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Gyro-kinetic investigation of the dynamics of geodesic acoustic modes

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Geodesic acoustic modes (GAMs) [1], are oscillating axisymmetric perturbations that are unique to configurations with closed magnetic field lines with a geodesic curvature, like tokamaks. They are the oscillating counterparts of the zero frequency zonal flow (ZFZF) [2] and are examples of zonal structures. GAMs are non-linearly generated by turbulence and are of great interest to magnetic fusion reactors due to their potential capabilities of regulating microscopic turbulence and its associated heat and particle transport.

A key aspect in the linear gyro-kinetic theory of GAMs is the determination of the mode frequency and damping rate. The main damping mechanism of GAM is collisionless damping. Analytical expressions for GAM frequency and damping rate can be found, for example, in Ref. [3]. This study was carried out assuming Maxwellian distributions of ions and electrons. H. Ren in Ref. [4], studied the impact of ion temperature anisotropy on GAM frequency and growth rate in the limit of a vanishing electron to ion temperature ratio. Ions in this study were described by a bi-Maxwellian distribution.

In this work, we investigate the linear dynamics of GAMs with a bi-Maxwellian distribution of ions and assuming adiabatic electrons as in Refs. [3],[5]. We generalize the work in Ref. [4], to a general value of electron to ion temperature ratio and by keeping account of a gyro-tropic ion temperature anisotropy. We show that in the appropriate limits, we recover the GAM dispersion derived in Refs. [4], [5] from the general GAM dispersion relation we derived. From our study, we find that the ion temperature anisotropy yields a sensible modification to both the real and imaginary part of the frequency, as both tend to be increasing functions of $\chi=\frac{T_{\perp i}}{T_{\|i}}$, (Parallel and perpendicular temperatures are defined with respect to the equilibrium magnetic field), and this result is strongly affected by the electron to ion temperature ratio, $\tau=\frac{T_e}{T_i}$, with $T_i=\frac{T_{\|i}+2T_{\perp i}}{3}$, (see figure).

References

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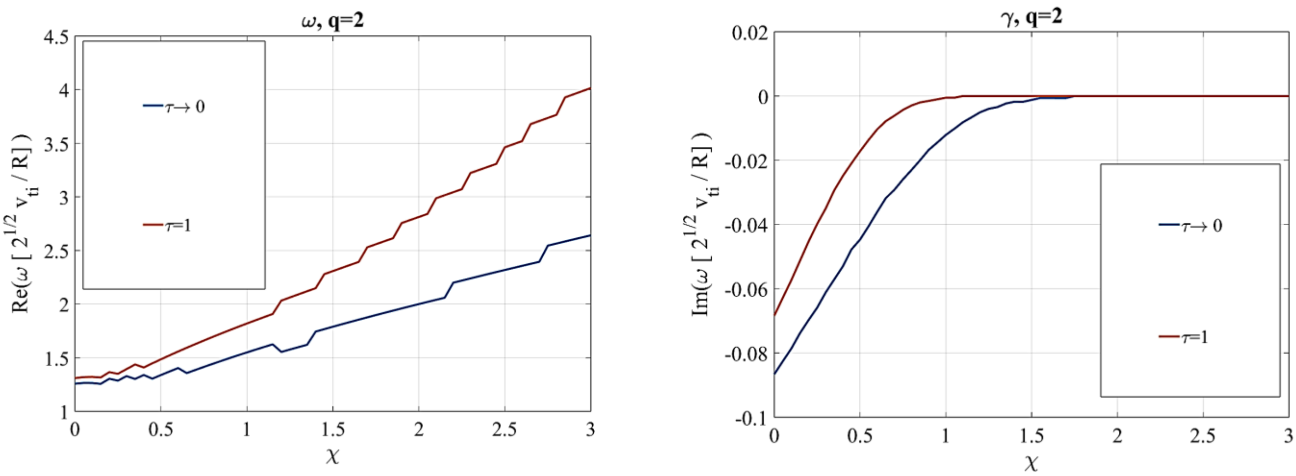

(a) (b)

Figure: Effects of ion temperature anisotropy, $\chi=\frac{T_\perp}{T_\|}$, on GAM dynamics for different values of electron to ion temperature ratio (τ)for a safety factor q=2. (a) GAM frequency, (b) GAM damping rate.