Integrated modeling of steady-state scenarios and heating and current drive mixes for ITER

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Abstract. Recent progress on ITER steady-state (SS) scenario modeling by the ITPA-IOS group is reviewed. Code-to-code benchmarks as the IOS group's common activities for the two steady state scenarios (weak shear scenario and internal transport barrier scenario) are discussed in terms of transport, kinetic profiles, and heating and current drive sources using various transport codes. Weak magnetic shear scenarios integrate the plasma core and edge by combining a theory-base transport model (GLF23) with scaled experimental boundary profiles. The edge profiles (at normalized radius $\rho = 0.8–1.0$) are adopted from edge localized mode-averaged analysis of a DIII-D ITER Demonstration discharge. A fully noninductive SS scenario is achieved with fusion gain $Q = 4.3$, noninductive fraction $f_{\rm NI} = 100\%$, bootstrap current fraction $f_{\rm BS} = 63\%$, and normalized beta $\beta_{\rm N} = 2.7$ at plasma current $I_{\rm p} = 8$ MA and toroidal field $B_{\rm T} = 5.3$ T using ITER day-1 heating and CD capability. Substantial uncertainties come from the outside the radius of setting the boundary conditions ($\rho = 0.8 - 1.0$). The present simulation assumed $\beta_N(\rho)$ at the top of pedestal is about 25% above the peeling-ballooning threshold. Overall, the experimentally scaled edge is an optimistic side of the prediction. ITER will have a challenge to achieve the boundary, considering different operating conditions ($T_e/T_i \approx 1$ and density peaking). A number of SS scenarios with different heating and current drive mixes in a wide range of conditions were explored by exploiting the steady-state solution procedure for the GLF23 transport model. The results are also presented in the operation space for DT neutron power versus stationary burn pulse duration with assumed poloidal flux availability at the beginning of stationary burn, indicating that the long pulse operation goal (3000 s) at $I_{\rm p} = 9$ MA is possible. Source calculations in these simulations have been revised for electron cyclotron current drive including parallel momentum conservation effects and for neutral beam current drive with finite orbit and magnetic pitch effects.

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