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Multiscale modelling of sheath physics in edge transport codes

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Power exhaust constitutes one of the primary challenges for future fusion devices. Given the fact that scaling parameters have not been clearly identified, the prediction for divertor plasma conditions relies mainly on simulation with transport edge codes like Soledge2D-Eirene that is used in the present work. For charged species, treated with a fluid model, the simulation domain does not extend all the way to the wall, because of the existence of the sheath. Even though it is very thin compared to the extension of the Scrape-Off Layer (SOL), it plays an important role for the plasma wall interactions and SOL physics. By accelerating the ions towards the wall, it acts both on the energy and the angle of the impinging species, which affect the sputtering yield and reflection coefficients. The latter has a direct effect on the plasma parameters close to the surface. Additionally sheath physics has an important role in the prompt redeposition of eroded W ions, reducing considerably the erosion of plasma facing components and plasma contamination.

The work presented here is based on a multiscale approach where the sheath physics is simulated using a 1D PIC code. The latter provides in particular the distribution of incidence angle, twisting angle and energy at impact as a function of the plasma parameters in the vicinity of surface. This model, which is now fully implemented, exhibits incidence angles shallower than expected from simple models. A markedly higher temperature in the divertor is obtained for a flat surface and is due to reflection coefficients that increase with decreasing incidence angles. Additional effects are investigated like the surface roughness and the sensitivity of the model to the reflection database obtained by TRIM close to the physical sputtering threshold where is it known to be unreliable. In a first approximation, roughness is implemented as a Probability Density Function (PDF) and tends to bring the divertor temperature down by increasing the incidence angle. A parametric study of the role of reflection coefficients in high recycling conditions, where most of edge transport code results rely on an assumed binding energy of 1 eV, is also conducted. This work shows the importance of a comprehensive sheath model and reliable reflection data on the way to predictive plasma edge modelling tools.

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