Investigation of the pump-out effect by resonant magnetic perturbations in ASDEX Upgrade

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Resonant magnetic perturbations (RMPs) are considered as an efficient method to mitigate (in the sense of reduced stored energy losses) or suppress the Edge Localized Mode (ELM) instability in tokamaks. However, a clear reduction of plasma density ('pump-out') is often observed when RMPs are applied, which leads to deterioration of the H-mode edge pedestal pressure and therefore reduced confinement.

Recent experiments in ASDEX Upgrade aimed to characterize the pump-out effect and its parameter dependencies. When magnetic perturbations penetrate to resonant surfaces, magnetic field lines and equipotential field lines get perturbed locally. This in turn can lead to enhanced radial transport by changes in the ExB drift velocity [1]. In scans of the safety factor, no singular behavior such as an increase of the RMP induced particle transport was found if rational surfaces resonant with the magnetic perturbation were moved through the zero crossings of the electron perpendicular velocity and radial electric field at the pedestal top. If cross-field flows vanish at rational surfaces, no shielding currents for the MP are induced, and therefore a resistive plasma response can develop.

In ELM suppressed H-modes, however, enhanced fluctuations in the edge transport barrier region are observed with conventional reflectometers. Experiments with rigid rotations of the RMP field reveal their toroidally asymmetric amplitude, indicating that the enhanced fluctuation levels are an effect of the 3D perturbation field. Discharges with a modulation of the RMP field strength were performed in order to identify the plasma layer in which particle transport is modified by the RMPs. The phase profiles of the plasma density response to the modulation suggest that particle transport is modified in the H-mode edge transport barrier region. The implications of these observations for models of the pump-out effect will be discussed.

[1] Heyn et al, Nucl. Fusion **54** (2014) 064005