Alfvén eigenmode driven by alpha particles and NBI energetic particles

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Alfvén eigenmodes (AE) can be destabilized by populations of energetic particles (EP). We use a linearized gyrofluid model to investigate the properties of the instabilities driven by energetic particles in ITER and LHD. The model consists of the reduced MHD equations in a full 3D system, coupled with equations of density and parallel velocity moments for the energetic particles [1]. Landau damping and resonant destabilization effects are included using a closure relation [2].

In the case of ITER, we consider two energetic particle sources: neutral beam injection (NBI) and alpha particles. The results show that the AEs are mainly destabilized by alpha particle drive. In addition, modifying the NBI injection intensity, beam energy or energetic particle density profile only slightly changes the AE growth rate and frequency. The combined effect of alpha and NBI energetic particles leads to AEs with lower growth rates compared with AEs destabilized by NBI or alpha energetic particles individually, indicating that the instability Landau damps on the lower energy NBI population. The AEs destabilized are $n > 11$ toroidal AE (TAE) localized in the reverse shear region (n is the toroidal number) showing a larger toroidal coupling compared to low-n TAE ($n < 11$), that are stable.

In the case of LHD, the sources are two neutral beam injectors with different injection energies. For low density / magnetic field discharges, an $n = 1$ TAE is stabilized if one of the NBI lines is deposited off axis and the EP density profile is flatter compared to the other EP species, although lower growth rates are observed if the energy of one NBI line is smaller than the other. Including two fluid effects in the LHD case leads to the destabilization of Beta Acoustic AE (BAAE). Adding helical coupling effects in the LHD case leads to a stronger damping in multi-NBI simulations for the $n = 2, 8, 12$ helical family and weaker damping for the $n = 1, 9, 11$ helical family compared to simulations with only toroidal couplings.

References

[1] J. Varela, D.A. Spong and L. Garcia, *Nucl. Fusion* **57**, 046018 (2017)

[2] D.A. Spong, B.A. Carreras and C.L. Hedrick, *Phys. Plasmas B* **4**, 3316 (1992)