Modification of the local edge stability by the plasma response to non-axisymmetric magnetic perturbations in ASDEX Upgrade

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The application of externally applied non-axisymmetric magnetic perturbation (MP)-fields is a promising method to mitigate or even suppress the repetitive impulsive energy loss due to edge localised modes (ELMs) which is expected to be intolerable in low-collisionality H-mode plasmas of future fusion devices.

The mitigation of ELMs and the consequent reduction of the pedestal pressure (density 'pump-out') are strongly related to the amplification of the externally applied MP-field by marginally stable ideal kink modes at the edge. The 3D boundary displacement from these kink modes is characterised by toroidally localised diagnostics with high radial resolution in combination with toroidally rotating n=2 MP-fields. The important role of these kink modes in the ELM mitigation is supported by the following findings [1]: 1. Same dependence of the measured displacement and ELM behaviour on the applied poloidal mode spectrum, 2. Agreement of the measured displacements with ideal 3D magnetohydrodynamic (MHD) code predictions (e.g. MARS-F, VMEC), 3. Calculated displacements from the vacuum field approximation clearly underestimate the experimental observations.

We also demonstrate experimentally that the induced 3D MHD geometry modifies the local stability at the edge. An additional ideal MHD mode with ballooning structure in-between ELMs is observed 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 realistic 3D equilibrium from VMEC shows that the dominant reason for the local ballooning destabilisation is the 3D distortion of the local magnetic shear. Our investigations suggest that the observed reduction of the edge pedestal pressure in H-mode due to the application of MPs results from a change of the edge stability boundary introduced by the 3D perturbation of the local magnetic shear. Additionally, not only the observed ballooning mode before the ELM, but also the dynamics of the following ELM crashes are influenced by the local lower stability.

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