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Progress towards self-consistent treatment of turbulence in edge plasma modelling codes

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Mean-field transport codes are the key tools for the understanding of Scrape-Off-Layer and divertor regimes. They rely on models in which simple closures are used to model average fluxes and stresses due to fluctuations. In particular, turbulent transport is commonly described via a gradient-diffusion hypothesis and ad-hoc diffusion coefficients. However, these coefficients differ from one case to the other and must be considered as free parameters, which reduces drastically the predictive capabilities of these codes.
We here report progress made towards allowing a self-consistent treatment of turbulent transport in edge modelling codes. We consider two ways forward: on the one hand, direct numerical simulation of turbulence in 3D global simulations; on the other hand, innovative ideas to refine the description of transverse transport in mean-field transport codes and improve their predictive capabilities. This work is made possible by the joint exploitation of a 2D mean field code and a 3D global turbulence code, namely SOLEDGE2D and TOKAM3X.
In a first part, we report the latest advances of these tools. We first present recent upgrades of the SOLEDGE2D-EIRENE plasma and neutrals solver. Multi-fluid equations for impurities as well as drifts have now been implemented. These new capabilities are illustrated by applications to the modelling of ASDEX, WEST and TCV in a snow-flake configuration. Concerning TOKAM3X, two major advances have been achieved: simulations in X-point geometry have been performed and the code has been successfully coupled to the EIRENE kinetic neutrals code. We will show how the X-point impacts the properties of edge turbulent transport while preserving the main features observed in limited simulations. We will also present first results on the mutual interaction between fluctuations and atomic physics.
We finally propose a novel approach to the modelling of transverse transport in mean field codes. The new model transposes to magnetized plasmas k-epsilon turbulence models long used in computational fluid dynamics. It depends on more universal parameters than gradient-diffusion closures and is able to capture key properties of edge turbulence physics. As a first step, we show how a simplified k-epsilon model allows one to recover self-consistently the ballooning properties of radial turbulence transport and the related asymmetric flows.

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