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Effect of external magnetic perturbations on the EXTRAP T2R reversed-field pinch plasma

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The plasma braking due to resonant and non-resonant magnetic perturbations (MPs) is experimentally studied in the EXTRAP T2R [1] reversed-field pinch (RFP) and the results compared with theoretical models adapted to the RFP configuration.
The resonant MP produces the tearing mode (TM) braking and, eventually, when the MP amplitude is above the locking threshold, the TM locking. The unlocking is reached only reducing the resonant MP amplitude below the locking threshold. The hysteresis is experimentally studied and the physical mechanisms that leads to an unlocking amplitude lower than the locking amplitude is ascribed to the relaxation of the velocity reduction profile. The experimental results are consistent with a localized electromagnetic torque that acts on the rotating TM island with a braking that spreads to the surrounding plasma via the viscous torque, in agreement with theoretical model described in reference [2].
The non-resonant MP produces a braking torque that affects the entire core region and it is not localized to any specific position. This is in contrast to the braking produced by a resonant MP, where the torque is localized at the resonance. The experimental results show that the non-resonant MP torque is not simply related to the amplitude of the applied perturbation, but it is well correlated to the plasma displacement produced by the perturbation. This result is consistent with the prediction of a torque produced by neoclassical toroidal viscosity (NTV) effects. The NTV torque has been calculated by adapting the model described in reference [3] to EXTRAP T2R. The comparison between experimental braking torque and NTV torque shows a qualitative good agreement both concerning the shape of the torque radial profile and the torque dependence on the plasma displacement.
The work shows that in EXTRAP T2R the braking induced by resonant and non-resonant MPs is produced by different physical mechanisms. The resonant MP torque is consistent with a braking electromagnetic torque that acts on the rotating TM. The non-resonant MP torque is consistent with a braking NTV torque that acts on the flow in the entire core region.

[1] Brunsell P.R., et al. Plasma Phys. Control. Fusion 43, 1457 (2001).
[2] Fitzpatrick R. et al., Phys. Plasmas 8 4489 (2001).
[3] Sun Y et al., Nucl. Fusion 52 083007 (2012)

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