5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

Linear excitation of low frequency Alfven and acoustic modes without energetic particles in tokamak plasmas

I.Chavdarovski[1], F.Zonca[2,4] and L.Chen[3,4]
[1] Korea Institute of Fusion Energy
[2] C.R. ENEA Frascati
[3]Dept. of Physics and Astronomy, Univ. of California, Irvine
[4]Institute for Fusion Theory and Simulation, Zhejiang University
e-mail (speaker):chavdarovski@gmail.com

The linear effects of core plasma on the excitation of Alfvenic modes with frequencies below that of Beta-induced Alfven Eigenmodes (BAEs) are examined within the framework of the Generalized fishbone-like dispersion relation (GFLDR).[1] This equation depicts a unifying picture for various Alfvenic fluctuations, as well as energetic particle continuum modes. Kinetic treatment of the circulating[2] and trapped particles[3] bounce and precessional motion is applied to properly describe these low frequency fluctuations. The formalism of the GFLDR contains all the necessary ingredients to determine the dynamics of these modes, and explain experimental results. To identify the modes, aside from the frequency and damping rate, their polarization is also considered.

Beta-induced Alfven Acoustic Eigenmodes (BAAEs)[4] with mixed Alfvenic and acoustic polarization and frequency of the order of thermal ions periodic motion exist in this gap, but are shown to be heavily damped by the thermal ions and parallel electric field.[5,6] The energetic particles are not efficient in resonantly driving the BAAEs[7]. These modes are, however coupled to the Kinetic Ballooning Modes (KBMs)[1] via the ion diamagnetic frequency ω_{*Pi}, which significantly decreases their damping rate. For large values of the diamagnetic frequency and ion temperature gradient the BAAEs cross the stability threshold, opening the possibility for non-resonant excitation by energetic particles, or precessional resonant excitation by thermal ions (or electrons). These effects, however will significantly alter the polarization of both the BAAEs and KBMs.[6]

For small values of the diamagnetic frequency, the KBMs have a significantly lower damping rate and a frequency close to the diamagnetic frequency. This changes for higher $\eta_i = \omega_{*Ti}/\omega_{*ni}$ values, where the damping rate is growing with the ion temperature and ω_{*Pi}, due to the coupling of the KBM to the BAE[2] and BAAE.[6]

Non-resonant effects of the background (or hot) plasma can provide enough drive to destabilize Low Frequency Modes (LFMs), as reactive instability[8], where the mode frequency is not determined by particle resonances, but by the thermal plasma diamagnetic frequency. A number of experiments[8] have shown these LFMs appearing near the minimum of the safety factor q of a reversed shear scenario in a 'Christmas lights' pattern, due to the time evolution of q, which passes through several rational numbers. The LFMs are driven by high thermal electron temperature and they also resonantly interact with the precessional motion of the trapped thermal particles.

References

[1] S.T. Tsai and L.Chen, Phys. Fluids **B 5** (1993) 3284
[2] F. Zonca *et al*, Plasma Phys. Control. Fusion **38** (1996) 2011
[3] Chavdarovski, I., and Zonca, F., Plasma Phys. Control. Fusion **51**, (2009) 115001 (22pp)
[4] N.N. Gorelenkov *et al*, Phys. Lett. A **370** (2007) 70
[5] F. Zonca, *et al,* Journal of Physics: Conference Series **260** (2010) 012022
[6] I. Chavdarovski, *et al,* Plasma Phys **21**, (2014) 052506
[7] L. Chen, *et al,* Phys of Plasmas **24**, (2017) 072511
[8] W.W. Heidbrink, *et al,* Nucl. Fusion **61** (2021) 016029 (16pp)

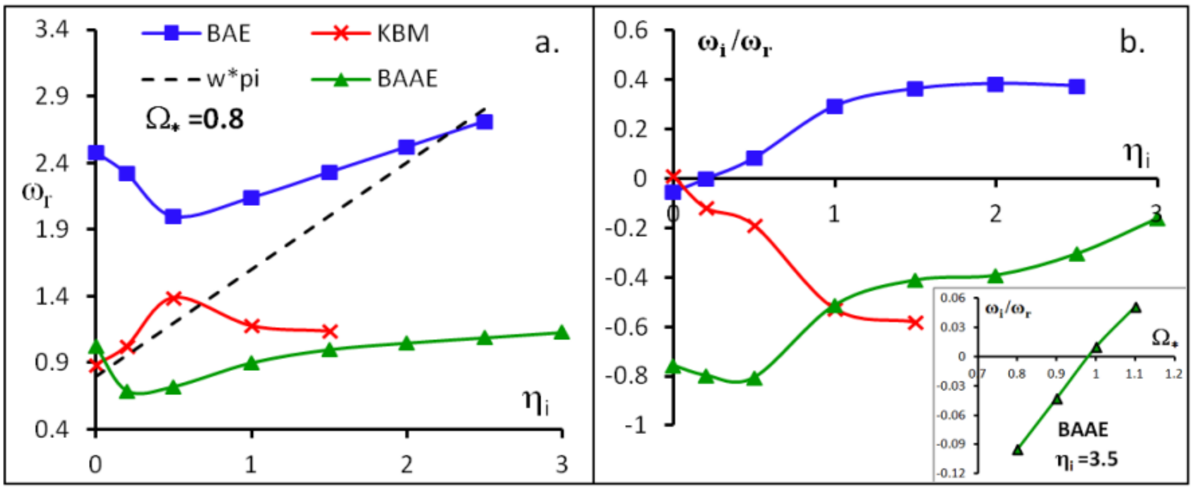

Figure 1 Coupling of the low frequency Alfven and acoustic modes through the diamagnetic frequency. a. Real frequency vs η_i; b. Normalized growth rate