The increase in L-H power threshold due to externally applied non-axisymmetric magnetic perturbations in ASDEX Upgrade

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To avoid damage from edge localized modes (ELMs) in H-mode plasmas, ITER will rely on the application of external non-axisymmetric magnetic perturbation (MP) fields to suppress ELMs reliable immediately after the transition to H-mode (L-H transition). Previous studies showed that MPs can increase the L-H power threshold (P_{LH}), which might challenge the H-mode access in ITER due to a heating power that is marginal above the predicted P_{LH} [1]. In ASDEX Upgrade, we examine the impact of the MP-coil configurations, like the alignment or the strength of the MP-field, on the P_{LH} to find possibilities to avoid an increase in the P_{LH} while securely suppressing ELMs.

Our comprehensive study shows that P_{LH} can double when the MP-field is aligned to maximise the plasma response at the edge calculated by the linear resistive MHD code MARS-F. Since this is the same condition needed to suppress ELMs by MPs, the alignment is not a possible parameter to suppress ELMs while avoiding an increase in P_{LH}. Nevertheless, we observe that the increase in P_{LH} requires a critical MP-field strength, which is above the one needed to sustain ELM suppression. This opens a window in the MP-field strength in which ELM suppression without the increase in P_{LH} is possible in ASDEX Upgrade.

Dedicated experiments in L-mode show that above the same critical MP-field strength the $E \times B$ velocity (v_{ExB}) profile at the edge flattens and reverses from the electron into the ion diamagnetic direction, which connects the changes in the v_{ExB} profile with the increase in P_{LH}. More heating power establishes the same shear in the v_{ExB} profile at the L-H transition as without MPs. The additional torque from the MPs elevates the v_{ExB} profile at the L-H transition into the ion diamagnetic direction compared to observations in axisymmetric plasmas. The elevated v_{ExB} profile is not explained by 3D neoclassical theory calculated by NEO2.

Since linear MHD calculations do not capture the dynamics of the reversal in the v_{ExB} profile and thus the increase in P_{LH}, we extend initial modelling with non-linear resistive 2-fluid MHD calculations using the TM1 code.

[1] Y. R. Martin *et al*, Journal of Physics: Conference Series, 123(1):012033, 2008.