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Impact of finite-orbit-width (FOW) effects on energetic particle-driven geodesic acoustic mode (EGAM)

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This study explores the impact of FOW effects on EGAMs [1]. A gyrokinetic dispersion relation for EGAM is derived under the assumption of a double shifted Maxwellian distribution (along the parallel velocity) for energetic particles. The dispersion relation is numerically solved and validated against gyrokinetic simulations performed with the NEMORB code [2]. The results show that the dispersion relation successfully reproduces simulation findings, confirming that FOW enhances EGAM damping. Notably, when the FOW becomes sufficiently large, a new unstable EGAM branch, termed δEGAM (δ: FOW of passing thermal ions), emerges with a frequency exceeding that of the standard GAM. This phenomenon is consistent with recent analytic EGAM results obtained using a slowing-down distribution for energetic particles [3]. Experimentally, LHD has reported EGAM activity with a frequency higher than the standard GAM, which may be linked to the δEGAM identified in this study [4]. Furthermore, the FOW-enhanced damping of conventional EGAM could play a crucial role in bulk ion heating via GAM channeling [5]. MEGA simulations suggested that this energy transfer occurred primarily through a higher-order transit resonance condition, rather than simple Landau resonance [6]. This theoretical study provides a comprehensive explanation for these experimental results and may have greater implications for future tokamaks utilizing strong NBI heating.

References

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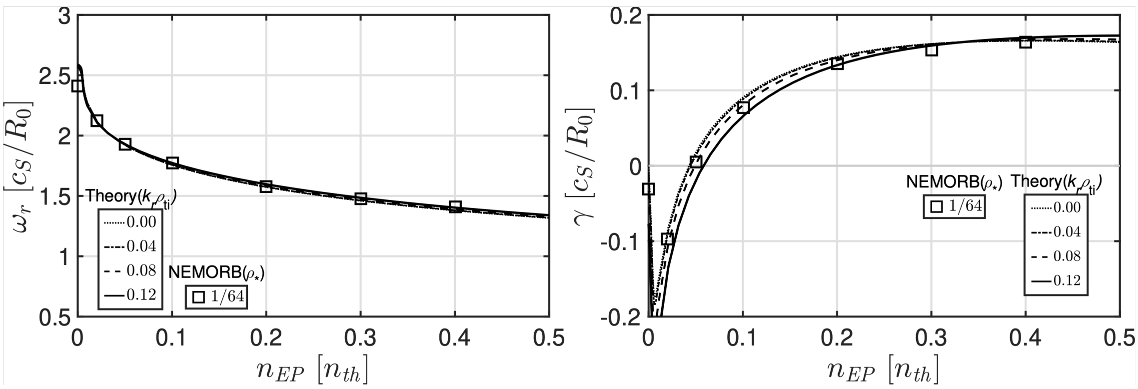

Figure 1. Comparison of the real frequency and growth/damping rates of EGAM between NEMORB simulation with adiabatic electrons and for $q = 2$ and $\bar{u}_{\parallel EP} = 2.8$.

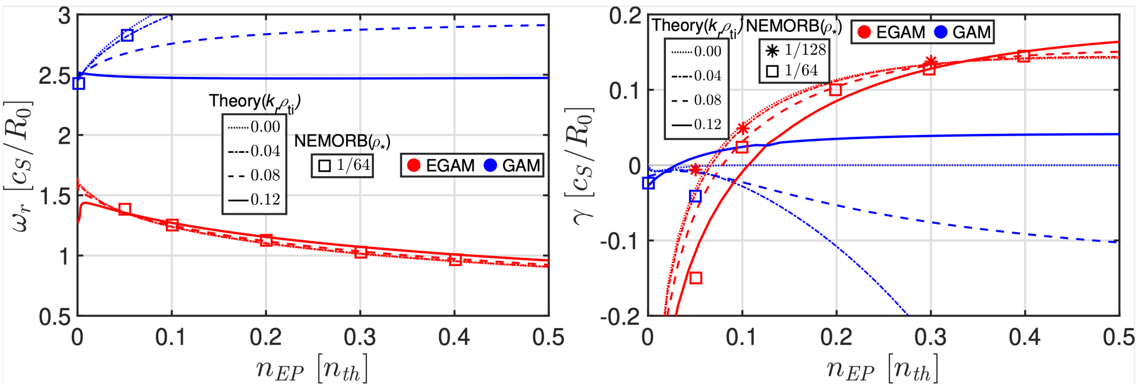

Figure 2. Comparison of the real frequency and growth/damping rates of EGAM between NEMORB simulation with adiabatic electrons and for $q = 3$ and $\bar{u}_{\parallel EP} = 2.8$.