2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

Energetic Geodesic Acoustic Mode as a two-stream instability and EGAM linear mode study in various regimes

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The energetic-particle-induced geodesic acoustic modes (EGAMs) [1,2] are n=0 coherent fluctuations in toroidal magnetic confined plasmas. An unstable branch of EGAM was found using fluid theory [3] with fast ions characterized by their narrow width in energy distribution and collective transit along field lines. This mode, with a frequency much lower than the thermal GAM frequency, is confirmed as a new type of unstable EGAM: a reactive instability similar to the two-stream instability. One found that the drive of EGAMs can change from reactive to the inverse Landau damping type (dissipative) as the energy width of the fast ions broadens (slows down), as shown in Figure 1. The mode frequency and growth rate is studied locally on a flux surface and globally with the inclusion of fast ion finite drift orbit effect (FOW) [4]. The growth rate of reactive EGAMs with counter-passing ions is found to exceed that with co-passing ions, consistent with finding in DIII-D that the former is more often observed.

For EGAMs in the parameter regime of experiments, the fast ion drift orbit is usually comparable to radial mode width. An investigation over EGAMs linear mode structure is carried out numerically with full fast ion drift orbit effects, in a variety of regimes (ICRH, beam injection, reactive or dissipative). One example of an ICRH fast ion driven EGAM is given in Figure 2. The properties of EGAMs across different regimes are also compared.

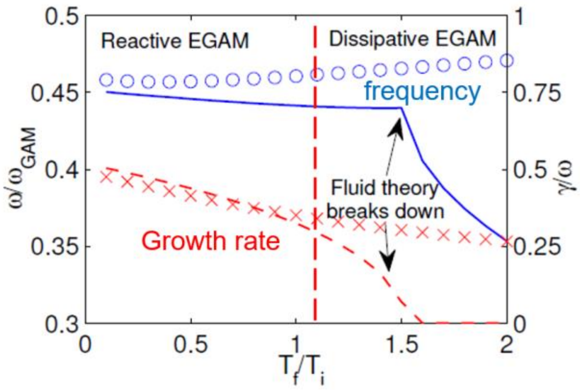

Figure 1. Real frequency in fluid (blue solid line) and kinetic (blue circle) theory, and growth rate in fluid (red broken line) and kinetic (red cross) theory versus fast particle energy width T_f. When the beam distribution changes from a single-energy beam to a gentle slope with a wide energy spread, the drive of the EGAMs changes from reactive to the inverse Landau damping type.

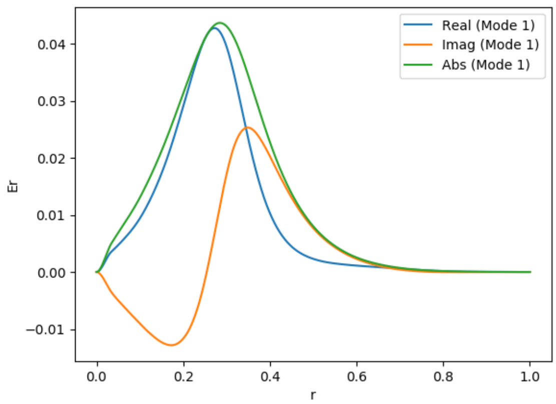

Figure 2. The radial mode structure (radial electric field) of an inverse-Landau-damping type EGAM driven by ICRH fast ions with JET like parameters, a bi-Maxwellian fast ion distribution function, $\omega \approx \omega_{GAM}$ at plasma core and γ/ω=4%.

References

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