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Plasma–surface related three-dimensional modeling results for Wendelstein 7-X and EAST

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Present-day fusion devices are operated with a multitude of diagnostics in different locations, with which important insight in plasma profiles is obtained. However, since the detected signals only represent a spatially small part of the machine, the experiment natively exhibits blind spots, in particular in the three dimensional edge plasma region, where flux surface averaging reductions are inappropriate. Theory, and especially numerical simulation, may bridge over these unknown areas in order to complete the complex physical picture of the nature of the plasma profile.

The fluid plasma edge Monte-Carlo code (EMC3) [1] coupled to the kinetic (neutral) transport code EIRENE [2,3] is a commonly used fully dimensional plasma edge simulation code for treating such complex magnetic configurations. EMC3 bases on a Monte-Carlo algorithm for a reduced set of Braginskii equations formulated in a Fokker-Planck scheme, while EIRENE solves extended Boltzmann equations in full phase-space directly.

Because of its intrinsically 3D structure, one of the main applications of EMC3-EIRENE is the simulation of scrape-off layer physics for the stellarator Wendelstein 7-X. However, also in tokamaks 3D effects may play an important role, e.g. when using resonant magnetic perturbations to suppress the formation of ELMs.

With this contribution, we present recent results obtained with EMC3-EIRENE. After the study of the divertor manipulator concept and design [4], we stress the importance of kinetic treatment of certain minority ions at the example of helium operation in Wendelstein 7-X [5]. Subsequently, we apply the 3D resolved virtual diagnostics module of EIRENE, capable of simulating a fully synthetic helium beam diagnostic and present results on effective charge state distribution modeling. The same computational tools are then applied to intrinsically 3D Lower-Hybrid Wave induced magnetic perturbation modeling on EAST. We close with a discussion and outlook of the physical impact the enhanced kinetic ion transport description in EIRENE has on both, stellarator and tokamak simulations.

[1] Y. Feng et al., J. Nucl. Mater, 266-269, 812 (1999)

[2] http://www.eirene.de on 2nd Feb 2018

[3] D. Reiter et al., Fusion Sci. Technol, 47 (2), 172 (2005)

[4] M. Rack et al., Plasma Sci. Technol, accepted (2018)

[5] M. Rack et al., Nucl. Fus. 57, 056011 (2017)

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