§21. Simulations of Electron Bernstein Waves and Zonal Flow Damping in Helical Systems

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1) Simulation of EBW and EBCD in CHS

Recent work at the CHS experiment in NIFS has revealed an enhancement of the stored energy that is thought to be due to the absorption of Electron Bernstein Waves (EBW). The O-mode wave utilised in the shot studied (#129213) has its resonant region beyond the O-mode cutoff. Thus, in this case, the power deposition can only exist after mode-conversion into a EBW which is unaffected by cutoffs due to its electrostatic nature. In the present work, simulations of OXB mode-conversion and EBW absorption are performed for this experimental scenario with the ART code [1](see Fig.1). In addition, self-consistent MHD equilibria with Booststrap Current (BC) (calculated with the VMEC [2] and the TERPSICHORE [3] codes, respectively) are carried out in order to establish which fraction of the measured total current is due to the BC. A discrepancy between BC and total current may suggest the presence of EBW induced current (EBCD). EBCD is estimated with the JALON module [4] implemented within the ART ray-tracing code [5]. The final aim is the reproduction of the experimental results when both EBCD and BC are calculated self-consistently with the equilibrium.

This studies are to be bench-marked with calculations carried out with the TRUBA code [6] in CIEMAT (Madrid, Spain).

2) Gyrokinetic simulation of zonal-flow evolution in multiple-helicity helical fields

Experimental results in LHD have shown an improvement of the confinement when the magnetic axis of the configuration is shifted inwards and a deterioration when it is shifted outwards. Zonal Flows (ZF) are widely accepted to be a source of reduction of anomalous transport and, hence, of enhancement of the confinement when they are not fully damped in the long term. This fact has been theoretically studied in the past for tokamaks [7] and later extended to helical systems [8]. In addition, gyrokinetic simulations in helical systems with single-helicity magnetic fields have also been performed [8,9]. However, the modelling of the LHD shifted-axis configurations requires the inclusion of multiple-helicity terms in the magnetic field expansion. At present, linear gyrokinetic Vlasov simulations of ZF and Geodesic Acoustic Mode (GAM) damping in multiple-helicity configurations are in progress together with their comparison with the unstable modes behaviour. The results of these simulations will provide a starting point to non-linear calculations required to describe accurately the turbulent transport in these multiple-helicity scenarios. Finding a correspondence between certain multiple-helicity terms and the ZF damping will help to elucidate the optimal magnetic geometry for greater improvement of confinement.

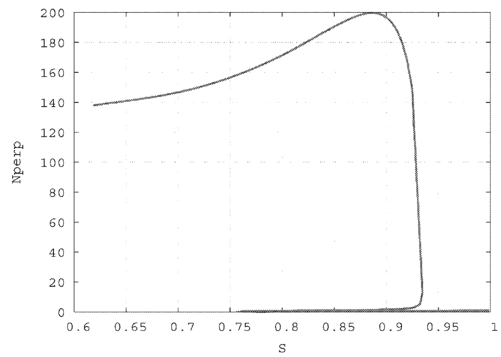

Fig.1. $N_\perp$ profile for CHS shot #129213. The characteristic OXB mode conversion behaviour can be seen, i.e., $N_\perp$ goes to 0 at the O-X conversion region (O-mode cutoff, $\omega = \omega_{pl}$) and becomes a vertical line in the Upper Hybrid Resonance Layer where the X-B mode conversion takes place. The power deposition occurs beyond the O-mode cutoff region.

References

1) S.P. Hirshman and Hogan, Jour. Comp. Phys. **63**, 329 (1986).
2) W.A. Cooper *et al*, Plas. Phys. Cont. Fusion **44**, B357 (2002).
3) F. Volpe, PhD Thesis Max-Planck Institute (2003).
4) F. Castejon and S. Eguilior, Plas. Phys. Cont. Fusion **45**, 159 (2003).
5) S.Ferrando i Margalet, PhD Thesis CRPP Lausanne (2005).
6) F. Castejon *et al*, Fus. Scie. Techn. **46**, 327 (2004).
7) M. N. Rosenbluth and F. L. Hinton, Phys. Rev. Lett. **80**, 724 (1998).
8) H. Sugama and T.-H. Watanabe, Phys. Rev. Lett. **94**, 115001 (2005).
9) H. Sugama and T.-H. Watanabe, Phys. Plasmas **13**, 012501 (2006).