Theoretical and Experimental study of the threshold for kinetic-MHD Beta Alfvén Eigenmode fast particle destabilization in Tore-Supra

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Supra-thermal particles can destabilize MHD modes in a tokamak plasma, which may degrade the confinement of fast particles. This issue is particularly critical in burning plasmas, planned for future tokamak devices such as ITER, where a good confinement of fast fusion-born alpha particles confinement is essential for the sustainment of the burn. Therefore, understanding the conditions for MHD modes driven by fast particle is of major importance.

In this study, our focus is the destabilization of Beta Alfvén Eigenmodes (BAEs), observed in DIII-D and TFTR [1] in the acoustic frequency range. These have been identified on Tore Supra on both the reflectometry and the ECE correlation diagnostics. In the absence of fast particles and neglecting Landau damping as a first approximation, we can derive the BAE dispersion relation and get a picture of its spatial structure, using a variational formalism and a gyrokinetic-MHD model for the plasma. As found by F. Zonca *et al.* [2] in the ballooning representation, the mode can be viewed as a combination a dominant (m, n) mode coupled to its sidebands due to kinetic compressibility effects. The main mode radial structure arises from the matching of an ideal MHD structure with an inertial layer, where kinetic effects play a major role. When fast particle excitation and damping processes are introduced, using a perturbative analysis, the BAE may be destabilized, and the modified dispersion relation provides the instability growth rate. In particular, our treatment shows the existence of a theoretical threshold for BAE excitation, corresponding to the balance of ion Landau damping and fast trapped ion excitation.

We currently investigate the relevance of this threshold with Tore-Supra experimental observations, using both theoretical and numerical results for the BAE structure and simulation results from the code PION [3] to access the fast ion distribution function. First results of this investigation will be presented.

References:

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