Predictive Integrated Modeling Simulations Using a Combination of NTCC H-mode Pedestal and Core Models

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US-Japan JIFT Workshop, Kyoto Japan
December 15-17, 2003

Predictive integrated modeling (frequently referred to as predictive transport modeling) of tokamak plasmas involves the interaction between transport, sources, sinks, equilibrium, and large scale instabilities, to predict temperature, density, and other profiles. Integrated modeling simulations are used to understand the physics of confinement, to optimize the performance of tokamaks, and to predict the expected fusion power production in planned burning plasma experiments. Before the development of predictive boundary conditions, the temperatures and densities at the edge of the simulations were taken from experimental data. The simulations yielded core plasma profiles that were consistent with experimental data within measurement errors. As a first step in developing predictive boundary conditions for simulations of H-mode discharges, static models (without the effect of periodic ELM crashes) were developed for the height of the H-mode pedestal. These pedestal models were combined with models for the plasma core, such as the Multi-Mode, GLF23, and mixed-Bohm/gyro-Bohm anomalous transport models, to predict the temperature and density profiles in H-mode discharges. In more recent simulations, dynamic models for the pedestal and ELMs at the edge of H-mode plasmas are used to produce time-dependent simulations of plasma profiles from the magnetic axis to the separatrix. MHD stability codes are used to calibrate the models that trigger ELM crashes within the integrated modeling code. A geographically distributed collaboration developed the NTCC project, which has explored the use of modern computer software engineering to produce Web-invocable, community-owned integrated modeling codes. The NTCC module library (which is available at http://w3.pppl.gov/NTCC) was established in order to facilitate the development of integrated modeling codes. A review process is in place to ensure that modules conform to the Module Library standards. The exchange between the author of each module and the reviewer often results in improvements to the module and its documentation. Currently, there are 44 modules in the Module Library, including modules for transport, plasma heating, equilibrium and MHD stability, H-mode pedestal, neutral gas, atomic and nuclear reaction rates, and numerical and visualization tools.