b\bar{b}$ associated with the Z boson.

11:42
I12 7 Search for Associated Production of Z and Higgs Bosons in $\mu^+\mu^-b\bar{b}$ Final States HUISHI DONG, *State University of New York, Stony Brook* D0 COLLABORATION, We present the preliminary studies on the search for a light mass Standard Model Higgs Boson produced in association with a Z boson in the $\mu^+\mu^-b\bar{b}$ channel at DØ Run II. With the available recorded luminosity more than three times the Run I luminosity, we also present our current understanding of the most significant background to this process, namely the QCD production of $b\bar{b}$ associated with the Z boson.

11:54
I12 8 Search for Associated Production of Z and Higgs Bosons in $\nu\bar{\nu}b\bar{b}$ Final States MICHELE PETTENI, *Imperial College, London* D0 COLLABORATION, Studies are presented from the DØ experiment at Fermilab for the search for a light Standard Model Higgs Boson in association with a Z boson, which decays invisibly to $\nu\bar{\nu}$. This channel relies on the identification of two b-tagged jets from the Higgs Boson decay and on the measurement of a large imbalance in the transverse energy (E_T) of the event. This channel is challenging as the decay signatures are common in QCD and instrumental backgrounds.

12:06
I12 9 Search for Higgs Boson in $WW^{(*)}$ Decays MAXIM TITOV, *Freiburg University* D0 COLLABORATION, The process $H \to WW^{(*)} \to \ell^+\ell^-$ ($\ell = e,\mu$) is studied in $p\bar{p}$ collisions at the center of mass energy $\sqrt{s} = 1.96$ TeV with the upgraded DØ detector at the Fermilab Tevatron accelerator. A Higgs particle with a mass greater than 140 GeV primarily decays into a of W-bosons and the semi-leptonic decay channels of the W provide a clear signature. Apart from the Standard Model Higgs, for which a discovery will only be possible at highest integrated luminosities, exotic models with enhanced cross sections may be probed already with data corresponding to integrated luminosities of a few hundred pb^{-1}.

SESSION I13: TOP QUARK PROPERTIES II
Sunday Morning, 23 April 2006
Cumberland G, Hyatt Regency Dallas at 10:30
Ann Heinson, University of California, Riverside, presiding

10:30
I13 1 Measurement of the Top Quark Charge at DØ ANN HEINSON,* *University of California, Riverside* DZERO COLLABORATION, We report on a measurement of the charge of the top quark by resolving the kinematic ambiguity between the standard model scenario of a charge 2/3 quark decaying to W^+b and an exotic scenario of a charge $-4/3$ quark decaying to W^-b. We distinquish between the two scenarios by measuring the charge of the b jet that is kinematically most consistent with arising from the same top quark as the charged lepton.

*Speaker's name will be submitted later.

10:42
I13 2 A Measurement of Top Quark Charge in CDF* ZEYNEP GUNAY, *Michigan State Univ.* CDF COLLABORATION, The top quark was discovered in 1995 by the CDF and D0 experiments at Fermilab. Since its discovery there have been several measurements of the top quark's mass and cross section. Due to this quark's special role in electroweak symmetry breaking, other parameters such as its charge and spin should also be measured. After 3 years of taking data for Run II CDF now has enough statistics to attempt to measure the top quark's charge for the first time. The Standard Model predicts the top quark charge to be $+2/3$ but alternative theories allow a fourth generation exotic quark with a charge of $-4/3$. We present a method for measuring the sign of the top charge via its decay products and placing a limit on the likelihood of our data being consistent with the Standard Model.

*For the CDF Collaboration.

10:54
I13 3 Measurement of $B(t \to Wb)/B(t \to Wq)$ at DØ REINHARD SCHWIENHORST, DØ COLLABORATION, We report on a measurement of the ratio $R = B(t \to Wb)/B(t \to Wq)$. In the standard model this ratio is > 0.998 at the 95% confidence level. Experimentally, we measure the ratio by noting the fraction of candidate events that have 0, 1, or 2 b-tagged jets.

11:06
I13 4 Measurement of the W Boson Helicity in Top Quark Decay at DØ BRYAN GMYREK, *University of Arizona* DZERO COLLABORATION, We report on a measurement of the fraction of right-handed W bosons in top quark decay. In the standard model, this fraction is too small to measure with the current data sample, so a nonzero value would be a clear sign of new physics. The measurement uses $t\bar{t}$ events in both the lepton+jets and dilepton decay channels, and is based upon the helicity angle θ^* between the charged lepton and top quark directions in the W boson rest frame.

11:18
I13 5 Measurement of the WW Production Cross Section and Anomalous Couplings in e+e-, emu, and mu+mu-Final States

at Dzero MICHAEL COOKE, *Rice University* DZERO COLLABORATION, Data collected from April 2002 to December 2005 by the Dzero experiment at a center of mass energy of 1.96 TeV is used to measure the cross section of WW pair production in the e+e-, e mu, and mu+mu-final states. One and two dimensional 95% Confindence Level limits on anomalous WWZ/ WWPhoton trilinear couplings based on the W boson decays are also obtained, assuming the SU(2) × U(1) group symmetry of the electroweak regime.

11:30
I13 6 Measurement of the W+jets Inclusive Jet Multiplicity Cross Sections at CDF DALE STENTZ, *Northwestern University* CDF COLLABORATION, We present preliminary measurements of the inclusive jet multiplicity cross sections for W + jets events produced in $p\bar{p}$ collisions at $\sqrt{(}s$ = 1.96 TeV. W bosons are identified by their decays to electrons and muons in a data sample corresponding to an integrated luminosity of approximately 350 pb^{-1}.

11:42
I13 7 Measurement of the WW Cross Section at the Tevatron SHIH-CHIEH HSU, ELLIOT LIPELES, KEVIN McCARTHY, MARK NEUBAUER, FRANK WÜRTHWEIN, *University of California, San Diego* CDF COLLABORATION, We present a measurement of W^+W^- production at $\sqrt{s}$ = 1.96 TeV using $\approx$ 800 pb^{-1} of data accumulated with the CDF II detector. We select events where both W bosons decay to a charged lepton and neutrino. The measured cross section is compared to a next-to-leading order (NLO) calculation.

11:54
I13 8 Search for ttH at CDF STAN LAI, *University of Toronto* CDF COLLABORATION, The search for the elusive Higgs boson is an important goal for hadron collider experiments. The Fermilab Tevatron collides protons and anti-protons at a centre-of-mass energy of 1.96 TeV, and is currently the only collider that has the potential to produce Higgs bosons. We present a search for $p\bar{p} \rightarrow t\bar{t}H$ production at the Collider Detector at Fermilab (CDF). Though such a process has a very small cross section, the final event topology is quite distinct, making it an interesting channel to study as it tests our understanding of the particles produced in association with top quarks. This measurement complements other searches for the Higgs boson using different channels at CDF.

12:06
I13 9 Search for the FCNC Decay top→ cZ* INGYIN ZAW, *Harvard University* CDF COLLABORATION, We search for the flavor-changing neutral current decay of the top quark t→ cZ at CDF in p-pbar collisions at 1.96 TeV. This decay is extremely rare in the Standard Model and a signal at the Tevatron would be an indication of New Physics. Using Z+jets events with a lifetime tag, we are sensitive to branching fractions less than 10%.

*For the CDF Collaboration.

SESSION I16: SHERWOOD II
Sunday Morning, 23 April 2006; Landmark D, Hyatt Regency Dallas at 10:30
Zhi Hong Lin, U.C. Irvine, presiding

10:30
I16 1 Break.

11:00
I16 2 Renormalization of plasma turbulence leading to fractional differential equations.*
R. SANCHEZ, *Oak Ridge National Laboratory*

Several phenomenological models for plasma turbulent transport have been recently proposed that are based on the use of fractional differential operators. These operators provide with a mathematical framework that may outperform the standard diffusive paradigm when it comes to capturing much of the strange phenomenology encountered in tokamak plasmas: canonical profiles, anomalous confinement scalings, off-axis peaking, etc. The reason is simple: fractional operators are designed to model transport mechanisms that lack characteristic time and/or spatial scales, which appears to be the situation pointed to as relevant by the observed tokamak phenomenology. However, it has remained always unclear how fractional operators (non-local and non-Markovian in nature) can be derived from (and reconciled with) the usual equations for mass, moment and energy turbulent transport. In this contribution we start from the simplest turbulent transport equation (the advection of tracers by a turbulent flow with prescribed statistics) and show how to establish such connection by developing a new renormalization scheme that avoids the limitations of standard quasilinear renormalization theory. This result not only establishes the missing physical link with the phenomenological models but also suggests more efficient avenues for transport modeling in both real experiments and state-of-the-art transport codes.

*In collaboration with B.A. Carreras, ORNL; D.E. Newman, University of Alaska-Fairbanks; V.E. Lynch, ORNL; and B.Ph. van Milligen, CIEMAT, Spain.

11:30
I16 3 Parametric Dependencies of Transport Using Gyrokinetic Simulations Including Kinetic Electrons.*
J.E. KINSEY, *LeHigh University*

Nonlinear gyrokinetic simulations are used to systematically study the effects of ExB shear, magnetic shear, safety factor q, Ti/Te, collisionality, plasma beta, and shaping on turbulent energy, particle, and momentum transport due to ion temperature gradient (ITG) and trapped electron modes (TEM) using the GYRO code [1]. Previous work has tended to focus on ITG modes with adiabatic electrons for a single reference case. Here, we report on over 300 nonlinear kinetic electron simulations to be used for benchmarking and transport model development. In simulations varying q, the energy transport exhibits a linear q-scaling while the particle diffusivity can be insensitive to q. For shifted circle geometry, the effect of ExB shear on both ITG and TEM transport is well modeled by a simple quench rule. The quench rule needs to be modified, however, for real geometry. The nonlinear results are compared against quasilinear (QL) diffusivity ratios to assess the accuracy of QL theory on a per-mode basis. In collaboration with R.E. Waltz and J. Candy, General Atomics. [1] J. Candy and R.E. Waltz, Phys. Rev. Lett. **91**, 045001 (2003).

*Work supported by U.S. DOE under DE-FG03-95ER54309, DE-FG03- 92ER54141.

12:00
I16 4 Long time simulations of microturbulence.*
W.W. LEE, *Princeton Plasma Physics Laboratory*

Physics and numerical issues associated with the long time simulations of microturbulence are addressed in the present paper. Firstly, the applications of the Fluctuation-Dissipation Theorem for the noise properties in a nonlinearly saturated system and their subsequent verifications using gyrokinetic particle simulation are discussed. The important finding here is that discrete particle noise, when using insufficient number of particles, will always enhance the transport. Secondly, the use of the global toroidal gyrokinetic particle simulation code (GTC) [1] for investigating the long time behavior of microturbulence is presented. The central issues are: 1) what are the nonlinear physics that are responsible for the steady state turbulence and 2) their numerical convergence and noise properties. The physics focus here is on the ion temperature gradient (ITG) drift turbulence. The effects of the often-neglected velocity space nonlinearity [1] on the production of zonal flow, energy conservation, the evolution of the steady state turbulence and, consequently, the resulting thermal transport are studied. The convergence studies using very large number of particles per cell (from 10 to 1000) have also shown that numerical noise play very insignificant role in the observed steady state thermal transport. This work is supported by the DoE SciDAC GPS Center. [1] Z. Lin et al., Science **281**, 1835 (1998). [2] W. W. Lee, Bull. Am. Phys. Soc. Bull. Am. Phys. Soc. **49**(8) 135 (2004).

*In collaboration with T. Jenkins, S. Ethier, and W. X. Wang, Princeton Plasma Physics Laboratory, Princeton, NJ 08540.

SESSION J1: TOP IS TEN
Sunday Afternoon, 23 April 2006; Landmark A, Hyatt Regency Dallas at 13:15
Harry Weerts, Argonne National Laboratory, presiding

13:15
J1 1 Top at Run II and LHC Prospects.
EVA HALKIADAKIS, *Rutgers University*

The top quark is the most massive elementary particle in the Standard Model (SM) observed to date. It was discovered ten years ago at Fermilab's Tevatron, currently the highest energy hadron collider in the world, until the Large Hadron Collider (LHC) at CERN turns on in 2007. Measurements of top quark production and decay properties provide direct tests of the SM and could yield sensitive probes of new phenomena beyond the SM. In this talk, we present recent top quark physics results from the CDF and DZero collaborations with data collected from the ongoing Run II of the Tevatron. Additionally, we review of the prospects for studies of the top quark at the LHC.

13:51
J1 2 Single Top Production.
REINHARD SCHWIENHORST, *Michigan State University*

Even though it has been ten years since the top quark discovery, still only very little is known experimentally about this elusive particle. Understanding in particular the electroweak interaction of the top quark is important because of the connection to electroweak symmetry breaking. At hadron colliders, this interaction produces the unique final state signature of only a single top quark. I will present the current status of searches for electroweak production of single top quarks.

14:27
J1 3 Top Theory.
LYNNE ORR, *University of Rochester*

A decade after the discovery of the top quark, we still have much to learn. As the heaviest fermion, the top quark is bound to tell us something about electroweak symmetry breaking and the origin of mass, and may even play a special role. In this talk I review the role of the top quark in the Standard Model and in new physics scenarios. I also discuss what we have to learn from top physics studies in present and future high energy experiments.

SESSION J2: A HIGH LUMINOSITY LEPTON ION COLLIDER TO STUDY QCD
Sunday Afternoon, 23 April 2006; Landmark B, Hyatt Regency Dallas at 13:15
Richard G. Milner, Massachusetts Institute of Technology, presiding

13:15
J2 1 Design Considerations for a High Luminosity Lepton Ion Collider.*
MANOUCHEHR FARKHONDEH, *MIT-Bates Center, POBox 946, Middleton, MA 01949*

Studies are underway in the US to design a lepton-ion collider (EIC) with high luminosity (10^{-33} $cm^{-2}s^{-1}$) and high center-of-mass energy centered around the existing nuclear physics accelerators at either BNL or Jefferson Lab. EIC will be optimized for studying of the formation and structure of hadrons in terms of their quark and gluon constituents. For the RHIC-based collider, eRHIC, two options are under consideration, a more mature option based on a ring-ring concept with e^-/e^+-p and e^-/e^+-A collisions and a more ambitious design with a linac-ring architecture. Ions from the existing RHIC hadron ring will collide with 5–10 GeV electrons or positrons, either from a new electron/positron storage ring or a very high current cw electron linac. In both options, high current electron bunches in the polarized injector must be precisely synchronized with proton or ion bunches in the RHIC ring. The stacking option in the ring-ring design considerably reduces the required bunch charge from the polarized source. The polarized source requirements for the eRHIC linac-ring design are very demanding requiring sources capable of producing highly polarized cw currents of 200-300 mA. Another more futuristic option for Electron Ion Collider is being considered at Jefferson Lab (ELIC) based on the existing CEBAF superconducting linac, a new circulating electron ring and a hadron ring. The circulating figure-8 electron ring in this concept is intended to reduce the demanding high current injected polarized beam from the linac. In this paper, we present for the two options of eRHIC, the design considerations and requirements, and machine and polarized source parameters. The design considerations and machine parameters for ELIC will also be presented in this paper.

*This work supported by Department of Energy.

13:51
J2 2 Study of spin structure of the nucleon using a lepton-ion collider.
ABHAT DESHPANDE, *SUNY Stony Brook & RIKEN-BNL Research Center*

Construction of a high intensity, high energy polarized lepton beam facility to collide with the polarized proton beams of the existing Relativistic Heavy Ion Collider (RHIC), will allow polarized deep inelastic scattering off protons up to center of mass energies of $\sim$ 100 GeV. The physics potential of such a facility have been studied in various workshops over the years, and will be summarized in this talk. We show that several important and unique measurements in spin physics could only be possible using this facility, eRHIC. They include the spin structure function $g_1(x,Q^2)$ of the proton at low x, precision measurement of the polarized gluon distribution through multiple processes such scaling violations, di-jet production over a large x range, heavy quark and anti-quark flavor distributions using measurement of parity violating spin structure functions $g_5(x,Q^2)$, parton distributions of the polarized photons and many more. Bjorken spin sum rule,

one of the the most fundamental spin sum rules in QCD could also be addressed with unprecedented precision with eRHIC if the polarized 3He++ could accelerated and stored in the RHIC. As such eRHIC promises extremely significant leaps in our understanding of the nucleon spin structure and of QCD, complementary and often beyond what is possible with RHIC spin and the present fixed target polarized DIS experiments at CERN, DESY and Jlab.

14:27
J2 3 The glue that binds us all: Probing gluonic matter with an electron-ion collider.
RAJU VENUGOPALAN, *Brookhaven National Laboratory*

Very little is known about the gluonic content of nuclear matter. Answering this question is crucial to our picture of hadron and nuclear collisions at high energies. We discuss some ideas about the nature of gluonic matter and how these can be tested at a future electron-ion collider.

SESSION J4: PRECISION COSMOLOGY
Sunday Afternoon, 23 April 2006; Marsalis A, Hyatt Regency Dallas at 13:15
John Beacom, Ohio State University, presiding

13:15
J4 1 Recent Results from WMAP.*
LYMAN PAGE, *Princeton University*

The Wilkinson Microwave Anisotropy Probe (WMAP) has been measuring both the temperature and polarization anisotropies in the CMB for over four years. The maps from WMAP are one of the key elements in the foundation of the standard model of cosmology. In this talk we review the results from the second WMAP release with an emphasis on the new science we have learned.

*WMAP is a made possible through the support of NASA.

13:51
J4 2 Probing Dark Energy with Galaxy Clusters.
JOSHUA FRIEMAN

The abundance and spatial clustering of galaxy clusters provides a promising probe of the nature of the dark energy, sensitive to both geometry and the rate of growth of large-scale structure. This talk will provide an overview of future surveys aimed in part at exploiting this technique, discuss the main systematic effects which potentially limit its precision, and describe methods for controlling and mitigating those uncertainties. A hallmark of future cluster surveys will be the confluence of multiple methods for observing clusters, including optical, weak lensing, Sunyaev-Zel'dovich, X-ray, and dynamical measures of cluster properties.

14:27
J4 3 Dark Energy and Cosmic Sound.*
DANIEL EISENSTEIN, *University of Arizona*

I present galaxy clustering results from the Sloan Digital Sky Survey that reveal the signature of acoustic oscillations of the photon-baryon fluid in the first million years of the Universe. The scale of this feature can be computed and hence the detection in the galaxy clustering serves as a standard ruler, giving a geometric distance to a redshift of 0.35. I will discuss the implications of this measurement for the composition of the universe, including dark energy and spatial curvature. I will close with a discussion of the prospects for future redshift surveys to use the acoustic peak to map the expansion history of the universe.

*Work supported by NSF and the Sloan Foundation.

SESSION J5: PIONEERING WOMEN ASTRONOMERS
Sunday Afternoon, 23 April 2006; Pegasus B, Hyatt Regency Dallas at 13:15
Marc Sher, William and Mary, presiding

13:15
J5 1 Henrietta Leavitt: Turn of the Century Trailblazer.
JEAN TURNER, *UCLA*

This abstract was not received electronically.

13:51
J5 2 Cecilia Payne-Gaposchkin: A Stellar Pioneer (The Dorritt Hoffleit Lecture).
KATHERINE HARAMUNDANIS

In a world of Newtonian mechanics and Darwinian evolution, we also have Paynian composition of the stars and universe. While Payne, later Payne-Gaposchkin, did not extend her data and conclusions to the universe, her 1925 monograph, described by Otto Struve as ''the most brilliant PhD thesis ever written in astronomy,'' is a pioneering landmark that for the first time combined astronomical observations of stellar spectra with the then new atomic theories of Bohr and Saha. Her conclusions were suppressed by her advisor, H.N. Russell, but she wisely published her data with a disclaimer. Though facing overt gender discrimination throughout her career, and suffering the ''pink paycheck'' so well known to many women, she persevered and, towards the end of her working lifetime at Harvard University, became Chairman of the Department of Astronomy, a department she had helped to establish with the exuberant director Harlow Shapley in the 1920s and 1930s. One colleague, who called her ''An Astronomer's Astronomer,'' admired her as a person of great kindness, graciousness, humor and humility, who conveyed her love for the science ''lucidly and enthusiastically.'' She never lost her love and ardor for astronomy and astrophysics and made innumerable contributions to these sciences. Her work continues to inspire and provoke those working in the field, and she remains a model for all scientists to follow.

14:27
J5 3 Never A Team Member; Suddenly A Team Leader!
JILL TARTER, *SETI Institute*

In the 1960's there weren't many female engineering students, and ''teaming'' was not an official part of the curriculum. Teams were formed casually, as a way to share the enormous load of lab reports and problem sets – that is unless you were one of those female students. Physical isolation and institutional lockdown in the female dorms made my participation in study teams extremely difficult. As a result, I got a better formal education (working all the problem sets myself), but I missed out on learning a very practical skill. Leading a team is hard work, particularly if you've never been a member of a team. One solution is to work harder than almost anyone else. Another trick is to choose a small pond in which to be a big frog. I chose SETI (the search for extraterrestrial intelligence) because I was captured by the idea that I live among the first generation of humans who can try to answer this ancient question (Are we alone?) by making observations, rather than accepting some belief system. I'm still hooked by that concept and struggling to make the pond bigger (and financially secure) to bring in the next generation and the generation-after-that, for as long as it may take to end our cosmic isolation, or accept our singularity.

SESSION J6: LABORATORY ASTROPHYSICS: DYNAMO AND THE MAGNETOROTATIONAL INSTABILITY
Sunday Afternoon, 23 April 2006; Cumberland J, Hyatt Regency Dallas at 13:15
Steven Cowley, University of California, Los Angeles, presiding

13:15
J6 1 Angular Momentum Transport in Accretion Flows.*
JEREMY GOODMAN,

Accretion disks are central to astrophysical phenomena ranging from planets to black holes and quasars. They can be powerful energy sources: quasar disks convert rest mass to radiant energy more efficiently than fusion. Accretion requires a mechanism to dissipate orbital energy. Evidence that the mechanism is MHD turbulence driven by magnetorotational instability (MRI) is summarized, and the drawbacks of alternative mechanisms are briefly discussed. Despite theoretical and numerical advances, fundamental questions about MRI remain open: in particular, mechanisms of saturation,

tolerance of non-ideal MHD effects, and relevance to magnetic dynamos. The prospects for addressing these questions through laboratory experiments is assessed.

*Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas.

13:51
J6 2 Magnetic Field Generation in the Madison Dynamo Experiment.
CARY FOREST, *University of Wisconsin, Madison*

The Madison dynamo experiment is designed to self-generate magnetic fields from flows of conducting metal in a simply connected spherical geometry. Thus far, the experiment has been operated at ~ 60% of its design speed (1/3 of its maximum power) achieving a Magnetic Reynolds numbers (based on propellor tip speed) of 130 (comparable to the core of the Earth). The technical operation of the experiment (transfers of liquid sodium, rotating seals, etc) has been demonstrated. The experimental approach to understanding the electromagnetic properties of the flowing sodium involves comparisons between experimental measurements of the magnetic field in the sodium experiment, measurements of the velocity field in a dimensionally identical water experiment, and predictive MHD codes that model the currents induced in the turbulent flows by externally applied fields. Self-excitation has not yet been observed, rather experiments have been performed using externally applied magnetic fields. Initial experimental results include: direct observation of the production of a toroidal (an east-west component inside the sphere) magnetic field from a dipolar magnetic field; the expulsion of an applied magnetic field by vortical fluid motion; generation of a dipole magnetic field by a mean-field EMF; measurement of the turbulent shredding of a large scale magnetic field by small scale turbulence in the velocity field; and intermittent self-excitation of the dynamo eigenmode. Future plans will be discussed, including the strategy for observing self-excitation.

14:27
J6 3 Magnetorotational and dynamo instabilities in liquid sodium experiments.*
DANIEL LATHROP, *University of Maryland*

Experiments conducted in liquid sodium confined between a rotating inner sphere and a concentric outer sphere show a host of MHD behavior. With a sufficiently strong external coaxial magnetic field, this system exhibits the magnetorotational instability. The primary instability shows a continuous bifurcation to a rotating $m = 1$ pattern in the magnetic field, and concomitant oscillations in the velocity field. By varying both the rotation rate and the external magnetic field (made dimensionless as the magnetic Reynolds number and the Lundquist number respectively), we have navigated the parameter plane to observe a number of states with distinct dominant wavenumber and parity. The onset conditions compare favorably with expectations from linear stability calculations. This is remarkable considering the significant background turbulence (15% to 25% turbulent intensity) in the base state. Finally we have explored the suitability of spherical Couette flow to show dynamo action.

*This research is supported by the National Science Foundation.

SESSION J7: ASTROPARTICLE PHYSICS II
Sunday Afternoon, 23 April 2006
Pegasus A, Hyatt Regency Dallas at 13:15, presiding

13:15
J7 1 Ultrarelativistic Magnetic Monopole Flux Constraints from RICE DANIEL HOGAN, *University of Kansas* RICE COLLABORATION, The Radio Ice Cherenkov Experiment (RICE) is a radio array buried in the Antarctic ice. A Monte Carlo simulation has been developed to model the behavior of an ultrarelativistic magnetic monopole propagating through the ice and RICE's response. With this, we've determined RICE's effective volume for detecting these particles as a function of monopole mass, charge, and gamma-value. As previously reported, RICE failed to detect an in-ice high-energy Cherenkov radiation signal consistent with a relativistic magnetic monopole over roughly two years of livetime. From this null result and the effective volume calculation, we can extrapolate upper bounds on ultrarelativistic magnetic monopole flux. Provisional values are presented.

13:27
J7 2 Pair production with neutrinos in an intense, background magnetic field TODD TINSLEY, *Rice University* We present a detailed calculation of the electron-positron production rate for the process $\nu \rightarrow \nu e\bar{e}$ in an intense, homogenous, background magnetic field. We compute rates for all neutrino flavors and within the framework of the Standard Model. Such an interaction could be relevant in astrophysical phenomena where neutrinos play a dominant role in energy transport and there exist large magnetic fields. Our presentation includes results for various combinations of Landau-levels over a range of possible incoming neutrino energies and relevant magnetic field strengths.

13:39
J7 3 Astrophysical Searches for Lorentz Violation MATTHEW MEWES, *Marquette University* ALAN KOSTELECKY, *Indiana University* Observations of photons from cosmologically distant objects yield some of the most stringent constraints on deviations from perfect Lorentz symmetry in nature. General violations of Lorentz invariance are described by the Standard-Model Extension, which predicts birefringence of light in vacuo. This talk will discuss results of recent searches for birefringence in light that has propagated over cosmological distances.

13:51
J7 4 Dispersive Extinction Theory of Cosmic Red Shift – An Alternative to the Big Bang Theory LING JUN WANG, *University of Tennessee at Chattanooga* A dispersive extinction theory is presented to explain the cosmic red shift and the 2.7 K background radiation as an alternative to the currently prevailing Doppler shift theory and the Big Bang Theory. According to this theory, the cosmic red shift and the 2.7 K background radiation are due to the dispersive scattering and absorption of star light by the space medium. An estimate of the non-linear absorption constant is given by comparing the result to the Hubble constant derived from the observational data. An experimental method is designed to test the validity of the dispersive extinction theory as opposed to the Doppler shift theory. Keywords: red shift, Doppler shift, Big Bang Theory, dispersive extinction theory.

14:03
J7 5 A Newtonian Solution to the Missing Matter Problem GARY HUNTER, ALAN MARTINEZ, JAMES ESPINOSA, *University of West Georgia* Over fifty years ago, Fritz Zwicky made the discovery that galaxies contain insufficient matter to explain their flat velocity curves. The standard solution to this problem has been the introduction of dark matter. For over thirty years, scientists have searched for this missing matter under many different forms such as MACHOs and WIMPs. Twenty years ago, Milgrom modified Newton's second law to account for these flat velocity curves and more recently, Cooperstock and Tieu have applied General Relativity to galactic rotation and produced flat rotation curves. We have developed a modified Newtonian Law of Gravity, which has accounted for the results of the three classic tests of General Relativity, and have applied it to galactic rotation. Our results agree with observations and eliminate the need for dark matter.

14:15
J7 6 The St. Petersburg State University Experiment That Discovered the Photon Acceleration Effect KONSTANTIN GRIDNEV, RUSSELL MOON, VICTOR VASILIEV, Using the principles of the Vortex Theory, it was theorized that when a photon encounters an electromagnetic field, both the velocity and the frequency of the photon will change. To prove this revolutionary idea an experiment was devised using a laser interferometer and two electromagnets. The electromagnets were arranged so that when the beam splitter divided the initial beam of laser light into two secondary beams; one of the two secondary beams passed back and forth between the two magnets. With the DC current to the electromagnets turned off, the two beams formed an interference pattern on the target screen. When the current to the electromagnets was suddenly turned on, the pattern fluctuated wildly until the two beams again reached a quiescent state creating a stable pattern on the screen; when the current to the electromagnets was suddenly turned off, again the pattern fluctuated wildly until it reached a quiescent state forming the initial stable pattern on the screen. It was determined that this new effect was a phenomenon created by the changing frequency of the laser light whose velocity is increasing as it passes between the expanding electromagnetic field of the magnets. Because it is a new phenomenon in science revealing that the speed of light is not a constant but indeed can be varied, it possesses great historical significance. It is called the Photon Acceleration Effect.

14:27
J7 7 Thermalization Tendency of ElectroMagnetic Radiation in Transit Through AstroPhysical Mediums C.F. GALLO, *Superconix* As ElectroMagnetic Radiation from a hot source transits through a cooler interacting medium, the following are demonstrated from thermodynamic arguments. (1) The "hot" radiation always loses some energy to the cooler interacting medium. (2) Detailed behavior depends upon the microscopic nature of the interacting medium. (3) A Redshift will occur, but not necessarily imitate the wavelength dependence of the Doppler Redshift. (4) A Doppler-type redshift will occur only if the interaction cross-section is directly proportional to the photon energy. (5) The loss of radiative energy to the intergalactic medium will contribute to the Cosmic Microwave Background Radiation. The following characteristics depend upon the detailed nature of the interacting medium. (1) The photon energy loss per collision. (2) The magnitude (cross-sections) of the thermalization process. (3) The energy dependence of the cross- section for various mediums. (4) Forward propagation characteristics of the Redshifted EM radiation. Although the effects are small, the cumulative redshift in astrophysical situations can be significant. Earthly experiments are planned.

14:39
J7 8 Einstein's concept of space as energy field, or dark matter as property of space JACQUES LEIBOVITZ, *Retired* Einstein insisted that there is no empty space, that there is no space without a field. He stated also [1921, Stafford Little Lectures at Princeton] that "besides the energy density of the matter there must also be given an energy density of the gravitational field, . . . " There follows that it is a field of corresponding equivalent distributed mass density. Space is also elastic and compressible. From these three properties, an equation of state is derived, followed by the derivation of an equation governing the distribution of space mass density around galaxies, the galactic flat rotation curve, and Milgrom's equation for the motion of galaxies in clusters and super clusters. The results suggest that space may be the heretofore-elusive dark matter. The distribution of space density around the Sun is derived. It shows that NASA's Pioneer anomaly (J. D. Anderson et al., Phys. Rev. D, **65**, 082004) extends to about 188 AU from the Sun. Beyond 188 AU, the anomaly decreases as R increases and, at sufficiently large distance, decreases as $1/R$. Verifiable tests are proposed. Some related future research topics are listed.

14:51
J7 9 Matching Scherrer's k essence argument with alterations of di quark scalar fields permitting an eventual cosmological constant dominated inflationary expansion ANDREW BECKWITH, We previously showed that we can use di-quark pairs as a model of how nucleation of a new universe occurs. We now can construct a model showing evolution from a dark matter dark energy mix to a pure cosmological constant cosmology due to changes in the slope of the resulting scalar field, using much of Scherrer's k-essence model. This same construction permits a use of the speed of sound, in k essence models evolving from zero to one. Having the sound speed eventually reach unity permits matching conventional cosmological constant observations in the aftermath of change of slope of a di-quark pair generated scalar field during the nucleation process of a new universe.

15:03
J7 10 An Origin for Gravity and Electromagnetism when Mass and Specific Density are Statistical Intensive Parameters GEOFFREY HOLSTROM, *Victor Valley College, SBVC, CHC, San Bernardino Co., CA* Mass and specific density can be understood as intensive parameters on the distributions of formation intervals, X and V, for a particle. (ijmpa v20 #15 6/20/05 p3317) Once properties form, space and time make sense for the particle. (Every X must have the same mass.) Mass can then be located by the average $< x >$, with time as a parameter: the Dirac equation. Mass has a fluctuation, essential for its generation. Quantum mechanics does not see this as it deals only with the average of the mass operator. Maxwell's equations occur as properties do form. Geometry again appears. The created particle properties can be located by using the Dirac equation. The curvature operator is averaged, and the coordinates are $< x >$ and t. A source is the intensive property of specific density. Averages are in flat as properties form in flat. Gravity occurs when properties do not form. Average of the curvature then gives an equation for the divergence of the full Riemann curvature plus the average of a three-index operator (A). Coordinates are again $< x >$ and t. It is an identical zero unless the space of the averages is curved. The Einstein equation can be generated from it, with T, if needed, put in by hand. Using the Weyl tensor, the Ricci and (A) tensors can be related. In empty space, (A) is zero, and the Ricci tensor is zero, as with Einstein. In non-empty space, components that are unable to form properties, are used to create (A). The equation for the derivatives of the Ricci tensor must match to it. There is no property serving as a source.

SESSION J8: MINISYMPOSIUM: NUCLEI AND NUCLEAR MATTER AT NON-NORMAL DENSITY II
Sunday Afternoon, 23 April 2006; Cumberland A, Hyatt Regency Dallas at 13:15
William Lynch, Michigan State University, presiding

Invited Papers

13:15
J8 1 Mechanism of Isospin Equilibration in Semi-Peripheral Heavy Ion Reactions.* MALGORZATA ZIELINSKA-PFABE, *Smith College*

The BUU formalism with the inclusion of fluctuations was used to study a mechanism of isospin equilibration in semi-peripheral collisions of heavy ions close to the Fermi energy. In order to investigate the density dependence of the asymmetry term in the nuclear equation of state (i.e. the asy-stiffness of the equation of state) the calculations with different parametrization of this term were performed. It has been found that the low density interface between the interacting nuclei which develops in semi-peripheral collisions plays an important role in controlling the currents of neutrons and protons. The isospin transport is affected by an interplay between drift and diffusion being driven by differences in N/Z ratio and by density gradients. Both, the drift and the diffusion are sensitive to the asy-stiffness of the nuclear equation of state. A study of the isospin transport ratio shows that the experiment seems to favor a more asy-stiff equation of state and that a more asy-soft equation leads to a larger isospin equilibration. We may conclude that the charge equilibration measurements for semi-peripheral collisions provide an effective tool to investigate the properties of asymmetric nuclear matter. In collaboration with Massimo Di Toro, Maria Colonna, and Virgil Baran, LNS, Catania, Italy; and Hermann Wolter, University of Munich, Munich, Germany.

*M.Z.P. would like to express her gratitude to NSF for supporting her research.

Contributed Papers

13:51
J8 2 Constraining properties of neutron stars with heavy-ion reactions BAO-AN LI, *Arkansas State University* LIE-WEN CHEN, *Shanghai JiaoTung University* CHE MING KO, *Texas A&M University* ANDREW W. STEINER, *Los Alamos National Laboratory* Nuclear reactions induced by stable and/or radioactive neutron- rich nuclei provide the opportunity to pin down the equation of state of neutron-rich matter, especially the density (ρ) dependence of its isospin-dependent part, i.e., the nuclear symmetry energy E_{sym}. A conservative constraint, $32(\rho/\rho_0)^{0.7} < E_{sym}(\rho) < 32(\rho/\rho_0)^{1.1}$, around the nuclear matter saturation density ρ_0 has recently been obtained from the isospin diffusion data in intermediate energy heavy-ion collisions. We review this exciting result and discuss its consequences and implications on nuclear effective interactions, radii and cooling mechanisms of neutron stars.

14:03
J8 3 Density dependence of the symmetry energy in the equation of state of asymmetric nuclear matter D.V. SHETTY, S.J. YENNELLO, G.A. SOULIOTIS, *Cyclotron Institute, Texas A&M University, College Station, TX 77843* The density dependence of the symmetry energy is an important ingredient in the equation of state of asymmetric nuclear mater. This currently unknown quantity is key to understanding the structure of systems as diverse as the atomic nuclei and neutron stars. Theoretical calculations predict wide variety of different forms of the density dependence of the symmetry energy. Results from various different measurements constraining this dependence will be presented.

14:15
J8 4 Nucleon Diffusion Observables in heavy ion reactions MANYEE TSANG, *Michigan State University* The study in heavy ion collision in the past years has focused on the understanding of the properties of bulk nuclear matter at densities above and below the saturation density. One promising observable to study the den-

sity dependence of the symmetry energy term in the nuclear Equation of State is the isospin diffusion. The idea is that the symmetry term in the nuclear EOS acts as the driving force that ''transports'' neutron and/or protons between the projectile and target during the multifragmentation process The isospin transport observable constructed with the isoscaling parameters has been used to constraint the equation of state which describes the dynamics of heavy ion reactions. In this talk, we will explore other observables that can be used to construct the isospin transport ratios. This work is supported by the National Science Foundation under Grant Number PHY-01-10253

14:27

J8 5 Studying the symmetry energy of excited projectile-like sources* AUGUST L. KEKSIS, M. VESELSKY, G.A. SOULIOTIS, E. BELL, J. GAREY, M. JANDEL, S. PARKETON, C. RICHERS, A. RUANGMA, D.V. SHETTY, E.M. WINCHESTER, S.J. YENNELLO, *Cyclotron Institute Texas A&M University* Quasiprojectile, or projectile like, sources were reconstructed from the reactions 32 & 45 MeV/nucleon 40Ar, 40Ca & 48Ca on 112Sn & 124Sn. The technique of isoscaling was used on the isotopic yields from these sources to determine the isoscaling parameter alpha. Alpha was also determined from the isotopic yields created by a hybrid model, which uses the Deep Inelastic Transfer, DIT, code to simulate the interaction stage and the Statistical Multifragmentation Model, SMM, to simulate the breakup stage of these quasiprojectile sources. The experimental results were compared to the theoretical results for various parameterizations of the symmetry energy used by the model.

*Funding provided by DOE grant DE-FG03-93ER40773 and by the Robert A. Welch Foundation grant A-1266.

14:39

J8 6 Exploring the Evolution of the Symmetry Energy of Hot fragments from the Compound Nucleus towards Bulk Multifragmentation G.A. SOULIOTIS, A.S. BOTVINA, D.V. SHETTY, A.L. KEKSIS, E. BELL, M. JANDEL, M. VESELSKY, S.J. YENNELLO, *Cyclotron Institute, Texas A&M University* High-resolution mass spectrometric data on the isotopic distributions of projectile-like fragments (heavy IMFs and heavy residues) from peripheral collisions of heavy neutron-rich beams (86Kr and 64Ni at 25MeV/nucleon) on a variety of targets are systematically compared with calculations of a hybrid model appropriate for this energy regime. The model consists of a well-tested deep-inelastic transfer model (DIT) for the dynamical stage of the collision and the latest version of the Statistical Multifragmentation model (SMM05) for the deexcitation stage. SMM05 allows the variation of the symmetry energy of hot primary fragments as a function of excitation energy (E*/A). The comparisons point to a gradual evolution (a linear decrease - to first approximation) of the symmetry energy coefficient of the binding energy from $\sim$ 25MeV/nucleon around E*/A=2 MeV/nucleon and below (essentially characterizing the compound nucleus regime) towards $\sim$ 15 MeV/nucleon at E*/A 4 MeV/nucleon (corresponding to mulk multifragmentation). Comparison of the present results with recent multifragmentation studies will be presented. Consequences of the observed gradual decrease of the symmetry energy to the distribution of hot exotic nuclei in the multifragmentation of neutron-rich systems and in supernova environments will be discussed.

14:51

J8 7 Neutron-Proton Transverse Emission Studies as a Signature of the Asymmetry Term of the Nuclear EOS MICHAEL FAMIANO, *Western Michigan University* WILLIAM LYNCH, TSANG BETTY, *NSCL* LEE SOBOTKA, ROBERT CHARITY, KOMAROV SERGEI, *Washington University in St. Louis* ANDREW ROGERS, *NSCL* Neutron and proton transverse emission ratios are studied from the reactions ^{124}Sn+124Sn and ^{112}Sn+^{112}Sn at 50 MeV/A as a signature of the density dependence of the asymmetry term of the nuclear EOS. Transverse neutron-proton emission ratios are compared to t/^{3}He ratios in the same framework. Results are compared to predictions from transport calculations, and future experiments are discussed.

SESSION J9: DOUBLE BETA DECAY
Sunday Afternoon, 23 April 2006
Cumberland B, Hyatt Regency Dallas at 13:15
Andrew Hime, Los Alamos National Laboratory, presiding

13:15

J9 1 Status of EXO-200 FRANCISCO LEPORT, *Stanford University* EXO COLLABORATION, EXO-200 (Enriched Xenon Observatory-200kg) is an experiment designed to detect the double-beta decay of ^{136}Xe. It will use 200 kg of Xe, isotopically enriched to 80% in ^{136}Xe, which is currently on hand at Stanford University. The Xe will be used as an active medium in the detector, and will be contained in liquid form in an ultra-low background, TPC. EXO-200 will be the first low-background detector to make large-scale use of Large Area Avalanche Photodiodes (LAAPDs), used to collect scintillation light. The simultaneous collection of ionization charge and scintillation light for every event has been proven to dramatically improve energy resolution. EXO-200 will be housed under a $\sim$ 2000 meter water-equivalent overburden at WIPP, New Mexico. Once completed, it will be the largest running double-beta decay experiment. It is designed to achieve competitive sensitivity for the neutrinoless double-beta decay mode ($0\nu\beta\beta$), as well as measure the as yet unobserved two neutrino double-beta decay mode ($2\nu\beta\beta$) of ^{136}Xe.

13:27

J9 2 A linear ion trap for the Enriched Xenon Observatory EXO BJÖRN FLATT, RALPH DEVOE, GIORGIO GRATTA, MATTHEW GREEN, JESSE WODIN, *Stanford University* EXO COLLABORATION, The Enriched Xenon Observatory for double beta decay attempts to answer one of the greatest outstanding questions in neutrino physics by performing a direct measurement of the majorana neutrino mass through the investigation of neutrinoless double beta decay ($0\nu\beta\beta$) of ^{136}Xe. The major advantage of Xenon as a source is the ability to detect the Ba ion daughter directly through laser induced fluorescence spectroscopy; this technique would allow for an essentially background-free measurement. First investigations of Ba spectroscopy were done in a hyperbolic Paul-trap. This talk discusses the trapping of single barium ions in buffer gasses, as well as the design and implementation of a linear ion trap, which allows for external loading of ions, for use in the Barium tagging aspect of a liquid Xenon double beta decay experiment.

13:39

J9 3 Pulse Shape and Segmentation Analysis in Germanium Detectors for Double-Beta Decay VICTOR M. GEHMAN, *Los Alamos National Laboratory/University of Washington* STEVEN ELLIOTT, DONGMING MEI, *Los Alamos National Laboratory* ALBERT YOUNG, HENNING BACK, *North Carolina State University* MAJORANA COLLABORATION, The Majorana Project will endeavor to provide direct limits on the effective Majorana mass of the electron neutrino through the measurement of neutrinoless double-beta decay in ^{76}Ge. Our goal is an experiment sensitive to the effective neutrino mass at the level of a few hundred meV scalable to a sensitivity of approximately 50 meV. One technique the Majorana Project will exploit to separate signal from background events is the combination of pulse shape analysis and detector segmentation. This background reduction is possible because double-beta events are very spatially localized (or single-site) in a germanium detector array, whereas likely backgrounds will be more spatially extended (or multi-site). In this report, we present a series of experiments using double-escape peaks as surrogate single-site events and full-energy γ peaks as surrogate multi-site events. These data were taken at LANL using a "CLOVER" detector (an array of four 800g, two-fold segmented germanium detectors) with a ^{56}Co source. We will also discuss a similar experiment performed using the Free Electron Laser at TUNL and SEGA (a twelve-fold segmented detector enriched to 86% in ^{76}Ge).

13:51

J9 4 Neutron-induced Background for Double-Beta Decay Experiments via Inelastic Scattering Processes* DONGMING MEI, STEVE ELLIOTTS, VICTOR GEHMAN, *Los Alamos National Laboratory* ANDREW HIME, *Los Alamos National Laboratory* KAREEM KAZKAZ, *University of Washington* MAJORANA COLLABORATION, We investigate several $Pb(n,n'\gamma)$ and $Ge(n,n'\gamma)$ reactions using a segmented clover detector. With and without an AmBe neutron source, we can separate the 2615-keV γ-ray produced from the $^{208}Pb(n,n'\gamma)$ reaction from the more familiar ^{208}Tl decay. The detection rate of the 2615-keV γ-ray produced via the $^{208}Pb(n,n'\gamma)$ reaction is determined. We emphasize that the 2615-keV γ-ray and the other high energy γ-rays from $Pb(n,n'\gamma)$ reactions can be a significant background for double beta decay experiments which use lead as a massive inner shielding and the background level depends on the depth of a specific underground laboratory. The excitation γ-ray lines through $Ge(n,n'\gamma)$ reactions are also observed. We consider the contribution of such backgrounds and the limitation in sensitivity of next generation searches for neutrinoless double beta decay using enriched germanium detectors and develop the the depth requirements of such detectors under different shielding configurations.

*This work is supported in part by the U.S. Department of Energy and by the Los Alamos Directed Research and Development Program.

14:03

J9 5 An update on the Majorana-Gerda simulation package (MaGe)* MICHAEL MARINO, *University of Washington* MAJORANA COLLABORATION, The Majorana collaboration is proposing to build an experiment to search for neutrinoless double-beta decay ($0\nu\beta\beta$) from ^{76}Ge using segmented HPGe detectors. The collaboration has partnered with the Gerda collaboration[1] to create a joint simulation package (MaGe) based upon CERN's Geant4[2] simulation engine and Root[3] analysis software. MaGe provides an adaptable and comprehensive simulation environment to model detector response, pulse formation, and background processes for a variety of detector parameters and geometries. This presentation will include an introduction to the important components of MaGe and present the latest results for background simulations of the Majorana reference design as well as its expected sensitivity to $0\nu\beta\beta$ decay of ^{76}Ge. A complementary talk will be given addressing verification of the simulation package.

*This work is supported by the DOE Office of Nuclear Physics.
[1]Gerda Collaboration, Proposal to LNGS, available (12 Jan 2006) http://www.mpi-hd.mpg.de/ge76/proposal_21sept.pdf.
[2]Geant4 - A Simulation Toolkit, Nuclear Instruments and Methods A **506**, 250–303 (2003).
[3]ROOT - An Object Oriented Data Analysis Framework, Nuclear Instruments and Methods A **389**, 81–86 (1997).

14:15

J9 6 Verification of the Majorana-Gerda Simulation Package (MaGe) A. G. SCHUBERT, MAJORANA COLLABORATION, Determining whether neutrinos are Majorana or Dirac particles is of vital importance to the physics community. The Majorana experiment seeks to address this question by searching for neutrinoless double-beta decay using germanium crystals enriched in ^{76}Ge. The Majorana and Gerda[1] collaborations have jointly developed MaGe, a Geant4[2] and ROOT[3] based simulation framework, to aid in the design and analysis phases of both experiments. Several Monte Carlo studies of existing detectors were performed using the MaGe package. Comparisons between the experimental data and the simulation results are used to verify MaGe's performance. The simulations that will be discussed are a study of neutron production from a SLAC e^- beam experiment[4], studies of a PNNL low-background HPGe material sampling detector with multiple sources, and a study of a LANL HPGe Clover detector with an AmBe source. This work is supported by the DOE Office of Nuclear Physics.

[1]The Gerda Collaboration, Gerda, (2004) 12 Jan 2006 http://www.mpi-hd.mpg.de/ge76/proposal_21sept.pdf.
[2]S. Agnostinelli et al., Geant4 - A Simulation Toolkit, Nucl. Instr. and Meth. **A 506**, 250 (2003).
[3]Brun, R. and F. Rademakers, ROOT - An Object Oriented Data Analysis Framework., Nucl. Instr. and Meth. A **389**, 81 (1997).
[4]S. Taniguchi et al., Nucl. Instr. and Meth. A **503**, 595 (2003).

14:27

J9 7 Updates on Cuoricino and CUORE THOMAS D. GUTIERREZ, *Lawrence Berkeley National Laboratory* CUORICINO COLLABORATION, CUORE COLLABORATION, Overviews of the neutrinoless double beta ($\beta\beta0\nu$) decay experiments Cuoricino and CUORE (Cryogenic Underground Observatory for Rare Events) will be presented. Cuoricino is currently the largest double beta decay experiment in operation and consists of 40 kg of TeO_2 crystals that act both as source and detector. The proposed CUORE experiment will consist of 988 TeO_2 crystals with a total source/detector mass of 750 kg. Updates from Cuoricino on the $\beta\beta0\nu$ limit for ^{130}Te as well as evaluations of other decays will be presented.

14:39

J9 8 A Search for Two-Neutrino Double-Beta Decay of ^{130}Te to the First Excited 0^+ State in ^{130}Xe with the

CUORICINO Detector* IULIAN BANDAC,† *University of South Carolina* CUORICINO COLLABORATION, We will discuss the results of an experimental search for two-neutrino $\beta\beta$ decay of ^{130}Te to the first excited 0^+ state in ^{130}Xe using the data from the CUORICINO detector. The CUORICINO array consists of 44 cubic crystals of TeO_2 $5 \times 5 \times 5cm^3$ of natural concentration 33.8% and 18 crystals $3 \times 3 \times 6cm^3$ four of them being isotopically enriched, two in ^{130}Te and the other two in ^{128}Te. The detector is operated in the Gran Sasso Underground Laboratory in Assergi, Italy at a depth of about 3500 m.w.e. We are considering different scenarios by searching for coincidences between different neighboring detectors. First we look for all events that are between the threshold and the maximum energy for the two emitted electrons 739.5 keV and for which there is one or more coincidences. Then among these select those for which their energy summed to 1793.5 ± 100 keV. These will include all events in which both gamma rays completely escape from the detector. Then we demand a triple coincidence leading to a background almost zero. In this way we can put a best bound on, or measure the half life.

*NSF Grants Phy-0139294 and Phy-0500337.
†CUORICINO Collaboration.

14:51
J9 9 Status of CUORE: Bolometric Search for Neutrinoless Double Beta Decay REINA MARUYAMA, *UC Berkeley/LBNL* CUORE COLLABORATION, CUORE is a bolometric neutrinoless double beta decay experiment currently under development at Gran Sasso National Laboratory. It will consist of 988 TeO_2 crystals weighing a total of 750 kg. The primary goal is to look for neutrinoless double beta decay of Te-130. Most experimental techniques have been demonstrated in the currently running prototype Cuoricino, however a few technical challenges remain. The key to the success for CUORE lies in ensuring ultra-low radioactive backgrounds in the detector and having well-characterized uniform thermistors for each crystal to measure the energy deposited from a nuclear decay. Recent R&D developments for CUORE will be discussed, including background studies and thermistor production.

SESSION J10: CHARM MIXING, RARE D AND K DECAYS
Sunday Afternoon, 23 April 2006
Cumberland C, Hyatt Regency Dallas at 13:15
Ian Shipsey, Purdue University, presiding

13:15
J10 1 Search for Charm Mixing with Flavor Tagged Dalitz Plots from $\psi(3770) \rightarrow D\bar{D}$ ERIC WHITE, *University of Illinois* CLEO COLLABORATION, A quantum correlated $(C=-1)$ $D\bar{D}$ state is produced from $\psi(3770) \rightarrow D\bar{D}$. Reconstructing one of the D mesons as a CP eigenstate, $y = \Delta\Gamma/2\Gamma$ can be determined by measuring the flavor specific branching ratios of the other meson. The flavor tag width is independent of the CP quantum number however the branching ratio is inversely proportional to the total width. Consequently, charm threshold experiments have time-integrated sensitivity to y. Several multi-body D^0 decays proceed through intermediate states that are CP eigenstates, such as $D^0 \rightarrow K^0_S f_0, f_0 \rightarrow \pi\pi$ and $D^0 \rightarrow \rho\pi^0, \rho \rightarrow \pi\pi$. The presence of mixing through y would introduce an intensity modulation across the Dalitz plot (for flavor tagged D's relative to the Dalitz plot observed in uncorrelated production) as a function of the CP of the contributing amplitudes. We present a study of the sensitivity to y with the anticipated CLEO-c data set.

13:27
J10 2 Measurement of the Strong Phase of $D^0 \rightarrow K^-\pi^+$ Relative to $\overline{D^0} \rightarrow K^-\pi^+$ with CLEO-c Data ALEXANDER SCOTT, *University of Minnesota* CLEO COLLABORATION, Quantum correlations in $\psi(3770) \rightarrow D^0\overline{D^0}$ decays introduce sensitivity to charm mixing, doubly-Cabibbo-suppressed decay amplitudes, and strong phases into time-integrated D^0 and $\bar{D}^0$ decay rates. In this talk we describe the selection of CP-eigenstate D^0 and $\overline{D^0}$ tags in a sample of $\sim$ 300 pb^{-1} of e^+e^- annihilation data collected with the CLEO-c detector at the Cornell Electron Storage Ring. We use these tags and the quantum coherence of the $D^0\overline{D^0}$ pair to measure the rates for $D^0 \rightarrow K^-\pi^+$ decays separately for CP-even and CP-odd states. We use the asymmetry between these rates to obtain a measurement of the relative strong phase δ, which is an important ingredient for the interpretation of charm-mixing and CKM measurements at higher energies. Projections of the ultimate sensitivity for this determination with the full CLEO-c data sample are given.

13:39
J10 3 Determination of Charm-Mixing and Doubly-Cabibbo-Suppressed Decay Parameters with CLEO-c Data ADAM LINCOLN, *Wayne State University* CLEO COLLABORATION, Information about charm mixing and doubly-Cabibbo-suppressed decays, as well as improved precision for measurement of the D^0-decay strong phase, can be obtained by combining multiple decay-rate measurements in $\psi(3770) \rightarrow D^0\overline{D^0}$ events. We use a sample of $\sim$ 300pb^{-1} collected with the CLEO-c detector to measure the absolute branching fractions for semileptonic decays of D^0 mesons for which flavor and CP properties are inferred from an accompanying hadronic tag and the quantum coherence of the initial $D^0\overline{D^0}$ pair. We describe the fitting procedure for combining these and hadronic decay measurements, give results for current data, and project the ultimate sensitivity with the full CLEO-c sample for the relative strong phase δ and mixing amplitude y.

13:51
J10 4 Search for D^0 mixing in $D^0 \rightarrow K^-\pi^+\pi^-\pi^+$ YI ZHENG, *Massachusetts Institute of Technology* BABAR COLLABORATION, We report on studies of the right sign and wrong sign decays of $D^0 \rightarrow K^-\pi^+\pi^-\pi^+$ using 230.4fb^{-1} of data collected by the BaBar experiment. The preliminary measurement of the doubly Cabbibo-suppressed rate for the $D^0 \rightarrow K^-\pi^+\pi^-\pi^+$ decay is presented, which can provide insights into searching for D^0 mixing via this hadronic decay of neutral D meson.

14:03
J10 5 Flavor changing radiative D meson decays TIM KLEIN, *University of Minnesota* CLEO COLLABORATION, Flavor changing radiative decays of the bottom quark provide tests of the Standard Model and powerful constraints on new physics. A better understanding of the long distance contributions to these processes

may help reduce theoretical uncertainties on the predicted rates. Flavor changing radiative D meson decays are dominated by long distance contributions due to a vector meson coupling to a photon and are suitable for confronting predictions of nonperturbative mechanisms. We present a measurement of the branching fraction of $D^0 \to \phi\gamma$ in 281^{-1} of data collected by the CLEO-c detector at the Cornell Electron Storage Ring. We also present a measurement of the branching fraction, $D^0 \to \phi\pi^0$, a significant background to the radiative decay.

14:15

J10 6 Search for Flavor-Changing Neutral-Current Charm Decays at BaBar BRIAN PETERSEN, *Stanford University* BABAR COLLABORATION, We present a search for flavor-changing neutral-current charm meson and baryon decays using data collected by the BaBar experiment. Flavor-changing neutral-current decays occur only through loop diagrams in the Standard Model and are therefore sensitive to certain types of new physics. The strongest constraints at present come from K and B decays, but charm decays are potentially also sensitive to new physics. The analysis will present a search for the decay modes $D^+ \to \pi^+\ell^+\ell'^-$, $D_s^+ \to K^+\ell^+\ell'^-$, and $\Lambda_c^+ \to p\ell^+\ell'^-$.

14:27

J10 7 The Search for $K_L \to \pi^0\pi^0\gamma$ DAVID SMITH, *University of Virginia* KTEV COLLABORATION, This talk describes a search for the rare decay $K_L \to \pi^0\pi^0\gamma$ conducted using data from the KTeV experiment. KTeV is a high-energy physics experiment that ran at Fermilab from 1997 to 1999, dedicated to searching for rare K_L decays and to extracting CP violation parameters such as ϵ'/ϵ. The decay $K_L \to \pi^0\pi^0\gamma$ is an electric quadrupole (E2) decay that is forbidden to fourth order in Chiral Perturbation Theory, and is interesting as a probe of the theory to the sixth order. Howver, the decay is experimentally hard to find due to a large background of $K_L \to 3\pi^0$ decays with one missing photon. The data sample used consisted of events with one of the internal photons converting to a Dalitz pair; this was done because of the sensitivity of the KTeV charged trigger. The primary background mode consisted of $K_L \to 3\pi^0$ events with one missing photon; a subsample of this mode, in which the missing photon was assumed to go down a calorimeter beam hole, was used as a normalization mode due to the similar topology and large number of events. Both the 1997 and 1999 KTeV data was used in a blind analysis to conduct the search for $K_L \to \pi^0\pi^0\gamma$ outlined in this talk.

14:39

J10 8 Latest KTeV results on the study of the decay $K_L \to \pi^+\pi^-\gamma$ MICHAEL RONQUEST, *University Of Virginia* FNAL KTEV/E832 COLLABORATION, This talk will present to date the most precise determination of the parameters that describe the M1 direct photon emission process in the decay $K_L \to \pi^+\pi^-\gamma$. The M1 process, along with the inner bremsstralung process, dominates this decay. This study was conducted using data collected during the 1997 run of the KTeV E832 experiment at Fermilab. A search for the CP violating E1 direct photon emission process will also be presented.

SESSION J11: ADVANCES IN NUMERICAL RELATIVITY I

Sunday Afternoon, 23 April 2006
Cumberland E, Hyatt Regency Dallas at 13:15
Bernard Kelly, The University of Texas at Brownsville, presiding

13:15

J11 1 Elliptic gauge conditions for binary black hole evolutions HARALD PFEIFFER, *California Institute of Technology* Elliptic gauge conditions have many attractive features for black hole evolutions and have been used very successfully in simulations in one and two spatial dimensions. In three dimensions, however, elliptic gauge conditions have hardly been explored because of the traditionally high computational cost. With recent efficient elliptic solvers, computational cost is greatly reduced, and 3-D black hole evolutions employing elliptic gauge conditions become possible. This talk presents preliminary results, addressing questions like: Do elliptic gauge conditions control effectively the coordinates and the location of the black holes? How often does one have to solve elliptic equations? What is the computational cost?

13:27

J11 2 Constraint damping in the KST evolution system ROBERT OWEN, *Caltech* Much effort in recent years has been directed toward expressing the evolution equations of general relativity in forms where constraint violations are dynamically damped away during the simulation. We will discuss a trick which naturally appears in the context of explicit first-order reductions of second-order evolution systems. This trick presents a simple means to modify the evolution of certain constraints, without altering hyperbolicity. As an example, we will discuss a generalization of the KST evolution systems, that damps away most constraints exponentially on a tunable timescale, and present results of its use in numerical simulations.

13:39

J11 3 Expanding Cosmological Spacetimes Containing Gravitational Waves BEVERLY K. BERGER, *National Science Foundation* Most analysis of expanding cosmologies focus on matter (exotic or otherwise) in a spatially homogeneous background although spatial inhomogeneities clearly exist. To examine the possible effects of these inhomogeneities on expanding cosmologies, models with 3-torus topology and spatial dependence only in one direction are considered. The behaviors of vacuum and fluid-filled cases are contrasted with the vacuum and fluid-filled anisotropic but spatially homogeneous Kasner models where it is known that the latter case approaches isotropy. The results of numerical simulations will be used to illustrate unusual behavior for vacuum spatially inhomogeneous models as well as their approach to the standard cosmology when matter dominates the dynamics.

13:51

J11 4 Finite Elements in Numerical Relativity MATTHEW ANDERSON, LUIS LEHNER, JORGE PULLIN, *Louisiana State University* We employ finite elements in solving the Einstein equations for hyperspherical black hole and black string spacetimes. We present examples solving the elliptic initial data equations to study the possible black string-hole transition in higher dimensional gravity.

14:03

J11 5 Gravitational Collapse With Distributed Adaptive Mesh Refinement STEVEN LIEBLING, *C.W. Post – Long Island University* LUIS LEHNER, PATRICK MOTL, *Louisiana State University* DAVID NEILSEN, *Brigham Young University* TANVIR RAHMAN, *C.W. Post – Long Island University* OSCAR REULA, *Universidad Nacional de Cordoba* Gravitational collapse is studied using distributed adaptive mesh refinement (AMR). The AMR infrastructure includes a novel treatment of adaptive boundaries which allows for high orders of accuracy. Results of the collapse of Brill waves to black holes are presented. Combining both vertex centered and cell centered fields in the same evolution is discussed.

14:15

J11 6 The Lazarus Project II: Space-like extraction with the Quasi-Kinnersley tetrad* MANUELA CAMPANELLI, *The University of Texas at Brownsville* BERNARD KELLY, *The University of Texas at Brownsville* CARLOS LOUSTO, *The University of Texas at Brownsville* The Lazarus project was designed to make the most of limited 3D binary black-hole simulations, through the identification of perturbations at late times, and subsequent evolution of the Weyl scalar Ψ_4 via the Teukolsky formulation. Here we report on new developments, employing the concept of the ''quasi-Kinnersley'' (transverse) frame, valid in the full nonlinear regime, to analyze late-time numerical space-times that should differ only slightly from Kerr. This allows us to extract the essential information about the background Kerr solution, and through this, to identify the radiation present. We explicitly test this procedure with full numerical evolutions of Bowen-York data for single spinning black holes, head-on and orbiting black holes near the ISCO regime. These techniques validate previous Lazarus results, provide a measure of the errors intrinsic to the method, and give as a by-product a more robust wave extraction method for numerical relativity.

*We acknowledges financial support from NSF grants PHY-0140326 and PHY-0354867, and NASA NAG5-13396.

14:27

J11 7 Wave extraction using the Newman-Penrose formalism: Theory and applications ANDREA NEROZZI, *University of Texas at Austin* MARCO BRUNI, *Institute of Cosmology and Gravitation. University of Portsmouth. Portsmouth UK* VIRGINIA RE, *School of Physics and Astronomy. University of Birmingham. Birmingham UK.* LIOR M. BURKO, *University of Alabama at Huntsville* Newman-Penrose quantities such as Weyl scalars are potentially a powerful wave extraction tool especially in those cases where a solid wave extraction technique has not been developed yet, like, for example, in simulations relying on the ADM formulation of Einstein's equations. Here we present the progress done in building up a novel technique which optimizes the process of calculating Weyl scalars for wave extraction purposes and we apply these results to a specific numerical example.

14:39

J11 8 Estimating the gravitational-wave content of initial-data sets for numerical relativity using the Beetle–Burko scalar LIOR M. BURKO, *University of Alabama in Huntsville* The Beetle–Burko radiation scalar is a gauge independent, tetrad independent, and background independent quantity that depends only on the radiative degrees of freedom where the notion of radiation is incontrovertible, and can be computed from spatial data as is typical in numerical relativity simulations even for strongly dynamical spacetimes. We show that the Beetle–Burko radiation scalar can be used for estimating the graviational-wave content of initial-data sets in numerical relativity, and can thus be useful for the construction of physically meaningful ones, and the identification of ''junk'' data on the intial value surface. We apply this method for the case of a momentarily stationary black hole binary, and demonstrate how the Beetle–Burko scalar distinguishes between Misner and Brill–Lindquist initial data. The method, however, is robust, and is applicable to generic initial data sets. In addition to initial data sets, the Beetle–Burko radiation scalar is equally applicable also for evolution data.

14:51

J11 9 Simulation of a Boosted Black Hole with Overlapping Coordinate Systems PAUL WALTER, ANDREA NEROZZI, RICHARD MATZNER, *University of Texas at Austin* MATT ANDERSON, *Louisiana State University* UNIVERSITY OF TEXAS AT AUSTIN COLLABORATION, LOUISIANA STATE UNIVERSITY COLLABORATION, We discuss the simulation of a boosted Kerr-Schild black hole using overlapping spheriodal grids around the excision region. We make use of constrained evolution, periodically solving the constraints to better than truncation error. Fisheye is used to increase the size of the domain while Robin boundary conditions are used at the outer boundary. We discuss the current state of the code and the impediments to long-time integration.

15:03

J11 10 Evaluating Spectral Techniques in Numerical Relativity* MICHAEL BOYLE, LEE LINDBLOM, HARALD PFEIFFER, MARK SCHEEL, *California Institute of Technology* LAWRENCE KIDDER, *Center for Radiophysics and Space Research, Cornell University* We analyze the behavior of a pseudo-spectral code evolving the KST formulation of Einstein's equations. In an effort to better compare different analytical formulations of Einstein's equations and numerical techniques for implementing them, a set of standardized tests for numerical relativity codes has been suggested by the ''Apples with Apples'' collaboration. The tests involve simple, three-dimensional space-times with known analytic solutions evolved in a space without boundaries (a 3-Torus) with prescribed evolution parameters such as resolution and time step. We have implemented these tests with our code. We find that the exponential convergence of spectral spatial differentiation and the stability of the KST formulation allow us to evolve these spacetimes on low-resolution grids, limited most strongly by machine precision. We derive expressions to estimate the growth of errors due to machine precision in arbitrary spacetimes, and show that these limits are easily achieved by our code, with good stability of the analytical formulation and numerical implementation.

*This work was supported in part by NSF Grant PHY-0099568 and by NASA Grant NAG5-12834.

SESSION J12: HIGGS PHYSICS II
Sunday Afternoon, 23 April 2006
Cumberland F, Hyatt Regency Dallas at 13:15
Dan Amidei, University of Michigan, presiding

13:15

J12 1 Mass Effects in $Wb\bar{b}$ Production at Hadron Colliders FERNANDO FEBRES CORDERO, LAURA REINA, *FSU* DOREEN WACKEROTH, *SUNY at Buffalo* We present the NLO QCD corrections to the process $p\bar{p},pp \rightarrow Wb\bar{b}$ including full mass effects. We study in detail the impact of mass terms in the theoretical prediction of cross sections and distributions. The $Wb\bar{b}$ mode is an important background for several processes, in particular for the associated W production of a SM light Higgs.

13:27

J12 2 On a General Procedure for Evaluating Higher Order Radiative Corrections for LHC Physics* MIKHAIL KALMYKOV, SWAPAN MAJHI, BENNIE F.L. WARD, SCOTT A. YOST, *Baylor University* The anticipated role of precision theoretical predictions for LHC physics processes necessitates the development of efficient, reliable and rigorous theoretical tools to evaluate QCDXEW higher order radiative corrections to such processes. In this talk, we present the elements and status a new methodology which is ultimately aimed at providing the exact higher order corrections needed for exactly resummed QCDXEW MC event generators, which are also under our development so that we may realize an event-by-event comparison between theory and the precision LHC data.

*Work supported by US DOE grant #DE-FG02-05ER41399 and NATO grant PST.CLG.980342.

13:39

J12 3 Search for Technicolor Production at DØ SATISH DESAI, *State University of New York, Stony Brook* D0 COLLABORATION, One of the most important unresolved issues in particle physics is the nature of electroweak symmetry breaking. In the Standard Model, this question is addressed by the Higgs field, but alternate models have been proposed. One such model is Technicolor, which predicts a wide array of heavy composite particles. A search for $\rho_{TC} \rightarrow W\pi_{TC} \rightarrow \mu\nu bq$ in data collected at Run II of the DØdetector is presented, and a limit is set on the production of Technicolor production in $p\bar{p}$ collisions.

13:51

J12 4 Measurement of the $W^{\pm} + b\bar{b}$ Cross Section at CDF* MITCH SODERBERG, *Univ. of Michigan* CDF COLLABORATION, We present a preliminary measurement of the $W^{\pm} + b\bar{b}$ production cross section in $p\bar{p}$ collisions at 1.96 TeV at the Collider Detector at Fermilab (CDF). We measure the cross section using events that contain one high transverse momentum lepton, missing transverse energy, and one or two jets including one jet tagged with a displaced secondary vertex. We use the invariant mass of the vertex to discriminate between b-quark jets, c-quark jets, and mistags.

*For the CDF Collaboration.

14:03

J12 5 Search for Neutral Supersymmetric Higgs Bosons in bbh MARINE MICHAUT, *DAPNIA/SPP, Saclay* D0 COLLABORATION, Many extensions of the Standard Model predict greatly enhanced production rates of neutral Higgs bosons in association with bottom quarks. The Tevatron Run II data collected by the DØ detector are used to search for Higgs bosons in bh ($\rightarrow b\bar{b}$) and $b\bar{b}h$($\rightarrow b\bar{b}$) channels that result to $3b$-jet and $4b$-jet final states, respectively. The status of the current data analysis, and expectations for Run II are presented.

14:15

J12 6 Search for Higgs Produced in Association with b Quarks in $p\bar{p}$ Collisions at $\sqrt{s}$ = 1.96 TeV with Higgs Decaying into $\tau^+\tau^-$ YURY POGORELOV, *University of Notre Dame* D0 COLLABORATION, A search for the Higgs boson in the Minimal Supersymmetric Standard Model (MSSM) is performed using a data sample collected with the DØ detector, where one tau decays into a muon and the other one decays hadronically, and btag is used for b-jet identification.

14:27

J12 7 SM Higgs Boson Discovery Potential at CMS via WBF, $H \rightarrow ZZ \rightarrow llvv$ UGUR AKGUN, A. MESTVIRISHVILI, A.S. AYAN, F. DURU, E. NORBECK, Y. ONEL, S. WANG, *University of Iowa* CMS COLLABORATION, Among the four different production mechanisms of the Standard Model (SM) Higgs boson, Weak Boson Fusion (WBF) has the second largest cross section. This channel has a unique signature because it produces high energy quark jets in the forward and backward directions, which allows the background to be reduced, and makes WBF production a strong candidate for SM Higgs discovery. We report the CMS discovery potential for the SM Higgs boson, produced via WBF and decaying to a pair of Z^0 bosons, with one Z^0 decaying to e^+e^- and the other to $\nu_e\bar{\nu}_e$.

14:39

J12 8 MSSM Higgs boson reconstruction at CMS via $ggH \rightarrow \tau\tau \rightarrow llvvvv$ FIRDEVS DURU, U. AKGUN, *University of Iowa* S. KUNORI, *U. Maryland* Y. ONEL, *University of Iowa* CMS COLLABORATION, The associated Higgs production mechanism $gg \rightarrow b\bar{b}H/A$ can be strongly enhanced in the Minimal Supersymmetric Standard Model (MSSM). Regardless of the production mechanism, the decay of a Higgs Boson into a pair of τ- leptons has a very unique topology that allows reconstruction of the invariant mass of the Higgs, using collinear approximation, with well-measured E_T. Since the τ can decay to an electron or muon plus E_T the presence of two soft b-jets with leptons (or jets, in the case of hadronic τ decays) and E_T can be the signature of new physics. The hermetic calorimeter coverage of the CMS experiment provides the needed E_T resolution for this potential discovery channel. In this report we discuss the invariant mass reconstruction efficiencies of CMS for leptonic $gg \rightarrow b\bar{b}H/A \rightarrow \tau^+\tau^-$ decay at large $tan\beta$, as well as the background from Drell-Yan production.

SESSION J13: PARTICLE THEORY
Sunday Afternoon, 23 April 2006
Cumberland G, Hyatt Regency Dallas at 13:15
Joseph Lykken, Fermilab, presiding

13:15

J13 1 Supersymmetry from a Fundamental Statistical Theory: Further Implications ROLAND ALLEN, SEIICHIROU YOKOO, *Physics Dept., Texas A&M Univ.* (1) The most natural form of the supersymmetry in the preceding abstract appears to contain no auxiliary fields, but to require instead that there are two sfermions for each fundamental fermion, and two gauginos for each gauge boson. The supersymmetry algebra and physical predictions are then quite unconventional. (2) The theory of the previous abstract leads to many features of standard physics, but does not produce the terms in the action for noninteracting gauge, gaugino, gravitational, and gravitino fields. We interpret these terms as arising from a response of the vacuum that is analogous to the Landau diamagnetic response of a metal. The smallness of the cosmological constant then results from a simple principle: The vacuum does not contribute to the stress-energy tensor, but is instead responsible for the Einstein-Hilbert action itself. (3) The initial statistical theory suggests a mechanism for scale-invariant fluctuations which is quite different from that of inflationary models.

13:27

J13 2 Supersymmetry from a Fundamental Statistical Theory SEIICHIROU YOKOO, ROLAND ALLEN, *Physics Dept., Texas A&M Univ.* We derive a nearly-standard form of supersymmetry from a quite nonstandard fundamental theory, which is motivated by two ideas: (1) A Euclidean path integral in quantum physics is equivalent to a sum-over-states in statistical physics. This suggests that a fundamental description of nature at the Planck scale is likely to be statistical. (2) A truly fundamental theory should explain the origin of spacetime, quantum fields, gravity, gauge fields, and supersymmetry. We start with a statistical picture that has been introduced elsewhere [1] and add some new understanding. First, we emphasize that the imaginary random Gaussian potential of Ref. 1 (c) must be regarded as an additional postulate of the theory. Second, we point out that the more natural description of fundamental bosons (including Higgs bosons and sfermions) is one in which they have spin zero (as in Ref. 1(a)) rather than spin 1/2 (as in Ref. 1(b)). There are then at least two novel predictions of the theory presented here: the lack of a conventional coupling to gravity for Higgs bosons and sfermions, and violation of Lorentz invariance for fermions at very high energy [2]. [1] R.E. Allen, (a) hep-th/9612041; (b) hep-th/0008032; (c) hep-th/0310039. [2] R.E. Allen and S. Yokoo, Nuclear Physics B (Proc. Suppl.) **134**, 139 (2004); hep-th/0402154.

13:39

J13 3 Further Development of HS Field Theory ABDULMAJEED ABDURRAHMAN, JACQUELINE FARIDANI, *Shippensburg University of Pennsylvania* MAHMOUD GASSEM, *American University in London* We present a systematic treatment of the HS Field theory of the open bosonic string and discuss its relationship to other full string field theories of the open bosonic string such as Wittens theory and the CVS theory. In the development of the HS field theory we encounter infinite dimensional matrices arising from the change of representation between the two theories, i.e., the HS field theory and the full string field theory. We give a general procedure of how to invert these gigantic matrices. The inversion of these matrices involves the computation of many infinite sums. We give the values of these sums and state their generalizations arising from considering higher order vertices (i.e., more than three strings) in string field theory. Moreover, we give a general procedure, on how to evaluate the generalized sums, that can be extended to many generic sums of similar properties. We also discuss the conformal operator connecting the HS field theory to that of the CVS string field theory.

13:51

J13 4 Fermion Generation and Mixing from Dualized Standard Model JACQUELINE FARIDANI, ABDULMAJEED ABDURRAHMAN, *Shippensburg University* The puzzle of fermion generations and mass hierarchy are recognized as one of the biggest problems in particle physics. In this work, we present a possible explanation of this puzzle using a non-abelian generalization of electric-magnetic duality. This duality implies the existence of another symmetry dual to color which is necessarily broken when color is confined. This dual color predicts the 3 fermion generations and suggests a Higgs mechanism for breaking the generation symmetry. The fermion mass hierarchy and mixing patterns are also explained. Quarks and leptons are seen to have very different mixing patterns in agreement with experiment. The model offers a perturbative method for calculating mixing parameters and mass ratios between generations, allowing us to calculate to 1-loop order all the 9 CKM matrix elements for quarks, the neutrino oscillation angles and some other quantities. The model is also highly predictive giving correlated predictions in low energy flavor changing neutral current effects and in ultra-high energy post-GZK air shower events from cosmic rays.

14:03

J13 5 Hidden/Observable Sector Symmetries from Heterotic Strings BEN DUNDEE, *Baylor University* JOHN PERKINS, *Baylor University, AMD* GERALD CLEAVER, *Baylor University* As a rule, phenomenologically viable string models have matter which is not charged under the standard model gauge group, but rather under other gauge groups. In this research, we have attempted to construct a model in which there is complete symmetry between the hidden and observable sector, using the free fermionic formulation of the heterotic string. Despite symmetric boundary conditions between the two sectors, an asymmetry in the GSO projection prohibits the low energy effective field theory from exhibiting sector symmetry. In the specific examples shown, an expected non-chiral Pati-Salam mirror universe model—$[SU(4)_C \times SU(2)_L \times SU(2)_R]^O \times [SU(4)_C \times SU(2)_L \times SU(2)_R]^H$—is transformed into a chiral model with enhanced hidden sector gauge symmetry and reduced observable sector gauge symmetry—$[SU(4)_C \times SU(2)_L]^O \times [SO(10) \times SU(2)_R]^H$.

14:15

J13 6 Status of the Heterotic String Optical Unification Investigation GERALD CLEAVER, JOHN PERKINS, BEN DUNDEE, RICHARD OBOUSY, MATT ROBINSON, *Baylor University* STEPHANIE HATTEN, *Walla Walla College* ERIC KASPER, *Texas A&M* CASSEL SLOAN, *College of Charleston* KRISTIN SLOAN, *East Tennessee State University* A weakly coupled heterotic string model was recently constructed that offers the possibility of optical unification. Whether optical unification can be realized depends on the availability of anomaly-canceling

D- and F-flat directions meeting certain phenomenological requirements. This paper reports on the current status of a systematic investigation of the optical unification properties of a subset of flat directions of this model that are stringently flat.

14:27

J13 7 Direct evidence for the Maldacena conjecture for $\mathcal{N}$ = (8,8) super Yang-Mills theory in 1+1 dimensions* UWE TRITTMANN, *Otterbein College* We solve $\mathcal{N}$ = (8,8) super Yang-Mills theory in 1+1 dimensions at strong coupling to directly confirm the predictions of supergravity at weak coupling. We do our calculations in the large-N_c approximation using Supersymmetric Discrete Light-Cone Quantization with up to 3 $\times$ 10^{12} basis states. We calculate the stress-energy correlator $\langle T^{++}(r)T^{++}(0)\rangle$ as a function of the separation r and find that at intermediate values of r the correlator behaves as r^{-5} to within errors as predicted by weak-coupling supergravity. We also present an extension to significantly higher resolution of our earlier results for the same correlator in the $\mathcal{N}$ = (2,2) theory and see that in this theory the correlator has very different behavior at intermediate values of r.

*Work supported by the Research Corporation.

14:39

J13 8 Supersymmetry, the Casimir effect and speculative propulsion RICHARD OBOUSY, GERALD CLEAVER, *Baylor University* Within the framework of brane-world models it is possible to account for the cosmological constant by assuming supersymmetry is broken on the 3-brane but preserved in the bulk. An effective Casimir energy is induced on the brane due to the boundary conditions imposed on the compactified extra dimensions. It will be demonstrated that modification of these boundary conditions allows a spacecraft to travel at any desired speed due to a local adjustment of the cosmological constant which effectively contracts/expands space-time in the front/rear of the ship resulting in motion potentially faster than the speed of light as seen by observers outside the disturbance.

SESSION K1: POSTER SESSION: MAGNETICALLY CONFINED PLASMA I

Sunday Afternoon, 23 April 2006
Landmark Circle, 2:00pm–5:00pm, Hyatt Regency Dallas at 14:00

K1 1 Kinetic Self-Organization of Microinstabilities in Astrophysical and in Laboratory Plasmas GIOVANNI LAPENTA, *Los Alamos National Laboratory* Microinstabilities can be considered as effective collisions. The small scale electromagnetic fluctuations due to microinstabilties can be considered as collisions on the particles, leading to a similar point-like and instantaneous-like change in the particle momentum. This paradigm, the anomalous transport paradigm, requires us to derive theories that can predict the correct transport parameters (particularly the anomalous viscosity and anomalous resistivity) from the properties of the microinstabilties. Our recent work [1–3] has shown that another possible effect of microinstabilties is to lead to a direct macroscopic change in the equilibrium by affecting the plasma flow, temperature anisotropy and current profile on a macroscopic level. Our previous work has focused on space and astrophysical systems. But similar effects can be considered for experimental plasmas. A particularly intriguing possible analogy is with zonal flows and "angular momentum generation" believed to be happening in accretion disks in astrophysical systems [4] and with the "spontaneous toroidal rotation" of axisymmetric plasmas in fusion devices such as Jet and Alcator C-Mod [5]. [1] G. Lapenta, J.U. Brackbill, W.S. Daughton, Phys. Plasmas **10**, 1577 (2003). [2] W. Daughton, G. Lapenta, P. Ricci, Phys. Rev. Lett. **93**, 105004 (2004). [3] P. Ricci, J.U. Brackbill, W.S. Daughton, G. Lapenta, Phys. Plasmas **11**, 4102 (2004). [4] B. Coppi, Nucl. Fusion 42 1–4 (2002). [5] E. S. Marmar et al., Fusion Energy 2002 (IAEA, Vienna) Paper OV/4-1.

K1 2 Emergence of large scale magnetic fields by relaxation in laboratory and astrophysical plasmas XIANZHU TANG, *Los Alamos National Laboratory* ALLEN BOOZER, *Columbia University* Magnetic relaxation is an extreme form of self-organization by which magnetic energy and helicity injected on small scales are transported to and accumulated on system scale magnetic fields by plasma fluctuations. Many fusion concepts rely on magnetic relaxation to generate and sustain the confining magnetic field. Examples include the reversed field pinch, spheromak, and spherical torus. Naturally occurring plasmas such as that in the giant radio lobes powered by the accretion disks of super-massive black holes are also subject to magnetic relaxation. A unified physics description of these relaxation processes can be found by an analogy to the familiar driven nonlinear oscillator. The fully relaxed Taylor state corresponds to the linear oscillator limit, where a primary resonance confines the energy input to the system scale magnetic fields. Like a nonlinear oscillator, the linear resonances are regularized by any of plasma inertia, finite pressure, and non-uniform normalized parallel current density in a partially relaxed plasma. The bifurcated regularized solutions are shown to have distinct physics interpretation and significance, and are intimately connected to the nonlinear dynamics that facilitate the relaxation. X.Z. Tang and A.H. Boozer, PRL, 225004 (2005); PRL, 155002 (2005); Phys. Plasmas, 102102 (2005).

K1 3 Fractional diffusion models of non-local transport DIEGO DEL-CASTILLO-NEGRETE, *Oak Ridge National Laboratory* A class of models based on the use of fractional derivative operators is proposed to describe nonlocal transport in magnetically confined plasmas. Fractional operators incorporate in a unified framework non-Fickian transport, non-Markovian (memory) effects, and non-diffusive scaling. Recently, this formalism was applied to study transport in pressure-gradient-driven plasma turbulence [1]. Here we present new results that incorporate finite-size domain effects, boundary conditions, sources, spatially dependent diffusivities, and general asymmetric fractional operators. The model is applied to describe, at a phenomenological level, non-diffusive, non-local transport processes observed in fusion plasmas, including anomalous confinement time scaling, up-hill transport, rapid cold-pulse propagation, and on-axis peaking with off-axis fuelling. [1] D. del-Castillo-Negrete et al., Phys. Plasmas **11**, 3854 (2004); Phys. Rev. Lett. **94**, 065003 (2005).

K1 4 Nondiffusive transport in electron temperature gradient turbulence KYLE GUSTAFSON,* *Department of Physics,*

University of Maryland DIEGO DEL CASTILLO NEGRETE, *Oak Ridge National Laboratory* MICHAEL BARNES, *Department of Physics, University of Maryland* WILLIAM DORLAND, *Department of Physics, University of Maryland* Numerical studies of electron temperature gradient turbulence (ETG) indicate that nonlinear effects boost the observed transport beyond the level expected from quasilinear analysis. In particular, the formation of radially extended streamers seems to facilitate rapid transport. We use the nonlinear gyrokinetic code GS2 to study transport of tracers through streamers embedded in $\mathbf{E} \times \mathbf{B}$ turbulence. In particular, we explore the role of such coherent structures in inducing long particle displacements (Levy-flight), and study the non-Gaussian scaling of the probability density function in space and time. Motivated by previous studies in pressure-gradient driven plasma turbulence and flows with similar topology, we explore the use of fractional diffusion operators to model transport by streamers in ETG turbulence. Fractional diffusion operators are integro-differential operators providing a natural mathematical framework to describe non-Gaussian and non-Markovian (memory-dependent) transport processes.

*Supported by the Fannie and John Hertz Foundation.

K1 5 Sources and Sinks of Zonal Flow Shear in Tokamak Microturbulence* ANDRIS DIMITS, DAN SHUMAKER, WILLIAM NEVINS, *Lawrence Livermore National Laboratory* The relative contributions of various physics terms to the driving and damping of the zonal flows in gyrokinetic simulations of toroidal ion temperature gradient (ITG) turbulence are investigated using a specialized simulation diagnostic. The development and verification of this diagnostic, which directly evaluates contributions of the terms to the rate of change of the mean squared zonal flow shear, were presented previously (A.M. Dimits et al., APS-DPP02 meeting). We have found that in the turbulent finite-transport regime of toroidal ITG turbulence, the zonal flow shear is generated primarily through the Reynolds' stress term and dissipated by the transit-time damping terms. Application of an analogous diagnostic to experiments would require modification of the approach to use measurements of the flow field quantities in a small number of localized regions instead of over full flux-surfaces. Our simulations have addressed this by showing that useful zonal-flow-balance information can be obtained with as few as four poloidal samples.

*Work performed for USDOE by Univ. California LLNL under contract W-7405-ENG-48.

K1 6 Calculation of Self-Consistent Turbulence and Transport in the Tokamak Edge* M.V. UMANSKY, T.D. ROGNLIEN, R.H. COHEN, L.L. LODESTRO, X.Q. XU, *Lawrence Livermore National Lab* Results of a self-consistent simulation of turbulence and transport in the tokamak edge are presented. The calculations are done with the transport code UEDGE and the turbulence code BOUT. The turbulence fluxes and background profile data are exchanged between the codes using effective iteration schemes. A midplane limiter case is presented here. The limiter causes parallel plasma losses that strongly affect the radial plasma profiles, and the limiter sheath supports conducting-wall instabilities. Two regimes are observed: (i) weakly intermittent turbulence when the flow shear is large, and (ii) strongly intermittent turbulence when the flow shear is small. The weakly intermittent regime is characterized by small, frequent transport bursts. In this case a large separation of time scales between turbulence and transport allows efficient coupling of turbulence and transport, yielding self-consistent quasi-stationary solutions. The strongly intermittent regime is characterized by large infrequent bursts of transport. In this case the coupling method based on separation of time scales loses its efficiency since the time scales of transport and turbulence overlap, and important nonlinear response functions, e.g. the material erosion rate, can not be correctly described by the time-average profiles.

*Work performed for U.S. DOE by UC LLNL under contract W-7405-Eng-48 and was supported by LDRD project 03-ERD-009.

K1 7 Microinstabilities in quasi-helically symmetric stellarators* TARIQ RAFIQ, CHRIS HEGNA, *University of Wisconsin* The linear stability of electron drift modes, dissipative trapped electron modes (DTEM) and ITG modes is investigated in the electrostatic limit using ballooning formalism. For all these modes, a shooting technique is used and WKB type boundary conditions are applied. The three-dimensional equilibria is calculated for a quasihelically symmetric (QHS) stellarator and a configuration whose symmetry is spoiled by the presence of mirror contribution to the magnetic spectrum. The dependence of the drift wave spectrum of stable and unstable modes, on various equilibrium parameters are investigated. The DTEM growth rate is calculated using perturbative approach. Multiple classes of helically-localized and toroidally-localized eigenfunctions in the ballooning space are taken into account. The helically trapped modes are found to be most destabilizing in the QHS configuration, while in the Mirror configuration the toroidally trapped modes are found unstable. The magnitude of the growth rate is found to be higher in the Mirror configuration except for cases with peaked density profiles.

*This research was supported by the U.S. DOE under Grant No. DEFG02-99E54546.

K1 8 Existence of Magnetic Surfaces in 3-D Configurations* A.D. TURNBULL, *General Atomics* A general expression is derived for the existence of magnetic surfaces in 3-D. The expression is valid in an arbitrary coordinate system, which is important when axisymmetry is violated. In the general case, surfaces exist if and only if a simple 1-D equation, equivalent to $\mathbf{B} \cdot \nabla F$, has solutions F with certain desired conditions imposed. For example, F must be periodic in angle-like coordinates and monotonic in radial-like variable, s. Applied to a torus, the fact that surfaces are guaranteed to exist with any special symmetry, drops out trivially from this formulation. One can also use alternative representations for **B**, such as the Clebsch form, to obtain further insight into the conditions where solutions exist. Analogous expressions are also obtained for the existence of current surfaces. Conditions can then be obtained for the existence of both current and magnetic surfaces, yielding criteria for proper nested flux surfaces. Force balance then imposes additional conditions; for ideal MHD, the key

condition is the obvious one that $\mathbf{B}\times(\nabla\times\mathbf{B})$ can be written as the gradient of a potential, which can then be equated to the pressure.

*Work supported by US DOE under DE-FG03-95ER54309.

K1 9 Rotation Profiles in DIII-D From Neoclassical Viscosity* R.W. JOHNSON, W.M. STACEY, *Fusion Research Center, Georgia Institute of Technology* J. MANDREKAS, *Office of Fusion Energy Sciences, US DoE* Radial and poloidal profiles of rotation and density are calculated using neoclassical viscosity for a variety of discharges in DIII-D. Several confinement regimes (L-mode, L-mode with Internal Transport Barrier, H-mode, and H-mode with Quiescent Double Barrier) are investigated. Predicted toroidal velocities agree reasonably well with measured values for all regimes. Poloidal density asymmetries remain within 10-20% of the flux-surface average value. Toroidal velocity is shown to have a poloidal profile rather than rotating rigidly. Transport of angular momentum is shown to arise mostly from gyroviscosity whilst leaving room for other (anomalous) transport mechanisms.

*Work supported by: DoE grant ER54538.

K1 10 Methodology of Nonlinear Solver Module, GCNM, as an NTCC Module and SWIM Component* H.E. ST. JOHN, L.L. LAO, *General Atomics* M. MURAKAMI, J.M. PARK, *Oak Ridge National Laboratory* The success of stiff, drift wave type transport models such as GLF23 has necessitated introduction of new methods for solving transport equations. A Globally Convergent Newton Method (GCNM) module, which is part of the ''Predictive Transp'' project, and which will be one of the optional solvers in the SWIM project was developed to deal with this issue. GCNM is a Newton-based solver for small sets ($<$ 500) of nonlinear equations typically encountered in the space and time discretized versions of transport equations. GCNM was designed to be used by other transport codes which must supply the time dependent sources required to solve the equations. For time independent situations GCNM can be used to directly find steady-state solutions without coupling to other codes. This has proved advantageous in ITER AT modeling where the current relaxation time is sufficiently large to preclude time-stepping methods. We describe the initial release of the module and its use.

*Work supported by US DOE under DE-FG03-95ER54309 and DE-AC05-00OR22725.

K1 11 Coherent Structures in Magnetic Confinement Systems* W. HORTON, *University of Texas at Austin, IFS* Coherent structures are long-lived, nonlinear localized solutions of the selfconsistient plasma-electromagnetic field equations. They contain appreciable energy density and control various transport and magnetic reconnection processes in plasmas. These structures are self-binding from the nonlinearity balancing, or overcoming, the wave dispersion of energy in smaller amplitude structures. The structures evolve out of the nonlinear interactions in various instabilities or external driving fields. The theoretical basis for these structures are reviewed giving examples from various plasma instabilities and their reduced descriptions from the appropriate partial differential equations. A classic example from drift waves is the formation of monopole, dipole and tripolar vortex structures which have been created in both laboratory and simulation experiments. For vortices, the long life-time and nonlinear interactions of the structures can be understood with conservation laws of angular momentum given by the vorticity field associated with dynamics. Other morphologies include mushrooms, Kelvin-Helmholtz vorticity roll-up, streamers and blobs. We show simulation movies of various examples drawn from ETG modes in NSTX, H-mode like shear flow layers in LAPD and the vortices measured with soft x-ray tomography in the GAMMA 10 tandem mirror. Coherent current-sheet structures form in driven magnetic reconnection layers and control the rate of transformation of magnetic energy to flow and thermal energy.

*Work supported by DOE grant DE-FG02-04ER5474.

K1 12 An Incompressible Fluid Model for High-Speed Pellet Propagation in Guide-tubes* F.W. PERKINS, *General Atomics* This work reports theoretical models developed to support optimization of pellet-fueling. Experiments show pellet penetration will be optimized by high-field-side, high-speed launch. In present pellet systems, acceleration takes place outside the main tokamak chamber and pellets must propagate at high velocity through curved guide tubes to reach the desired HFS launch point. If the pellet velocity V exceeds a critical value $V_c \approx$ 300m/s, then centrifugal force will breakup the pellet in agreement with observations. In the limit $V >> V_c$, the pellet material can be modeled as an incompressible granular fluid of DT dust fragments and an equation is developed for its length l along the guide tube. The solution shows that l depends only on the angle the guide tube bends and not on the pellet speed. If a v-notch guide tube is used with a right-angle bend, the pellet as emerges as a highly elongated DT dust cloud, essentially a fluid jet. Further analysis shows this jet to be unstable and breakup into a series of droplets is expected. Ablation calculations based on droplet size result in poor penetration.

*Work supported by US DOE under DE-FC02-04ER54698.

K1 13 Physics with Reduced Parameters by the Ignitor Experiment* G. CENACCHI, *Associazione Euratom-ENEA sulla Fusione, Italy* A. AIROLDI, D. FARINA, *CNR-IFP, Italy* B. COPPI, *M.I.T.* The Ignitor experiment is designed to produce plasma currents up to 11 MA and magnetic fields up to 13 T,[1] but its operational life will include ''preparatory'' discharges at reduced machine parameters that are expected to access significant plasma regimes. In this context a careful analysis has been carried out to verify the consistency of the plasma parameters to be obtained, in particular the ideal ignition conditions in D-T plasmas with considerable pulse lengths, with the characteristics of the poloidal and toroidal field systems. To this end many simulations were carried out by the JETTO code, that is capable of taking into account the evolution of relevant free-boundary plasma equilibria. Two scenarios with magnetic fields up to 9 T and appropriate levels of injected (RF) heating were investigated: ''limiter'' (no X-point) configurations with plasma currents up to 7 MA, and double X-point configurations with plasma currents up to 6 MA. Proper programming of the density evolution and of the RF injection lead to reach and to maintain steady state conditions with peak temperatures around 6 keV (ideal ignition for the considered profiles) and significant α-particle production. The relevant pulse flat-top length can be about 8 seconds.

*Sponsored in part by ENEA and CNR of Italy, and by the U.S. D.O.E.

[1]B. Coppi, A. Airoldi, et al., *Nucl. Fusion* **41**, 1953 (2001).

K1 14 MHD modeling of disruption mitigation by high-pressure gas jet on Alcator C-Mod V.A. IZZO, R.S. GRANETZ, M.L. REINKE, *MIT* D.G. WHYTE, M. BAKHTIARI, *Univ. Wisconsin, Madison* MHD plays an important role in a massive-gas-jet-induced thermal quench in the case that only shallow impurity penetration is possible. This is seen in a series of NIMROD simulations with an assumed fixed penetration depth and a simple impurity radiation model. These simulations qualitatively reproduce several characteristics of a real C-Mod thermal quench triggered by gas jet injection. The simulations predict the fastest quench when the impurities penetrate to the q=2 surface, with an increasing delay preceding the quench as the separation between the penetration depth and q=2 increases. This prediction can be tested experimentally by scanning the q_{95} of the target plasma over a wide range of values. By coupling NIMROD with the 0D radiation code KPRAD, simulations with accurate radiation rates, tracking all charge state populations, are possible for several gas species. In addition, models for neutral penetration and subsequent impurity mixing are included in the code with the goal of achieving quantitative predictability for gas jet disruption mitigation. Initial results from the new code are presented. Accuracy of the impurity penetration and mixing is assessed by comparison with experimental bolometry data.

K1 15 Multi-Scale Interaction of a Tearing Mode with Drift Wave Turbulence: A Minimal Self-Consistent Model CHRIS McDEVITT, PAT DIAMOND, *University of California at San Diego* A minimal self-consistent model of the multi-scale interaction of a tearing mode with drift wave turbulence is presented. For simplicity, we consider a tearing instability in a cylindrical plasma interacting with electrostatic drift waves. Wave kinetics and adiabatic theory are used to treat the feedback of tearing mode flows on the drift waves via shearing and radial advection. The stresses exerted by the self-consistently evolved drift wave population density on the tearing mode are calculated by mean field methods. The principal effect of the drift waves is to pump the resonant low-m mode via a negative viscosity, consistent with the classical notion of an inverse cascade in quasi-2D turbulence. We study, two types of low-m, resonant structures. The first is a localized, electrostatic vortex mode, the width of which is set by resistively dissipated magnetic field line bending, and whose growth rate is given by $\gamma = (|\nu_T|^{2/3}/\eta^{1/3})(v_A q_y/L_s)^{2/3}$, where ν_T is the turbulent viscosity. The second is like a usual tearing mode, which matches the interior layer (with negative viscosity) to an MHD exterior, via Δ'. Outgoing wave boundary conditions are imposed in order to effect the match. The growth rate in the turbulent viscosity dominated regime is given by $\gamma = (\eta^{5/6}/|\nu_T|^{1/6})(q_y v_A/L_s)^{1/3}\Delta'$.

K1 16 Transport of dust particles in fusion devices A.YU. PIGAROV, S.I. KRASHENINNIKOV, Large production rates and spreading of dust throughout the device volume are very important safety issues for next-step fusion projects (both: magnetic and inertial). A physical model for dust transport includes the dynamics dust-plasma, dust-turbulence, and dust-surface interactions. The dynamics is strongly coupled to heating, charging, erosion, evaporation, and thermo-chemical properties of dust particles. Recent developments in the model and their impact on the dust motion are highlighted. The model is incorporated into the DUSTT code [A. Pigarov, PoP **12**, 122508 (2005)]. Results of carbon-dust dynamics and transport in plasma are shown for NSTX and DIII-D tokamaks. The simulations demonstrate that dust particles can be very mobile, accelerate to large velocities ($>$ 100 m/s), and penetrate deeply toward plasma core. Predictions for dust penetration into ITER plasma are also presented. Under standard tokamak plasma conditions, dust particles experience the net erosion or sublimation. However, as discussed, in some cases (for example, parasitic plasmas that occur underneath a dome), the dust particles can even grow from net deposition when a low-Te low-density plasma contains significant concentrations of impurities. Modeling is presented for transport of dust particles outside the working chamber, i.e. in pumping or diagnostics ports. Results of multi-parametric analysis of dust penetrability are discussed. Work supported by USDoE grant DE-FG02-04ER54739.

K1 17 Stability of zonal flows in finite beta tokamak plasmas* PARVEZ GUZDAR, ROBERT KLEVA, *IREAP, University of Maryland, College Park, MD* The generation of zonal flow in finite beta plasmas is an active area of research. These flows play a significant role in determining the level of transport caused by the resistive drift-Alfven and drift-ballooning modes which occur in the edge region of tokamak plasmas. Thus understanding the stability of zonal flows can provide key understanding of the transitions triggered in the edge region. We have developed a new eigenvalue code to investigate the stability of zonal flows in finite beta plasmas. The code determines the eigenvalues and eigenmodes associated with all branches of modes present in the given system of equations. We will primarily focus on results for the tokamak edge plasmas where finite beta effects are enhanced by steep pressure gradients and high safety factor q. We will present results of the stability of the zonal flows as a function of the two key dimensionless parameters, the classical ideal ballooning stability parameter and the diamagnetic parameter. The relevance of this study to regulating edge transport will be discussed.

*Work supported by DOE.

K1 18 Dimensionless scaling laws of confinement in fusion plasmas with the 5D non-linear GYrokinetic SEmi-LAgrangian code (GYSELA) V. GRANDGIRARD ET AL., *Association Euratom-CEA, CEA/DSM/DRFC, Cadarache, France* This work addresses non-linear global gyrokinetic simulations of ITG turbulence in a simple toroidal geometry with the GYSELA code. This code solves the gyrokinetic equation for ions, coupled to a quasi-electroneutrality condition. The electron response is assumed adiabatic. The particularity of GYSELA code is to solve the Vlasov-Poisson like system on a fixed grid with a Semi-Lagrangian (SL) scheme [1] for the entire distribution function. The 4D non-linear drift-kinetic version of the code has already shown the interest of such a SL method [2]. The energy conservation, which is recognized as a key test of validity, was achieved with an accuracy better than 2.5%. Results with the new 5D version of GYSELA will be presented, in particular a scan of turbulent transport for several values of the normalized gyroradius ρstar. The aim is to determine the dimensionless scaling law of confinement and to compare it with previous studies in this field [3]–[4]. [1] E. Sonnendrücker et al, Journal of Comput. Physics, **149**, 201–220 (1999). [2] V. Grandgirard et al, accepted in Journal of Comput. Physics. [3] J. Candy and R.E. Waltz, Phys. Rev. Lett. **91**, (2003). [4] Z. Lin et al., Phys. Rev. Lett. **82**, (2002).

K1 19 A New X-ray Imaging Crystal Spectrometer for Measurements of the Ion-Temperature Profile in Tokamak Plas-

mas * M. BITTER, C. BUSH, K. W. HILL, L. ROQUEMORE, B. STRATTON, D. MASTROVITO, P. BEIERSDORFER, *Lawrence Livermore National Laboratory* M. F. GU, *Stanford University* J. E. RICE, *MIT* Future large tokamaks, such as ITER, require new diagnostic concepts for measurements of the ion-temperature profile, since the currently used methods, which are based on neutral charge-exchange recombination spectroscopy, may not be applicable due to the fact that, at high plasma densities, neutral beams will not penetrate to the core of the plasma. An alternative method relies on Doppler broadening measurements of X-ray lines emitted from highly charged high-Z ions. However, the X-ray crystal spectrometers, used so far, have recorded spectra from only a single sightline through the plasma and have therefore provided only a single point of an ion-temperature profile. Therefore, a new X-ray imaging crystal spectrometer is presently being developed. This spectrometer consists of a spherically bent crystal and a two-dimensional position-sensitive detector and can simultaneously record spectra from multiple sightlines through the plasma. The spatial resolution in the plasma of about 1–3 cm is only determined by the height of the crystal and the Bragg angle. The paper will present the spectrometer concept and results obtained with a prototype instrument. *Work supported by DOE contract DE-AC02-76-CH03073 and DOE grant 1083.

K1 20 Simulation of plasma and impurity parallel flows, blob dynamics and cross-field transport asymmetry effects in tokamak SOL* A.YU. PIGAROV, S.I. KRASHENINNIKOV, G. YU, *UCSD* B. LABOMBARD, *MIT* T.D. ROGNLIEN, *LLNL* Recent experiments on several tokamaks have showed strong cross-field (CF) plasma convection due to intermittency (e.g., blobs) as well as the existence of large-Mach-number parallel plasma flows (LPPFs) in the SOL. Here we, firstly, report on the progress in our studies of dynamics and stability of coherent structures (blobs, dips) based on comprehensive 2D edge turbulence models. Secondly, multi-fluid 2D simulations of edge plasma and neutral gas transport are performed with the UEDGE code to explore potential driving mechanisms of LPPFs. We employ multi-ion diffusive-and-convective model for anomalous CF plasma transport. The model introduces asymmetric (ballooning-like) 2D profiles for CF transport coefficients, which are adjusted to match a representative set of experimental data. The UEDGE results on LPPFs are presented for SN L-mode shots in NSTX, C-Mod, and DIII-D tokamaks. The roles of asymmetric intermittent CF transport, magnetic configuration and classical drifts in affecting the plasma flows are highlighted. The influence of these flows on divertor detachment, material migration, and main chamber recycling are discussed. Finally, we analyze the behavior of impurity ions in the SN SOL. Impurity sources and parallel flows of impurity ions are simulated with UEDGE under assumption of high LFS/HFS asymmetry of CF transport. Simulations show that in L-mode shots all charge states of impurity ions are highly entrained by background plasma flows. In the far SOL, impurity ions tend to have the same flow velocity as the deuterium ions, so that impurities are highly supersonic when the deuterium plasma flow is near-sonic. The outboard main-chamber wall can be an important net source of impurities, whereas both divertors can behave as net sinks for impurities. Work performed under USDoE grant DE-FG02-04ER54739.

*Simulation of plasma and impurity parallel flows, blob dynamics and cross-field transport asymmetry effects in tokamak SOL.

K1 21 ECRH and its effects on neoclassical transport in stellarators JAECHUN SEOL, C.C. HEGNA, *University of Wisconsin-Madison* The effect of ECRH heating on the neoclassical transport of conventional stellarators is addressed. In the absence of symmetry, neoclassical transport of stellarators is not favorable in the low-collisional regime. This transport mechanism is particularly important in ECRH heated plasmas where a large energetic trapped electron population is produced. However, a self-consistently generated EXB poloidal drift reduces the direct loss of trapped particles. A large radial electric field is built up by energetic trapped particles generated by electron cyclotron resonance heating (ECRH) yielding the ''electron root.'' We present a calculation that proceeds by solving for the lowest order electron distribution function using a Fokker-Planck equation for ECRH. Energetic electron generation is modeled using a quasilinear model ECRH diffusion. The radial particle fluxes are calculated by solving the 1^{st} order Fokker-Planck equation. The radial electric field is determined from the ambipolarity condition of the particle fluxes. Implications for the achievement of electron root and associated enhanced confinement regimes will be addressed. For sufficiently large applied ECRH fields, the quasilinear description of wave-particle interaction is not generally valid. Efforts to extend the diffusion operator to account for nonlinear effects will be addressed. *Research is supported by U.S. Department of Energy Grant No. DE-FG02-99ER54546.

K1 22 Two-Fluid Plasma Steady States* LINDA SUGIYAMA, *M.I.T.* H.R. STRAUSS, *N.Y.U.* J. BRESLAU, G. FU, *P.P.P.L.* Two-fluid plasma models, which allow the electron and ion fluids to move independently, have important consequences for magnetically confined plasma behavior, compared to MHD. Two-fluid steady states can be described analytically in terms of the canonical momenta and generalized vorticities of the two species (e.g. [1]), but the models contain free functions and do not really describe the conditions that hold in nonlinear numerical simulations. The plasma edge and surrounding vacuum region, which supplies global boundary conditions for the plasma in MHD, possesses additional degrees of freedom in a two-fluid model, including possible large localized poloidal flows, radial electric fields, and separate species pressure gradients. Non-fluid, kinetic effects may also be important. These questions are investigated for high temperature fusion plasmas. with the help of the M3D initial value code.
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*Work supported by the U.S. Department of Energy.

K1 23 Magnetic island induced bootstrap current on island evolution* K.C. SHAING, *University of Wisconsin* In a previous paper [K. C. Shaing, and D. A. Spong, Phys. Plasmas **13**, (2006)], the effects of the even component (relative to the mode rational surface) of the magnetic island induced bootstrap current on the island dynamics in tokamaks are investigated, The magnetic island induced bootstrap current is a consequence of the symmetry breaking associated with a magnetic island embedded in an equilibrium magnetic field. It is found that island induced bootstrap current density contributes a term that is proportional to the width of the island, and the poloidal plasma beta, the ratio of the plasma pressure to the poloidal magnetic field pressure, to the island evolution equation. This term imposes a lower limit on the absolute value of the tearing mode stability parameter for the island to be unstable at high poloidal plasma beta. The theory is extended here to including the effects of the odd component of the magnetic island induced bootstrap current on the island evolution equation by taking into account the asymmetric island shape relative to the mode rational surface in the derivation of the island evolution equation.

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K1 24 Simulation of the time development of EBW emission from NSTX J. PREINHAELTER, J. URBAN, *Czech Academy of Sciences* G. TAYLOR, S. DIEM, *PPPL* L. VAHALA, *Old Dominion Univ.* G. VAHALA, *William & Mary* Time evolution of ECE spectra in 20-40GHz range were simulated for NSTX plasmas. The code is based on the full wave solution of the cold plasma wave propagation used for determination of EBW-X-O and EBW-X mode conversion efficiencies and on the determination of the effective radiation temperature from simultaneous solution of EBW ray evolution and integration of the radiative transfer equation. The method was successfully used for determination of the central temperature in NSTX from detected EBW signal at 16.5GHz [1]. The time development of the frequency spectra of EBW emission from the new NSTX antenna is simulated. For the shots (#117970-#117982), the most intense radiation occurs at f = 25GHz. In this case EBW starts at the plasma center and is radiated mainly from the second harmonic [2]. We obtained detailed information how the ECE intensity is connected with the plasma parameters so the simulations allow determination of the EBW usability for plasma diagnostics and proposal of parameters for ECCD application. [1] J. Preinhaelter et al, 16th Topical Conf. on RF Power in Plasmas, Park City, Utah, B-05, AIP Conference Proceedings 787, ed. Stephen J. Wukitch, Paul T. Bonoli (2005), 349–352. [2] J. Urban, J. Preinhaelter, G. Taylor, L. Vahala, G. Vahala: Simulation of ECE frequency spectra for NSTX and comparison with new radiometer results. 47th APS-DPP, October, 2005. Denver, Colorado. *Work supported by U.S. Dept. of Energy.

K1 25 Recent Progress Toward an Integrated Particle Simulation of Plasma Edge* C.S. CHANG, S.H. KU, *Courant Institute-NYU* W.W. LEE, *PPPL* S. PARKER, *Univ. Colorado* Z. LIN, *UC Irvine* J. CUMMINGS, *Caltech* M. ADAMS, *Columbia Univ.* F. HINTON, *General Atomic* S. ETHIER, *PPPL* CPES TEAM, A SciDAC Fusion Simulation Prototype Center has recently been formed in an effort to understand the edge pedestal physics. The main activity is (a) to build a gyrokinetic particle code for the edge plasma, which spans the region from the pedestal top to the first wall and (b) to construct an integrated simulation framework for coupling of the edge kinetic code with a two-fluid MHD code for an immediate application to the physics of the pedestal-ELM cycle. The gyrokinetic particle code is for an integrated simulation of the neoclassical kinetic ion-electron physics together with the turbulence and neutral physics, in a realistic wall and flux surface geometry for the present and future tokamak devices. A two-fluid MHD code is for easier modeling of the ELM crash, in close coupling with the kinetic code. Even though the main part of the pedestal exists inside the separatrix surface, the pedestal physics is most likely coupled to the scrape-off layer plasma properties. Thus, a comprehensive understanding of the edge plasma dynamics will be necessary. We will report our recent progresses in the 5D edge neoclassical physics simulation and understandings, numerical work in the self-consistent turbulence simulation, and kinetic-MHD coupling of ELM activity.

*Center for Plasma Edge Simulation.

K1 26 Progress on long-time kinetic simulation of tokamak turbulence with very weak dissipation SCOTT PARKER, YANG CHEN, JASON KAHUT, *University of Colorado, Boulder* Recent progress on convergence studies of long-time simulations for both electron-temperature-gradient (ETG) and ion-temperature-gradient driven microturbulence will be reported. It was surprising to us to find that low-noise ETG turbulence simulations are well-converged with rather modest particle number (30-70 million particles). Progress on the particle-continuum method [Vadlamani et al., *Comp. Phys. Comm.*, **164**, 209 (2004)] will also be reported. The particle-continuum method is really a general class of a variety of methods and has been shown to solve the so-called "growing weight problem" in two-dimensional simulations. The method is implemented in four-dimensions with the $\mu\nabla B$ force neglected. In this case, $v_\parallel$ is a constant of motion and resetting of the particle δf on a four-dimensional grid is more reasonable. Discussion of issues related to applying particle continuum method in five dimensions will also be presented. Work supported by DOE SciDAC Gyrokinetic Particle Simulation Center and Center for Plasma Edge Simulation.

K1 27 Novel aspects of linear wave conversion in burning plasmas* A. J. BRIZARD, *Saint Michael's College* E. R. TRACY, *College of William and Mary* A. N. KAUFMAN, *LBNL, UC Berkeley* We report on our investigation of several novel aspects of linear wave conversion (a.k.a. mode conversion) in burning plasmas. These include (1) the effects of an inverted population of energetic particles (e.g., fusion products), giving rise to negative-energy modes [1] and, thus, lead to absolute instabilities when counterpropagating rays of opposite energy signs resonantly interact [2]; and (2) the triplication of conversion due to the presence of internal transport barriers (associated with shear-flow layers) overlapping the conversion region. [1] A. J. Brizard and A. N. Kaufman, Phys. Rev. Lett. **76**, 1639 (1996); Phys. Plasmas **3**, 64 (1996). [2] A. J. Brizard, J. J. Morehead, A. N. Kaufman, and E. R. Tracy, Phys. Rev. Lett. **77**, 1500 (1996); Phys. Plasmas **5**, 45 (1998).

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K1 28 Anomalous Absorption of X2-Driver Pump Power in DIII-D Tokamak Plasma Via Relativistic Electron Bernstein Modes and Lower Hybrid Waves V. STEFAN, *Tesla Laboratories, The Stefan University, 1010 Pearl Street, P. O. Box 2946, La Jolla, CA 92038* Recently[1] I have reported on anomalous absorption of relativistic electron Bernstein modes (R-E-B) for various driver-plasma parameters in Spherical Tokamaks and DIII-D Tokamak. plasma. Here I focus on X2-Driver Pump decay in DIII-D Tokamak plasma involving lower-hybrid waves (LHW). This channel involves the Brillouin scattering of X2-Mode into another (X2)'-mode coupled to the lower-hybrid waves (LHW). The nonlinearly generated (X2)'-Mode propagates toward the second harmonic electron cyclotron layer, whereby it is absorbed through R-E-B-Mode conversion, as in case of linear propagation-absorption channel. This leads to a strongly localized absorption. The weak LHWs are collisionally absorbed in the dense plasma region transferring the energy to ion plasma component—bulk plasma heating. The secondary decays of X2, X1, and EB modes, are taken into account in evaluation of energy confinement time in multi-ion plasmas

[1]V. Stefan, Anomalous Absorption of R-E-B Modes Due to Raman and Brillouin Scattering, and Two EB-Mode Decay of X2-Driver in DIII-D Tokamak Plasma, 16th Topical Conf. on RF Power in Plasmas [Park City, 2005] V. Stefan, Enhanced Thermonuclear Yield Due to Low-Harmonic REB Modes in Spherical Tokamak Plasmas, Sherwood-2005 [Stateline, Nevada, USA].

K1 29 Coulomb Collision Algorithms for Particle Codes* BRUCE COHEN, *Univ. Calif. Lawrence Livermore Nat. Lab.* This paper surveys some of the particle code algorithms used to model Coulomb collisions in fully ionized plasmas, e.g., pair-wise operators such as the Takizuka-Abe[1] scheme and extensions,[2] Langevin equation collision operators,[3,4] and partially linearized gyrokinetic collisions operators for strongly magnetized plasmas.[5,6,7] Some recent experience is reported.[8] Issues such as physics completeness, accuracy, and comparative algorithm performance are highlighted. 1. T. Takizuka and H. Abe, J. Comput. Phys. **25**, 205 (1977). 2. K. Nanbu, Phys. Rev. E **55**, 4642 (1997). 3. M.E. Jones et al., J. Comp. Phys. **123**, 169 (1996). 4. W.M. Manheimer, M. Lampe, G. Joyce, et al., J. Comp. Phys. **138**, 565 (1997). 5. X.Q. Xu and M.N. Rosenbluth, Phys. Fluids B **3**, 627 (1991). 6. A.M. Dimits and B.I. Cohen, Phys. Rev. E **49**, 709 (1994). 7. Z. Lin, W. M. Tang, and W. W. Lee, Phys. Plasmas **2**, 2975 (August 1995). 8. B.I. Cohen et al., "Effects of ion-ion collisions and inhomogeneity in two-dimensional kinetic ion simulations of stimulated Brillouin backscattering," accepted for publication in Phys. Plasmas (2006).

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K1 30 Modelling the effect of toroidal plasma rotation on drift-magnetohydrodynamic modes in tokamaks IAN CHAPMAN, TIM HENDER, SERGEI SHARAPOV, *UKAEA Fusion Association* GUIDO HUYSMANS, *Association EURATOM-CEA Cadarache* ANATOLII MIKHAILOVSKII, *RRC Kurchatov Institute* A new code, MISHKA-F has been developed in order to investigate linear MHD stability of ideal and resistive eigenmodes with respect to the effects of toroidal rotation in tokamaks in general toroidal geometry with the ion diamagnetic drift effect taken into account. Benchmark tests show good accordance with analytic theory for the stability limits of the n/m=1/1 internal kink mode with respect to toroidal rotation. Also, the stabilizing effect of the ion diamagnetic drift frequency on the internal kink mode is found to be more effective at finite flow shear. The stabilization of ballooning modes by toroidal rotation agrees well with analytic predictions if the local magnetic shear is below a critical value, above which no stabilization is exhibited. The effect of high flow shear is also analyzed for sawtoothing discharges in MAST, where it is found that stabilization of the n=1 internal kink mode by toroidal rotation may account for the observed sawtooth period increase. This work was funded by EURATOM and UK EPSRC.

K1 31 Real geometry gyrokinetic PIC computations of ion turbulence in advanced tokamak discharges with SUMMIT/PG3EQ_NC* JEAN-NOEL LEBOEUF, VIKTOR DECYK, TERRY RHODES, *UCLA* ANDRIS DIMITS, DAN SHUMAKER, *LLNL* The PG3EQ_NC module within the SUMMIT Gyrokinetic PIC FORTRAN90 Framework makes possible 3D nonlinear toroidal computations of ion turbulence in the real geometry of DIII-D discharges. This is accomplished with the use of local, field line following, quasi-ballooning coordinates and through a direct interface with DIII-D equilibrium data via the EFIT and ONETWO codes, as well as Holger Saint John's PLOTEQ code for the (R, Z) position of each flux surface. The effect of real geometry is being elucidated with CYCLONE shot #81499 by comparing results from PGEQ_NC to those of its circular counterpart. The PG3EQ_NC module is also being used to model ion channel turbulence in advanced tokamak discharges # 118561 and 120327. Linear results will be compared to growth rate calculations with the GKS code. Nonlinear results will also be compared with scattering measurements of turbulence, as well as with accessible measurements of fluctuation amplitudes and spectra from other diagnostics.

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K1 32 Effects of Plasma Shaping on Nonlinear Gyrokinetic Turbulence E. A. BELLI, G. W. HAMMETT, *PPPL* W. DORLAND, *U. Maryland* The effects of flux surface shape on the gyrokinetic stability and transport of tokamak plasmas have been studied using the GS2 code. Studies of the scaling of nonlinear turbulence with shaping parameters have been performed starting with a representative JET-like flux surface and artificially varying elongation, triangularity and their radial gradients together using the Miller analytic equilibrium formalism[1] to approach the circular limit via linear interpolation. Both linearly and nonlinearly, high shaping was found to be a stabilizing influence on the ITG turbulence, and a scaling of the heat flux with elongation of $\chi \sim \kappa^{-1.5}$ or κ^{-2} (depending on the triangularity) was observed. While this is not as strong as empirical elongation scalings, it was also found that high shaping results in a larger Dimits upshift of the nonlinear critical gradient due to enhanced zonal flows. The effects of electromagnetic dynamics coupled with shaping are also presented. For electromagnetic runs, beta is varied with shaping to keep the Troyon-normalized beta fixed while also holding q_{95} fixed. These results indicate that beta strongly affects the electron transport, particularly for more circular plasmas, and may lead to unsaturated transport in some cases, even well below the linear ballooning limit.

[1]R. Miller et al., Phys. Plasmas **5**, 973 (1998).

K1 33 The Columbus Concept* M. SALVETTI, B. COPPI, *M.I.T.* A spectrum of experiments is required for a "Science First" approach to fusion research.[1] The possible discovery of new phenomena and the understanding of known ones, i.e. sawtooth oscillations, under fusion burning conditions will cetainly influence the design of future fusion reactors. The Columbus concept[2] takes advantage of the Ignitor R&D effort, including the construction of full size component prototypes. Relative to Ignitor, Columbus is characterized by increased linear dimensions ($R_0 \cong 1.5$ m is the plasma torus major radius) and by lower current densities in the magnets and within the plasma column. The toroidal magnetic field is decreased by the factor 12.6/13 and the average poloidal field produced by the plasma current is about equal to that of Ignitor for comparable values of the magnetic safety factor (q_0). The reference plasma current is $I_p \cong 12.2$ MA, the value that ITER would produce for the same q_0 but without reaching ignition. The machine is based on cryogenic resistive magnet technologies and an optimized plasma confinement configuration which allow it to reach (real) ignition conditions by fusion reactions. Columbus is proposed for construction in the U.S.

*Sponsored in part by the U.S. D.O.E.
[1]B. Coppi, MIT-RLE Report PTP02/04 (2002), Presentation to the NRC.
[2]B. Coppi and M. Salvetti, MIT-RLE Report PTP02/06.

K1 34 Nonlinear Two Fluid and Kinetic ELM Simulations* H.R. STRAUSS, *NYU* L. SUGIYAMA, *MIT* C.S. CHANG, S. KU, B. HIENTZSCH, *NYU* J. BRESLAU, W. PARK, R. SAMTANEY, M. ADAMS, *PPPL* S. JARDIN, Simulations of ELMs using dissipative MHD, two fluid MHD, and neoclassical kinetic physics models are being carried out using the M3D code [1]. Resistive MHD simulations of nonlinear edge pressure and current driven instabilities have been performed, initialized with realistic DIIID equilibria. Simulations show the saturation of the modes and relaxation of equilbrium profiles. Linear simulations including two fluid effects show the stabilization of toroidal mode number n = 10 modes, when the Hall parameter H, the ratio of ion skin depth to major radius, exceeds a threshhold. Nonlinear simulations are being done including gyroviscous stabilization. Kinetic effects are incorporated by coupling with the XGC code [2], which is able to simulate the edge plasma density and pressure pedestal buildup. These profiles are being used to initialize M3D simulations of an ELM crash and pedestal relaxation. The goal is to simulate an ELM cycle. [1] Park, W., Belova, E.V., Fu, G.Y., Tang, X.Z., Strauss, H.R., Sugiyama, L.E., Phys. Plas. **6**, 1796 (1999). [2] Chang, C.S., Ku, S., and Weitzner, H., Phys. Plas. **11**, 2649 (2004)

*Supported by U.S.D.O.E.

K1 35 Is the Adabatic Ion Approximation Valid for Electron-Temperature-Gradient Turbulence Simulations?* J. CANDY, R.E. WALTZ, *General Atomics* C. ESTRADA-MILA, *University of California, San Diego* Gyrokinetic simulations of electron-temperature-gradient-driven turbulence normally rely upon an adiabatic ion (AI) approximation for numerical tractability. GYRO simulations using the AI approximation show that, in some regions of parameter space, simulations give rise to unbounded levels of turbulence. Such a result cannot be physical, suggesting a breakdown of the model equations. More expensive simulations which include the correct nonadiabatic ion response, on the other hand, are well-behaved and give rise to physically sensible levels of electron heat transport. We explore this topic in detail, departing from a low-shear, low-transport ETG-AI test case and moving to the high-transport regime. We remark that the low-shear departure point has been the subject of a previous benchmark effort [1], for which four codes (GYRO, GS2, PG3EQ and GENE) are in mutual agreement. [1] W. Nevins, et al., Bull. Am. Phys. Soc. **50**, 180 (2005), APS invited paper KI14.

*Work supported by the U.S. Department of Energy under DE-FG03-95ER54309.

K1 36 Phase Space Structures in Toroidal Ion Temperature Gradient Turbulence* T.-H. WATANABE, H. SUGAMA, *National Institute for Fusion Science, Toki, Japan* W. HORTON, *University of Texas at Austin, IFS* The velocity space structures of the ion distribution function associated with toroidal ion temperature gradient (ITG) driven turbulence is shown for the almost collisionless regime relevant to burning fusion plasmas. The zonal flows are taken into account and the geodesic acoustic mode (GAM) is reproduced with the neoclassical polarization from the trapped ions as well as the ballistic mode structures. Detailed plots of the ion velocity space showing clearly the different response of the trapped and passing ions in the zonal flows and the ITG modes are presented. The fine scale structures are resolved with velocity grid of 1025 $\times$ 65 which resolves the structures down to ν_{*i} = 0.04 deep into the banana regime. Runs are sufficiently long in time to establish a steady state in which the entropy production from the ion temperature gradient is followed through the turbulence and dissipated with a Lenard-Bernstein collision operator on the smalles scale of the velocity grid. The resulting gyro-Bohm coefficient for is 1.4 for the usual Cyclone DIII-D base case as reported in Watanabe and Sugama 2006.

*Work supported in part by grants-in-aid of Ministry of Education, Culture, Sports, Science and Technology (No. 14780387, 16560727, and 17360445) and in part by the National Institute for Fusion Science Collaborative Research Program (NIFS04KDAD003).

K1 37 Relation between Radial and Axial Losses in Tandem Mirrors J. PRATT, W. HORTON, H.L. BERK, *IFS, UT Austin* The tandem mirror still remains a potentially attractive magnetic confinement geometry. The absence of toroidal curvature and internal plasma parallel current gives the system strongly favorable stability. Additionally, GAMMA-10 experimental results demonstrate that sheared rotation can suppress turbulent radial losses. For an MHD stable system, we investigate the interplay between drift wave (ITG, ETG and Bohm) radial transport and axial losses. Using empirical energy confinement scaling laws from large ITER and ISS databases as upper bounds on the radial loss rates, we simulate radial transport using a transport barrier dynamics (TBD) code. Simulations are carried out for a machine of volume 212m^3 (central cell length/radius 30 m/1.5 m) with central cell field 3T. ITER stores 7022 MJ of energy in the toroidal magnetic field; in our tandem mirror design this energy is reduced to 954 MJ. Our simulations show that high core temperatures result in long Pastukhov loss times; drift wave radial transport dominates, except at the plasma edge, where pitch angle scattering causes losses.

K1 38 Gyrokinetic Simulations of Off-Axis Minimum-q Profile Corrugations* R.E. WALTZ, K.H. BURRELL, J. CANDY, *General Atomics* M.E. AUSTIN, *University of Texas, Austin* Quasi-equilibrium radial itprofile corrugations in the electron temperature gradient (ETG) are found at lowest order singular surfaces in global gyrokinetic (GYRO) code simulations of monotonic and off-axis minimum-q DIII-D discharges. The profile corrugation in the gradients are time average components of the zonal flows. As the off axis minimum-q=2 surfaces enters the plasma the corrugations are measurably large and appear to trigger an internal transport barrier (ITB). The corrugation in the electron temperature gradient have the bump-dip-bump structure seen in the DIII-D experiments. These profile corrugations constitute the first direct experimental observation of zonal flows in a tokamak plasma and confirm the physical reality of corrugations in a way not previously possible. Contrary to previous claims there is no dip in transport flow associated with the minimum-q "gap" in singular surface density. There is a strong dip in ion energy flow from the strong ExB shear corrugation and consistent with an ITB.

*Work supported by US DOE under DE-FG03-95ER54309 and DE-FG03-97ER54415.

K1 39 Nonlinear dynamics of turbulence driven vortex flows at low-q resonances P.H. DIAMOND, O.D. GURCAN, C.J. McDEVITT, *UCSD* T.S. HAHM, *PPPL* Motivated by recent observations of transport barrier formation near integer q surfaces, we consider the theory of turbulence driven vortex flows at low-q resonances. The essence of the problem is to understand the spatial relationship between profile modification at resonance and the pro-

file steepening immediately nearby. Flattening can be due to low-m resonant vortex modes driven by turbulence in a manner similar to zonal flows or the direct effect of secondary structures on profiles. Both will flatten turbulence intensity profiles on resonance, but steepen it nearby, thus enhancing shear flow drive by Reynolds stress and so producing a barrier. The key issue is to understand how low-q resonances modify the envelope, since it is this structure which ultimately controls the shear flow. We study envelope modifications expected at low-q surfaces, and examine the effect of turbulence spreading on the intensity profiles. We aim to elucidate te bifurcation threshold for barrier formation. References [1] M. Austin, APS Invited Talk, 2005. [2] C. J. McDevitt and P. H. Diamond, submitted to *Phys. Plasmas* (2005).

K1 40 Nonlinear Growth of a Line-tied g-Mode Near Marginal Stability* P. ZHU, C. C. HEGNA, C. R. SOVINEC, *University of Wisconsin-Madison* A theoretical framework has been developed for the study of the nonlinear gravitational (g-) mode of a line-tied flux tube near marginal stability. The theory is based on an expansion using two small parameters, $\epsilon \sim |\xi|/L_{eq} \ll 1$, and $n^{-1} \sim k_\parallel/k_\perp \ll 1$, with ξ denoting the plasma displacement, L_{eq} the characteristic equilibrium scale, $k_\parallel$ and $k_\perp$ the dominant wavenumber of perturbation parallel and perpendicular to equilibrium magnetic field lines respectively. When $\epsilon \sim n^{-1}$, the Cowley-Artun regime is recovered where plasma is to the lowest order incompressible [S. C. Cowley and M. Artun, Phys. Rep., **283**, 185-211 (1997)]. The detonation regime where the nonlinear growth of the mode is finite-time singular is a narrower subset of the Cowley-Artun regime. However, the validity of this regime breaks down when $\epsilon \gg n^{-1}$. In the intermediate nonlinear phase when $\epsilon \sim n^{-1/2}$, the lowest order plasma compression [$\sim \nabla \cdot \xi \sim \mathcal{O}(1)$] is nonzero. Direct MHD simulations with both a finite difference code and NIMROD indicate that the mode remains bounded in magnitude with a slightly reduced nonlinear growth [P. Zhu, A. Bhattacharjee, and K. Germaschewski, to appear in PRL (2006); P. Zhu, C. C. Hegna, and C. R. Sovinec, DPP2005]. During this phase, the coupled growth of the mode amplitude ξ and plasma compression may contribute to a nonlinear stabilization. The corresponding governing model equations for this intermediate nonlinear phase are derived.

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K1 41 Theory of turbulence spreading by penetrative convection and mode coupling O.D. GURCAN, P.H. DIAMOND, C.J. McDEVITT, *UCSD* T.S. HAHM, *PPPL* The intensity of inhomogenous turbulence may spread via avalanches or non-local mode couplings. These two processes are related and while mode coupling provides a mechanism for spreading, avalanches also, evolve the turbulence profile separately. Avalanches are the result of accumulation of density gradient in time at a slower time scale, resulting in intermittent, ''convective'' transport. It is essential to incorporate this effect to understand profile evolution and thus ''penetrative convection,'' which necessarily implies spreading. Here we consider a model that incorporates the effects of zonal flows, zonal ''density'' and fluctuation-fluctuation mode couplings as well as linear growth, non-linear damping and linear group propagation. We use an EDQNM type analysis of simple drift-wave turbulence within the Hasegawa-Wakatani model, to compute the effect of mode coupling between different k_y modes. We observe it is predominantly the internal energy [i.e. $|\tilde{n}|^2$], that is nonlinearly affected by these processes, whereas kinetic energy [i.e. $|\nabla\widetilde{\Phi}|^2$] simply follows due to linear coupling. Features, which distinguish between spreading by mode coupling and by penetrative convection will be elucidated and discussed.

K1 42 Equilibrium limits in the LDX experiment* LUCA GUAZZOTTO, JEFFREY FREIDBERG, JAY KESNER, *MIT* The Levitated Dipole Experiment (LDX) is an experiment based on an innovative magnetic confinement concept, which allows the confinement of high beta (1) plasmas. A critical figure of merit for such an experiment is the maximum beta that can be achieved during operation. In general, both equilibrium and stability limits must be determined. The present work focuses on the former limit. If toroidal effects are neglected, it is possible to determine the equilibrium beta limit analytically. LDX plasma has however a tight aspect ratio and toroidal curvature must therefore be considered. In the present work, equilibrium calculations obtained with the code FLOW [1] are presented. The code allows for arbitrary geometry, and has the additional properties of allowing toroidal flow and anisotropy to be included in the problem. Both properties are relevant to LDX, since LDX plasmas are expected to have macroscopic toroidal flow and finite anisotropy, due to the heating process. Numerical and analytical results are presented and discussed. [1] L. Guazzotto, R. Betti, J. Manickam and S. Kaye, Phys. Plasmas **11**, 604 (2004).

*This work was funded under contract number DE-AC05-06OR23100.

K1 43 Kinetic stability of internal kink in ITER* BO HU, R. BETTI, *University of Rochester* J. MANICKAM, *Princeton Plasma Physics Laboratory* ITER's standard operation baseline scenario is susceptible to the $m/n = 1/1$ internal kink instability. Kinetic effects modify the inertia and the perturbed energy of the mode, which are important to determine the mode stability. Numerical results are obtained for different q-profiles and plasma betas for ITER-like realistic equilibria using the QSOLVER and PEST1 codes and a kinetic postprocessor. The MHD branch is found to be fully stabilized by the trapped particle compressibility. The stability of the fishbone branch is also greatly affected by the kinetic effects. The trapped electrons contribute a Kruskal-Oberman term because electron collisionalty is much smaller than the mode frequency. Since the bounce frequency of the trapped thermal ions in the core region is close to the mode frequency, the trapped ion compressibility is reduced and damping is increased. Depending on the size of the $q = 1$ radius, the trapped alpha particles can be stabilizing or destabilizing. The kinetic ion inertia enhancement(including damping) is also considered and provides a stabilizing effect. The fishbone branch is found to be stable if the $q = 1$ radius is below a critical value.

*This work was supported by US DoE Contracts DE-FG02-93ER54215 and DE-AC02-76CH03073.

K1 44 Influence of Collisionality and Density Peaking on Thermal Transport* F. BOMBARDA, *Associazione Euratom-ENEA sulla Fusione, Italy* B. COPPI, *M.I.T.* A consensus has formed around the idea that electron collisionality plays a major role in determining the quality of thermal transport in toroidal plasmas. Future burning plasma experiments will operate at similar, relatively low values of the dimensionless collionality parameter ν_*, but at densities that for ITER are close to the critical density and

for Ignitor, thanks to its high current density, are about half that value. The trends of the energy confinement time with collisionality have been analyzed for early Ohmic plasmas in Alcator C-Mod and FTU. The former showed an almost linear correlation with $1/\nu_*$ followed by a saturated regime; the latter was characterized, at the time, by high impurity content and did not display any clear trend. For more recent, and cleaner, FTU data, the behaviour of τ_E as function of density and density profile peaking has been studied, for simple Ohmic and pellet injection discharges. The results have been compared with theory.[1] In order to ensure fine profile density control in Ignitor, especially during the critical phase of the initial current rise, a fast pellet injector is being built in collaboration between ENEA and ORNL. Possible experiments to be carried out on existing machines are presented that could add further support to the proposed ignition scenarios for Ignitor.

*Sponsored in part by ENEA and by the U.S. D.O.E.

[1]B. Coppi, M.I.T.-RLE Report PTP 04/07, Cambridge 2004.

K1 45 Renormalized linear gyrokinetics and recovery of ideal magnetohydrodynamics* L.-J. ZHENG, M. KOTSCHENREUTHER, J. W. VAN DAM, *Institute for Fusion Studies, University of Texas at Austin* The gyrokinetic formalism provides expeditious means for the kinetic analysis of both macro and micro plasma instabilities. In this work, we revisit linear electromagnetic gyrokinetics theory and find that the $\boldsymbol{J}_0 \times \delta\boldsymbol{B}$ effect on force balance is missing and the FLR effect is not retained fully in the conventional formalism. We show that two key modifications are needed to get consistent ordering in gyrokinetics: First, the gyrophase-dependent part of the perturbed distribution function, as well as its coupling to the gyrophase-independent distribution function, should be retained. Second, the solution of the equilibrium gyrokinetic distribution function should be carried out to sufficiently high order. With these modifications we can recover linear MHD from this new gyrokinetic formalism. New effects and potential future applications of this gyrokinetic theory will be discussed (*e.g.*, to resistive wall modes).

*Supported by the Office of Fusion Energy Science of the U.S. DOE under Grant DE-FG02-04ER54742.

K1 46 Effect of sheared axial flow on the stability of the interchange mode in a hardcore Z-pinch plasma J. P. FREIDBERG, A. KOUZNETSOV, J. KESNER, *Plasma Science and Fusion Center, Massachusetts Institute of Technology, Cambridge, MA 02139* It is well known that a static (i.e., $\mathbf{v}=0$) closed field line configuration, such as a Z-pinch, levitated dipole, or hard-core Z-pinch, can be stabilized against ideal MHD interchange modes if the plasma pressure falls off sufficiently rapidly with respect to increasing minor radius. The stabilizing effect is provided by plasma compressibility. However, many laboratory plasmas exhibit sheared velocity flows, $\mathbf{v}' \neq 0$ (due to non-ambipolar plasma transport) and this flow affects marginal stability. An analysis has been carried out to investigate the effect of axially sheared flow on ideal MHD stability in a hard-core Z-pinch. Specifically, the goal is to learn whether sheared flow is good, bad, or neutral for MHD stability? Analytic calculations of marginal stability for several idealistic velocity profiles have been carried out. It is found that all three options are possible depending on the shape of the shear profile. This reflects the competition between the destabilizing Kelvin-Helmholtz effect and the fact that shear makes it more difficult for interchange perturbations to form. Also numerical calculations will be presented using more realistic experimental profiles of pressure and velocity to compare with the idealized analytic profile results.

K1 47 Multi-Scale Interaction of a Tearing Mode with Drift Wave Turbulence: A Minimal Self-Consistent Model* C.J. McDEVITT, P.H. DIAMOND, *CASS and Physics, UCSD* A minimal self-consistent model of the multi-scale interaction of a tearing mode with drift wave turbulence is presented. We first consider the problem of a tearing instability in a cylindrical plasma interacting with electrostatic drift waves. Wave kinetics and adiabatic theory are used to treat the feedback of tearing mode flows on the drift waves via shearing and radial advection. The stresses exerted by the self-consistently evolved drift wave population density on the tearing mode are calculated by mean field methods. The principal effect of the drift waves is to pump the resonant low-m mode via a negative viscosity, consistent with the classical notion of an inverse cascade in quasi-D turbulence. This mechanism is similar to that by which drift wave turbulence drives zonal flows. The magnitude of the turbulent stresses is consistent with a gyro-Bohm diffusivity, and thus exceeds the magnitude of the inertia term for the tearing mode. We study, two types of low-m, resonant structures. The first is a localized, electrostatic vortex mode and the second is like a usual tearing mode, which matches the visco-resistive layer (with negative viscosity) to an MHD exterior. Outgoing wave boundary conditions are imposed in order to effect the match. Extensions to the Rutherford regime and inclusion of turbulence spreading effects will be discussed.

*This research supported by U.S. DOE under Grant No. FG02-04ER54738.

K1 48 Progress on gyrokinetic simulation of high-n energetic particle driven instabilities* YANG CHEN, SCOTT PARKER, *University of Colorado at Boulder* GUO-YONG FU, *Princeton Plasma Physics Laboratory* A hybrid model, in which ions are described by the gyrokinetic equations and electrons are treated as a massless fluid, has been developed for arbitrary shape flux surfaces and equilibrium profiles, based on the GEM turbulence simulation code [Y. Chen and S. E. Parker, J. Comp. Phys. **189** (2003)]. The perturbed magnetic field is given by $\delta\mathbf{B}_\perp = \nabla A_\parallel \times \mathbf{b}$, with $A_\parallel$ given by the parallel Ampere's law. The electric field is given by $\mathbf{E} = -\nabla\phi - (\partial A_\parallel/\partial t)\mathbf{b}$, with ϕ obtained from the quasi-neutrality condition. The primary coupling of the hot particles to the bulk plasma comes from the hot particle term in the quasi-neutrality condition. This hybrid model can be shown to reduce to the MHD equations for the shear Alfvén modes under the assumption $E_\parallel = 0$. Linear simulation shows the existence of global modes with TAE features in terms of mode location and frequency. However, small variation in the equilibrium profiles (such as q-profile and temperature profile) often leads to strongly unstable unphysical mode peaking at the inner mid-plane. We will attemp to resolve this difficulty, either by improving the electron model or by improving numerical algorithms to avoid the unphysical modes.

*Work supported by DOE SciDAC Gyrokinetic Plasma Simulation Center.

K1 49 Fluctuations and Correlations in tokamak plasmas* B. LI, R.D. HAZELTINE, *Department of Physics, Institute for Fusion Studies, University of Texas at Austin* The relation between stationary fluctuations of equilibrium states and irreversible processes is described. The wave-number dependence of spatial correlations in homogeneous systems is obtained from Einstein distribution, and the mean square of fluctuations is then calculated.

Using the fluctuation-dissipation theorem and a convective diffusion equation, the power spectrum and auto-correlation function are computed. The results are compared with the observed plasma density fluctuations in tokamak experiments.

*This work was supported by the U.S. Department of Energy.

K1 50 Tempest Neoclassical Simulation of Fusion Edge Plasmas* X.Q. XU, Z. XIONG, B.I. COHEN, R.H. COHEN, M. DORR, J. HITTINGER, G.D. KERBEL, W.M. NEVINS, T.D. ROGNLIEN, *LLNL* We are developing a continuum gyrokinetic full-F code, TEMPEST, to simulate edge plasmas. The geometry is that of a fully diverted tokamak and so includes boundary conditions for both closed magnetic flux surfaces and open field lines. The code, presently 4-dimensional (2D2V), includes kinetic ions and electrons, a gyrokinetic Poisson solver for electric field, and the nonlinear Fokker-Planck collision operator. Here we present the simulation results of neoclassical transport with Boltzmann electrons. In a large aspect ratio circular geometry, excellent agreement is found for neoclassical equilibrium with parallel flows in the banana regime without a temperature gradient. In divertor geometry, it is found that the endloss of particles and energy induces pedestal-like density and temperature profiles inside the magnetic separatrix and parallel flow stronger than the neoclassical predictions in the SOL. The impact of the X-point divertor geometry on the self-consistent electric field and geo-acoustic oscillations will be reported. We will also discuss the status of extending TEMPEST into a 5-D code.

*Performed for US DOE by LLNL under Contract W-7405-ENG-48.

K1 51 A finite volume Fokker-Planck collision operator in constants-of-motion coordinates* Z. XIONG, X. Q. XU, B. I. COHEN, R. COHEN, M. R. DORR, J. A. HITTINGER, G. KERBEL, W. M. NEVINS, T. ROGNLIEN, *LLNL* TEMPEST is a 5D gyrokinetic continuum code for edge plasmas. Constants of motion, namely, the total energy E and the magnetic moment μ, are chosen as coordinate s because of their advantage in minimizing numerical diffusion in advection operato rs. Most existing collision operators are written in other coordinates; using them by interpolating is shown to be less satisfactory in maintaining overall numerical accuracy and conservation. Here we develop a Fokker-Planck collision operator directly in (E,μ) space usin g a finite volume approach. The (E,μ) grid is Cartesian, and the turning point boundary represents a straight line cutting through the grid that separates the ph ysical and non-physical zones. The resulting cut-cells are treated by a cell-mergin g technique to ensure a complete particle conservation. A two dimensional fourth or der reconstruction scheme is devised to achieve good numerical accuracy with modest number of grid points. The new collision operator will be benchmarked by numerical examples.

*Work performed for USDOE by UC LLNL under contract W-7405-Eng-48.

K1 52 Collisional tests and an extension of the TEMPEST continuum gyrokinetic code* R.H. COHEN, M. DORR, J. HITTINGER, G. KERBEL, W.M. NEVINS, T. ROGNLIEN, Z. XIONG, X.Q. XU, *LLNL* An important requirement of a kinetic code for edge plasmas is the ability to accurately treat the effect of colllisions over a broad range of collisionalities. To test the interaction of collisions and parallel streaming, TEMPEST has been compared with published analytic[1] and numerical (Monte Carlo, bounce-averaged Fokker-Planck) results for endloss of particles confined by combined electrostatic and magnetic wells. Good agreement is found over a wide range of collisionality, confining potential and mirror ratio, and the required velocity space resolution is modest. We also describe progress toward extension of (4-dimensional) TEMPEST into a "kinetic edge transport code" (a kinetic counterpart of UEDGE). The extension includes averaging of the gyrokinetic equations over fast timescales and approximating the averaged quadratic terms by diffusion terms which respect the boundaries of inaccessable regions in phase space.

*Work performed for US DoE by UC LLNL under contract W-7504-Eng-48.

[1]F. Najmabadi, R.W. Conn and R.H. Cohen, Nucl. Fusion **24**, 75 (1984); T.D. Rognlien and T.A. Cutler, Nucl. Fusion **20**, 1003 (1980).

K1 53 Discrete particle noise in a nonlinearly saturated plasma* THOMAS JENKINS, W. W. LEE, *Princeton Plasma Physics Laboratory* Understanding discrete particle noise in an equilibrium plasma has been an important topic since the early days of particle-in- cell (PIC) simulation [1]. In this paper, particle noise in a nonlinearly saturated system is investigated. We investigate the usefulness of the fluctuation-dissipation theorem (FDT) in a regime where drift instabilities are nonlinearly saturated. We obtain excellent agreement between the simulation results and our theoretical predictions of the noise properties. It is found that discrete particle noise always enhances the particle and thermal transport in the plasma, in agreement with the second law of thermodynamics. [1] C.K. Birdsall and A.B. Langdon, *Plasma Physics via Computer Simulation*, McGraw-Hill, New York (1985).

*Work supported by U.S. DoE and the SciDAC project.

K1 54 Implementation and Verification of Two-fluid Modeling in NIMROD* C. R. SOVINEC, H. TIAN, *University of Wisconsin-Madison* D. C. BARNES, *University of Colorado at Boulder* A. Y. PANKIN, D. D. SCHNACK, *SAIC-San Diego* A second-order time advance for the two-fluid plasma model with equilibrium flow and drift has been developed and implemented in the NIMROD fusion MHD code. The algorithm retains the leapfrog character of the MHD algorithm [JCP **195**, 355 (2004)] but solves separate implicit advances for each field. Analysis shows that this approach is numerically stable at arbitrarily large time-step when advection and drift terms, including gyroviscosity, are time-centered in each segment of the leapfrog. Implementation relies on Krylov methods with sparse approximate matrices solved directly for preconditioning and with matrix-free computations in the Krylov-space iterations. The implementation is tested on linear wave, interchange, and magnetic reconnection problems where analytic results are readily available.

*Work supported by the U.S. Department of Energy.

K1 55 Profile Consistency and Resistive Relaxation of Field-Reversed Configurations* ELENA BELOVA, *PPPL* Two-dimensional numerical simulations are used to study resistive evolution and self-organization in Field-Reversed Configurations (FRC). It is shown that FRCs with various initial profiles and separatix shapes obtained by solving the Grad-Shafranov equation, evolve through resistive relaxation toward a specific family of

FRC equilibria with flat current profile and approximately elliptic separatrix shape. This class of profiles is shown to be an attractor, and the FRC in the relaxed state evolves in a self-similar manner. Axisymmetric simulation of FRC formation by the counter-helicity spheromak merging also show formation of FRCs with elliptical shape and approximately flat current profiles independent of the initial conditions, implying that this class of equilibria may correspond to a minimum-energy state. Unlike the force-free relaxed states in the low-beta plasmas, two-dimensional FRCs evolve towards zero-helicity, diamagnetic state, in which current is perpendicular to the magnetic field. An attempt is made to describe these states by a relaxation theory with two integral constraints.

*Supported by DOE contract DE-AC02-76CH03073.

K1 56 Finite Ion Orbit Effects on Magnetic Islands in Toroidal Plasmas XINZHENG LIU, *UW-Madison* CHRIS HEGNA, A kinetic theory for the interaction of ions with an isolated magnetic island in tokamak plasma is presented. We examine islands whose characteristic widths are larger than ion gyro radius but comparable to the ion banana width. In this regime, the ion response to the island has a non-local feature due to the banana drifts. When solving the drift kinetic equation for ions, a change in coordinates is used to account for this behavior. A bounce averaging procedure is developed to separate out and solve the lower order distribution function. Constraint relationships found from transport equations and collision operators are used to determine the distribution function, which is treated in different velocity regions. A self-consistent calculation for the electrostatic potential is proposed. The perturbed current is composed of the bootstrap current and the perpendicular neoclassical enhanced ion polarization current. The closure parallel current is calculated and compared with some recent numerical results. Using this current in Rutherford equation, the island width evolution equation is determined. A pair of self-consistent equations for the island width and rotation frequency is to be derived. The results are to be compared with calculations for large island width so as to yield a description of magnetic island width evolution from sub-banana width to macroscopic scale lengths.

K1 57 Direct Comparison of Gyrokinetic Turbulence Simulations with Phase Contrast Imaging Fluctuation Measurements* DARIN ERNST, *Mass. Inst. of Technology* A. LONG, *Cornell Univ.* N. BASSE, L. LIN, M. PORKOLAB, *Mass. Inst. of Technology* W. DORLAND, *Univ. Maryland* We have developed a synthetic diagnostic[1] for the GS2 gyrokinetic code for direct comparisons with phase contrast imaging (PCI) measurements of density fluctuations in Alcator C-Mod. The gyrokinetic simulation is carried out in a local, field line following flux-tube, while PCI measures density fluctuations along 32 chords passing vertically through the plasma cross-section.[2] Transforming from Clebsch to cartesian coordinates, and integrating appropriately over portions of the flux tube viewed by the diagnostic, yields a density fluctuation spectrum versus wavenumber k_R in the major radius direction. To achieve vertical localization, we examine an ITB case in which the spectrum is dominated by a strong trapped electron mode, localized near the half-radius. The wavelength spectrum from the simulations, using the synthetic diagnostic, closely reproduces the PCI spectrum. Contributions from k_ψ, where $\mathbf{B} = \nabla\alpha \times \nabla\psi$, downshift the GS2 k_α spectrum to improve upon our previous raw comparison with the PCI k_R spectrum.[3] [1]A. Long, D. R. Ernst et al., Bull. Am. Phys. Soc. **50**(8), 153, GP1.48, alsop. 235, LP1.37. [2]N. P. Basse et al., Phys. Plasmas **12**, 052512 (2005). [3]D. R. Ernst et al., 2004 IAEA Fusion Energy Conference, IAEA-CN116/TH/4-1; see also Phys. Plasmas **11** (2004) 2637.

*Supp. by DoE theory grant.

K1 58 Energy conserving and phase space area preserving fluid-kinetic plasma equations H. VERNON WONG, *Institute for Fusion Studies, University of Texas* Low frequency fluid-kinetic plasma equations, in which the total energy is conserved and the particle trajectories preserve their phase space area, are discussed. In a recent drift-kinetic analysis of the Vlasov equation [1], exact to order ϵ^2, where the ordering parameter ϵ is formally proportional to m/e (maximal ordering), these conservation properties are satisfied. Many terms, however, are typically small, and it is often the case that subsidiary orderings can be introduced to reduce the number of relevant terms and thereby simplify the equations. A procedure for introducing subsidiary orderings is described, while at the same time maintaining the above conservation properties, and a reduced set of fluid-kinetic equations is presented, equations which can be used to simulate the low frequency electromagnetic behaviour of magnetized plasmas. [1] H. Vernon Wong, Phys. Plasmas **12**, 112305 (2005).

K1 59 Feedback stabilization of resistive and ideal plasma modes with a resistive wall above the ideal wall limit JOHN M. FINN, *LANL* It has previously been found in tokamaks that feedback based on sensing the tangential component of the magnetic field at the wall is more effective than that based on the normal component of the field. We find that proportional feedback sensing the tangential component is capable of stabilization above the limit for tearing stability with an ideal wall. This stabilization occurs in a small range of parameters. If feedback is based on sensing a combination of the tangential and normal components, resistive plasma stability can be achieved in a large range of parameters above the ideal wall resistive plasma limit. In this regime, plasma rotation (or complex gain) is deleterious because it interferes with the control flux penetrating the wall. For ideal plasma modes, it is possible to get stabilization in the whole regime where wall stabilization occurs, albeit with possibly very large control parameters. In contrast to resistive plasma modes, it appears that stabilization above this range, where ideal plasma modes are unstable even with an ideal wall, is not possible. The relationship with the 'virtual shell' concept of Bishop will be discussed. This observation leads to the possibility in RPFs that single-helicity or quasi-single-helicity states can be obtained by controlling all unstable m=1 modes except for the primary single-helicity mode. Another possibility involves controlling the amplitude of the m=0, n=1 mode, which is typically stable but is driven by coupling of m=1 modes with different n.

K1 60 Electron Cyclotron Current Drive by Bernstein Waves* A.K. RAM, *PSFC, MIT* J. DECKER, Y. PEYSSON, *CEA-Cadarache, France* The high-β plasmas in spherical tori (ST), like in NSTX, are overdense to the traditional X and O modes in the electron cyclotron range of frequencies (ECRF). However, in the

same frequency range electron Bernstein waves (EBW) can propagate in ST plasmas and damp effectively on electrons at the Doppler-shifed electron cyclotron resonance or its harmonics. Since externally generated current is necessary for steady state operation and for controlling the current profile, we examine the role of EBWs in STs. We find that EBWs can generate plasma current by the Ohkawa scheme in the outer half of the plasma and the Fisch-Boozer scheme in the core of the plasma. The current drive efficiency is much higher with EBWs than with the traditional ECRF waves as the EBWs interact with more energetic electrons. We will discuss the properties of EBWs and their interaction with electrons for current drive. Results from two codes, one which solves the fully relativistic plasma dielectric tensor and the other which solves the drift kinetic equation for electrons, will also be presented.

*Supported by DoE Grants DE-FG02-91ER-54109 and DE-FG02-99ER-54521.

SESSION K15: APS JOURNAL EDITORS PANEL DISCUSSION
Sunday Afternoon, 23 April 2006
Cumberland K, Hyatt Regency Dallas at 14:00

14:00
K15 1 APS Journal Editors Panel Discussion The panel will include Editors from the Physical Review and Physical Review Letters journals. They will briefly discuss some current issues facing the journals, such as possible actions in response to the report of the PRL Review Committee. The perennial topic of education of referees and authors, and how to deal with relentless growth. Opinions on these issues, and others, will be solicited from the audience. The Editors will also respond to questions and comments.

SESSION L1: PHYSICS AT THE ENERGY FRONTIER
Sunday Afternoon, 23 April 2006; Landmark A, Hyatt Regency Dallas at 15:15
Robert Cahn, Lawrence Berkeley National Laboratory, presiding

15:15
L1 1
BEATE HEINEMAN, *University of Liverpool*

This abstract was not received electronically.

15:51
L1 2 Higgs Hunting at Hadron Colliders.
THOMAS JUNK, *University of Illinois at Urbana-Champaign*

The success of the $SU(2)_L \times U(1)_Y$ gauge model of the electroweak interactions relies on the breakdown of its symmetry to the $U(1)_{EM}$ group at low energies. The simplest mechanism for the spontaneous breakdown of this symmetry predicts the existence of a Higgs field with a nonzero vacuum expectation value, and the existence of a single scalar, observable particle, the Higgs boson. Supersymmetric models require at least two complex Higgs doublet fields with five physical Higgs states, and more exotic models predict even richer phenomena. Data accumulated to date favor models with a light Higgs boson, but direct searches have not yet shown evidence for such a particle. Constraints have been placed on the parameters of the Higgs sectors of many models. The current status of Higgs boson searches at the Tevatron will be reviewed, as well as projections for future sensitivity. The sensitivity of the LHC experiments to Higgs boson signals will also be reviewed.

16:27
L1 3 Theoretical Prospects at the Energy Frontier.
JONATHAN FENG, *UC Irvine*

I review the prospects for discovering new physics at high energy colliders, concentrating on spectacular signals that may reveal themselves in the first year of LHC operation.

SESSION L2: STUDY OF HADRON STRUCTURE USING SPIN POLARIZED BEAMS
Sunday Afternoon, 23 April 2006; Landmark B, Hyatt Regency Dallas at 15:15
Fulvia Pilat, Brookhaven National Laboratory, presiding

15:15
L2 1 RHIC: The world's first high energy polarized proton collider.*
MEI BAI, *Brookhaven National Laboratory*

The Relativistic Heavy Ion Collider (RHIC) at BNL has been providing polarized proton collisions at a beam energy of 100 GeV since 2001. As the world's first polarized proton collider, RHIC is designed to collide polarized protons at a maximum beam energy of 250 GeV and provides a unique opportunity to measure the gluon contribution to the spin of the proton and to study the spin structure of the proton. Unlike other high energy proton colliders, the added challenge for RHIC is to fight the various mechanisms in an accelerator that can lead to partial or total polarization loss due to the interaction of the spin vector with the magnetic fields. In RHIC, two Siberian snakes have been employed to avoid the spin depolarizing resonances driven by vertical closed orbit distortions and vertical betatron oscillations. Currently, polarized proton beams have been accelerated to 100 GeV without polarization loss. Some depolarization has been observed during acceleration from 100 GeV to 205GeV. This talk will report on the progress of the RHIC polarized proton program. Depolarizing mechanisms in RHIC will also be discussed.

*This work was performed under the auspices of the US Department of Energy and RIKEN Japan.

15:51
L2 2 Probing Hadron Structure at Jefferson Lab Using Polarized Electron Scattering.*
MATT POELKER, *Jefferson Lab*

Almost eighty percent of the present physics program at Jefferson Lab requires polarized electron beams to probe nuclear structure. The accelerator can provide beam to the three experimental halls simultaneously from the same 100 kV DC Gun and GaAs photocathode. Multiple hall operation is a key design feature of the lab that maximizes the physics output. However, multiple hall operation also imposes restrictions on users. For example, only specific beam energies can transfer the full component of longitudinal polarization from the source to multiple halls simultaneously. This talk describes the details of polarized beam delivery to experimental halls and the factors that affect beam quality, particularly those factors relevant for conducting parity violation experiments. In addition, the state-of-the-art and future prospects for higher current and beam polarization will be discussed.

*This work is supported by U.S. DOE under contract DE-AC05-84ER401050.

16:27
L2 3 Upgrades of the Polarized High Intensity Gamma-ray Source at Duke.
CALVIN HOWELL, *Duke University and TUNL*

The High Intensity Gamma-ray Source (HIγS) at the Duke Free Electron Laser Laboratory (DFELL) is operated jointly by the DFELL and the Triangle Universities Nuclear Laboratory. The gamma-ray beam is produced by Compton back scattering of UV photons off high-energy electrons circulating in the storage ring. A distinctive feature of this gamma-ray source is that the Compton scattering occurs inside the optical cavity of a FEL. The gamma-ray beam is nearly 100% polarized and its energy resolution is adjustable by collimation down to 1%. Major upgrades to the accelerators and the UV FEL at the DFELL will be completed in 2006 and 2007, respectively. These upgrades will increase the gamma-ray beam intensity and the capability for extending the energy reach of HIγS to slightly beyond the threshold for photoproduction of pions. The upgraded HIγS facility will be described and examples of proposed experiments to probe hadron structure using the beam at HIγS will be presented.

SESSION L3: ADVANCES IN NUMERICAL RELATIVITY II
Sunday Afternoon, 23 April 2006; Landmark C, Hyatt Regency Dallas at 15:15
Deirdre Shoemaker, The Pennsylvania State University, presiding

15:15
L3 1 Simulations of Binary Black Hole Mergers.
FRANS PRETORIUS, *University of Alberta*

I will review recent advances in the simulation of binary black hole mergers using a numerical scheme based on generalized harmonic coordinates. After a brief overview of the formalism and method I will show results from the evolution of several different classes of initial data, including unequal mass binaries and Cook-Pfieffer quasi-circular inspiral data sets.

15:51
L3 2 Numerical Simulation of Binary Black Holes.
LAWRENCE KIDDER

The coalescence of binary black hole systems is expected to be an excellent source of gravitational radiation for detectors such as LIGO and LISA. Robust, accurate, and long-term numerical simulations of astrophysically realistic binary black hole systems have yet to be achieved, but tremendous progress towards this goal has been made recently. I will discuss some of the challenges involved, present recent results, and speculate about solutions to some of the remaining problems.

16:27
L3 3 Neutron Stars in Compact Binaries.
THOMAS BAUMGARTE, *Bowdoin College*

In this talk I will review recent progress in numerical relativity simulations of neutron stars in compact binaries. I will first discuss the construction of initial data that model binary neutron stars and black hole-neutron star binaries in quasi-equilibrium. I will then describe dynamical evolution calculations of such binaries that simulate the neutron stars' coalescence, collapse or tidal disruption, and I will close by discussing some of the astrophysical implications of these simulations.

17:03
L3 4 Numerical simulations of generic singularities.
DAVID GARFINKLE, *Oakland University*

Numerical simulations are performed of the approach to the singularity of spacetimes with no symmetries. In all cases the singularity is spacelike, and as it is approached, it is local in the sense that the terms in Einstein's equation with spatial derivatives become unimportant compared to those with time derivatives. The dynamics thus becomes locally that of a homogeneous spacetime, though a different homogeneous spacetime for each spatial point. In the case of a scalar field, these homogeneous spacetimes are of the Kasner type with power law behavior of the scale factors. In the vacuum case, the homogeneous spacetimes are Mixmaster type, with oscillatory behavior.

SESSION L4: WOMEN IN SCIENCE POLICY
Sunday Afternoon, 23 April 2006; Marsalis A, Hyatt Regency Dallas at 15:15
Marc Sher, William and Mary, presiding

15:15
L4 1 What the Heck is Science Policy and Who Really Does It?
AMY FLATTEN, *American Physical Society*

The objective of this discussion is to provide graduate students and others with insights regarding careers in science policy—how a scientific graduate degree can lead to opportunities beyond the laboratory, combining scientific expertise with diverse interests such as business, international affairs and national security. The topics covered will include: 1) an overview of the U.S. Government bodies and other stakeholders involved in science policy development; 2) case studies to exemplify the ''process'' of science policy formulation; and 3) where/how one might explore a career in science policy. The speaker served from 1999–2004 with White House Office of Science and Technology Policy.

15:40
L4 2 A Capitol Hill Perspective.
KATHRYN CLAY, *Senate Energy and Natural Resources Committee*

Relatively few women receive advanced degrees in the sciences, and relatively few scientists find their way into staff positions on Capitol Hill. Yet in this staffer's experience, I count more female science Ph.D.s in my circle of colleagues than I counted female classmates in physics graduate school. Why, at least anecdotally, does it seem that women with advanced degrees in science are more likely than their male peers to leave the laboratory and join the policy lobby? My observations are based on my own work in energy and environmental policy as a staffer in both the U.S. Senate and the U.S. House of Representatives.

16:05
L4 3 Science Oversight from the Inside: Views from Service on Capitol Hill and NASA.
JENNIFER WISEMAN, *Johns Hopkins University*

This abstract was not received electronically.

16:30
L4 4 Discussion.

SESSION L6: SCHOLARS AT RISK
Sunday Afternoon, 23 April 2006; Cumberland J, Hyatt Regency Dallas at 15:15
Andrew Sessler, Lawrence Berkeley National Laboratory, presiding

15:15
L6 1 Academic Solidarity: Scholars at Risk and the Defense of Academic Freedom.
ROBERT QUINN, *Scholars at Risk Network*

This abstract was not received electronically.

15:51
L6 2 Sakharov and the Grey Zone: Difficult Areas of Human Rights Activity.
YURI ORLOV, *Laboratory for Elementary-Particle Physics, Cornell University*

Drawing on my experience in human rights work and my discussions with A. D. Sakharov, I will explore some difficult areas of human rights activity in which human rights defenders cannot reach a consensus on how to proceed, and even on how to define the problem.

16:27
L6 3 Scholars at Risk: A Case Study.
HADI HADIZADEH, *Ohio University*

It has been five years since some 60 political activists; many scholars and university professors among them, with alleged links to the so-called ''nationalist-religious'' group and the Freedom Movement of Iran (FMI) were arrested in March and April 2001 on a series of charges including plotting to topple the Islamic establishment in Iran. Almost all of those detained were later released on bail and stood trials before different branches of the Tehran Revolutionary Court, and court of appeals. All sessions and hearings were held behind closed doors! Final verdicts have been gradually delivered, but the judiciary refuses to enforce the sentences, drop the charges, or return the bails. The whole case has been turned into a Sword of Damocles held over the heads of all political activists who happen to be critical of the system.

SESSION L7: GALAXIES, AGNS AND GALACTIC GAMMA-RAY SOURCES
Sunday Afternoon, 23 April 2006
Pegasus A, Hyatt Regency Dallas at 15:15

15:15
L7 1 The effect of expansion on high-energy emission from AGN jets MARTIN POHL, *Iowa State University* We study the radiation yield of relativistic particles in AGN jet that undergo expansion. For that purpose we use a specific model of particle acceleration (Pohl & Schlickeiser 2000) that is based on aborted relativistic shock acceleration and the direct conversion of bulk flow energy into particle energy. While jet expansion must be expected on account of the high pressure in the jet emission zones, the structure of radio galaxies suggests that the expansion is moderate. For various expansion profiles we solve the jet propagation equation and the continuity equations of energetic particles in parallel to derive observable signatures of expansion. A comparison with data suggests that expansion is very inefficient indeed, and we speculate on possible reasons why that is so. Though our study is based on a particular jet model, its results can – within limits – be extrapolated to other scenarios, provided they are based on jets being matter-dominated.

15:27
L7 2 Multiwavelength Observations of 1ES 1959+650 in 2003, One Year After the Strong 2002 Outburst* KRISTOPHER GUTIERREZ, *WUSTL* JEFF GRUBE, *Leeds* HENRIC KRAWCZYNSKI, *WUSTL* MARGO ALLER, HUGO ALLER, *UMRAO* PATRICK CHARLOT, JEAN-FRANCOIS LE CAMPION, *Bordeaux Obs* VERITAS COLLABORATION, In April–May 2003, the blazar 1ES 1959+650 showed a very high level of X-ray activity. The 2–12 keV fluxes measured with the RXTE All Sky Monitor exceeded 10 mCrab for a number of days. This prompted a multiwavelength campaign of observations including triggering ToO pointed RXTE observations. RXTE observations totaling 33.7 ksec from May 2, 2003 to June 7, 2003 were complemented by TeV γ-ray observations taken with the Whipple 10m Cerenkov telescope, radio observations taken with the UMRAO radio telescope and optical observations taken at the Bordeaux optical observatory. While the X-ray flares were of intermediate amplitude, from 0.63 keV^{-1} cm^{-2} s^{-1} to 0.75 keV^{-1} cm^{-2} s^{-1} at 10 keV, observations did not result in the firm detection of any TeV flares. We will present the radio, optical, X-ray and TeV γ-ray observations taken during 2003 and compare them with earlier results from the years 2000 and 2002. Finally, we present fits of a Synchrotron Self-Compton model to the data.

*This work was supported by the DOE, NSF, and NASA (grant NAG 13770). UMRAO is partially supported by funds from the Michigan Dept. of Astronomy.

15:39
L7 3 GLAST and AGN Science LUIS C. REYES, *University of Maryland / Nasa - GSFC* GLAST LAT COLLABORATION, The Large Area Telescope (LAT) on board GLAST (Gamma-ray Large Area Space Telescope) is an instrument under construction to study the gamma-ray sky in the energy range 20 MeV to > 300 GeV with special interest in the previously unexplored region between a few GeV and a few hundred GeV. Among the high energy gamma-ray sources in the sky, the Blazar-class of AGNs are distinguished because of their brightness and very short term variability. GLAST's improved sensitivity with respect to previous missions will increase the number of known AGN gamma-ray sources from about 100 to thousands, with redshifts up to z> 4. Science returns with GLAST include: examination of the blazar sequence model, test of leptonic and hadronic models for particle acceleration, physics of relativistic jets, and evolution of Blazar AGNs population with cosmic time. Special consideration will be given to the possibility of using the large size of the GLAST Blazar catalog to distinguish intrinsic spectra of AGNs from the redshift dependent effects of attenuation by the Extragalactic Background Light (EBL). A measured attenuation as a function of AGN redshift would constitute and effective and unique probe to the optical-UV EBL.

15:51
L7 4 Plasma Component of Self-gravitating Disks and Relevant Magnetic Configurations* G. BERTIN, *Università di Milano* B. COPPI, *MIT* Astrophysical disks in which the disk self-gravity is more important than the gravity force associated with the central object can have significant plasma components where appreciable toroidal current densities are produced. When the vertical confinement of the plasma rotating structures that can form is kept by the Lorentz force rather than by the vertical component of the gravity force, the disk self-gravity remains important only in the radial equilibrium condition, modifying the rotation curve from the commonly considered Keplerian rotation. The equilibrium equations that are solved involve the vertical and the horizontal components of the total momentum conservation equations, coupled with the lowest order form of the gravitational Poisson's equation. The resulting poloidal field configuration can be visualized as a sequence [1] of Field Reverse Configurations, in the radial direction, consisting of pairs of oppositely directed current channels. The plasma density thus acquires a significant radial modulation that may grow to the point where plasma rings can form [2]. [1] B. Coppi, Phys. Plasmas, **12**, 057302 (2005). [2] B. Coppi and F. Rousseau, to be published in Astrophys. J. (April 2006).

*Sponsored in part by the U.S. Department of Energy.

16:03
L7 5 Magnetically limited X-ray filaments in young SNR MARTIN POHL, *Iowa State University* We discuss the damping of strong magnetic turbulence downstream of the forward shock of young supernova remnants (SNR). We find that strong magnetic fields, that have been produced by the streaming instability in the upstream region of the shock, or by other kinetic instabilities at the shock, may be efficiently damped, so the region of enhanced magnetic field strength would typically have a thickness of the order $l_d = (10^{16} - 10^{17})$ cm. The non-thermal X-ray filaments observed in young SNR are thus possibly limited by the magnetic field and not by the energy losses of the radiating electrons, so the thickness of the filaments would not be a measure of the magnetic field strength and claims of efficient cosmic-ray acceleration on account of a run-away streaming instability would appear premature. We emphasize the importance of radio polarimetry studies in determining the properties of strong magnetic turbulence near the forward shocks of SNR.

16:15
L7 6 Gamma-Ray Pulsars in the GLAST Era MARCUS ZIEGLER, *Santa Cruz Institute for Particle Physics, UCSC* GLAST LAT COLLABORATION, A gamma-ray pulsar is a rotating neutron star that emits gamma-ray photons. The EGRET experiment has found seven so far. Gamma-ray pulsars exhibit a range of characteristics with some emitting at radio wavelengths and others not at all. The upcoming GLAST mission will dramatically improve on EGRET's flux sensitivity and energy range. In this talk gamma-ray pulsar models will be discussed and how GLAST data might discriminate amongst them. Also a new method for blind pulsar searches will be presented.

16:27
L7 7 3D Modelling of the interaction of Pulsar Wind Nebula (PWN) with Interstellar medium TANVIR RAHMAN, *Long Island University* DAVID NEILSEN, ERIC HIRSCHMANN, *Brigham Young University* STEVE LIEBLING, *Long Island University* MALLORY ROBERTS, *Eureka Scientific* We have investigated, in three dimensions, the interaction of the Pulsar Wind Nebulae (PWN) with an interstellar medium. We have considered the case of asymmetric wind luminosity and investigated its impact on the bow shock structure and other observables. Our results are compared to several observations.

16:39
L7 8 Gravitational Reactors ORVIN WAGNER, *Wagner Research Laboratory* I suggest that the activity of black holes provides evidence for two different mechanisms. (1) Mass falling into a black hole makes it active. (2) When the maximum gravity in a black hole passes a certain threshold the cross section for gravity breakdown becomes finite. A ''black hole'' (it is assumed that a ''black hole'' is not a singularity but has volume) then becomes active and may throw off matter. We then have a ''gravitational reactor.'' Evidence for the latter: (1) Isolated quasars like HE0450-2958 (2) The mass of a quiet central ''black hole'' is proportional to the mass of the galaxy. Note that the gravitational field in a central ''black hole'' is reduced by the surrounding galaxy. (3) Quasars are very old (4) Central ''black holes'' provide an environment for star formation. (5) Note that star formation tends to end abruptly perhaps because the maximum gravitational field in the ''black hole'' has become too small for the reactor effect. I propose that the most important cause for galaxy formation in the early universe was from the gravitational breakdown of quasars. Quasars formed in the early universe when the mass density was greater. The evidence may require General Theory modification.

SESSION L8: NUCLEAR ASTROPHYSICS
Sunday Afternoon, 23 April 2006
Cumberland A, Hyatt Regency Dallas at 15:15
Betty Tsang, Michigan State University, presiding

15:15
L8 1 Equation of State for low density nuclear matter JUTRI TARUNA, BRADLEY A FUTCH, JORGE PIEKAREWICZ, *Florida State University* Neutron-rich matter at subnuclear densities—present in core-collapse supernovae and the crust of neutron stars—displays fascinating complex structures, such as spherical, slablike, and rodlike shapes. The equation of state and the spin-denpendent, two-body correlation function are computed via semi-classical Monte-Carlo simulations that incorporate a momentum-dependent two-body potential to simulate Pauli correlations.

15:27
L8 2 New Features in the Computational Infrastructure for Nuclear Astrophysics* M.S. SMITH, E.J. LINGERFELT, J.P. SCOTT, W.R. HIX, C.D. NESARAJA, *ORNL Physics Division* H. KOURA, *Japanese Atomic Energy Agency* L.F. ROBERTS, *Colorado College* The **Computational Infrastructure for Nuclear Astrophysics** is a suite of computer codes online at **nucastrodata.org** that streamlines the incorporation of recent nuclear physics results into astrophysical simulations. The freely-available, cross-platform suite enables users to upload cross sections and s-factors, convert them into reaction rates, parameterize the rates, store the rates in customizable libraries, setup and run custom post-processing element synthesis calculations, and visualize the results. New features include the ability for users to comment on rates or libraries using an email-type interface, a nuclear mass model evaluator, enhanced techniques for rate parameterization, better treatment of rate inverses, and creation and exporting of custom animations of simulation results. We also have online animations of r-process, rp-process, and neutrino-p process element synthesis occurring in stellar explosions.

*Managed by UT-Battelle, LLC, for the U.S. DOE under contract DE-AC05-00OR22725.

15:39
L8 3 Beta-decay of proton-rich nucleus ^{23}Al and astrophysical consequences* Y.J. ZHAI, V.E. IACOB, T. AL-ABDULLAH, C. FU, J.C. HARDY, N. NICA, H.I. PARK, G. TABACARU, L. TRACHE, R.E. TRIBBLE, *Cyclotron Institute, Texas A&M University* We will present the results of a β-decay study that was motivated by a nuclear astrophysics problem. For the first time γ-rays have been observed following the β decay of pure samples of ^{23}Al. We used the ^{1}H(^{24}Mg,2n)^{23}Al reaction and the MARS recoil separator of Texas A&M University. β and $\beta - \gamma$ coincidence measurements were made with a fast tape-transport system and β and γ-ray detectors. The experiment allowed us to measure β branching ratios and deduce logft values for transitions to 14 final states in ^{23}Mg, including the isobaric analog state, and from them to determine unambigously the spin and parity of ^{23}Al ground state to be $J^{\pi}=5/2^{+}$. We will discuss how this excludes the large increase in the radiative proton-capture cross section for the reaction ^{22}Mg(p,γ)^{23}Al at astrophysical energies which was implied by claims that the spin and parity is $J^{\pi} = 1/2^{+}$ [1,2], claims that motivated this study in the first place. The reaction is possible candidate to explain why space-based gamma-ray telescopes do not observe γ-rays from the decay of long-lived ^{22}Na formed in ONe novae explosions [3]: a larger cross section would be required to divert significant flux from the A=22 into the A=23 mass chain. [1] X. Z. Cai et al, Phys. Rev. C **65**, 024610 (2002). [2] H.-Y. Zhang et al., Chin. Phys. Lett. **19**, 1599 (2002). [3] M. Wiescher et al., Astrophys. J. **343**, 352 (1989).

*Work supported by DOE.

15:51

L8 4 Proton-transfer study of unbound ^{19}Ne states via ^{2}H(^{18}F, α+^{15}O)n* C.R. BRUNE, A. ADEKOLA, Z. HEINEN, M.J. HORNISH, T.N. MASSEY, A.V. VOINOV, *Ohio University* D.W. BARDAYAN, J.C. BLACKMON, C.D. NESARAJA, M.S. SMITH, *Oak Ridge National Laboratory* K. CHAE, Z. MA, *U. of Tenn* A.E. CHAMPAGNE, D.W. VISSER, *UNC - Chapel Hill* K.L. JONES, S.D. PAIN, J.S. THOMAS, *Rutgers* U. GREIFE, R. LIVESAY, M. PORTER-PEDEN, F. SARAZIN, *Colorado School of Mines* M. JOHNSON, *Oak Ridge Assoc. U.* C. DOMIZIOLI, R.L KOZUB, B. MOAZEN,† *Tenn Tech U.* The nuclear structure of ^{19}Ne near the proton threshold is of interest for understanding the rates of proton-induced reactions on ^{18}F in novae. The proton transfer reaction ^{18}F$(d,n)^{19}$Ne has been measured by bombarding a 720-μg/cm^2 CD_2 target with a 150-MeV $^{18}F^{9+}$ beam at ORNL's Holifield Radioactive Ion Beam Facility. The ^{19}Ne states of interest near the proton threshold decay by breakup into α + ^{15}O which are detected in coincidence with position-sensitive $E - \Delta E$ Si telescopes. The reconstruction of the relative energy reveals the excited states of ^{19}Ne which are populated. The mirror reaction ^{2}H(^{18}F,α+^{15}N)p has been measured simultaneously. The implications for the ^{18}F$(p,\alpha)^{15}$O reaction and ^{19}Ne-^{19}F mirror symmetry will be discussed.

*Work supported in part by the U.S. Department of Energy and National Science Foundation.

†and J.F. Shriner, N. Smith, Tenn Tech U.

16:03

L8 5 Level structure of ^{19}Ne from studies of the ^{17}O(^{3}He, n)^{19}Ne Reaction M.J. HORNISH, C.R. BRUNE, S.M. GRIMES, M.H. HADIZADEH, T.N. MASSEY, A.V. VOINOV, J.E. O'DONNELL, A. ADEKOLA, Z. HEINEN, C. MATEI, *Ohio University* In order to better understand the incomplete level structure of ^{19}Ne above proton threshold as it pertains to proton-induced reactions on ^{18}F in explosive astrophysical environments, a study of the ^{17}O(^{3}He,n)^{19}Ne reaction has been performed at the Edwards Accelerator Laboratory at Ohio University. Utilizing pulsed beams and neutron time-of-flight techniques, this study has been conducted at energies where the compound reaction model is the dominant mechanism. As such, this reaction will in principle populate all excited states, including any heretofore unidentified states. This technique will enable a precise determination of excited energies for individual levels. Furthermore, the experimental differential cross section for individual states can be compared to calculations employing the Hauser-Feshbach statistical model in an attempt to extract information on the spins of the excited states. The observed ^{19}Ne level structure from this reaction will be presented and its astrophysical implications will be discussed.

16:15

L8 6 Bulk Viscosity of Kaons in Warm CFL Quark Matter MATT BRABY, MARK ALFORD, *Washington University* SANJAY REDDY, *Los Alamos National Lab* THOMAS SCHAEFER, *North Carolina State University* We are interested in calculating the bulk viscosity of color superconducting quark matter inside neutron stars, taking into account the effects of the charged and neutral kaon modes. There have already been some calculations published calculating such transport properties as the specific heat and neutrino emissivities (Alford et al 2004, Reddy et al 2003), however a lot of the emphasis has been on calculating the bulk viscosity (Madsen 1992, Wang and Lu 1984). The bulk viscosity directly impact the dissipation of r-modes, a problem that has concerned astronomers for years. It seems quite reasonable to expect quark matter to have a different bulk viscosity than nuclear matter, so this provides a great test to distinguish between them.

SESSION L9: ULTRARELATIVISTIC HEAVY IONS
Sunday Afternoon, 23 April 2006
Cumberland B, Hyatt Regency Dallas at 15:15
Brant Johnson, Brookhaven National Laboratory, presiding

15:15

L9 1 Event-by-event K/pi Fluctuations at RHIC GARY WESTFALL, *Michigan State University* STAR COLLABORATION, We present the first results from measurements of event-by-event fluctuations in the K/π ratio for Au+Au collisions at $\sqrt{s_{NN}}$ = 20, 62.4, 130 and 200 GeV at the Relativistic Heavy Ion Collider using the STAR detector. We observe that dynamical fluctuations in the K/π ratio decrease as the collisions become more central. The excitation function for dynamical fluctuations in the K/π ratio in central collisions will be presented. The results will be compared with similar fluctuations measured at SPS energies.

15:27

L9 2 Coherent Exclusive ρ^0 Production in Ultra Peripheral Relativistic Heavy Ion Collisions with STAR* YURY GORBUNOV, *Creighton University* STAR COLLABORATION, We present a measurement of the coherent ρ^0 and direct $\pi^+\pi^-$ pair photo-production in ultra peripheral relativistic heavy ion collisions at $\sqrt{s_{NN}}$=200 GeV. At impact parameters larger then twice the nuclear radius, the nuclei do not physically collide, but interact via long-range electromagnetic fields. The process $AuAu \rightarrow Au^*Au^*\rho^0$ with accompanying mutual nuclear excitations is observed. The transverse momentum of the ρ^0 is peaked at low p_T which is consistent with coherent coupling to both nuclei. We report ρ^0 production cross section accompanied by mutual nuclear break-up and the ratio of direct pion to ρ^0 production.

*We thank the US DOE for support under grant DE-FG02-05ER46186.

15:39

L9 3 A method for directly measuring bremsstrahlung photons from jets JANETTE HANKS, *Columbia University* PHENIX COLLABORATION, Understanding the phenomenon of jet quenching is important to the study of heavy ion collisions and the medium they produce. Because of their lack of interaction with this medium, photons can provide information about the properties of the medium at the time of their production. In particular, Bremsstrahlung photons released by jets as they interact with the medium can be used for studying the evolution of the jets. \pardof the many sources of photons, the useful Bremsstrahlung photons make up a very small part of the total photon cross section, and so far indirect measurements made by looking for differences in photon spectra have not produced statistically significant results. Photons associated with a jet can be selected for through photon-jet correlations; however, most of the photons cor-

related with jets come from pi0 decays and other background sources. These backgrounds can be measured by reconstructing the invariant mass of gamma pairs. Given the higher statistics of the most recent PHENIX datasets, it may be possible to use this method to directly measure Bremsstrahlung photon spectra.

15:51

L9 4 Near field properties in relativistic heavy ion collisions YANG LI, RAINER FRIES, JOSEPH KAPUSTA, *University of Minnesota* We study the properties of the soft gluon field produced in relativistic heavy ion collisions. In the spirit of McLerran-Venugopalan model, we write the field potential in a power series of the proper time τ and solve the Yang-Mills equation along with color current conservation equations simultaneously. We find that the classical gluon field at small τ, i.e., the near field, is mainly longitudinal. We also calculate the energy-momentum tensor of the field. This gluon field will decay and thermalize into a quark gluon plasma. Our results can be used as the initial conditions for the consequent relativistic hydrodynamic description of the dense parton matter.

16:03

L9 5 Two-particle number and transverse momentum correlations in Au-Au collisions at RHIC* MICHAEL DAUGHERITY, *The University of Texas at Austin* STAR COLLABORATION, The related studies of two-particle correlations and event-by-event fluctuations have played important roles in the search for new physics through the experimental study of relativistic heavy ion collisions. We present a general method of determining two-particle correlations and show the relationship between these correlations and event-by-event fluctuations [1]. Data from the STAR experiment at RHIC for Au-Au collisions at $\sqrt{s_{NN}}$ = 62 and 200 GeV will be presented that show the energy and centrality dependences of several correlation measures. Since this analysis method is minimally biased and requires no high-p_t triggers, these results provide unique access for studying the hot, dense medium produced at RHIC, as well as shed new light on the sources of non-statistical fluctuations. [1] J. Adams et al. (STAR Collaboration), nucl-ex/0509030.

*Supported in part by The U. S. Dept. of Energy.

16:15

L9 6 Interpreting two-particle correlation and autocorrelation observables for proton-proton and Au-Au collision data from STAR LANNY RAY, *The University of Texas at Austin* STAR COLLABORATION, Central collisions between Au ions at RHIC produce several thousand charged particles, about a thousand of which are detected with the large acceptance Time Projection Chamber of STAR. Two-particle correlations and autocorrelations are presented for the 130 GeV (per nucleon pair) data for charged particles for large ranges of relative transverse momentum (2 GeV/c), pseudorapidity (2 units), and azimuthal angle (180 deg) [1]. We obtain similar correlation observables for high energy proton-proton data (CM energy 200 GeV) taken with STAR. We argue that combined analyses of inclusive single-particle distributions and two-particle correlation data will provide deeper insight into the nature of the hot, dense medium produced at RHIC than can be achieved with analyses of singles data alone. We present the evolution of the correlation distributions for Au-Au as the collision centrality increases from very peripheral to the most central. The results of the analyses suggest the occurrence of semi-hard parton scattering, strong medium induced modification of the fragmentation pattern for the scattered partons, dissipation of the parton transverse momentum to the bulk medium, development of opacity, and an alteration of the way in which the longitudinally expanding medium hadronizes. [1] J. Adams et al., nucl-ex/0408012; nucl-ex/0411003; nucl-ex/0406035. Supported in part by the U.S. Dept. of Energy.

16:27

L9 7 Advantage of U+U over Au+Au collisions at the Relativistic Heavy Ion Collider* CHANDRA NEPALI, GEORGE FAI, DECLAN KEANE, *Kent State University* In a graph of v_2/ϵ vs. $(1/S)(dN_{ch}/dy)$, STAR data [1] reach the reported perfect fluid value of v_2/ϵ for the most central Au+Au collisions at 200 GeV/nucleon. It is interesting to see whether a limit is reached asymptotically by the data when $(1/S)(dN_{ch}/dy)$ is increased further. Collisions of deformed uranium nuclei have been suggested to increase this quantity at fixed beam energy [2–4]. We have studied U+U collisions in a Monte-Carlo Glauber model and attempted to simulate realistic experimental conditions. We have examined $(1/S)(dN_{ch}/dy)$ under different centrality cuts and compared with Au+Au. The most desired U+U configuration (tip-to-tip) increases the $(1/S)(dN_{ch}/dy)$ by about 35% compared to Au+Au at b = 0 fm in the ideal case. In the context of real experiments and with available centrality cuts at the Relativistic Heavy Ion Collider, the predicted increase in $(1/S)(dN_{ch}/dy)$ is about 16% which we deem still a worthwhile gain. [1] J. Adams *et al.* [STAR], Nucl. Phys. A **757**, 102 (2005). [2] E. V. Shuryak, Phys. Rev. C **61**, 034905 (2000). [3] B. A. Li, Phys. Rev. C **61**, 021903 (2000). [4] U. W. Heinz and A. Kuhlman, Phys. Rev. Lett. **94**, 132301 (2005).

*This work was supported in part by US DOE grants DE-FG02-86ER40251 and DE-FG02-89ER40531.

16:39

L9 8 Studying Cosmic-Ray-Type Events Made in the Laboratory with CMS and CASTOR EDWIN NORBECK, Y. ONEL, *University of Iowa* A. PANAGIOTOU, *University of Athens, Greece* M. MURRAY, *University of Kansas* CMS COLLABORATION, The LHC at CERN will produce collisions between heavy ions at energies heretofore seen only in cosmic rays, 1144 TeV in the center of mass for Pb+Pb. Even with a colliding beam, the core of the shower appears at very small, forward angles. The small-angle, 0.1^o to 0.8^o, reaction products will be studied with a novel quartz-tungsten calorimeter, CASTOR, and a thin tracking detector, TOTEM-2. Products going into larger angles will be measured by the rest of the huge CMS experiment. These studies will provide, for the first time, a much needed calibration for cosmic-ray air-shower detectors. Cosmic-ray literature describes a wide variety of exotic events from collisions between ions up to Fe+air. Even more exotic events could be expected from Pb+Pb. CASTOR is designed to look for a variety of exotic phenomena that have been predicted. ''Strangelets'' are metastable, almost neutral, nuclei with nearly equal numbers of s, u, and d quarks. Matter, comprised of u, d, and s quarks is believed to form the core of neutron stars. ''Centauros'' or ''disoriented chiral condensates,'' whose nature has not been understood so far, would appear in CASTOR as an unusual distribution of the charges of pions. Also, at these angles and energy the gluons are expected to overlap to form a classical field known as a ''color glass condensate.''

SESSION L10: B MESON BRANCHING FRACTIONS
Sunday Afternoon, 23 April 2006
Cumberland C, Hyatt Regency Dallas at 15:15
Masahiro Morii, Harvard University, presiding

15:15
L10 1 Search for resonant decays in $B \to XK^*$, $X \to J/\psi\pi\pi$ BRANDON DRUMMOND, *University of Texas, Dallas* BABAR COLLABORATION, We present here a study of $B \to XK^*$ with $X \to J/\psi\pi\pi$ produced in approximately 280fb^{-1} of e^+e^- annihilations near $10.6GeV$. The search was carried out with data recorded by the BaBar experiment operating at the PEP-II asymmetric-energy e^+e^- storage rings at SLAC.

15:27
L10 2 Angular analysis of $B \to J/\psi K^*$, $B \to \psi(2S)K^*$ and $B \to \chi_{c1}K^*$ EMMANUEL LATOUR, *Ecole Polytechnique, Laboratoire Leprince-Ringuet* BABAR COLLABORATION, We present the angular analysis of $B \to J/\psi K^*$, $B \to \psi(2S)K^*$ and $B \to \chi_{c1}K^*$, using 209fb^{-1} data of the BaBar detector at the PEP- II asymmetric-energy e^+e^- storage rings at SLAC. This angular analysis aims at measuring the decay transversity amplitudes in absolute value and strong phases. This allows to probe the hadronic form factor models of the Factorization scheme in color-supressed modes. This study represents an update with increased luminosity for $B \to J/\psi K^*$ decays, the first BaBar measurement in $B \to \psi(2S)K^*$ decays, and the first measurement ever in $B \to \chi_{c1}K^*$ decays.

15:39
L10 3 Measurement of $\bar{B}^0 \to D^{(*)+}\pi^-$ and $B^- \to D^{(*)0}\pi^-$ decays HAIWEN ZHAO, *University of Mississippi* BABAR COLLABORATION, We present new measurements of branching fractions for the color-favored decays $\bar{B}^0 \to D^{(*)+}\pi^-$ and $B^- \to D^{(*)0}\pi^-$. Using a data set of integrated luminosity of 59.0 fb^{-1} taken with BaBar detector at the $\Upsilon(4S)$ resonance, we measured the branching fractions for these decays and obtained the strong phase difference between the $I = 1/2$ and $I = 3/2$ isospin amplitudes. The result suggests the presence of final state interactions in the $D^{(*)}\pi$ system.

15:51
L10 4 Observation and study of exclusive protonic B decays to $D^{(*)}p\bar{p}n\pi$, $n = 0,1,2$ final states TAE MIN HONG, *University of California, Santa Barbara* BABAR COLLABORATION, Using a data sample of 211fb^{-1} recorded by the BaBar detector at the PEP-II asymmetric-energy e^+e^- B Factory at SLAC, we perform measurements of the branching fractions for ten Cabibbo-favored B decays to final states of the form $\bar{B}^0, B^- \to D^{(*)}p\bar{p}n\pi$, $n = 0,1,2$.

16:03
L10 5 Search for B Meson Decays to Two Charm Baryons XUEDONG CHAI, *University of Iowa* BABAR COLLABORATION, We present measurements of the branching ratios of B decays to charm baryon pairs in the reactions $\bar{B} \to \Lambda_c\overline{\Lambda_c}K$ and $\bar{B} \to \Xi_c\overline{\Lambda_c}$. The analysis is based on a 210 fb^{-1} data sample collected by the BaBar detector at the PEP-II $e^\pm e^-$ storage rings at SLAC.

16:15
L10 6 Measurement of $\mathcal{B}(\overline{B^0} \to \Lambda_c^+\bar{p})$ at BaBar STEPHANIE A. MAJEWSKI, *Stanford University* BABAR COLLABORATION, We present a branching fraction measurement for the decay $\overline{B^0} \to \Lambda_c^+\bar{p}$ in a sample of 232 million $B\bar{B}$ pairs collected with the BaBar detector at the PEP-II e^+e^- storage rings at SLAC. Studies of these charmed baryonic B decays provide a way to check various theoretical models and aid in predicting the branching fractions of their charmless counterparts.

16:27
L10 7 Study of $B^- \to \Lambda_c^+\bar{p}\pi^-$ at BaBar BETH NOWADNICK, *Stanford University* BABAR COLLABORATION, We present a branching fraction measurement for the decay $B^- \to \Lambda_c^+\bar{p}\pi^-$ using data from 232 million $B\bar{B}$ pairs collected at the BaBar detector at the Stanford Linear Accelerator Center. We compare this branching fraction measurement to the branching fraction of the two-body mode $\overline{B^0} \to \Lambda_c^+\bar{p}$. This comparison can yield insight into the dynamics of baryon production. We also study the resonant substructure of the three-body decay.

16:39
L10 8 Dalitz plot analysis of $3\pi/K\pi\pi/K^0_SKK$ at BaBar GAGAN BIHARI MOHANTY, *University of Warwick* BABAR COLLABORATION, We present the measurement of decay amplitudes and phases in decays of B mesons to $\pi^+\pi^-\pi^+$, $K^+\pi^+\pi^-$ and $K^0_SK^+K^-$ final states. We use a sample of approximately 230 million B-meson pairs recorded at the $\Upsilon(4S)$ resonance by the BaBar detector at the PeP-II B-Factory at SLAC.

16:51
L10 9 Measurement of the branching fraction of B0 meson decay to $a_1\pi$ VINCENZO LOMBARDO, *INFN Sezione di Milano* BABAR COLLABORATION, We present a measurement of the branching fraction of the decay $B^0 \to a_1^+\pi^-$. The data set consists of approximately 218 million $B\bar{B}$ pairs produced in electron-positron annihilation at the PEP-II collider and recorded by the BaBar detector.

SESSION L11: EXPERIMENTAL GRAVITATION
Sunday Afternoon, 23 April 2006
Cumberland E, Hyatt Regency Dallas at 15:15
Duncan Brown, California Institute of Technology, presiding

15:15
L11 1 Post-Newtonian Gravity with Lorentz Violation QUENTIN G. BAILEY, ALAN KOSTELECKY, *Indiana University* Lorentz-symmetry violation is a popular candidate signal for Planck-scale physics. The general description of observable Lorentz-symmetry violation at low energies is given by the Standard-Model Extension (SME). This talk discusses the pure gravitational sector of the SME in the limit of Riemann geometry

and presents some key results for the post-newtonian limit. We outline several promising possibilities for experimental searches, including some with the potential to access unmeasured coefficients for Lorentz violation and others that could improve existing sensitivities.

15:27

L11 2 Building and Testing a New Apparatus for Measuring Mass-dependent Forces at Small Length Scales DAVID WELD, JING XIA, BLAS CABRERA, AHARON KAPITULNIK, *Stanford University* We will discuss the construction and initial testing of a new type of cantilever-based probe for measuring mass-dependent forces at length scales of order 10^{-5} meters. The apparatus is based on a cryogenic helium gas bearing with a hemispherical quartz rotor. The bearing housing contains a force-sensing microcantilever with a metallic test mass mounted on the tip. An alternating pattern of high- and low-density materials is embedded in the flat surface of the rotor so that when the rotor spins, the mass on the cantilever is subjected to an AC gravitational force. This design combines some of the geometrical advantages of torsion-balance experiments with the small face-to-face separation and good force sensitivity of our previous cantilever-based experiments [1,2]. [1] S. J. Smullin et al., Phys. Rev. D **72**, 122001 (2005). [2] J. Chiaverini et al., Phys. Rev. Lett. **90**, 151101 (2003).

15:39

L11 3 Design and performance of a sub-nanoradian resolution autocollimating optical lever* RAMANATH COWSIK, R. SRINIVASAN, S. KASTURIRENGAN, A. SENTHIL KUMAR, KASEY WAGONER, *Washington University, St. Louis* Precision goniometry using optics has the advantage that it does not impose much stress on the object of investigation and, as such, is adopted extensively in gravitational wave detection, in torsion balances investigating fundamental forces and in specialized studies of biological samples. It has potential applications in condensed matter physics. We have developed an autocollimating optical lever which has a very high resolution and dynamic range. An array of 110 slits, of 84 micron width and a pitch of 182 microns, is located in the focal plane of a field lens, of focal length 1000 mm, and is illuminated by a CCFL-tube. This array is imaged back on to the focal plane after retro-reflection from a mirror placed just beyond the lens. The image was recorded on a linear CCD array at the rate of 1000 images per second and was processed through a special algorithm to obtain the centroid. The instrument has a centroid stability of $\sim 3.10^{-10}$ rad.Hz$^{-1/2}$ and a dynamic range of $\sim 10^7$.

*This research is supported by Washington University and The McDonnell Center for The Space Sciences.

15:51

L11 4 Adaptive Mode matching in stable recycling cavities in Advanced LIGO* G. MUELLER, M.A. ARAIN, V. QUETSCHKE, D.H. REITZE, D.B. TANNER, *University of Floirda* The Laser Interferometer Gravitational-Wave Observatory has reached its design sensitivity and is currently in its fifth science run (S5). One of the main obstacles in reaching the design sensitivity was the imbalance of the RF-sidebands inside the unstable and thermally loaded recycling cavity, requiring the implementation of external thermal compensation and ultra-stable RF oscillators to overcome this problem. These effects will be amplified in Advanced LIGO, which will operate at 15 times greater laser power. Thermal deformations excite higher order spatial modes which are resonantly enhanced for the RF-sidebands and the gravitational-wave-induced signal sidebands. This may lead to signal loss and perhaps to instabilities which could prevent high power operation. We propose to develop stable recycling cavities and compensate the remaining thermally driven losses with an adaptive mode-matching system. We will discuss the physics behind these effects, describe how the system is analyzed, and discuss the current status of the analysis.

*This work is supported by the NSF Grants PHY-0354999 and PHY-0244902.

16:03

L11 5 The scaling of LIGO's coating thermal noise with beam shape* GEOFFREY LOVELACE, *Theoretical Astrophysics, California Institute of Technology* An option for Advanced LIGO is to alter the light beam's cross sectional shape so as to reduce thermal noise in the mirrors' substrates and coatings. The influence of beam shape on substrate noise is fairly well understood,[1] and J. Agresti has compared Gaussian and flat-top shapes for coating noise.[2] Unpublished analyses by R. O'Shaughnessy and S. Vyatchanin suggest that, if one approximates the mirrors as semi-infinite, the coating thermal noise below any point on the mirror surface is proportional to the square of the beam intensity itat that point, i.e., the noise obeys a itlocal scaling law. Using the fluctuation-dissipation theorem and elastostatics, I show that the correct scaling also includes itnonlocal terms. I comment on the implications of this result for Advanced LIGO.

*NSF grant PHY-0099568.

[1]E. D'Ambrosio, R. O'Shaughnessy, S. Strigin, K. Thorne and S. Vyatchanin, Phys. Rev. D submitted, gr-qc/0409075.

[2]Juri Agresti, preliminary results. LIGO-G050041-00-Z, available at http://www.ligo.caltech.edu/.

SESSION L12: EXCLUSIVE D MESON DECAYS
Sunday Afternoon, 23 April 2006
Cumberland F, Hyatt Regency Dallas at 15:15
Todd Pedlar, Luther College, presiding

15:15

L12 1 A study of the Decays $D \rightarrow K,\pi e\nu$ BATBOLD SANGHI, *Purdue University* CLEO COLLABORATION, The CLEO-c experiment at the CESR e^+e^- collider has collected 281 pb^{-1} of data at the $\psi(3770)$ resonance. Using this data sample, we have reconstructed events where one D meson has decayed into a hadronic final state and the other D meson has decayed as $D \rightarrow Ke\nu$ or $D \rightarrow \pi e\nu$. In this talk we present improved measurements of the absolute semileptonic branching ratios and form factors in $D \rightarrow K,\pi e\nu$. We fit the q^2 distributions using several form factor models and measure $V_{cs(d)} \times f_+(0)$. Using $V_{cs(d)}$ values obtained from the unitarity of the CKM matrix, $f_+(q^2)$ is measured and compared with LQCD predictions. We also report measurements of V_{cs} and V_{cd}.

15:27
L12 2 A Study of the Charmed Semileptonic Decays $D^0 \to K^{\pm}e\nu$, $D^0 \to \pi^{\pm}e\nu$, $D^{\pm} \to K^0e\nu$ and $D^{\pm} \to \pi^0e\nu$ NADIA ADAM, *Cornell University* CLEO COLLABORATION, Using a sample of 1.8 million $D\bar{D}$ mesons collected at the $\psi(3770)$ with the CLEO detector, and a reconstruction method based on the full event hermeticity, we measure branching fractions and branching fraction ratios for the four exclusive semileptonic decay modes $D^0 \to K^{\pm}e\nu$, $D^0 \to \pi^{\pm}e\nu$, $D^{\pm} \to K^0e\nu$ and $D^{\pm} \to \pi^0e\nu$. Form factors are measured using a fit to the branching fraction results in five q^2 bins. Three form factor models are explored, the simple pole model, the modified pole model and a series parameterization model. In addition we fit for the CKM matrix element $|V_{cs}|$ and the ratio $|V_{cd}|/|V_{cs}|$.

15:39
L12 3 Study of the Decay $D \to \rho e\nu$ GUANGSHUN HUANG, *Purdue University* CLEO COLLABORATION, Using 281 pb^{-1} of data collected with the CLEO-c detector at the $\psi(3770)$ resonance, we discuss improvements on branching fraction measurements and studies of form factors for the semileptonic decays $D^0 \to \rho^-e^+\nu$ and $D^+ \to \rho^0e^+\nu$.

15:51
L12 4 Studies of Rare Semileptonic D meson Decays BO XIN, *Purdue University* CLEO COLLABORATION, Using a 281 pb^{-1} data sample collected by the CLEO-c detector at the $\psi(3770)$ resonance, we search for rare semileptonic D meson decay modes, including $\eta e\nu$, $\eta' e\nu$ and $\phi e\nu$.

16:03
L12 5 Investigation of $D^+ \to \tau^+\nu$ NABIL MENAA, *Syracuse University* CLEO COLLABORATION, Using data taken with the CLEO-c detector at the $\psi(3770)$ resonance, we compare our recent measurement of $\mathcal{B}(D^+ \to \mu^+\nu)$ with $\mathcal{B}(D^+ \to \tau^+\nu)$. The ratio of branching ratios should be 2.65 in the Standard Model with any deviation indicating a breakdown of lepton universality.

16:15
L12 6 Measurement of the ratio of branching fractions $\mathcal{B}(D^0 \to K^+\pi^-)/\mathcal{B}(D^0 \to K^-\pi^+)$ using the CDF II Detector ROBERT HARR, *Wayne State* CDF COLLABORATION, We present a preliminary measurement of the ratio, R_D, of the branching fraction for the doubly Cabibbo-suppressed decay $D^0 \to K^+\pi^-$ to that for the Cabibbo-favored decay $D^0 \to K^-\pi^+$. Charge conjugate decays are implicitly included. A signal of 2005 $\pm$ 104 events for the decay $D^0 \to K^+\pi^-$ is obtained using the CDF II detector at the Fermilab Tevatron collider. The data set corresponds to an integrated luminosity of 0.35 fb^{-1} produced in $\bar{p}p$ collisions at $\sqrt{s}$ = 1.96 TeV. Assuming no mixing and no CP violation, we find R_D = 4.05 $\pm$ 0.21(stat.) $\pm$ 0.12(syst.) $\times$ 10^{-3}. This measurement is consistent with the world average, and comparable in accuracy with the best measurements from other experiments.

16:27
L12 7 $D \to KK$ decays HIRO MIYAKE, *Cornell University* CLEO COLLABORATION, The CLEO-c experiment at the CESR e^+e^- collider has collected 281 pb^{-1} of data at the $\psi(3770)$ resonance. Using this data sample we have studied Cabibbo suppressed decays of D mesons to final states with kaons. We present preliminary results for the branching fractions of the two-body decays $D^0 \to K^+K^-$, $D^0 \to K^0_SK^0_S$, and $D^+ \to K^+K^0_S$.

16:39
L12 8 A measurement of the relative phases and amplitudes of $D0 \to K^{*+}K^-$ and $D0 \to K^{*-}K^+$ PARAS NAIK, *University of Illinois* CLEO COLLABORATION, Using a Dalitz Plot technique to investigate $D^0 \to K^+K^-\pi^0$ decays in the CLEO III data set, we have measured the relative amplitudes and phases of the charmed decays $D^0 \to K^{*+}K^-$ and $D^0 \to K^{*-}K^+$.

16:51
L12 9 Search for the decay D to mu mu at CDF Run II EDMUND BERRY, *University of Chicago* CDF COLLABORATION, We report on a search for the flavor-changing neutral current decay D0 to mu+mu- in pp-bar collisions at sqrt = 1.96 TeV using 330 pb-1 of data collected by the CDF experiment at the Fermilab Tevatron Collider. A displaced-track trigger selects long-lived D0 candidates in the D0 to mu+mu- search channel. The kinematically similar D0 to pi+pi- channel is used for normalization, and the Cabbibo-favored D0 to K-pi+ channel is used to optimize the selection criteria in an unbiased manner. This analysis is an extension of a previous search using 65 pb-1 of data, when a limit was set on the branching fraction, B(D0 to mu+mu-) less than 2.5 $\times$ 10(−6) at the 90 percent confidence level.

SESSION L13: TOP QUARK MASS MEASUREMENTS
Sunday Afternoon, 23 April 2006
Cumberland G, Hyatt Regency Dallas at 15:15
Eva Halkiadakis, Rutgers University, presiding

15:15
L13 1 Top Quark Mass Measurement in Lepton+Jets Channel Using the Transverse Decay Length of b-Hadrons from Top Decays CHRIS HILL, *UC Santa Barbara* CDF COLLABORATION, We have developed a novel method to measure the mass of the top quark using the transverse decay length of b-hadrons from top decays. This technique relies solely on tracking and thus avoids the jet energy scale uncertainty that is common to all other methods. We have applied this new method to a lepton +jets top sample corresponding to 0.7 fb^{-1} and have extracted a measurement of the top quark mass. While this result is not a competitive measurement by itself, since the decay length technique is uncorrelated with other methods, it will help to reduce the overall uncertainty on the top's mass in combination with other Tevatron measurements.

15:27
L13 2 Measurement of the top quark mass at D0 using lepton +jets events CARLOS GARCIA, *University of Rochester* We report on the measurement of the top quark mass using ttbar candidates in the lepton+jets final states. For each event a probability is calculated as a function of the top mass and the overall jet energy scale. The top mass and jet energy scale are extracted by maximizing a likelihood constructed as the product of the single event probabilities. The overall jet energy scale is constraint by the two hadronic jets forming a W-boson. This reduces the large uncertainty due to the jet energy scale.

15:39
L13 3 Top Quark Mass in Dilepton Channel* BO JAYATILAKA, *Univ. of Michigan* CDF COLLABORATION, We present a measurement of the top quark mass in events in the dilepton channel produced in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV using 700 pb^{-1} of data collected at the CDF II detector. We extract the top quark mass from a probability that a given event is consistent with $t\bar{t}$ decaying to a final state including two leptons. The probability is evaluated using a differential cross-section for $t\bar{t}$ production and decay. The effect of background events in the sample is accounted for in the probability calculation by evaluating differential cross sections for major background processes. A previous measurement using this method yielded the most precise single measurement of the top quark mass in the dilepton channel to date.

*For the CDF Collaboration.

15:51
L13 4 Measurement of the Top Quark Mass at DØ using Dilepton Events JOERG MEYER, DØ COLLABORATION, We report on a measurement of the top quark mass using $t\bar{t}$ candidates in the dilepton final states. The kinematics of these events are solved for a range of assumed top quark masses, and the relative likelihood of each solution is assessed. Information from the complete set of events is combined in a maximum likelihood fit to extract the top quark mass and its uncertainty.

16:03
L13 5 Top Quark Mass Measurement in the All-hadronic Channel* GHEORGHE LUNGU, *Univ. of Florida* CDF COLLABORATION, We present here a preliminary measurement of the top quark mass in the all-jet final state, where both W's decay hadronically. The measurement is performed using $p\bar{p}$ collision data at $\sqrt{s}$ = 1.96 TeV at the Collider Detector at Fermilab. The method employed uses matrix element information to weigh each event configuration according to the probability for it to originate from ttbar production and decay at a given top mass. All the event probabilities are multiplied to yield a total likelihood which depends on the top mass. The estimated mass is the value at which the total likelihood is minimized.

*For the CDF Collaboration.

16:15
L13 6 Top Quark Mass Measurement in Lepton+Jets Channel Using a Matrix Element Method* BRIAN MOHR, *UCLA* CDF COLLABORATION, We present a measurement of the mass of the top quark from $p\bar{p}$ to $t\bar{t}$ events in the lepton plus jets channel. We use events from 681 pb^{-1} of data from collisions at 1.96 TeV observed with the Collider Detector at Fermilab (CDF). The largest systematic uncertainty is convoluted with the statistical error using an in-situ measurement of the hadronic W boson mass. A likelihood is calculated for each event using a leading-order $t\bar{t}$ and W+jets cross-section, and parameterized parton showering. The final measured top quark mass and JES systematic is extracted from a joint likelihood of the product of the individual event likelihoods.

*For the CDF Collaboration.

16:27
L13 7 Top Quark Mass Measurment in Lepton+Jets Channel Using a Template Method* WOJTEK FEDORKO, *Univ. of Chicago* CDF COLLABORATION, We present a measurement of the top quark mass employing the template method with data collected by the CDF Run II detector. We select lepton+jet events to isolate top-antitop pair production in a 690 pb^{-1} sample of proton- antiproton collisions at $\sqrt{s}$ = 1.96 TeV. In each event we use kinematic constraints on the pair of top quarks and their decay products to determine a reconstructed top quark mass. We simultaneously determine the invariant mass of the decaying W boson to calibrate the energy response of the detector. The reconstructed top quark mass and W boson invariant mass distributions are fit to Monte Carlo derived templates in a simultaneous likelihood fit to extract the top quark mass and an in-situ measurement of the jet energy scale.

*For the CDF Collaboration.

16:39
L13 8 Top Quark Mass Measurement in Lepton+Jets Channel Using a Multivariate Technique* JOHN FREEMAN, *LBNL* CDF COLLABORATION, We present a preliminary measurement of the top quark mass using the Run II data collected with the CDF detector at Fermilab. The $t\bar{t}$ events produced in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 GeV are reconstructed in the lepton+jets channel. Using a matrix element method with transfer functions derived from Monte Carlo to connect jets to partons, we calculate a likelihood for each event to be a top candidate at several possible top masses. Taking into account the presence of background and using additional kinematics variables we derive a value for the top mass.

*For the CDF Collaboration.

SESSION L16: LABORATORY ASTROPHYSICS I
Sunday Afternoon, 23 April 2006; Landmark D, Hyatt Regency Dallas at 15:15
Hantao Ji, Princeton Plasma Physics Laboratory, presiding

15:15
L16 1 Spontaneous reconnection in a laboratory experiment.*
JAN EGEDAL, *MIT*

A new experimental configuration has been developed for study of collisionless reconnection in the Versatile Toroidal Facility (VTF) at MIT. A parameter regime of special interest exists where the reconnection process appears in rapid bursts. This provides a unique opportunity to study the ''trigger problem'' of reconnection in current sheets confronting the unresolved issues related to the spontaneous and explosive onset of events observed both on the sun and in the Earth magnetotial. Our measurements include the detailed time evolution of the plasma density, current density, the magnetic flux function, the electrostatic potential and the reconnection rate. I will discuss the new experimental scenario and present our detail observations of fast spontaneous reconnection in the VTF current sheet.

*In collaboration with Will Fox, Noam Katz, and Miklos Porkolab, Massachusetts Institute of Technology.

15:35
L16 2 Kinking and merging of flux ropes in the Relaxation Scaling Experiment.*
T. INTRATOR, *Los Alamos National Laboratory*

In solar, space, laboratory and astrophysics, magnetic fields and currents coexist, and frequently align and twist themselves into current ropes, and form the building blocks of magnetohydrodynamics (MHD). Their relaxation is bound up with the dynamics, which is omitted from the Taylor relaxation picture. For instance, magnetic fields and currents on the Sun are sheared and twisted as they store energy, experience instability, open into interplanetary space, eject the plasma trapped in them, and cause a flare. At LANL, the Relaxation Scaling Experiment (RSX) provides a simple means to systematically characterize the linear and non-linear evolution of driven, dissipative, unstable plasma-current filaments. The topology evolves in three dimensions, supports multiple modes, and can bifurcate to quasi-helical equilibria. We observe saturation to a helical state that is a candidate for a general relaxation process. We characterize experimentally magnetic structure of a kinking, rotating and merging flux ropes. We show that non line tied flux ropes are more unstable than line tied ones, i.e. at half the Kruskal-Shafranov threshold for J/B, and sketch a theoretical model for this. In collaboration with I. Furno, Los Alamos National Laboratory; D. Ryutov, Lawrence Livermore National Laboratory; L. Dorf, T. Nussinov, A. Light, and G. Lapenta, Los Alamos National Laboratory; and S. Abbate, Torino Politecnico.

*LANL Laboratory Directed Research and Development 20060394ER.

15:55
L16 3 Laboratory experiments on nonlinear Electron MHD phenomena.*
REINER STENZEL, *UCLA*

In a large laboratory plasma highly nonlinear magnetic field-plasma interactions are studied in the regime of Electron MHD (EMHD). A pulsed magnetic field is applied with a loop antenna and the resultant field is measured with magnetic probes. Topologies of field-reversed configurations (FRC), spheromaks or strong mirrors are generated. These fields propagate as highly nonlinear whistler modes through the stationary ion background. Whistler spheromaks propagate along the ambient magnetic field at a speed which decreases with amplitude. The field tilts (precesses) with increasing amplitude. The field at the leading front steepens to a few c/ω_{pe}, i.e. forms a itwhistler shock. The electrons in the (predominantly) toroidal current ring are heated and produce visible light. The source of heating is not significantly modified by heat conduction and radiation losses. The collision of two counter-propagating whistler spheromaks leads to a itwhistler FRC with net zero helicity. Whistler mirrors are produced when the wave field adds to the ambient field. These structures propagate faster than spheromaks and linear whistlers. The toroidal current is predominantly an electron Hall current which produces no electron heating. Collisions between opposing whistler mirrors produces no significant electron heating by Fermi acceleration. Field topologies lacking axial symmetry, as in strong whistler turbulence, may be characterized by a mixture of magnetic energy convection and dissipation.

*In collaboraton with Manuel Urrutia and Kyle Strohmaier, UCLA.

16:15
L16 4 High velocity plasma jets and 3D magnetic structure in the Swarthmore reconnection experiment.*
MICHAEL BROWN, *Swarthmore College*

Several new experimental results are reported from plasma merging studies at the Swarthmore Spheromak Experiment (SSX) with relevance to three dimensional magnetic reconnection in laboratory and space plasmas. First, recent high-resolution velocity measurements of impurity ions using ion Doppler spectroscopy (IDS) show bi- directional outflow jets at $40km/s$ (nearly the Alfvén speed). Second, ion heating to nearly 10^6K is observed after reconnection events in a low density regime. Third, the out-of-plane magnetic field in a reconnection volume shows a quadrupolar structure at the ion inertial scale (c/ω_{pi}). Time resolved vector magnetic field measurements on a 3D lattice ($\mathbf{B}(\mathbf{r},t)$) enables this measurement. Each of these measurements will be related to and compared with similar observations in a solar or space context.

*Supported by DOE, NSF, and Center for Magnetic Self Organization.

16:35
L16 5 Simulation of astrophysical jets in a laboratory experiment.*
PAUL BELLAN, *Caltech*

Astrophysical jets are routinely simulated in a reproducible, well-diagnosed laboratory experiment. The experimental sequence starts by imposing a vacuum poloidal magnetic field linking a disk electrode to a co-planar annular electrode. Neutral gas (H, Ne, N, or Ar) is then injected via 8 nozzles located on the disk and 8 nozzles on the annulus. A 120 μF capacitor bank power supply charged to 4-7 kV is applied via ignitron switches across the electrodes, breaking down the injected gas to form plasma. The low impedance (< 10 mΩ) of the highly conducting plasma causes the power supply to behave as a current source, rather than a voltage source. The discharging capacitor bank drives a $\sim$ 100 kA poloidal electric current through the plasma; this current initially flows in eight distinct 'spider legs' (see photo in April meeting poster) that span from the disk to the annulus. The spider legs quickly merge via mutual attraction of their currents to form the simulated astrophysical jet. The axial gradient of the toroidal magnetic field energy density provides the force that accelerates the jet. The mass flux boundary condition at the electrodes is tightly coupled to the jet behavior. The jet is 'fueled' by plasma ingested from the nozzles and the accumulation (pile-up) of the ingested plasma collimates the jet because of the associated pile-up of frozen-in toroidal magnetic flux convected with the plasma. The jet undergoes a kink instability when it becomes long enough to satisfy the Kruskal-Shafranov $q = 1$ condition.

*In collaboration with Setthivoine You and Gunsu Yun, Caltech.

16:55
L16 6 The Liquid Sodium Dynamo Experiment, NMTech and LANL.*
STIRLING COLGATE, *Los Alamos National Laboratory*

The liquid sodium $\alpha\omega$ dynamo experiment is designed to demonstrate how magnetic fields are generated in AGN and stars. Naturally occurring large scale astrophysical flows, Keplerian flow and star-disk driven plumes or scale-height buoyant plumes in stars create large scale $\alpha\omega$ dynamos where diffusive transport of magnetic flux by turbulence is much less than the advected magnetic flux, thus constraining turbulent diffusion, a common problem with Dudley James type flow experiments. The constraint on turbulence is the gradient of angular momentum in stable Couette flow in the experiment, the anologue of Keplerian flow or entropy gradient in stars. The experiment consists of two coaxial cylinders, $r_1 = 15$ cm, $r_2 = 30$ cm, $\Omega_1/\Omega_2 = 4$ i.e., limiting stable Couette flow. We expect an ω-gain of the toroidal field of $Rm/2\pi = 20$. The MRI will be tested at a sensitivity of $\Delta B/B \sim 10^{-3}$. The α gain is driven by off-axis, axial plumes as in convection in a rotating frame. Because of the high ω gain, the turbulence generated by the plumes should be fractionally small. The apparatus has been built and tested with hot oil and water in the laboratory and we have measured, in agreement with theory, the low turbulence expected of stable Couette flow at the level of the Ekman flow. In collaboration with Hui Li, Howard Beckley, LANL; David Westpfahl, Rocky Gianni, James Slutz, Zeb Westrom, and Joesph Jordon, NMIMT.

*Supported by DOE, LANL, Univ. Calif., NMIMT.

SESSION M1: APS AWARD PRESENTATIONS, PAST PRESIDENT'S ADDRESS AND LILIENFELD PRIZE TALK
Sunday Evening, 23 April 2006; Landmark A, Hyatt Regency Dallas at 17:15
John Hopfield, APS President, Princeton University, presiding

17:15
M1 1 Award Presentations.

17:45
M1 2 APS Past President's Address: Looking Back on the World Year of Physics 2005.
MARVIN COHEN, *University of California, Berkeley and Lawrence Berkeley National Laboratory*

I had the privilege of being APS President during the celebration of the World Year of Physics 2005. I will describe some of my experiences and discuss some perspectives about APS and about physics.

18:15
M1 3 Lilienfeld Prize Talk: Persistent Challenges of Quantum Chromodynamics.
MIKHAIL SHIFMAN, *University of Minnesota*

Unlike some models whose relevance to Nature is still a big question mark, Quantum Chromodynamics will stay with us forever. Quantum Chromodynamics (QCD), born in 1973, is a very rich theory supposed to describe the widest range of strong interaction phenomena: from nuclear physics to Regge behavior at large E, from color confinement to quark-gluon matter at high densities/temperatures (neutron stars); the vast horizons of the hadronic world: chiral dynamics, glueballs, exotics, light and heavy quarkonia and mixtures thereof, exclusive and inclusive phenomena, interplay between strong forces and weak interactions, etc. Efforts aimed at solving the underlying theory, QCD, continue. In a remarkable entanglement, theoretical constructions of the 1970s and 1990s combine with today's ideas based on holographic description and strong-weak coupling duality, to provide new insights and a deeper understanding.

SESSION O1: PLENARY SESSION II
Monday Morning, 24 April 2006; Landmark A, Hyatt Regency Dallas at 8:30
William Carithers, Lawrence Berkeley National Laboratory, presiding

8:30
O1 1 Highlights of Neutrinos in Cosmology.
NICOLE BELL, *CalTech*

Neutrinos play unique roles in many epochs of the Universe's evolution. Important information can be gleaned from neutrino evolution during the big bang nucleosynthesis era, while at later times neutrinos have a significant impact on the cosmic microwave background and large scale structure power spectra. For example, cosmological data now place the tightest constraints on neutrino mass, though there is scope to evade these limits if the physics of the neutrino sector is non-standard. We outline the wealth of information that can be revealed by studying the sea of relic neutrinos.

9:06
O1 2 Plasma Turbulence in Astrophysics and in the Laboratory.*
WILLIAM DORLAND, *Department of Physics, University of Maryland*

Turbulence plays a critical role in plasma systems ranging from laboratory fusion experiments to astrophysics. In nearly collisionless systems, modeling this turbulence is challenging because of the kinetic nature of the dominant dissipation processes and because of the strong nonlinear interactions that control the dynamics. On the other hand, the range of spatio-temporal scales that must be simultaneously resolved is not as large as in neutral fluid turbulence. A new class of ''gyrokinetic'' codes developed for fusion are facilitating the exploration of plasma turbulence across a broad range of problems. In fusion applications, fluctuations driven by local pressure gradients cause energy and momentum to leak from the magnetic containers shielding hot plasma from the cold surrounding surfaces. A major surprise from the models is that transport may be dominated by self-generated, small-scale streams that convect the high temperature extended distances across the confining magnetic field. Experiments are now being carried out to search for these streams. In astrophysics an important issue is how large-scale turbulent energy is absorbed as it cascades to small spatial scales. Whether the energy is dumped into electrons or ions in accretion flows and other applications impacts both the dynamics of the system and our ability to interpret observations through measurement of radiation from distant sites throughout the universe. Results from the first self-consistent calculations of the collisionless absorption of turbulent energy cascades for astrophysical applications will be presented.

*This work supported in part by the Center for Multiscale Plasma Dynamics.

9:42
O1 3 Bringing Hearing to the Deaf–Cochlear Implants: a Technical and Personal Account.
IAN SHIPSEY, *Purdue University*

Cochlear implants are the first device to successfully restore neural function. They have instigated a popular but controversial revolution in the treatment of deafness, and they serve as a model for research in neuroscience and biomedical engineering. In this talk the physiology of natural hearing will be reviewed from the perspective of a physicist, and the function of cochlear implants will be described in the context of historical treatments, electrical engineering, psychophysics, clinical evaluation of efficacy and personal experience. The social implications of cochlear implantation and the future outlook for auditory prostheses will also be discussed.

SESSION P1: DPF AND DPB PRIZE SESSION
Monday Morning, 24 April 2006; Landmark A, Hyatt Regency Dallas at 10:45
Gerald Dugan, Cornell University, presiding

10:45
P1 1 Theories beyond the standard model, one year before the LHC.*
SAVAS DIMOPOULOS, *Stanford University*

Next year the Large Hadron Collider at CERN will begin what may well be a new golden era of particle physics. I will discuss three theories that will be tested at the LHC. I will begin with the supersymmetric standard model, proposed with Howard Georgi in 1981. This theory made a precise quantitative prediction, the unification of couplings, that has been

experimentally confirmed in 1991 by experiments at CERN and SLAC. This established it as the leading theory for physics beyond the standard model. Its main prediction, the existence of supersymmetric particles, will be tested at the large hadron collider. I will next overview theories with large new dimensions, proposed with Nima Arkani-Hamed and Gia Dvali in 1998. This links the weakness of gravity to the presence of sub-millimeter size dimensions, that are presently searched for in experiments looking for deviations from Newton's law at short distances. In this framework quantum gravity, string theory, and black holes may be experimentally investigated at the large hadron collider. I will end with the recent proposal of split supersymmetry with Nima Arkani-Hamed. This theory is motivated by the possible existence of an enormous number of ground states in the fundamental theory, as suggested by the cosmological constant problem and recent developments in string theory and cosmology. It can be tested at the large hadron collider and, if confirmed, it will lend support to the idea that our universe and its laws are not unique and that there is an enormous variety of universes each with its own distinct physical laws.

*The works cited for the Sakurai Prize were supported by the National Science Foundation.

11:31
P1 2 Photonic Band Gap accelerator demonstration at Ku-band.
EVGENYA SMIRNOVA, *Los Alamos National Laboratory*

We report the design, fabrication and high power testing of a high gradient electron accelerator with a photonic band gap (PBG) structure. The photonic band gap structure confines a fundamental TM_{01}-like accelerating mode, but does not support higher order modes (HOM). The absence of HOM is a major advantage of the PBG accelerator, since it suppresses dangerous beam instabilities caused by wakefields. The PBG structure was designed as a triangular lattice of metal rods with a missing central rod forming a defect confining the TM_{01}-like mode and also allowing the electron beam to propagate along the axis. The design frequency of the six-cell structure was 17.14 GHz, to match an available klystron and linac. The absence of HOM was confirmed in cold test. The PBG structure was excited by 2 MW, 100 ns pulses from the klystron. A 16.5 MeV electron beam was transmitted through the PBG accelerator. The observed electron beam energy gain of 1.4 MeV, measured using a magnetic spectrometer, corresponds to an accelerating gradient of 35 MeV/m, in excellent agreement with theory. PBG accelerators are a promising approach to future high gradient accelerators.

12:02
P1 3 Search for high energy axions with the CAST calorimeter.
DAVID MILLER,* *University of Chicago*

The observed CP conservation, in the strong interactions is an unexpected and unresolved feature of the theory of QCD. The introduction of a new $U(1)$ symmetry can resolve this so-called ''strong-CP problem.'' This symmetry, however, leads to a new boson, the axion, which is predicted to couple to photons and nucleons and may be produced in the nuclear and plasma processes of stars. The CERN axion solar telescope (CAST) experiment is designed to detect such solar axions by converting them into real photons in a magnetic field. We focus on the CAST γ-ray calorimeter which extends the sensitivity of the CAST experiment into the MeV region by searching for an excess signal during solar alignment due to high energy axions emitted in nuclear processes in the sun. The large increase in ''axion luminosity'' provided by the sun and the increased axion-to-photon conversion probability in the refurbished LHC magnet make the CAST experiment uniquely sensistive to an axion signal. In the case of zero signal above background, background subtraction from the solar alignment ''tracking'' data allows a direct search for anomalous excess events. Using existing helioseismology limits on the axion flux from the sun, the mass and photon-coupling of an axion or new axion-like boson are constrained using limits on the observed flux of axions in the detector. In this way, limits are obtained without requiring detailed knowledge of nuclear mixing matrices for each production mechanism and the CAST helioscope search can be extended beyond specific nuclear transitions and can consider nuclear axion emission from the sun more generally. For a 5.5 MeV axion-photon conversion spectrum, which is a highly motivated channel, the limit on the axion-to-photon coupling obtained is $g_{a\gamma\gamma} \leq 2 \times 10^{-9}$ GeV^{-1} for $0.1 \leq m_a \leq 0.9$ eV, which is are slightly more restrictive than both the current experimental limits as well as those from helioseismology.

*LeRoy Apker Award.

SESSION P2: NEUTRINOS II
Monday Morning, 24 April 2006; Landmark B, Hyatt Regency Dallas at 10:45
Rabi Mohapatra, University of Maryland, presiding

10:45
P2 1 Next generation of neutrino-less double beta decay experiments and their reach.
PETR VOGEL, *California Institute of Technology*

Study of the neutrino-less double beta decay is a sensitive, and likely the only practical, tool of testing whether the total lepton number is conserved or not, and consequently whether neutrinos are Majorana fermions as many particle physics models suggest. Moreover, if the neutrino-less decay is ever observed, and if one can convincingly show that the virtual

exchange of light Majorana neutrinos is responsible, a unique information on the absolute neutrino mass could be deduced from the experimentally determined decay rate. In the talk I will briefly review the present status of the existing experiments and describe the next generation of proposals with ~ 100 kg sources that should reach sensitivity to ~ 0.1 eV effective neutrino mass and explore the so-called ''degenerate'' mass region as well as test the existing claim of observation of the decay. This neutrino mass range can and will be explored also by observational cosmology and/or tritium beta decay, probes that are independent on the charge conjugation properties of the neutrinos. I will also review the status of the determination of the corresponding nuclear matrix elements and their uncertainties which are an important part of the problem, needed for interpreting and planning of the experiments. In longer run, experiments with ~ ton size sources are envisioned that will extend the sensitivity to the effective masses to the range of 10-20 meV, and thus explore the ''inverted hierarchy'' neutrino mass region. Several of the ~ 100 kg proposed experiments could be enlarged to this size, provided that the projected background suppression can be achieved. Thus, within the next decade or so, there is a realistic chance that a substantial part of the allowed neutrino mass range will be explored.

11:21
P2 2 Recent Results from the MINOS Experiment.*
HUGH GALLAGHER, *Tufts University*

MINOS is a long baseline neutrino oscillation experiment using a neutrino beam from the Fermilab Neutrinos at the Main Injector (NuMI) facility. It is a two detector experiment with a 980 ton Near Detector at Fermilab and a 5400 ton Far Detector at a distance of 735 km in the Soudan mine in northern Minnesota. MINOS is a precision experiment to measure the oscillation parameters associated with the atmospheric neutrino mass splitting previously explored by the SuperKamiokande and K2K experiments. The experiment will also extend the existing limits on sub-dominant muon to electron neutrino oscillations and make the first neutrino/ anti-neutrino separated measurements of atmospheric neutrino oscillations. MINOS began data taking in the NuMI beam in March 2005 and has recorded data from over 1e20 protons on target. The performance of the MINOS detectors and the NuMI beam during the first year of operations will be described, and preliminary results from beam neutrinos in the Near and Far detectors are presented. This is the largest sample of neutrino interactions collected in a long baseline detector to date.

*For the MINOS Experiment. This work was supported by the U.S. Department of Energy, the U.K. Particle Physics and Astronomy Research Council, the U.S. National Science Foundation, and the State and University of Minnesota.

11:57
P2 3 KamLAND.
BRUCE BERGER, *Lawrence Berkeley National Laboratory*

KamLAND is a one-kiloton liquid-scintillator detector sensitive to antineutrinos through inverse beta decay. The experiment, located underground in the mountains of central Japan, was designed to look for the disappearance of antineutrinos produced in nuclear power reactors at a typical baseline of 180 km. The KamLAND collaboration made the first observation of the disappearance of reactor antineutrinos, and subsequently observed distortions of the antineutrino energy spectrum consistent with neutrino oscillation. We have made precise measurements of the neutrino oscillation parameters based on the rate and energy spectrum of observed antineutrinos. KamLAND has also studied other physics topics, most notably geologically-produced antineutrinos. The collaboration is planning a detector upgrade to dramatically reduce low-energy backgrounds through purification of the liquid scintillator. This upgrade will allow sensitivity to solar neutrinos through elastic scattering interactions down to energy deposits below 300 MeV, in particular ^{7}Be neutrinos. These measurements will test the MSW (Mikheev-Smirnov-Wolfenstein) explanation of solar neutrino flavor change, and they will both test and constrain the solar standard model. I will summarize KamLAND physics results to date and discuss the prospects for future measurements.

SESSION P3: INNOVATIVE PROGRAMS IN K-12 TEACHER PREPARATION
Monday Morning, 24 April 2006; Landmark C, Hyatt Regency Dallas at 10:45
Ramon Lopez, Florida Institute of Technology, presiding

10:45
P3 1 The Team Model of PhysTEC at Ball State University.*
DAVID GROSNICK, *Ball State University*

The Physics Teacher Education Coalition, sponsored jointly by the APS, AAPT, and AIP, is a national program designed to enhance the quality and quantity of science teachers. Components of this program have contributed to the successful

recruitment of pre-service teachers at Ball State University and the retention of in-service teachers across the state of Indiana. Some of these components are: a mentoring program, a system of decision points along science education students' career paths, active participation by teachers-in-residence, course reform, and curriculum development. These programs, along with results and successes, will be discussed.

*Work sponsored by PhysTEC and supported by grants from the National Science Foundation and FIPSE.

11:21
P3 2 Preparing Physics and Chemistry Teachers at the University of Arizona.
INGRID NOVODVORSKY, *Univ. of Arizona*

Beginning in 2000, science majors at the University of Arizona who wish to teach in middle or high schools have enrolled in the College of Science Teacher Preparation Program (CoS TPP). Students in the program take General Education courses, content courses, and science pedagogy courses that make them eligible for teacher certification. Students can remain in their science degree programs, and take the required science pedagogy courses, or they can enroll in a BS in Science Education degree that includes the pedagogy courses, with concentrations available in Biology, Chemistry, Earth Science, and Physics. Science educators from six different departments, two permanent Adjunct Instructors, and two Teachers in Residence teach the program's courses. (One of the Teachers in Residence is supported by the PhysTEC project.) Most of the pedagogy courses include field experiences in area science classrooms; the program works with some 115 mentor teachers from throughout the Tucson area, who host preservice teachers in their field experiences. In the first six years of the program, 14 program graduates have been chemistry and physics teachers. This compares to a total of six chemistry and physics teachers produced by the College of Education program in the four years preceding the creation of the CoS TPP. In this presentation, I will describe the unique features of the courses that prospective chemistry and physics teachers take and the field experiences in which they participate. In addition, I will describe how PhysTEC-supplied resources have been used to improve the program, and the ways in which we are assessing the program's success.

11:57
P3 3 The Learning Assistant Model for Science Teacher Recruitment and Preparation.*
VALERIE OTERO, *University of Colorado at Boulder*

There is a shortage of high quality physical science teachers in the United States. In 2001, less than 50% of teachers who taught physics held a major or minor in physics or physics education (Neuschatz & McFarling, 2003). Studies point to itcontent knowledge as one of the two factors that is positively correlated with teacher quality. However, those directly responsible for the science content preparation of teachers, specifically science research faculty, are rarely involved in focused efforts to improve teacher quality or to create alternative paths for becoming a teacher. What role should science research faculty play in the recruitment and preparation of science teachers? How might teacher recruitment and preparation be conceived so that science research faculty members' participation in these efforts is not at odds with the traditional scientific research foci of science research departments? To address this issue, we have coupled our teacher recruitment and preparation efforts with our efforts for transforming our large-enrollment, undergraduate science courses. This is achieved through the itundergraduate Learning Assistant (LA) program, where talented mathematics and science majors are hired to assist in transforming large enrollment courses to student-centered, collaborative environments. These LAs are the target of our teacher recruitment efforts. Science research faculty, in collaboration with faculty from the school of education have established a community that supports LAs in making decisions to explore K12 teaching as a career option. Fifteen percent of the LAs who have participated in this program have entered teaching credential programs and now plan to become K12 teachers. An added effect of this program is that research faculty have developed skills and knowledge regarding inquiry-based and student-centered pedagogy and theories of student learning. The Learning Assistant program has led to increased subject matter knowledge among learning assistants, increased interest in K-12 teaching as a career, and increased appreciation and understanding of student-centered and inquiry-based learning. Data to support these claims will be presented. Neuschatz, M. & McFarling, M. (2003). Broadning the Base: High School Physics Education at the Turn of a New Century, AIP Report No. R-439.

*This work was partially supported by an NSF grant DUE-0302134.

SESSION P4: GRAVITATIONAL WAVE SOURCES AND PHENOMENOLOGY
Monday Morning, 24 April 2006; Marsalis A, Hyatt Regency Dallas at 10:45
Gabriela Gonzalez, Louisianna State University, presiding

10:45
P4 1
CURT CUTLER, *Jet Propulsion Laboratory*

This abstract was not received electronically.

11:21
P4 2 Source-modeling, detection and science of gravitational waves from compact binaries.
ALESSANDRA BUONANNO, *University of Maryland*

Compact binaries made of black holes and/or neutron stars are the most promising sources for laser-interferometer gravitational-wave detectors on the earth. In this talk I will review the analytical approximation schemes and the template families developed to catch the tiny waves buried in the detector noise and extract astrophysical information from them.

11:57
P4 3 Gravitational Radiation from Intermediate-Mass Black Holes.
COLE MILLER, *University of Maryland*

Stellar-mass black holes (up to approximately 20 solar masses) and supermassive black holes (millions to billions of solar masses) have been well-established for many years. More recently, X-ray observations have strongly suggested the existence of intermediate-mass black holes (IMBHs) in the hundreds to thousands of solar masses. Candidate IMBHs are often associated with dense young stellar clusters, and may represent the present-day counterparts to the earliest stellar black holes at redshifts up to roughly 20. Gravitational waves from mergers of IMBHs with themselves or with supermassive black holes would be visible to these high redshifts, and could carry unique information about star formation and the hierarchical assembly of structure as well as producing high-signal extreme mass ratio inspiral events that test strong-gravity predictions of general relativity. We will discuss the astrophysical context of gravitational radiation from IMBHs and the prospects for detection with future ground-based and space-based instruments.

SESSION P6: THE POSTDOCTORAL EXPERIENCE
Monday Morning, 24 April 2006; Cumberland J, Hyatt Regency Dallas at 10:45
Minesh Bacrania, APS FGSA Chair, presiding

10:45
P6 1 What is a Post-Doc?*
A. BAHA BALANTEKIN, *University of Wisconsin-Madison*

It is commonplace for physics Ph.D.'s spend a number of years at universities, government laboratories, and research institutes as postdoctoral associates before they assume permanent positions. In this talk the expectations and the responsibilities of this career stage will be explored from both the young scientists' and employer's perspectives.

*Supported in part by the National Science Foundation.

11:05
P6 2 Experiences from a Varied Career in Physics.
KATHERINE FRAME, *Los Alamos National Laboratory*

I received my doctorate in Experimental High Energy Physics from Michigan State Univeristy. My thesis was based on my work with QCD jet physics at the D0 collider experiment at Fermi National Laboratory. My first postdoctoral position was with Oxford University working on solar neutrino oscillations at the Sudbury Neutrino Observatory (SNO). Following this, I joined what is now the Nuclear Nonproliferation Safeguards, Science and Technology group (N-1) at Los Alamos National Laboratory. Over this time, I've worked on a wide range of physics topics in a wide range of physical and social environments. I would like to share some of the experiences I've had working in such varied environment and the thoughts that have guided me on my path that eventually led me from basic research to a more applied field.

11:25
P6 3 Postdoctoral Opportunities in Medical Physics.
KENNETH HOGSTROM, *Department of Physics and Astronomy, Louisiana State University*

The medical physicist is a professional who specializes in the application of the concepts and methods of physics to the diagnosis and treatment of human disease. Medical physicists identify their primary discipline to be radiation therapy (78%), medical imaging (16%), nuclear medicine (3%), or radiation safety (2%). They state their primary responsibility to be clinical (78%), academic (9%), research (4%), etc. Correspondingly, medical physicists reveal their primarily employment to be a private hospital (42%), university hospital (32%), physicist's service group (9%), physician's service group (9%), industry (5%), and government (3%). The most frequent job of medical physicists is clinical radiation therapy physicist, whose clinical duties include: equipment acquisition, facility design, commissioning, machine main-

tenance, calibration and quality assurance, patient treatment planning, patient dose calculation, management of patient procedures, development of new technology, radiation safety, and regulatory compliance. The number of medical physicists in the United States can be estimated by the number of members of the American Association of Physicists in Medicine (AAPM), which has increased $\approx$ 5.5% annually since 1969, currently being $\approx$ 5,000. New positions plus retirements create a current need $>$ 300 new medical physicists per year, which exceeds supply. This is supported by the steady growth in average salaries, being $\approx$ \$100,000 for PhDs entering the field and reaching $\approx$ \$180,000. Graduate programs alone cannot meet demand, and physicists entering the field through postdoctoral training in medical physics remain important. Details of postdoctoral research programs and medical physics residency programs will provide direction to physics PhD graduates interested in medical physics. [The AAPM, its annual Professional Information Report, and its Public Education Committee are acknowledged for information contributing to this presentation.]

11:45
P6 4 An Overseas Postdoctoral Experience: or There and Back Again.
GLENN HORTON-SMITH, *Kansas State University*

It is possible for a U.S. citizen to gain a PhD in Hobbit-like fashion, never adventuring outside his or her home state, let alone outside the country. This is the story of one such Hobbitish PhD who found himself with the opportunity to have his first postdoctoral experience in north-east Japan, took it, and what happened after. The tale will include the following: my postdoc hunting experience and decision making process as a grad student (such as it was); my experience overseas; my experience finding a faculty position; and whatever lessons I can draw from this for graduate students preparing for the postdoc search today.

12:05
P6 5 Question and Answer Session.

The audience is invited to participate in an open discussion with the speakers on the topics covered in this series of talks.

SESSION P7: COSMIC RAYS AND SOLAR PHYSICS I
Monday Morning, 24 April 2006
Pegasus A, Hyatt Regency Dallas at 10:45

10:45
P7 1 Searching for high energy cosmic ray electrons using the Earth's magnetic field. S. NUTTER, *Northern Kentucky University* C. BOWER, *Indiana University* S. COUTU, *Pennsylvania State University* M. DUVERNOIS, *University of Minnesota* A. MARTELL, D. MULLER, *University of Chicago* J. MUSSER, *Indiana University* M. SCHUBNELL, G. TARLE, A. YAGI, *University of Michigan* The Cosmic Ray Electron Synchrotron Telescope (CREST) instrument is a balloon payload designed to measure the flux of primary cosmic ray electrons at energies greater than 2 TeV. Because electrons at these energies lose energy rapidly during propagation through the interstellar medium, their detection would indicate the existence of sources which are within a few kiloparsecs. In order to obtain the needed large exposure time and aperture of the detector, we use an approach that depends on the detection of synchrotron photons emitted when the electrons travel through the earth's magnetic field. Such photons have energies in the x-ray and gamma-ray region, hence CREST incorporates an array of inorganic scintillators. Since the primary electrons do not need to pass through the detector, the effective detection area is much larger than the actual detector array size. To verify the technique and to determine background count rates, a prototype array of BGO and BaF2 crystals was flown on high altitude balloon from Ft. Sumner, N.M. in autumn 2005. The full detector system is currently under construction. It will consist of a 1600 crystal array, and will be carried on Long-Duration Balloons on circumpolar trajectory.

10:57
P7 2 Measurement of the Relative Abundances of the Ultra-Heavy Galactic Cosmic-Rays ($30 \leq Z \leq 40$) at the Top of the Atmosphere with TIGER B.F. RAUCH, W.R. BINNS, M.H. ISRAEL, J.T. LINK, L.M. SCOTT, *Washington University, St. Louis, MO 63130, USA* L.M. BARBIER, J.R. CUMMINGS, G.A. DE NOLFO, J.W. MITCHELL, R.E. STREITMATTER, *NASA/ Goddard Space Flight Center, Greenbelt, MD 20771, USA* S. GEIER, R.A. MEWALDT, S.M. SCHINDLER, E.C. STONE, *California Institute of Technology, Pasadena, CA 91125, USA* C.J. WADDINGTON, *University of Minnesota, Minneapolis, MN 55455, USA* Observations of Ultra-Heavy (UH) galactic cosmic rays (GCR) help to distinguish the possible origins of GCRs. The Trans-Iron Galactic Element Recorder (TIGER) is designed to measure the charge (Z) and energy of GCRs using a combination of four scintillation counters, two Cherenkov counters, and a scintillating fiber hodoscope. TIGER has accumulated data on two successful flights from McMurdo, Antarctica: the first launched in December of 2001 with a total flight duration of 31.8 days and the second in December of 2003 with a total flight duration of 18 days. The two flights of TIGER achieved sufficient statistics and charge resolution to resolve $\sim$ 140 particles with $Z > 30$, and have provided the best measurements to date for $_{30}$Zn, $_{31}$Ga, $_{32}$Ge, and $_{34}$Se. We present the relative abundances of the UH-GCRs as measured by TIGER and as propagated to the top of the atmosphere. These abundances are compared with GCR source models.

11:09
P7 3 Co/Ni Ratio in Galactic Cosmic Rays: Results from the TIGER-2001 Flight G.A. DE NOLFO, L.M. BARBIER, J.R. CUMMINGS, J.W. MITCHELL, R.E. STREITMATTER, *NASA/ GSFC, Greenbelt MD 20771* W.R. BINNS, M.H. ISRAEL, J.T.

LINK, B.F. RAUCH, L.M. SCOTT, *Washington U., St. Louis MO* S. GEIER, R.A. MEWALDT, S.M. SCHINDLER, E.C. STONE, *Caltech, Pasadena CA* C.J. WADDINGTON, *U. of Minnesota, Minneapolis MN* M.E. WIEDENBECK, *Jet Propulsion Lab, Pasadena CA* The Trans-Iron Galactic Element Recorder (TIGER) has completed two successful Antarctic flights in December/ January of 2001 and 2003. TIGER was designed to observe elements in galactic cosmic rays (GCR) ranging from $14 \leq Z \leq 40$ over an extended energy range. Observations of the isotopes of Co and Ni at low energies, in particular, the observation of ^{59}Ni and ^{59}Co from the Cosmic Ray Isotope Spectrometer on Advanced Composition Explorer, indicate that a significant time delay ($> 7.6\times10^4$ yr) exists between nucleosynthesis and acceleration of GCRs. While TIGER is not able to resolve isotopes, observations of the elemental abundance of Co and Ni at energies higher than CRIS/ACE further constrain models for GCR acceleration and propagation. With a 2001 flight of nearly 32 days, TIGER collected sufficient statistics to study the Co/Ni elemental ratio over a wide range in energy from $\sim$ 0.8–5 GeV/nucleon. We present the Co/Ni ratio observed from TIGER's first successful Antarctic flight in 2001 and compare these results with previous observations and with the predictions from GCR propagation models.

11:21

P7 4 The High Resolution Fly's Eye Detector and Measurement of the UHECR Spectrum WILLIAM HANLON, *University of Utah* THE HIGH RESOLUTION FLY'S EYE (HIRES) COLLABORATION, The High Resolution Fly's Eye detector is an atmospheric fluorescence detector that has been searching for ultra high energy cosmic rays since 1997. It was designed to observe cosmic rays with energies above 3×10^{18} eV in stereo. A brief description of the detector and techniques used to observe these elusive particles will be presented. Recent stereoscopic spectrum results will also discussed.

11:33

P7 5 Search for Cross-Correlations of Ultra–High-Energy Cosmic Rays CHAD FINLEY, STEFAN WESTERHOFF, *Physics Dept. Columbia University* HIRES COLLABORATION, The High Resolution Fly's Eye (HiRes) experiment is a stereo air fluorescence detector for the study of cosmic rays with energies above 5×10^{17} eV. Arrival directions of cosmic rays observed in stereo can be resolved with a typical uncertainty on the order of 0.5°, making the experiment ideal for small-scale anisotropy studies. We will review recent claims of evidence for correlations between ultrahigh-energy cosmic rays and active galaxies of the BL Lac subclass, and we will describe tests of these claims with new data.

11:45

P7 6 New methods to search for Cross-Correlations between UHECR data and BL Lac sources. RASHA ABBASI, HIGH RESOLUTION FLY'S EYE (HIRES) COLLABORATION, The arrival direction study of Ultra High Energy Cosmic Rays gives us potentially an insight on their origin. The High Resolution Fly's Eye (HiRes) is a stereo air fluorescence experiment that detects cosmic rays with energies greater than $\sim 10^{18}$ eV. The angular resolution of HiRes is approximately 0.6^o. This small uncertainty is well suited for small-scale anisotropy studies. Here we present the correlation of the observed cosmic rays by HiRes with some astronomical sources, in particular with BL Lac sources, which are a subclass of active galaxies.

11:57

P7 7 On Measuring the Ultra High Energy Cosmic Ray Spectrum above 3×10^{18} eV by Pierre Auger Observatory* JOONG LEE, *University of California at Los Angeles* PIERRE AUGER COLLABORATION, We report the Ultra High Energy Cosmic Ray (UHECR) spectrum above 3×10^{18} eV measured by Pierre Auger Observatory (PAO). PAO uses both the Fluorescence detector (FD) and the water cerenkov tank surface detectors (SD). PAO offers an exciting opportunity to compare the systematics of and cross-calibrate FD and SD for the first time.

*Supported by grant from the U.S. Department of Energy (DOE).

12:09

P7 8 Observation of the GZK Cutoff DOUGLAS BERGMAN, *Rutgers University* HIRES COLLABORATION, The GZK Cutoff is the predicted end of the cosmic ray spectrum at an energy of about 6×10^{19} eV, and is due to interactions between the cosmic rays and the microwave background. The cutoff was predicted soon after the discovery of the Cosmic Microwave Background, and has been called the Holy Grail of Ultrahigh Energy Cosmic Ray physics. We use evidence from fits to the published HiRes Monocular differential spectra and from the $E_{1/2}$ criterion, the energy at which the measured integral spectrum is half the expected integral spectrum with no cutoff, to argue that HiRes has observed this cutoff.

12:21

P7 9 MARIACHI - Detecting Ultra High Energy Cosmic Rays with radar* HELIO TAKAI, *Brookhaven National Laboratory* Ultra High Energy Cosmic Rays with energies in excess of 10^{20}eV (100 EeV) have been detected by several experiments. They present a conundrum whose solution may provide insight into the origins and evolution of the universe. There are no known sources within our galaxy or those close to us that could accelerate particles to these almost macroscopic energies, and yet the turn-on of pion production through the interactions of high energy charged particles with the 2.7K microwave background provides a strong limit for propagation from greater distances. The detection of UHECR to date has been accomplished either by detection of the particles from the extensive air showers by ground arrays or by means of detection of the light produced by the EAS in the atmosphere from Cerenkov radiation. MARIACHI (Mixed Apparatus for Radar Investigation of Cosmic-rays of High Ionization) is an innovative concept that will explore the detection of UHECR by bi-static radar using VHF transmitters. If successful, the MARIACHI technique will allow for detection of UHECR economically over much larger areas than currently possible, and might provide for detection of the associated ultra high energy neutrino flux. MARIACHI is also innovative in that ground array detectors that will initially confirm the radio signals are scintillator arrays to be built and operated by high school students and teachers. We will present the present status of the experiment.

*This work is supported in part by a NSF-CISE and EPP grant.

SESSION P8: MINISYMPOSIUM: PARTON DISTRIBUTIONS AT LARGER X: DATA AND CHALLENGES
Monday Morning, 24 April 2006; Cumberland A, Hyatt Regency Dallas at 10:45
Cynthia Keppel, Hampton University/Jefferson Lab, presiding

Invited Papers

10:45
P8 1 The CTEQ Global Fitting Project and the Impact of PDF's at Large-x.*
JOSEPH OWENS, *Florida State University*

The status of CTEQ global fitting activities is reviewed with a special emphasis on the large-x region. The impact of new data sets included in the fits will be discussed along with the importance of reducing the errors on the distribution functions at large values of x. Specific topics include nuclear corrections, next-to-next-to leading order evolution, and recent applications of resummation techniques.

*Work supported in part by the U.S. Department of Energy.

Contributed Papers

11:21
P8 2 QCD results from NuTeV and some remarks on target mass corrections VOICA RADESCU,* *University of Pittsburgh* NUTEV COLLABORATION, NuTeV is a precision Neutrino-Nucleon DIS experiment that took place at Fermilab in the 1996-97 fixed target run. Its unique design allowed us to obtain high statistics samples of separate ν and $\bar{\nu}$ beams. The kinematic range in x goes from $0.01 > x > 0.8$ with an average $Q^2 \sim 20GeV^2$. We report here a new determination of α_S from scaling violations of the structure functions F_2 and xF_3 using NLO QCD models. The fit requires a correction for the target mass effect. This correction proved to create some confusion and we will also discuss this.

*For NuTeV collaboration.

11:33
P8 3 Neutron Structure Functions at Large x: Status of the BONUS Experiment IOANA NICULESCU, *James Madison University* BONUS COLLABORATION, While an impressive amount of high quality nucleon structure function data exists, there nonetheless remain unmeasured areas. Most notably, the lack of a neutron target has made direct comparisons between proton and neutron structure functions nearly impossible both in the resonance region and at large x. The ''Barely off Shell Nucleon Structure (BONUS) Collaboration'' has constructed a novel radial time projection chamber (RTPC) that uses a gas electron multiplier readout to detect slow, backward- going spectator protons resulting from electron-deuteron interactions. Spectator protons in the RTPC are detected in coincidence with electrons in the CEBAF Large Acceptance Spectrometer (CLAS) in Hall B at Jefferson Lab, thereby ensuring an inclusive electron-neutron scattering event. Two months of data (roughly 900 million triggers) were collected in late 2005 at beam energies from 1.1 to 5.3 GeV. Preliminary neutron elastic and resonance results will be discussed, focusing on the performance of the RTPC in CLAS.

11:45
P8 4 Probing the Large-x Structure of the Proton with Drell-Yan Scattering at Fermilab PAUL E REIMER, *Physics Division, Argonne National Laboratory* FNAL E866/NUSEA COLLABORATION, FNAL E906 COLLABORATION, The Drell-Yan reaction can be used to probe the parton distribution of the interaction hadrons. In a fixed target environment, where the detector acceptance selects only large-x_F events, Drell-Yan probes the high-x (Bjorken-x) valence distributions of the beam and the low- to intermediate-x sea antiquark distributions of the target. Fermilab E866/NuSea has measured the Drell-Yan absolute cross section of 800 GeV/c protons on hydrogen and deuterium targets. These data are the first measurements of the Drell-Yan cross section in pp collisions over a broad kinematic region and the most extensive study to date of the Drell-Yan cross section in pd collisions. The absolute cross sections, with full radiative corrections, will be presented and comparisons made with with next-to-leading order calculations based on modern parton distributions. The results show that recent global parton distribution fits provide a good description of the light antiquark sea in the nucleon over the range $0.03 < x_{target} < 0.15$. When projected against x_{beam} the data indicate that most modern parton distributions appear to overestimate the valence parton distributions at large-x. We plan to extend these studies in Fermilab E906, which will use a 120 GeV/c proton beam from the Fermilab Main Injector to collect better statistics at even larger values of x_{beam}.

11:57
P8 5 Measurements of Hydrogen and Deuterium Inclusive Resonance Cross Sections at Intermediate Q^2 for Parton-Hadron Duality Studies SIMONA MALACE, *Hampton University* JEFFERSON LAB HALL C E00-116 COLLABORATION, Results from the Jefferson Lab E00-116 experiment that ran in Summer of 2003 will be presented. The experiment extended to higher Q^2 the precision measurements of inclusive nucleon resonance electroproduction cross sections from hydrogen and deuterium targets. The data cover a kinematic range of (3.9 – 7.2) GeV^2 in Q^2 and (0.5 – 0.9) in x, and will be used in conjunction with the elastic and inelastic data for precision experimental tests of parton-hadron (Bloom-Gilman) duality in the structure functions. E00-116 data that access the high x region will also be used

to constrain higher moments of the structure functions and to extract matrix elements of higher-twist operators. This data will also provide a constraint for the F_2^d/F_2^p ratio and therefore possibly be of utility in reducing the uncertainties on pdf curves at high x.

12:09
P8 6 Monitoring the Transition from Perturbative to Non-perturbative QCD through Parton-Hadron Duality* SIMONETTA LIUTI, *University of Virginia* Parton-hadron duality, or the similarity between hadronic cross sections in the deep inelastic region and in the resonance region, encompasses a range of phenomena where one expects to observe a trasmogrification from partonic to hadronic degrees of freedom. A fully satisfactory theoretical description of this phenomenon, that became to be accepted as a ''natural'' feature of hadronic interactions, is still nowadays very difficult to obtain. In this contribution, by conducting an analysis of the most recent polarized and unpolarized inclusive electron scattering data, we present evidence that standard perturbative QCD approaches might not be adequate in order to describe parton-hadron duality. In particular, we unravel a discrepancy in the behavior of the extracted power corrections in the DIS and resonance regions, respectively.

*Department of Energy grant no. DE-FG02-01ER41200

SESSION P9: MINISYMPOSIUM: ADVANCES IN ZERO- AND FINITE-TEMPERATURE LATTICE QCD
Monday Morning, 24 April 2006; Cumberland B, Hyatt Regency Dallas at 10:45
Ron Soltz, Lawrence Livermore National Laboratory, presiding

Invited Papers

10:45
P9 1 Lattice simulations of strongly interacting matter under extreme conditions.
PETER PETRECZKY, *BNL*

I am going to review current status of lattice QCD at finite temperature and its implication on Quark Gluon Plasma seacrh at RHIC, including the transition temperature, equation of state, mesonspectral functions. A special attention will be devoted to heavy quark potentials, quarkonia spectral functions, and heavy quark transport.

11:21
P9 2 Lattice QCD and Nuclear Physics.
MARTIN SAVAGE, *University of Washington*

I will discuss the progress that is being made toward computing the interactions between nucleons using lattice QCD.

Contributed Papers

11:57
P9 3 Phase Diagram of Two-Color lattice QCD in the chiral limit SHAILESH CHANDRASEKHARAN, FU-JIUN JIANG, *Duke University* We study thermodynamics of strongly coupled lattice QCD with two colors of massless staggered fermions as a function of the baryon chemical potential μ in 3 + 1 dimensions using a new cluster algorithm. We find evidence that the model undergoes a weak first order phase transition at $\mu = 0$ which becomes second order at a finite μ. Symmetry considerations suggest that the universality class of these phase transition should be governed by a $O(N) \times O(2)$ field theory with collinear order, with $N = 3$ at $\mu = 0$ and $N = 2$ at $\mu \neq 0$. The universality class of the second order phase transition at $\mu \neq 0$ appears to be governed by the decoupled XY fixed point present in the $O(2) \times O(2)$ field theory. Finally we show that the quantum ($T = 0$) phase transition as a function of μ is also second order and can be understood as a mean field transition.

12:09
P9 4 Extrapolation Formulas for Neutron EDM Calculations in Lattice QCD DONAL O'CONNELL, *Caltech* MARTIN SAVAGE, *University of Washington* Lattice QCD is rapidly progressing toward being able to reliably compute the electric dipole moment of the neutron as a function of the strong CP-violating parameter $\bar{\theta}$. Present day calculations are performed at unphysical values of the light quark m asses, in volumes that are not exceptionally large and at lattice spacings that are not exceptionally small. We use chiral perturbation theory to determine the leading contributions to the neutron electric dipole moment at finite volume, and in partially-quenched calculations.

12:21
P9 5 Lattice QCD calculations of B meson properties and consequences for quark flavor phenomenology MATTHEW WINGATE, *University of Washington* CHRISTINE DAVIES, *University of Glasgow* ALAN GRAY, EMEL GULEZ, *Ohio State University* PETER LEPAGE, *Cornell University* JUNKO SHIGEMITSU, *Ohio State University* HPQCD COLLABORATION, Lattice QCD calculations now include the effects of 2 light sea quarks and 1 strange sea quark through the use of an improved staggered fermion action. Consequently, results important to phenomenology are free of the approximate 10% errors inherent in the quenched approximation. This talk reports on calculations of the B and B_s decay constants, matrix elements relevant for neutral B meson mixing, and $B \to \pi \ell \nu$ form factors. The focus of the talk will be on the current lattice uncertainties, the prospects for reducing them, and the role the results will play in flavor physics phenomenology.

12:33
P9 6 QCD thermodynamics with $N_f = 3, 2 + 1$ near the continuum limit at realistic quark masses TAKASHI UMEDA, MICHAEL CHENG, NORMAN CHRIST, CHULWOO JUNG, FRITHJOF KARSCH, ROBERT MAWHINNEY, PETER PETRECZKY, KONSTANTIN PETROV, CHRISTIAN SCHMIDT, *Brookhaven National Laboratory* We report our study of the thermodynamics with 3 and 2+1 flavors of QCD. In order to investigate the properties near the continuum limit we adopt improved staggered (p4) quark actions coupled with a tree-level Symanzik improved glue on $N_t = 4$ and 6 lattices. The simulations are performed with small light quark masses at which the pion mass is about 200 MeV or larger. In this talk we present several thermodynamical quantities such as critical temperature, phase diagram, and equation of states. To estimate the systematic uncertainties of these results, we also compare the results with several types of improved staggered quark action.

SESSION P10: 50 YEARS SINCE THE DISCOVERY OF PARITY NONCONSERVATION IN THE WEAK INTERACTIONS III

Monday Morning, 24 April 2006; Cumberland C, Hyatt Regency Dallas at 10:45
Susan Seestrom, Los Alamos National Laboratory, presiding

10:45
P10 1 The Question Answered.
RALPH P. HUDSON, *National Institute of Standards and Technology (retired)*

Fifty years ago, theoreticians T.D. Lee and C.N. Yang reached the conclusion that no experimental evidence existed to show that parity is conserved in weak interactions. The speaker will explain how it happened that a team of physicists at the U.S. National Bureau of Standards in Washington, DC came to perform the revolutionary experiment that demonstrated the failure of parity conservation in nuclear beta-decay.

11:21
P10 2 Chien-Shiung Wu as a Person and a Scientist.
VINCENT YUAN, *Los Alamos National Laboratory*

Chien-Shiung Wu is well known for her outstanding contributions to Nuclear Physics in Parity Violation and Beta Decay. I will discuss my view of her as seen from my vantage point as her son.

11:57
P10 3 Looking through the Mirror: Future Directions in Parity Violations.
M. RAMSEY-MUSOLF, *California Institute of Technology*

Over the past fifty years, studies of parity violation (PV) involving atoms, nuclei, and elementary particles have taught us a great deal about the electroweak and strong interactions. The future of this field promises to be equally rich. In this talk, I discuss new initiatives using PV to study weak interactions among quarks, to probe the structure of the nucleon, and to search for physics beyond the Standard Model.

SESSION P11: FOCUS SESSION: SPACE-BASED GRAVITATIONAL WAVE DETECTION

Monday Morning, 24 April 2006; Cumberland E, Hyatt Regency Dallas at 10:45
Curt Cutler, Jet Propulsion Laboratory, presiding

Invited Papers

10:45
P11 1 The LISA Observatory: Preparing for a bountiful harvest.*
NEIL CORNISH, *Montana State University*

The Laser Interferometer Space Antenna (LISA) will simultaneously detect many thousands of low frequency gravitational wave signals at high signal to noise. The science potential associated with this haul is tremendous, ranging from the exploration of galaxy formation through the observation of coalescing supermassive black hole binaries, through constraints on population synthesis models derived from a census of galactic binaries, to tests of fundamental physics using extreme mass ratio inspirals and optically resolved galactic binaries. Extracting all of this information from one or two time series poses a challenge that is very different to the one encountered with high frequency gravitational wave

observations. I will describe recent progress in addressing the LISA data analysis problem, and our plans for a community wide effort to develop a full data analysis pipeline.

*Supported by NASA Grant NNG05GI69G.

Contributed Papers

11:21

P11 2 Using Gravitational Waves from Intermediate Mass Black Holes to Test the No Hair Theorem JAMES GRABER, *LC* We used to think that supermassive black holes (SMBHs) were rare, perhaps only occurring in quasars. Now we think they are common, occurring in almost every galaxy. A similar change of opinion may soon occur concerning intermediate mass black holes (IMBHs), whose very existence is still in doubt. However, some evidence suggests there may be at least several IMBHs in every galaxy and other evidence suggests that IMBHs are frequent in globular clusters. If so, IMBH-SMBH mergers may be the most common high signal-to-noise ratio BH-BH merger events seen by LISA. It turns out that these intermediate mass ratio inspirals (IMRIs) can be used to make a very clean test of the black hole no-hair theorems by means of Ryan's method [Ryan, F. D., Phys. Rev. D **52**, 5707 (1995)]. In this paper, we discuss using IMRIs to make this test. IMRIs may be easier to detect than extreme mass ratio inspirals (EMRIs) because they will have a higher signal to noise ratios than EMRIs at a comparable distance. The measure and dimensionality of the search space necessary to find EMRIs in the LISA data may also be significantly smaller than the search space necessary to find EMRIs, making them easier to find in the first place, and easier to analyze in the second place. We point out how to take advantage of these facts by focusing on gravitational waves from relatively early in the IMRI inspiral.

11:33

P11 3 Observing the final moments of massive black hole mergers with LISA JOHN BAKER, *NASA-GSFC* Mergers of binary black hole systems are one of the strongest sources of gravitational radiation expected to be observed by LISA. Recent advances in modeling the final merger and ringdown of comparable-mass systems, particularly via numerical relativity simulations, are dramatically expanding our understanding of these systems and the radiation they generate. We summarize recent modeling results, highlighting the work of Goddard's numerical relativity group, and apply this emerging knowledge to the problem of observing the final moments of binary black hole mergers with LISA.

11:45

P11 4 Darwin's Design: Genetic Algorithms and Likelihood Surfaces in LISA Data Analysis JEFF CROWDER, NEIL CORNISH, LUCAS REDDINGER, *Montana State University - Bozeman* Thousands of low frequency gravitational wave sources will be detectable by the Laser Interferometer Space Antenna (LISA). A data analysis method has to be found to handle the large number of sources, many of which will have signals overlapping. This talk will focus on a new method for gravitational wave data analysis that provides simultaneous solutions for multiple sources within a chosen frequency band. This approach uses Genetic Algorithms (GAs) to perform searches of simulated LISA data. GAs show great promise in handling multiple source signals. Results, extracted from simulated LISA data, will be presented showing how GAs will be able to address the LISA low frequency problem of large numbers of overlapping signals. Additionally, this talk will discuss features of likelihood surfaces that exist for various sets of simulated LISA data, and how these features affect parameter extraction for all methods of data analysis. A comparison of several types of search techniques and how the likelihood surface features affect their efficacy will presented.

11:57

P11 5 LISA Interferometer Test Bench at UF SRIDHAR REDDY GUNTAKA, RACHEL J CRUZ, J IRA THORPE, MICHAEL HARTMAN, DAVID B TANNER, GUIDO MUELLER, *University of Florida* LISA, a joint NASA/ESA space mission to detect gravitational waves in the 10^{-4} to 10^{-1}Hz frequency band, is scheduled to launch in 2015. LISA will consist of three spacecraft in a heliocentric orbit forming a triangle with a 5 Gm baseline. In order to detect gravitational waves, LISA will use laser interferometry to measure changes in spacecraft separations with pm accuracy. The interferometer signals will be dominated by laser frequency noise. The dominant laser frequency noise will be subtracted from the data stream by post-processing the data using time delay interferometry (TDI). This algorithm relies on a strong correlation between all LISA signals taken at different times and different spacecraft as well as on very low noise and large dynamic range phase meters and on accurate timing information. At the University of Florida, we are developing an experimental LISA simulator to test implementations of various aspects of LISA interferometry and TDI. Realistic light travel times between the spacecraft are simulated using an electronic phase delay technique. In this paper we will present preliminary results of an experimental implementation of TDI to test LISA-like signals in the laboratory. This work is supported by NASA grant BEFS04-0019-0019.

12:09

P11 6 Progress towards experimental verification of arm-locking for LISA JAMES THORPE, SHAWN MYTRIK, RACHEL CRUZ, GUIDO MUELLER, *Dept. of Physics, University of Florida* The proposed space-based interferometric gravitational wave detector LISA will be used to study gravitational waves in the mHz regime. It consists of three spacecraft located at the vertices of a 5 Gm triangle, each containing two freely-falling proof masses. The distances between the proof masses will be monitored using laser interferometry in an effort to detect modulations due to gravitational waves. Orbital motion will cause arm-length mismatches in the constellation to a level of approximately 1%, which will cause laser frequency noise to couple into the interferometer output. In order to achieve the sensitivity required to detect gravitational waves, the laser frequency noise must be suppressed to an acceptable level. One proposed technique for reducing laser frequency noise in LISA is arm-locking, wherein some combination of the LISA arms is used as a frequency reference. We propose a method for evaluating arm-locking in an electro-optic laboratory model of LISA. This model includes lasers with LISA-like noise characteristics as well as realistic light travel delays achieved using an electronic phase delay method [Class. Quantum Grav. **22**, S227–S234 (2005)]. Current progress and results will be presented. This work is supported by NASA grant BEFS04-0019-0019.

SESSION P12: BS, BC LIFETIMES AND MIXING
Monday Morning, 24 April 2006
Cumberland F, Hyatt Regency Dallas at 10:45
Nigel Lockyer, University of Pennsylvania, presiding

10:45
P12 1 Hadronic Decays for the B_s Oscillation Measurement at DØ GERNOT WEBER, *Institut fuer Physik, Mainz, Germany* DZERO COLLABORATION, The status of the measurements of hadronic B_s decays at the DØ experiment at Fermilab is presented. DØ limits of the mass difference Δm_s in the B_s system have been obtained so far using semileptonic decays. Due to the fact that in hadronic B_s decays all daughter particles are reconstructible a much better sensitivity for larger Δm_s values is expected here. Results of the present performance of the triggering strategy and reconstruction of hadronic B decays will be shown.

10:57
P12 2 Study of B_s oscillations using semileptonic decays DAN KROP, *Indiana University* DZERO COLLABORATION, We report preliminary results on the search for B_s oscillations using approximately 910 pb^{-1} of data taken at the DØ experiment during Run IIa at the Tevatron. We search for oscillations in the time dependence of semileptonic decays of the B_s, $B_s \rightarrow D_s lX$ where the flavor of the B_s at production is determined by studying inclusive properties of the event.

11:09
P12 3 Same Side Kaon Tagging Studies in Fully Reconstructed Decays GIAN PIERO DI GIOVANNI, *LPNHE Universite de Paris* CDF COLLABORATION, Currently the Tevatron is the only place where B_s mesons are produced. The mass difference of the B_s and its antiparticle is not yet known. We present here the development of a b-quark flavor tagger that largely enhances the sensitivity power of the CDF experiment to observe B_s oscillations. This b-quark flavor tagging algorithm is based on the charge correlation between the signal B meson and the fragmentation tracks produced nearby. Relying on simulation events, we evaluate the performance of the same side (flavor) tagger on fully reconstructed Bu, Bd and Bs decay modes.

11:21
P12 4 B_s Mixing Results for Hadronic and Semileptonic Decays at CDF JEFFREY MILES, *MIT* CDF COLLABORATION, We report preliminary results for B_s oscillation from CDF Run II at the Fermilab Tevatron collider. The analysis combines hadronic and semileptonic channels from 355 pb^{-1} of data collected by a displaced-track trigger which uses CDF's precision silicon tracking. New techniques in flavor tagging and event reconstruction and the addition of new decay modes yield a significant improvement in mixing sensitivity as compared to earlier CDF results.

11:33
P12 5 A precise measurement of the B_s^0 lifetime ALBERTO SANCHEZ, *CINVESTAV, Mexico* DZERO COLLABORATION, We report the lifetime measurement of the flavor–specific B_s^0 meson decay $B_s^0 \rightarrow D_s^- \mu^+ \nu X$, using approximately 400 pb^{-1} of data collected by the DØ detector during 2002–2004. We have reconstructed 5176 $D_s^- \mu^+$ candidate events, from which we have measured the B_s^0 lifetime with a combined statistical and systematic uncertainty of less than 16 μm which is the currently most precise measurement of the B_s^0 lifetime.

11:45
P12 6 Measurement of the B_c Lifetime Using the $B_c \rightarrow J/\psi + \mu^\pm + X$ Decay Channel MARK HARTZ, *University of Pittsburgh* CDF COLLABORATION, We report on a measurment of the lifetime of the B_c meson in the semileptonic decay mode $B_c \rightarrow J/\psi + \mu^\pm + X$ with $J/\psi \rightarrow \mu^+\mu^-$. The measurement utilizes 360 pb^{-1} of data collected with the CDF II detector during Run II of the Fermilab Tevatron in pbarp collisions at $\sqrt{s}$ = 1.96 TeV. We build a likelihood function, consisting of signal and background lifetime distribution functions, which is maximized when applied to the data sample of $J/\psi + \mu^\pm$ events to extract a measurement of the lifetime.

11:57
P12 7 Study of the B_c lifetime via the decay $B_c \rightarrow J/\psi\mu\nu X$ LEAH WELTY-RIEGER, *Indiana University* DZERO COLLABORATION, The B_c meson is unique as a meson in that it contains two different, yet heavy quarks, resulting in a lifetime that is expected to be shorter than the other b hadrons. Using approximately 1 fb^{-1} of data collected with the DØ detector at the Fermilab Tevatron during Run rmII, the B_c meson in the semileptonic mode $B_c^\pm \rightarrow J/\psi\mu^\pm\nu X$ is studied. Preliminary results on the measured lifetime of this particle are presented.

12:09
P12 8 Probing Quark Fragmentation with Ds-K Correlations at CDF NIHARIKA RANJAN, *Purdue University* CDF COLLABORATION, High statistics samples of Ds+ and D+ decays have been recorded with the CDF-II detector at the Fermilab Tevatron. To conserve strangeness, prompt Ds+ mesons are expected to be frequently produced in association with K- mesons. The differences between the kinematic distributions of kaons produced in association with Ds+ compared with those produced in association with D+ mesons is sensitive to details of the quark fragmentation process that have not previously been studied directly. An accurate modelling of kaon production in association with heavy quark fragmentation is needed to determine the effectiveness of a "same-side kaon tag" which is expected to provide a powerful means of determining the production flavor of B_s^0 mesons and should significantly improve the sensitivity of the analysis of B_s^0 oscillations at CDF.

SESSION P13: PARTICLE SEARCHES I
Monday Morning, 24 April 2006
Cumberland G, Hyatt Regency Dallas at 10:45
Vladimir Litvin, California Institute of Technology, presiding

10:45
P13 1 Search for Gluino and Squark Production in Mutijets plus Missing Transverse Energy Final States at the Tevatron XAVIER PORTELL, CARLOS SANCHEZ, *IFAE Barcelona* CDF COLLABORATION, We present results on a search for squarks and gluinos in proton-antiproton collisions with a center-of-mass energy of 1.96 TeV, based on 371 pb^{-1} of data collected

by the CDF detector during Run II. Events with multiple jets and large missing energy in the final state are studied within the framework of minimal supergravity and assuming R-parity conservation. No excess with respect to the Standard Model predictions is observed and new limits on the gluino and squark masses are extracted.

10:57
P13 2 Search for the Associated Production of Charginos and Neutralinos with the DØ Detector OLAV MUNDAL, *Freiburg University (Germany)* DZERO COLLABORATION, A search for associated production of charginos and neutralinos is performed using data recorded with the DØ detector at a $p\bar{p}$ center-of-mass energy of 1.96 TeV at the Fermilab Tevatron Collider. This analysis considers final states with missing transverse energy and three leptons, including hadronic decays of tau leptons. With a dataset corresponding to an integrated luminosity of about 1 fb^{-1}, the analysis is probing chargino masses beyond existing limits from LEP and previous Tevatron Run II analyses.

11:09
P13 3 Limit on the Associated Production of Charginos and Neutralinos in ppbar collisions at $\sqrt{s}$ = 1.96 TeV SOURABH DUBE, JOHN ZHOU, SUNIL SOMALWAR, *Rutgers University* GIULIA MANCA, BEATE HEINEMANN, MARTIN GRIFFITHS, *University of Liverpool* ANADI CANEPA, ELSE LYTKEN, *Purdue University* VLADIMIR REKOVIC, JOHN STROLOGAS, MICHAEL GOLD, *University of New Mexico* CDF COLLABORATION, We search for the associated production of charginos and neutralions in ppbar collisions at $\sqrt{s}$ = 1.96 TeV measured with the CDF experiment at the Fermilab Tevatron. The results are obtained from high-pt and medium-pt lepton triggers, using channels with three leptons and two like-sign leptons, with $\sim$ 350 pb^{-1} of data. Limits on the production time branching ratio as well as excluded region in the minimal supergravity SUSY framework are presented.

11:21
P13 4 Search for Chargino-Neutralino Production with Low Pt Electrons SOURABH DUBE, JOHN ZHOU, SUNIL SOMALWAR, *Rutgers University* CDF COLLABORATION, We present a search for associated production of Chargino-Neutralino decaying to three leptons, with approximately 700 pb^{-1} of p-pbar collision data at $\sqrt{s}$ = 1.96 TeV, collected with the CDF Run2 detector. The search is performed in the framework of mSUGRA. Two of the three leptons in the final state must be electrons and the third object is a track making the analysis sensitive to tau channels. Major backgrounds are identified and calculated. Preliminary results in the form of production cross section limit are presented.

11:33
P13 5 Search for SUSY at Tevatron Run II from Chargino-Neutralino Production in Low Pt Di-muon Channel VLADIMIR REKOVIC, JOHN STROLOGAS, MICHAEL GOLD, *University of New Mexico* CDF COLLABORATION, Minimal Supersymetric Standard Model(MSSM) predicts the production of tri-lepton events at the Tevatron via chargino-neutralino production. We will present our sensitivity to discovery of this production in low Pt di-muon channel. We use the data set with some 800 pb^{-1} of data taken by the CDF-II detector during Run II of the Tevatron, which is about eight times the data collected in Run I of Tevatron.

11:45
P13 6 Sensitivity for the Discovery of Supersymmetry in the Leptons plus Jets YURIY PAKHOTIN, B. SCURLOCK, *University of Florida* CMS COLLABORATION, Preparations are underway to search for possible signatures of Supersymmetry (SUSY) in the inclusive leptons plus jets and missing transverse energy (MET) as well as semi-inclusive topologies involving same-sign dimuon final states, using the Compact Muon Solenoid (CMS) experiment at the Large Hadron Collider. This talk reports on the expected performance of CMS, using a full simulation of the detector, and studies its effect on SUSY discovery potential. The primary background sources to SUSY are expected to arise from QCD mulitjets, top anti-top, and W/Z production. Strategies for reducing this background, both from the online CMS trigger and from offline data analysis, as well as understanding and controlling systematic uncertainties, are presented.

11:57
P13 7 Search for Pair Production of Scalar Top Quarks Each Decaying to a τ Lepton and a b Quark in 1.96-TeV $p\bar{p}$ Collisions VADIM KHOTILOVICH, *Texas A&M University* CDF COLLABORATION, We present the results of a search for pair production of scalar top quarks ($\tilde{t}_1$) in an R-parity violating supersymmetry scenario, in 322 pb^{-1} of $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV, collected by the Collider Detector at Fermilab (CDF). We assume each stop quark always decays into a τ lepton and a b quark, and that the final state is either an electron or a muon from the leptonic τ decay, a hadronically decaying τ lepton, and two or more jets. Two candidate events pass our final selection criteria, consistent with the expectation from standard model sources. We set a 95% confidence level limit $m(\tilde{t}_1) > 151$ GeV comparing with the next-to-leading order cross section. This limit is also fully applicable to the case of the third generation scalar leptoquark (LQ_3) assuming a 100% branching ratio for the $LQ_3 \rightarrow \tau b$ decay mode.

SESSION P16: SHERWOOD III
Monday Morning, 24 April 2006; Landmark D, Hyatt Regency Dallas at 10:45
Linda Sugiyama, PSFC, Massachusetts Institute of Technology, presiding

10:45
P16 1 Momentum transport from magnetic reconnection in flowing plasmas.*
FATIMA EBRAHIMI, *University of Wisconsin-Madison*

Magnetic fluctuations arising from MHD instabilities can cause momentum transport both in laboratory and astrophysical plasmas. We investigate momentum transport from current-driven reconnection, likely a powerful mechanism in laboratory fusion plasmas and possibly important in astrophysical venues. Momentum transport is examined, both analytically

and numerically, using the Maxwell stress associated with tearing instabilities. We study momentum transport from single tearing modes, and transport from multiple tearing modes. We find that spontaneous reconnection of a single tearing mode in a plasma with equilibrium flow can transport momentum, but that transport is substantially enhanced in the presence of multiple modes due to nonlinear mode coupling. It is shown that the major contribution of single tearing mode to momentum transport arises from the inner layer solutions. The nonlinear, 3D, resistive MHD code DEBS, with an ad-hoc term added to the momentum equation, is employed to study momentum transport from multiple tearing modes. The role of coupled spontaneous and nonlinear driven reconnection are examined. Theoretical results are compared with measurements of momentum transport and Lorentz forces in the MST reversed field pinch experiment.

*In collaboration with S. C. Prager, V. V. Mirnov, and C. R. Sovinec, University of Wisconsin and Center for Magnetic Self-Organization in Lab and Astrophysical Plasmas.

11:15
P16 2 Piecewise-Beltrami MHD equilibria.*
ROBERT DEWAR, *The Australian National University*

An algorithm for constructing 3-dimensional toroidal MHD equilibria that converged rapidly to arbitrary accuracy would be useful not only for design and experimental interpretation purposes but as a constructive solution to the fundamental mathematical existence problem [H. Grad, Phys. Fluids **10**, 137 (1967)]. A construction based on minimizing the pressure + magnetic energies cannot converge to arbitrary accuracy if ideal MHD constraints (frozen-in flux) are imposed everywhere because of the generic existence of islands and chaotic field line regions between invariant (KAM) tori. Instead we freeze the topology only on selected surfaces with irrational rotational transforms and, in between, impose only conservation of magnetic helicity, leading to piecewise-flat-pressure Beltrami ($\nabla \times B = \mu B$) equilibria. Little generality is lost, because, if KAM surfaces are of full measure a smooth pressure profile can be approximated with arbitrary accuracy by increasing the number of ''barrier'' surfaces. To this end, cylindrical stepped equilibria have been constructed semi-analytically, and the Beltrami field between two nested 3-D toroidal flux surfaces solved numerically using the method of lines. In collaboration with Matthew Hole, The Australian National University, Dept. of Theoretical Physics, RSPhysSE; and Stuart Hudson, Princeton University Plasma Physics Laboratory.

*Project supported by the Australian Research Council.

11:45
P16 3 Pure electron plasmas in a stellarator: Theory and experiment.*
THOMAS SUNN PEDERSEN, *Columbia University*

The confinement of non-neutral plasmas by magnetic surfaces, such as those of a tokamak or a stellarator, is a new area of plasma research. The theory of such plasmas, which range from single component to quasi-neutral, has had a rapid development in recent years. The primary focus has been on pure electron plasmas, in particular the properties of low density electron plasma equilibria. The equilibrium equation is a Poisson-Boltzmann equation for the electrostatic potential which has been solved numerically in realistic three-dimensional geometries. Pure electron plasmas confined on magnetic surfaces are now being studied in several experiments, including the recently operational Columbia Non-neutral Torus (CNT). CNT is an ultralow aspect ratio stellarator at Columbia University, which is devoted to the study of plasma confinement on magnetic surfaces over the full range of plasma neutrality: single component to quasi-neutral. These experiments have already confirmed one theoretical prediction: The existence of macroscopically stable equilibria. We will report on theoretical predictions and experimental measurements of equilibrium, stability, and confinement, and will discuss work in progress on the inclusion of a finite ion fraction and the effects of high electron densities. In collaboration with Allen H. Boozer, Remi G. Lefrancois, Jason P. Kremer, Quinn R. Marksteiner, and John Berkery, Columbia University.

*Supported by DOE and NSF, grant #PHY-04-49813 and PHY-03-17359.

12:15
P16 4 Parallel closures for transport applications.*
J.-Y. JI, *Utah State University*

We present recent advances in solving the steady-state closure problem with applications to parallel transport in magnetically confined plasmas. First, we present a treatment of the linearized Coulomb collision operator for ionized plasmas. Moment expansion of a distribution function reduces the collision operator to products of moments and speed dependent terms that include the full particle and field responses. This approach preserves the conservation properties of the collision operator for each moment and provides for quantitative, collisional transport coefficients. Next, we discuss converting ordered kinetic equations into a small set of coupled ordinary differential equations for higher-order moments. By preserving the collisionless response of free-streaming particles and the nonlinear temperature and density dependence in thermodynamic drives, we study parallel transport in the nearly collisionless core of magnetically confined plasmas and

in edge plasmas where density and temperature vary significantly along magnetic field lines. Finally, we discuss the solution of the coupled higher-order moment equations in the NIMROD code and apply this solution in studies of parallel electron heat transport in the SSPX experiment[1] and large tokamaks. In collaboration with E.D. Held, Utah State University and C.R. Sovinec, University of Wisconsin-Madison.

*Research supported by the U.S DOE under grant Nos. DE-FG02-04ER54746, DE-FC02-04ER54798 and DE-FC02-05ER54812.

[1]E. B. Hooper *et al.*, Nucl. Fusion **39**, 863 (1999).

SESSION 1A: RISING ABOVE THE GATHERING STORM
Monday Afternoon, 24 April 2006; Landmark D, Hyatt Regency Dallas at 12:45

12:45
1A 1
NORMAN AUGUSTINE

SESSION Q1: NEUTRINOS I
Monday Afternoon, 24 April 2006; Landmark A, Hyatt Regency Dallas at 13:30
George Fuller, University of California, San Diego, presiding

13:30
Q1 1 Cosmic Microwave Background and Large Scale Structure Measures of Neutrino Mass.
KEVORK ABAZAJIAN, *Los Alamos National Laboratory*

The clustering of matter on the largest, cosmological scales has provided a window on the mass of the particle with the smallest cross-section, the neutrino. This results from the effects of the expected background of relic cosmological neutrinos on clustering from the largest to smallest scales in the linear theory of cosmological structure growth in combination with precision measures of cosmological matter clustering from observations of the cosmic microwave background and from galaxy surveys. I will review the theoretical underpinnings and caveats of the inferred neutrino mass limits from cosmological large scale structure and the status of current observations from the Wilkinson Microwave Anisotropy Probe of the the cosmic microwave background as well as the large scale structure measures from the Sloan Digital Sky Survey. In addition, I will highlight future cosmological probes of neutrino properties.

14:06
Q1 2 Neutrinos and Neutrino Physics: Still Center Stage in Core Collapse Supernovae.
ANTHONY MEZZACAPPA, *Oak Ridge National Laboratory*

Ascertaining the core collapse supernova mechanism and understanding all of the phenomena associated with such stellar explosions, such as their element synthesis and gravitational wave signatures, neutron star kicks, the spin of pulsars at birth, etc., will require three-dimensional precision models that include realistic neutrino transport, stellar core fluid instabilities, rotation, magnetic fields, a realistic stellar core equation of state for both sub- and super-nuclear densities, and realistic weak interactions. Only in the last decade has supernova modeling broken free from the confines of spherical symmetry. I will review the current state of the art. Even the most fundamental questions remain: How do core collapse supernovae explode? What role do the neutrinos play? While a recent emphasis has been placed on the role of magnetic fields in generating core collapse supernova explosions, the neutrinos still occupy center stage. Moreover, in light of the now experimentally determined fact that neutrinos have mass, neutrino transport in core collapse supernovae takes on a whole new complexity. Previously, neutrino transport was well described by Boltzmann kinetic theory, but now more faithful modeling will require quantum kinetics. The role of neutrino mixing in the core collapse supernova mechanism remains virtually unexplored, with the potential for significant surprises. It is, as I will discuss, one of the frontiers in core

collapse supernova theory. Finally, the development of precision three-dimensional supernova models will provide yet another scientific opportunity beyond the chance to ascertain how stars die and produce the elements necessary for life. Together with detailed observations, especially of the neutrino and gravitational wave emissions in the event of a Galactic supernova, detailed supernova models will allow us to use core collapse supernovae as laboratories for fundamental physics. I will discuss some of the possibilities.

14:42
Q1 3 The Neutrino World.
BORIS KAYSER, *Fermilab*

The discovery of neutrino mass has raised very interesting questions about the neutrinos and their connections to the rest of physics and astrophysics. We will discuss these questions and the ideas for answering them through future experiments. Ultimately, one would like to discover the origin of neutrino mass. We will discuss some speculations on this origin.

SESSION Q2: IMPLICATIONS OF QCD PHASE TRANSITIONS
Monday Afternoon, 24 April 2006; Landmark B, Hyatt Regency Dallas at 13:30

13:30
Q2 1
ISMAIL ZAHED

14:06
Q2 2 Hitchhiker's Guide to the Early Universe.
PAUL STANKUS, *Oak Ridge National Laboratory*

The new standard picture of the early, expanding and accelerating Universe is reviewed at an accessible level. The Hubble expansion, the Robertson-Walker metric, and the cosmological constant are discussed. Special emphasis is placed on the thermal history of the early Universe, with the goal of appreciating the relevance of the QCD phase transition.

14:42
Q2 3 Probing the Properties of the Big Bang Quark Matter.
KRISHNA RAJAGOPAL, *Massachusetts Institute of Technology*

The combination of experiments at the Relativistic Heavy Ion Collider and calculations of QCD thermodynamics done using the methods of lattice gauge theory are revealing the properties of the matter that filled the universe in the microseconds after the big bang. I will present a look at what we have learned recently, and what we may hope to learn soon. Given that the former includes surprises–who could have guessed that the first property of the quark-gluon plasma we would learn about from RHIC would be its shear viscosity, leave apart that the quark-gluon plasma would prove to be such an ideal liquid? The latter comes with no guarantees. Along the way, I will mention an insight that has come from calculations done using AdS/CFT dualities first developed by string theorists.

SESSION Q3: PARTICLE ACCELERATION
Monday Afternoon, 24 April 2006; Landmark C, Hyatt Regency Dallas at 13:30
James Drake, University of Maryland, presiding

13:30
Q3 1 Observing Particle Acceleration with RHESSI.
DAVID SMITH, *University of California, Santa Cruz*

The Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) was designed to study particle acceleration in solar flares by imaging spectroscopy of both bremsstrahlung from electrons and nuclear lines from ion interactions. I will review several of the major results of these studies since the launch of RHESSI in February 2002. RHESSI's x-ray and gamma-ray detectors are also being used to study electrons accelerated to high energies in other sites, such as the Crab nebula and thunderclouds on Earth; I will review the status of these observations as well.

14:06
Q3 2 Current Status of Shock Acceleration Theory.
LUKE DRURY, *Dublin Institute for Advanced Studies*

The main features of nonlinear diffusive shock acceleration are now reasonably well understood after several decades of work by many individuals. Several distinct approaches have converged to give a reasonably consistent picture of the process. These will be briefly described. The interesting new development in the last few years is the increasing attention being paid to mesoscopic instabilities and their potential importance for magnetic field amplification, This may well be the last missing piece of the jig-saw, but raises serious technical problems for the theoretical study of the acceleration process as well as some fascinating physics issues.

14:42
Q3 3 The importance of magnetic-field angle in diffusive shock acceleration of cosmic rays.
JOE GIACALONE, *University of Arizona*

We discuss the physics of charged-particle acceleration by shock waves, focussing on the importance of the shock-normal angle. This has important applications for our understanding of supernovae shocks, the solar-wind termination shock, and propagating shocks near the Sun. For the case in which the shock normal is parallel to the incident field - a parallel shock - acceleration of particles to very high energies (e.g. the knee in the cosmic-ray spectrum, or $>$ GeV energy solar cosmic rays) requires very special conditions to explain the observations. These include a strong increase in the magnetic field, perhaps due to excitation from the streaming cosmic rays. In this talk, we show that no such special circumstances are required when one considers acceleration at nearly perpendicular shocks. We suggest that the observations of high-energy charged particles can be accounted for using reasonable values for the diffusion coefficients and observed shock speeds. A critical issue in the theory of diffusive shock acceleration at nearly perpendicular shocks is the well-known injection problem. We suggest that, in actuality, there is no such injection problem and, in fact, the acceleration efficiency does not depend strongly on the shock-normal angle. This can be understood in terms of the increased cross-field transport arising from so-called field-line random walk due to the large-scale (ccompared to the particle gyroradii) turbulent magnetic field.

SESSION Q4: THREE-BODY SYSTEMS
Monday Afternoon, 24 April 2006; Marsalis A, Hyatt Regency Dallas at 13:30
Werner Tornow, Duke University, presiding

13:30
Q4 1 Two-Body Photodisintegration of ^{3}He Between 0.4 and 1.5 GeV.
YORDANKA ILIEVA,* *The George Washington University*

The $\gamma^3\mathrm{He} \rightarrow pd$ reaction was measured with the CLAS detector at Jefferson Lab for photon energies between 0.4 and 1.5 GeV and proton CM angles θ^p_{CM} between 40° and 140°. It is complementary to the three-body breakup of ^{3}He with respect to studying three-body mechanisms. At all photon energies for our experiment, the differential cross sections exhibit a very strong forward-to-backward asymmetry — approximately one order of magnitude. An interesting feature of the differential cross sections is that their slope does not depend on the photon energy and there is a change of slope at $\theta^p_{CM} = 120°$ seen at all photon energies. The invariant cross sections fall off with s (where s is the total CM energy)

much faster than expected by the quark counting rules [1]. The latter predict that in the asymptotic regime $t \to \infty$ the invariant cross sections should scale as s^{-17}, whereas our data scale as s^{-22}. A comparison of our preliminary results with the cross sections predicted by Jean-Marc Laget's model [2] shows that the differential cross sections for angles greater than 60° are sensitive to contributions from three-body mechanisms. The relative importance of the latter, with respect to one- and two-body mechanisms, is larger at 0.6 - 0.8 GeV than at higher energies. This has already been observed in our data for $\gamma^3\mathrm{He} \to ppn$ [3] and seems to be a characteristic of the three-body mechanisms at medium energies.

*For the CLAS Collaboration.
[1]S.J. Brodsky and G.R. Farrar, Phys. Rev. Lett. **31**, 1153 (1973). 2. J-M. Laget, Phys. Rev. C **38**, 2993 (1988). 3. S. Niccolai et al., Phys. Rev. C **70**, 064003 (2004).

14:06
Q4 2 Probing Short Range Nuclear Properties in Photodisintegration of Few-Nucleon Systems.*
MISAK SARGSIAN, *Florida International University*

High momentum transfer photodisintegration reactions involving few-nucleon systems represent a powerful tools for studying the nuclear dynamics at short space-time separations. We review on several aspects of this research, such us understanding the nature of short range three nucleon correlations, studying the mechanism of three-nucleon forces and probing the dynamics of quark-hadron transition in the nuclear medium. Particular processes we review are the high Q^2 three-body break up reactions, 90^0 center of mass photodisintegration of pp and pn pairs in the ^3He as well as production of energetic deuterons in the current fragmentation region of the reaction. We demonstrate how these studies could allow us to extract unique information about properties of strong interaction which are inaccessible in studies of nucleon-nucleon scattering.

*Research is supprted by U.S. Department of Energy grant.

14:42
Q4 3 Three-nucleon forces: New developments.
EVGENY EPELBAUM, *Thomas Jefferson National Accelerator Facility*

It is well known from microscopic few- and many-body studies that three-nucleon forces are important for quantitative understanding of various phenomena in nuclear physics. Three-nucleon forces that cannot be reduced to pair-wise nucleon-nucleon interactions arise naturally in the context of meson-exchange theory and at the more fundamental level of QCD. Chiral effective field theory provides a powerful and promising approach to determine two-, three- and more-nucleon forces in a systematic way based on the approximate and spontaneously broken chiral symmetry of QCD. Recent developments along these lines will be discussed. Future directions in this field will be outlined.

SESSION Q5: EVOLUTION: FROM THE BIG BANG TO US
Monday Afternoon, 24 April 2006; Pegasus B, Hyatt Regency Dallas at 13:30
Barbara Levi, Physics Today, presiding

13:30
Q5 1 Evolution of the Universe.
JOEL PRIMACK, *University of California, Santa Cruz*

Cosmology is in the midst of a scientific revolution that is establishing its lasting foundations. The good agreement between many different sorts of observations and the predictions of the now-standard Lambda Cold Dark Matter (LCDM) theory gives us hope that this is humanity's first picture of the history of the universe as a whole that might actually be true. An unexpected feature of this new picture is that we humans appear to be central or special in many ways – for example, we are made of the rarest stuff in the universe (stardust); we are intermediate in size between the smallest possible size (the Planck length) and the largest size (the cosmic horizon); and we are living at a pivotal time: the period in the history of the universe when its expansion began to accelerate rather than slow down, and in the middle of the ten-billion-year lifetime of our solar system and of the billion year most habitable period of our planet, and at what must be the end of the exponential growth of human impact on the earth. This talk[1] will review key observations that support modern cosmology, describe some symbolic ways of understanding the modern cosmos, and discuss some possible implications of a cosmic perspective for our 21st century worldview.

[1]Based on a new book, The View from the Center of the Universe: Discovering Our Extraordinary Place in the Cosmos, by Joel R. Primack and Nancy Ellen Abrams (Riverhead Books, April 2006).

14:06
Q5 2 Evolution of a Habitable Planet.
JAMES KASTING, *Penn State University*

Earth has remained habitable, and inhabited, over most of its 4.5-Gyr history despite an appreciable (30%) increase in solar luminosity over time and despite catastrophic events such as asteroid impacts and ''Snowball Earth'' episodes that have threatened biological survival on a global scale. Life has survived partly because of the resilience of the biota and partly because of feedback mechanisms that help to stabilize Earth's global climate. In particular, buildup of volcanic CO_2 during times when the climate is cold provides a strong negative feedback that helps keep Earth within the temperature regime favorable to life. The same processes that help stabilize Earth's climate should operate on other Earth-like planets, if they exist; thus, it is plausible that life could exist elsewhere. This hypothesis is now on the verge of being tested. NASA's twin itTerrestrial Planet Finder (TPF) missions, which could be launched as early as 2015-2020, will look for Earth-like planets around nearby stars and, if they are found, provide spectroscopic information on their atmospheres. Between them, these missions should be able to look for absorption bands of O_2, H_2O, CO_2, and O_3. Both O_2 and O_3 are considered to be good indicators of life for planets orbiting within the liquid water habitable zone of their parent star. NASA should be encouraged to give these missions high priority, so that we can answer these fundamental questions about the distribution of life in the universe.

14:42
Q5 3 Evolution of Biological Diversity.
DUANE JEFFERY, *Professor of Integrative Biology, BYU*

A conservative estimate posits approximately ten million species presently inhabiting Earth, and these are clearly only a small fraction of those that have existed throughout Earth's history. Although various types of selective mechanisms have been identified as generating this diversity, and several chance mechanisms as well, the relative importance of these mechanisms is not firmly resolved. We review the current status of the discussion and some of the associated political and social ramifications.

SESSION Q6: ADVANCED ACCELERATION TECHNIQUES FOR FUTURE ENERGY FRONTIER ACCELERATORS
Monday Afternoon, 24 April 2006; Cumberland J, Hyatt Regency Dallas at 13:30
James Rosenzweig, University of California, Los Angeles, presiding

13:30
Q6 1
PATRIC MUGGLI, *Univeristy of Southern California*

This abstract was not received electronically.

14:06
Q6 2 Prospects for a TeV Laser Wakefield Accelerator.
WARREN MORI, *UCLA*

This abstract was not received electronically.

14:42
Q6 3 Ultra-strong plasma lenses for final focus and other applications.
JAMES ROSENZWEIG, *UCLA*

This abstract was not received electronically.

SESSION Q8: ELECTROMAGNETIC INTERACTIONS
Monday Afternoon, 24 April 2006
Cumberland A, Hyatt Regency Dallas at 13:30
Ioana Niculescu, James Madison University, presiding

13:30

Q8 1 K^{*0} photoproduction off the proton at CLAS* ISHAQ HLEIQAWI, KEN HICKS, *Ohio University* CLAS COLLABORATION, The photoproduction of vector mesons has previously focused on the nonstrange sector, with ρ, ω or ϕ mesons in the final state. The lightest vector meson with nonzero strangeness is the K* of which little is known for photoproduction. The large acceptance of the CLAS detector makes it possible to capture both K* decay products, the pion and the kaon. In this talk we will show differential cross sections for the $K^{*0}\Sigma^+$ final state over photon energies ranging from about 1.8 to 3.0 GeV. These data are compared with a theoretical model by Zhao itet al. using a quark-model for the K*-baryon couplings. Our data show that the forward-angle data are well described by the t-channel, hence providing constraints for the $K^*\Sigma N$ coupling constant At larger angles, the s-channel is well described by the model of Zhao et al. over a range of angles and photon energies. The K* couplings determined from our data will more tightly constrain calculations for scalar kaon production, where K* exchange occurs as a virtual particle in the t-channel.

*Supported by NSF grant PHY-0244999.

13:42

Q8 2 The Neutron Charge Form Factor at Low Q^2 EUGENE GEIS, RICARDO ALARCON, *Arizona State University* MICHAEL KOHL, RICHARD MILNER, VITALY ZISKIN, *MIT-Bates Laboratory* BLAST COLLABORATION, At the MIT-Bates Linear Accelerator Center, the neutron charge form factor G_E^n has been measured by means of (e,e'n) quasielastic scattering of polarized electrons from vector-polarized deuterium. The experiment used the longitudinally polarized stored electron beam of the MIT-Bates South Hall Ring along with an isotopically pure, highly vector-polarized internal atomic deuterium target provided by an atomic beam source. The measurements have been carried out with the symmetric Bates Large Acceptance Spectrometer Toroid (BLAST) with enhanced neutron detection capability. From the beam-target double polarization asymmetry with the target spin oriented perpendicular to the momentum transfer the form factor G_E^n is extracted over a range of four-momentum transfer Q^2 between 0.12 and 0.60 $(GeV/c)^2$ with minimized systematic dependencies.

13:54

Q8 3 Inclusive Electron-Nucleus Scattering at $x > 1$ and High Q^2 DONAL DAY,* *University of Virginia* Inclusive electron scattering from nuclei provides a rich, yet complicated mixture of physics that has yet to be fully exploited. The cross section at high momentum transfer arises from several reactions including quasi–elastic scattering from nucleons and deep inelastic scattering from the quark consitituents of the nucleons. Inclusive electron scattering presents the opportunity to investigate the transition from a regime where nucleon degrees of freedom hold sway to one where the more fundamental QCD interactions, involving quarks and gluons, are expected to dominate. Data at large values of x over a range of Q^2 can be employed to study a wide variety of topics: nuclear momentum distributions, medium modifications of nucleon properties, the influence of final state interactions and the approach to y-scaling, the strength of nucleon-nucleon correlations at large x, and the approach to x- scaling. We recently completed such an experiment in Jefferson Lab's Hall C in which 6 GeV electrons were scattered from both few-body nuclei and heavy nuclei at high momentum transfers. This experiment significantly extended the kinematic region at high momentum transfer and large (negative) y (corresponding to large Bjorken x), explored in previous experiments. After a brief statement of the physics motivation for this experiment, we will present preliminary results.

*For the XEM Collaboration.

14:06

Q8 4 CLAS g10 Analysis on Single Photopion Productions from Deuterium* WEI CHEN, *Duke University/TUNL* Photopion productions from nucleons are essential probes of the transition from meson-nucleon degrees of freedom to quark-gluon degrees of freedom in exclusive processes. The cross sections of these processes are also advantageous, for the investigation of the oscillatory behavior around the quark counting prediction, since they decrease relatively slower with energy compared with other photon-induced processes. Recent data from JLab experiment E94-104 [1,2] show dramatic change in the scaled differential cross-section from the $\gamma n \rightarrow \pi^- p$ and $\gamma p \rightarrow \pi^+ n$ processes in the center of mass energy between 1.8 GeV to about 2.4 GeV. We are carrying out a CLAS approved analysis [3] of the JLab CLAS g10 data on the $\gamma n \rightarrow \pi^- p$ to investigate this dramatic behavior in much finer photon energy bins. Furthermore, the angular dependence of the scaling behavior for this process will also be studied in detail. We will report preliminary results from this analysis in this presentation. [1] L.Y. Zhu *et al.*, Phys. Rev. Lett. **91**, 022003 (2003). [2] L.Y. Zhu *et al.*, Phys. Rev. C **71**, 044603 (2005); nucl-ex/0409018. [3] http://www.tunl.duke.edu/~mep/clas/caa_pion.pdf.

*This work is supported by U.S. Department of Energy under contract number DE-FG02-03ER41231.

14:18

Q8 5 Search for the Onset of Color Transparency : JLab E02-110 experiment LAMIAA EL FASSI, *Argonne National Laboratory* CLAS COLLABORATION,* The JLab E02-110 experiment was carried out in 2003-2004 using the CEBAF Large Acceptence Spectrometer (CLAS) located in Hall B at Jefferson Laboratory. The main goal of this experiment is to look for the onset of Color Transparency (CT) in the exclusive incoherent ρ^0 electroproduction on deuterium, carbon and iron. These measurements study the Q^2 dependence of the nuclear transparency T_A, the ratio of the nuclear per-nucleon (σ_A/A) to the free nucleon (σ_N) cross sections, at fixed coherence length l_c of quark-antiquark fluctuations of the virtual photon. A significant increase of T_A with Q^2 would be a signature of CT. A brief description to the experiment and the ongoing analysis work will be presented in this talk.

*On behalf of CLAS Collaboration.

14:30

Q8 6 Precise Measurement of the Nuclear Dependence of the EMC Effect AJI DANIEL, *University of Houston* E03-103 COLLABORATION, Since the original observation of the modification of nuclear structure functions by the European Muon Collaboration, there has been intense experimental and theoretical efforts aimed at understanding nuclear effects in parton distribution func-

tions. However, the experimental focus has been mainly on heavy nuclei. I will present preliminary results from Jefferson Lab experiment E03-103, a high precision measurement of the EMC effect with emphasis on the large x_{Bj} region and few-body nuclei. Data on light nuclei, ^{3}He and ^{4}He, will allow direct comparison to "exact," few-body calculations of the EMC effect and will allow an unambiguous determination of the functional form of the A-dependence of the EMC effect. The large x_{Bj} data are particularly sensitive to conventional nuclear physics effects such as binding and Fermi motion and will constrain models that incorporates these effects. This, in turn, will provide information on the role of these conventional nuclear physics effects at lower x_{Bj} where, more exotic effects are thought to be important.

14:42

Q8 7 Double and target asymmetries for the $ep \rightarrow e'p\pi^0$ production ANGELA BISELLI, *Fairfield University* CLAS COLLABORATION, An extensive experimental program to measure the spin structure of the nucleons is carried out in Hall B with the CLAS detector at Jefferson Lab using a polarized electron beam incident on a polarized target. Spin degrees of freedom offer the possibility to test, in an independent way, existing models of resonance electroproduction. The present analysis selects the exclusive channel $\vec{p}(\vec{e},e',p)\pi^0$ from data taken in 2000-2001, to extract single and double asymmetries in a Q^2 range from 0.2 to 0.75 GeV^2 and a W range from 1.1 to 1.6 GeV. Results of the asymmetries will be presented as a function of the center of mass decay angles of the π^0 and compared with the unitary isobar model MAID [1], the dynamic model by Sato and Lee [2] and the dynamic model DMT [3]. [1] D. Drechsel et al., Nucl. Phys. A **645**, 145–174 (1999). [2] H. Lee, Nucl. Phys. A **513**, 511 (1990). [3] S. S. Kamalov, Phys. Lett. B **522**, 522 (2001).

14:54

Q8 8 Exploration of Short Range Nucleon-Nucleon Correlations at JLab DOUGLAS HIGINBOTHAM, *Jefferson Lab* JEFFERSON LAB HALL A COLLABORATION, Measuring the probability of a nucleon-nucleon short range correlation inside a nucleus has historically been problematic. Competing mechanisms, such as final state re-scattering and meson exchange currents, can produce the same final state as one would expect from an initially correlated pair. Preliminary results of recent Jefferson Lab measurements, performed at kinematics which minimize the effects of such competing mechanisms, will be presented along with a quantitative picture of clustering in the nucleus.

15:06

Q8 9 Study of the Exclusive d(e,e′p)n Reaction Mechanism at High Q^2 NATALIA DASHYAN, KIM EGIYAN, *Yerevan Physics Inst., Armenia and Jefferson Lab, USA* CLAS COLLABORATION, High Q^2 d(e,e′p)n scattering is one of the simplest and best ways to investigate the short range properties of the deuterium wave function (WF), possible modifications of the bound nucleon structure, as well as of the structure and nature of short range nucleon correlations (SRC). For these investigation, the mechanisms of this reaction should be understood properly. Although the d(e,e′p)n reaction is the simplest one, its mechanism remains to be checked at high Q^2: short distances are involved and, therefore, it is unclear what degrees of freedom (nucleonic or quark-gluonic) play a more important role in electron-nucleon interaction. There are also subtle interplays between the interaction of different intermediate exited states of the struck fast nucleon with the second nucleon. To solve these problems the reaction should be investigated as completely as possible, at different kinematic conditions. We investigated the d(e,e′p)n reaction mechanism in the Q^2 = (2 – 6) GeV^2 interval using the CLAS detector at Jefferson Lab. The angular and momentum distributions of recoil neutrons were studied in detail at momenta of p_n = (0 - 2) GeV/c and in angular (relative to the transfered momentum direction) range 20^o - 160^o. The experimental data are compared with the theoretical calculations [1] based on the diagrammatic approach of, and reasonable agreement was obtained at least in the momentum range $p_n \leq$ 1 GeV/c. [1] J.-M. Laget, Phys. Lett. **B609**, 49 (2005).

SESSION Q9: NUCLEAR STRUCTURE
Monday Afternoon, 24 April 2006
Cumberland B, Hyatt Regency Dallas at 13:30
Carlos Bertulani, University of Arizona, presiding

13:30

Q9 1 The correlation of nucleon masses to nuclear stability is investigated E. PAMFILOFF, *UGA, Dept. Phys. and Astro., Optigon R&D, retired* The decay chains and series of unstable isotopes and radioisotopes are studied with particular detailed analysis of nuclei masses and the change in mass experienced by individual nucleons of parent, daughter and product isotopes or other emissions. The data shows a direct correlation between the nucleon mass of a stable product nucleus and that of an unstable parent or daughter nucleon during the transition. This suggests that in addition to proton and neutron quantities, nuclear stability is dependent upon specific mass benchmarks for the nucleons of stable nuclei. It also indicates the probability that 238U is the parent of a series of stable and unstable isotopes situated below the Pb threshold with an unambiguous connection to stable 56Fe nucleons. To confirm these conclusions, the natural and artificial alpha emitter isotopes were also evaluated by the meticulous analysis of nucleon masses relative to the 1H proton. The developed database and system of evaluation allow those decay chain products of uncertain origin to be traced from unstable or stable nuclei back to the immediate source isotope in the series and then to the most probable origin. Often, more than one possible transition source isotope is identified. The system provided good results when tested against the incident and product particles of high and low energy interactions, including events of nuclear transmutation. Every transition from the initial nuclide to the final stable daughter or product demonstrates a strong correlation with a specific mass benchmark per nucleon as a third condition of nuclear stability.

13:42

Q9 2 Moments Method for the Nuclear Density of States EDGAR TERAN, CALVIN JOHNSON, *San Diego State University* We utilize statistical spectroscopy to model the nuclear level density in the interacting shell model. Low-lying statistical moments of each configuration of the shell model space are computed. Partial (configuration) densities are generated from the moments, and the sum of all the contributions is the total level density. Modified Breit-Wigner (MBW) distributions are used to model the partial densities. The properties of such functions allow for exact reproduction of the moments at large asymmetries, which are needed to accurately reproduce the overall level density. We

work in the sd-shell with USD interaction, and the pf-shell with GXPF1, FPD6G an KB3G interactions. Results from level densities generated with method will be shown in the sd-shell and pf-shell, as well as comparisons to exact calculations and experimental data.

13:54

Q9 3 Level density of ^{60}Ni from ^{59}Co(d,n) and ^{58}Fe(^{3}He,n) reactions* A.V. VOINOV, S.M. GRIMES, S.I. AL-QURAISHI, C.R. BRUNE, M.H. HADIZADEH, M.J. HORNISH, T.N. MASSEY, J. O'DONNELL, A. SALAS, *Dept. of Physics and Astronomy, Ohio Univ.* The level density of ^{60}Ni in the region below the particle separation energy has been obtained from neutron evaporation spectra measured in the ^{59}Co(d,n) and ^{58}Fe (^{3}He,n) reactions at the Edwards Accelerator Laboratory at Ohio University. The main limitation of such a technique is an unknown distortion of the neutron spectra due to direct and pre-equilibrium reaction mechanisms. The purpose of this experiment was to measure the level density of ^{60}Ni and estimate the contribution of the direct reaction mechanism, which is expected to be different for different incoming particles. The energy spectra and angular distribution of neutrons have been measured from both reactions. Both angular distributions exhibit a forward peaking shape due to the contribution from direct reaction mechanism The level density function has been extracted from neutron spectra taken from backward angles. The good statistics in the region of known discrete levels of residual ^{60}Ni allowed one the absolute normalization of the obtained level density function. The level densities of ^{60}Ni obtained from both reactions agree well, which indicates that the compound reaction is the major contribution to the differential reaction cross sections taken from backward angles. The Fermi-gas level density parameters have been obtained and compared to systematics.

*Authors acknowledge support from Department of Energy.

14:06

Q9 4 High-spin states in ^{83}Se N. FOTIADES, *LANL* A.F. LISETSKIY, *NSCL/MSU* J.A. CIZEWSKI, *Rutgers* R. KRÜCKEN, *T.U.München* R.M. CLARK, P. FALLON, I.Y. LEE, A.O. MACCHIAVELLI, *LBNL* J.A. BECKER, W. YOUNES, *LLNL* High-spin states in ^{83}Se have been studied following the fission of the ^{226}Th compound nucleus formed in a fusion-evaporation reaction (^{18}O at 91 MeV on ^{208}Pb). The Gammasphere array was used to detect γ-ray coincidences. This is the first observation of high-spin states above the $9/2^+$ ground state of this nucleus and extends the level scheme up to spin $(17/2^+)$. The coupling of the neutron hole in the $g_{9/2}$ orbital, which forms the ground state of ^{83}Se, to the 2^+ and 4^+ yrast states in the ^{84}Se core can account for the first four high-spin states in ^{83}Se. There is generally good agreement between the experimentally observed high-spin states and predictions of shell-model calculations. This work has been supported in part by the U.S. Department of Energy under Contracts No. W-7405-ENG-36 (LANL), AC03-76SF00098 (LBNL) and W-7405-ENG-48 (LLNL) and by the National Science Foundation (Rutgers).

14:18

Q9 5 Internal Conversion Coefficient Measurements of Transitions in ^{167}Lu G. GÜRDAL, *Clark University; WNSL, Yale University* C.W. BEAUSANG, *University of Richmond* D.S. BRENNER, *Clark University* H. AI, R.F. CASTEN, A. HEINZ, E. WILLIAMS, *WNSL, Yale University* B. CRIDER, R. RAABE, *University of Richmond* D.J. HARTLEY, *United States Naval Academy* M. CARPENTER, R.V.F. JANSSENS, T. LAURITSEN, C.J. LISTER, D. SEWERYNIAK, S. ZHU, *Argonne National Laboratory* A.A. HECHT, *Argonne National Laboratory; University of Maryland* J.X. SALADIN, *University of Pittsburgh* Experimental internal conversion coefficients can be used to determine the multipolarities of electromagnetic transitions between nuclear energy levels and thus are valuable for assigning or confirming spins and parities of excited states. The normal and highly deformed bands of ^{167}Lu were populated by the ^{123}Sb(^{48}Ca,4n) reaction. Five fold γ or γ-γ-e coincidence measurements were performed using Gammasphere and ICE Ball arrays at ANL. Internal conversion coefficients were determined for transitions in ^{167}Lu and multipolarities were deduced. The preliminary results of the analysis will be presented. This work was supported by the U.S.D.O.E grants DE-FG02-88ER40417, DE-FG02-91ER-40609, DE-FG-05NA25929, DE-FG02-05ER41379, by the NSF grant number PHY-0300673 and in part by the U.S. Department of Energy, Office of Nuclear Physics, under Contract No. W-31-109-ENG-38.

14:30

Q9 6 Further tests of internal-conversion theory with precise γ- and x-ray spectroscopy. N. NICA, W.E. ROCKWELL, J.C. HARDY, V.E. IACOB, H.I. PARK, J. GOODWIN, *Texas A&M University* M.B. TRZHASKOVSKAYA, *Petersburg Nuclear Physics Institute* Recently we reported [1] a measurement of the K-shell internal conversion coefficient (ICC) of the 80.2-keV $M4$ transition in ^{193}Ir^m. Our result, α_K=103.0(8), agreed well with the value 103.5(1) calculated with the K-shell hole accounted for in the ''frozen orbital'' approximation, and disagreed strongly with the value 92.2(1) calculated when the hole is ignored, a common approach taken in the past. Of the 100 transitions listed and compared with theory in the review by Raman et al. [2], this is the most sensitive to the treatment of the hole. However, there are some other cases listed where experiment disagrees significantly with both types of calculation, making it difficult for one to wholeheartedly endorse the ''frozen orbital'' calculation. As a further step in settling this issue, we report here a measurement of the ratio of α_K values for the 127.5-keV $E3$ transition in ^{134}Cs^m and the 662-keV $M4$ transition in ^{137}Ba. Our preliminary result, α_K(Cs)/α_K(Ba)=30.4(3), should be compared with the experimental ratio quoted in [2], 28.8(5), and with calculated ratios, 30.0 (hole) and 29.5 (no hole). The disagreement between experiment and theory is now removed and, furthermore, our result again points to the calculation that includes the hole. [1] N. Nica et al., Phys. Rev. C **70**, 054305 (2004). [2] S. Raman et al., Phys. Rev. C **66**, 044312 (2003).

14:42

Q9 7 Search for the Wobbling Mode in ^{171}Ta* D.J. HARTLEY, W.H. MOHR, J.R. VANHOY, *US Naval Academy* M.A. RILEY, A. AGUILAR, C. TEAL, *Florida State* R.V.F. JANSSENS, M.P. CARPENTER, F.G. KONDEV, A.A. HECHT, T. LAURITSEN, E.F. MOORE, S. ZHU, *Argonne National Lab* M.K. DJONGOLOV, M. DANCHEV, L.L. RIEDINGER, *Tennessee* G.B. HAGEMANN, G. SLETTEN, *NBI* P. CHOWDHURY, S.K. TANDEL, *Massachusetts-Lowell* W.C. MA, *Mississippi State* S.W. ODEGARD, *Oslo* Perhaps the strongest evidence for a nucleus possessing *stable* triaxial deformation is the observation of a wobbling excitation. Such exotic sequences have been con-

firmed in $\pi i_{13/2}$ bands of $N \approx 94$ Lu nuclei [1], and the region may extend to $N \approx 100$ in Hf nuclei. However, it has not been possible to confirm the presence of wobbling structures in the heavier isotopes [2]. In order to determine whether stable triaxiality plays a role in $N \approx 100$ nuclei, an experiment was conducted to search for the wobbling mode in ^{171}Ta. High-spin states in ^{171}Ta were produced in the ^{124}Sn(^{51}V,4n) reaction and the γ rays were detected with Gammasphere. Although the $i_{13/2}$ band was extended to (101/2), no wobbling structure was identified. The implications of this result on the region of triaxiality will be discussed. [1] S.W. Odegard *et al.*, Phys. Rev. Lett. **86**, 5866 (2001). [2] D.J. Hartley *et al.*, Phys. Lett. B **608**, 31 (2005).

*Sponsored by NSF and DOE under grant nos. PHY-0300673, PHY-0139950, DE-FG02-96ER40983, W-31-109-ENG-38.

14:54

Q9 8 Full major-shell calculation for states that are degenerate in a single-j-shell calculation ALBERTO ESCUDEROS, LARRY ZAMICK, *Rutgers University* SHADOW ROBINSON, *University of Southern Indiana* In a previous work[1], we explained why certain states were degenerate in the single j shell for an interaction in which the isospin $T = 0$ two-body matrix elements were set to zero. The degeneracy splitting was recovered by reintroducing the full interaction. In this work, we perform a full fp-shell calculation with the FPD6 interaction to obtain these energy splittings; the interaction obtained by setting the $T = 0$ matrix elements to zero but keeping the $T = 1$ ones unchanged will be called T0FPD6. Comparing the results with FPD6 and T0FPD6, we can see that most of the splitting in a complete shell calculation (but not all) comes from the $T = 0$ part of the interaction. For example, the $(9_1^+ - 10_1^+)$ splitting in ^{44}Ti is 1.214 MeV for FPD6, but it is only 0.094 MeV for T0FPD6. In ^{47}V, the $(29/2_1^- - 31/2_1^-)$ splitting is 0.780 MeV with FPD6, in agreement with the experimental value of 0.765 MeV, but T0FPD6 yields only 0.072 MeV. In general, we observe a continuity in the splittings between the single-j and the full-fp calculations; only in two cases we see an inversion of the states. These two cases involve low angular momentum states ($1/2^-$ in ^{43}Sc and 3^+ in ^{44}Ti), for which there tends to be much more configuration mixing.

[1]A. Escuderos, B.F. Bayman, L. Zamick, and S.J.Q. Robinson, Phys. Rev. C **72**, 054301 (2005).

SESSION Q10: RARE B DECAYS
Monday Afternoon, 24 April 2006
Cumberland C, Hyatt Regency Dallas at 13:30
Brendan Casey, Brown University, presiding

13:30

Q10 1 Search for the radiative leptonic decay $B \to \gamma \ell \nu_\ell$ GREGORY DUBOIS-FELSMANN, *California Institute of Technology* BABAR COLLABORATION, We present the results of a search for charged B meson decays into $\gamma \ell \nu_\ell$, where $\ell = e, \mu$. We use a sample of approximately 232 million $B\bar{B}$ pairs recorded at the $\Upsilon(4S)$ resonance by the BaBar detector at the PEP-II asymmetric-energy B Factory at SLAC. This decay mode is related to the theoretically clean purely leptonic decay, but with a larger branching fraction due to the lack of helicity supression. An observation of this decay could be used either to evaluate the B meson pseudoscalar decay constant f_B or, with an independent determination of f_B, to test theoretical models of charmless B decays.

13:42

Q10 2 Measurement of exclusive $B \to X_u l \nu$ branching fractions using semileptonic tags SHENJIAN CHEN, *University of Colorado* BABAR COLLABORATION, Using 210 fb^{-1} of $\Upsilon(4S)$ data collected with the BABAR detector at the PEP-II storage ring, we report the result of a measurement of branching fractions of exclusive $B \to X_u \ell \nu$ decays. The accompanying B mesons are tagged with semileptonic $B \to D^{(*)} \ell \nu$ decays.

13:54

Q10 3 Search for $B^0 \to K^{*0} K_S^0$ decay at BaBar STEPHEN FOULKES, *University of California, Riverside* BABAR COLLABORATION, We present the result of a search for rare decays of B mesons into $K^{*0} K_S^0$ where $K^{*0} \to K^+ \pi^-$ and $K_S^0 \to \pi^+ \pi^-$. We use a sample of approximately 227 million B-meson pairs recorded at the $\Upsilon(4S)$ resonance by the BaBar detector at the PeP-II B Factory at SLAC. This decay mode provides input to theoretical studies of rare B decays using flavor-symmetry or factorization methods.

14:06

Q10 4 Search for the rare decays $B \to \rho\gamma$ and $B^0 \to \omega\gamma$ KARSTEN KOENEKE, *Massachusetts Institute of Technology* BABAR COLLABORATION, Rare B decays that follow a $b \to d\gamma$ transition are sensitive to the ratio $|V_{td}/V_{ts}|$ and are a promising probe for new physics. Decays of this type are most easily accessible through the rare decays $B \to \rho\gamma$ and $B^0 \to \omega\gamma$. We present preliminary results of a search for these decays in a sample of approximately 300 million $B\bar{B}$ pairs collected with the BaBar detector at the PEP-II asymmetric-energy B Factory at SLAC.

14:18

Q10 5 Search for rare flavor-changing and electroweak penguin decays of the B_s^0 meson RALF BERNHARD, *Physik Institut der Universitat Zurich, Switzerland* DZERO COLLABORATION, Using 1 fb^{-1} of data collected with the DØ detector in Run II of the Tevatron, limits are presented for searches for the rare flavor changing neutral current decay $B_s^0 \to \mu^+ \mu^-$, as well as $B_s^0 \to \mu^+ \mu^- \phi$. The former decay mode is particularly sensitive to supersymmetric extensions of the Standard Model. For the latter mode, a measurement of the branching ratio could validate the prediction of the Standard Model.

14:30

Q10 6 Lepton-flavour violating decays, $\tau \to l\pi^0 / l\eta / l\eta'$ SANJAY SWAIN, *Stanford Linear Accelerator Center* BABAR COLLABORATION, Searches for lepton-flavor violating decays of τ leptons will be presented, with emphasis on channels lM^0 where l is an electron or muon and M^0 is a π^0, η or η' meson. The analyses use data collected in e^+e^- collisions at a centre-of-mass energy of 10.58 GeV with the BABAR detector at the PEP-II storage rings.

14:42
Q10 7 Search for Lepton Flavor Violation in Υ Decays WILLIAM LOVE, *Pittsburgh* CLEO COLLABORATION, Using the data collected with the CLEO III detector at CESR we report on the first search for Lepton Flavor Violation in the decays of the $\Upsilon(1S)$, $\Upsilon(2S)$, and $\Upsilon(3S)$ resonances. After describing the various components of our unbinned maximum-likelihood fit, we present fits to background data, signal Monte Carlo, and signal data. The discovery of LFV in Υ decays could be explained by low-mass quantum gravity, Abdus-Salam leptoquarks, or neutrino oscillations arising in SUSY models.

14:54
Q10 8 Hadronic spectrum of the $\tau^- \to \pi^-\pi^0\nu$ decay RAHMAT RAHMAT, *University of Oregon* BABAR COLLABORATION, We describe a study of the invariant mass spectrum of the hadronic system in the $\tau^- \to \pi^-\pi^0\nu$ decay, using the BaBar detector at SLAC. We describe how the $\pi^-\pi^0$ spectral function inferred from the invariant mass spectrum can be used as a test of the Conserved Vector Current hypothesis. We also discuss the implications of our study in estimating the hadronic contribution to the muon anomalous magnetic moment.

SESSION Q11: SIMULATIONS OF BINARY BLACK HOLE MERGERS
Monday Afternoon, 24 April 2006
Cumberland E, Hyatt Regency Dallas at 13:30
Carlos Lousto, The University of Texas at Brownsville, presiding

13:30
Q11 1 Accurate Evolutions of Orbiting Black Hole Binaries Without Excision YOSEF ZLOCHOWER, MANUELA CAMPANELLI, CARLOS LOUSTO, *The University of Texas at Brownsville* We present a new technique for evolving moving black holes without excision. Our technique, which is based on a regularization of the standard ''puncture'' approach to the BSSN evolution system, allows for stable evolution of orbiting black-hole binaries. We used this technique to evolve a set of pre-ISCO binaries and show the resulting waveforms as well as the tracks of the individual horizons.

13:42
Q11 2 Unequal-Mass Binary Black Hole Inspirals* DEIRDRE SHOEMAKER, FRANK HERRMANN, PABLO LAGUNA, *Penn State* We present results from fully nonlinear simulations of inspiralling, unequal mass binary black holes. We show waveforms of the dominant $l = 2,3$ modes. The power spectrum of these modes yields insight on how the mass ratio in a binary impacts the degree of complexity of the emitted waveforms. In addition, we provide approximate estimates of energy and angular momentum radiated as well as kick velocities from gravitational radiation recoil.

*Work supported by NSF grants PHY 0114375, PHY-0244788 and PHY-0354821.

13:54
Q11 3 Binary Black Hole Evolutions with Moving Punctures: Methods and Numerical Codes. PEDRO MARRONETTI, WOLFGANG TICHY, *Florida Atlantic University* BERND BRUEGMANN, *University of Jena* Binary Black Holes are strong emitters of gravitational waves and their behavior during the last few orbits can only be accurately described by full general relativistic simulations. Here we present the numerical techniques and programs used for the simulation of such binaries. Our evolutions are performed using the BSSN formulation and the recently introduced ''moving punctures'' technique. We present the details of our numerical setup, as well as gauge choices and boundary conditions.

14:06
Q11 4 Binary Black Hole Evolutions with Moving Punctures: Final orbits, merger and ringdown. WOLFGANG TICHY, PEDRO MARRONETTI, *Florida Atlantic University* BERND BRUEGMANN, *University of Jena* We present results of simulations of black hole binaries in circular orbits covering the last orbit and the merger and ringdown phases. These simulations are performed using the BSSN formulation and the recently introduced ''moving punctures'' technique. We compare different implementations of this technique and discuss how they affect convergence. We also cover in detail the results of our orbiting punctures simulations and their dependence on grid size and resolution. In addition, we discuss quality control curves and constraint satisfaction.

14:18
Q11 5 How to move a black hole JAMES VAN METER, JOHN BAKER, JOAN CENTRELLA, DAE-IL CHOI, MICHAEL KOPPITZ, *NASA/GSFC* Recent demonstrations of uncexcised, puncture black holes traversing freely across computational grids represent a revolutionary advance in numerical relativity. Stable and accurate simulations of multiple orbits, and their radiated waves, have resulted. This capability is critically undergirded by careful choices of gauge and formulation of the evolution equations. Here we describe the relevant techniques, analytically justify their necessity, and numerically demonstrate their efficacy.

14:30
Q11 6 Gravitational waveforms from equal mass binary black hole systems MICHAEL KOPPITZ, JOHN BAKER, DAE-IL CHOI, JOAN CENTRELLA, JAMES VAN METER, *NASA / GSFC* Using recently developed techniques for evolving binary black hole systems we report on evolutions of black holes through orbits, merger, and subsequent ringdown. The evolutions show stability and accuracy such that we can report convergent waveforms and energy conservation. The influence of the initial data is evaluated, the dependency of the dynamics from the initial separation tested, and a heuristic waveform template presented.

14:42
Q11 7 Gravitational Radiation Recoil from Merging Massive Black Hole Binaries* DAE-IL CHOI, *NASA/GSFC, USRA* JOHN BAKER, JOAN CENTRELLA, *NASA/GSFC* MICHAEL KOPPITZ, JIM VAN METER, *NASA/GSFC, NRC* One key area of interest for numerical relativity is calculation of kicks in merging massive black hole binaries where linear momentum, as well as energy and angular momentum, is lost due to asymmetric radiation of gravitational waves. As a result, the merger remnant receives a kick also known as gravitational rocket effect. High kick velocities, comparable or higher than escape velocites of the

host structures, will provide a critical input to our understanding of various aspects of massive black hole evolutions in the universe. I describe a recent calculation of the kick velocities from simulations of the merging massive black hole binaries. Starting from reasonable initial data for quasi-circular configurations of non-equal mass and non-spinning black hole binary, simulations are carried out through merger and ringdown. From mergers with different mass ratio and different initial separations, kick velocities are estimated based on gravitational waveforms extracted in the wave-zone. I discuss astrophysical implications of the magnitude of the kicks.

*Supported by NASA ATP#02-0043-0056.

SESSION Q12: BARYONS AND B LIFETIME STUDIES
Monday Afternoon, 24 April 2006
Cumberland F, Hyatt Regency Dallas at 13:30
William T. Ford, University of Colorado, presiding

13:30

Q12 1 Production of Charm Baryons in CDF II ELENA VATAGA, *University of New Mexico* CDF COLLABORATION, Using the data collected with the CDF Run II detector preliminary results on ground state charm baryon Λ_c^+ and $\Sigma_c^{++,0}$ will be presented. The results are based on a large data sample made available by the displaced track trigger. The results on $\Sigma_c^{++,0}$ are the measurements made at Tevatron hadron collisions for the first time.

13:42

Q12 2 BaBar Searches for Double Charm Baryons ADAM EDWARDS, *Stanford University* BABAR COLLABORATION, We present the results of searches for $\Xi_{cc}^+ \rightarrow \Lambda_c^+ K^- \pi^+$ and $\Xi_{cc}^{++} \rightarrow \Lambda_c^+ K^- \pi^+ \pi^+$. The decay $\Lambda_c(2880) \rightarrow \Lambda_c^+ \pi^- \pi^+$ is used as a control and reference mode. We search wide mass regions for the Ξ_{cc}^+ and Ξcc++baryons that include several previously reported signals and theoretical predictions. Experimentally observing double charm baryons is a major step in scrutinizing predictions involving diquarks in theoretical QCD. Our data set was collected with the BaBar detector at the PEP-II e^+e^- storage rings and consists of 210 fb-1 collected on theY(4S) resonance, and 22 fb-1collected approximately 40MeV below this resonance.

13:54

Q12 3 Studies in heavy baryon chiral perturbation theory T. BRIAN BUNTON, *Duke University* We investigate heavy baryon chiral perturbation theory (HBChPT) and its convergence properties by considering different power counting schemes and higher order terms. We apply these modifications to strong decays of the decuplet baryons and to axial currents of the octet baryons. Then we turn to weak decays of the octet and decuplet. We hope to improve the extraction of low energy constants of the theory with the goal of providing improved predictions for octet and decuplet baryon observables, including those involved in hypernuclear decay.

14:06

Q12 4 Numerical calculations of electromagnetic contributions to baryon masses PHUOC HA, *Towson University* We calculate numerically the electromagnetic contributions to the baryon masses which we analyzed recently using the heavy-baryon approximation in chiral effective field theory and methods developed in our earlier analyses of the baryon masses and magnetic moments. We find that the effects of the quark masses, the Coulomb and moment-moment interactions, and the mesonic corrections account fairly well for a pattern of coefficients in a mass-difference Hamiltonian that describes well the accurately known baryon mass splittings.

14:18

Q12 5 B^+, B^0, B_s^0, Λ_B lifetimes and lifetime ratios. CHUNLEI LIU, *University of Pittsburgh* CDF COLLABORATION, We present new, high-statistics measurements of b hadron lifetimes from exclusive decays containing a J/ψ selected using a dimuon trigger in CDF. The analysis uses about 800 pb^{-1} of data from Run II of the Tevatron collider. In addition to the channels $B^+ \rightarrow J/\psi K^+$, $B^0 \rightarrow J/\psi K^{0*}$, $B^0 \rightarrow J/\psi K_s^0$, which are well measured at B factories, we measure lifetimes of Λ_b and B_s^0, (unique to the Tevatron) in the channels $B_s^0 \rightarrow J/\psi\phi$ and $\Lambda_b \rightarrow J/\psi\Lambda^0$. Systematic errors in the ratios of lifetimes are minimized by the consistent use of the J/ψ vertex across all decay channels, to estimate proper decay time.

14:30

Q12 6 Monte Carlo Free Estimation of the B^+ Meson Lifetime Using a Hadronic Decay Mode AZIZUR RAHAMAN, *University of Oxford* CDF COLLABORATION, We present a new measurement of the B^+ meson lifetime from exclusive decays ($B^+ \rightarrow \overline{D^0}\pi^+$), selected using CDF's hadronic B trigger from about 800 pb^{-1} of data from Run II of the Tevatron collider. The bias induced by this trigger is corrected on an event-per-event basis, using observed kinematic event variables, with no dependence on Monte Carlo simulation. The analysis is complementary to CDF's previously published analyses, which uses an efficiency curve obtained from simulation, and has independent systematic uncertainties.

14:42

Q12 7 Measurement of the Λ_b lifetime in $p\bar{p}$ Collisions at $\sqrt{s}$ = 1.96 TeV MICHAEL SCHMIDT, *Johns Hopkins University* CDF COLLABORATION, The lifetime of the Λ_b baryon is presently the most interesting of all b-hadron lifetimes, and at the same time the least well known experimentally. We study the lifetime of the Λ_b baryon using $\Lambda_b \rightarrow \Lambda_c^+ \pi^+$ decay mode in 360 pb^{-1} of CDF data. Our $\Lambda_b \rightarrow \Lambda_c^+ \pi^+$ sample has in excess of 1400 events and is the largest sample of Λ_b decays in existence. We study the effects of the trigger bias and the presence of physics backgrounds on the measurement of the lifetime of Λ_b.

14:54

Q12 8 Λ_b lifetime measurement using semileptonic decays at DØ MARCUS LEWIN, *Lancaster University* DZERO COLLABORATION, Using approximately 1 fb^{-1} of data collected by the DØ detector in Run II, a sample of over 2000 $\Lambda_b \rightarrow \Lambda_c \mu X(\Lambda_c \rightarrow K_s p)$ decays has been reconstructed. We present preliminary results of a measurement of the Λ_b lifetime using this sample.

15:06
Q12 9 Study of the form factor in semileptonic Λ_b decays ABAZ KRYEMADHI, *University of Virginia* DZERO COLLABORATION, We measure the Λ_b baryon form factor using the exclusive decay $\Lambda_b^0 \to \Lambda_c^+ \mu^- \bar{\nu}$ followed by $\Lambda_c^+ \to p^+ K_S^0$ and $K_S^0 \to \pi^+ \pi^-$. The data sample corresponds to an integrated luminosity of approximately 1 fb^{-1}, recorded with the DØ detector in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. We present a preliminary result on the Isgur-Wise slope.

SESSION Q13: PARTICLE SEARCHES II
Monday Afternoon, 24 April 2006
Cumberland G, Hyatt Regency Dallas at 13:30
Beate Heinemann, University of Liverpool, presiding

13:30
Q13 1 Minimal Supergravity with $m_0^2 < 0$ BRYAN SMITH, JONATHAN FENG, ARVIND RAJARAMAN, *University of California, Irvine* We extend the parameter space of minimal supergravity to negative values of m_0^2, the universal scalar mass parameter defined at the grand unified scale. After evolving to the weak scale, all scalars can be non-tachyonic with masses consistent with collider constraints. This region of parameter space is typically considered excluded by searches for charged dark matter, since the lightest standard model superpartner is a charged slepton. However, if the gravitino is the lightest supersymmetric particle, the charged slepton decays, and this region is allowed. This region provides qualitatively new possibilities for minimal supergravity, including spectra with light sleptons and very heavy squarks, and models in which the lightest slepton is the selectron. We show that the $m_0^2 < 0$ region is consistent with low energy precision data and discuss its implications for particle colliders. These models may provide signals of supersymmetry in even the first year of operation at the Large Hadron Collider.

13:42
Q13 2 Search for Multi-photon Signatures in $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV OLEKSIY ATRAMENTOV, *Iowa State University* D0 COLLABORATION, A preliminary cross section for the inclusive multiphoton production is presented, as measured by the Run II DØ detector at the Fermilab Tevatron $p\bar{p}$ collider. Photon candidates with transverse momenta greater than 15 GeV/c and within the pseudorapidity of $|\eta| < 2.5$ are considered. Selection criteria for photon candidates as well as the estimation of background contributions from QCD and EW processes are presented. Event topologies with $\gamma\gamma\gamma + X$ in the final state which are relevant for fermiophobic Higgs boson searches in two Higgs doublet and triplet models are emphasized. Preliminary limits on the mass of fermiophobic Higgs boson are set.

13:54
Q13 3 Search for Randall-Sundrum excitations of gravitons decaying into two photons for CMS at LHC VLADIMIR LITVIN, H. NEWMAN, *California Institute of Technology* M.-C. LEMAIRE, *Saclay, France* CMS COLLABORATION, The CMS detector discovery potential for resonant production of the massive Kaluza-Klein excitations predicted by the Randall-Sundrum model is studied. Full simulation and reconstruction are used to study the diphoton decay of Randall-Sundrum gravitons. For an integrated luminosity of 30 fb^{-1}, the diphoton decay of Randall- Sundrum gravitons can be discovered at the 5σ level for masses up to 1. $61 TeV/c^2$ for the case of weak coupling between graviton excitations and Standard model particles (c = 0.01). Heavier resonances can be detected if the coupling is larger (c = 0.1), with a mass reach of 3.95 TeV/c^2.

14:06
Q13 4 Sensitivity to Contact Interactions from Quark Compositeness at CMS SELDA ESEN, *FNAL* ROBERT HARRIS, *FNAL* CMS COLLABORATION, CMS will measure dijets in proton-proton collisions at $\sqrt{s}$ = 14 TeV. The angular distribution of dijets as a function of invariant mass is sensitive to a contact interaction among quarks that could arise if quarks are not point-like particles. The sensitive part of the angular distribution is measured by the dijet ratio: the number of dijet events with $|\eta| < 0.5$ divided by the number of dijet events with $0.5 < |\eta| < 1.0$. As a function of dijet invariant mass, we present estimates of the dijet ratio for both the QCD background and a contact interaction signal. For integrated luminosities of 100 pb^{-1}, 1 fb^{-1} and 10 fb^{-1}, we present CMS capability to exclude or discover contact interactions from quark compositeness.

14:18
Q13 5 Sensitivity to Dijet Resonances at CMS KAZIM GUMUS, NURAL AKCHURIN, *Texas Tech University* SELDA ESEN, ROBERT HARRIS, *FNAL* CMS COLLABORATION, CMS will measure the dijet mass spectrum in proton-proton collisions at $\sqrt{s}$ = 14 TeV and will search for narrow resonances. For an integrated luminosity of 1 fb^{-1} the measured dijet mass spectrum of the QCD background is expected to extend from 0.3 to 6 TeV for jet $|\eta| < 1$. For integrated luminosities of 100 pb^{-1}, 1 fb^{-1} and 10 fb^{-1}, we present CMS capability to exclude or discover several models of narrow dijet resonances: excited quarks, axigluons or colorons, E6 diquarks, color octet techirhos, Randall-Sundrum gravitons, and new electoweak gauge bosons W′ and Z′.

14:30
Q13 6 Search for Heavy Right-handed Quarks in the Electron-Muon+X channel MARSHALL COLLIN WOLFE, *University of Chicago* CDF COLLABORATION, We present a search for new, heavy objects in the electron-muon channel at CDF using 300 pb^{-1} of data. To probe the reach of the search, we set a cross section limit on a 300 GeV right handed down type quark predicted by Bjorken, Pakvasa and Tuan.

14:42
Q13 7 Search for long-lived neutral particles TODD ADMAS, *Florida State University* DZERO COLLABORATION, We have performed a search for a relatively long-lived neutral particle using the DØ experiment. The particle is allowed to decay significantly away from the production (at least 5 cm), but still within the inner tracking detector. We search for a decay to two muons and missing energy, using the muon tracks to identify the displaced vertex. Background is found to be small and estimated from the data. We present the results of our search and a comparison to the limit set by NuTeV for dimuon events in the 3–15 GeV mass region.

SESSION Q14: HISTORY OF PHYSICS
Monday Afternoon, 24 April 2006
Cumberland I, Hyatt Regency Dallas at 13:30
Robert H. Romer, Amherst College, presiding

13:30

Q14 1 Was Nazi Germany on the Road to an Atomic Bomb after all? HARRY LUSTIG, *The City College of the City University of New Yrok (emeritus)* The story of Germanys efforts to develop a nuclear weapon during World War II is a much written about and contentious subject. However there has been agreement on one thing: by the end of the War the Germans had not achieved and were nowhere near to building a bomb. The dispute therefore has been about why Germany did not succeed. Now, from Germany, comes a challenge to this truth, in the provocative book ''Hitlers Bombe'' by Rainer Karlsch. The bombshell in ''Hitlers Bombe'' is the assertion that German scientists developed and tested a primitive fission and fusion nuclear weapon in March 1945. Karlsch bases this claim on testimony of witnesses in 1962, previously secret Russian documents, and the results of soil tests carried out in 2004 and 2005. However the physics is very murky and it seems out of the question that Germany had enough Uranium 235 or produced any Plutonium for a bomb. ''Hitlers Bombe'' also makes other, better documented and more credible revisionist assertions. These include the claim that the Nazis did continue to try to build a bomb after 1942 and that not Werner Heisenberg, but Kurt Diebner and Walther Gerlach were then the leaders of the German Uranium project. Karlschs book therefore deserves more attention from physicists and historians than it has received in the United States.

13:54

Q14 2 Einstein and Oskar Klein: The Fifth Dimension as a Bridge across Quantum Chasms PAUL HALPERN, *Univerisity of the Sciences in Philadelphia* In the mid 1920s, various physicists grappled with the underlying mechanisms for quantization. While at Ann Arbor, Oskar Klein developed a deterministic theory based upon the assumption of an undetectable fifth-dimension. With the rise of modern quantum mechanics, Klein, along with his colleagues, embraced the idea of wave functions acting in Hilbert space, and abandoned, for a time, the concept of an extra physical dimension. During the same period, Einstein, in contrast, began to explore five-dimensional unified field theories—first along with Walther Mayer, then with Peter Bergmann and Valentine Bargmann. This talk will explore connections—conceptual and philosophical—between Einstein's and Klein's theories, analyze the differences, examine the correspondence between the two theorists, and delve into the reasons each came to embrace and abandon the idea of the fifth dimension.

14:18

Q14 3 SED Alumni—Breeding ground for scientists BENJAMIN BEDERSON, *New York University* In 1943 the US Army established the Special Engineering Detachment (SED), in which mostly drafted young soldiers possessing some scientific credentials (though usually quite minimal) were reassigned from other duties to the Manhattan Project to assist in various research and development aspects of nuclear weapons. The Los Alamos contingent, never more than a few hundred GIs, worked with more senior scientists and engineers, often assuming positions of real responsibility. An unintended consequence of this circumstance was the fact that being in the SEDs turned out to be a fortuitous breeding ground for future physicists, chemists, and engineers. SEDs benefited from their close contacts with established scientists, working with them side by side, attended lectures by luminaries, and gained invaluable experience that would help them establish academic and industrial careers later in life. I will discuss some of these individuals (I list only those of whom I am personally aware). These include Henry ''Heinz'' Barschall,* Richard Bellman*-RAND Corporation, Murray Peshkin-ANL, Peter Lax-Courant Institute, NYU, William Spindel*-NRC,NAS, Bernard Waldman- Notre Dame, Richard Davisson*-U of Washington, Arnold Kramish-RAND, UNESCO, Josef Hofmann-Acoustic Research Corp, Val Fitch-Princeton U. *Deceased.

14:42

Q14 4 Rosenfeld, Bergmann, and the Invention of Constrained Hamiltonian Dynamics DONALD SALISBURY, *Austin College* Significant progress in the invention of constrained Hamiltonian dynamics was made by Leon Rosenfeld in a paper he published in the Annalen der Physik in 1930. He applied his general formalism to general relativity with electrodynamical field and Dirac electron sources. His proposed Hamiltonian will be compared and contrasted with an independently developed precursor investigated by Peter Bergmann and collaborators in 1949–50.

15:06

Q14 5 Historic Patterns in Astronomical Incomprehension VIRGINIA TRIMBLE, *UC Irvine & Las Cumbres Observatory* Because astronomy is old, it has had a chance to display some very prolonged battles in the war between ideas (theories) and observations (data) that we call science. It is possible to discern two major patterns – data leading vs. ideas leading – and very short to very long durations of the events that eventually led to understanding. A variant has the community converging with vigor around a wrong answer (gamma ray bursters are a recent example). The talk will explore some of the author's favorite examples of each pattern. These include the rapid basic understanding of quasars and pulsars vs. the extremely long times required to figure out the solar corona and pulsating variable stars. Among the cases where theory has led via prediction, discovery was almost immediate for 21 cm radio emission and superluminal motion in quasars, but very slow for fluctuations in the cosmic microwave background radiation, certain kinds of polarization, and (surely a record never to be broken) heliocentric parallax.

SESSION R1: POSTER SESSION: MAGNETICALLY CONFINED PLASMA II
Monday Afternoon, 24 April 2006
Landmark Circle, 2:00pm–5:00pm, Hyatt Regency Dallas at 14:00

R1 1 Particle-based closure relations for Neoclassical MHD Studies* D. SPONG, S.P. HIRSHMAN, D. DEL-CASTILLO NEGRETE, E. D'AZEVEDO, R. MILLS, M. FAHEY, *ORNL* The nonlinear dynamics of neoclassical MHD tearing modes (NTM) are significantly influenced by the variation of the local (perturbed) bootstrap current within magnetic tearing mode island regions. The bootstrap current is introduced into the MHD equations

through closure relations involving the parallel component of the pressure tensor. The three-dimensional magnetic field structure within island regions, coupled with the need to retain one and possibly tw velocity dimensions motivates the use of Monte Carlo methods. We have adapted the DELTA5D stellarator particle code for the calculation of such closure relations. A new delta-f partitioning has been used so that plasma flows and gradients can be held constant while viscous coefficients are calculated by the particle code. This method has been successfully tested against the DKES code for axisymmetric equilibria. Second, an improved compressed representation of the magnetic field data has been developed using principal orthogonal decomposition methods and singular value decomposition. This has been applied to data from the M3D MHD code and should lead to improved performance and a decreased memory footprint for the particle calculation.

*This work was performed at Oak Ridge National Laboratory, managed by UT-Battelle, LLC, for the U.S. Dept. of Energy under contract DE-AC05-00OR22725.

R1 2 Blobs, momentum transport and tokamak rotation* J.R. MYRA, D.A. D'IPPOLITO, D.A. RUSSELL, *Lodestar Research Corp.* S.I. KRASHENINNIKOV, *UCSD* B. COPPI, *MIT* This paper examines how instabilities in the vicinity of the last closed surface (LCS) can provide a mechanism for tokamak rotation. Our hypothesis is: (i) that edge instabilities saturate by the generation of filamentary coherent structures (blobs) which convect radially outward towards the wall; and (ii) when the underlying unstable waves have a preferred phase velocity, momentum can be transferred to the blobs and lost from the core plasma, providing a recoil force that rotates the core. To test these ideas, a simple two field (2D PDE) model similar to the Wakatani-Hasegawa and blob models is proposed which embodies the essential features of electrostatic drift wave instability and curvature-driven blob transport in a layer near the LCS. The resulting equations are solved numerically in the strong (order unity fluctuation) limit. Then, employing an exact momentum conservation law, we derive a diagnostic to account for momentum flow across the LCS, and use it to obtain the net edge momentum source for tokamak rotation due to turbulence-generated ExB flows.

*Supported by USDOE grant DE-FG02-97ER54392.

R1 3 A Gyrotron-Powered Pellet Accelerator for Tokamak Fueling* P.B. PARKS, F.W. PERKINS, *General Atomics* A novel pellet acceleration concept [1] using microwave power from MW gyrotron sources has been developed that could pave the way for high-speed $>$ 3 km/s inner-wall pellet injection on ITER-class tokamaks. The concept is based on the principal of a gun, where a high-pressure propellant gas drives the projectile down the barrel. In the proposed concept, the high gas pressure is created by evaporative explosion of a composite ''pusher'' medium attached behind the DT fuel pellet. The pusher consists of micron-sized conducting particles, (Li, Be, C) embedded uniformly in a D_2 ice slug with $<$ 5% volume concentration, thus facilitating microwave energy absorption by dissipation of eddy currents flowing within the conducting particles only. Microwave power is delivered to the pusher along a waveguide, which also serves as the pellet launch tube. A scaling law predicts that a pellet of mass M accelerated over a distance L reaches a velocity $v \cong (PL/M)^{1/3}$, where P is the gyrotron power. [1] P. Parks & F. Perkins, US patent application ''Microwave-Powered Pellet Accelerator,'' No. 11/256/662, October 21, 2005.

*Work supported by the US DOE under DE-FG03-95ER54309.

R1 4 Gyrokinetic particle simulation of global Alfven modes in toroidal geometry IGOR HOLOD, ZHIHONG LIN, YASUTARO NISHIMURA, *University of California, Irvine* Global Alfven modes are important for energy confinement studies, since thay can resonantly interact with fusion alfa-particles. The electromagnetic version of GTC PIC code has been devoloped in order to be capable to describe these modes. In the code ions are treated kinetically, while electrons are adiabatic in the zeroth order of an expansion based on the smallness of electron-to-ion mass ratio. Toroidal coupling of different shear Alfven modes leads to the apperance of gaps in the continuum frequency spectrum. Inside these gaps Toroidal Alfven Eigenmodes (TAE) can exist. Keeping electromagnetic effects by taking into account magnetic field perturbations in the simulations, gives us a possibility to observe various Alfven modes, in particular TAE. Starting with random perturbations of vector potential, the shear Alfven modes die out due to the continuum damping and the dstinctive peaks inside TAE frequency gaps are observed. Linear dispersion relation of the observed modes is compared with analytical theory to benchmark the simulations.

R1 5 Regularization of Transport Bifurcation Models* L. BERIA, M.A. MALKOV, P.H. DIAMOND, *CASS and Physics Dept., UCSD* A simple theoretical understanding of what regulates the width of both ITB and H-mode layers remains elusive. One-field models ''solve'' the problem via the Maxwell construction, and related phase coexistence criteria. Unfortunately, an interesting barrier model must evolve two independently driven fields, such as density and temperature. We present an analytical solution of a simple two-field model. The problem of regularization, encountered previously, is solved by retaining pressure profile curvature effects in the electric field shear. Retaining such effects allows us to determine when a transition actually occurs within the interval of possible transitions. In fact, transitions are predicted to occur at the lower end (in heating power) of the co-existence range. This softens threshold requirements. A testable consequence of this approach is that the model predicts that transitions may occur in regimes of flat density. Ongoing work is aimed at exploring the effect of noise.

*Supported by US DoE.

R1 6 Momentum transport in magnetic islands F.L. WAELBROECK, *Institute for Fusion Studies, U. Texas* D. GRASSO, F. PORCELLI, C. TEBALDI, *Politecnico de Torino, Italy* We examine the transport of momentum across an island using the reduced magnetohydrodynamic (RMHD) model. We find that the Reynolds stress gives rise to a momentum source proportional to the resistivity. As a result of the frozen-in property the transport of momentum can be described by a one-dimensional equation, even for islands with finite aspect-ratio. We present numerical and analytic solutions of this transport equation and compare these solutions to numerical solutions of the full time-dependent RMHD equations. Of particular interest is the momentum transport in islands where the helical current density reverses sign. In such islands, the Reynolds stress also reverses sign, creating the possibility for localized zonal flow generation.

The constant-psi approximation, however, fails in the presence of current reversal. We have developed new equilibrium solutions for thin islands that we plan to use to examine the transport of momentum in the presence of current reversal.

R1 7 The Effects of Improved Equilibrium Accuracy on Resistive DCON* ALAN H. GLASSER, *Los Alamos National Laboratory* Numerical computation of the outer region matching data for resistive and other singular MHD modes of axisymmetric toroidal plasmas is much more sensitive to errors in the equilibrium solution of the Grad-Shafranov Equation (GSE) than corresponding ideal MHD stability analysis. While many direct and inverse GSE solvers are capable of producing sufficiently accurate solutions for ideal analysis, most have difficulty achieving adequate resolution and iterative convergence for resistive analysis. We have developed a Grad-Shafranov refiner using high-order spectral elements to improve on the accuracy of such solutions. The direct form of the GSE is solved iteratively, starting from an inaccurate initial solution, to obtain a highly accurate final solution, using the flux coordinates of the initial equilibrium, then mapped to a new refined inverse form. The effects of improved accuracy on resistive DCON will be shown.

*This work was supported by DOE Contract No. W-7405-ENG-36.

R1 8 Characteristics of impurity production and transport in ITER edge plasmas* T.D. ROGNLIEN, R.H. BULMER, M.E. RENSINK, *LLNL* J.N. BROOKS, *ANL* The mixed-material (C, W, Be) aspect to the ITER wall makes it especially important to model to determine the intermixing of materials owing to spatial transport and redeposition of sputtering materials. Here the 2D UEDGE transport code includes both lower and (more remote) upper X-points to model the edge plasma with the possible existence of strong convective radial transport. The charge-exchange neutral hydrogen flux to the wall is assessed with the DEGAS 2 Monte Carlo neutral code. The impurity level in the edge plasma and the spatially dependent redeposition fluxes of different impurities are modeled from the multi-component fluid model using approximate sputtering rates. The fluid results are also compared to the WBC ion Monte Carlo code. The WBC model includes a more detailed sputtering model and kinetic effects that can be important in the low density and near-surface regions.

*Work performed under the auspices of USDOE by UC LLNL contract No. W-7405-ENG-48, and also for USDOE by ANL.

R1 9 UEDGE Simulation of Triple-X Divertors J. WILEY, M. KOTSCHENREUTHER, P. VALANJU, M. PEKKER, *IFS Univ of Texas at Austin* T. ROGNLIEN, *LLNL* Novel magnetic divertors with additional X-points downstream from the main plasma X-point have been proposed to overcome reactor heat flux limitations. These divertor designs may allow a fully detached state at the divertor plate - without the poor confinement and disruptive tendencies by avoiding x-point MARFEs found in conventional divertor magnetic geometries. These new configurations are examined using UEDGE for existing machines that are considering experimental implementation of these divertors: PEGASUS, MAST, and EAST (Chinas new long-pulse, superconducting tokamak) as well as proposed reactor designs.

R1 10 Resistive MHD simulations in support of SSPX* E.B. HOOPER, B.I. COHEN, L.L. LODESTRO, *LLNL* C.R. SOVINEC, *U. Wisc.* The SSPX spheromak has obtained Btor > 0.6T, Te=350eV and t(pulse)$\approx$ 3ms. NIMROD simulations are used to interpret results, guide experiments, and explore upgrades. Voltage spikes during formation and sustainment are interpreted as reconnection across an n=1, negative-current layer close to the mean-field x-point. Field lines are chaotic during these events, causing rapid electron energy loss to the walls; Te$<$ 50eV in experiment and simulation during strong helicity injection. Sustainment occurs at a high ratio of gun current to bias flux. During slow plasma decay at low gun current, high Te results when magnetic fluctuations are low ($<$ 1%). If q crosses low-order rational surfaces, islands form causing reduced energy confinement. Fieldlines can become chaotic (Lyapanov length $> 4\pi$R); if they reach walls Te drops to $<$ 50eV. Changing Zeff=1 to 2.3 (SSPX value) increases ohmic heating and decreases parallel thermal conduction, affecting spheromak evolution. An experimental upgrade to allow bias field reduction following formation may allow increased efficiency operation.

*Work performed under auspices of the U. S. DOE by U. California LLNL under contract No. W-7405-Eng-48.

R1 11 Application of GTC-Neo neoclassical transport code for realistic tokamak cases* G. REWOLDT, W.X. WANG, J. MANICKAM, W.M. TANG, *Princeton Plasma Physics Lab* The GTC-Neo neoclassical transport code [W.X. Wang et al, Comp. Phys. Commun. **164**, 178 (2004)] calculates neoclassical transport quantities for tokamaks, including particle, momentum, and energy fluxes, poloidal velocities, and radial electric fields. It is interfaced with numerically-calculated non-circular-cross-section MHD equilibria. Unlike previous calculations, it includes effects of finite orbit width (banana width), for both standard and non-standard orbits. Using input data from experimentally-derived TRANSP calculations, the GTC-Neo code has now been applied to nine NSTX shots, in both L- and H-modes, and one DIII-D shot. The GTC-Neo simulations suggest that there may exist nonlocal features in the ion neoclassical transport for NSTX plasmas. There is additional ''nonlocal smoothing'' in the ion heat flux profile. While GTC-Neo results are sometimes comparable to standard (NCLASS) neoclassical results, the included finite-orbit-width effects generally bring the simulated ion heat transport closer to the experimental measurements. For an ITB case, GTC-Neo gives a larger electric field peak than NCLASS, at the ITB location. A limitation of the GTC-Neo code now is the inclusion only of electrons and one hydrogenic ion species; it is planned to add an impurity species to the GTC-Neo calculation in future work.

*Work supported by U.S. DOE Contract No. DE-AC02-76-CHO-3073 and by SciDAC GPS Center.

R1 12 Nonlinear stability of rotating plasmas in a mirror geometry* A. Y. AYDEMIR, *Institute for Fusion Studies, The University of Texas at Austin, TX 78712* In a previous work, we studied the magnetohydrodynamic (MHD) equilibrium and stability of a mirror plasma in which a strong azimuthal rotation is driven by an externally applied radial electric field.[1] Although the interchange-stabilization through flow-shear[2] was confirmed, centrifugally confined ''detached states'' obtained in this geometry were found to be linearly unstable to a wide range of other fluid modes driven by the rotation itself. These negative linear stability results left open the question of whether the unstable modes would

be nonlinearly stabilized at modest amplitudes or have catastrophic consequences. The goal of the present work is to follow their nonlinear evolution and determine their effect on confinement. [1] A. Y. Aydemir, Phys. Plasmas **11**, 5065 (2004). [2] Yi-Min Huang and A. B. Hassam, Phys. Rev. Lett. **87**, 235002-1 (2001).

*Work supported by U.S. Department of Energy Contract No. DE-FG03-96ER-54346.

R1 13 Dilemma of Drift-Tearing Modes* V. ROYTERSHTEYN, B. COPPI, C. CRABTREE, *MIT* The theory of the drift-tearing mode [1] predicts that in the presence of a realistic transverse electron temperature gradient the mode is stable due to the effects of electron Landau damping or parallel electron thermal conductivity in both collisionless [2] or weakly collisonal [3] regimes typical of modern day experiments on magnetically confined plasmas. The apparent contradiction of this result with the relevant experimental observations calls for consideration of effects outside the scope of conventional linear theory. A radial local ''dip'' in the longitudinal electron thermal conductivity has been shown to restore a significant mode growth rate [4]. A more drastic option is a local flattening of the radial electron temperature profile. We argue that the presence of background short-wavelength microturbulence, associated with Inhomogeneous Electron Temperature (IET) modes can increase the longitudinal ''thermal resistivity'' locally and lower the excitation threshold of drift-tearing modes. [1] B. Coppi, Phys. Fluids, **8** 2273 (1965); [2] B. Coppi et al., Phys. Rev. Letters, **42**, 1058 (1979); [3] J. Drake et al., Phys. Fluids, **25**, 2509 (1983); [4] V. Roytershteyn et al., Paper P2-27, 2005 Sherwood Conference.

*Supported in part by the U.S. D.O.E.

R1 14 Magnetic topology effects on ion flows* ANDREI N. SIMAKOV, *Los Alamos National Laboratory* PETER J. CATTO, *MIT Plasma Science and Fusion Center* We consider the effect of magnetic topology on the Pfirsch-Schlüter flows inside the separatrix of a tokamak for reversal in the direction of (i) the plasma current or poloidal magnetic field, (ii) the toroidal magnetic field, or (iii) both; and for (iv) a switch between lower and upper X-point operation. We find that the results of the magnetic topology changes on the flows observed in Alcator C-Mod are consistent with the predictions of neoclassical theory when both the up-down symmetric and up-down asymmetric drives for toroidal rotation are retained.

*Work supported by U.S. D.o.E.

R1 15 Nonlinearly driven second harmonic of Alfvén cascades* B. N. BREIZMAN, *The University of Texas at Austin* H. SMITH, M. LISAK, D. ANDERSON, *Chalmers University of Technology, Göteborg, Sweden* In recent experiments on Alcator C-Mod [J.A. Snipes et al., Phys. Plasmas **12**, 056102 (2005)], measurements with Phase Contrast Imaging through the plasma core show a second harmonic of the basic Alfvén cascade (AC) signal. The present paper describes a theory that interprets the second harmonic perturbation as a nonlinear sideband produced by the Alfvén cascade eigenmode via quadratic terms in the magnetohydrodynamic equations. It is shown that in a low-pressure plasma the non-linear coupling to compressional Alfvén perturbations and acoustic perturbations can be neglected when calculating the second harmonic intensity. The derived expressions for the second harmonic density perturbation can be used together with the experimental measurements to determine the AC amplitude inside the plasma, rather than just at the edge as with magnetic probes.

*Work supported by the U.S. DOE Contract No. DE-FG03-96ER-54346 and by Euratom.

R1 16 Particle-in-cell simulations of electromagnetic turbulence with kinetic electrons JEROME LEWANDOWSKI, *Princeton University* The accurate treatment of electron dynamics in global (toroidal) particle-in-cell simulations is a considerable challenge from the numerical standpoint. The large thermal velocity of the (transit) electrons imposes a stringent condition on the time step for a brute force method. In the electrostatic case, it has been shown that the splitting scheme [1] for the electron dynamics is more accurate, both in the linear and nonlinear regimes, that the conventional perturbative delta f scheme. We present the electromagnetic version of the splitting scheme and specifically discuss the issues of energy and momentum conservation properties, the importance of the initial loading in phase space [2], and the spatial and time resolution requirements. [1] J.L.V. Lewandowski, Physics of Plasmas **8**, 3204 (2003). [2] J.L.V. Lewandowski, Physics Letters A **313**, 291 (2003).

R1 17 Pressure Gradient Effects on Alfven Cascade Modes in Tokamaks G.Y. FU, *Princeton Plasma Physics Laboratory* H.L. BERK, *Institute for Fusion Studies* Alfven cascade modes are discrete shear Alfven eigenmodes localized at the radius of minimum of safety factor in tokamak plasmas with reserved shear q profiles [1]. The mode frequency is given by $\omega \sim (n - m/q_{min})V_A/R$ over most parameters, and transforms to the geodesic acoustic mode near rational field lines. The mode is seen in experiments, where the mode frequency sweeps up as q drops. Numerical results indicate that the plasma pressure gradient helps establish the mode [2], in contrast to a previous analytic prediction [3] that the pressure gradient term hinders mode establishment. here a modification of the analysis is developed to include a previously neglected interchange term due to the favorable average curvature of a tokamak. This is the key addition that is needed for the pressure gradient to be favorable for the establishment of a cascade mode, and thereby explain the numerical results. [1] H. L. Berk et al., Phys. Rev. Lett. **87**, 185002 (2001). [2] G. J. Kramer et al., Plasma Phys. Controlled Fusion **46**, L23 (2004). [3] B. N. Breizman et al., Phys. Plasmas **12**, 112506 (2005).

R1 18 Phase space gradient driven descrete compressional Alfven eigenmodes in NSTX and DIII-D NIKOLAI GORELENKOV, ERIC FREDRICKSON, *PPPL, Princeton University* WILLIAM HEIDBRINK, *University of California, Irvine* The spectrum of Compressional Alfvén Eigenmodes (CAE) is analyzed and shown to be discrete in tokamaks with low aspect ratio, such as NSTX, as well as in the DIII-D. The study is focused on recent similarity experiments on NSTX and DIII-D in which sub-cyclotron frequency instabilities of CAEs were observed at similar plasma conditions. The discrete spectrum of CAEs is characterized by three mode numbers (M,S,n), where M, S, and n are poloidal, radial and toroidal mode numbers, respectively. Expected mode frequency splitting corresponding to each of these mode numbers seem to be observed in experiments and is consistent with our numerical analysis. The polarization of the observed CAE magnetic field oscillations in NSTX was measured and also

consistent with the numerical analysis, which helps to identify this activity as CAEs. CAE mode structure was simulated to be localized in both radial and poloidal directions with typical radial localization towards the plasma edge and poloidal localization at the low field side of the plasma cross section.

R1 19 On Heat Loading, Divertors, and Reactors MICHAEL KOTSCHENREUTHER, PRASHANT VALANJU, SWADESH MAHAJAN, JAMES WILEY, *Institute for Fusion Studies, Univ. of Texas at Austin* We show that the relatively low thermal power handling capacity of the standard divertors (used in current as well as projected machines) forces extremely high ($\sim$ 95%) radiation fractions f_{Rad} in power reactors with characteristically large heating powers (much larger than ITER-FEAT). Independent of how one apportions this radiation (in the SOL or in the core), such high values of f_{Rad} have profound and deleterious consequences on the core confinement and stability to the extent that a high power hypothetical reactor operating with the standard divertor will not be able to meet the daunting confinement requirements. Even operation in the ITB mode could not lead to a dependable power reactor with acceptable economics. By designing a divertor with a considerably enhanced thermal capacity (through a flaring of the field lines) we have proposed a way out of the disabling core confinement and stability problems caused by high f_{Rad}. We suggest a possible class of experiments which could lay the foundation for an efficient and attractive path to practical fusion power.

R1 20 Computing Coherent Structures with Chebyshev-Fourier Pseudospectral Techniques in Confinement Systems* J.C. PEREZ, W. HORTON, *University of Texas at Austin, IFS* R. DAHLBURG, *Naval Research Laboratory* Chebyshev-tau pseudospectral methods have been widely used for decades in the linear and nonlinear simulations of neutral fluid dynamics. In this work, we apply these techniques to different reduced models of fluid like plasma equations that describe various instabilities commonly present in many plasma confinement configurations, ranging from laboratory to space plasmas. Nonlinear high-resolution simulations are performed for a plasma slab, periodic in one direction and satisfying Dirichlet boundary conditions in the other. As opposed to Fourier-Fourier methods, usually applied to homogeneous problems, the Chebyshev-Fourier method allows for the study of equilibrium states that are inhomogeneous along one direction and have Dirichlet, Neumann or Robin boundary conditions. Adaptive fifth/sixth order RK time integration scheme is used to advance the initial condition. Simulations show the formation of long-lived coherent structures from different equilibrium states with a random noise initial perturbation. The morphologies of the structures obtained include mushrooms, associated to the Rayleigh-Taylor Instability, Kelvin-Helmholtz vorticity roll-up, streamers and blobs. The simulations examples are in conexion to shear flow experiments in the Large Plasma Device.

*Work supported by DOE grant DE-FG02-04ER5474.

R1 21 Nonlocal Property of a Hall-MHD Contact Discontinuity* ELIEZER HAMEIRI, A contact discontinuity may model a transport barrier or a plasma-vacuum interface. One outstanding question concerning such a discontinuity is whether, in a two-fluid plasma, the electron fluid is allowed to cross the discontinuity even if the ion fluiid does not (because of the ''contact'' nature). Indeed we find that such a situation is possible in Hall-MHD, implying that the discontinuity problem is a global problem, where in order to preserve charge neutrality in the volume bounded by the contact discontinuity, electrons leaving the volume at one point have to be compensated for by electrons crossing in the opposite direction at another point. We carry out a full linear treatment of a toroidal plasma, deriving also stability criteria that conflict with some previous results[1,2] which ignored the issue of nonlocality and its implication for the appropriate jump conditions.

*This work is supported by U.S. Dept. of Energy Grant DE-FG02-86ER53223.

[1]U. Schaper, J. Plasma Phys. **30**, 169 (1983).
[2]Rosenau et al., J. Plasma Phys. **21**, 385 (1975).

R1 22 Triple-X Divertor Coil Designs for EAST, PEGASUS, MAST, and Reactors PRASHANT VALANJU, MICHAEL KOTSCHENREUTHER, JAMES WILEY, MIKHAIL PEKKER, *Institute for Fusion Studies, Univ. of Texas at Austin* WILLIAM ROWAN, HUANG HE, *Fusion Research Center, Univ. of Texas at Austin* Novel magnetic divertor with additional X-points downstream from main plasma X-point have been proposed to overcome reactor heat flux limitations. PEGASUS, MAST, and EAST (China's new long-pulse, superconducting tokamak) are considering experimental implementation of these divertors. MHD equilibria, optimized coil designs, sensitivity to plasma motion, stresses, and heating will be presented for these machines as well as for some reactor designs.

R1 23 Bicubic Bezier patches and finite element method for non-linear MHD codes OLIVIER CZARNY, GUIDO HUYSMANS, *DRFC / CEA Cadarache* For the numerical simulation of Edge Localised Modes, the presence of a separatrix (X-point) plays a important role for the relevant MHD instabilities i.e. external kink modes and ballooning modes. To investigate the MHD stability in plasmas with a separatrix, a new non-linear MHD code —named JOREK— is under development which treats both the closed field lines inside the separatrix and the open field lines outside. The current version of the code solves reduced MHD equations, using generalized finite elements which allow flexibility in the plasma geometry. Moving to more complete equations needs optimization of the code efficiency as far as memory is concerned, that is, decreasing the number of degrees of freedom required for a given accuracy. We have developed an approach based on bicubic Bezier surfaces which are commonly used in Computed Aided Design. This approach differs from Hermite's method in that it provides geometric continuity (G^1) while Hermite's formulation imposes more restrictive parametric continuity (C^1). As a consequence, Bezier formalism makes it easier to implement a grid refinement strategy (*h* adaptivity). Furthermore the method ensures continuous gradients of physical variables. We present some results from 2D MHD codes (Soloviev equilibrium, reduced MHD) in order to illustrate both validity and advantages of the approach.

R1 24 Multiply Resonant Resistive Stability in DIII-D Plasmas* D.P. BRENNAN, A.D. TURNBULL, M.S. CHU, L.L. LAO, *General Atomics* L.E. SUGIYAMA, *Massachusetts Institute of Technology* MHD stability of resistive modes in the presence of multiple resonant surfaces, including central sawtooth oscillations, is examined using reconstructions of experimental equilibria in DIII-D. Coupling to other rational surfaces, especially the 1/1, is

important even at low beta. The outer ideal MHD and inner tearing layer solutions are important in determining mode stability. The PEST3 code is used to determine matrix solutions for the ideal MHD n=1 mode that has singular jumps at each rational surface. This outer region matrix of solutions is matched asymptotically to the resistive MHD inner layer solutions, where the equilibrium configuration differs significantly in high and low beta plasmas. The most important effects in the dispersion relation are the resistive interchange parameter D_R and the coupling to the 1/1 surface. Two-fluid diamagnetic effects were examined in the uncoupled case, and modify the growth rates significantly. Electron and ion diamagnetic effects are important at large diamagnetic frequencies.

*Work supported by US DOE under DE-FG03-95ER54309.

R1 25 Ray tracing for ballooning modes in quasi-symmetric stellarators* E. MONDLOCH, A. S. WARE, *University of Montana* R. SANCHEZ, *Universidad Carlos III de Madrid* D. S. SPONG, D. DEL-CASTILLO-NEGRETE, *Oak Ridge National Laboratory* The ray tracing techniques introduced by Dewar and Glasser [R. L. Dewar and A. Glasser, Phys. Fluids **26**, 3038 (1983)] are used to examine global ballooning stability for three different quasi-symmetric stellarator equilibria: the quasi-poloidally symmetric QPS, the quasi-helically symmetric HSX, and the quasi- axisymmetric NCSX. In the ray tracing method, global ballooning mode stability is calculated by following rays in the eigenvalue space determined by the results of local, infinite- n ballooning theory. For all three of these configurations, the unstable structures are of the localized, ballooning type and are limited to narrow bands of field lines. This is true even well above a marginal stable β. The range of $alpha$ (where α is the field line label) for which unstable surfaces are found is broader in QPS than in NCSX while the range of θ_k (where $\theta_k = k_q/k_\alpha$ is the ballooning parameter) for which unstable surfaces are found is narrower in QPS than in NCSX. For HSX, the weak global shear results in modes which only weakly depend on the ballooning parameter, θ_k. This weak dependence makes the ray tracing for HSX challenging.

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R1 26 Large Turbulent Transport of Alpha Particles in Reactor Plasmas* C. ESTRADA-MILA, *University of California, San Diego* J. CANDY, R.E. WALTZ, *General Atomics* The study of energetic particle transport in fusion plasmas has been largely confined to processes connected with MHD oscillations, whereas the effect of core microturbulence on alpha particle transport has received little attention. Indeed, the itconventional wisdom is that fast particles do not interact with small-scale perturbations because of gyroradius and drift averaging effects. In this poster we present a systematic study of the behavior of energetic species in ITER. Using gyrokinetic simulations from the GYRO code [1,2], we found that alpha particles interact strongly with core ITG turbulence. The most surprising finding of this work is that the fluxes per particle of alphas can be stronger than the main ion fluxes counterpart, as opposed to itconventional wisdom where species with large gyroradii do not interact with the turbulence. [1] J. Candy and R.E. Waltz, J. Comput. Phys. **186**, 545 (2003). [2] J. Candy and R.E. Waltz, Phys. Rev. Lett. **91**, 45001 (2003).

*This work supported by the US DOE under DE-FG03-95ER54309.

R1 27 Quasilinear MHD model to determine beta and energy confinement time in a hardcore Z-pinch magnetic configuration ALEXEI KOUZNETSOV, JEFFREY FREIDBERG, JAY KESNER, *MIT PSFC* The energy confinement time of plasma is a critical figure of merit for any magnetic configuration. In addition to the magnetic configuration itself, energy confinement depends on experimentally controlled parameters such as the edge conditions and the shape of the heating profile. This paper deals with the hardcore Z-pinch magnetic configuration, which can be considered to be an approximation to a large aspect ratio levitated dipole. We assume classical transport in the MHD stable region and carry out quasilinear diffusion analysis in the unstable region. Using quasilinear approximation, we analytically showed that a violation of the MHD stability condition results in enhanced particle and energy transport, which brings pressure profile back to marginal stability and forces particle density to be linearly proportional to $\oint d\ell/B$. Self-consistent numerical calculation of the density and pressure profiles allowed us to determine energy confinement time as the experimental parameters are varied. The resulting power law for beta and energy confinement time is discussed.

R1 28 Bootstrap current in optimized stellarators* A.S. WARE, *University of Montana* D.A. SPONG, L.A. BERRY, S.P. HIRSHMAN, J.F. LYON, *Oak Ridge National Laboratory* This work examines bootstrap current and its impact on the equilibrium properties in optimized stellarators. Two independent methods are used to calculate the bootstrap current: a fast code based on a calculation in an asymptotically collisionless limit [K. C. Shaing, *et al.*, Phys. Fluids B **1**, 148 (1989)] and a fluid moments approach that self- consistently calculates the neoclassical transport coefficients, including the bootstrap current [D. A. Spong, Phys. Plasmas **12**, 056114 (2005)]. The bootstrap current calculations from the two codes were done for low density, ECH-heated and high density, ICH-heated plasmas. In the configurations examined here, namely, the Quasi-Poloidal Stellarator (QPS), the National Compact Stellarator Experiment, the Helically Symmetric Experiment (HSX), the Large Helical Device, and the Wendelstein- 7X Stellarator (W7-X), the bootstrap currents predicted from the two codes agree qualitatively for both ICH and ECH profiles. A self-consistent bootstrap current results in a negligible increase in the rotational transfrom for W7-X, an increase in the rotational transform for QPS, and a larger decrease in the rotational transform for HSX.

*Work supported by U.S. Department of Energy under Grant DE-FG02-03ER54699 at the University of Montana and Contract DE-AC05-00OR22725 at ORNL with UT-Battelle, LLC.

R1 29 The high-frequency gyrokinetic model ROMAN KOLESNIKOV, W.W. LEE, *Princeton Plasma Physics Laboratory* As demonstrated earlier [1], the linear gyrokinetic formulation for $\rho/L_B \ll 1$ can be generalized to include the high frequency ion cyclotron waves, where ρ is the ion gyroradius and L_B is the scale length of the ambient magnetic field. In this paper, we present an extended nonlinear δf gyrokinetic particle simulation model that can be used to study tokamak physics in the arbitrary

frequency regime. The model is based on the separation of the ion gyromotion from its gyrocenter motion, and it is fully equivalent to the original Lorentzian description for $\rho/L_B \ll 1$. As such, the original Vlasov equation can be divided into a gyrophase independent part and a gyrophase dependent part. For the latter, we have developed a numerical scheme to simulate the fast ion gyromotion as well as the polarization effects in the electrostatic limit. The numerical properties of this new gyrokinetic formulation resulting from the separation of time scales between gyromotion and gyrocenter motion will be reported. The comparisons of the simulations for Bernstein harmonics between the conventional Vlasov-Poisson scheme and the new high frequency gyrokinetic model will also be discussed. [1] H. Qin, W. M. Tang, W. W. Lee, and G. Rewoldt, Phys. Plasmas **6**, 1575 (1999).

R1 30 Gyrokinetic simulations of magnetic reconnection PAOLO RICCI, BARRETT ROGERS, *Dartmouth College* WILLIAM DORLAND, TOMO TATSUNO, *University of Maryland* We present linear and nonlinear simulations of magnetic reconnection in a simple slab geometry using the GS2 code. The GS2 code treats both the electrons and the ions gyrokinetically, and includes effects such as trapped particles and the out-of-plane magnetic field perturbations due to finite plasma beta. We show numerical convergence studies in both the linear and nonlinear cases, and compare the GS2 results to those obtained using a simple two-fluid model. We address the dependence of the reconnection rate on the ion-to-electron temperature ratio, the plasma beta, the simulation box geometry, and the mass ratio.

R1 31 Impact of the Reynolds Stress on Edge Poloidal Flow Generation* N. D. DANIELS, A. S. WARE, *University of Montana* B. A. CARRERAS, *Oak Ridge National Laboratory* D. E. NEWMAN, *University of Alaska - Faribanks* C. HIDALGO, *CIEMAT* A one-dimensional transport model is used to study the impact of the form of the Reynolds stress on edge poloidal flow generation during gas puffing experiments. Gas puffing at the edge of the TJ-II stellarator has been used to control the development of an edge poloidal velocity shear layer [C. Hidalgo *et al.*, Phys. Rev. E **70**, 067402 (2004)]. In this work, a numerical transport model is used to examine for hysteresis in the development of an edge poloidal velocity shear layer due to a modeled gas puff. The transport model [D. E. Newman *et al.*, Phys. Plasmas **5**, 938 (1998)] couples together density, ion temperature, electron temperature, poloidal flow, toroidal flow, radial electric field, and a fluctuation envelope equation which includes a shear-suppression factor and now implements a modified Runge-Kutta with adaptive time-stepping. Two different models of the Reynolds stress generation of poloidal flow are examined. The first model requires a gradient in the product of the sqare of the fluctuation amplitude and the radial electric field shear for the generation of flow. The second model requires only a gradient in the radial electric field. Both models are tested for parameters consisting with the TJ-II experiment. The impact on flow generation is discussed.

*Work supported by U.S. Department of Energy under Grant DE-FG02-03ER54699 at the University of Montana.

R1 32 Delta-f particle-in-cell simulation of X-B mode conversion N. XIANG, J.R. CARY, D.C. BARNES, *Univ. of Colorado* J. CARLSSON, *Tech-X Corp.* Low-noise, delta-f particle-in-cell algorithm has been implemented in VORPAL, a massive parallel, hybrid plasma modeling code [Chet Nieter and John. R. Cary, J. Comp. Physics **196**, 448 (2004)]. This computation method allows us to simulate the mode conversion between the extraordinary wave (X) and electron Bernstein wave (EBW) in both linear and nonlinear regimes. In the linear regime, it is found that a full X-B mode conversion can be obtained for optimized parameters as $\omega/\omega_{ce} < 2$ (ω is the driving frequency and ω_{ce} is the electron cyclotron frequency). No 100% conversion is found for ω/ω_{ce} moderately larger than 2. The simulation results agree with the predictions of Ram's theory (Ram & Schultz, Phys. Plasma 4084 (2000)). The agreement indicates that X-B mode conversion can be well described by the quadratic wave equation based on cold plasma approximation, and this is consistent with the phase-space picture of mode conversion. It is also shown that the conversion efficiency is significantly affected by the gradient of magnetic fields. When the amplitude of the incident X wave increases, it is shown that the nonlinear self-interaction of the electron converted EBW gives rise to the second harmonic generation at a pump power as low as three orders smaller than the electron thermal energy. If the fundamental EBW is sufficiently large, the non-propagating third and fourth harmonic modes are also generated. *The work was supported by DOE Contract No. DE-FG02-04ER54735.

R1 33 Spontaneous tearing instability of m=0 modes in the RFP* V.V. MIRNOV, *University of Wisconsin and Center for Magnetic Self-Organization in Lab and Astrophysical Plasmas* Standard RFP discharges in the Madison Symmetric Torus (MST) exhibit cyclic sawtooth oscillations associated with core (m=1, n=6,7) and edge (m=0, n=1) resonant tearing modes. It is believed that the core tearing modes are spontaneously unstable while linearly stable m=0 modes are nonlinearly driven by coupling to core resonant modes. This scenario of forced m=0 magnetic reconnection is based on robust linear stability properties demonstrated in the past by various Δ' calculations. These earlier results have indicated that the m=0 tearing mode is mainly stable. Recent MST experiments have shown [1] that in some regimes with improved plasma confinement the m=0 mode becomes linearly (spontaneously) unstable. This motivated our interest in revisiting the m=0 tearing mode analysis including a broader range of current profiles. We introduced a three-parameter cylindrical model which permits to vary the radial position and the width of the current gradient independently and found a wide class of unstable current profiles. We report on ideal MHD Δ' analysis as well as the results obtained from a cylindrical resistive eigenvalue code. [1] S.H. Choi et al., submitted to Phys. Rev. Lett.

*The work is supported by NSF and DOE.

R1 34 Kinetic simulation of burning plasmas GIOVANNI LAPENTA, *LANL* Burning plasmas pose new challenges to the fusion theory community. The presence of hot alpha particles generated by fusion reactions introduces new scales and new processes not important in conventional plasmas. Particularly challenging is the fact that the gyroradius of alpha particles can become significant and require a more carefull analysis. For example, in ITER the regular ions at 10keV will have a gyroradius of the order of a tenth of a centimiter, but the alpha particles generated at 3.5MeV will have a gyroradius of 10cm. This scale is no longer small compared to may important processes developing in a fusion device (e.g. neoclassical tearing islands). Therefore many of the approximations we are accustomed to, will no longer be

accurate. We present here an approach that is ideally suited to study alpha particles in burning plasmas: the implicit moment kinetic particle in cell method implemented in the code CELESTE. We discuss the method and its aplication to burning plasmas.

R1 35 Current and potential distribution in a divertor with toroidally-asymmetric biasing of the divertor plate D.D. RYUTOV, R.H. COHEN, *Lawrence Livermore National Laboratory* G.F. COUNSELL, P. HELANDER, *Culham Science Centre* Toroidally-asymmetric biasing of the divertor plate may increase convective cross-field transport in SOL and thereby reduce the divertor heat load. Experiments performed with the MAST spherical tokamak generally agree with a simple theory of non-axisymmetric biasing. However, some of the experimental results have not yet received a theoretical explanation. In particular, existing theory seems to overestimate the asymmetry between the positive and the negative biasing. Also lacking a theoretical explanation is experimentally observed increase of the average floating potential in the main SOL in the presence of biasing. We attempt to solve these problems by accounting for the closing of the currents (driven by the biasing) in a strong-shear region near the X-point. We come up with a picture which, at least qualitatively, agrees with these experimental results. Work performed for the US DOE by UC LLNL under contract W-7405-Eng-48; work at Culham jointly funded by the UK Dept. of Trade and Ind. and Euratom.

R1 36 Reduced two-fluid equations for plasma dynamics on the diamagnetic drift scale* JESUS J. RAMOS, *M.I.T.* A reduced system of finite-Larmor-radius two-fluid equations is derived, based on the ''paraxial'' or ''long-thin'' approximation, namely a large-aspect-ratio and long-parallel-wavelength ordering for plasmas in a strong guide magnetic field of weak curvature. The main new features are the full account of diamagnetic effects associated with temperature gradients and the allowance for strong pressure anisotropies, with dynamically evolved ion and electron parallel and perpendicular pressures. A slow dynamics ordering is assumed, whereby flow velocities and time derivatives are respectively comparable to the diamagnetic drift velocities and frequencies. Arbitrary three-dimensional background geometries are considered, but the analysis is later specialized to the tokamak-relevant case of an axisymmetric background. The final reduced system takes into account all the two-fluid effects associated with the Hall physics in the generalized Ohm's law, the ion gyroviscosity, the ion and electron pressure anisotropies (sometimes called parallel viscosities) and the diamagnetic perpendicular heat fluxes, within the assumed orderings. The parallel heat fluxes do not contribute to these lowest-order reduced equations by virtue of the large-aspect-ratio and small-parallel-gradient orderings, with the result that the system is consistently closed except for the collisional terms.

*Work supported by the U.S. Department of Energy.

R1 37 On transport barriers in a nontwist map model of a reversed magnetic shear tokamak with ergodic magnetic limiter ALEXANDER WURM, *Dept. of Physical and Biological Sciences, Western New England College* KATHRIN FUCHSS, P.J. MORRISON, *Institute for Fusion Studies and Department of Physics, The University of Texas at Austin* Recently, the magnetic field line structure of reversed magnetic shear tokamaks has been modeled by an area preserving nontwist map that includes non-integrable perturbations describing ergodic magnetic limiters [1]. An expansion around the equilibrium shearless curve (corresponding to the main transport barrier in the model) showed that the map is locally equivalent to the standard nontwist map with an additional perturbation due to the limiter [2]. We investigate the effect of this perturbation on the resilience of transport barriers and separatrix reconnection scenarios that have been studied extensively in the case of the standard nontwist map. [1] K. Ullmann and I.L. Caldas, Chaos, Solitons and Fractals, **11**, 2129 (2000). [2] J.S.E. Portala, I.L. Caldas, R.L. Viana, and P.J. Morrison, preprint (2005).

R1 38 Multimode wave-particle interactions and the quasilinear transition RODERICK VANN, *University of York, U.K.* BORIS BREIZMAN, *University of Texas at Austin* Multiple mode interactions are ubiquitous in fusions plasmas. In the generic kinetic picture, the excitation of waves leads to the formation of potential wells corresponding to islands in phase space in which some of the particles are trapped. Island coalescence may lead to energy avalanche across a large phase space region. In the limit that modes are far apart (i.e. their island widths are much less than the mode separation), the particle dynamics of the modes can be treated independently; if there are many modes close together, the quasilinear approximation applies and multimode interactions may be treated as a diffusion in velocity space. We consider the intermediate regime of several modes whose island widths are comparable to their separation and investigate under what conditions the modes interact. Our Vlasovian model equations allow for an arbitrary number of modes which couple solely through the spatially-averaged component. The equations are integrated via a time-splitting algorithm which calculates the advective terms using the Piecewise Parabolic Method. The code has already successfully been applied in the single mode case (e.g. to study mode chirping); it is extended to handle multiple modes via a Fourier representation in velocity space. In this Poster we introduce the numerical algorithm and present preliminary results of multimode coupling. This work was funded in part by Euratom and the UK EPSRC.

R1 39 Effects of short wavelength turbulence associated with inhomogeneous electron temperature modes* KEVIN TAKASAKI, BRUNO COPPI, CHRIS CRABTREE, VADIM ROYTERSHTEYN, *MIT* The background short wavelength turbulence that is generated by modes associated with the combined effects of magnetic field and electron temperature gradient is shown to be relevant to three important physical issues. First, due to an enhanced ''thermal resistivity'' along the magnetic field lines, drift-tearing modes may become unstable in weakly collisional or collisionless plasmas. Second, in the central region of the plasma column the short wavelength modes can produce a particle inflow, which in the outer region of the plasma column can be explained by the finite electron collisional thermal conductivity [1]. Finally, the influence of the different topologies that the considered modes can have on magnetic reconnection at the microscopic scale is pointed out. [1] B. Coppi and C. Spight, Phys. Rev. Lett. **41**, 551 (1978).

*Supported in part by U.S.D.O.E.

R1 40 Transport bursts in simulations of tokamak edge turbulence* ROBERT KLEVA, PARVEZ GUZDAR, *IREAP, University of Maryland, College Park, MD* The character of particle and energy transport in simulations of tokamak edge turbulence is determined by the magnitude of the density gradient. Edge

turbulence becomes increasingly intermittent as the edge density gradient increases. Beyond a critical limit in the edge density gradient, the transport is dominated by short, repetitive bursts of particles and energy outward toward the wall. These bursts are extremely ballooning in character, strongly localized on the large major radius side of the torus. The duration of a burst is of the order of the ballooning growth time $t_0 = (RL_n)^{1/2}/c_s$, where c_s is the sound speed, R is the major radius of the torus, and L_n is the density gradient scale length. With further increases in the edge density gradient, the fluxes of energy and particles in the bursts become larger in magnitude. The particle and energy bursts seen in the simulations are similar to the bursts in D_α radiationseen during edge- localized modes (ELM's) in tokamaks.

*Work supported by DOE.

R1 41 Successes of the "Accretion Theory" for the Spontaneous Rotation Phenomenon and Relevent Theoretical Issues* J. THOMAS, B. COPPI, *MIT* A considerable series of experiments have shown evidence for the key elements of the "Accretion Theory" [1,2] of the Spontaneous Rotation Phenomenon in axisymmetric plasmas with rather diverse magnetic confinement configurations (tokamaks with and without divertors, RFP's, etc.). These elements are: i.) angular momentum is "ejected" toward the material wall surrounding the plasma; ii.) angular momentum of the opposite sign is transported from the edge of the plasma column toward the center; iii.) rotation is strongly affected by the physical regime and the magnetic configuration of the outer region of the plasma column; iv.) rotation is inverted in the transition from the L-regime to a good ion confinement regime; v.) the phase velocities of the mode excited near the edge are inverted in this transition. In the good ion confinement regime the edge-modes that scatter angular momentum to the wall are expected to have phase velocities in the direction of the electron diamagnetic velocity while the modes transporting angular momentum toward the center from the edge have opposite phase velocities. Experimental observations have also confirmed this expectation. [1] B. Coppi, Nucl. Fus. **42**, 1 (2002). [2] B. Coppi, MIT-RLE Report PTP 02/05, Cambridge 2002.

*Sponsored in part by the U.S. D.O.E.

R1 42 Single helicity and quasi-single helicity states in RFPs GIAN LUCA DELZANNO, LUIS CHACON, JOHN M. FINN, *LANL* We present a systematic study of single helicity (SH) states and quasi-single helicity (QSH) states in RFPs. We begin with cylindrical paramagnetic pinch equilibria with uniform resistivity, characterized by a single dimensionless parameter proportional to the toroidal electric field, or the RFP toroidal current parameter Θ. For suficiently high Θ, there are several unstable $m = 1$ ideal MHD instabilities, typically one of which is nonresonant, with l/n just above $q(r = 0)$. We evolve these modes nonlinearly to saturation for low Hartmann number H. We then obtain the $m = k = 0$ quasilinear profiles, which typically have toroidal field reversal, and study their stability. For typical cases, these profiles may remain unstable to tearing modes, but only for sufficiently high H. For lower H these states are stable. We show results indicating the proximity of these thresholds to the thresholds between SH and QSH behavior.

R1 43 Effect of parallel electric field on ion heating in RFPs* VLADIMIR SVIDZINSKI, VLADIMIR MIRNOV, STEWART PRAGER, *University of Wisconsin-Madison* Strong ion heating is observed in the reversed field pinch (RFP). During a sawtooth crash in the Madison Symmetric Torus RFP the ion temperature can spontaneously double in 100 microseconds. It is also observed that high Z impurities are heated stronger than bulk ions. The possibility of ion heating due to tearing instabilities is examined. Our previous study examined the heating due to viscous damping of strongly localized perpendicular flows existing in the vicinity of resonant surface in tearing mode. Here we present the results due to the parallel electric fields in the tearing mode. We estimate the parallel electric field in the vicinity of resonant surface from the two fluid equations in which the electric field is mainly balanced by the parallel pressure gradient. The perturbed pressure profile is found from the cylindrical tearing eigenmode in resistive MHD approximation. The ion heating in the electric field with the parallel gradient is estimated from numerical solution of kinetic equation with Landau collision operator. The potential energy of high Z impurities in such a field can exceed their thermal energy, thus the effective heating is expected.

*Work supported by U.S. DOE and NSF.

R1 44 Breakup of shearless tori in the standard nontwist map KATHRIN FUCHSS, *Dept. of Physics, Inst. for Fusion Studies, UT Austin* ALEXANDER WURM, *Dept. of Phys. and Biol. Sc., Western New England College, Springfield* P. J. MORRISON, *Dept. of Physics, Inst. for Fusion Studies, UT Austin* The standard nontwist map is a simple model for degenerate Hamiltonian systems that describe, e.g., magnetic field lines in toroidal plasma devices with reversed magnetic shear profile. As a numerically easily accessible system, this map can be used to gain understanding of basic field line features, such as the breaking of transport barriers represented by shearless invariant tori. Breakup of several sample tori with noble winding numbers have been studied in the past.[1] Here, for a sequence of noble tori, tori breakup is investigated systematically, in order to gain insight into how the breakup of different tori are interrelated and whether the sequence can describe the breakup of non noble tori as a limiting case. [1] D. Del-Castillo-Negrete, J. M. Greene, and P. J. Morrison, Physica D **100**, 311 (1997); A. Apte, A. Wurm, and P. J. Morrison, Physica D **200**, 47 (2005); K. Fuchss, A. Wurm, A. Apte, and P. J. Morrison, preprint/submitted to Chaos (2006).

R1 45 Propagation of global shear Alfven waves in gyrokinetic tokamak plasmas Y. NISHIMURA, Z. LIN, I. HOLOD, L. CHEN, *UC-Irvine* V. DECYK, *UCLA* S. KLASKY, *ORNL* K. MA, *UC-Davis* M. ADAMS, *Columbia University* S. ETHIER, T. HAHM, W. LEE, J. LEWANDOWSKI, G. REWOLDT, W. WANG, *PPPL* Employing the electromagnetic gyrokinetic simulation models,[1,2] Alfven wave dynamics in global tokamak geometry is studied. Based on a small parameter expansion by the square-root of the electron-ion mass ratio, the fluid-kinetic hybrid electron model[2] solves the adiabatic response in the lowest order and solves the kinetic response in the higher orders. We verify the propagation of shear Alfven waves in the absence of drives or damping mechanisms by perturbing the magnetic field lines at $t = 0$ in a global eigenmode structure. The Alfven wave experiences continuum damping.[3] In the presence of energetic particles, excitations of toroidal Alfven eigenmode (TAE) is expected within the frequency gap.[4] With the η_i gradient drive, at a critical

β value, the kinetic ballooning mode (KBM)[5] is excited below the ideal MHD limit.

[1]W.W. Lee *et al.*, Phys. Plasmas **8**, 4435 (2001).
[2]Z. Lin and L. Chen, Phys. Plasmas **8**, 1447 (2001).
[3]J.A. Tataronis and W. Grossman, Z. Phys. **14**, 203 (1973).
[4]C.Z. Cheng, L. Chen, and M.S. Chance, Ann. Phys. **161**, 21 (1984).
[5]C.Z. Cheng, Nucl. Fusion **22**, 773 (1982).

R1 46 Progress in Gyrokinetic Particle Simulation of Electron Transport in Fusion Plasmas* ZHIHONG LIN, *University of California, Irvine* Electron thermal transport driven by electrostatic drift-wave turbulence in tokamak plasmas is studied using full device gyrokinetic particle simulations. Trapped electrons are found to enhance ion temperature gradient (ITG) turbulence by mostly not responding to the ITG modes and thus induce relatively low level of electron transport. On the other hand, resonant excitation of trapped electron mode (TEM) turbulence leads to large electron thermal and particle transport. TEM modes have much broader linear spectrum and the nonlinear saturation is characterized by two-step processes. Shorter wavelength modes saturate first and induce high electron thermal transport but relatively small ion transport; longer wavelength modes saturate later and induce higher ion thermal and particle transport.

*Work supported by SciDAC.

R1 47 Observations from the CDX Nonlinear Sawtooth Study J. BRESLAU, W. PARK, S. HUDSON, S. JARDIN, *PPPL* H. STRAUSS, *NYU* We present two separate sets of observations from modeling sawteeth in the CDX tokamak with the M3D code [1] as part of a cross-code benchmark. One is that, in addition to the internal kink, the starting equilibrium is linearly unstable to a range of high-n resistive ballooning-like modes [2], which can only be suppressed by the assumption of extremely high perpendicular heat transport. There is evidence that such transport is present in CDX itself, possibly induced by the edge modes [3], which would thereby saturate nonlinearly. Analysis of field line stochasticity as a mechanism for this saturation will be presented. The second topic is the finding that the sawtooth, though fundamentally a 1,1 mode, has considerable structure in the toroidal direction which is not easily resolved even with the retention of tens of mode numbers in the nonlinear run. The demands of a convergence study are therefore more stringent than might at first be supposed; implications for the development of predictive capability are discussed. [1] W. Park et al., Phys. Plasmas **6**, 1796 (1999). [2] H.R. Strauss. Phys. Fluids **24**, 2004 (1981). [3] B.A. Carreras and P.H. Diamond, Phys. Fluids B **1**, 1011 (1989).

R1 48 Implicit PIC Studies of MHD Instabilities D.C. BARNES, W.D. NYSTROM, *Coronado Consulting* We are studying the gravitationally driven interchange (g-mode) with implicit PIC. In addition to full implicit PIC, we also use an implicit hybrid approach with electrons described by fluid equations, and full, Lorentz force ion orbits. We have also implemented a delta-f approach (QIP). The models are described in detail and numerical properties considered. Conservation laws are shown to hold for appropriate time centering. We examine the effects of iterating the particles in concert with the moment equations, in contrast with the standard approach of using the moment equations only for the field solve. Implicit systems are solved with Krylov methods (GMRES) with 1 or 2D preconditioning matrices. Preliminary results for the g-mode will be presented.

R1 49 Self-sustaining vortex perturbations in smooth shear flows* JUHYUNG KIM, JEAN C. PEREZ, WENDELL HORTON, *Institute for Fusion Studies, The University of Texas at Austin, Austin, Texas 78712, USA* GEORGE D. CHAGELISHVILI, R. G. CHANISHVILI, J.G. LOMINADZE, *Abastumani Astrophysical Observatory, A. Kazbegi 2a, Tbilisi 0160, Georgia* JOHN C. BOWMAN, *Department of Mathematical and Statistical Sciences, University of Alberta, Edmonton, Alberta, Canada, T6G 2G1* The nonlinear dynamics of coherent cyclonic and anticyclonic vortices in plane flow with constant shear is investigated numerically using a Fourier pseudospectral code. The flow is asymptotically linearly stable, but is highly non-normal, allowing transient perturbations to gain energy from the background shear flow. This linear transient growth interplays with nonlinear processes and can lead to change the asymptotic behavior. We show that a fixed background shear flow can maintain finite amplitude cyclonic vortices indefinitely in time through a positive feedback mechanism between the nonlinear interactions and the external shearing of the vortex flow. A plasma laboratory experiment is suggested based on the results of this investigation.

*The work was supported in part by the Department of Energy Grant No. DE-FG03-96ER-54346, the ISTC Grant G-1217, and the Natural Sciences and Engineering Research Council of Canada.

R1 50 Ignited Spherical Tokamaks and their super-critical regime* LEONID ZAKHAROV, *Princeton University, PPPL* The LiWall concept, which is now completed, and based on it Ignited Spherical Tokamaks (IST) for developing a fusion power reactor is outlined. With a central fueling of the plasma by the neutral beam injection and with pumping boundary conditions the temperature profiles inside the plasma will be automatically flattened, thus eliminating the major channel of energy loss due to the ion-temperature gradient instability. Such a property would change the entire approach to tokamak magnetic fusion and make it consistent with the power reactor development. The self-consistency of the LiWall concept (only 7 years old) and resulting IST, in terms of stability (both internal and free-boundary), confinement, high power density, fueling, external control of the density and bootstrap current, and power extraction is discussed. The unique combination of the small size of IST, large Shafranov shift and a good confinement exceeding what is necessary for ignition would constitute a new, super-critical ignition (SCI) regime, which significantly simplifies the physics and the design of IST and the way to the power reactor.

*This work supported by DoE contract No. DE–AC02–76–CHO–3073.

R1 51 Two-dimensional simulations of the inertial electrostatic confinement device ALBERTO MAROCCHINO, GIOVANNI LAPENTA, EVSTATI EVSTATIEV, RICHARD NEBEL, JAEYOUNG PARK, *LANL* We discuss the application of the CELESTE simulation package to the simulation of the experiments conducted at the Los Alamos Inertial Electrostatic Confinement (IEC) device. Recently considerable experimental advances have been made in understanding of the stability of the virtual cathode and in the physics of POPS. This momentous experimental advance requires a new simulation effort for explaining the new experimental findings, particularly in the area of stability of the configurations obtained experimentally. We have conducted a 2D

stability study of the virtual cathode in the IEC device using the DEMOCRITUS package. DEMOCRITUS is a 2D general geometry electrostatic PIC code. In the present study we have done complete stability study and investigate the two-stream instability occuring in the IEC device.

R1 52 Analytically and numerically computed tokamak equilibria at unity beta* RUSSELL NECHES, STEVEN COWLEY, PIERRE-ALEXANDRE GOURDAIN, JEAN-NOEL LEBOEUF, *UCLA* The characteristics of near unity-β equilibria are investigated with two codes. CUBE is a multigrid Grad-Shafranov solver, and ACUBE was written to compute solutions using analytic unity-β equilibria [S.C. Cowley *et. al.*, 1991]. Results from each method are quantitatively compared in several distinct equilibrium conditions. These comparisons corroborate the theoretical results and provide benchmarks for high-resolution numerical results available from CUBE. These tools facilitate exploration of many properties of high-β equilibria, such as a highly diamagnetic plasma and its ramifications for stability and transport as β approaches unity.

*Work supported by USDOE through the Fusion Science Center for Multiscale Plasma Dynamics.

R1 53 Progress and plans for the PTRANSP project* STEPHEN JARDIN, LONG-POE KU, CHARLES KESSEL, DOUG McCUNE, *PPPL* HOLGER STJOHN, *General Atomics* LINDA LODESTRO, *LLNL* GLEN BATEMAN, ARNOLD KRITZ, *LeHigh U* PTRANSP TEAM, We describe progress on a two-year multi-institutional project to perform a significant upgrade of the TRANSP code by implementing several new predictive capabilities. The product will be an integrated predictive transport code that is fully coupled to the UEDGE edge transport code and to a number of existing MHD equilibrium and stability codes and transport models. This capability will be of immediate benefit to the U.S. ITER physics team by providing a unique advanced ITER discharge simulation capability. It will also provide opportunities for collaboration and code sharing with our international partners. Progress to date has been made in the areas of extracting utilities from the TRANSP code that can be accessed by an external driver. The utility XPLASMA is being used to represent the plasma state. The solver routine has been hardened so that it can use extremely stiff transport models such as GLF23 without relaxation or other smoothing techniques. Examples of these are presented.

*This work was supported by the Department of Energy, OFES.

R1 54 Stability of high beta poloidal configurations in tokamak geometries. P.-A. GOURDAIN, S.C. COWLEY, J.-N. LEBOEUF, R.Y. NECHES, *UCLA Physics Department* The resilience of high beta plasmas to internal instabilities precluding high kinetic pressure in conventional tokamaks remains to be fully examined. In fact, a bell shape current profile restricts the stability of these plasmas below the Troyon limit. Furthermore, such configurations exhibit little magnetic shear as the safety factor q varies from 1 at the center of the plasma to only 3 at the edge. We propose to explore the stability of highly shifted plasma equilibria using the high beta ideal MHD code CUBE and the stability code DCON. Using the geometry and magnetic field of the Electric Tokamak, we will demonstrate that fixed-boundary plasmas with Shafranov shifts on the order of unity are stable for several MHD criteria such as Mercier, resistive or high-n ballooning. The strong magnetic shear of these configurations makes them quite attractive for turbulence suppression and ballooning stability. Stable plasmas with a peak beta of 15% and a shift of 75% have been reached. A stable path from regular to highly shifted current profile configurations will also be discussed.

R1 55 Fullwave coupling to a 3D antenna code using Green's function formulation of wave-particle response JOHN WRIGHT, PAUL BONOLI, *MIT-PSFC* MARCO BRAMBILLA, *Max-Planck Institute for Plasma Physics* VITO LANCELLOTI, RICCARDO MAGGIORA, *Politecnico diTorino* MARK CARTER, *ORNL* RF-SCIDAC TEAM, Using the fullwave code, TORIC,and the 3D antenna code, TOPICA, we construct a complete linear system for the RF driven plasma. The 3D finite element antenna code, TOPICA, requires an admittance, **Y**, for the plasma, where $B = Y \cdot E$. In this work TORIC was modified to allow excitation of the (Eη, Eζ) electric field components at the plasma surface, corresponding to a single poloidal and toroidal mode number combination (m,n). This leads the tensor response: $Y = \left(\begin{smallmatrix} Y_{\eta\eta} & Y_{\eta\zeta} \\ Y_{\zeta\eta} & Y_{\zeta\zeta} \end{smallmatrix}\right)$, where each of the Yn submatrices is Nm in size. It is shown that the admittance matrix is equivalent to a Greens function calculation for the fullwave system and in addition, the net work done in the calculation is on the order of twice a single fullwave calculation. After the admittance calculation is done, the response of a plasma to an antenna driven at a given frequency can be calculated by only running the TOPICA code for a new antenna geometry. In tests of loading, TOPICA has been able reproduce loading of the Alcator D antenna (S12 coefficient accurately).

R1 56 Tetrahedral Mesh MHD Simulations and Taylor States of HIT-SI GEORGE MARKLIN, TOM JARBOE, *Plasma Science and Innovation Center, University of Washington, Seattle, WA 98195* This poster will report on progress to validate a tetrahedral mesh resistive MHD code by doing simulations of the HIT-SI experiment at the University of Washington and comparing the results to experimental data and to Taylor state calculations. The experiment has two AC helicity injectors which generate a rotating n=1 field structure that is expected to undergo Taylor relaxation (magnetic reconnection conserving global helicity) to form and sustain a time independent n=0 spheromak. Taylor state calculations show what is to be expected if complete relaxation occurs. MHD simulations will show varying degrees of relaxation depending on how much physics is included in the MHD model. Initial simulations will only include resistive MHD and should underestimate the rate of magnetic reconnection and the amount of relaxation that occurs. Experimental observations should be bracketed by the simulation results and the Taylor states. Comparisons of predicted magnetic field structure from the MHD simulations and the Taylor states to probe and flux loop measurements will indicate how much relaxation is occurring and whether the physics included in the MHD model is adequate to predict it. Over time, more physics will be added into the MHD code until predictability is achieved.

R1 57 Overview of Experimental and Theoretical Studies of the Periodically Oscillating Plasma Sphere (POPS) RICHARD NEBEL, JAEYOUNG PARK, EVSTATI EVSTATIEV, ALBERTO MAROCCHINO, GIOVANNI LAPENTA, LUIS CHACON, *Los Alamos National Laboratory* Theoretical work has suggested that a tiny oscillating ion cloud may undergo a self-similar collapse that can result in the periodic and simultaneous attain-

ment of ultra-high densities and temperatures. A remarkable feature of these oscillations is that they stay in local thermodynamic equilibrium (lte) at all times independent of the collisionality of the system (i.e. they are exact solutions of the Vlasov equation for Maxwellian distribution functions). In recent experimental work on the INS-e device at LANL we have observed the POPS oscillations by resonantly driving the plasma at the POPS frequency. Ongoing theoretical work is focused in two areas: multidimensional kinetic simulations of the stability of the virtual cathode and space charge neutralization during the ion collapse phase of the POPS oscillation. POPS simulation results indicate that significant gains in plasma compression can be achieved by properly programming the electron distribution function at the boundary. Two dimensional kinetic simulations indicate that the virtual cathode stability to electron-electron two-stream modes is similar to the 1-D result.

R1 58 Full Orbit PIC in NIMROD CHARLSON KIM, *University of Washington - PSI Center* PLASMA SCIENCE AND INNOVATION CENTER TEAM, The primary goal of the Plasma Science and Innovation Center (PSI Center) is to refine and optimize existing MHD codes to achieve improved predictability for emerging concept (EC) experiments. Kinetic effects have been shown to play a dominant role in some EC experiments, particularly in FRC stability[1]. The PSI Center will extend the hybrid kinetic-MHD implementation in NIMROD[2] from the drift kinetic model to the full kinetic model to include sufficient physics to accurately account for these effects, in particular large Larmour radius. The Boris push has been implemented for particles in NIMROD. However, this places a severe timestep restriction on the particle time step. We discuss several strategies for circumventing this restriction to simulate on the MHD time scale. We will show some of the preliminary results from the implementation of full orbit (Lorentz force) particles coupled to the NIMROD code.

[1]E. Belova et al., "Numerical Study of tilt stability of prolate field-reversed configurations," PoP **7**, 4996, 2000.
[2]C.C. Kim et al., "Hybrid Kinetic-MHD Simulations in General Geometry," CPC **164**, 448, 2004.

R1 59 Nonlinear Energy Transfer in Ion Temperature Gradient Turbulence* W.X. WANG, T.S. HAHM, W.W. LEE, G. REWOLDT, W.M. TANG, *Princeton Plasma Physics Lab.* Nonlinear energy couplings in ion temperature gradient (ITG) turbulence are studied by global gyrokinetic particle simulation of shaped toroidal plasmas based on DIII-D geometry. It is observed that the average toroidal mode number is rapidly down-shifted by 2/3 along the $m/n \sim q$ surface, coincidently occurring during the turbulence saturation process. This indicates that the ITG saturation is strongly correlated with nonlinear energy transfer to longer-wavelength modes. The nonlinear toroidal coupling is considered as a dominant channel for the energy transfer to low-n modes, and simultaneously, to strongly damped high-n modes, resulting in the overall spectrum down-shift. Our numerical experiments suggest that the zonal flows can drive turbulence. However, the associated energy coupling is very weak. In contrast, the zonal flows are shown to extract a large amount of energy from turbulence components during their generation process. This, in part, represents turbulent transport reduction by zonal flows. In addition, zonal flows also affect the nonlinear energy coupling process in k-space by transferring turbulence energy faster and more efficiently from unstable modes to stable modes, compared to the case without zonal flows. This is compared to the corresponding effect of an applied equilibrium radial electric field determined by the neoclassical dynamics.

*Work supported by U.S. Department of Energy and SciDAC GPSC.

R1 60 Study of a simulated sustained edge-current driven spheromak in SSPX geometry* LYNDA LODESTRO, B.I. COHEN, E.B. HOOPER, *Lawrence Livermore National Laboratory* C.R. SOVINEC, *University of Wisconsin* The sustainment of current in the core of a toroidal plasma by electrostatic edge-current drive requires the radial transport of current across imperfect magnetic surfaces. Full sustainment concurrent with adequate energy confinement has been difficult to find either experimentally or numerically. A NIMROD simulation in SSPX geometry with fixed bank current has recently been extended to nearly an L/R time, and exhibits apparent steady-state cycles with time-averaged sustainment: intervals of closed surfaces and peaked temperature profiles, punctuated by short bursts with voltage spikes and open surfaces. The confinement properties of this simulation will be analysed, and results presented.

*Work performed under auspices of the U.S. DOE by U. California LLNL under Contract No. W-7405-ENG-48.

R1 61 ASTROPHYSICS POSTERS

R1 62 Discovery of the Nearby Universal Center Disproves Big Bang's F-L Spacetime Expansion Hypothesis, Showing the Big Bang Is False Science, Being the Greatest Faux Pas in the History of Science and Disqualifying It From Being Taught in Public Schools ROBERT GENTRY, Hubble's galactic redshift-distance relation is known as the greatest astronomical discovery ever. I will show, however, that he strongly opposed the most obvious interpretation of his own observations and how this has influenced generations of astronomers to follow his steps and develop the big bang theory based on the F-L spacetime expansion hypothesis. Based on my Preprints "Discovery of a Major Contradiction in Big Bang Cosmology Points to the New Cosmic Center Universe Model," CERN Ext-2003-021, and "New Cosmic Center Universe Model Matches Eight of Big Bang's Major Predictions Without the F-L Paradigm," CERN Ext-2003-022, I will discuss why F-L expansion is fatally flawed and why a new cosmic model is a viable replacement. More astrophysical results are available at www.orionfdn.org. These papers were submitted to and received arXiv numbers in 2001 but P. Ginsparg and Cornell continue to suppress their release. The Center of the Universe discovery and the New Cosmic Model affirm the Genesis six day record of God's creation of the heavens, or visible universe (Ps.33:6,9), just as my earlier discoveries and publications unequivocally affirm Earth's almost instantaneous creation (www.halos.com). God left evidence of His creatorship and the validity of His Creation Commandment (Exodus 20:11) for all who look.

SESSION S1: HIGH POWER PROTON DRIVERS FOR ACCELERATOR-BASED NEUTRINO PHYSICS
Monday Afternoon, 24 April 2006; Landmark A, Hyatt Regency Dallas at 15:30
Thomas Roser, Brookhaven National Laboratory, presiding

15:30
S1 1 Physics of a long and very long baseline neutrino program.
MILIND DIWAN, *Brookhaven National Laboratory*

I will discuss opportunities in neutrino oscillation physics using conventional high energy accelerator neutrino beams. I will first discuss the properties of the beams and the expected event rates for various concepts that are under discussion. The physics goal is to measure known oscillation parameters precisely, find the conversion of muon to electron neutrinos at accelerator energies, and discover violation of the CP symmetry in the lepton sector if it exists. With the current knowledge of neutrino parameters, we already have a good understanding of the beam power level, detector size, and the baseline needed for such an experiment. We can optimize the experimental parameters to obtain the best possible sensitivity. I will describe this optimization. In my conclusion, I will describe a possible project that takes full advantage of existing accelerator facilities at Fermilab or Brookhaven and couples the beam to a very large detector at a new deep underground science laboratory.

16:06
S1 2 The Proton Driver Proposals.
GIORGIO APOLLINARI, *Fermi National Accelerator Laboratory*

This abstract was not received electronically.

16:42
S1 3 J-PARC Project in Japan.
SHOJI NAGAMIYA, *KEK, Japan*

From the spring of 2001 a new accelerator complex, called the J-PARC, has been under construction by the cooperation between two organizations, KEK and JAEA, where KEK is a high-energy organization and JAEA is a nuclear power organization in Japan. The main goal of the J-PARC is to accelerate and use high-power MW-class proton beams at 3 GeV and 50 GeV. The 3 GeV beams will be used for production of spallatiion neutron beams and muon beams for the study of materials and life sciences. A rapid cycle synchrotron of 25 Hz is prepared for this purpose. On the other hand, the 50 GeV beams will be used for production of intense kaon beams (for kaon factory) and neutrino beams, where the latter beams will be detected at the Superkamiokande detector located at about 300 km from the J-PARC site. The entire budget that were already approved is over 1,500 Oku Yen (about 1.3 billion dollars). Overall, two third of the construction work is completed. The anticipated completion of the construction is late 2008. In the talk I would like to present the current status of the project including accelerator construction, physics opportunities and other major issues of the project.

SESSION S2: DNP PRIZE SESSION
Monday Afternoon, 24 April 2006; Landmark B, Hyatt Regency Dallas at 15:30
Bradley Sherrill, Michigan State University, presiding

15:30
S2 1 Universality of the weak interaction.
IAN TOWNER, *Queen's University, Kingston, Ontario K7L 3N6*

One test of the universality of weak interactions is to demonstrate that the Cabibbo-Kobayashi-Maskawa matrix is unitary. The first-row test that the sum of the squares of the first-row elements add to one requires precision experiments in nuclei, neutrons, pions and kaons and precision calculations of symmetry-breaking and radiative corrections. This talk will give the current status of the first-row test and elaborate on the theoretical corrections.

16:06
S2 2 Superallowed Nuclear Beta Decay: A Window on the Weak Interaction.
J.C. HARDY, *Texas A&M University*

For more than 50 years, superallowed $0^+ \rightarrow 0^+$ beta decay has been used to probe the weak interaction. By now, more than a dozen such superallowed transitions are known to $\sim 0.1\%$ precision. The results provide an exacting confirmation of the Conserved Vector Current hypothesis and are also a key component in the most demanding available test of the unitarity of the Cabibbo-Kobayashi-Maskawa matrix. This talk will present the current status of measured results, describe some contemporary experiments and indicate the prospects for future improvements.

16:42
S2 3 The Bethe Prize Talk.
JAMES TRURAN, *University of Chicago*

This abstract was not submitted electronically.

SESSION S3: THE HELIOSPHERIC TERMINATION SHOCK
Monday Afternoon, 24 April 2006; Landmark C, Hyatt Regency Dallas at 15:30
Martin Lee, University of New Hampshire, presiding

15:30
S3 1 Voyager at the Heliosphere's Termination Shock: Energetic Particle Observations.
ROBERT DECKER, *Johns Hopkins Univ. Applied Physics Lab.*

The Voyager 1 spacecraft encountered the termination shock of the solar wind in mid-December of 2004 and entered the heliosheath. Voyager 1 was then 94.0 AU from the Sun and at N34^o heliographic latitude. Since that time until at least day 10 of 2006 (97.8 AU), the spacecraft has remained in the heliosheath. We will describe intensities and angular distributions of ions $>$ 40 keV and electrons $>$ 26 keV associated with the termination foreshock region, termination shock, and heliosheath. These measurements are from the Low Energy Charged Particle instruments on Voyagers 1 and 2. Notable features observed thus far in the heliosheath particle data from Voyager 1 include: (1) high, relatively smooth intensities devoid of the large, quasi-recurrent fluctuations that characterized intensities in the foreshock region; (2) ion energy spectra from 40 keV to several MeV that are well fit by a power-law in energy with spectral slope ≈ -1.5; (3) large reductions in the amplitudes and occurrence rates of anti-sunward, near-azimuthal beaming anisotropies that were routinely seen in the foreshock ion data; and, (4) radial plasma flow speeds, estimated from analysis of low-energy ion angular distributions, that remain less than $\sim$ 100 km/s. We are fortunate to be currently receiving heliosheath data from Voyager 1 and solar wind data from Voyager 2, which is now in termination foreshock region. Voyager 2 began measuring low intensities of termination shock precursor protons in late 2004 (75 AU, S26^o). By mid-2005 (77 AU), the intensity of 3–17 MeV protons measured at Voyager 2 reached levels comparable to those observed at Voyager 1 during the latter half of 2002 (85–87 AU). Ion data at Voyager 2 show quasi-recurrent intensity variations and near-azimuthal beaming anisotropies that are directed mainly sunward, opposite to the mainly anti-sunward beaming anisotropies measured in the termination foreshock by Voyager 1.

16:06
S3 2 Imaging the Global Interaction between the Heliosphere and the Interstellar Medium with IBEX.
EBERHARD MÖBIUS, *Space Science Center and Department of Physics, University of New Hampshire*

The solar wind carves out a large void — the heliosphere — into the surrounding interstellar plasma. Because the sun moves relative to the local interstellar cloud at $\approx$ 26 km/s an interstellar wind of neutral gas blows through our solar system, and in spite of the large size of the helio-sphere we can probe this flow for He and O near Earth. At a distance of about 100 AU the solar wind slows down to subsonic speed through interaction with the interstellar medium, thus form-ing the termination shock. Here ions are accelerated efficiently, preferably those created from inflowing interstellar gas and then picked up by the solar wind. Through charge exchange with interstellar gas atoms these accelerated ions form energetic neutral atoms (ENA), which — if released towards the Earth — will arrive on a straight trajectory, carrying with them the information about the energy spectra and spatial distribution of the energetic ions at the termination shock. Two highly sensitive ENA cameras on the Interstellar Boundary Explorer (IBEX) will capture the interstellar O flow and take ENA images of the termination shock over the energy range 10 – 6000 eV for the first time. These observations will provide insight into the interaction of the he-liosphere with the interstellar medium in the mutual boundary region as well as into the nature of the termination shock and its global structure.

16:42
S3 3 The Mysteries Associated with the Acceleration of Energetic Particles at the Termination Shock of the Solar Wind.
LEN FISK, *University of Michigan*

The Voyager 1 spacecraft has crossed the Termination Shock of the solar wind, a long-awaited goal in the exploration of the outer heliosphere. There were great expectations for the Termination Shock as the site for the acceleration of Anomalous Cosmic Rays (ACRs), presumably by diffusive shock acceleration. ACRs result from interstellar neutral gas that is ionized and accelerated in the solar wind, by over four orders of magnitude in energy. In fact, the intensity of the ACRs did not peak at the shock crossing seen by Voyager. Low-energy energetic ions ($<$ 3 MeV/nucleon) are abruptly accelerated at the Termination Shock, but these particles have the unusual feature that their spectral shape is constant, independent of the change in flow speed at the shock, unlike the predictions of diffusive shock acceleration. Observational constraints on theories for particle acceleration at the Termination Shock will be reviewed and a possible theory for the acceleration of the low-energy energetic ions will be discussed.

SESSION S4: FHP/FPS AWARD SESSION
Monday Afternoon, 24 April 2006; Marsalis A, Hyatt Regency Dallas at 15:30
George Lewis, Peace Studies Program, Cornell University, presiding

15:30
S4 1 Pais Prize Lecture: History and Physics.
JOHN HEILBRON, *UC Berkeley*

Modern history and experimental physics entered the university together, in the course of the eighteenth century. They shared several practices and projects. Historians began to emphasize physical factors, and so drew on, and occasionally contributed to, meteorology and physical geography; and they developed ancillary disciplines, like numismatics, diplomatics, and paleography, which required the analysis of metals, paper, and inks, and the careful comparison of material objects. In physics, historical reviews of newer subject matters, such as electricity, optics, and pneumatics, guided instruction where neither the facts nor their interpretation compelled consensus. The inherently historical science, geology, was a favorite subject of the age: the earth received a history, and the cosmos, too; evolutionary ideas found applications everywhere. The new physics and the new history became potent weapons of Enlightenment. A product of their collaboration is the lengthiest history of physics ever written, J.G. Fischer's itGeschichte der Physik (8 vols., 1801-1808). It appeared within a series edited by Johnn Gottfried Eichhorn, Germany's leading exponent of the ''higher criticism,'' the corrosive application of historical and literary considerations to the stories of the Old Testament. The writings of historians like Eichhorn were more subversive than the work reported by Fischer in so far as humans are more concerned with their place in the world than with the details of its behavior. The coincidental matriculation of modern history and experimental physics, and its consequences, will be discussed.

16:06
S4 2 Szilard Prize Lecture: Seismic Monitoring of Nuclear Explosions.
PAUL RICHARDS,* *Columbia University*

Seismic monitoring of the more than 2000 nuclear test explosions since 1945 has been vigorously pursued, both to track the weapons development of potential adversaries, and to support initiatives in nuclear arms control, including various test ban treaties. Major funding from the US Department of Defense built up new global seismographic networks and over several decades established practical capability in monitoring nuclear explosions ''teleseismically'' (i.e. from distances more than about 1500 km), for tests that the testing nation did not attempt to conceal. What then is the capability to monitor compliance with, for example, the Comprehensive Nuclear-Test-Ban Treaty (CTBT) of 1996, particularly if evasion scenarios are considered? Note that the CTBT, though not ratified by some countries (including the US), is now being monitored by networks that include seismographic stations at ''regional'' distances ($<$ 1500 km) from candidate explosion locations. Years of R and D have shown that regional signals can be used to monitor down to yields significantly lower than can be detected and identified teleseismically. A US National Academy of Sciences study in 2002 concluded that ''an underground nuclear explosion cannot be confidently hidden if its yield is larger than 1 or 2 kt.'' About 1000 earthquakes and chemical explosions are now detected per day, and documented via seismic data, providing plenty of challenges for nuclear explosion monitoring organizations. Explosion monitoring capability will improve in many parts of the world, due to the growth of networks that monitor even small earthquakes to study seismic hazard. But political problems can impede improved international explosion monitoring, due to national restrictions on data access.

*A member of the American Geophysical Union.

16:42
S4 3 Burton Award Lecture: A.Q. Khan and Illicit Nuclear Trade.
DAVID ALBRIGHT, *Institute for Science and International Security*

This abstract was not received electronically.

17:18
S4 4 Sakharov and the Grey Zone: Difficult Areas of Human Rights Activity.
YURI ORLOV, *Laboratory for Elementary-Particle Physics, Cornell University*

Drawing on my experience in human rights work and my discussions with A. D. Sakharov, I will explore some difficult areas of human rights activity in which human rights defenders cannot reach a consensus on how to proceed, and even on how to define the problem.

SESSION S6: PANOFSKY PRIZE SESSION
Monday Afternoon, 24 April 2006; Cumberland J, Hyatt Regency Dallas at 15:30
Bill Carrithers, Lawrence Berkeley National Laboratory, presiding

15:30
S6 1 Lifetime Measurements with Mark II's First Vertex Detector.
JOHN JAROS, *Stanford Linear Accelerator Center*

The lifetimes of the (then) newly discovered tau lepton and b hadrons were unmeasured when detectors began studying 30 GeV e+e- collisions at the PEP and PETRA storage rings. The addition of a high precision drift chamber, the Mark II Secondary Vertex Detector, led the Mark II collaboration to make its first significant measurements of the tau and charmed particle lifetimes. The b hadron lifetime was popularly presumed to be very short, and out of reach. But with a healthy dose of luminosity during 1982-1983, both the MAC and Mark II experiments at PEP saw unmistakable signs that the b lifetime was in fact long, measured it, and showed that the responsible CKM element, Vbc, was small. I'll review this history, talk about the rather far reaching implications of a long b lifetime, and chart the rapid progress in the art of vertex detection.

16:06
S6 2 B meson decay and CP symmetry violation from e^+e^- experiments.
WILLIAM T. FORD, *University of Colorado*

The study of structure in the time evolution of neutral B - B-bar pairs has provided a a key ingredient in the quantitative understanding of quark flavor mixing and its role in accounting for CP violation in weak decays. After some recollections regarding the determination of the time scale of b quark decay, I review the observations that have emerged from experiments at electron-positron colliders of B - B-bar mixing and CP-violation asymmetries. I consider some of the ongoing measurements that serve to over constrain the Standard Model of weak interactions in the quark sector, and potentially to indicate the limits of the model. I conclude by describing the prospects for future gains in the sensitivity of these and successor experiments.

16:42
S6 3 Impact of the Long B-Lifetime on Other Areas of Particle Physics.
NIGEL LOCKYER, *University of Pennsylvania*

The surprisingly long b-lifetime has had an amazing impact on many physics topics since it was first measured in 1983. The development of sophisticated silicon vertex detectors needed to ''tag'' the long lived b-quark followed at LEP, the Tevatron, the B-factories, and today at the LHC. These technological developments and the history of the first measurement in the MarkII detector will be discussed by J. Jaros in this session. This presentation will concentrate primarily on physics topics pursued at the Tevatron Collider and CDF in particular that were made possible by the long lifetime of the b-quark. First, the TeV collider program, LEP, and the B factories at SLAC and KEK have made remarkably precise measurements of the B mesons and baryons that utilized the long b-lifetime in addition to the pioneering B measurements at Cornell and DESY. The B-factory measurements, including CP violation, will be discussed by W.T. Ford in this session as well as the first measurement in the MAC detector. The Tevatron and LEP have made remarkable measurements of the B_s and Λ_b which continue to improve. Perhaps the biggest role of the long b-lifetime has been in the discovery and study of the top quark. Both CDF and D0 use the lifetime as one of the main selection criteria of top events in addition to a high P_T lepton. Our present knowledge of the top cross section and mass are a result of measurements

that identify top by tagging the b-jets. CDF also had a first look at CP violation in the B system resulting in a 2-sigma measurement, which hinted that CP violation in the b-system appeared to be large and consistent with the standard model. Presently, the long lifetime of the B_s meson is being used to measure mixing in that system, a much anticipated result expected from the Tevatron. The long b-lifetime is critical for searches of the standard model and supersymmetric Higgs bosons decaying into $b\bar{b}$ quarks. The LHC_b experiment at the LHC will make next generation measurements in the b-quark system, again, made possible by the long b-lifetime. The Atlas and CMS detectors at the LHC will exploit the long b-lifetime in their searches for the Higgs bosons and supersymmtry and the detectors being designed for the International Linear Collider will also utilize the long lived b-quark. A brief discussion of these measurements will be presented.

SESSION S10: FOCUS SESSION: UNDERGRADUATE AND GRADUATE EDUCATION
Monday Afternoon, 24 April 2006; Cumberland C, Hyatt Regency Dallas at 15:30
Bruce Ackerson, Oklahoma State University, presiding

Invited Papers

15:30
S10 1 Assessing the Effectiveness of the HBL Pedagogy.
CHARLES HASTY, *Oklahoma State University*

An exploratory set of studies was conducted to compare the effectiveness of the Hypothesis-Based Learning (HBL) and Physics by Inquiry (PBI) pedagogies. During two different semesters (fall 2003 and spring 2004), 83 Oklahoma State University elementary education students (77 female, 6 male) received identical content instruction differing only in pedagogy. Students were assessed regarding self-efficacy, physics expectations, science process skills, and physics content. Analyses reveal that HBL and PBI cause statistically similar gains in elementary education students' self-efficacy scores and physics expectations. Both populations were similar before and after instruction, with similar changes in performance occurring on the same items; no statistically significant differences were caused by pedagogy. Analysis revealed that both groups scored approximately 90% on the process instrument and were not statistically different. While no significant differences in Exam Item performance existed for Light and Color or Astronomy by Sight problems, HBL caused a significant student score improvement on the Electric Circuits problem. The major analysis conclusion is that HBL produces largely the same results as PBI, providing explicit evidence that open and directed inquiry pedagogies can be equally effective.

Contributed Papers

16:06
S10 2 Implementation, Analysis, and Assessment of On-Line Teaching Evaluations JERRY ARTZ, ANDREW RUNDQUIST, *Hamline University* This ongoing project involves the introduction of the new, on-line teaching evaluation that enables students to anonymously assess their teachers and courses via computer. Over the past three years of this program, student compliance has been voluntary and has varied from a high of 73%, during the pilot program, to a low of 46% during the spring of 2005. Possible reasons for the lower compliance and measures that were taken in order to increase the compliance will be discussed. Such measures may have helped increase the compliance to 64% during the fall of 2005. The evaluation instrument, student compliance, analysis of data, and assessment will be discussed. Comparisons continue to be made (1) by grade received, (2) by class standing, (3) by ethnicity, (4) by gender and (5) of science versus non-science courses. In addition to common questions answered by all students, the on-line form allows instructors to add course-specific questions. Additional disciplinary-breadth assessment questions were added for the fall 2004 evaluation. Ongoing problems that have resulted from the introduction of on-line teaching evaluations will be discussed along with successes.

16:18
S10 3 Teaching Einstein: From epicycles to the equivalence principle* BEN BROMLEY, MARIA CRANOR, *University of Utah* In Fall 2005, under the auspices of the University of Utah's Office of Undergraduate Studies, we launched a new physics course on the life and work of Albert Einstein. A condition imposed on the new class was that it be taught completely free of mathematical content. In this talk we discuss our goals for the course, and present our conclusions about its effectiveness. We propose further innovations, such as structuring our history-based curriculum to admit students of varied mathematical abilities, from incoming freshmen to physics graduate students who are largely ignorant of the historical development of their science. This course has made us converts to the idea that an historical approach can greatly increase the appeal of science to the general student population.

*We are grateful for support from the University of Utah's Office of Undergraduate Studies.

16:30
S10 4 Teaching Quantum Physics Without Paradoxes in Introductory Physics Courses* ART HOBSON, *University of Arkansas* Although the resolution to the wave-particle paradox has been known for 80 years, it is seldom presented. Briefly, the resolution is that both material particles and photons are the quanta of

spatially continuous but energetically quantized fields. But because the resolution resides in quantum field theory and is not usually spelled out in ordinary language, it is neither generally understood nor generally taught, especially not in the context of non-relativistic quantum physics in general introductory physics courses for scientists and non-scientists. Why not teach from the beginning that electrons are quantized excitations of a real physical field, the ''electron field''? Four experimental results form a good framework for teaching: interference fringes in the double-slit experiments for light and for electrons, and the isolated photon and electron interactions that appear on the screen in the same two experiments done with low-intensity beams.

*American Journal of Physics, July 2005, pp. 630–634.

16:42
S10 5 Clickers in the Classroom: More than just Interactive Engagement* BRIAN PYPER, *Brigham Young University-Idaho* Classroom personal response systems and their effective use have been demonstrated and reported on previously. (1) This past semester, we performed a small experiment using the 'clickers' to investigate student learning in somewhat more depth, telling us some interesting things about how students are able to gauge their own learning, as well as differences in approaches to the material by gender. (1) N.W. Reay, et al, ''Toward the effective use of voting machines in physics lectures,'' Am. J. Phys. 73(6), 554–558 (June 2005).

*Partially supported by the Jacob Spori Memorial Fund for Student Research.

16:54
S10 6 Peer-led instruction for a qualifying exam preparatory course or: How I learned to stop worrying and love the PhD Qualifying Exam WARREN CHRISTENSEN, LARRY ENGELHARDT, *Iowa State University* In the spring of 2004, the authors were charged with the task of creating and administering a qualifying exam preparation curriculum that would strive to assist graduate students studying for their comprehensive physics exam. We incorporated many pedagogical techniques that have been proven effective at nearly all levels of instruction by leading researchers in the field of physics education. Our primary focus was on peer-led instruction and time-on-task doing actual problems from previous qualifying exams. After a brief but precise lecture covering essential ideas over a particular subject matter, students spend most of class time working in small groups and presenting worked problems at the board. At all times, the focus was on student explanations concerning the fundamental concepts behind a specific problem, as well as contemplating variations to broaden understanding and challenge students to think on their feet. We found that students who attended and participated regularly in class could be correlated with those students who achieved high marks on the exam.

17:06
S10 7 Defend Science: The Attack on Scientific Thinking and What Must Be Done JASON CURTIS, *UC Berkeley / Defend Science Project* ''In the United States today science, as science, is under attack as never before (Defend Science, defendscience.org).'' Beyond, and underlying, the many particular attacks and outrages in different spheres and policy areas is the question of the scientific method and whether it is going to be upheld and applied, or whether – even in the realm of science itself – that method is going to be replaced by something antagonistically opposed to the scientific method. These attacks are increasingly coming from powerful forces, in and out of the Bush administration, with an extreme right-wing political agenda, a Biblical-literalist ideological agenda, and theocratic aspirations for society. Individual scientists may be atheists, agnostics, or may hold various religious beliefs, but if religious and theistic elements are forced into the definition of science, then the scientific process is undermined and science cannot really be practiced. We can and must develop a society wide battle, initiated by scientists, but involving ever growing masses of people to defend science and scientific thinking. Scientists from various fields must be mobilized to issue a public call to millions with this urgent message as the beginning of this effort. I will discuss the necessity, possibility, and some initial efforts toward developing this kind of societal movement in defense of science.

SESSION S11: SOURCES OF GRAVITATIONAL WAVES
Monday Afternoon, 24 April 2006
Cumberland E, Hyatt Regency Dallas at 15:30
John Baker, Goddard Space Flight, presiding

15:30
S11 1 Search techniques for gravitational wave bursts from cosmic strings XAVIER SIEMENS, JOLIEN CREIGHTON, *University of Wisconsin – Milwaukee* IRIT MAOR, *Case Western Reserve University* SAIKAT RAY MAJUMDER, KIPP CANNON, JOCELYN READ, *University of Wisconsin – Milwaukee* We discuss data analysis techniques that can be used in the search for gravitational wave bursts from cosmic strings. In the absence of a detection, we show how to set upper limits based on the loudest event. Using Initial LIGO sensitivity curves, we show that these upper limits may result in interesting constraints on the parameter space of theories that lead to the production of cosmic strings.

15:42
S11 2 Self force on a particle in curved spacetime SWAPNIL TRIPATHI, ALAN WISEMAN, JOHN FRIEDMAN, TOBIAS KEIDL, *University of Wisconsin-Milwaukee* The finite part of the self force on a static scalar charge in a Schwarzschild spacetime is calculated here using a mode by mode expansion of Green's function. The Quinn-Wald axioms [2,3] have been used to regularize the self force. The directional part of the self force has been identified and substracted which simplfies the calculation a lot by making it possible to use symmetries. The motivation for this calculation is to develop techniques and formalism for use in calculations of the self forces (dissipative and conservative) acting on charges and masses moving in black hole spacetimes. [1] A.G. Wiseman, Phys. Rev. D **61**, 084014 (2000). [2] T.C. Quinn, Phys. Rev. D **62**, 064029 (2000). [3] T.C. Quinn, R.M. Wald Phys. Rev. D **56**, 3381 (1997).

15:54
S11 3 Static Electromagnetic and Gravitational Perturbations of Schwarzschild Spacetime TOBIAS KEIDL, JOHN FRIEDMAN, SWAPNIL TRIPATHI, ALAN WISEMAN, *University of*

Wisconsin–Milwaukee This talk describes an explicit computation of the perturbed gravitational field of a static point mass and of the electromagnetic field of a point charge in Schwarzschild background. Starting from the Teukolsky equation,[1] we calculate the gauge invariant Weyl Tensor components. By using free radial functions implicit in the Cohen-Kegeles prescription,[2] and by adding a mass perturbation outside of the Cohen-Kegeles gauge one can construct a gauge in which the metric is regular. The result is subtle, involving the piecing together of gauges regular above and below the position of the particle. The method is likely to be valid for particles in a Kerr geometry.

[1]Teukolsky, S. A., Astrophys. J., **185**, 635–647 (1973).
[2]Kegeles, L. S. and Cohen, J. M., Phys. Rev. D **19**, 1641–1664 (1979).

16:06
S11 4 Self-force in a gauge appropriate to separable wave equations* JOHN FRIEDMAN, TOBIAS KEIDL, SWAPNIL TRIPATHI, ALAN WISEMAN, *University of Wisconsin-Milwaukee* SAMUEL GRALLA, *University of Chicago* Gravitational waves from the inspiral of a stellar-size black hole to a supermassive black hole can be accurately approximated by a point particle moving in a Kerr background. The talk presents progress on computing the self-force in a gauge that is constructed from the gauge-invariant Weyl tensor. The gauge and the renormalization method are chosen to compute a perturbed metric and renormalized self-force from the Teukolsky equation. The method is related to earlier work by Cohen, Kegeles, Lousto, Detweiler, and Whiting, and to the MiSaTaQuWa renormalization.

*Work supported in part by NSF Grant PHY0503366.

16:18
S11 5 Extreme mass ratio inspirals via a multiple time expansion TANJA HINDERER, EANNA FLANAGAN, *Cornell University* Extreme mass ratio inspirals such as a stellar mass compact object orbiting a massive black hole at the center of a galaxy are an important source for the planned space-based gravitational wave detector LISA. To extract information from the signal requires accurate theoretical models as templates for matched filtering. One of the approaches for generating detection templates, the use of conservation laws, relies on the adiabatic approximation and there are some concerns as to the reliability of this approximation because in the weak field regime, it neglects important contributions to the phase from conservative pieces of the self-acceleration. We analyze this problem using a multiple time expansion, which is a standard tool for describing dynamical systems. This method allows us to show rigorously that the adiabatic approximation correctly gives the leading order phasing and establishes a mathematical framework for calculating the post- adiabatic phasing needed for measurement templates.

16:30
S11 6 The validity of the adiabatic approximation for extreme-mass ratio inspirals MARC FAVATA, EANNA FLANAGAN, *Cornell University* The inspiral of a compact object into a massive black hole is one of the primary sources of gravitational waves for the planned Laser Interferometer Space Antenna (LISA). The detection of these sources relies on the accurate modeling of the binary dynamics. A precise description of the binary orbit requires an evaluation of the self-force. The adiabatic approximation, which consists of using the time-averaged rates of change of the three conserved quantities for geodesic motion using a prescription derived by Mino, greatly simplifies computation of the orbital evolution. The accuracy of this approximation has been debated in the literature; in particular it has been suggested that the approximation is poor for eccentric orbits. Using post-Newtonian expansions we estimate the error in the waveform's phase for slightly eccentric orbits, generalizing previous estimates for circular orbits. The results indicate that adiabatic waveforms will likely be accurate enough for detection templates. We also show that the approximation becomes poor at low frequencies, in agreement with arguments of Pound, Poisson and Nickel; however those frequencies are outside LISA's waveband.

16:42
S11 7 Perturbations of Schwarzschild black holes in the Lorenz gauge: Formulation and numerical implementation* CARLOS LOUSTO, *The University of Texas at Brownsville* LEOR BARACK, *University of Southampton, England* We reformulate the theory of Schwarzschild black hole perturbations in terms of the metric perturbation in the Lorenz gauge. In this formulation, each tensor-harmonic mode of the perturbation is constructed algebraically from 10 scalar functions, satisfying a set of 10 wavelike equations, which are decoupled at their principal parts. We solve these equations using numerical evolution in the time domain, for the case of a pointlike test particle set in a circular geodesic orbit around the black hole. Our code uses characteristic coordinates, and incorporates a constraint damping scheme. The axially-symmetric, odd-parity modes of the perturbation are obtained analytically. The approach developed here is especially advantageous in applications requiring knowledge of the local metric perturbation near a point particle; in particular, it offers a useful framework for calculations of the gravitational self force.

*We acknowledges financial support from NSF grants PHY-0140326 and PHY-0354867, and NASA NAG5-13396.

SESSION S12: CP VIOLATION IN B MESON DECAYS
Monday Afternoon, 24 April 2006
Cumberland F, Hyatt Regency Dallas at 15:30
Masahiro Morii, Harvard University, presiding

15:30
S12 1 Measurement of the branching fraction of $B^+ \to \rho^+\rho^0$ KATHARINE SCHOFIELD, *University of Liverpool* BABAR COLLABORATION, We present a measurement of the branching fraction, the fraction of longitudinally polarized events and charge asymmetry of the decay $B^+ \to \rho^+\rho^0$. The data set for this analysis was recorded with the BaBar detector and corresponds to 210.5fb^{-1} (231 million $B\bar{B}$ pairs).

15:42
S12 2 CP Asymmetries in $B \to \pi^+\pi^-K_S$, $K^+K^-K_S$ Decays in the $f_0(980)$ Mass Region RUPAK DUTTA, SUSAN GARDNER, *University of Kentucky* We consider the branching ratios and direct and time-dependent asymmetries in $B \to f_0(980)K_S \to (\pi^+\pi^-, K^+K^-)K_S$ decays to the end of determining the deviation of the time-dependent asymmetry from

$\sin(2\beta)$ arising from Standard Model physics. We construct the $f_0(980)$ from isospin-zero $\pi^+\pi^-$ and K^+K^- final states, employing scalar form factors consistent with chiral constraints at low energies and utilize QCD factorization for the $B \to f_0(980)K_S$ decay amplitudes.

15:54
S12 3 Study of CP violation in $B^0 \to \pi^0\pi^0K^0_S$ decay at BaBar MAHALAXMI KRISHNAMURTHY, *University of Tennessee* BABAR COLLABORATION, We present the measurement of the time-dependent CP asymmetry for the neutral B-meson decay into the $CP = +1$ final state $K^0_S\pi^0\pi^0$. We use a sample of approximately 227 million B-meson pairs recorded at the $\Upsilon(4S)$ resonance by the BaBar detector at the PeP-II B-Factory at SLAC. From a maximum likelihood fit we extract the mixing-induced CP-violation parameter $S = 0.84 \pm 0.71 \pm 0.08$ and the direct CP-violation parameter $C = 0.27 \pm 0.52 \pm 0.13$, where the first uncertainty is statistical and the second systematic. We compare intensities of subdecay modes with expectations from related B-decay modes.

16:06
S12 4 $B \to h^+h^-$ results from 360pb^{-1} at CDF SONIA BUDRONI, *University of Pisa* CDF COLLABORATION, We report an update of the analysis of $B^0_{(}s \to h^+h'^-$ decays (where h and h′ denote K or pi) with 360 pb^{-1} of proton-antiproton collisions at $\sqrt{(}s$=1.96 TeV, with the CDF II detector at the Tevatron Collider. The results include a measurement of direct CP-violating asymmetry between $B^0 \to K^+pi^-$ and $\overline{B^0} \to K^-\pi^+$ decay-rates at the 4% level, based on a sample of about 1600 events.

16:18
S12 5 Study of the $B \to K^{*0}\rho$ modes at BaBar MARC ESCALIER, *Saclay* BABAR COLLABORATION, We present preliminary measurements of branching fraction, polarization and charge asymmetry for the decays $B \to K^{*0}\rho$. We use a data sample of more than 230 million $B\bar{B}$ pairs collected with the BaBar detector at the PEP-II asymmetric-energy B-factory at SLAC.

16:30
S12 6 Study of the $B \to K^{*+}\rho$ modes at BaBar WOOCHUN PARK, *University of South Carolina* BABAR COLLABORATION, We present measurements of branching fraction, polarization and direct-CP asymmetry in the charmless B meson decays to final states containing $K^{*\pm}$ and ρ mesons using 205 fb^{-1} of data collected with the BABAR detector at the PEP-II asymmetric e^+e^- collider at SLAC.

16:42
S12 7 $B^+ \to D^0K^+$ decays at CDFII PAOLA SQUILLACIOTI, *University of Siena* CDF COLLABORATION, The measurement of BRs and asymmetries of $B^\pm \to D0K^\pm$ modes is a theoretically clean method for the determination of the CKM angle γ. We present first results of the analysis of these modes at a hadron collider, from a sample of 360 pb^{-1} of data collected with the CDFII detector at the Tevatron collider at Fermilab.

16:54
S12 8 Measurement of time-dependent CP asymmetries in $B^0 \to J/\psi\pi^0$ decays KATHERINE GEORGE, *University of Liverpool* BABAR COLLABORATION, We present new results on the measurement of CP asymmetries in $B^0 \to J/\psi\pi^0$ decays using approximately 230 million $\Upsilon(4S) \to B\bar{B}$ decays collected by the BaBar detector at the PEP-II asymmetric-energy B factory. The Cabibbo-suppressed $b \to ccd$ tree amplitude has a time-dependent asymmetry in these decays that is related to the unitarity triangle angle β. Penguin amplitudes in these decays contribute at the same order, thus the measured CP asymmetry probes the size of the penguin decay amplitudes.

SESSION S13: TOP QUARK PRODUCTION
Monday Afternoon, 24 April 2006
Cumberland G, Hyatt Regency Dallas at 15:30
David Cline, University of California, Los Angeles, presiding

15:30
S13 1 Measurement of the ttbar production cross section at D0 using dilepton events SUSAN BURKE, *University of Arizona* We report on the measurement of the ttbar production cross section with candidate events in the dilepton final state. The ttbar signal is discriminated from background processes by requiring two identified leptons and using kinematic criteria that exploits the presence of neutrinos and energetic jets in ttbar events.

15:42
S13 2 Measurement of the ttbar production cross section at D0 using lepton + track events DMITRI DENISOV, DØ COLLABORATION, We report on the measurement of the ttbar production cross section with candidate events in the dilepton final state in which only one of the leptons satisfies our usual identification criteria, while the other appears as an isolated charged track. The ttbar signal is discriminated from background processes by requiring at least one b-tagged jet and using kinematic criteria that exploits the presence of neutrinos and energetic jets in ttbar events.

15:54
S13 3 Top Dilepton Cross Section Measurement Using the Tight Lepton+Isolated Track Sample* CORRINNE MILLS, *UC Santa Barbara* CDF COLLABORATION, We present a top pair production cross section measurement in the dilepton channel using 750pb^{-1} of Run II data. We select events with one well-identified lepton, an isolated track, and a significant amount of missing transverse energy. The expected and observed numbers of events with 0 and 1 jets, where background is the dominant contribution, agree well. We measure the top dilepton cross section for events with 2 or more jets and show the kinematic distributions of the signal sample compared to the Standard Model expectation.

*For the CDF Collaboration.

16:06
S13 4 Measurement of the ttbar production cross section at D0 using b tagging FLORENT CHEVALLIER, *LPSC, Grenoble, France* We report on the measurement of the ttbar production cross section using candidate events in the lepton plus jets final state. The ttbar signal is discriminated from background processes by the requirement of one or more identified b jets.

16:18
S13 5 Top Pair Production Cross Section Measurement in Lepton+Jets Channel Using Jet Probability b-Tagging* ENRIQUE PALENCIA, *Univ. of-Cantabria* CDF COLLABORATION, We present a preliminary measurement of the $t\bar{t}$ pair production cross section in the collisions of protons and anti-protons at 1.96 TeV using 320 pb^{-1} of data collected by the Collider Detector at Fermilab (CDF). The measurement uses $t\bar{t}$ decays into final states which contain one high transverse momentum lepton, high missing transverse energy and multiple jets, where one of the jets is required to be identified as a *b*-jet candidate from the information of the track's impact parameter resolution using the SVXII Silicon Vertex detector. The performance of the tagging algorithm used in this analysis (Jet Probability) is also discussed.

*For the CDF Collaboration.

16:30
S13 6 Precision Measurement of $t\bar{t}$ Production Cross Section using Lepton+Jets Events with Advanced b-Tagging Techniques* MICHAEL McFARLANE, *LBNL* CDF COLLABORATION, We present the measurement of the $t\bar{t}$ production cross section using events with one charged lepton and jets from $p\bar{p}$ collisions at $\sqrt{s}$ = 1.96 TeV. In these events heavy flavor quarks from top quark decay are identified using advanced multivariate b-tagging technique with the existing secondary vertex taggers SecVtx and JetProb, as well as other jet kinematic variables. The measurement uses the data collected up to Fall 2005 by the Collider Detector at Fermilab (CDF), which corresponds to an integrated luminosity of about 700 pb^{-1}. Results are consistent with Standard Model $t\bar{t}$ production.

*For the CDF Collaboration.

16:42
S13 7 Measurement of the ttbar production cross section at D0 using kinematic information SU-JUNG PARK, DØ COLLABORATION, We report on the measurement of the ttbar production cross section using candidate events in the lepton plus jets final state. The ttbar signal is discriminated from background processes using kinematic information. Several kinematic variables are combined into a multivariate discriminant to maximize the separation between signal and background.

16:54
S13 8 Measurement of the ttbar production cross section at D0 using all-hadronic events MARC-ANDRE PLEIER, DØ COLLABORATION, We report on the measurement of the ttbar production cross section with candidate events in the all-hadronic final state. The ttbar signal is discriminated from the QCD multijet background process by requiring at least one b-tagged jet and by using kinematic criteria. Several kinematic criteria are combined into a neural network to maximize the discrimination between signal and background.

17:06
S13 9 NLO Studies of Electroweak Production of Top Quarks JORGE A. BENITEZ, RAYMOND BROCK, REINHARD SCHWIENHORST, QING-HONG CAO, C.-P. YUAN, *Michigan State University* We have studied the effect of NLO calculations in the separation of the S and T channels for the electroweak production of top quarks. To find correlations among the different variables, we have used not only the well-known topological and kinematical variables, but also some functions which explore symmetry properties of the angular distributions.

SESSION S16: LABORATORY ASTROPHYSICS II
Monday Afternoon, 24 April 2006; Landmark D, Hyatt Regency Dallas at 15:30
Parvez Guzdar, University of Maryland, presiding

15:30
S16 1 Ion Heating During Reconnection Events in MST.*
DARREN CRAIG, *University of Wisconsin - Madison*

Magnetic reconnection is often accompanied by plasma heating in both laboratory and astrophysical situations, but the mechanism which converts the released magnetic energy to thermal energy remains unclear. In the Madison Symmetric Torus, spontaneous bursts of reconnection heat plasma ions, resulting in a doubling of the temperature in about one-hundred microseconds. Recent advances in diagnostics allow us to spatially and temporally resolve this heating for both majority deuterium and impurity ions. We find that the heat source is active throughout the plasma volume and appears stronger for impurities, implying a dependence on ion mass and/or charge. The heating is strongest when many nonlinearly coupled reconnection sites are active and weaker when only a few are active. Theoretical work to assess the importance of viscous damping of the flows associated with reconnection suggests they could be important. Work is supported by U.S.D.O.E. and N.S.F.

*In collaboration with D.J. Den Hartog, D.A. Ennis, G. Fiksel, S. Gangadhara, V.V. Mirnov, S.C. Prager, and V.A. Svidzinski, University of Wisconsin - Madison and the Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas.

15:50
S16 2 Ion Heating by Alfven Waves and Reconnection in NSTX.*
E.D. FREDRICKSON, *Princeton Plasma Physics Laboratory*

The evolution of laboratory and astrophysical plasmas depends on the flow of energy between the ''equilibrium'' configuration, waves in the plasma and the thermal plasma. We explore two examples of this energy flow. In the first example, data from NSTX is examined for evidence that CAE in the frequency range from ~ 0.2 fci to ~ 1.2 fci excited by super-thermal ions might heat the thermal ions. Theory indicates that only a relatively small portion of the beam power would go into exciting the CAE on NSTX, and observations indicate that the amplitude of these waves, deduced from density fluctuations, is below the stochastic threshold for heating. Another example examines how internal magnetic reconnections can lead to heating of the thermal ions. One model postulates the excitation of a high frequency wave, which then damps on the ions. High frequency waves are indeed seen to follow some NSTX reconnection events. The second invokes direct acceleration of the thermal ions by the induced electric field [P. Helander, L.-G. Eriksson, R.J. Akers et al., Phys. Rev. Lett. **89**, 235002-1 (2000)]. In collaboration with S.S. Medley, Princeton Plasma Physics Laboratory.

*Work supported by U.S. DOE Contract DE-AC02-76CH0307.

16:10
S16 3 Wave Experiments in Dusty Plasmas: Linear and Nonlinear.
JOHN GOREE, *The University of Iowa, Dept. of Physics and Astronomy*

A dusty plasma is an ionized gas containing small particles of solid matter, which are typically nanometer or micron size. These particles gain a large electrical charge by collecting electrons and ions from the ambient plasma. Examples of astrophysical dusty plasmas include the interstellar medium, comet tails and the rings of Saturn. The charged particles in a dusty plasma act like highly-charged super-massive ions, except that their charge is not fixed. Like ions, they can oscillate in response to electric fields, so that waves can propagate. These waves have very low frequencies, due to the heavy mass of the particles. Laboratory experiments are done by seeding microspheres into a glow-discharge plasma. In the presence of gravity, they can form a horizontal layer levitated by the electric field of a sheath. These particles are imaged directly, using video cameras, as they move about. Experiments have been performed to observe compressional and shear electrostatic waves. Experiments with low-amplitude linear waves as well as high-amplitude nonlinear waves will be described. At high amplitudes, compressional waves exhibit three-wave mixing. These experiments were performed in dusty plasmas that are strongly-coupled, with particles arranged in an ordered structure like molecules in a liquid or solid. Work supported by DOE and NASA.

16:30
S16 4 Spontaneous Double Layer Formation in Expanding Plasmas.*
XUAN SUN, *West Virginia University*

A double layer (DL) is a localized region of electric field characterized by a strong potential gradient. Particle acceleration in DLs has been proposed as a mechanism for astrophysical phenomena such as energetic electrons in the auroral zone and energetic ions emitted by the Sun during solar flares. In laboratory plasmas, DLs are typically created at the interface of two different plasmas or by driving a current in a single plasma. Recently, DLs have been observed to spontaneously develop in three different, current-free, expanding helicon plasmas: Chi-Kung at ANU, MNX at PPPL, and HELIX at WVU. We will present measurements of the DL structure in HELIX and MNX. Both DLs have a total potential drop of 3–4 kT_e and length scales smaller than ion-neutral mean-free-path. The spatial structure of the DL and ion acceleration in the DL is consistent with the predictions of Monte-Carlo, Particle-in-Cell simulation. Based on the experimental parameters, we hypothesize that DL formation is triggered when the ion-neutral collisional mean free path exceeds the magnetic field gradient scale length. Similar to the DLs occurring in nature, those two helicon DLs, as well as the DL in Chi-Kung, occur in the region of strong magnetic field gradient. We will also present measurements of the effect of magnetic field strength on DL structure and show that the DL continues to strengthen after many tens of ms in a pulsed helicon plasma.

*In collaboration with Costel Biloiu and Earl Scime, West Virginia University; and Sam Cohen, Princeton Plasma Physics Laboratory.

16:50
S16 5 Laboratory Studies of Turbulence Associated with Localized Current Layers.
STEPHEN VINCENA, *UCLA Department of Physics and Astronomy*

Localized current layers are a natural consequence of the interaction of the solar wind with the earth's magnetic field. In particular, field-aligned currents dynamically link the active magnetotail to the auroral ionosphere. Within these currents there may develop small-scale phenomena such as density-gradient or shear-driven instabilities, or electron solitary structures and micro-turbulence which may profoundly influence the larger-scale dynamics of the system. The Basic Plasma Science Facility (BaPSF) at UCLA offers a unique opportunity to model magneto/heliospheric phenomena,

including current sheets. We present measurements from laboratory experiments of an electron current sheet which is several ion-gyroradii thick by up to ten Alfvén wavelengths along the field (1cm by 20m). The current sheet leads to a depletion of the background plasma, forming a field-aligned density depression. Drift-Alfvén waves are spontaneously excited and drive cross-field particle transport which relaxes the density gradient and modulates the current flow. We will also present initial results of small-scale electric field spikes within the current sheet using specially fabricated dipole probes with separation on the order of the Debye length—here 13 microns. These measurements are motivated by the observation of electron solitary structures throughout the magnetosphere.

17:10
S16 6 Nonlinear interactions between shear Alfvén waves in a laboratory plasma.*
TROY CARTER, *Dept. of Physics and Astronomy and Center for Multiscale Plasma Dynamics, UCLA*

Electromagnetic turbulence is thought to play an important role in plasmas in astrophysical settings (e.g. the interstellar medium, accretion disks) and in the laboratory (e.g. transport in magnetic fusion devices). From a weak turbulence point of view, nonlinear interactions between shear Alfvén waves are fundamental to the turbulent energy cascade in magnetic turbulence. An experimental investigation of nonlinear interactions between shear Alfvén waves in the Large Plasma Device (LAPD) will be presented. Two Alfvén waves, generated by a resonant cavity, are observed to beat together, driving a low frequency perturbation at the beat frequency. The low frequency perturbation then scatters the Alfvén waves, generating a series of sidebands. The observed interaction is very strong, with the normalized amplitude of the driven low frequency mode comparable to the normalized magnetic field amplitude ($\delta B/B$) of the interacting Alfvén waves. Experimental details of this interaction will be presented along with other phenomena associated with large amplitude Alfvén waves in LAPD, including electron heating and background density modification. Initial results from counter-propagating wave interaction experiments will also be discussed. In collaboration with Brian Brugman, Dept. of Physics and Astronomy and Center for Multiscale Plasma Dynamics, UCLA.

*Supported by DOE grant DE-FG02-02ER54688 and by DOE Fusion Science Center Cooperative Agreement DE-FC02-04ER54785.

SESSION T2: DNP BUSINESS MEETING
Monday Evening, 24 April 2006
Landmark B, Hyatt Regency Dallas at 17:30

SESSION T4: FPS BUSINESS MEETING
Monday Evening, 24 April 2006
Marsalis A, Hyatt Regency Dallas at 17:30

SESSION T5: DPB BUSINESS MEETING AND RECEPTION
Monday Evening, 24 April 2006
Reverchon B, Hyatt Regency Dallas at 17:30

SESSION T7: DAP BUSINESS MEETING
Monday Evening, 24 April 2006
Pegasus A, Hyatt Regency Dallas at 17:30

SESSION T11: GFB BUSINESS MEETING
Monday Evening, 24 April 2006
Cumberland E, Hyatt Regency Dallas at 17:30

SESSION T12: GGR BUSINESS MEETING
Monday Evening, 24 April 2006
Cumberland F, Hyatt Regency Dallas at 17:30

SESSION T14: FHP BUSINESS MEETING
Monday Evening, 24 April 2006
Cumberland I, Hyatt Regency Dallas at 17:30
Robert H. Romer, Amherst College, presiding

SESSION V1: PLENARY SESSION III
Tuesday Morning, 25 April 2006; Landmark A, Hyatt Regency Dallas at 8:30
Brad Sherrill, Michigan State University, presiding

8:30
V1 1 The Science of Nanotubes.
ALEX ZETTL, *University of California, Berkeley*

Nanotubes formed from carbon or boron nitride have highly unusual electronic and mechanical properties. Depending on composition and geometry, they range from excellent metals to wide-bandgap semiconductors. They can be grown with length-to-diameter aspect ratios exceeding 10 million, and are axially exceptionally stiff yet form nearly ideal frictionless bearings. This talk will address the exciting basic science as well as applications of nanotubes and nanotube-based nanoelectromechanical systems.

9:06
V1 2 Searching for gravitational waves with LIGO.
GABRIELA GONZALEZ,* *Louisiana State University*

The LIGO gravitational wave observatories are now taking data, having reached their design sensitivity. The LIGO scientific Collaboration is actively searching the data for signals from rotating stars, from stochastic backgrounds, from binary neutron star and black hole systems, and from transient sources like supernovas and collisions of black holes. We will show the sensitivity achieved by the detectors and present the latest results in the search for gravitational waves. We will also describe the worldwide effort for present and future detectors.

*For the LIGO Scientific Collaboration.

9:42
V1 3 Matter, Energy, Space and Time: The International Linear Collider Physics Prospects and International Aspects.
ALBRECHT WAGNER, *DESY*

Over the past century, physicists have sought to explain the character of the matter and energy in our universe, to show how the basic forces of nature and the building blocks of matter come about, and to explore the fabric of space and time. In the past three decades, experiments at laboratories around the world have given us a precise confirmation of the underlying theory called the itstandard model. These particle physics advances have a direct impact for our understanding of the structure of the universe, both at its inception in the Big Bang, and in its evolution to the present and future. The final synthesis is not yet fully clear, but we know with confidence that major discoveries expanding the standard model framework will occur at the next generation of accelerators. The Large Hadron Collider (LHC) being built at CERN will take us into the discovery realm. The proposed International Linear Collider (ILC) will extend the discoveries and provide a wealth of precision measurements that are essential for giving deeper understanding of their meaning, and pointing the way to further evolution of particle physics in the future. A world-wide consensus has formed for a baseline ILC project at energies of 500 GeV and beyond. The choice of the superconducting technology as basis for the ILC has paved the way for a global design effort which has now taken full speed.

SESSION W1: SHEDDING LIGHT ON DARK ENERGY
Tuesday Morning, 25 April 2006; Landmark A, Hyatt Regency Dallas at 10:45
Natalie Roe, Lawrence Berkeley National Laboratory, presiding

10:45
W1 1 Cosomolgy using Type Ia SNe from the Supernova Legacy Survey.
D. ANDREW HOWELL, *University of Toronto*

The Supernova Legacy Survey (SNLS) is a five-year program which will use around 700 high-redshift Type Ia Supernovae (SNe Ia) to constrain the average equation-of-state of dark energy, w. The survey uses griz rolling light-curves sampled every 3-4 days in dark or gray time, with SN types and redshifts determined from follow-up spectroscopy using Gemini, the VLT, and Keck telescopes. The first results from the survey indicate that in a flat universe Omega_Matter

=0.263 +/− 0.042, and w=-1.02 +/− 0.09 (stat) when combined with the constraint from baryon acoustic oscillations. We give an update on the current status of the survey, including evidence that the rates and properties of SNe Ia vary as a function of their progenitor stellar population. Using a two-component model, we constrain the expected evolution of average SN Ia properties with redshift and place limits on progenitor models.

11:21
W1 2 Theoretical Overview of Dark Energy.
ERIC LINDER, *University of California - Berkeley*

Recent developments in understanding the influence of dark energy dynamics on cosmological observables have led to several insights in how to reveal the nature of dark energy. This includes the categorization of many physics models for the dark energy into either freezing or thawing behavior, recognition of differences from the inflation scenario, and methods for robustly distinguishing a physical dark energy from a modification of gravitational physics. These have definite consequences for experiment design, such as prescription of the relative precision needed for dynamics measurements, the need for probes of both cosmological expansion and large scale structure growth, and how dark energy microphysics can contribute a theory-induced systematics limit on many techniques.

11:57
W1 3 Weak Gravitational Lensing and Dark Energy.
GARY BERNSTEIN, *University of Pennsylvania*

Weak gravitational lensing is a means of measuring the expansion history of the Universe and the growth of the structures contained within. Both quantities are altered by the existence of dark energy or by alterations to General Relativity. I will describe the methods, potential, and limitations of the weak lensing method, and the practical steps necessary for its full exploitation.

SESSION W2: NOTES FROM UNDERGROUND
Tuesday Morning, 25 April 2006; Landmark B, Hyatt Regency Dallas at 10:45
George Fuller, University of California, San Diego, presiding

10:45
W2 1 Status and Prospects for the EXO experiment.
GIORGIO GRATTA, *Stanford University*

EXO (Enriched Xenon Observatory) is a program to ultimately build a 10-ton class neutrino-less double-beta decay experiment using 136-Xe. EXO will perform a background-free experiment by combining the energy and position of the decay electrons with the identification of the final state nucleus (Ba) by means of high resolution atomic spectroscopy. I will describe the state of the R&D on the spectroscopic tagging of single Ba atoms extracted from a volume of liquid xenon and discuss the construction of the EXO-200 detector. EXO-200 will be the largest double-beta decay experiment ever built, employing 200 kg of xenon enriched to 80% in the isotope 136.

11:21
W2 2
MARK VAGINS, *University of California, Irvine*

This abstract was not received electronically.

11:57
W2 3 AMANDA & IceCube: Status and Prospects.
AZRIEL GOLDSCHMIDT, *Lawrence Berkeley National Laboratory*

With 677 optical sensors buried in South Pole ice at depths between 1.5 and 2 kilometers, AMANDA-II is currently the largest high-energy neutrino telescope in operation. Searches for extraterrestrial neutrino sources in data collected with this array since its completion in 2000 have so far yielded null results. Construction of the much larger IceCube array began in early 2005 and is scheduled to continue for another four years until a volume of 1 km3 is instrumented with ~ 4,500 sensors. In this talk I will summarize some of the AMANDA-II results and I will describe the performance of the first elements of the technologically superior IceCube array.

SESSION W3: COSMIC GAMMA-RAY BURSTS
Tuesday Morning, 25 April 2006; Landmark C, Hyatt Regency Dallas at 10:45
Charles Meegan, National Space Science and Technology Center, presiding

10:45
W3 1 Gamma Ray Burst Discoveries by the Swift Mission.
NEIL GEHRELS,* *NASA-GSFC*

Gamma-ray bursts are among the most fascinating occurrences in the cosmos. They are thought to be the birth cries of black holes throughout the universe. The NASA Swift mission is an innovative new multiwavelength observatory designed to determine the origin of bursts and use them to probe the early Universe. Swift is now in orbit since November 20, 2004 and all hardware is performing well. A new-technology wide-field gamma-ray camera is detecting a hundred bursts per year. Sensitive narrow-field X-ray and UV/optical telescopes, built in collaboration with UK and Italian partners, are pointed at the burst location in 50–100 sec by an autonomously controlled ''swift'' spacecraft. For each burst, arcsec positions are determined and optical/UV/X-ray/gamma-ray spectrophotometry performed. Information is also rapidly sent to the ground to a team of more than 50 observers at telescopes around the world. The first year of findings from the mission will be presented. There has been a break-through in the long-standing mystery of short GRBs; they appear to be caused by merging neutron stars. High redshift bursts have been detected leading to a better understanding of star formation rates and distant galaxy environments. GRBs have been found with giant X-ray flares occurring in their afterglow.

*On behalf of the Swift team.

11:21
W3 2 GRBs as probes of relativistic jet physics and cosmology.*
DIETER HARTMANN, *Clemson University*

Key observational properties of long-duration and short-duration GRBs will be reviewed briefly and discussed in the context of current theoretical models. Emphasis will be on a critical assessment of what we know with confidence and the extent of speculation. The discussion will include issues regarding the central engine, progenitors, afterglows, and host galaxy properties. We address the extent to which GRBs may serve as a probe of ultra-relativistic physics, and their use as a tool of cosmology. The latter issue is divided into their use for determining cosmological parameters and their use as background ''light bulbs'' to trace cosmic chemical evolution.

*I acknowledge support from the Swift team and NASA INTEGRAL GI grant NNG05GA12G.

11:57
W3 3 Discovery and Identification of the Very High Redshift Afterglow of GRB 050908 and Prospects for the Future.
DAN REICHART, *University of North Carolina*

I will report our discovery of the afterglow of GRB 050904 and our identification of GRB 050904 as the first very high redshift GRB. I will also discuss prospects for the future use of GRBs as probes of the early universe.

SESSION W5: ABRUPT CLIMATE CHANGE SCENARIO
Tuesday Morning, 25 April 2006; Pegasus B, Hyatt Regency Dallas at 10:30
Tina Kaarsberg, U.S. Department of Energy, presiding

10:30
W5 1 Negative Emissions Technology.
DANNY DAY, *EPRIDA*

Although ''negative emissions'' of carbon dioxide need not, in principle, involve use of biological processes to draw carbon out of the atmosphere, such ''agricultural sequestration'' is the only known way to remove carbon from the atmosphere on time scales comparable to the time scale for anthropogenic increases in carbon emissions. In order to maintain the ''negative emissions'' the biomass must be used in such a way that the resulting carbon dioxide is separated and permanently sequestered. Two options for sequestration are in the topsoil and via geologic carbon sequestration. The former has multiple benefits, but the latter also is needed. Thus, although geologic carbon sequestration is viewed skeptically by some environmentalists as simply a way to keep using fossil fuels—it may be a key part of reversing accelerating climate forcing if rapid climate change is beginning to occur. I will first review the general approach of agricultural sequestration combined with use of resulting biofuels in a way that permits carbon separation and then

geologic sequestration as a negative emissions technology. Then I discuss the process that is the focus of my company—the EPRIDA cycle. If deployed at a sufficiently large scale, it could reverse the increase in CO2 concentrations. I also estimate the benefits —carbon and other—of large scale deployment of negative emissions technologies. For example, using the EPRIDA cycle by planting and soil sequestering carbon in an area about 3X the size of Texas would remove the amount of carbon that is being accumulated worldwide each year. In addition to the atmospheric carbon removal, the EPRIDA approach also counters the depletion of carbon in the soil—increasing topsoil and its fertility; reduces the excess nitrogen in the water by eliminating the need for ammonium nitrate fertilizer and reduces fossil fuel reliance by providing biofuel and avoiding natural gas based fertilizer production.

11:05
W5 2 Cool Roofs to Save Money and Delay Global Warming.
ARTHUR ROSENFELD, *California Energy Commission*

White roofs, and now cool-colored roofs, with a high reflectivity or ''albedo'' have a long history (best known around the Mediterranean) of keeping buildings and cities cool. In modern times, cool roofs have been shown to reduce air conditioning (a-c) demand and slow the formation of ozone (smog). Studies establishing a typical 10% reduction in a-c demand and electricity savings due to white roofs in California (CA) resulted in the 2005 CA new building energy efficiency standard prescribing that low-slope roofs be white, but exempting sloping roofs for aesthetic reasons. The advent (thanks to physicists' efforts) of inexpensive colored pigments with high albedo has led to 2008 CA standards requiring that even sloping roofs be cool. Here, I show that cooling the planet by reducing urban albedo through white and other cool roofs is a direct effect, much larger and immediate than the 2nd-order cooling from reduced CO2 from reduced a-c use. I then investigate widespread deployment of cool roof in major tropical and temperate cities, which cover 2% of global land area and have a proportionately higher albedo impact due to lower latitude. Here, cool roofs and cooler pavements can raise urban albedo by 10%. This directly drops the global average temperature by ~ 0.05 /deg C. Though small compared to a likely 3 /deg C rise by 2060, an immediate drop of 0.05 /deg C represents a reprieve in global warming of 1 year, and represents avoiding a year's current annual world emissions of CO2, i.e. 25 GT(CO2). At a trading price of $25/tCO2, this is worth ~ $625B. Cooling the planet also could save annually hundreds of $billions on a-c electric bills. Finally I suggest policies to increase cool roof deployment, for example, developed world Kyoto signatories could use its CDM (Clean Development Mechanism) for cool roof programs in developing countries.

11:40
W5 3 Lessons from Katrina: Flood Management Technology Strategies for the US.
GERALD GALLOWAY, *University of Maryland*

Coastal and riverine flooding and hurricane-driven storms have long plagued those in the United States who live or work on or near the shoreline or the rivers edge. The devastation wrought by Hurricane Katrina brought the challenge of protecting against such events to the political and technical forefront. The predicted impacts of global warming strongly suggest that our floodplains and coastlines could be at greatly increased risk. This presentation will review the development of the U.S. program for providing structural protection, discuss the effectiveness of employing levees, dams, floodways, beach nourishment and storm barriers in this struggle, highlight the changes over the last two decades that have gradually shifted the focus from a structural-only approach to one that includes the non-structural approaches such as wise land use, wetland restoration, relocations, insurance, floodproofing, and emergency warning and evacuation. Using post-Katrina planning as an example, it will explore what new approaches can be taken. Should New Orleans take a ''levees only'' approach to its protection? or should attention to New Orleans be part of a coastal Louisiana integrated flood damage reduction and coastal restoration strategy. The nation needs to make changes in its water resources policies and investment strategy to deal with the new threat that it now faces.

SESSION W6: RESEARCH ON TEACHING THERMAL PHYSICS AND QUANTUM MECHANICS
Tuesday Morning, 25 April 2006; Cumberland J, Hyatt Regency Dallas at 10:45
Paula Heron, University of Washington, presiding

10:45
W6 1 Investigations of Upper Division Student Understanding of Thermal Physics.*
JOHN THOMPSON, *Department of Physics and Astronomy and Center for Science and Mathematics Education Research, The University of Maine*

In research on the teaching and learning of upper-level (junior-senior) thermal physics, we are probing student understanding of topics that are taught at the introductory level (e.g., work, heat, the first and second laws of thermodynamics, entropy) as well as more advanced topics (e.g., thermodynamic potentials, the Maxwell relations, chemical potential). Many of our findings are consistent with prior work at the introductory level [1,2], however we find some differences for 2nd law topics. Preliminary results suggest that upper-level undergraduates often enter a thermal physics course with little

understanding of entropy, and emerge from the course with an ability to apply some features of entropy and the 2nd Law appropriately. Difficulties with specific properties of entropy persist, especially with the state function property. Another aspect of this research deals with student functional understanding of mathematical concepts applied in the context of thermal physics (e.g., path integrals, partial differentiation). Most system properties can be represented as partial derivatives of one variable with respect to another while holding appropriate others fixed. Our findings indicate that although students are able to take partial derivatives easily, many students have difficulty understanding the mathematical and/or physical significance of their differentiation, even after instruction. I will present data regarding student understanding of mixed second-order partial differentiation in general, and the Maxwell relations in particular. Finally, I will discuss the development of instructional materials to address specific difficulties found in our research. 1. M.E. Loverude, C.H. Kautz, and P.R.L. Heron, Am. J. Phys. **70**, 137 (2002). 2. D.E. Meltzer, Am. J. Phys. **72**, 1432 (2004).

*Supported in part by NSF grant PHY-0406764.

11:21
W6 2 Improving Student Understanding of Quantum Mechanics.*
CHANDRALEKHA SINGH, *University of Pittsburgh*

We are investigating the difficulties that students have in learning upper-level quantum mechanics and designing quantum interactive learning tutorials (QuILTs). Our investigation includes interviews with individual students and the development and administration of free-response and multiple-choice tests. The preliminary results from the QuILTs are promising. Coauthors: Mario Belloni and Wolfgang Christian, Davidson College.

*Supported by NSF PHY-0244708 and DUE-0126439.

11:57
W6 3 Addressing students' reasoning difficulties in thermal physics.*
DAVID E. MELTZER, *Department of Physics, University of Washington*

Recent investigations into student learning of thermal physics at the undergraduate level have shown that most students in introductory courses face significant obstacles in mastering fundamental concepts in this area. [M. E. Loverude, C. H. Kautz, and P. R. L. Heron, Am. J. Phys. **70**, 137 (2002); D. E. Meltzer, Am. J. Phys. **72**, 1432 (2004).] Results from a variety of institutions indicate that up to 80% or more of all students fail to complete introductory courses with an ability to use the first law of thermodynamics in problem solving, while related confusion with entropy and second-law concepts is also widespread. Our ongoing investigation of student learning of thermal physics at the advanced undergraduate (junior-senior) level is probing the evolution of students' reasoning as they attempt to integrate the macroscopic and microscopic /statistical viewpoints into a coherent understanding. This work confirms that difficulties with fundamental concepts persist for a majority of students at this level as well. Among the specific difficulties identified are a strong tendency to attribute state-function properties to process-dependent quantities such as heat and work, a complementary failure to recognize the state-function property of entropy in irreversible processes, and confusion regarding the application of the second law to entropy changes in non-isolated systems. I will present data that characterizes these learning difficulties in more detail and reflects their prevalence at different levels of instruction. We have been developing and testing a variety of pedagogical strategies aimed at addressing these difficulties at both the introductory and advanced undergraduate level. I will outline and discuss these strategies along with a preliminary assessment of their effectiveness, and show examples of the curricular materials that are under development.

*Supported in part by NSF DUE 9981140 and PHY 0406724

SESSION W7: COSMIC RAYS AND SOLAR PHYSICS II
Tuesday Morning, 25 April 2006
Pegasus A, Hyatt Regency Dallas at 10:45

10:45
W7 1 Upper Limit of the Diffuse Flux of UHE Neutrinos from HiRes Data WEIRAN DENG, KAI MARTENS, *University of Utah* HIRES COLLABORATION, The cosmic ray spectrum as measured by HiRes experiment suggests the existence of GZK neutrinos. We describe the HiRes neutrino simulation and present a first result from the neutrino search in the data.

10:57
W7 2 An Upper Limit on the Photon Flux above 10^{19} eV DAVID BARNHILL, *UCLA* PIERRE AUGER COLLABORATION, The Pierre Auger Observatory is designed to investigate the highest energy cosmic rays. Of particular interest is the composition of these cosmic rays as it indicates the nature of the source. In this presentation, data from the surface detector of the Pierre Auger Observatory will be compared to monte carlo predictions based on a primary photon assumption. A prescription will be set forth in determining primary photon candidates and a resulting upper limit on the photon flux will be presented.

11:09
W7 3 Stringent Constraint on Galactic Positron Production JOHN BEACOM, *Ohio State University* The intense 0.511 MeV gamma-ray line emission from the Galactic Center observed by INTEGRAL requires a large annihilation rate of nonrelativistic positrons. If these positrons are injected at even mildly relativistic energies, higher-energy gamma rays will also be produced. We calculate the gamma-ray spectrum due to inflight annihilation and

compare to the observed diffuse Galactic gamma-ray data. Even in a simplified but conservative treatment, we find that the positron injection energies must be $\lesssim$ 3 MeV, which strongly constrains models for Galactic positron production, especially dark matter annihilation.

11:21
W7 4 Planck Scale Cosmic Rays* BENNIE WARD, *Baylor University* We argue that the final state of Hawking radiation for a very massive black hole results in a Planck size remnant which may decay into Planck scale cosmic rays.

*Work supported by US DOE grant #DE-FG02-05ER41399 and NATO grant PST.CLG.980342.

11:33
W7 5 Comparison of Electron Stochastic Acceleration Models with RHESSI Hard X-ray Observations of Solar Flares PAOLO GRIGIS, ARNOLD BENZ, *ETH Zurich, Switzerland* Acceleration of charged particles in a plasma by means of stochastic interactions with turbulent waves is very efficient and therefore is often invoked as the key mechanism acting in solar flare electron acceleration. We compare the photon spectra produced by electrons accelerated using the Transient Time Damping (TTD) mechanism with the detailed hard X-ray observations provided by RHESSI for footpoint and looptop sources, showing the soft-hard-soft behavior in the spectral evolution. The TTD model with a simple leaky box escape term fails to quantitatively match the observed spectral behavior, requiring too large variations in photon flux over the range of observed spectral indices. We discuss more realistic models and further modifications needed to reproduce the RHESSI observations.

11:45
W7 6 Development of the FNIT detector for 2-20 MeV solar neutrons* ULISSE BRAVAR, PAUL J. BRUILLARD, *University of New Hampshire* ERWIN O. FLUECKIGER, *University of Bern* ALEC L. MACKINNON, *University of Glasgow* JOHN R. MACRI, MARK L. MCCONNELL, *University of New Hampshire* MICHAEL R. MOSER, *University of Bern* JAMES M. RYAN, *University of New Hampshire* The Fast Neutron Imaging Telescope (FNIT) is a newly developed neutron detector with imaging and energy measurement capabilities, sensitive to neutrons in the 2–20 MeV energy range. FNIT was conceived as a candidate instrument for the Solar Sentinels program. Its design is optimized to measure neutrons produced in solar flares from the inner heliosphere. The detection principle is based on multiple elastic neutron-proton scatterings in plastic scintillators. By measuring the scattering coordinates and determining the energy of recoil protons and time of flight of scattered neutrons, the energy spectrum and incident direction of primary neutrons can be reconstructed. We present the results of recent laboratory efforts and describe the performance of the FNIT prototype.

*Development of the FNIT detector for 2–20 MeV solar neutrons

11:57
W7 7 The Presence of the Chromosphere: Evidence for a Liquid Model of the Sun PIERRE-MARIE ROBITAILLE, *The Ohio State University* Critical Opalescence occurs at the critical point. It is that point in the phase diagram where the transition between liquid and gas is no longer discernable. In the laboratory, critical opalescence occurs as the meniscus disappears. There is often strong scattering of light and a transparent solution becomes cloudy. In approaching the critical point gases slowly begin to gain order as they prepare to enter the condensed state. In this presentation, it will be advanced that the Chromosphere of the Sun represents matter at the critical point. As such, the Chromosphere experiences a unique combination of temperature, pressure and gravity wherein the gaseous matter in the corona is preparing to condense onto a liquid photosphere. It is consequently stated that the very existence of the Chromosphere, constitutes a powerful piece of evidence in favor of condensed models of the Sun (http://www.arxiv.org/html/astro-ph/0410075 [1]). Additional evidence for a liquid plasma model of the Sun will also be presented.

SESSION W8: MINISYMPOSIUM: HEAVY QUARK ENERGY LOSS & FLOW
Tuesday Morning, 25 April 2006; Cumberland A, Hyatt Regency Dallas at 10:45
Peter Jacobs, Lawrence Berkeley National Laboratory, presiding

Invited Papers

10:45
W8 1 Identified particle transverse momentum distributions upto 12 GeV/c from Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV.*
HAIDONG LIU, *USTC/LBL/BNL*

Ultra-relativistic Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV at RHIC create a hot and dense medium that exhibits novel properties. Study of these properties and hadronization mechanisms of the medium requires identified particle results over wide transverse momentum (p_T) range since different mechanisms govern hadron production in different kinematic regions. Particle identification at low, intermediate and high p_T is achieved from Time Projection Chamber and Time-of-Flight system at STAR. In this talk, we present the p_T distributions of $\pi^{\pm}$, p and $\bar{p}$, their nuclear modification factors and particle ratios from 200 GeV Au+Au collisions up to 12 GeV/c at mid-rapidity. We discuss the relative baryon enhancement at intermediate p_T and the flavor dependence of the energy loss. We also discuss the possible transition between jet dominant fragmentation and quark coalescence at hadronization.

*On behalf of the STAR Collaboration.

Contributed Papers

11:21
W8 2 Heavy-quark observables at RHIC from parton transport theory DENES MOLNAR, *Purdue Univ. and RIKEN/BNL Research Center* There are several indications that an opaque partonic medium is created in energetic Au+Au collisions ($\sqrt{s}$ ~ 100 GeV/nucleon) at the Relativistic Heavy Ion Collider (RHIC). At the extreme densities of ~ 10–100 times normal nuclear density reached even heavy-flavor hadrons are affected significantly. Results on heavy-quark observables will be presented based on the parton transport model MPC, focusing on the nuclear suppression pattern and the azimuthal anisotropy (''elliptic flow''). I will contrast the opacities extracted from light and heavy-flavor observables and will test whether both open and hidden heavy-flavor observables can be explained in the parton transport framework.

11:33
W8 3 Hadron-Hadron Angular Correlations in $\sqrt{s_{NN}}$ = 62.4 GeV Au+Au Collisions at RHIC-PHENIX MICHAEL McCUMBER, *SUNY Stony Brook* PHENIX COLLABORATION, The study of medium effects in $\sqrt{s_{NN}}$ = 200 GeV Au+Au collisions at RHIC via jet properties extracted from di-hadron opening angle correlations has yielded the observation of significant modification of the away-side jet. We analyze $\sqrt{s_{NN}}$ = 62.4 GeV Au+Au collisions and find that the away-side jet modification persists at this lower energy. We present the results of corrected angular correlation measurements and also a novel technique for model-independent quantification of the away-side jet shape. We compare our results to measurements made in other colliding systems and in other energies.

11:45
W8 4 Photon-hadron and π^0-hadron azimuthal jet correlations in $\sqrt{s_{NN}}$ = 200 GeV Cu-Cu collisions at RHIC ANDREW ADARE, *University of Colorado* PHENIX COLLABORATION, Angular correlation of final-state particles provides an informative probe of the dense, hot matter produced in high-energy nuclear collisions. A brief description of the technique of angular pair correlations and their application to QCD jet analysis in heavy-ion collisions is presented in addition to preliminary results from $\gamma - h$ and $\pi^0 - h$ azimuthal pair correlations from the PHENIX experiment at RHIC.

11:57
W8 5 Jet Trigger Analysis for the ALICE Electromagnetic Calorimeter* CHRISTOPHER ANSON, *Creighton University* ALICE-USA COLLABORATION, The analysis of jets in ultra-relativistic heavy ion collisions with the ALICE experiment at the LHC requires a sophisticated trigger scheme to acquire a high statistics sample of high p_t jets. This can be implemented using the large area electromagnetic calorimeter (EMCal) proposed by the ALICE-USA Collaboration. A Level 1 EMCal jet trigger will be discussed and compared to an idealized leading pi0 trigger in order to elucidate the underlying trigger behavior. The effect of fluctuations in the rather large background will be explored. It will be shown that a Level 1 trigger can select appropriate jet events efficiently while reducing the data rate to the required level. The necessity of a further reduction of the data rate requires the use of an efficient higher level multiplicity dependent jet trigger which will be discussed.

*Supported by the Office of Science, U.S. Department of Energy.

12:09
W8 6 Jet studies in preparation for ATLAS: From pp to heavy ion collisions ARTHUR MORAES, *BNL* ATLAS COLLABORATION, The Large Hadron Collider (LHC) will collide protons at centre-of-mass energies many times greater than any sub-atomic particle collision ever performed in laboratory and will also run a variety of ion beams, thus providing proton-ion and ion-ion collisions. Designed to perform very precise measurements at the LHC, the ATLAS detector will play a key role in revealing the most interesting and complicated features of proton-proton, proton-nucleus and nucleus-nucleus collisions at the LHC. Understanding the structure of jets will be of fundamental importance in the identification of the Higgs and Supersymmetry in proton collisions, as well as a variety of other new physics phenomena in heavy ion collisions such as jet quenching. The ATLAS calorimeter is particularly well designed and should allow excellent jet energy and profile measurements. This talk focuses on jet studies in preparation for heavy ion collisions at ATLAS. Predictions for jet distributions in proton-proton collisions will also be shown and used to provide insights into the measurement of new physics signatures in heavy ion collisions.

SESSION W9: NUCLEAR THEORY II
Tuesday Morning, 25 April 2006
Cumberland B, Hyatt Regency Dallas at 10:45
Vladimir Zelevinsky, Michigan State University, presiding

10:45
W9 1 Spectroscopy of Medium to Heavy Λ-Hypernuclei JEFF McINTIRE, *Indiana University* We develop a method for calculating the doublet splittings of select ground-state Λ-hypernuclei. This hypernuclear spectroscopy is conducted by supplementing the self-consistent single-particle equations with an effective interaction, which follows directly from the underlying lagrangian, to simulate the residual particle-hole interaction. Our previous investigation, performed using only the leading-oreder contributions to the particle-hole interaction, was inadequate. In the present work, this method is improved upon by increasing the level of truncation in the residual interaction to include gradient couplings to the neutral vector meson. As a result, we obtain a realsitic description of the effect of these gradient couplings on the doublet orderings and splittings.

10:57
W9 2 A Simple Five-Dimensional Wave Equation for a Dirac Particle N. REDINGTON, M.A.K. LODHI, *Texas Tech University* A first-order relativistic wave equation is constructed in five dimensions. Its solutions are eight-component spinors, which are interpreted as single-particle fermion wave functions in four-dimensional spacetime. Use of a ''cylinder condition'' (the removal of explicit dependence on the fifth coordinate) reduces each eight-component solution to a pair of degenerate four-component

spinors obeying the Dirac equation. This five-dimensional method is used to obtain solutions for a free particle and for a particle moving in the Coulomb potential. It is shown that, under the cylinder condition, the results are the same as those from the Dirac equation.

11:09
W9 3 Convergence of the Born Series with Low-Momentum Potentials SUNETHRA RAMANAN, SCOTT K. BOGNER, RICHARD J. FURNSTAHL, *The Ohio State University* ACHIM SCHWENK, *University of Washington* The nonperturbative nature of nucleon-nucleon potentials as a function of a momentum cutoff is studied using Weinberg eigenvalues as a diagnostic. This investigation extends an earlier investigation into the convergence of the Born series for scattering to partial waves beyond the $^3S_1 - ^3D_1$ channel and to positive energies. As the cutoff is lowered using renormalization-group or model-space techniques, the evolution of nonperturbative features at higher cutoffs from strong short-range repulsion and the iterated tensor interaction are monitored via the complex Weinberg eigenvalues. When these eigenvalues all lie within the unit circle, the T-matrix expansion in terms of the potential V is perturbative, with the magnitude of the largest eigenvalues setting the rate of convergence. Major decreases in the magnitudes of repulsive eigenvalues are observed as the Argonne v_{18} potential is evolved to low momentum, even though two-body observables are unchanged. The efficacy of separable approximations to the potential derived from the Weinberg analysis is studied as a function of cutoff.

11:21
W9 4 Three-body model of the ^{12}C nucleus with distortion of α-clusters IGOR FILIKHIN, VLADIMIR SUSLOV, BRANISLAV VLAHOVIC, *North Carolina Central University* The Faddeev equations in configuration space are used to study ^{12}C nucleus considered as 3α-cluster system. The model includes a phenomenological (Ali-Bodmer) pair potential, a three-body potential, and takes into account the Coulomb interaction. The range parameter of the three-body potential is fixed by adjusting the position of the diffraction minimum of the ^{12}C elastic form factor. It is shown that the model must be supplemented by assumption of a distortion in the charge density of an α cluster inside the ^{12}C nucleus. The model allows to reproduce well observed characteristics of the low-lying 0^+ levels for ^{12}C.

11:33
W9 5 The Average Uncertainty of a Three Dimensional Nuclear Oscillator STEWART BREKKE, *Northeastern Illinois University (former grad student)* Consider a three dimensional nuclear oscillator in a solid. The position vector is r = $((A \cos a))^2 + (B \cos b)^2 + (C \cos c)^2)^{1/2}$, where A,B,C are amplitudes of oscillation. If A=B=C, Δ p $\geq$ h/2(π)(Δ r), p(av) is the average momentum of the oscillator, a=b=c, then Δ p(av)= h/2(π)$(3\Delta A \cos^2)^{1/2}$, if Δ A is the uncertainty in the amplitude. The maximum cos = 1, minimum cos = 0 and RMS cos =0.707(average) so max.uncertainty Δ p(av)= infinite, min uncertainty Δ p(av)$\geq$ h/10.83Δ A and average uncertainty Δ p (av) =h/3.45 ΔA. This paper suggests the concept of average uncertainty.

11:45
W9 6 Photon Acceleration Effect KONSTANTIN GRIDNEV, RUSSELL MOON, VICTOR VASILIEV, Using the principles of the Vortex Theory, it was theorized that when a photon encounters an electromagnetic field, both the velocity and the frequency of the photon will change. To prove this idea an experiment was devised using a laser interferometer and electromagnets. The electromagnets were arranged so that when the beam splitter divided the initial beam of laser light into two secondary beams; one of the two secondary beams passed back and forth between the magnets. With the DC current to the electromagnets turned off, the two beams formed an interference pattern on the target screen. When the current to the electromagnets was suddenly turned on, the pattern fluctuated wildly until the two beams again reached a quiescent state creating a stable pattern on the screen; when the current to the electromagnets was suddenly turned off, again the pattern fluctuated wildly until it reached a quiescent state forming the initial stable pattern on the screen. It was determined that this new effect was a phenomenon created by the changing frequency of the laser light whose velocity is increasing as it passes between the expanding electromagnetic field of the magnets. Because it is a new phenomenon in science revealing that the speed of light is not a constant but indeed can be varied, it possesses great historical significance.

11:57
W9 7 The Neutrino Mass AMAGH NDUKA, *Federal University of Technology, Owerri, Nigeria* We discuss the fundamental (elementary) particles scheme (FPS), and deduce therefrom the mass of the neutrino.

12:09
W9 8 Checkerboard Theory of the Nucleus. THEODORE LACH, The Checker Board Model (CBM) is a 2D model of the nucleus that proposes that the synchronization of the 2 outer rotating quarks in the nucleons accounts for magnetic moment of the nucleons and that the magnetic flux from the nucleons couples (weaves) into the 2D checker board array structures and this magnetic coupling in addition to electrostatic forces of the rotating and stationary quarks accounts for the apparent strong nuclear force. The symmetry of the He nucleus helps explain why this 2D structure is so stable. This model explain the mass of the proton and neutron, along with their magnetic moments and their absolute and relative sizes in terms of the above structure and predict the masses of two newly proposed quarks (1): the ''up'' and the ''dn'' quarks. Since the masses of the ''up'' and ''dn'' quark determined by the CBM (237.31 MeV and 42.392 MeV respectively) did not fit within the standard model as candidates for u and d, a new model (New Physics) had to be invented. This new particle physics model predicts that nature has 5 generations not 3. (1). T.M. Lach, Checkerboard Structure of the Nucleus, Infinite Energy, Vol. 5, issue 30, (2000). (2). T.M. Lach, Masses of the Sub-Nuclear Particles, nucl-th/0008026, @http://xxx.lanl.gov/.

12:21
W9 9 The Neutral Pentaquark RUSSELL MOON,* *Consultant* FABIAN CALVO,† *Consultant* VICTOR VASILIEV,‡ *Prof., Dr.* Using the principles of the Vortex Theory, it was discovered that when the gamma ray strikes a nucleon, the positively charged pentaquark (and the K^- meson) had to be created by the collision with neutron. This discovery further reveals that if the gamma ray strikes a proton it can create a Neutral Pentaquark (and a D^+

meson). The neutral pentaquark will consist of an up, up, down, down, and an anti-charm quark, while the D^+ meson will consist of a charm and an anti-down quark. The neutral pentaquark will later decay into a neutron and D^0 meson. Because the vortex theory also reveals that the strong force couples a proton to a neutron, the neutron that was coupled to the proton in the nucleus will also be found amid the debris particles. 1. R. G. Moon, The Vortex Theory, The Beginning. Gordons Publications of Fort Lauderdale Fla., 2003, 184 pp. 2. R. G. Moon, The Vortex Theory Explains the Quark Theory. Gordons Publications of Fort Lauderdale Fla., 2005, 205 pp. 3. R.G. Moon, V.V. Vasiliev, The bases of the vortex theory, Book of abstracts The 53 International Meeting on Nuclear Spectroscopy and Nuclear structure, NUCLEUS-2003, October 7–10, 2003, Moscow, St.-Petersburg, Russia, 2003, p.251. 4. R.G. Moon, V.V. Vasiliev, The Vortex Theory and Some Interaction in Nuclear Physics, Book of abstracts The 54 International Meeting on Nuclear Spectroscopy and Nuclear Structure, NUCLEUS-2004, June 22-25, 2004, Belgorod, Russia, 2004, p. 259 5. R.G. Moon, V.V. Vasiliev, Explanation of the Conservation of Lepton Number, Book of abstracts LV National Conference on Nuclear Physics, Frontiers in the Physics of Nucleus, June 28-July 1, 2005, Saint-Petersburg, Russia, 2005, p. 347.

*Independent Researcher, Florida, USA.
†Independent Researcher, Argentina.
‡Independent Researcher, Russia.

SESSION W10: HEINEMAN PRIZE SESSION
Tuesday Morning, 25 April 2006; Cumberland C, Hyatt Regency Dallas at 10:45
Pierre Sikivie, University of Florida, presiding

10:45
W10 1 Current Topics in the Theory of Supergravity.* SERGIO FERRARA, *CERN*

The attractor mechanism for extremal black holes in extended supergravity will be discussed, especially in the context of Calabi-Yau compactifications to four-dimensional flat space.

*CERN, Geneva, Switzerland.

11:21
W10 2 Supergravity and the AdS/CFT Correspondence. DANIEL FREEDMAN

The AdS/CFT correspondence asserts that one can obtain precise information about certain 4-dimensional non-abelian gauge theories without gravity by studying 5-dimensional gravitational theories in anti-de Sitter space. Miraculously classical computations in the gravity theory give information about the strong coupling behavior of the gauge theory, information which cannot be obtained from known methods of quantum field theory. Much of the initial evidence that the AdS/CFT correspondence is correct came from the study of supergravity in 5 and 10 dimensions. Selected examples of the techniques and results will be presented in this talk.

11:57
W10 3 New aspects of old minimal supergravity. PETER VAN NIEUWENHUIZEN

After discussing how supergravity was discovered in 1976,and how it fits in with old ideas of Einstein, Hilbert, Weyl, Wigner, Cartan, Noether and others, we present some new aspects of ''old minimal N=1'' supergravity.

SESSION W11: GRAVITATIONAL WAVE SEARCHES
Tuesday Morning, 25 April 2006
Cumberland E, Hyatt Regency Dallas at 10:45
Lior Burko, The University of Alabama, Huntsville, presiding

10:45
W11 1 The LIGO Scientific Collaboration search for inspiralling binary neutron stars DUNCAN BROWN, *Caltech* LIGO SCIENTIFIC COLLABORATION, The three LIGO interferometers and the GEO600 interferometer operate as a network of detectors under the LIGO Scientific Collaboration (LSC). This network has now reached unprecedented levels of sensitivity. In this talk we will present the status and current results from the binary neutron star search in LIGO/GEO data.

10:57
W11 2 Search for Gravitational Wave Bursts in Data from the LIGO S4 Run PETER SHAWHAN, *California Institute of Technology* FOR THE LIGO SCIENTIFIC COLLABORATION, In early 2005, the LIGO Scientific Collaboration conducted a fourth science run, called S4, with the LIGO and GEO 600 gravitational wave detectors. This run featured improved sensitivities and fairly high duty cycles for all detectors. Data from the three LIGO detectors has been used to carry out a search for short-duration gravitational wave signals of arbitrary form with frequency content between 64 Hz and 1600 Hz. Results from this search will be presented, including studies of the sensitivity of the search for various signal waveforms.

11:09
W11 3 Searching the LIGO data for coincidences with Gamma Ray Bursts ALEXANDER DIETZ, *Louisiana State University* LIGO SCIENTIFIC COLLABORATION, The discovery that short Gamma Ray Bursts (GRB) also occur in old elliptical galaxies supports the idea that they are generated by the merger of two neutron stars or a neutron star with a black hole, after they spiral together due to emission of gravitational waves. Because the exact position of those GRB is known in most cases, we are searching the LIGO data at those times with an analysis pipeline, which also runs online. Injections have been performed to test this analysis pipeline and to test the detection statistics. The status of this search is presented in this talk.

11:21
W11 4 Stackslide search for continuous gravitational waves using LIGO S4 data GREGORY MENDELL, *LIGO Hanford Observatory* ON BEHALF OF THE LIGO SCIENTIFIC COLLABORATION, The LIGO Scientific Collaboration has developed several methods to search for continuous gravitational-wave signals, for example from rotating asymmetric neutron stars. We present an overview of the Stackslide method, and a status report on its application to LIGO data taken during the fourth science run (S4). Progress on plans to incorporate this method into future hierarchical searches will also be presented.

11:33
W11 5 Broadband Search for Continuous-Wave Gravitation Radiation with LIGO VLADIMIR DERGACHEV, *University of Michigan* LIGO SCIENTIFIC COLLABORATION, Isolated rotating neutron stars are expected to emit gravitational radiation of nearly constant frequency and amplitude. Searches for such radiation with the LIGO interferometers are underway, using data taken from LIGO's first several data runs. Because the gravitational wave signal amplitudes are thought to be extremely weak, long time integrations must be carried out to detect a signal. This requires consideration of motion of the Earth (daily rotation and orbital motion) which induces substantial modulations of detected frequency and amplitude that are highly dependent on source location. We will describe an algorithm called PowerFlux, used to account for these modulations, when summing power spectral density estimates incoherently over long time intervals. Instrumental artifacts that contribute to false signals for certain frequencies and sky directions will also be discussed. We will describe progress in applying PowerFlux to a broadband search in data from the 30-day fourth LIGO Science Run (S4) and to the first two months of the ongoing S5 run.

11:45
W11 6 Coherent searches for periodic gravitational waves from unknown isolated sources and Scorpius X-1: Results from the second LIGO science run KEITA KAWABE, *LIGO Hanford Observatory, California Institute of Technology* LIGO SCIENTIFIC COLLABORATION, We present results from two searches for periodic gravitational waves using the most sensitive few hours of data from the second LIGO science run. The first search targets isolated previously unknown neutron stars and covers the entire sky in a frequency band between 160 and 728.8 Hz assuming a frequency derivative less than 4E-10 Hz/s. The second search targets the accreting neutron star in the low-mass X-ray binary system Scorpius X-1 and covers the band 464–484 Hz and the band 604–624 Hz, as well as two orbit parameters. With these analyses we present the first broad-band wide parameter space upper limits on periodic gravitational waves from coherent search techniques. The methods utilized here lay the foundations for upcoming hierarchical searches of more sensitive data which may detect astrophysical signals.

11:57
W11 7 The Q Pipeline search for gravitational-wave bursts with LIGO SHOUROV CHATTERJI, *Caltech LIGO Laboratory* LIGO SCIENTIFIC COLLABORATION, The Q Pipeline is a multiresolution time-frequency search for gravitational-wave bursts of a priori unknown waveform. The method coherently searches data from multiple interferometric detectors for signal content within a well-defined region of time, frequency, and Q space. Here Q is the dimensionless quality factor of a signal as well as the approximate number of oscillations of its time-domain waveform. This talk briefly reviews the motivation for such a search, outlines its essential components, and sets forth a complete analysis pipeline. We then present the current status of the method applied to recent data from the LIGO detectors.

12:09
W11 8 Search for Gravitational Wave Bursts in LIGO's S5 run IGOR YAKUSHIN, *LIGO Livingston Observatory, Caltech* LIGO SCIENTIFIC COLLABORATION, By the end of 2005, the LIGO detectors reached their design sensitivity. The S5 run started in November 2005, and is expected to collect a year's worth of coincident data. We present the status of the search for unmodeled short-duration bursts during the first few months of the S5 run.

12:21
W11 9 Search for gravitational wave bursts associated with gamma-ray bursts using LIGO detectors VIRGINIO SANNIBALE, *for the LIGO Scientific Collaboration* We present the status of searches for gravitational-wave bursts associated with gamma-ray bursts (GRBs) that were detected by satellite experiments during LIGO science runs. A search for associated gravitational waves from individual GRBs, as well as a statistical search for a cumulative gravitational wave signal from the GRB sample, were made. These searches were confined to short time windows surrounding each GRB trigger.

SESSION W12: BS, B*, ETA-B DECAYS
Tuesday Morning, 25 April 2006
Cumberland F, Hyatt Regency Dallas at 10:45
Robert Cahn, Lawrence Berkeley National Laboratory, presiding

10:45
W12 1 Inclusive b production measurement with CMS at LHC DAVID CLINE, VALERY ANDREEV, STAN OTWINOWSKI, *UCLA* CMS COLLABORATION, At the LHC new opportunities to improve our understanding of the physics of the B quark will become available because of the high statistics data samples and high center-of-mass energy that the new accelerator will provide. The CMS collaboration will measure the cross section for inclusive b production in proton-proton collisions at $\sqrt{s}$ = 14 TeV. A study has been performed to investigate methods of identifying b

jets (b "tagging") in an inclusive sample of events containing jets and at least one muon. We present CMS's capability to measure the inclusive b production cross section as function of B-hadron transverse momentum and pseudorapidity.

10:57
W12 2 Study of orbitally excited B mesons at CDF JENNIFER PURSLEY, *Johns Hopkins University* CDF COLLABORATION, Using data collected by the Run II Collider Detector at Fermilab (CDF), we study the properties of the lowest orbitally excited (L = 1) B mesons, collectively denoted as the B^{**}. We reconstruct B^{**} candidates in two B^+ decay channels: $B^+ \to J/\psi K^+$, $J/\psi \to \mu^+\mu^-$ and $B^+ \to \bar{D}^0\pi^+$, $\bar{D}^0 \to \mathcal{E}^+\pi^-$. Through a simultaneous fit of both channels, we measure the masses of the two narrow B^{**} states.

11:09
W12 3 Study of B^{**} and B_s^{**} MARK WILLIAMS, *Lancaster University* DZERO COLLABORATION, Using 1 fb^{-1} of data collected with the DØ detector of the Tevatron, the excited states containing a b quark B_1, B_2^* and B_{s2}^* are selected in exclusive decays. A precise measurement of their masses, widths, and branching rates is reported.

11:21
W12 4 Measurement of $\mathcal{B}(B_s \to D_s^+ D_s^-)$ JAMES WALDER, *Lancaster University* DZERO COLLABORATION, The branching ratio $\mathcal{B}(B_s \to D_s^+ D_s^-)$ provides an alternative way to estimate the width difference in the B_s system. We report a preliminary result on the measurement of the branching ratio of the decay $B_s \to D_s^+ D_s^-$ using 1 fb^{-1} of data collected with the DØ detector of the Tevatron.

11:33
W12 5 Measurements of the Exclusive Decays of the $\Upsilon(5S)$ to $B^{(*)}\bar{B}^{(*)}(\pi)(\pi)$ Final States and Improved B_s^* Mass Measurement KEVIN ZHANG, *Syracuse University* CLEO COLLABORATION, From 420 pb^{-1} of data collected on the $\Upsilon(5S)$ resonance using the CLEO III detector, we measure production fractions of $B^{(*)}\bar{B}^{(*)}(\pi)(\pi)$ final states and find that $B^*\bar{B}^*$:$B\bar{B}^*$:$B\bar{B}$ are produced with a ratio of about 3:1: < 1, consistent with predictions of the Unitarized Quark Model. Limits on the production of other final states will also be presented. Our results are also use to extract the most precise B_s^* mass value to date.

11:45
W12 6 Observation or the B_s Meson at the $\Upsilon(5S)$ VICTOR PAVLUNIN, *Purdue University* CLEO COLLABORATION, Using the CLEO detector at the Cornell Electron Storage Ring, we have observed the B_s meson in e^+e^- annihilation at the $\Upsilon(5S)$ resonance. We have established that at the energy of the $\Upsilon(5S)$ resonance B_s production proceeds predominantly through the creation of $B_s^*\bar{B}_s^*$ pairs. We find $\sigma(e^+e^- \to B_s^*\bar{B}_s^*) = [0.11^{+0.04}_{-0.03}(\text{stat.}) \pm 0.02(\text{syst.})]$nb. The mass of the B_s^* meson is measured to be $M_{B_s^*} = [5.414 \pm 0.001(\text{stat.}) \pm 0.003(\text{syst.})]$ GeV/c^2.

11:57
W12 7 Measurements of Inclusive Yields of B and B_S Mesons into ϕ RADIA SIA, *Syracuse University* CLEO COLLABORATION, Using data taken at both the $\Upsilon(4S)$ and $\Upsilon(5S)$ resonances, with the CLEO III detector, we report on the yields of B and B_S mesons into ϕ mesons.

12:09
W12 8 Search for η_b via exclusive decay mode $\eta_b \to K_s^0 K^+ \pi^-$ XURONG CHEN, *University of South Carolina* BABAR COLLABORATION, We discuss the possibility to search for η_b candidate with 211 fb^{-1} of data collected by the BaBar detector at the PEP-II asymmetric e^+e^- collider at SLAC in the mass range $8.5 < M_{K_s^0K^+\pi^-} < 10.5\,GeV/c^2$ in inclusive $e^+e^- \to \eta_b X$ reactions, where η_b is detected in its $K_s^0K^+\pi^-$ decay mode. The event selection is studied on Monte Carlo samples, and the expected background yield is compared to what is observed in data for $6.5 < M_{K_s^0K^+\pi^-} < 8.5\,GeV/c^2$. A toy Monte Carlo study is performed to establish the sensitivity to the number of signal candidates in the sample, and to estimate the expected upper limit on $\sigma(e^+e^- \to \eta_b X) \times \mathcal{B}(\eta_b \to K_s^0K^+\pi^-)$ that we will be able to set if no signal is detected.

SESSION W13: PARTICLE PHYSICS INSTRUMENTATION
Tuesday Morning, 25 April 2006
Cumberland G, Hyatt Regency Dallas at 10:45
Stephen Magill, Argonne National Laboratory, presiding

10:45
W13 1 The upgrade of BABAR Muon Detector JINLONG ZHANG, *University of Colorado* The muon system is critical for the long-term BaBar physics program. The original muon detector using the Resistive Plate Chambers (RPCs) has been degrading rapidly. In 2002 the Limited Streamer Tube (LST) technology was chosen for the upgrade of the barrel part of the muon detector. The design, production, quality control (QC) and installation of the LSTs will be discussed. The gas system, high voltage system and the readout system of the LST detector will be described. The data taking experience with the partially installed LST system in 2005 will be presented in several aspects such as the detector performance and the impact on physics.

10:57
W13 2 QUARTIC: A Fast Time-of-flight Counter PEDRO DUARTE, *University of Texas, Arlington* FP420 COLLABORATION,* We present preliminary studies of a fast time-of-flight counter. This counter makes use of the Cerenkov effect to provide precise timing (10 to 30 psec scale) for protons scattered at small angles. One application is a proposed upgrade to the ATLAS and CMS detectors (FP420) that adds proton taggers 420 m upstream and downstream of the central detectors. Fast time-of-flight counters could be used to dramatically decrease backgrounds to events with a massive central system and forward/backward protons, by using timing to confirm that the protons originate from the same event vertex as the central system.

*Joint ATLAS/CMD R&D collaboration.

11:09
W13 3 3D Track Triggering at CDF BRANDON PARKS, CDF COLLABORATION, In order to account for increased luminosity in the Tevatron at Fermilab, an upgrade of the Level 1 tracking system at CDF is necessary. The CDF detector utilizes a Central Outer Tracker (COT), which consists of 96 layers of wires arranged in 8 superlayers that provide information on the momentum and trajectory of charged particles created in collisions between protons and anti-protons. The COT alternates between axial superlayers which provide tracking information only in directions transverse to the beam-line and stereo superlayers that also provide tracking information parallel to the beam-line. The eXtremely Fast Tracker (XFT) is responsible for Level 1 track finding, and is currently only using axial data to reconstruct tracks at CDF. The XFT upgrade involves the addition of the Stereo Linker Association Module (SLAM). The SLAM will utilize the previously existing XFT setup as well as information from the stereo superlayers in the COT to identify useful 3-dimensional tracks. I will give an overview of the hardware configuration and describe the SLAM pattern recognition algorithms.

11:21
W13 4 CMS Forward Pixels Assembly and Quality Control* ARTUR APRESYAN, GINO BOLLA, DANIELA BORTOLETTO, PETRA MERKEL, IAN SHIPSEY, *Purdue Univeristy, IN 47907* The CMS pixel detector at the LHC will consist of two barrel layers and two end disks in the forward and backward direction. The end disks contain $\sim$ 800 silicon detector modules called plaquettes for a total of $\sim$ 18 million 100 $\times$ 150 μm pixels. Each plaquette is composed of a silicon sensor bump-bonded to custom-made readout electronics mounted on a high density interconnect. We present the automated procedures developed for assembly quality control which are sensitive to missing bump-bonds. We also discuss the module performance optimization, such as the threshold equalization among all pixels on a chip, which is necessary for physics data taking.

*DOE Grant number DE-FG02-91ER40681A29.

11:33
W13 5 Production and Testing of the CMS Silicon Tracker Outer Barrel TIMOUR TEN, E. SHABALINA, C.E. GERBER, *University of Illinois at Chicago* CMS COLLABORATION, USCMS Silicon tracker group at FNAL is assembling and testing 50% of the Silicon Tracker Outer Barrel modules. We describe module production and testing procedures. We discuss in detail the long-term module test stand that has been operating at Fermilab since Fall 2004. The readout system of the stand is similar in design to the Data Acquisition chain of the actual detector. The test setup runs thermal cycles between + 40°C and − 40°C, providing testing conditions close to the CMS operating environment. We summarize the results of the Long Term testing of more than 1700 modules.

11:45
W13 6 Construction and Testing of Rods for the Tracker Outer Barrel of the CMS Detector PUNEETH KALAVASE,* *UC Santa Barbara* CMS COLLABORATION, The tracking system of the CMS detector at the Large Hadron Collider (LHC) consists of pixels around the beampipe and silicon strips at larger radii. This constitutes an application of silicon strips detectors on an unprecedented scale. The components of the outer barrel (TOB) portion of this detector are being assenbled at Fermilab and UC Santa Barbara. In this talk we will discuss the assembly and testing of the TOB-"rods," the basic self-contained structures of the TOB.

*On behalf of the US-CMS Tracker Collaboration.

11:57
W13 7 Status of the Endcap Muon System for the Compact Muon Solenoid Experiment KHRISTIAN KOTOV,* *University of Florida* CMS COLLABORATION, Presented are the design and status of the Endcap Muon System of the Compact Muon Solenoid (CMS) detector under construction for the Large Hadron Collider, a 14 TeV proton-proton collider. The CMS Endcap Muon System consists of 468 Cathode Strip Chambers with a total sensitive area of 6000 square meters, and it provides a spatial resolution of 100 microns per track in a six-plane chamber. The system provides muon identification, momentum measurement, and a Level-1 trigger. It is currently fully installed, and cosmic-ray data is being recorded at CERN.

*On behalf of the CMS Endcap Muon Subsystem Collaboration.

12:09
W13 8 Status and Design of CMS Level 1 Trigger System SANG-JOON LEE,* *Rice University* CMS COLLABORATION, We present the design and status of the Level 1 trigger system for the Compact Muon Solenoid (CMS) detector at the Large Hadron Collider (LHC). The CMS Level 1 trigger system contains a Calorimeter Trigger, a Muon Trigger and a Global Trigger. Its purpose is to reduce the event rate from the 40 MHz crossing rate to a maximum output rate of 30 kHz. This maximum rate is estimated by appling a conservative safety margin to the maximum input rate tolerable to the higher level trigger system (100 kHz).

*On behalf of the CMS Level 1 Trigger Subsystem Collaboration.

SESSION W15: POSTER SESSION IV: POST-DEADLINE POSTERS
Tuesday Morning, 25 April 2006
Landmark Circle, 10:30am–2:00pm, Hyatt Regency Dallas at 10:30

W15 1 Search for Ultra High Energy Neutrinos with AMANDA-II LISA GERHARDT, *University of California, Irvine* ICECUBE COLLABORATION, AMANDA-II is a large volume neutrino telescope, designed to measure the energetic neutrino flux from astrophysical sources. A search for neutrinos exceeding 1 PeV has been performed using data collected by AMANDA-II in 2000. At these energies, the Earth is opaque to neutrinos. This, combined with the limited overburden above the detector, concentrates the expected signal at the horizon. A method of separating signal from the background of high energy downward going air showers has been developed and the results are discussed.

W15 2 Neutrino Search and Performance of AMANDA-II using Transient Waveform Recorders ANDREA SILVESTRI, *University of California, Irvine* ICECUBE COLLABORATION COLLABORATION, AMANDA-II data acquisition electronics was upgraded in January 2003 to readout the complete waveform from the buried PMTs using Transient Waveform Recorders (TWR). We perform the same atmospheric neutrino analysis on data collected in 2003 by the TWR and standard AMANDA data acquisition system. Good agreement in event rate and angular distribution verify the baseline performance of the TWR system. A search of the northern hemisphere for localized neutrino event clusters is also performed, no statistical significant excess has been observed.

W15 3 Report on the search for binary black holes inspiral in S3 and S4 LIGO data THOMAS COKELAER, *Cardiff University* LIGO COLLABORATION, We report on the search for gravitational waves emitted by non-spinning binary black hole inspirals in data taken during the third and fourth LIGO science runs (S3 and S4). We give an overview of the data taken during these sciences runs as well as the target waveforms that we are searching for in this analysis. We briefly describe how the data is filtered and emphasize the difficulties of the search. We report on the status of these searches and prospects for similar searches over the next few years.

W15 4 Search for gravitational waves associated with the SGR1806-20 hyperflare using the Hanford LIGO detectors LUCA MATONE, *Columbia University* LIGO SCIENTIFIC COLLABORATION COLLABORATION, On Dec. 27th, 2004, SGR1806-20 emitted a record flare; at the time of the event the Hanford (WA) H1 LIGO detector was in operation. We present the status of the search for gravitational-wave emission associated with this extraordinary event.

W15 5 Galaxy mass distributions without dark matter or modified Newtonian mechanics KENNETH NICHOLSON,* *Caltech Alumni* Given the galaxy dimensions (including thickness) and rotation profile, a method is arranged to find the mass and density distribution in the defined envelope that will cause that rotation profile with near-exact speed matches. Newton's law is unchanged. Surface-light intensity or dark matter are not needed. Errors in previous methods are discussed. Thickness is considered important and some useful thickness distributions are shown that account for an exponential "atmosphere." Equation development and proof of equations are shown for the forward problem (rotation profile from mass distribution). Also it is shown that the acceleration at the rim of a constant-SMD flat disk is nearly 3 times that of a sphere of the same mass and radius. With the reverse problem (mass distribution from rotation profile) results for several galaxies are presented in dimensionless plots allowing easy comparisons. Total mass results for galaxies are about 2/3 those found using dark-matter spheres.

*Re.tired engineer

W15 6 Impact of Gravitational Variations on Aging SHANTILAL GORADIA, *Gravity Research Institute, Inc.* Einstein's 1919 removal of the cosmological constant as a consequence of his analysis suggests a synonymy between gravitation and nuclear force, which is complimentary and supplementary to my suggestion of the synonymy between nuclear force and gravitation supporting the inflationary universe in version 2 of http://www.arXiv.org/physics/0210040 and vice versa. In version 1 of the same article, I am going a step deeper to suggest that all coupling constants are increasing with time consistent with Dirac's LNH and an observation that the universal constant of gravity is decreasing with time. The variations of coupling constants must inevitably impact the binding energy of organic particles resulting in an impact on the chemical energy output of the power plants of biological cells (DNA of Mitochondria). The web site http://home.comcast.net/~neardeath/science/001_pages/28.htm suggests a link between such energy outputs and aging. If the changes in the chemical energy output can be compensated by some means, it may be possible to reverse the aging process. This makes it important to establish weather the universal constant of gravity is changing as once reported. Gravity cannot be discounted as weak as done in the past, because the coupling constants it generates are not weak, nor fixed.

W15 7 Simultaneous Detection and Classification of Acoustic Emissions in Integrated Diagnostics with Yield in Aluminum* DEVENDRA PARMAR, *Hampton University, Hampton, VA 23608* HAMPTON UNIVERSITY TRANSPORTATION CENTER TEAM, Acoustic emission (AE) experiments were conducted on a strained aluminum (10 cm × 9 cm × 0.25 cm) specimen. Studies were conducted with the goal to characterize AE associated with material yield developed due to high loading and to correlate the course of the yield with AE signals. The American Association of State Highway and Transport Officials (AASHTO) listed aluminum as one of the structural components of highway brides[1] with unit weight of 2800 $kg.m^{-3}$. The specimen, mounted on the load frame, was held on each end by the wedge grips and was electromechanically tested in a tension mode at rates of extension of 0.0333 mm/s and 0.0666 mm/s. Load was applied to the test frame via moving cross heads. A load transducer (load cell) mounted in series with the specimen measured the applied load by converting it into an electrical signal. Results are analyzed using defect zone model in which location of the defect is determined from the measurement of the arrival time of the signal at two different sensors placed at strategically around the source of emission from the test object. The sensor that detects the signal first is identified to be in the defect zone. [1]AASHTO LRFD Bridge Design Specifications, 1994.

*Work supported by DOT Assistance No. DTOS59-05-G-00018.

W15 8 Color screening in Quark-Gluon plasma at low and high temperatures OLAF KACZMAREK, *Bielefeld University* FRITHJOF KARSCH, PETER PETRECZKY, FELIX ZANTOW, *Brookhaven National Laboratory* Using quark antiquark free energies we define different length scales which describe the screening length in hot QCD. We find that these length scales drop rapidly in the vicinity of the phase transition and indicate distances which are about twice as large than the inverse Debye mass found in earlier studies. On the one hand our results show no or only little differences when changing from quenched to 2-flavor QCD. On the other hand our analysis supports recent findings that indicate that J/Ψ will show significant medium modifications only at temperatures well above T_c.

W15 9 The WARP program for Direct WIMP Dark Matter Search. Results from the operation of a 2.3 liter detector pro-

totype in Gran Sasso CRISTIANO GALBIATI, *Princeton University* WARP COLLABORATION, The WARP detector is characterized by a unique technology for the identification of nuclear recoils, eventually induced by WIMPs' interactions with argon. The detection technique takes advantage of a double discrimination between argon recoils and gamma or beta induced background, providing a discrimination power against betas potentially in excess of one event over 10^8. The 100 liter (140 kg) detector, presently under construction and to be commissioned during the second half of 2006, will be also equipped with an active shield for identification and rejection of neutron induced recoils. A 2.3 liter volume prototype (3 kg active mass, 1.8 kg fiducial mass) is installed in Gran Sasso since May 2004 and was run underground in several operating conditions: with and without gamma shielding, with and without neutron shielding. Our measurements confirm the discrimination power indicated above. I will present results on the characterization of the background. I will also present results of a run for direct search of WIMP Dark Matter, with the complete neutron and gamma shielding, in which a total exposure of about 80 kg · day was accumulated.

W15 10 Generating Scale-invaraint Power Spectrum in String Gas Cosmology ALI NAYERI, *Department of Physics, Harvard University* ROBERT BRANDENBERGER, *Department of Physics, McGill University* CUMRUN VAFA, *Department of Physics, Harvard University* We study the generation of cosmological perturbations during the Hagedorn phase of string gas cosmology. Using tools of string thermodynamics we provide indications that it may be possible to obtain a nearly scale-invariant spectrum of cosmological fluctuations on scales which are of cosmological interest today. In our cosmological scenario, the early Hagedorn phase of string gas cosmology goes over smoothly into the radiation-dominated phase of standard cosmology, without having a period of cosmological inflation. Furthermore, we find that string thermodynamics implies that the fluctuations are Gaussian, and that the spectrum of tensor perturbations will exhibit a scale-invariant spectrum as well. We contrast the predictions of string gas cosmology in the Hagedorn phase with that of scalar field driven inflation, and comment on the possibility of observationally distinguishing between the two scenarios in future experiments.

W15 11 Global Guiding-Center Particle Simulation of Minority ICRH Heated Plasmas in a Tokamak JAE-MIN KWON, *Princeton Plasma Physics Laboratory, U.S.A. and Korea National Fusion Research Center, Korea* C.S. CHANG, S. KU, *Courant Institute, New York University, New York, U.S.A.* D. McCUNE, C.K. PHILLIPS, *Princeton Plasma Physics Laboratory, Princeton, NJ, U.S.A.* A global numerical simulation of RF heating of a multi-species kinetic plasma has been performed using a particle-in-cell guiding center code in tokamak geometry. The resonant minority ion species interacts with a prescribed rf wave and with the main ions, collisionally exchanging momentum and energy. The majority ions interact with each other collisionally (conserving momentum and energy) and with the minority ions. Generation of a global radial electric field and plasma rotation are evaluated self-consistently with the rf interaction and Coulomb collisions. It is found that the RF-driven radial transport can induce radial electric field and rotation profiles that significantly exceed the conventional neoclassical level for moderate RF-power. High field side heating produces a significantly greater flow shear than central and low field side heating in these simulations. Finite orbit excursion effects play an important role in producing these results. Detailed analysis of the observed phenomena using the time evolution of ion distribution functions will be presented. Coupling with a wave code and application of the technology to the NUBEAM Monte Carlo code will also be discussed.

W15 12 Prospects for Measuring Neutrino-Nucleus Coherent Scattering at a Stopped-Pion Neutrino Source KATE SCHOLBERG, *Duke University* Coherent neutral current neutrino-nucleus elastic scattering has never been observed. Although the cross-section is very high, nuclear recoil energies are very small. However, detection of the process may be within the reach of the new generation of low-threshold detectors. A promising prospect for the first detection of this process is an experiment at a high flux stopped-pion neutrino source such as the SNS. I will present some preliminary rate calculations and discuss sensitivity of such a measurement to new physics.

W15 13 Properties of the Generalized Kodama States ANDREW RANDONO, *University of Texas at Austin* The original incarnation of the Kodama/Chern-Simons State of canonical quantum gravity employs a restriction of the phase space to self-dual connections thereby fixing the Immirzi parameter at the unit imaginary, $\gamma = i$. We recently proposed a generalization of the state for arbitrary values of the Immirzi parameter and gave strong evidence to suggest that the generalized state is also a solution to the Hamiltonian constraint of canonical quantum gravity. We suggested that for real values of γ, the generalized state is CPT invariant, delta-function normalizable, and invariant under large gauge transformations. Follow-up investigations have revealed that the state can be written as the exponent of the second Chern class minus the Euler charactersitic, pulled back to a 3-dimensional spacelike boundary, thereby yielding an intrinsically 4-dimensional definition and an intimate connection with known topological field theories. Furthermore, the state has a simple semi-classical interpretation as the WKB state corresponding to spacetimes with constant 4-curvature. There is an infinite family of such spacetimes each characterized by the equivalence class of 3-curvatures modulo gauge transformations and diffeomorphisms, R. To each of these classical spacetime configurations there exists a generalized Kodama state $|\psi_R\rangle$. A formal argument shows that these states are expected to be orthogonal with respect to a natural inner product: $\langle\psi'_R|\psi_R\rangle = \delta(R' - R)$.

W15 14 Event Shapes at the Tevatron LESTER PINERA, ANDREY KORYTOV, *University of Florida* ALEXANDER PRONKO, *Fermilab* CDF COLLABORATION, We present a complementary set of "Indirectly Global Event Shapes" proposed for study at hadron colliders. These observables are designed to reconcile the seemingly conflicting theoretical requirement of "globalness" with the realities of the hadron collider environment—namely, the limited detector coverage in the forward region. Of particular interest is the study of event shape distributions as a means of understanding non-perturbative hadronization effects. Specifically, these are considered within the Dokshitzer-Marchesini-Weber (DMW) analytical model of power corrections. We present a preliminary account of two observables, the central transverse thrust and thrust minor, as measured using the CDF detector at the Tevatron.

W15 15 Nonlinear Evolution of the Tearing Mode NUNO LOUREIRO, *CMPD / PPPL* STEVE COWLEY, *UCLA / Imperial College London* WILLIAM DORLAND, *UMD* MALCOLM HAINES, *Imperial College London* ALEXANDER SCHEKOCHIHIN, *University of Cambridge* We present recent numerical results on the nonlinear evolution of the strongly and weakly driven resistive tearing mode. Slab geometry is adopted and the equations of reduced-MHD (RMHD) are used. A high-resolution numerical scan of the parameter space (Δ', η) shows that, in general, the tearing mode evolves through five stages: exponential growth, algebraic growth (Rutherford stage), X-point collapse followed by current-sheet exponential reconnection (Sweet–Parker stage), tearing instability of the current sheet (generation of secondary islands), and saturation. The X-point collapse occurs at a critical island width that scales as $Wc \sim 1/\Delta'$. During the collapse, reconnection proceeds with a rate $\propto \eta^{1/2}$. The resulting current sheet becomes unstable if it has a length-to-width ratio that exceeds a certain critical value. Secondary islands are then formed, the evolution of which occurs in a self-similar way to the original perturbation. At low Δ', the saturation amplitude is shown to be in good agreement with recent analytic theories. At large Δ' we show that the saturated amplitude depends on the existence of a previous collapse.

W15 16 Challenges and Issues of Radiation Damage Tools for Space Missions RAM TRIPATHI, JOHN WILSON, *NASA Langley Research Center* NASA has a new vision for space exploration in the 21st Century encompassing a broad range of human and robotic missions including missions to Moon, Mars and beyond. Exposure from the hazards of severe space radiation in deep space long duration missions is "the show stopper." Thus, protection from the hazards of severe space radiation is of paramount importance for the new vision. Accurate risk assessments critically depend on the accuracy of the input information about the interaction of ions with materials, electronics and tissues. A huge amount of essential experimental information for all the ions in space, across the periodic table, for a wide range of energies of several (up to a Trillion) orders of magnitude are needed for the radiation protection engineering for space missions that is simply not available (due to the high costs) and probably never will be. In addition, the accuracy of the input information and database is very critical and of paramount importance for space exposure assessments particularly in view the agency's vision for deep space exploration. The vital role and importance of nuclear physics, related challenges and issues, for space missions will be discussed, and a few examples will be presented for space missions.

W15 17 Implementation and Effects of Fluctuations in Heavy Ion Reactions MALGORZATA ZIELINSKA-PFABE, ALEXIS KNAUB, SELAMNESH NIDA, *Smith College, Northampton, MA 01063* VIRGIL BARAN, MARIA COLONNA, MASSIMO DI TORO, *LNS Catania, Italy* HERMANN WOLTER, *University of Munich, Germany* Collisions between heavy ions have been studied within the semi-classical mean field formalism (BUU/BNV). The effects of the neglected higher order terms were included as a fluctuation of the distribution function. Two methods of implementing these fluctuations were considered. In the first method, one assumes a local thermal equilibrium and determines the variances of the density distribution. The density fluctuations are introduced randomly, according to these variances. In a second approach, a gauged numerical noise serves as an origin of fluctuations. The way in which the mean field evolves the fluctuations, depends on the stability of the system. A test particle method was used to solve the BUU equation. The calculations were performed for the Sn+Sn collisions at 50 MeV per nucleon at the impact parameters of 2 and 6 fm. Several obserables were considered: charge distribution of the observed fragments, charge asymmetry of the fragments, their kinetic energy and velocities, light particle yields, and time evolution of the number of prodced fragments. The two methods of introducing fluctuations lead to quite similar results. There are, however, minor differences in the dynamical evolution of some of the observables.

W15 18 Magnetic Islands Stabilization by Plasma Compressibility Effects in a Tokamak A.I. SMOLYAKOV,* X. GARBET, M. OTTAVIANI, *Association EUTRATOM-CEA, CEA/DSM/DRFC, CEA Cadarache, 13108 St Paul Lez Durance France* It is shown that the stability of rotating magnetic islands in a tokamak plasmas is affected by plasma compressibility related to the geodesic curvature in inhomogeneous magnetic field. A robust stabilizing contribution has been found to the Rutherford evolution equation. It is suggested that this mechanism is responsible for the instability threshold for neoclassical tearing modes.

*Also at the University of Saskatchewan, 116 Science Place, Saskatoon S7N 5E2 Canada.

W15 19 A Search for Signatures of Dark Matter with AMS-01 SA XIAO, GRAY RYBKA, *MIT* GIANPAOLO CAROSI, *Livermore National Laboratory* PETER FISHER, FENG ZHOU, *MIT* AMS COLLABORATION, Weakly Interacting Massive Particles (WIMPs) are one of the possible candidates of cold dark matter. A general feature of many of these WIMP candidates, such as the supersymmetric neutralino, is that they are Majorana particles (equal to their own antiparticle) and can annihilate to stable standard model particles such as electrons, protons, etc. These annihilation products can give rise to anomalous features in the otherwise smooth charged cosmic ray spectra. We search for such features in the charge Z=−1 spectra (electrons and antiprotons) of AMS-01. We use DarkSUSY to predict the annihilation channels given certain suppersymmetric models and then use PYTHIA to determine the spectra of the decay products (electrons and antiprotons). We then use the galactic propagation software GALPROP to determine the spectra after propagation given various plausible propagation models, and study the uncertainty in our final dark matter annihilation search induced by propagation effect.

W15 20 Status of the XENON Direct Dark Matter Detection Experiment RICHARD HASTY, *Yale University* XENON COLLABORATION, The XENON collaboration is developing a dark matter detector using liquid xenon (LXe) as the target medium for detecting Weakly Interacting Massive Particles (WIMPs). The goal of the collaboration is to operate an array of LXe time projection chambers (TPCs) with 1000 times greater sensitivity to WIMPs than current direct dark matter detection experiments. Recent measurements by members of the XENON collaboration demonstrate the promise of the LXe TPC approach, particularly measurements of the scintillation efficiency and charge extraction from nuclear recoils in LXe. The collaboration is currently installing a 10 kg fiducial volume prototype in the Gran Sasso National Laboratory in Italy for low background operation.

W15 21 Study of Avalanche Photodiodes as photosensors for liquid xenon scintillation light* PETER SHAGIN, ROMAN GOMEZ, UWE OBERLACK, *Rice University* RICHARD FARRELL, MICKEL McCLISH, *Radiation Monitoring Devices, Inc.* PRICILLA CUSHMAN, BRIAN SHERWOOD, *University of Minnesota* We report on measurements with large area Avalanche Photodiodes (APD) as photodetectors for the ultraviolet scintillation light of liquid xenon (LXe). The APD, fabricated by Radiation Monitoring Devices Inc., was mounted inside the LXe detector, and scintillation light produced by Po-210 alpha particles was measured for a wide range of voltages and temperatures between 167 K and 178 K. The dark current of the cooled APDs is much reduced, and a maximum stable gain of 5600 was achieved. Based on a Monte Carlo simulation for the scintillation light collection, the quantum efficiency of the APD was estimated to be 34% at 175 nm. We performed quantum efficiency scans of the APD at UV and optical wavelengths at room temperature to evaluate the uniformity of the response. The high quantum efficiency and gain of the APD, together with its compactness, relatively large area ($\sim$ 1 cm^2), and the favorable ratio of active to passive sensor area, make it an interesting alternative to PMTs for UV photon sensing in LXe detectors, especially for experiments requiring a high light yield. Possible applications include positron emission tomography, neutralino dark matter search, or Compton Telescopes for gamma-ray astronomy.

*This work was supported in part by NASA grant NNG05WC24G.

W15 22 Broadband generation produced in Raman-active crystals by two- and three-color femtosecond laser pulses MIAOCHAN ZHI, DMITRY PESTOV, XI WANG, ROBERT MURAWSKI, ALEXEI SOKOLOV, *Texas A&M University* We observe broadband generation by non-collinearly focusing two- or three-color ultrashort laser pulses into Raman-active crystals. The generated spectrum extends from infrared to ultraviolet, and consists of discrete spatially-separated Raman sidebands. Up to 20 sidebands are observed when two-color fs-laser pulses interact with PbWO4 crystal. Similar generation is observed in diamond. By applying the third probe beam, about 50 sidebands are generated through the Raman-resonant four wave mixing. By looking at the coherent Stokes and anti-Stokes signal with delayed probe pulse, we can see that multiple Raman levels are excited by the short (50 fs) pulses used. Combining the multiple generated sidebands may prove to be a way to synthesize subfemtosecond pulses.

W15 23 Delta Radiative Decay in the MiniBooNE Experiment LAURA GLADSTONE, *Columbia University* MINIBOONE COLLABORATION, The MiniBooNE experiment at Fermilab is a $\nu_\mu \rightarrow \nu_e$ oscillation search. A signal event (an electron and excited neucleon from a neutrino which oscillated) is expected only a few hundered times thoughout the neutrino run. The rare radiative decay of the delta resonance occurs with similar frequency. It is similarly identified by an electromagnetic signal, in this case from photon conversion, and an excited nucleon.

W15 24 Multimode Analysis of SHG Signal from Complex Biological Systems: Parameterization of Regional and Global Features Using Nearest-Neighbor Analysis and Wavelet Transforms KAREN REISER, *Department of Neurological Surgery University of California, Davis* CLAYTON BRATTON, *Department of Physics University of California, Davis* We have developed a novel computational approach for quantifying structural disorder in biomolecular lattices with nonlinear susceptibility based on analysis of polarization-modulated second harmonic signal. Transient, regional disorder at the level of molecular organization is identified using a novel signal processing algorithm sufficiently compact for near real-time analysis with a desktop computer. Global disorder within the biostructure is assessed using a two-dimensional wavelet transform of the magnitude and phase of the second harmonic signal. Selection of coefficients and the specific wavelet family is based on topological considerations. Experimental results suggest our signal processing method represents a robust, scaleable tool that allows us to detect both regional and global alterations in signal characteristics of biostructures with a high degree of discrimination.

W15 25 Plasma Cleaning Gold Nanorods to Make Better Biosensors PETER SCULLY, *Department of Physics, Rice University* JASON HAFNER, *Department of Physics, Department of Chemistry, Rice University* This study seeks to improve the efficacy of gold nanorods for use as biosensors. Noble metal particles have optical properties that differ from the bulk medium, in particular, they exhibit strong absorbance of light at certain wavelengths. The wavelength at which this occurs depends upon the dielectric properties of both the particles and the medium. This opens up the possibility of using these nanoparticles as biological sensors. The binding of molecules in the vicinity of a noble metal nanoparticle causes a change in the medium dielectric which can be detected by a peak shift in the absorption spectrum of the particles. We believe the mPEG-SH, a stabilizing agent, is lowering the sensitivity of the dielectric dependence and that by removing the mPEG-SH, sensitivity can be increased.

W15 26 Large Lepton EDM from Heavy Right Handed (Majorana) Neutrinos SAIFUDDIN RAYYAN, *Virginia Tech* CP violation in the leptonic sector has not been observed yet. Very strong constraints come from the current limits on the electric dipole moment (EDM) of the electron (and muon). In the recent model proposed by Takeuchi and others to explain the NuTeV anomaly, TeV Heavy Right Handed Neutrinos (HRHN's) mix heavily with the standard model neutrinos in a specific sea-saw like texture. Among the phenomenological consequences of this model is the possibility of a large CP violation in the leptonic sector. The Majorana nature of the (HRHN) results in new (two loop) diagrams leading to non-zero CP violation. The large mixing of the HRHN's can result in a huge enhancement to the value of CP violation and lepton EDM produced by these diagrams. The result of the calculation of the diagrams will be presented. The value of the predicted EDM will be discussed for different ranges of parameters and the most recent limits on the electron and muon EDM will be used to constrain the model.

W15 27 Simulations of Edge Localized Modes and Pellet Injection* RAVI SAMTANEY, *Princeton Plasma Physics Laboratory* We present preliminary results of 3D adaptive mesh refinement (AMR) simulations of edge localized modes (ELMs) and pellet injection, both of which are critical for ITER. It is widely accepted that the most like fueling technique for ITER will be via

pellet injection; and that the high confinement mode (H-mode) operation of ITER will be accompanied by ELMs. The two application discussed above are related because pellets have been utilized to control the ELM frequency. Furthermore it is known that pellets can be associated with transitions from the low confinement mode to H-mode, as well as the occurrence of neoclassical tearing modes. In this presentation, we discuss the planned development of an AMR code which will be utilized for pellet injection and the simulations of ELMs. Both phenomena entail extremely fine resolution in the regions of interest, which necessitates the use of AMR meshing technologies. For ELM simulations, a semi-implicit approach is developed to model the vacuum region as a high-resistivity low-temperature plasma. The pellet injection problem poses interesting numerical challenges which stem from the large density gradients in the vicinity of the pellet, the large disparity between the pellet and device size, and the non-local electron heat transport. Generalized upwinding techniques are employed to deal with sharp gradients while the electron heat transport is modeled by a semi-analytical kinetic treatment [1]. Preliminary simulation results of both pellet injection and ELMs will be presented along with a discussion of the planned future work in this areas. [1] R. Ishizaki et al. Phys. Plasmas **11**, 4064–4080 (2004).

*This work was supported by USDOE Contract no. DE-AC020-76-CH03073. This work is a collaboration between the CEMM SciDAC Project (PI: Stephen C. Jardin, PPPL) and the APDEC SciDAC Project (PI: Phillip Colella, LBNL).

SESSION W16: SHERWOOD IV
Tuesday Morning, 25 April 2006; Landmark D, Hyatt Regency Dallas at 10:45
Eric Held, Utah State University, presiding

10:45
W16 1 Nonlinear Evolution of Nonthermal Ion Distributions in the Presence of High Power Ion Cyclotron Resonance Heating.*
PAUL BONOLI, *Plasma Science and Fusion Center, MIT*

The nonlinear evolution of nonthermal ion distribution functions in the presence of high power ICRF waves is of great interest in both present day tokamaks and in future burning plasmas. Wave-particle interactions of special interest include evolution of the ion distribution due to wave-driven velocity space diffusion, as well as ICRF wave interaction with nonthermal distributions of fast neutral beam ions and fusion generated alpha-particles. In order to accurately simulate these interactions a full-wave field solver has been developed to compute the wave propagation using a plasma response that is valid to all orders in the ion Larmor radius and is valid for arbitrary ion particle distributions. A novel reformulation of the quasilinear diffusion coefficient has made it possible to couple electric field predictions from this field solver to a bounce averaged Fokker Planck code. The combined model is then iterated until a self-consistent ion particle distribution is achieved. We have also coupled a Monte Carlo orbit code to a full-wave field solver in order to explore situations where finite orbit effects may be important. Results and implications from these combined models will be discussed for experiments in the DIII-D, NSTX, and Alcator C-Mod devices.

*Supported by the US Department of Energy SciDAC Program.

11:15
W16 2 How Good is a Quasilinear ICRH Operator? A New Method for ICRH Simulation in a Guiding Center Code.*
CHOONG-SEOCK CHANG, *Courant Institute-NYU*

The widely used form of conventional quasilinear cyclotron resonance heating operator was derived in a homogeneous system, and then extended to an inhomogeneous system assuming that the resonance layer is thin enough to ignore the inhomogeneity effects and the resonance time is short enough to neglect the nonlinear interactions. It is also assumed that the Coulomb collisions are weak enough not to interfere with the quasilinear wave-particle interaction process within a resonance layer, but strong enough to decorrelate the consecutive resonance layers (in addition to the multi-mode decorrelation). However, a six dimensional numerical Lorentz-force simulation reveals that these assumptions break down in many physical situations and can yield incorrect estimate of quasilinear heating rate. Detailed description on the validity of the quasilinear theory will be presented, in comparison with the six dimensional numerical results, under assumed rf field profiles of practical interest. Based upon the six dimensional study, we also report a new reduced method to evaluate the ion cyclotron resonance interaction in a guiding center kinetic code, which can accurately include the effects of nonlinear orbit distortion, wave inhomogeneity, magnetic field inhomogeneity (trapped-passing particles), multiple wave numbers, and Coulomb collisions. In collaboration with Gunyoung Park, Dept. of Physics, KAIST, Daejon, 305-701, Korea.

*Work supported by US DOE and Korean KSTAR project.

11:45
W16 3 Ion acceleration in laser-irradiated micro-clusters.*
ALEXEY AREFIEV

A theory has been developed to describe ion acceleration in dense laser-irradiated clusters that are smaller than the laser wave-length [1]. The theory reveals that the breakdown of quasineutrality affects cluster dynamics in a dramatic way: the laser can create a positively charged ion shell that expands due to its own space-charge much faster than the central part of the cluster. The theory also shows a trend for the electrons to have a two-component distribution: a cold core that responds to the laser field coherently and a hot halo that undergoes stochastic heating. The hot electrons expand together with the equal number of ions accelerated to supersonic velocities in a double layer at the cluster edge. The mechanism produces ions with energies grater than the ponderomotive potential. A spectrum of ions produced by large clusters is found from a kinetic model of the hot-electron halo that takes into account electron cooling due to the cluster expansion. The halo makes ion spectrum anisotropic, which is consistent with recent experimental results. The theory of ion acceleration suggests that larger deuterium clusters can significantly enhance the neutron yield in laser-cluster experiments. [1] B.N. Breizman and A.V. Arefiev, Phys. Plasmas 12, 056706 (2005).

*In collaboration with Boris Breizman, Institute for Fusion Studies, The University of Texas at Austin.

12:15
W16 4 Nonadiabatic Ponderomotive Barriers.*
ILYA DODIN, *Princeton University*

A ponderomotive potential is an effective potential seen by a particle in ac field in average over the fast oscillations. It is not a true potential though, and, if the ac field is in resonance with particle natural oscillations, the particle can exhibit irreversible drift motion [1-3]. A new ponderomotive potential is found for this case that can capture nonadiabatic dynamics [4]. The particle drift in this new potential resembles the motion of a quantum object in a conservative field [5]. Among other applications, these nonadiabatic potentials can perform selective separation and cooling of plasma species or drive electric current by asymmetrically transmitting thermal particles in a preferential direction [1, 2, 6]. [1] N.J. Fisch, J.M. Rax, and I.Y. Dodin, Phys. Rev. Lett. **91**, 205004 (2003). [2] I.Y. Dodin, N.J. Fisch, and J.M. Rax, Phys. Plasmas **11**, 5046 (2004). [3] I.Y. Dodin and N.J. Fisch, J. Plasma Phys. **71**, 289 (2005). [4] I.Y. Dodin and N.J. Fisch, Phys. Lett. A **349**, 356 (2006). [5] I.Y. Dodin and N.J. Fisch, Phys. Rev. Lett. **95**, 115001 (2005). [6] I.Y. Dodin and N.J. Fisch, Phys. Rev. E **72**, 046602 (2005).

*In collaboration with N. J. Fisch. The work is supported by DOE contract DE-AC0276-CHO3073.

SESSION X1: DARK MATTER
Tuesday Afternoon, 25 April 2006; Landmark A, Hyatt Regency Dallas at 13:30
Elena Aprile, Columbia University, presiding

13:30
X1 1
IAN HINCHLIFFE, *Lawrence Berkely National Lab*

This abstract was not received electronically.

14:06
X1 2 Direct searches for dark matter: On the verge of something big.
TOM SHUTT, *Case Western Reserve University*

After nearly two decades of work, direct searches for WIMP dark matter in our galaxy have started to probe the range of WIMP properties favored by supersymmetry. The next decade promises a large increase in the reach of experiments, with existing experiments, such as CDMS and EDLEWEISS, fielding larger arrays of detectors with lower backgrounds, and an exciting set of new technologies based on noble liquids and bubble chambers promising economical scale-up to very large mass detectors. Experiments currently under construction will deeply probe the parameter space of supersymmetric WIMP models, and will set the stage for very large-scale experiments to follow. I will survey these developments, highlighting physics issues driving several detection strategies, and the status, plans and reach of current and upcoming experiments.

14:42
X1 3 Dark matter detection and galactic halo models.
PIERRE SIKIVIE, *U. of Florida and CERN*

Reliable knowledge concerning the structure of galactic halos is of paramount importance to direct and indirect searches for dark matter on Earth. Nonetheless no consensus has been reached at present on any detailed model of the Milky Way halo. I'll discuss the three main approaches which have been pursued, the assumptions underlying each approach, and the predictions each approach makes for signals in dark matter searches.

SESSION X2: PHYSICAL PROPERTIES OF PARTONIC MATTER
Tuesday Afternoon, 25 April 2006; Landmark B, Hyatt Regency Dallas at 13:30

13:30
X2 1 Viscosity in Heavy Ion Collisions.
DEREK A. TEANEY, *Department of Physics & Astronomy, SUNY at Stony Brook*

I first review the successes and failures of describing the dynamics of a heavy ion collision with ideal hydrodynamics. Then, I estimate how a finite (but small!) viscosity modifies the results of these simulations and constrains their region of applicability. In particular, I will discuss the elliptic flow and the spectra of light hadron species. I will also discuss the flow and suppression of heavy quarks which provide a good probe of the transport properties of the medium. Throughout, I will make connections with calculations based on kinetic theory.

14:06
X2 2 Beacons of light–photon emission from hadronic collisions.
STEFAN BATHE, *Brookhaven National Laboratory*

Direct photons do not interact strongly with the medium produced in relativistic heavy-ion collisions, which makes them an exceptional observable: at intermediate pT they provide information on the early stage of heavy-ion collisions; at high pT they constitute a crucial reference for the medium modification of high-pT hadron production which has been observed. The PHENIX experiment at RHIC has found a significant excess of direct photons above the background from decay photons in Au+Au collisions at 200 GeV at both high and intermediate pT. Furthermore, direct photon production in p+p and d+Au collisions has been measured, allowing a fundamental test of QCD as well as constraining the effects of cold nuclear matter. A systematic study of direct photon production will be presented and put into the context of theoretical models and earlier measurements.

14:42
X2 3 Jet quenching and the opacity of matter.
PETER JACOBS, *Lawrence Livermore National Laboratory*

I will discuss recent progress in measurements of jet quenching and what can be learned from them about dense QCD matter.

SESSION X3: MAGNETARS
Tuesday Afternoon, 25 April 2006; Landmark C, Hyatt Regency Dallas at 13:30
David Palmer, Los Alamos National Laboratory, presiding

13:30
X3 1 Magnetars.
KEVIN HURLEY, *UC Berkeley Space Sciences Lab.*

A growing body of evidence has accumulated over the past 10 years that there is a class of Galactic neutron stars with magnetic field strengths of the order of 10^{15} G - the strongest known fields in the universe. These magnetars come in at least two classes, the soft gamma repeaters and the anomalous X-ray pulsars (SGRs and AXPs). I will review the

observations of the SGRs, which sporadically emit short pulses of X-rays (energies up to ~ 100 keV) and more rarely, giant flares with gamma-rays into the MeV range and the most intense fluxes ever observed at Earth. Studies of the SGRs suggest that they should be present and detectable in nearby galaxies, where they would appear to be short cosmic gamma-ray bursts. I will discuss the evidence that such a burst has been observed.

14:06
X3 2 Fast X-ray Oscillations During Magnetar Flares.
TOD STROHMAYER, *NASA*

We report on recent studies of high frequency variability during magnetar giant flares. These oscillations may represent the first observations of global shear oscillations in neutron star crusts, and can provide a new tools to study neutron star structure.

14:42
X3 3 Solar physics of magnetars.
MAXIM LYUTIKOV, *UBC*

Two closely related types of neutron stars – Anomalous X-ray Pulsars and Soft Gamma Ray Repeaters, commonly called magnetars – posses magnetic field exceeding quantum critical fields. Dissipation of these fields powers persistent and bursting emission and produces occasionally giant flares. Using analogies with the Sun, I will describe magnetospheric structure of magnetars, the way magnetic dissipation can proceed in the relativistically strong regime and how giant flares, analogues of coronal mass ejections, may develop. Finally, I will discuss how the observed non-thermal spectra can be formed through resonant cyclotron scattering of surfaces radiation.

SESSION X5: ELEMENTS OF A REAL ENERGY STRATEGY
Tuesday Afternoon, 25 April 2006; Pegasus B, Hyatt Regency Dallas at 12:15
Anthony Nero, Lawrence Berkeley National Laboratory, presiding

12:15
X5 1 Scientific challenges in sustainable energy technology.
NATHAN LEWIS, *California Institute of Technology*

We describe and evaluate the technical, political, and economic challenges involved with widespread adoption of renewable energy technologies. First, we estimate fossil fuel resources and reserves and, together with the current and projected global primary power production rates, estimate the remaining years of oil, gas, and coal. We then compare the conventional price of fossil energy with that from renewable energy technologies (wind, solar thermal, solar electric, biomass, hydroelectric, and geothermal) to evaluate the potential for a transition to renewable energy in the next 20–50 years. Secondly, we evaluate - per the Intergovernmental Panel on Climate Change - the greenhouse constraint on carbon-based power consumption as an unpriced externality to fossil-fuel use, considering global population growth, increased global gross domestic product, and increased energy efficiency per unit GDP. This constraint is projected to drive the demand for carbon-free power well beyond that produced by conventional supply/demand pricing tradeoffs, to levels far greater than current renewable energy demand. Thirdly, we evaluate the level and timescale of R&D investment needed to produce the required quantity of carbon-free power by the 2050 timeframe. Fourth, we evaluate the energy potential of various renewable energy resources to ascertain which resources are adequately available globally to support the projected demand. Fifth, we evaluate the challenges to the chemical sciences to enable the cost-effective production of carbon-free power required. Finally, we discuss the effects of a change in primary power technology on the energy supply infrastructure and discuss the impact of such a change on the modes of energy consumption by the energy consumer and additional demands on the chemical sciences to support such a transition in energy supply.

12:50
X5 2 Hybrid vehicle technologies and their potential for reducing oil use.
JOHN GERMAN, *American Honda Motor Co.*

Vehicles with hybrid gasoline-electric powertrains are starting to gain market share. Current hybrid vehicles add an electric motor, battery pack, and power electronics to the conventional powertrain. A variety of engine/motor configurations are possible, each with advantages and disadvantages. In general, efficiency is improved due to engine shut-off at idle, capture of energy during deceleration that is normally lost as heat in the brakes, downsizing of the conventional engine, and, in some cases, propulsion on the electric motor alone. Ongoing increases in hybrid market share are

dependent on cost reduction, especially the battery pack, efficiency synergies with other vehicle technologies, use of the high electric power to provide features desired by customers, and future fuel price and availability. Potential barriers include historically low fuel prices, high discounting of the fuel savings by new vehicle purchasers, competing technologies, and tradeoffs with other factors desired by customers, such as performance, utility, safety, and luxury features.

13:25
X5 3 Nuclear Power Now and in the Near Future.
WILLIAM BURCHILL, *Texas A&M University*

The presentation will describe the present status of nuclear power in the United States including its operating, economic, and safety record. This status report will be based on publicly-available records of the U.S. Department of Energy, the U.S. Nuclear Regulatory Commission, and the Institute of Nuclear Power Operations. The report will provide a brief description and state the impact of both the Three Mile Island and Chernobyl accidents. It will list the lessons learned and report significant improvements in U.S. nuclear power plants. The major design differences between Chernobyl and U.S. nuclear reactors will be discussed. The presentation will project the near future of nuclear power considering the 2005 Energy Bill, initiatives by the U.S. Department of Energy and industry, and public opinions. Issues to be considered include plant operating safety, disposition of nuclear waste, protection against proliferation of potential weapons materials, economic performance, environmental impact and protection, and advanced nuclear reactor designs and fuel cycle options. The risk of nuclear power plant operations will be compared to risks presented by other industrial activities.

SESSION X16: RESEARCH ON TEACHING LARGE ENROLLMENT CLASSES
Tuesday Afternoon, 25 April 2006; Landmark D, Hyatt Regency Dallas at 13:30
David Meltzer, University of Washington, presiding

13:30
X16 1 Research-based modifications to traditional introductory laboratories.*
STEPHEN KANIM, *New Mexico State University*

We are developing a set of laboratories based on research into student understanding of various topics in introductory mechanics. While intended for students in the algebra-based introductory course, many of these labs will also be suitable for students in calculus-based courses. To facilitate adoption, where possible we are using equipment that is commonly used in traditional introductory labs. We have found that in many cases, student difficulties with underlying concepts call into question the assumptions underlying the design of standard labs. These difficulties hinder student understanding of the intended purpose and results. We will give examples of these difficulties, of the exercises we have developed intended to address them, and of preliminary assessments of student performance. In addition, we describe some preliminary research into some differences between students in the algebra- and calculus-based courses, and the instructional implications of these differences. In collaboration with Luanna Ortiz, Arizona State University, and Michael Loverude, California State University Fullerton.

*Supported by NSF grants DUE-0341333, DUE-0341289, and DUE-0341350.

14:06
X16 2 Using Physics Education Research to Improve Student Learning in Large Enrollment Courses.
TIM STELZER, *University of Illinois*

The department of physics at the University of Illinois has systematically restructured its introductory calculus and algebra based physics courses. These changes were based on work from the physics education research community, including Peer Instruction, Just In Time Teaching, Tutorials and Context Rich Problem Solving. I will discuss the issues involved in institutionalizing these changes to the courses that have now been taught by more then 50 faculty members within the department. I will also show qualitative and quantitative results of the impact changes have had.

14:42
X16 3 Replicating Physics Education Reforms: How (and why) to keep a good thing going.*
STEVEN POLLOCK, *University of Colorado, Boulder*

What does research tell us about dealing with the large introductory physics classes that are a fact of life at so many Universities? In particular, what does it mean to successfully replicate course transformations, between or within institutions? We report on our efforts to implement several widely studied PER-based transformations, including peer instruction and Washington Tutorials [1], and show how and why (some) educational reforms and research can transfer

successfully. In successive semesters with multiple instructors, we measure results similar to those seen by the original authors of the reforms - namely, significantly improved conceptual mastery. We also document the support of productive attitudes and beliefs, albeit with some student discontent. We examine our data from a theoretical perspective involving several levels: tasks, situations, and broader educational structures. We find each of these layers, and their interplay, are critical in the successful implementation of these reforms. This framework may prove useful for understanding and adapting features that shape when and why a given implementation might be successful and sustainable. [1] McDermott, L. and Shaffer, P.,''Tutorials in Introductory Physics,'' Prentice Hall, 2002.

*Supported in part by NSF-STEMP-TP Colorado 0203022, NSF-CCLI 0410744, Colorado PhysTEC (APS/AIP/AAPT 4626B).

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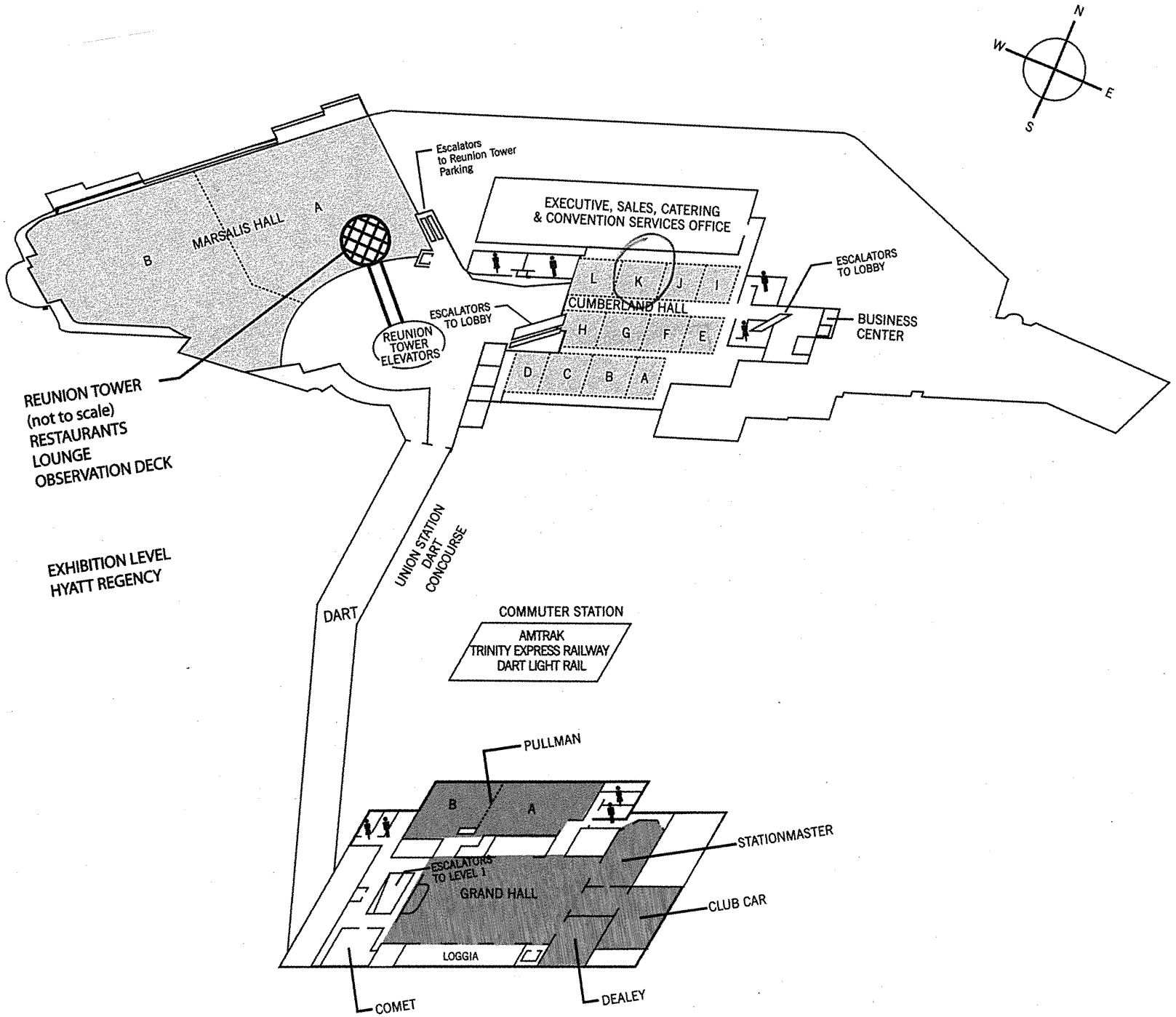
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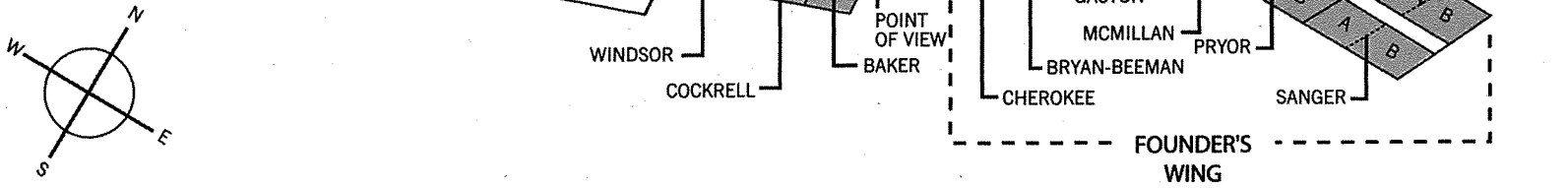
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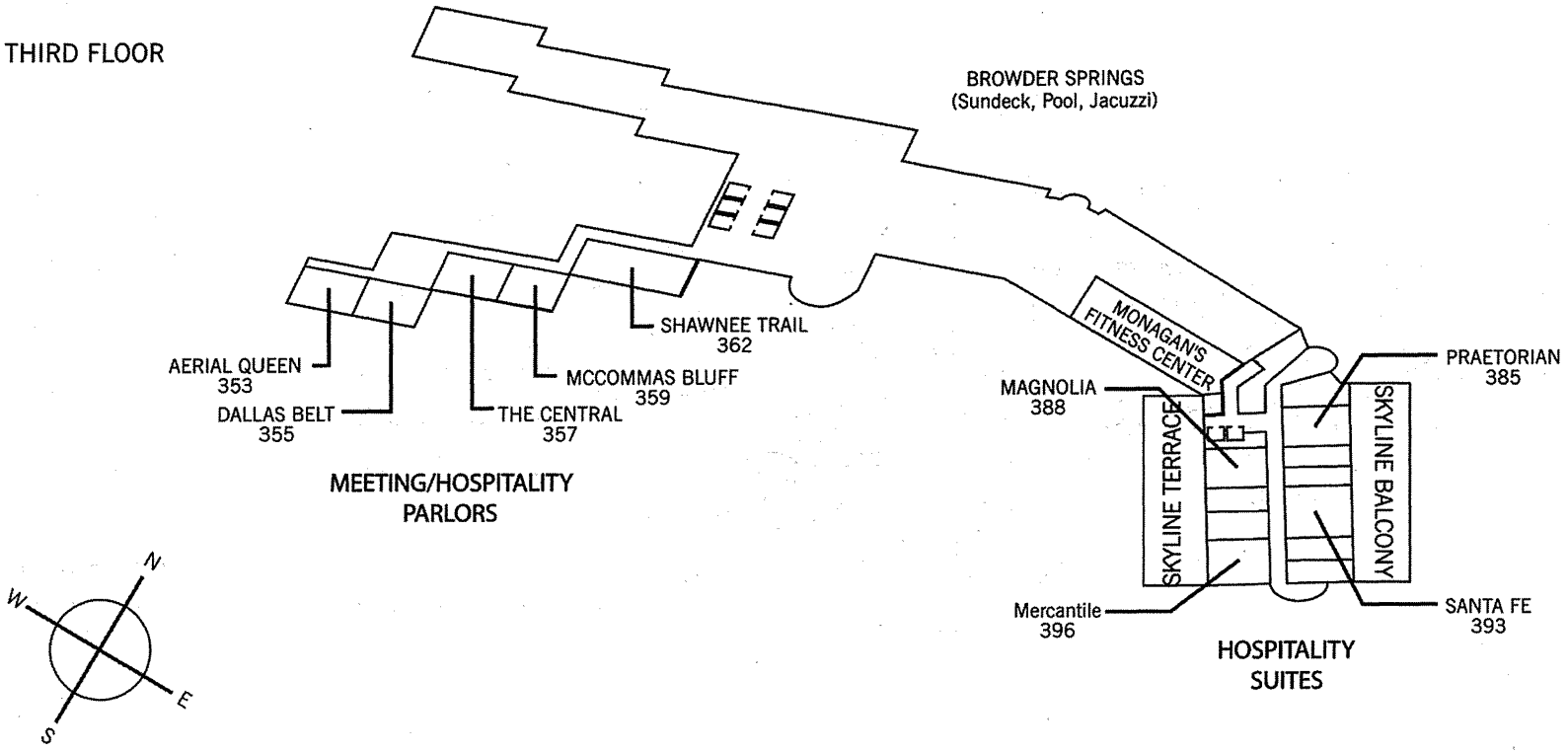
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On the Cover: ''Spider'' pattern of plasma emerging from nozzles. Phys. Rev. Lett. **95**, 045002 (2005).

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