Advanced MHD models of anisotropy, flow and chaotic fields

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Large scale neutral beam heating, the growing importance of either deliberate or spontaneous equilibrium 3D structure, and the increased diversity, accuracy and resolution of plasma diagnostics have driven more advanced force balance models as well as new approaches to equilibrium reconstruction, such as Bayesian inference techniques [1]. In this work we focus on the development of two MHD force balance models, discuss their constraint to laboratory data, and scope their potential to describe astrophysical phenomena.

EFIT TENSOR is an implementation of the axis-symmetric guiding centre plasma which supports pressure anisotropy and toroidal flow. Figure 1 shows an example application to MAST with significant anisotropy $p_\perp$ / $p_\parallel$ ~ 1.7. The parallel pressure surfaces (solid) are significantly displaced relative to poloidal flux (dashed). The presence of toroidal flow and anisotropy can result in significant changes on the *q* profile. [2]

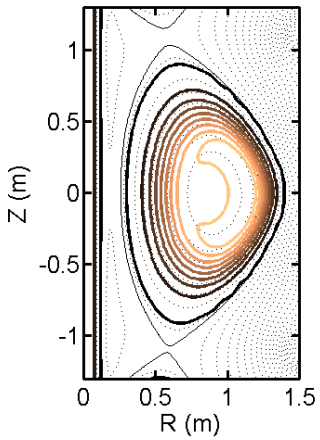

Fig. 1: EFIT TENSOR calculation of the poloidal cross section of MAST for discharge 18696 at 290ms.

We also report on the development and numerical implementation of multi-region relaxed MHD variational principle, which comprises different Taylor relaxed regions separated by singular currents at ideal MHD interfaces. This model [3], which supports stepped pressure profiles, enables the resolution of chaotic fields and magnetic islands which occur in toroidal asymmetric plasmas. Figure 2 shows an example of the application of the MRXMHD model to the quasi-single helicity state in RFX-mod. Both magnetic axes can be reproduced in addition to island structure and significant amounts of chaos.

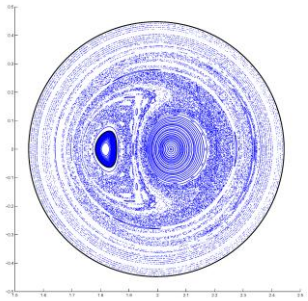

Fig. 2: Poincaré plot of the magnetic field of a quasi-single-helicity state of RFX-mod, computed by MRXMHD code SPEC.

Finally, we comment on wider research in theory and modelling at the ANU, including the interpretation of wave mode activity in MAST and KSTAR tokamaks, the H-1 heliac, and helicon wave fields in the plasma-surface materials device MAGPIE.

[1] G T von Nessi, M J Hole, J Svensson, L Appel, Phys. Plas. 19, 013106 (2012).

[2] M J Hole, G von Nessi, M Fitzgerald, K G McClements, J Svensson, Plas. Phys. Con. Fus. 53 074021, (2011).

[3] S R Hudson, R L Dewar, M J Hole and M McGann Plas. Phys. Con. Fus. 54, 014005, (2012).