Modelling of the beam-driven plasma neutraliser

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In the International Thermonuclear Experimental Reactor (ITER), the neutral-beam injector (NBI) is designed to deliver a power of 33MW by injecting deuterium at 1 MeV. The neutralisation of positively charged deuterium is inefficient at such energies which requires to generate, to accelerate and to neutralise negatively charged deuterium ions. Notably, different schemes of neutralisation have been proposed including gas, plasma and photo-neutralisation [1]. We focus on the plasma neutraliser [2] which is a good trade-off between cost and neutralisation yield. Recent modelling work suggests that the plasma could be sustained by the negative ion beam itself, alleviating the operation of an external plasma source [3]. The stripped electrons and the electrons created by beam ionisation of the background gas must be magnetically confined. We conduct particle test calculations in a magnetic bottle, adding ionisation, to assess the electrons residence time before studying the plasma neutraliser by means of fully self-consistent particle-in-cell (PIC) simulations [4]. In the latter, we calculate the value of the 272eV stripped electron current necessary to achieve a plasma density $\sim 1.0 \times 10^{18}\text{m}^{-3}$ in a background magnetic field. The 2D simulation domain corresponds to a longitudinal cut of the neutraliser that contains the magnetic field lines. The effect of angle scattering and of energy partitioning between primary and secondary electrons resulting from impact ionisation is investigated together with the voltage bias at the end lines of the magnetic field.

References

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