Simulation and measurement of rarefied gas flow and neutral density profiles through a large multi aperture multigrid negative ion accelerator

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Abstract:

In large multi-aperture, multi-grid negative-ion accelerator for fusion application, the background gas density in the electrostatic accelerator causes a loss of negative-ion current and the formation of dangerous stray particles. In addition, to sustain in dynamic equilibrium a sufficient gas pressure in the plasma ion-source, a very large pumping speed is typically necessary. This paper presents and compares simulations and measurements of gas flows and background pressure profiles, through the electrostatic accelerator of the SPIDER beam source, the full-size prototype source of the ITER neutral beam injectors. The gas pressure profiles through the ion accelerator were measured by multiple movable capacitive pressure gauges, mapping the uniformity of the profiles along nine beamlets at three different filling pressures. The gas flow simulations in molecular flow regime were performed with a large-scale view-factor model, and with a single-aperture periodic test particle Monte Carlo model. The models reproduced the measured pressure profiles but additionally, provided also the profiles of local gas density. The gas conductance and the profiles calculated with the full-scale gas flow model correctly reproduce the measured profiles, and the transversal non-uniformities over the 1.6 m × 0.6 m cross section. The calculated gas density profile is also verified by comparing the two different numerical approaches. The gas flow model validated at room temperature can be used to simulate the pressure profile during operation, in presence of gas heating and dissociation by the source plasma.