Deterministic and stochastic modelling of particle exhaust in the sub-divertor region of W7-X

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In the present work, a deterministic approach is applied to simulate the rarefied gas flow in the particle exhaust system of Wendelstein 7-X (W7-X) stellarator fusion device. The Knudsen number in this system may vary from free molecular up to the viscous regime and the flow behaviour must be described by the Boltzmann equation. In the present work, the Boltzmann equation is approximated by the well-known BGK kinetic model supplemented with the deterministic discrete velocity method (DVM). In addition, the problem has also been studied by solving the Boltzmann equation with the stochastic direct simulation Monte Carlo (DSMC) method.

The above mentioned numerical methods are specific solvers included in the numerical suite DIVGAS, which within EUROfusion, consists the main numerical tool for modelling the particle exhaust system for tokamaks [1,2] and recently for stellarators. The DIVGAS code uses the parallelization technique MPI and it performs reasonably well for both increase in load and increase in number of MPI tasks specifically for HPC use.

Extended comparisons between the deterministic and stochastic simulation data in terms of all macroscopic quantities of practical interest, namely, pressure, number density, temperature, and pumping fluxes, are performed. Moreover, detail study on the computational cost, namely the CPU wall time and the needed iterations for convergence will be presented. It is observed that by comparing the DVM and DSMC numerical results a good agreement within 3% is obtained. All present numerical simulations have been performed in MARCONI HPC.

References

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