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NTM Excitation by Sawtooth Crashes and the Suppression of their Onset by Resonant Magnetic Perturbation

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Neoclassical tearing modes (NTMs) can degrade plasma confinement or even lead to disruptions in existing tokamak discharges. To understand their triggering mechanism by sawtooth crashes and the effect of error fields or externally applied resonant magnetic perturbations (RMPs) on their onset remain to be important for ITER or a fusion power plant. In this paper these two issues are studied numerically based on the two-fluid equations, using ASDEX Upgrade experimental parameters as input.

(a) **Triggering of NTMs by sawtooth crash**: Numerical calculations have been carried out to study the triggering of NTMs by sawtooth crashes. In toroidal geometry, the nonlinear harmonics of the m/n=1/1 mode, the 2/2 component, can have a large amplitude during the sawtooth crash and possibly drive a 3/2 seed island via toroidal mode coupling, where m (n) is the poloidal (toroidal) mode number. As expected, it is found that the onset of the 3/2 NTM is most effective for large sawtooth amplitudes, high plasma beta value and low relative frequency between these two modes. The 3/2 magnetic perturbations first have the feature of an ideal mode across the q=3/2 surface and show a tearing character only later in time. The latter is in very good agreement with experiments. The observed immediate increase of the 3/2 magnetic signal after a sawtooth thus represents an ideal magnetic perturbation rather than a magnetic island.

(b) **Effect of RMPs on NTMs**: In several tokamak experiments a stabilization of rotating magnetic islands by static RMPs of moderate amplitude have been observed. This is consistent with our numerical results showing that a magnetic island can be suppressed by a static RMP of the same helicity in a certain range of RMP amplitude, if the local perpendicular electron fluid velocity at the resonant surface is sufficiently large. Due to the electron diamagnetic drift, the mode stabilization effect by RMPs is much stronger in the two-fluid case than in the single fluid case. The mechanism only works for moderate RMP amplitudes. In case of a too large RMP amplitude, the island growth is supported by the RMPs, resulting in a large locked magnetic island.

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