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TH/P2-02: Progress in the Plasma Science and Innovation Center

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Highlights of recent progress in the Plasma Science and Innovation (PSI) Center include adding reacting neutrals in the MHD model, providing capability for CAD description to grid generation to MHD simulation, incorporating energetic particles in extended MHD modeling, simulating 3D physics with Hall MHD, such as rotating magnetic field (RMF) current drive and inductive asymmetric current drive. The PSI Center is a collaborative effort to refine existing computational tools with the goal of improving computational predictability. The Center collaborates with experimental research groups to test the codes and to support the experiments. The Center refines primarily NIMROD and HiFi to have sufficient physics, boundary conditions, and geometry to be calibrated with experiments to achieve predictive capabilities. This paper describes some of the recent code advances, applications to experimental devices, and comparison to experimental data. The HIT-SI bow tie spheromak uses geometrically asymmetric injectors to inject helicity. From experimental data and Hall-MHD NIMROD simulations, the spheromak is formed and sustained by a combination of reconnection and quiescent dynamo drive. The HiFi code uses a 3D finite element spatial discretization that uses a multiblock grid, imported from a CAD description from the experimental design. The grid quality is determined using an a priori error estimator that identifies regions that need improved grid resolution. The TCSU field reversed configuration (FRC) investigates RMF current drive to generate and sustain an FRC. Three-dimensional Hall-MHD NIMROD simulations using experimental parameters show the generation of an FRC with toroidal magnetic field and size that compare well with experimental results. A reacting plasma model, which has a singly ionized plasma and a dynamic, neutral gas, that undergo ionization, recombination, and charge exchange reactions, has been implemented in HiFi and used to simulate the ELF experiment of an FRC plasma drifting through a background of initially static neutral gas. The FRC leading edge ionizes and imparts momentum to the neutral gas. By collaborating with a variety of experiments, the PSI Center is able to focus efforts on adding appropriate physics capabilities to existing fluid codes and thereby provide computational support and eventually predictive capability for experiments.

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