Non-linear parallel Monte Carlo simulations of neutral species in Pilot-PSI and Magnum-PSI

R.C. Wieggers*, H.J. de Blank, W.J. Goedheer

FOM Institute for Plasma Physics Rijnhuizen, Association EURATOM-FOM, Trilateral Euregio Cluster, Nieuwegein, The Netherlands
** Email: wieggers@rijnhuizen.nl*

A newly developed parallel non-linear Monte Carlo code has been used to investigate the neutral species in the linear plasma generators Pilot-PSI [1] and Magnum-PSI [2]. The plasma conditions in these devices are similar to those expected in the ITER divertor. Detailed modeling of Pilot-PSI and Magnum-PSI and comparison with experimental data will contribute significantly to both our understanding of strongly magnetized high density low temperature plasmas and to code validation, needed for simulations of divertor plasmas in ITER and DEMO.

The Monte Carlo code calculates the particle density, temperature and flow of the different neutral species in the system. The neutral particles are simulated by independent random walks on a fixed plasma and neutral background. In order to calculate the neutral background correctly, it is iteratively updated until convergence is reached. In every iteration step, the simulated test-particles will collide with an updated neutral background, and the prescribed plasma background. Collision databases describe the interaction with the plasma species [3]. For neutral-neutral collisions, the BGK approximation is used. Processes involving heavy particles depend on the kinetic energies in the center of mass frame, processes involving electrons depend on the local electron temperature. The test-particles collide with the background species, for which we assume a local shifted Maxwellian distribution. This description enables us to study the influence of plasma flows and plasma rotation on the neutral particles.

In this paper we report on the behavior of atomic and molecular hydrogen in and around a plasma beam. Based on Thomson scattering and information from various other diagnostics on Pilot-PSI, we prescribe a plasma background with axial flow and rotation due to the ExB drift. The neutral density, flow and temperature resulting from interaction with the plasma is studied. Processes like molecular assisted recombination (MAR) and charge exchange are important in the high density, low temperature plasmas of Pilot-PSI and Magnum-PSI. The MAR process is implemented as a charge exchange process, immediately followed by the dissociative recombination step. Simulations of an axially uniform section of the beam show the importance of the recycling at the vessel wall. Atomic hydrogen associates at the walls, forming molecules that return to the plasma where they are partly dissociated again, mostly by MAR processes. Results from the simulations are compared with spectroscopic measurements of the Doppler shifted line radiation of atomic hydrogen [4], using collisional radiative modeling.

Besides the properties of the neutral species, the local particle, momentum and energy sources and sinks for the plasma species are calculated. Calculation of this data is the first step in future coupling of our Monte Carlo code to plasma fluid codes like B2.5 [5].

[1] G.J. van Rooij et al., Appl. Phys. Lett. **90** (2007) 121501
[2] A.W. Kleyn et al., Vacuum **80** (2006) 1098
[3] R.K. Janev et al., Springer Series on Atoms and Plasmas, Springer (1987)
[4] A.E. Shumack et al., Phys. Rev. E **78** (2008) 046405
[5] R. Schneider et al., Contrib. Plasma Physics **46** (2006) 3