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Experimental assessment of Toroidal Alfvén Eigenmode control using externally applied resonant magnetic perturbations in the ASDEX Upgrade tokamak

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In magnetically confined fusion devices, super-thermal particles must be well confined until they slow down to the plasma bulk. Fusion born alpha particles as well as energetic particles produced by external heating systems such as neutral beam injectors (NBI) or ion cyclotron resonance heating (ICRH) are, however, a source of free energy that can destabilize a rich spectrum of Alfvén Eigenmodes (AEs) through resonant wave-particle interactions. A net wave-particle energy and momentum exchange is often accompanied by a particle radial transport that can affect the plasma fusion performance as well as threaten the vacuum vessel integrity. Toroidally induced Alfvén Eigenmodes (TAEs) are one of the most deleterious AEs in present tokamaks and are thought to pose some threats in next step fusion devices such as ITER. Several TAE control techniques are currently being developed in tokamaks and stellarators [1]. Among others, externally applied Resonant Magnetic Perturbations (RMPs) have shown their potential to mitigate or even suppress TAEs in present tokamaks [1, 2]. A robust theory that allows us to predict their capability to control TAEs in ITER still needs to be developed.

We present here the experimental assessment of the RMP capability to control TAEs via dedicated experiments in the ASDEX Upgrade (AUG) tokamak with different RMP toroidal and poloidal spectra, energetic particle distributions, equilibrium helicities and plasma collisionalities. RMPs with n=1, 2 and 4 are applied to low collisionality plasma discharges with a differential phase (ΔΦUL) scan between the upper and lower set of the AUG RMP coils and different energetic particle distributions. The energetic particle distribution is produced by NBI beams with variable energies and injection geometries and ICRF minority heating. RMPs with n=1 have the strongest impact on the energetic particle distribution and related AE activity. In agreement with the Edge Resonant Transport Layer (ERTL) theory [3], a narrow RMP ΔΦUL window has been observed to have a clear impact on the observed TAE activity. The ERTL properties for different scenarios will be presented together with the most recent experimental and modelling results. Based on these results, the capability to control the energetic particle distribution and related AE activity in ITER will be discussed.

[1] M. Garcia-Munoz et al., Plasma Physics and Control Fusion 61, 054007 (2018)
[2] A. Bortolon et al., Phys. Rev. Lett. Lett. 110, 265008 (2013)
[3] L. Sanchis-Sanchez et al., Plasma Physics and Control. Fusion 61, 014038 (2018)

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