The Impact of Symmetry Breaking on Pedestal Stability of Tokamak Plasmas

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H-mode tokamak plasmas are typically characterised by quasi-periodic instabilities called edge localised modes (ELMs) driven by unstable peeling-ballooning modes [1]. For large scale fusion power plants, the predicted particle and heat fluxes are unacceptable, and an active ELM control method is required. One promising method relies on the application of external non-axisymmetric resonant magnetic fields (RMPs), where ELM mitigation or even complete suppression is observed. The symmetry breaking results in coupling of axisymmetric toroidal modes and significant modification of the plasma stability is observed above a critical value of the applied RMP field as well as poloidal localisation of the peeling-ballooning mode at locations where the 3D normal displacement of the equilibrium crosses zero $\xi_N \sim 0$. We present a new computational framework that aims to understand the effect of RMPs on both plasma equilibria and stability. The ELITE [2] code is extended to find the linearised plasma response. This linear plasma response is used with the peeling-ballooning eigenmodes of the axisymmetric system (also calculated by ELITE) to calculate the change in 3D stability. Previous work based on perturbation theory was performed to probe the effect of toroidal coupling [3]. In the limit where the external RMP field δB_N is small with respect to the axisymmetric field B_0, $\delta B_N/B_0 \sim 10^{-4}$, perturbation theory is shown to be an accurate approximation. Therefore, a certain axisymmetric toroidal mode n couples only to the $k=n\pm N$ mode, where N is the applied mode number of the RMP field. For a monotonically increasing growth rate spectrum, the lower sideband has a destabilising contribution while the higher sideband has a stabilising contribution. A new analysis is based on a variational approach to examine the impact of non-axisymmetry on the ideal MHD plasma stability via minimisation of the individual poloidal harmonics of the axisymmetric toroidal basis functions for the triplet $\{n-N,n,n+N\}$.

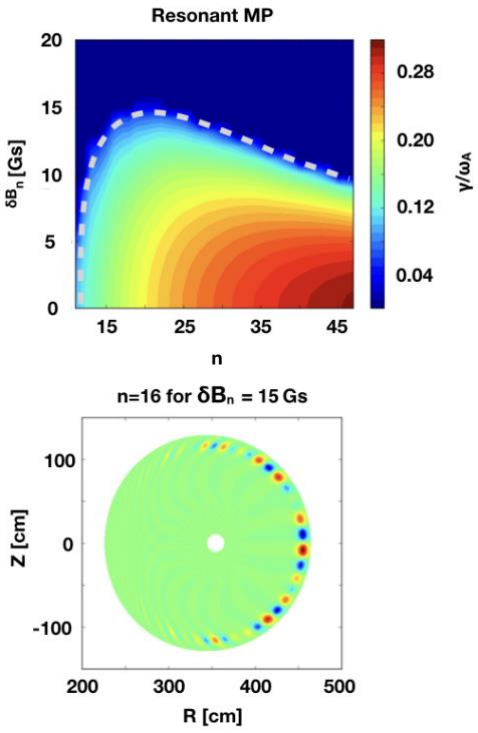

Figure 1. 3D Peeling-Ballooning stability for a resonant N=3 RMP field (top) and the mode structure of a 3D n=16 peeling-ballooning mode (bottom).

References

1) P.B. Snyder et al., *Physics of Plasmas* **9**, 2037 (2002)

2) H.R. Wilson et al., *Physics of Plasmas* **9**, 1277 (2002)

3) C.C. Hegna, *Physics of Plasmas* **21**, 072502 (2014)