Integrated modeling of H-mode tokamak plasma confinement

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A new integrated model based on engineering parameters (IMEP) [1, 2] has been developed to predict the confinement of H-mode plasmas. A new pedestal transport model, based on multi-device experimental observations, is included into the ASTRA [3] transport code, which, together with the TGLF [4] and NCLASS [5] turbulent and collisional transport models, simulates the evolution of the profiles over the whole plasma radius. The MISHKA [6] MHD stability code tests the stability to peeling-ballooning modes, to find the highest stable pedestal pressure. A simple scrape-off layer (SOL) model has been also implemented, providing the boundary conditions at the separatrix. No profile measurements are required as input, and the only inputs of IMEP are the magnetic field, the plasma current, the heating power, the fueling rate and the plasma geometry. The final result of the workflow are the kinetic profiles which are used to calculate the plasma stored energy and the energy confinement time. This automated modeling framework has been extensively validated on a database of 50 stationary phases of ASDEX Upgrade discharges, including wide variations in heating power, current, magnetic field, triangularity, and fueling. IMEP reproduces the change in pedestal and global confinement with significantly higher accuracy than scaling laws. The generalization of the pedestal model to a dimensionless form allows the application of IMEP to devices with different sizes, where experimental boundary conditions have to be used in replacement of the AUG specific SOL model. Dedicated modeling of C-Mod and JET plasmas, in addition to AUG, extends the range of parameters over which it is validated, including the plasma size. These results give confidence that IMEP has the potential to increase the reliability of the predictions of future fusion tokamak reactors.

References

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