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Experimental conditions for suppressing Edge Localised Modes by magnetic perturbations in ASDEX Upgrade

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Full suppression of Edge Localised Modes (ELMs) by magnetic perturbations (MP) in high-confinement mode (H-mode) plasmas has been obtained in ASDEX Upgrade (AUG) in a shape-match experiment with DIII-D [Nazikian, IAEA FEC 2016]. In contrast to previous scenarios where ELMs were mitigated by MP, full ELM suppression in AUG requires stronger shaping. This finding has been attributed to larger pedestal plasma pressure, which in turn leads to stronger amplification of the external MP by marginally stable, edge localised, kink-peeling modes.
Recent experiments in AUG aimed to identify critical parameters for accessing ELM suppression: Safety factor, plasma rotation, plasma edge density and collisionality. Edge safety factor scans in the range of $q_{95} = 3.6-4.2$ showed a window $q_{95} = 3.66 - 3.91$ for ELM suppression with $n = 2$ MP.

In the ELM suppression scenario used so far, there is a clear maximum edge density (3.5×10^{19} m^{-3}) for ELM suppression, which can also be expressed as a collisionality limit.
Our present data set is still too sparse to discriminate between these quantities. In H-modes with ELM mitigation or ELM suppression, the pedestal pressure is typically 32% below that of ELMy H-mode with MP switched off and still somewhat below that of phases with MP-mitigated ELMs.

The resonant, field-aligned MP components near the top of the H-mode edge gradient region are believed to be essential for ELM suppression [Wade, Nucl. Fus. 2015] and their strength in turn depends (in two-fluid MHD) on the absence or presence of electron flow across the magnetic field ($v_{\mathrm{e},\perp}$) which can induce helical currents that shield the MP. In our experiment we find that the toroidal rotation at the pedestal top, measured by charge exchange recombination spectroscopy on B^{5+} impurities, varies widely,
$v_{\mathrm{tor}} = 0 - 40\tilde{}$km/s. There is also significant variation of $v_{\mathrm{e},\perp}$, despite ELM suppression being maintained. This includes cases with zero-crossing in the
pedestal region (weak shielding) and cases where $v_{\mathrm{e},\perp}$ (in electron drift direction) in the entire pedestal region is sufficiently strong to shield the resonant plasma response everywhere.

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