

## Energetic Geodesic Acoustic Mode as a two-stream instability

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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 are studied locally on a flux surface and globally with the inclusion of fast ion finite drift orbit effect (FOW) [4]. Again using the fluid theory by adding higher order drift terms, we are able to derive a global dispersion relationship given the fast ion and bulk plasma profiles – a second order ODE. The radial mode structure is obtained such as Figure 2, with the mode width depending on fast ion parameters. The growth rate of global 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.

### References

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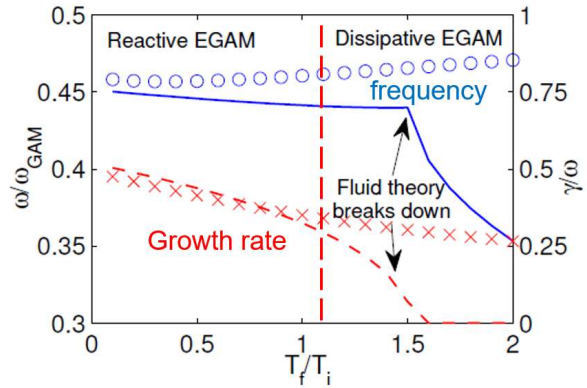


Figure 1. Real frequency in fluid (blue solid line) and kinetic (blue circle) theory, and growth rate in fluid (red broken line) and kinetic (red cross) theory versus fast particle energy width  $T_f$ . When the beam distribution changes from a single-energy beam to a gentle slope with a wide energy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

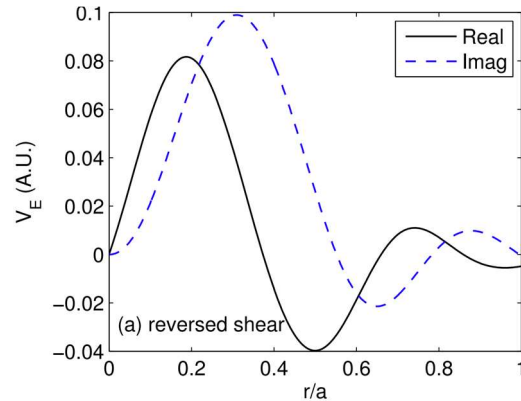


Figure 2. Reactive EGAM radial mode structure of a reversed sheared plasma.