The CETOP (Center for Edge of Tokamak OPtimization) SciDAC-5 project and nonlinear ELMs

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The CETOP project is a new SciDAC-5 project for the “Development of High-Fidelity Simulation Capabilities for ELM-free Design”, with the overarching objective to develop simulation capability and to perform extended MHD and (drift-gyro) kinetic simulations of non-ELMing (and some ELMing) regime operating points to close gaps in understanding, prediction and optimization of edge stability for an FPP. I will present an overview of the CETOP project, as well as a summary of our initial results. We utilize a hierarchy of models (using M3D-C1, NIMROD, XGC, MARS-K/Q codes) to capture multiscale edge physics. Our objectives are: 1- inclusion of non-ideals effects, plasma shaping, multi-species and nonlinear physics in extended MHD, 2- coupling of extended MHD, XGC, drift kinetic, including full nonlinear benchmark between extended MHD, gyrokinetics and NIMROD DK, 3- to develop advanced time discretizations and transition to GPU accelerated architectures for our MHD codes to enable higher-fidelity multi-species simulations, 4- to apply ML techniques for extracting reduced-order models, data reduction, and feature extraction to the existing non-ELM database (based on interpolation of data), and to extrapolate to new parameter regimes for ELM-free optimization. The latter will be combined with high fidelity simulations for FPP design optimization. Two extended MHD studies in ELM-free regimes will be presented. First NIMROD, M3D-C1 and MARS-Q benchmark studies of NSTX for the wide-pedestal ELM-free scenarios, have been performed. Our initial NIMROD results show that toroidal flows play an important role in the onset of marginally stable peeling-ballooning in both MHD and 2-fluid regimes. Second, our linear and nonlinear NIMROD simulations of negative triangularity in DIII-D show a persistent reconnecting global n=1 mode. This work was supported by the U.S. Department of Energy under contract number DE-AC02-09CH11466 through the Scientific Discovery through Advanced Computing (SciDAC) program under Field Work Proposal No. 3221.