Fast-Ion Edge Resonant Transport Layer Induced by Externally Applied 3D Fields in the ASDEX Upgrade Tokamak

L. Sanchis[1*], M. Garcia-Munoz[1], A. Snicker[2], J. Galdon-Quiroga[1], D. A. Ryan[3], M. Nocente[4], J. F. Rivero-Rodriguez[1], L. Chen[5], F. Zonca[5,6], W. Suttrop[7], E. Viezzer[1], M. A. Van Zeeland[8], D. Zarzoso[9], ASDEX Upgrade and EUROfusion MST1§ Teams

[1]Dept. of Atomic, Molecular and Nuclear Physics, Universidad de Sevilla, 41012, Spain; [2]Dept. of Applied Physics, Aalto University, FI- 00076, Aalto, Finland; [3]CCFE, Culham Science Centre, OX14 3DB, Abingdon, UK; [4]Universita degli Studi di Milano-Bicocca, Piazza della Scienza 3, 20126, Milano, Italy; [5]IFTS, Zhejiang University, 310027, Hangzhou, China; [6]ENEA C. R,. 65-00044, Frascati, Italy; [7]Max Planck Institut für Plasmaphysik, Boltzmannstrasse 2, 85748, Garching, Germany; [8]General Atomics, CA 92186-5608, San Diego, USA; [9]Laboratoire PIIM, Aix-Marseille Université, France

*Email: lsanchis@us.es

Externally applied 3D fields are routinely used in present tokamaks to mitigate or even suppress ELMs [1]. Symmetry breaking 3D fields can, however, cause significant fast-ion losses threatening the integrity of future large devices. The impact of externally applied 3D fields on the ELM stability depends strongly on the poloidal spectra of the applied perturbative fields [2]. Recent experiments in the ASDEX Upgrade tokamak have revealed the existence of an Edge Resonant Transport Layer (ERTL) responsible for the fast-ion losses observed in the presence of externally applied 3D fields. The amplitude and velocity-space distribution of the measured fast-ion losses depends on the 3D field poloidal spectrum, the magnetic background helicity (q_{95}) and the plasma collisionality.

Full orbit simulations carried out with the ASCOT code using the plasma response calculated with MARS-F reproduce a strong correlation of fast-ion losses with the 3D fields' poloidal spectra showing also that toroidal sideband harmonics can modify significantly the overall fast-ion losses. The plasma response can reduce or amplify the resonant fast-ion transport. Externally applied 3D fields induce a variation in the particle toroidal canonical momentum (δP_φ) that is maximized around the separatrix due to the overlapping of a large number of linear and nonlinear resonances between the perturbative fields and the particle orbital frequencies. Figure 1 shows the fast-ion $\langle \delta P_\varphi \rangle$ as a function of particle energy and initial position in the presence of an externally applied 3D field caused by the ELM mitigation coils in AUG with a differential phase between the upper and the lower set of coils of $\Delta\phi_{UL}$=40º. The fast-ion ERTL depends strongly on the particle pitch-angle, but not significantly on the particle energy suggesting that similar resonances may also exist for thermal ions and thus shedding some light on the physics underlying the thermal density pump-out commonly observed with externally applied 3D fields. The implications of the results presented here for the fast-ion confinement in ITER with externally applied 3D fields will be discussed.

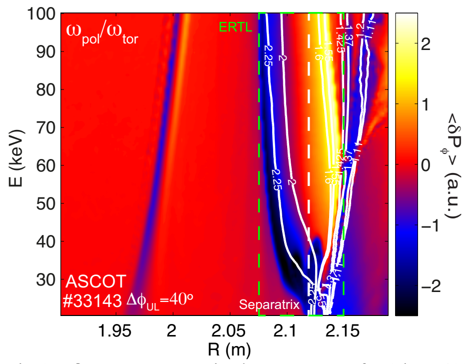

Fig 1. $\langle \delta P_\varphi \rangle$ structures in the presence of a $\Delta\phi_{UL}$=40º magnetic perturbation configuration overlapped with matching orbital resonances ($\omega_{pol}/\omega_{tor}$). Black-blue areas represent outwards transport while yellow-white means inwards transport.

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[2] R. Nazikian et al, Physical Review Letters, **114** 105002 (2015)
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