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Self-Consistent Coupling of DSMC Method and SOLPS Code for Modeling Tokamak Particle Exhaust

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From both the physical and the technical point of view, the description of gas dynamics in the divertor and vacuum systems in tokamak fusion reactors poses a challenging task because of the wide range of regimes covered by the flow: from continuum and slip regimes in the plasma, to transition and free molecular flow in the sub-divertor region. Nevertheless, over the past few years, significant progress has been made in modeling the complex system of the sub-divertor region: a valid tool that has been proven able to describe such a range of gas rarefaction is the Direct Simulation Monte Carlo (DSMC) Method. The present work aims to give a qualitative study of the neutral particle recirculation flows under different pumping conditions in the JET sub-divertor. So far, investigations of the neutral gas flow in both ITER and JET sub-divertor areas have been performed by successfully implementing DSMC using the input data from a SOL plasma modelling code, such as SOLPS and EDGE2D.

Nevertheless, until now there was a simple one-way coupling between a plasma and DSMC code, where the output information from the edge plasma code was imposed on the DSMC algorithm as inlet boundary condition. This paper will improve such a coupling by applying an iterative, but still manual, interaction between the two approaches. Specifically, the data containing the information on the recirculation flow towards the divertor, output of the first DSMC simulation, will be in turn used by the SOLPS code as neutral particle influx boundary condition in the private flux region. After performing the plasma edge calculation, the new estimated incoming flux to the sub-divertor will be used as updated inlet boundary condition for the next DSMC simulation. Therefore, an iterative procedure will be established until convergence is achieved and a self-consistent solution is reached: this will lead to understand and quantify the mutual influence between the two regions via neutral particle recirculation.

The study will be performed for the case of a 2D symmetric and simplified geometry of the JET sub-divertor, and will be focused on plasma scenarios with high and medium electron density cases.

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