ECCD-induced tearing mode stabilization in coupled IPS/NIMROD/GENRAY HPC simulations

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Neoclassical tearing modes (NTMs), which degrade plasma confinement and may also trigger disruptions in toroidal plasmas, have successfully been suppressed or controlled in many experiments by the local application of electron cyclotron current drive (ECCD) in or near the magnetic island formed by the NTM. The development of integrated, predictive models to determine optimal strategies for stabilizing these modes in ITER is a subject of ongoing interest. The Integrated Plasma Simulator (IPS) framework, developed by the SWIM Project Team, facilitates self-consistent simulations of complicated plasma behavior by managing the coupling of multiple codes modeling different spatial and temporal scales in the plasma. Here, we apply its capability to investigate the stabilization of tearing modes by ECCD, using thousands of processors and multiple codes on NERSC HPC platforms.

Under IPS control, the NIMROD code (MHD) evolves fluid equations to model bulk plasma behavior, while the GENRAY code (RF) calculates the self-consistent propagation and deposition of RF power in the ensuing plasma profiles. A third code (QLCALC) constructs moments of the quasilinear diffusion tensor (induced by the RF) from the NIMROD and GENRAY data; these moments in turn influence the dynamics of current, momentum, and energy evolution in NIMROD's equations. In addition, multiple analysis codes generating contour, Poincare, and time-history plots are concurrently run by the IPS framework, which aggregates these datasets on a web-based portal to generate a comprehensive overview of the coupled simulation as it proceeds.

Initial results from these coupled simulations are shown to correctly capture the physics of magnetic island stabilization [T. G. Jenkins et al., Phys. Plasmas **17**, 012502 (2010)] in the low-beta limit. Additionally, the development of a numerical plasma control system for active feedback stabilization of these modes is discussed, code verification activities are summarized, and an overview of ongoing model developments in the physics (neoclassical effects, closures, relativistic effects) and numerical (data storage issues, code building and execution) aspects of the project is presented.

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