Contribution ID: **124** Type: **Oral**

Model advancements in mean-field plasma edge codes to enable computationally achievable simulations of the ITER and DEMO reactors

Wednesday, 9 November 2022 11:40 (30 minutes)

Plasma edge codes are the workhorse for divertor design for future machines. Models that correctly account for kinetic neutrals, anomalous transport, and detailed wall geometry are essential to extrapolate current knowledge towards reactors. Yet, the required highly collisional regimes and large size lead to inacceptable runtimes. We report on the status and remaining challenges of some recently developed models to address these issues.

To accelerate the simulations in high-recycling and detached conditions, advanced fluid neutral (AFN) and hybrid fluid-kinetic approaches for the neutral particles were recently developed. The AFN models significantly improve the results of classic fluid neutral models due to improved boundary conditions and transport coefficients, consistently derived from the underlying kinetic description [1,2].

The AFN models provide an alternative for a kinetic model in high-collisional regimes, but these conditions are usually only present in a small part of the simulation domain. We give an overview of several hybrid fluid-kinetic approaches with their advantages and drawbacks that were developed to address this. The most mature approach uses a spatial decomposition of the computational domain in a fluid and kinetic part, superposed with a condensation process that transfers atoms from kinetic to fluid populations in high-collisional regions [4]. The hybrid model for the atoms is coupled to a kinetic model for the molecules, resulting in hybrid-kinetic discrepancies that remains within 20% [4,5] while providing a factor 10 speed-up. Extended hybrid methods to further eliminate model errors are being explored [6,7].

Accounting for anomalous transport in principle requires fluid turbulence codes, but their cost will remain prohibitive for routine reactor simulations in the near future. The current ad-hoc treatment in edge codes through manually tuned transport coefficients leads to large model uncertainties. Moreover, experimental data to tune the coefficients is not available for future reactors. A more self-consistent description of this transport has recently been developed, relating the transport coefficients to the turbulent kinetic energy κ, which is solved from a corresponding transport equation [8]. Analysis of turbulence simulations suggests that the diffusion coefficients scale with the square root of κ. The κ-model has proven successful in capturing some key features as the ballooned nature of anomalous transport [9,10].

These models are part of the newly developed extended-grids version of SOLPS-ITER [11], paving the way towards efficient and accurate edge simulations at the reactor scale with this package.

[1] N. Horsten, et al., Nucl. Fusion 57 (2017) 116043
[2] W. Van Uytven, et al., Nucl. Fusion (2022)
[3] D. Borodin, et al., Nucl. Fusion, accepted
[4] W. Van Uytven, et al., Contrib. Plasma Phys. (2022) e202100191
[5] N. Horsten, et al., Nucl. Mater. Energy, submitted
[6] N. Horsten, et al., J. Comput. Phys 409 (2020) 109308
[7] B. Mortier, et al., SIAM J. Sci. Comput. 44 (2022) A720
[8] R. Coosemans, et al., Contrib. Plasma Phys. 60 (2020) e201900156
[9] S. Carli, et al., Contrib. Plasma Phys. 60 (2020) e201900155
[10] W. Dekeyser, et al., Contrib. Plasma Phys. (2022) e202100190
[11] W. Dekeyser, et al., Nucl. Mater. Energy 27 (2021) 100999

Speaker's Affiliation

KU Leuven, Department of Mechanical Engineering

Member State or IGO

Belgium

Primary authors: Prof. BAELMANS, Martine (KU Leuven, Department of Mechanical Engineering); Dr DEKEYSER, Wouter (KU Leuven, Department of Mechanical Engineering); Dr HORSTEN, Niels (KU Leuven, Department of Mechanical Engineering); Dr COOSEMANS, Reinart (KU Leuven, Department of Mechanical Engineering); Mr VAN UYTVEN, Wim (KU Leuven, Department of Mechanical Engineering); Prof. BLOMMAERT, Maarten (KU Leuven, Department of Mechanical Engineering); Dr CARLI, Stefano (KU Leuven, Department of Mechanical Engineering); Mr MAES, Vince (KU Leuven, Department of Computer Science); Dr MORTIER, Bert (KU Leuven, Department of Computer Science); Prof. SAMAEY, Giovanni (KU Leuven, Department of Computer Science)

Presenter: Prof. BAELMANS, Martine (KU Leuven, Department of Mechanical Engineering)

Session Classification: Modelling

Track Classification: Modelling