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Studies of Magnetic Perturbations in High-Confinement Mode Plasmas in ASDEX Upgrade

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ASDEX Upgrade is equipped with two rows of in-vessel saddle coils for magnetic perturbations with toroidal mode numbers up to n=4. A reliable ELM mitigation regime has been found in which large type-I ELMs are suppressed, and replaced by a small form of ELMs with significantly reduced energy loss from the plasma and heat load to the divertor. This regime is accessible at high pedestal plasma density, typically n_{e,ped} > 65% n_GW, and high pedestal collisionality, nu*>1.2. The access conditions to this regime are studied in more detail in experiments with gas fueling ramps and coil current ramps.
The effect of magnetic perturbations on H-mode plasmas with low pedestal collisionality, $\nu^* < 0.5$, is studied in discharges without gas puff fueling. Accumulation of tungsten impurities, which can occur if eroded material from the fully tungsten-cladded wall penetrates into the plasma and is transported radially inward there, is avoided by strong central wave heating and large wall clearance.
With neutral beam injection in opposite direction to the plasma current (counter-injection), complete ELM suppression is obtained during brief periods, reminiscent of Quiescent H-mode (QH) plasmas. However, the Edge Harmonic Oscillation (EHO) characteristic for QH plasmas is not observed.
With co-injection, a systematic study has been undertaken to vary the conditions for penetration of the perturbation field into the plasma core: 1. Field-alignment of the magnetic perturbation (resonant or non-resonant perturbation), 2. Variation of plasma rotation and hence, perpendicular electron fluid flow velocity.For conditions with minimal field shielding, i.e. non-resonant field and vanishing perpendicular electron flow, significant rotation braking is caused by JXB torque from the m/n=1/1 sawtooth pre-cursor,
as demonstrated by a perturbation coil current modulation experiment. Under the same conditions, JXB torque from rotating neo-classical tearing modes is observed. In plasmas with small field shielding, a reduction of type-I ELM losses is often observed, along with a reduction of pedestal density (often dubbed “pump-out”). Further experimentation in near future aims to diagnose the field perturbation using rotating magnetic perturbations and to study parameter dependencies of perturbation effects in these scenarios.

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Author: Dr SUTTROP, Wolfgang (Max-Planck-Institut für Plasmaphysik)

Co-authors: Dr VIEZZER, Eleonora (Max-Planck-Institut für Plasmaphysik); Dr WOLFRUM, Elisabeth (Max--Planck-Institut für Plasmaphysik); Dr FUCHS, J. Christoph (Max-Planck-Institut für Plasmaphysik); Dr BARRERA

ORTE, Laura (Max-Planck-Institut für Plasmaphysik); Dr MCDERMOTT, Rachael (Max Planck Institut für Plasmaphysik); Dr FISCHER, Rainer (Max-Planck-Institut für Plasmaphysik); Dr FIETZ, Sina (Max-Planck-Institut für Plasmaphysik); Dr RATHGEBER, Sylvia (Max-Planck-Institut für Plasmaphysik)

Presenter: Dr SUTTROP, Wolfgang (Max-Planck-Institut für Plasmaphysik)

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