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# Experiments on Control of TAEs in ASDEX Upgrade and TCV plasmas with ECRH / ECCD

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In present-day magnetic fusion experiments, energetic particles produced by neutral beam injection (NBI) and/or ion cyclotron resonance heating (ICRH) often excite Alfvén Eigenmodes (AEs) [1]. The wave-particle momentum and energy exchange and accompanied non-classical transport of energetic particles can cause degradation in the plasma performance and particle loss threatening the plasma facing components. In view of the next step burning plasma experiments in ITER, possible control techniques are being developed for AEs driven by the fusion-born super-Alfvénic alpha-particles [2-4].
On ASDEX-Upgrade (AUG) tokamak, the very flexible and powerful electron cyclotron resonance heating (ECRH) system that was previously shown to facilitate Toroidal AE (TAE) excitation by ICRH ions [3], was used as electron cyclotron current drive (ECCD) for affecting magnetic shear at the position of TAEs. It was found that counter-ECCD applied just inside TAE decreases the magnetic shear strongly enough for the pressure suppression of TAE. This effect makes TAEs cease to exist in plasmas with plasma pressure high enough for the second ballooning stability zone. Further AUG experiments with four (out of six) gyrotrons delivering ECCD with mirror-controlled power deposition moving across the TAE structure have shown remarkable changes in TAE spectrum. In particular, depending on the ECCD power deposition along the vertical Z axis, TAEs of certain type disappeared, and TAEs of more core-localised type appeared, and time intervals free of TAEs
were also seen. The mirror-controlled ECCD was then incorporated into the TRANSP code so modelling of the time-dependent evolution of magnetic shear and other plasma profiles and fast ions became possible. The pressure effect and TAE damping effects are investigated in these AUG discharges, and extrapolation to ITER baseline scenario with ECCD is given.
On the TCV tokamak, a recently installed 1 MW 25 keV NBI combined with the existing ECRH allowed to join the study of ECRH/ECCD on beam-driven instabilities [5]. Plasma scenarios for Energetic Geodesic Acoustic Modes and TAEs were obtained on TCV, in the presence of simultaneous off-axis NBI and off-axis ECRH. No beam-driven instabilities were observed without ECRH, and the beam velocity was just above one third of Alfven velocity. The talk presents the status of the data analysis and the strategy for continuation of the experiments in view of the planned installation of the second high energy (50-60 keV) NBI.
References:
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[4] M. Garcia-Munoz et al., PPCF 61 (2019) 054007;
[5] A.Karpushov et al., EPS Conference, Milan (2019).

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