Title: **Extended MHD studies of ELM-free negative triangularity plasmas in DIII-D and the CETOP SciDAC-5 project**

F. Ebrahimi[1], T. Cote[2], J. King[3], A.O. Nelson[4], N. Leuthold[4], G. Yu[5], C. Paz-Soldan[4] and the CETOP team

Institutions: (1) PPPL (2) GA (3) FiatLux (4) Columbia University (5) UC Davis

Recent developments of ELM-free negative triangularity (NT) regimes via plasma shaping have exhibited interesting edge MHD dynamics [T. Cote et al. Plasma Phys. Control. Fusion 67 035033, 2025]. Here, we have performed global simulations for two strongly shaped NT DIII-D discharges with low and high beta, discharges 193754 and 193843, respectively. We model the entire plasma, including the core, edge, SOL and vacuum regions. Our two-fluid NIMROD simulations are consistent with experiments and show no ELM activity. Only slow-growing n=1 fluctuations are observed in the simulations. For the high beta case, a core n=1 hybrid pressure/current driven mode is found; while, for the low beta case a slow-growing tearing mode n=1, m=3 localized in the edge region is obtained. Unlike in ELMing DIII-D positive triangularity (PT) simulations, where the nonlinear mode coupling of intermediate-n PB modes causes reconnection-mediated ELM crash [Ebrahimi &Bhattacharjee Nucl. Fusion 63 126042, 2023], here consistent with the experiment, we obtain ELM-free NT states with only slow-growing edge n=1 fluctuations. For high beta NT plasma, nonlinear simulations show relaxation of plasma current via a two-fluid core dynamo effect. Comparison with ECE-I and other measurements and the effect of multi species are also being investigated. Some highlights of our CETOP (Center for Edge of Tokamak OPtimization) project for transition to GPU accelerated architectures to enable higher-fidelity NIMROD multi-species simulations, as well as application of ML techniques for ELM evolution forecasting based on DIII-D BES data, will also be presented. This work was supported by the DOE SciDAC program under Award Numbers DE-AC02-09CH11466, DE-FC02-04ER54698, DE-SC0023500, and DE-SC0022270.