Integrated modelling of tokamak plasma confinement combining core and edge pedestal physics

T. Luda, C. Angioni, M. Dunne, E. Fable, F. Ryter, G. Tardini, the ASDEX Upgrade Team, and the EUROfusion MST1 Team - Max-Planck-Institut für Plasmaphysik, Garching

A new theory-based approach to the integrated modelling of tokamak plasma confinement is being developed. The model aims at predicting the total stored energy and the plasma kinetic profiles, using only global parameters as inputs, such as the plasma current, the density and the heating powers. We use the TGLF model to evaluate the turbulent transport fluxes in the core region. In the pedestal region we assume ion neoclassical heat transport for both electrons and ions. The particle transport coefficient in the pedestal is determined empirically, and is kept fixed to a value which produces a density gradient similar to the experimental one.

These transport assumptions are implemented into the transport code ASTRA. We consider H-mode plasmas, and we simulate the density, and the electron and ion temperature profiles. We aim at simulating also the toroidal rotation profile, but for simplicity this is now kept fixed to the experimental measurements. For each ASTRA run, the user-chosen variables are the boundary conditions at the last closed flux surface, the pedestal width, and a scale factor for neoclassical transport in the pedestal. Using this model set-up, the applicability of TGLF in the plasma periphery is investigated, as well as the impact of different assumptions on the pedestal structure on the core.

Once the profiles computed by ASTRA (Te, ne, Ti, ..) have converged for a particular set of inputs, the plasma boundary, current, field and pressure and current density profiles are used as input for the MISHKA MHD stability code to evaluate the critical pedestal height/width combinations for various transport assumptions.

This modelling framework has been tested by simulating ASDEX Upgrade discharges. We show comparisons with experimental fuelling and power scans. The model can well capture the changes in the profiles due to the different combinations of fuelling and power levels, which affect the pedestal structure and the gradients in the core. We also show that the modelled pedestal height, the energy confinement time and the stored energy, are compatible with the experimental measurements.

The long term goal is to obtain a robust model for the entire plasma which can be applied to large experimental databases, in order to identify important hidden dependencies affecting the global plasma confinement, which are difficult to capture by statistical regressions on global parameters.