MHD limits in non-inductive tokamak plasmas: simulations and comparison to experiments on Tore Supra

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Non-inductive tokamak discharges with a flat or hollow current profile are prone to the triggering of large tearing modes when the minimum of the safety factor is just below a low order rational. This issue is of particular importance for discussing the optimal safety factor for MHD avoidance in Steady-State reactor plasmas.

Different non-linear regimes of such magnetic configurations are studied using the full MHD resistive MHD code XTOR [1]. This code takes into account finite thermal transport in the parallel and perpendicular directions, and covers the effect of the bootstrap current perturbation. Numerical simulations show that the non-linear stage of the Double-Tearing Mode (DTM) is governed by the full reconnection model, but a single tearing mode in a low magnetic shear configuration can have a similar impact on the confinement. The different regimes observed experimentally are recovered in the simulations: a small amplitude (2,1) DTM for close resonant surfaces as seen in Tore Supra [2], a sawtooth-like behaviour of the (2,1) Double-Tearing Mode as first seen in TFTR [3], or a large amplitude (2,1) tearing mode that severely degrades the energy confinement, as reported in Tore Supra [4], JET [5] or DIII-D [6]. Situations where qmin~1.5 with a stable n=1 mode, as seen in Tore Supra longest discharges, seem to put specific constraints on the MHD model that is used, since curvature stabilisation without transport terms as derived in [7] is the only mechanism that could explain linear stability.

Finally, the extrapolation to high beta will be discussed. The DTM is then replaced by the resistive infernal mode, but neoclassical effects become the main concern in the non-linear regime.

[1] H. Lütjens and J.-F. Luciani, submitted to Journal of Computational Physics (2008)
[2] P. Maget et al, Physics of Plasmas 14(5), 052509 (2007)
[3] Z. Chang, W. Park, E. D. Fredrickson et al., Phys. Rev. Lett. 77, 3553 (1996)
[4] M. Zabiégo et al, Plasma Phys. Controlled Fusion 43, 1625 (2001)
[5] J. Mailloux et al, 34rd European Physical Society Conference on Plasma Physics (P4.151), (2007)
[6] M.R. Wade et al Nucl. Fusion 43, 634 (2003)
[7] A. H. Glasser, J. M. Greene, and J. L. Johnson Physics of Fluids, 19(4), 567 (1976).