EMC3-Eirene simulations of the impact of Magnetic Perturbations on the neutral particle recycling in ASDEX Upgrade

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Magnetic Perturbations (MPs) are applied at ASDEX Upgrade (AUG) [1] and many other divertor Tokamaks in the world to mitigate Edge Localized Modes (ELMs), i.e. quasi-periodic expulsions of particles and energy that harm the surrounding plasma facing components. The non-axisymmetric MP fields strongly modify the magnetic structure of the plasma edge and lead to the formation of so-called lobes. While we reported recently on simulations with the Edge Monte Carlo 3D-Eirene (EMC3-Eirene) code package focussing on the plasma transport and the power deposition pattern at the target observed as a splitting of the strike line [2], here we focus on the impact of the MP fields on the neutral particle recycling. Neutral particles, although not affected directly by the MP fields can penetrate much deeper into the plasma in regions, where the electron temperature (and/or the density) is locally decreased due to the modified magnetic geometry of the plasma edge, i.e. at the target in between the lobes, as well as at several discrete positions around the separatrix. In this contribution we will discuss the hypothesis, whether the MPs globally enhance the fuelling efficiency in AUG compensating the enhanced outward transport from the plasma induced by the MPs. Since the cross-section for ionization depends very sensitively on the electron temperature in particular below 10 eV either the enhanced outward transport or the enhanced fuelling can dominate so that both a net increase and a decrease of the density in the confinement region are possible. Both situations, the ‘density pump-out’ and the ‘density pump-in’ were in fact observed at AUG [4]. In order to explain the findings in [4] we compared the neutral particle density in the confinement region in the simulation with and without MP fields at different levels of heating power (i.e. different $T_e$ distributions in the divertor).

Another experimental observation at AUG is a very high electron density at the high-field side about half way between the target and the mid-plane [3]. Although the origin of the density blob is not entirely understood we will include an additional (non self consistent) particle source in our simulations to investigate its impact on the discharge with and without MPs.

It is well known that high gas puff rates provoke a transition from large type-I ELMs to smaller type-III ELMs in AUG [5]. We will discuss the hypothesis of whether the MP fields facilitate the access to this regime even at lower puff rates.

References: