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Validation of a coupled core-transport, pedestal-structure, current-profile and equilibrium model[1]

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The first workflow capable of predicting the self-consistent solution to the coupled core-transport, pedestal structure, and equilibrium problems from first-principles and its experimental tests are presented. Validation with DIII-D discharges in high confinement regimes shows that the workflow is capable of robustly predicting the kinetic profiles from on axis to the separatrix and matching the experimental measurements to within their uncertainty, with no prior knowledge of the pedestal height nor of any measurement of the temperature or pressure. Self-consistent coupling has proven to be essential to match the experimental results, and capture the non-linear physics that governs the core and pedestal solutions. In particular, clear stabilization of the pedestal peeling ballooning instabilities by the global Shafranov shift and destabilization by additional edge bootstrap current, and subsequent effect on the core plasma profiles, have been clearly observed and documented. In our model, self-consistency is achieved by iterating between the TGYRO core transport solver (with NEO and TGLF for neoclassical and turbulent flux), and the pedestal structure predicted by the EPED model. A self-consistent equilibrium is calculated by EFIT, while the ONETWO transport package evolves the current profile and calculates the particle and energy sources. The capabilities of such workflow are shown to be critical for the design of future experiments such as ITER and FNSF, which operate in a regime where the equilibrium, the pedestal, and the core transport problems are strongly coupled, and for which none of these quantities can be assumed to be known. Self-consistent core-pedestal predictions for ITER, as well as initial optimizations, will be presented.

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