A self-consistent cross-field transport model for edge plasma simulations: SOLEDGE modelling and comparison with WEST experiments

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Operation of complex systems such as ITER or DEMO must rely on state-of-the-art knowledge in order to step towards novel experimental achievements. In that perspective, numerical simulations are powerful tools to prepare operation, and they must address open issues, mostly non-linear phenomena. The physics of the boundary layer between the plasma core and the plasma facing components then appears as critical with open issues regarding high performance divertor operation, the physics of H-mode transport barriers and more generally the interplay between core edge and divertor performance. We address here the effort towards predictive capabilities of 2D mean-field plasma edge transport codes, like SOLEDGE, that have the advantage to require a relatively small computational effort, while using, up to now, a simplified description of cross-field transport. A two-equation model to self-consistently determine cross-field fluxes in the edge and scrape-off layer (SOL) region of diverted plasma is used to complete the 2D transport description. Inspired by the Reynolds average Navier–Stokes simulations for neutral fluids, this model is based on the local evolution of the turbulent kinetic energy κ and its dissipation rate ε. These two equations are algebraically derived for RANS modeling and are adapted to describe self-consistent plasma turbulent transport. The general features of the model are discussed and specific closures are proposed based on the interchange turbulence.
Results of the 1D model are confronted to experimental evidence by analyzing the computed SOL width and comparing the results to the existing scaling laws for L-mode plasmas. Introducing a dependence on the shear of zonal flows, 1D simulations can exhibit an H-mode like transition when increasing the input power, generating an increased stored energy thanks to an interface barrier located at the separatrix. The model has also been stepped to 2D transport simulations with SOLEDGE-EIRENE code allowing for the confrontation to experimental data in WEST, showing a very good prediction of outer midplane experimental profiles as well as a good match with target profiles. The SOL width of WEST is also recovered. These results are promising to analyze transport in new divertor configurations as well as the physics of core-edge interplay, including self-consistent barrier formation when increasing the heating power.

References: S. Baschetti et al., 2021 Nucl. Fusion **61** 106020 and references therein.