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Impact of the 3D geometry from non-axisymmetric magnetic perturbations on the local edge stability in ASDEX Upgrade

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One method to mitigate or even suppress the repetitive impulsive energy loss due to edge localised modes (ELMs) is the application of externally applied non-axisymmetric magnetic perturbation (MP)-fields.

In high confinement mode (H-mode) plasma, these externally applied MP-fields excite marginally stable ideal kink modes at the edge, which amplify the MPs. These kink modes cause a helically symmetric displacement of the plasma boundary, which amounts to ≈ 1 cm in ASDEX Upgrade [1]. Their amplitude correlate with the mitigation as well as suppression of ELMs and the consequent reduction of the pedestal pressure (density pump-out). Toroidally localised diagnostics with high radial resolution in combination with toroidally rotating n=2 MP-fields are used to characterise the 3D boundary displacement. The amplitude, the toroidal phase and the dependence on applied poloidal mode spectrum of the displacements are in good agreement with 3D single fluid ideal magnetohydrodynamic (MHD) code predictions (MARS-F, VMEC). So far, we have no indication that resistive MHD modes (tearing modes) induced by mode penetration from the external MPs play a role.

The induced 3D MHD geometry does not only lead to significant displacements of the plasma boundary, but it also changes the local stability at the edge. We observe ideal MHD modes with ballooning structure only at certain field-lines (helical position) within the 3D geometry in the H-mode edge barrier region [2]. Infinite-n ballooning stability analysis using a 3D equilibrium from VMEC demonstrates that the local reduction of the magnetic shear causes strongest instability at exactly the same field lines. Perturbations of the local parallel current profile and the additional torsion due to the 3D geometric shape of the magnetic surface are responsible for the changes in local magnetic shear. Additionally, not only the ballooning modes, but also the dynamics of the ELM crashes are influenced by the 3D MHD geometry.

[1] M. Willensdorfer et al, Nucl. Fusion 57, 116047 (2017)

[2] M. Willensdorfer et al, Phys. Rev. Lett. 119, 085002 (2017)

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