Predictive integrated modelling of tungsten transport in AUG and WEST

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Tungsten is foreseen as plasma facing material in next generation tokamaks due to good properties such as sustainment of high heat and particle fluxes from the core, low erosion rates and limitation of the fuel retention. However, due to its high charge number, it is not fully ionised in the core and radiates, which can limit the plasma performances and even cause disruptions. It is thus crucial to predict and prevent such scenarios for reactor relevant conditions.

First principles simulations based on turbulent and neoclassical transport have been found to accurately reproduce W accumulation levels (e.g. [1]) when sufficient complexity is kept, i.e. poloidal assymetries enhancing neoclassical convection. Expanding on such well understood theoretical background of W transport and on the increasing maturity of integrated modelling (e.g. [2]), studies including the W concentration evolution have been flourishing whether it focuses on the accumulation problem [3] or on the impact of core MHD [4]. In the continuity of such works and with real time capable simulations of the W content in mind, a database of ASDEX Upgrade [5,6] and WEST plasmas are studied using the transport code ASTRA coupled to QuaLiKiz for the turbulent transport and NEO/NCLASS for neoclassical transport. A strong emphasis is given to accurate predictions of the W accumulation level, which requires in turn good predictions of the background profiles of electron density, ion and electron temperatures, toroidal rotation velocity (affects poloidal asymmetries) and in particular their corresponding gradients. Finally, investigations of the effect of sawteeth and neoclassical tearing modes on W are performed using reduced models.

This work serves as a preliminary step in view of real time capable and accurate simulations (via the use of Neural Networks for turbulent and neoclassical transport) regarding W density control for scenarios development and optimisation.

References

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