Sensitivity of scrape-off layer codes to modelling approaches

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The study of plasma exhaust remains a core focus of current efforts towards viable DEMO-class magnetically confined fusion devices. The scrape-off layer (SOL) features complex physics, making modelling assumptions inherently necessary. The impact of these choices on the results can be significant and can be difficult to interpret when using complex 2D and 3D codes.

1D SOL models offer a powerful platform to investigate fundamental model aspects thanks to their high interpretability and low computational cost. In this work, we compare two codes: SD1D [1], a highly flexible 1D fluid code part of BOUT++, and SOL-KiT [3], a 1D kinetic electron and fluid ion code featuring a collisional-radiative model and a self-consistent fluid electron mode. We consider two conditions in different levels of detachment corresponding to fully-fluid SOL-KiT simulations and study the discrepancies that arise when SD1D is used to reproduce the same conditions.

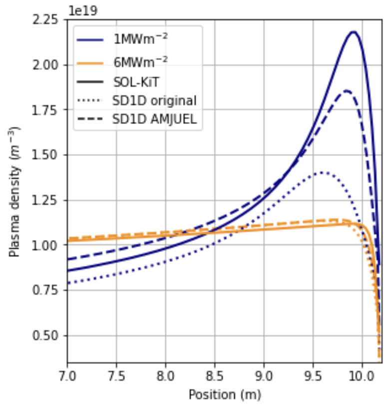

Figure 1: *Improvement in neutral density profile after AMJUEL rate implementation*

We investigate the root causes of each discrepancy and the corresponding modelling choices as we sequentially modify SD1D to gauge their impact. We find a difference in ionisation and recombination rates and improve the match by implementing rates from the AMJUEL database [2] (see Fig. 1). We also investigate the impact of the chosen charge exchange cross-sections and their implementation, the assumptions governing neutral diffusion, as well as the choices concerning the boundary conditions and other model parameters. We produce a version of SD1D which matches SOL-KiT well, enabling further comparative studies to leverage SOL-KiT's kinetic electron model and SD1D's flexibility as part of the BOUT++ framework.

References

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