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Evaluation of Predictive Capability for Hydrogenic and Impurity Density in L- and H-mode Tokamak Plasma using Multimode Transport Model

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Predictive capability of hydrogenic density and impurity density in L and H-mode plasma is strongly desirable to fully understand behaviors of plasma in tokamak, which can exhibit many modes of transports depending on the conditions of plasma. Combining many modes from turbulent transports, the Multi-Mode Model version 1995 (MMM95) includes coefficients from the Weiland model for the ion temperature gradient (ITG) and trapped electron modes (TEM), the Guzdar–Drake model for drift-resistive ballooning (RB) modes, and modified kinetic ballooning (KB) modes. In this work, the hydrogenic and impurity density profiles in L- and H-mode plasma are investigated using self-consistent modeling of BALDUR integrated predictive modeling code in which theory-based models are used. In these simulations, a combination of NCLASS neoclassical transport and MMM95 anomalous transport model is used to compute a core transport. The boundary conditions for temperature and density are taken to be at the top of the pedestal, where the pedestal values are taken from experiments. The predictive capability is determined by comparing the predicted profiles with experimental data in 24 discharges from various tokamaks and plasma conditions. Statistical analysis such as the average relative root mean square (RMS) deviation and offsets are used to quantify the agreement. The multi-parameters optimization technique is used to derive suitable coefficients for the MMM95 transport model. The simulation results show that even when the electron density and temperature profiles, and the ion temperature profiles agree well with experiments, yielding low RMS and correct trends, the impurity density profiles do not often agree with experiments, yielding much higher RMS and even opposite trends. The effects of KB and RB contribution are comparable on the impurity profiles. In addition, it is clear from the RMS optimization that a universal model with the same set of coefficients for all discharges is unlikely, but a range of each coefficient from each transport mode can be estimated for a given plasma regime.

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