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Non-linear modeling of the Edge Localized Mode control by Resonant Magnetic Perturbations in ASDEX Upgrade

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One of the foreseen methods to control the Edge Localized Modes (ELMs) in ITER is the application of Resonant Magnetic Perturbations (RMPs), proved capable to mitigate or suppress ELMs in existing tokamaks. However the significant uncertainties that remain regarding the way plasma flows and ELMs interact with RMPs must be overcome to give reliable predictions for ITER. This work aims at assessing the impact of the different plasma responses (including resonant and kink components) on the ELM mitigation, in order to move towards more quantitative understanding of current experiments and better predictive capabilities for future experiments.

Non-linear resistive MHD simulations were performed with the JOREK code, using input equilibrium profiles and n=2 RMP spectrum closely matching the experimental data of ASDEX Upgrade shots at low collisionality.

In a first step, the interaction between n=2 RMPs and plasma flows is considered without ELMs. In experiments, a given RMP coil configuration was identified to lead to a stronger ELM mitigation: this is found to be correlated with the largest excitation of the kink response in the vicinity of the X-point observed in our modeling with JOREK (in good agreement with other modeling performed with MARS-F and VMEC). On the resonant surfaces q=m/n located at the edge, the coupling between this excited kink component (poloidal mode m+2) and the resonant component m induces the amplification of the resonant component, resulting in an enhanced ergodicity at the edge. The ergodicity and the large displacement of temperature and density near the X-point therefore generate an increased radial transport.

In a second step, RMP effects on ELMs are considered in multi-harmonic n simulations. First results on the ELM mitigation induced by non-linear coupling of unstable modes with n=2 RMPs depending on the plasma response are presented and compared to experiments.

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