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Integrated Modeling of Core, Edge Pedestal and Scrape-Off-Layer for High Beta_N Steady-State Scenarios on DIII-D

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A new theory-based integrated modeling of Core, Edge Pedestal, and Scrape-Off-Layer (CESOL) has been developed, validated and used to project core to boundary solutions for an upgrade to DIII-D that will develop the plasma physics path to a steady state fusion reactor. It also represents a significant step towards a whole device modeling (WDM). The simulation reproduces DIII-D high N discharge measured profiles across regions from the magnetic axis to the divertor. CESOL consists of three independent, compound Integrated Plasma Simulator (IPS) workflows: IPS-FASTRAN (1-D core transport), IPS-EPED (edge pedestal), and IPS-C2 (2-D SOL plasma/neutral transport). In the core region FASTRAN computes all transport channels with TGLF and is self-consistent with an EPED edge pedestal. The total particle and energy fluxes are matched at the separatrix between the FASTRAN+EPED and C2 workflows in an iterative steady-state solution procedure. This specific coupling aims to determine the density and temperature at the separatrix, which are used to update the input to EPED and close the strong nonlinear dependency among the core, edge pedestal, and SOL regions. Projections for DIII-D upgrades indicate that fully non-inductive solutions will be able to probe critical stability, transport and energetic particle limits with reactor relevant broad current profiles (qmin>2) and N up to ~5 at low collisionality and a range of rotations. The use of ultrahigh harmonic 'helicon fast wave' or high field side LHCD extends scenarios to high density, low rotation and increased Te/Ti, reducing divertor heat flux by more than a factor of 2 with increased bootstrap current fraction, fBS~0.7. Helicon and LHCD also extend profile range, stability and N potential at low and high rotation. These techniques will be combined with new closed pumped upper and lower divertors, materials testing facilities, and 3D upgrades to develop integrated core-edge steady state solutions on DIII-D relevant to future fusion reactors.
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