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Hybrid kinetic-MHD simulations of TAE active control using RMPs in the ASDEX Upgrade tokamak

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Experiments in the ASDEX Upgrade (AUG) tokamak have shown that externally applied 3D fields may be used to control Toroidally Induced Alfven Eigenmodes (TAE) in neutral beam heated discharges with elevated q-profile and low collisionality [1]. TAEs have been fully suppressed or excited in identical discharges with n=2 3D fields by varying their poloidal spectrum.
The non-linear hybrid kinetic-MHD MEGA code has been applied to model these discharges to identify the underlying mechanism in a fully 3D geometry, including realistic equilibrium, beam geometry and plasma response to externally applied 3D fields. MEGA simulations using the δf method reproduce some key aspects of the experiments such as the TAE frequency, the dominant n number and the dependency of mode structure on the radial fast-ion profile generated by the applied NBI configuration. The simulated TAE growth rate is observed to depend on the poloidal spectrum of the externally applied 3D fields following the experimentally observed trend. 3D continuum calculations, using the Alfvén gap stability code STELLGAP, are used to study the impact of externally applied 3D fields on TAE continuum damping and compare it against fast-ion drive. Calculations of the particle variation of toroidal canonical momentum δP_ϕ induced by the applied 3D fields as a function of the poloidal spectrum shows that 3D fields transport is resonant and edge-localized [2]. Non-linear resonances between fast-ions and applied 3D fields overlap with wave-particle resonances responsible for TAE drive, enabling TAE control by populating or depopulating these resonances. The possibility of optimizing this TAE control method by using different toroidal periodicity on the externally applied 3D fields is discussed. The conclusions of these experiments and their implications towards ITER are examined.

[1] M Garcia-Munoz *et al*, Plasma Phys. Control. Fusion **61** 054007 (2019).
[2] L. Sanchis *et al*, Plasma Phys. Control. Fusion **61** 014038 (2019).

Country or International Organization

Spain

Primary author: GONZALEZ-MARTIN, Javier (University of Seville)

Co-authors: GARCIA-MUNOZ, Manuel (Max Planck Institute for Plasma Physics); TODO, Yasushi (National Institute for Fusion Science); SHARAPOV, Sergei (Culham Centre for Fusion Energy); SPONG, Donald (Oak Ridge National Laboratory); DUNNE, Mike (IPP-Garching); GALDON-QUIROGA, Joaquin (University of Seville); Mrs SANCHIS-SANCHEZ, Lucia (University of Seville); SALEWSKI, Mirko (Technical University of Denmark); Dr STRUMBERGER, Erika (max planck institute for plasma physics); SUTTROP, Wolfgang (Max-Planck-Institut für Plasmaphysik); WANG, Xin (Max Planck Institute for Plasma Physics); WILLENSDORFER, Matthias (IPP Garching)

Presenter: GONZALEZ-MARTIN, Javier (University of Seville)

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