Full-radius integrated modelling of H-mode confinement dependence on plasma size and predictions for ITER and DEMO

T. Luda, C. Angioni, C. Bourdelle, M. Dunne, E. Fable, D. Fajardo, F. Stefanelli, G. Tardini

Max–Planck–Institut fuer Plasmaphysik, Boltzmannstrasse 2, D–85748 Garching, Germany

Reliable predictions of the fusion performance for future fusion reactors require a reliable prediction of the kinetic profiles by means of integrated models. Current uncertainties revolve around the models describing turbulent transport in the core and pedestal structure at the edge. While the physics of core turbulent transport observed in today's experiments is well understood and theory based models have been successfully validated over large multi-machine experimental data, the same level of understanding is lacking for pedestal models. In this work we present the validation of the IMEP workflow [T. Luda et al *NF* 2020, T. Luda et al *NF* 2021, T. Luda et al *PPCF* 2022], which aims at bridging the gap between existing pedestal models, such as EPED, and the requirement of more reliable predictions of the pedestal pressure.

IMEP integrates a description of pedestal transport based on an empirical relation on the electron temperature gradient, the TGLF turbulent transport model, and the NCLASS neoclassical transport model within the ASTRA transport code. The pedestal pressure is determined by the combination of transport description and peeling–ballooning mode stability, which is calculated with the MISHKA code. Previous works have demonstrated IMEP's superior predictive capabilities, notably surpassing empirical scaling laws in predicting thermal energy for 50 ELMy H-mode plasmas on ASDEX Upgrade. Additionally, IMEP has accurately predicted pedestal pressure across databases from Alcator C-Mod, ASDEX Upgrade, and JET-ILW (for the peeling-ballooning limited cases), proving the capability of also capturing the increase of confinement with plasma size.

Given the significant difference in size between existing tokamaks and future reactors like ITER and DEMO, the question of the size scaling is explored here from a more general standpoint with a numerical size scan. The dependence of H-mode confinement with increasing plasma size predicted by IMEP is shown to be largely consistent with the IPB98(y,2) scaling law, more favorable than the ITPA20-IL, and close to the gyro-Bohm transport, well above the confinement of Bohm transport. From the general properties of the size dependence, we move to predictions of the ITER 15 MA baseline scenario, particularly demonstrating the limited impact of a reduction of heating power on the pedestal top pressure and the possibility of reaching operation which significantly exceeds Q = 10. Limits in the allowed W concentration are discussed. Finally projections for a DEMO reactor are presented.