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3D Perturbative Ideal MHD Stability in Tokamak Plasmas

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High confinement tokamak plasmas are characterised by a large edge current density and pressure gradient leading to destabilisation of edge localised modes (ELMs) [1] that are responsible for large heat loads on the divertor. In ITER, uncontrolled type-I ELMs are anticipated to produce power fluxes that are above melting point of tungsten [2] and active ELM control will be necessary for the safe operation of the reactor. One method for active ELM control uses non-axisymmetric resonant magnetic perturbations (RMPs) that result in mitigated [3] or even suppressed [4] ELM plasmas. The physics mechanisms responsible for the access of a suppressed or mitigated state still remains an unanswered question. RMPs create current layers at rational surfaces that potentially lead to formation of magnetic islands and relaxation of the profiles at the edge. However, island formation is suppressed if sufficiently strong flows or pressure gradient exists at the rational surfaces. In addition, the 3D nature of the external field has an impact on the plasma equilibrium and may change MHD stability boundaries directly affecting the onset of ELMs. In this work, the 3D ideal MHD stability is studied employing linear perturbation theory to examine the change in peeling-ballooning boundaries [5]. Preservation of nested flux surfaces is required for the validity of the perturbative approach, motivating our study of an ideal plasma response as a model for strong plasma shielding of the RMPs. The simulation of the non-axisymmetric part of the equilibrium for an applied external field is performed using a linear ideal stability code ELITE [6,7] and a non-linear ideal fluid model implemented with BOUT++ [8] for a circular large aspect ratio plasma. The ideal and incompressible plasma response produces large normal and divergent binormal plasma displacement localised around rational surfaces that create singular Pfirsch-Schluter currents. The axisymmetric toroidal modes are coupled due to geometrical effects and calculation requires information from the 3D part of the plasma equilibrium which we have calculated, see Fig.1. Future work will use this information to quantify the impact of RMPs to ideal MHD stability.

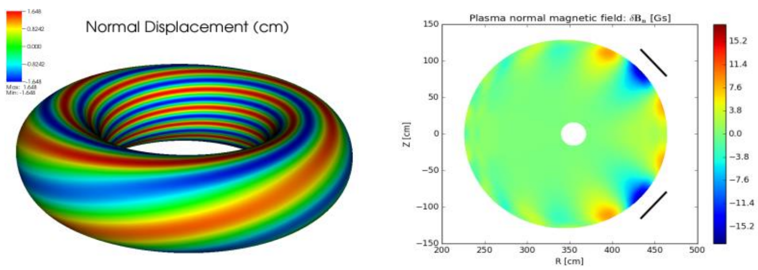

Figure 1: *Equilibrium plasma normal (A) displacement and (B) magnetic field for an even n=3 RMP magnetic field configuration evaluated using the modified ELITE code.*

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