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nHESEL predictions of density shoulder formation in JET-ILW H-, D-, T-isotope L-mode plasmas

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nHESEL simulations of L-mode JET ITER-like wall (JET-ILW) plasma edge and scrape-off layer (SOL) regions in protium, deuterium and tritium scenarios predict that the power flux across the separatrix scales inversely with the mass number *A* when the edge profiles are kept fixed across isotope species. This is consistent with experimental observations [1] and a desired feature for operations on future D-T devices such as ITER. Simulations with a higher *A* also show an increase in the density and power fall-off length in the outer midplane SOL, potentially resulting in an undesired increase of main-chamber plasma-wall interactions. The characteristics of the density shoulder are shown to depend on the divertor detachment scheme, interactions with neutral particles, and other plasma parameters such as electron density.

nHESEL is a drift-reduced two-fluid code that simulates the electron and ion densities and pressures, and the generalized vorticity, in a two-dimensional cross-field domain at the outer midplane of JET [2,3]. The effects of downstream conditions are included in the parameterized parallel loss terms. The plasma fields are self-consistently interacting with dynamic hydrogen isotope neutrals modelled as a multi-component fluid consisting of molecules, and Franck-Condon and charge-exchanged atoms.
It is demonstrated that the upstream simulations can estimate the power deposition profiles downstream, i.e., at the divertor targets for the different hydrogen isotopes. The heat flux to the divertor targets is another constraint that sets the required degree of detachment in ITER and future fusion power plants. The power fluxes predicted by the numerical simulations are consistent with those measured in JET and to those simulated with EDGE2D-EIRENE, [4]. The consistency gives confidence in the application of the model as a synthetic diagnostic, not only for local measurements at the outer midplane but also for downstream features such as target heat load profiles.

The increase in power flux across the separatrix with lower *A* is well understood from its explicit dependence in the instability-driving part of the generalized vorticity equation. The midplane SOL profiles are determined by the balance between cross-field and parallel transport, and by the volume sources from local interactions with neutrals. The larger fall-off length for larger *A* is mainly attributed to the lower parallel speed of the heavier isotopes.

References

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