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Simulation of neoclassical heavy impurity transport in AUG with applied 3D magnetic fields with the nonlinear MHD code JOREK

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An accumulation of heavy impurities in the tokamak core is detrimental for its performance and can lead to disruption of the plasma. In smaller to medium size tokamaks the effective neoclassical transport in the pedestal is radially inwards [3]. In larger tokamaks—e.g. ITER— where the temperature gradient is higher, the neoclassical transport is predicted to be outwards. The models are derived for axisymmetric quasi-steady-state plasmas. Applied 3D magnetic fields—i.e. Resonant Magnetic Perturbation (RMPs)— can be used to suppress Edge Localized Modes (ELMs). Experimentally it has been observed in AUG, the use of RMPs enhances the outflow of heavy impurities in the pedestal. There is no model which can predict neoclassical heavy impurity transport in these ergodized 3D magnetic fields self-consistently.

In this contribution we present our tungsten transport simulation for an ASDEX Upgrade plasma with applied RMPs. Our model utilizes a full-orbit pusher, ionization, recombination, effective line and continuum radiation and neoclassical collisions with the background plasma. The effective collisional radiative rates are from the OpenADAS database, the neoclassical collision operator uses the framework of Homma [4].
We have compared the average radial transport between axisymmetric and 3D RMP scenarios in the pedestal region. RMPs clearly cause enhanced transport. However, it is not just enhanced axisymmetric diffusion, but perpendicular transport has a equivalently strong component in the n=2 toroidal harmonic. Additionally to the enhanced transport we found that part of the W gets trapped in 3D potential wells in the Scrape-off layer as shown in Fig.1. With the newly developed neutral model [5], we can combine the interaction in the divertor with the 3D RMPs to model the tungsten transport from the divertor towards the core of the plasma.

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