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P4.1036 Impurity transport and its modification by MHD in tokamak plasmas with application to Tungsten in the WEST tokamak

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The concern about impurity migration in tokamak plasmas arises because of its considerable impact on core radiation, leading to performance degradation and potentially to confinement loss. Highly charged particles are particularly deleterious as not only their radiative emission is large but also their radial flux, since it is to first approximation proportional to their charge. This flux has a strong collisional contribution described by neoclassical theory [1], as well as a turbulent contribution. We address here the issue of the 'natural' impurity transport and poloidal distribution, i.e. without toroidal momentum source nor ion temperature anisotropy, by comparing analytical theory with numerical simulations with the XTOR code [2] where neoclassical physics [3] and impurity evolution [4] are implemented. The asymmetry pattern can be determined analytically and depends on both the equilibrium gradients and the collisional friction between the impurity and the main ion species. The neoclassical impurity flux and poloidal asymmetry are investigated in non linear simulations for a light impurity (162C) and a heavy one (17844W). We find that the radial impurity flux is strongly damped by the poloidal asymmetry, the drive being inward or outward, with a good agreement between theory and simulations. The application to a typical WEST plasma shows for example that the inward Tungsten flux (for a flat impurity profile) is reduced by more than a factor two at mid-radius compared with predictions without poloidal asymmetry, although their level remains below 5%.
The modification of impurity transport by a magnetic island is expected to be large, and some experimental observations confirm this, because the temperature screening effect that is driving outward flux is largely lost [5]. Numerical simulations for a (2, 1) island in WEST confirm this mechanism, with an inward flux that is increased, in qualitative agreement with the theoretical result where temperature screening is becoming less effective.
References [1] C. Angioni et al., Plasma Physics and Controlled Fusion 56, 124001 (2014). [2] H. Lütjens et al., Journal of Computational Physics 229, 8130 (2010). [3] P. Maget et al., Nuclear Fusion 56, 086004 (2016). [4] J.-H. Ahn et al., Plasma Physics and Controlled Fusion 58, 125009 (2016). [5] T. Hender et al., Nuclear Fusion 56, 066002 (2016).

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