Perturbative 3D Ideal MHD Stability of Tokamak Plasmas

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Control of edge localised modes (ELMs) is required for ITER to prevent damage to the divertor. One method of control is the application of non-axisymmetric resonant magnetic perturbations (RMPs). Experimentaly either ELM mitigation (increase of frequency) or complete suppression (removal) is seen. However, the physics mechanism responsible for the occurrence of those states is still an open question. In this work, the non-axisymmetric part of the equilibrium is postulated to have the key impact on MHD instabilities, potentially modifying stability boundaries. Linear perturbation theory is employed to study the 3D ideal MHD stability following the formalism of [C.C. Hegna, *Physics of Plasmas* **21**, 2014]. The symmetry breaking due to the non-axisymmetric equilibrium geometry induces toroidal mode coupling. A numerical framework for the calculation of coupling is developed, based on the ideal MHD stability code ELITE [H.R. Wilson et al., *Physics of Plasmas* **9**, 2002] that provides axisymmetric toroidal modes and fixed boundary non-axisymmetric equilibria. To validate result, the nonlinear MHD code BOUT++ [B.D. Dudson et al., *Computer Physics Communications* **180**, 2009] is employed to simulate mode coupling and qualitative agreement is observed. The external 3D field has a strong impact on stability above a certain threshold and decrease of MHD growth rates was observed due to stronger coupling with higher toroidal modes. Such a result could provide vital insight for understanding the exact mechanism responsible for ELM suppression and optimal RMP coil design.

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