Comparison and validation of tungsten transport simulations in the scrape-off layer of JET L-mode plasmas

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Tungsten impurity transport in JET low-confinement plasmas is simulated using the quasi-kinetic Monte Carlo code DIVIMP and the edge-fluid, kinetic neutral code EDGE2D-EIRENE. The simulation results of the two codes are compared to assess the level of agreement between Monte Carlo and fluid treatment of tungsten and to analyze the reasons to any significant discrepancies. Synthetic diagnostics of W I and W II spectral line radiation are used to validate the simulations against experimental measurements with divertor spectroscopy in the visible wavelength range.

The simulation cases are based on earlier impurity studies [1] and the divertor conditions range from low recycling to partially detached regimes. The power crossing the core boundary is 2.2 MW, split equally between the ion and electron channel, and the electron density at the outer mid-plane separatrix is varied. The impurity sources are determined by physical sputtering at the divertor tiles, mainly due to intrinsic beryllium ions and charge-exchange deuterium neutrals, consistent with previous work [2]. The background plasma solution and tungsten ionization source obtained from EDGE2D-EIRENE are used as inputs in DIVIMP to limit the comparison to tungsten ion transport.

DIVIMP and EDGE2D-EIRENE agree within 5% on tungsten deposition at each target and wall surface. The density distributions are qualitatively similar, but the DIVIMP predictions for total W content are around 50% higher for low and intermediate density cases compared to EDGE2D-EIRENE. The bundling effect of W ionization stages in EDGE2D-EIRENE [3] results in up to 33% lower average tungsten charge in the main chamber outer scrape-off layer (ranging from 2.4 to 7.2 in EDGE2D-EIRENE, 3.1 to 9.9 in DIVIMP), which in turn leads to weaker W trapping and thus lower W density in the upstream. The highest upstream W density was $3.5 \cdot 10^{14}$ m^{-3} in EDGE2D-EIRENE and $8.1 \cdot 10^{14}$ m^{-3} in DIVIMP. At the target boundaries W density in EDGE2D-EIRENE reaches values up to one order of magnitude higher than in DIVIMP due to the prescribed boundary condition for parallel W velocity. Additionally, the impurity pressure gradient force in EDGE2D-EIRENE was found to scale with the impurity temperature, while its DIVIMP equivalent, parallel diffusion, applies a different model based on the background ion temperature, density and impurity charge, yielding slightly more localized peaks in tungsten density near ionization sources.

[1] M. Groth et al., Nucl. Fusion **53** (2013) 093016.
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[3] J.D. Strachan et al., J. Nucl. Mater. **415** (2011) S501-S504

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