§17. Initial Value Problem of the Toroidal Ion Temperature Gradient Mode

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The ion temperature gradient mode (ITG mode) is considered as the most likely instability to cause the anomalous ion thermal transport observed in high ion temperature plasmas. We are concerned with the toroidal ITG mode which is driven by the ion temperature gradient combined with the toroidal magnetic ∇B-curvature drift.

The kinetic dispersion relation for the toroidal ITG mode including effects of the finite gyroradius and the toroidal resonance are derived by using the gyrokinetic equation for ions and the Boltzmann distribution for electrons with the charge neutrality condition.

Due to the quadratic form of velocities in the ∇B-curvature drift, the toroidal resonance has qualitatively different characteristics from the parallel drift resonance in the slab case. Thus, when we define the dispersion function on the complex-frequency ω-plane for the toroidal ITG mode, its analytic continuation requires a branch cut on the $\mathrm{Im}(\omega) < 0$ plane[1]. We need to take account of this property caused by the toroidal resonance in order to obtain the complex eigenfrequencies especially with negative imaginary parts from the dispersion relation[2].

In this work, the initial value problem of the toroidal ITG mode has explicitly formulated based on the Laplace transform. We treat appropriately a Landau contour and a branch cut for analytic continuation on the complex ω-plane by following Kim *et al*[2]. Then, we showed that the density and potential perturbations of the toroidal ITG mode contain two different types of temporal behavior: the normal modes and the continuum modes which correspond to contributions from the poles and the branch cut of the Laplace-transformed potential function on the complex ω-plane, respectively. The continuum mode is analitically shown to decay by power law and dominate the asymptotic behavior of the toroidal ITG mode for the stable case[3].

For stable system, we examined the case that the mode is localized at outermost point and that the initial perturbaion is propotional to Maxwellian and chargeneutrality condition is satisfied. Then it is shown that continuum mode become dominant after long time (Figure 1)[3].

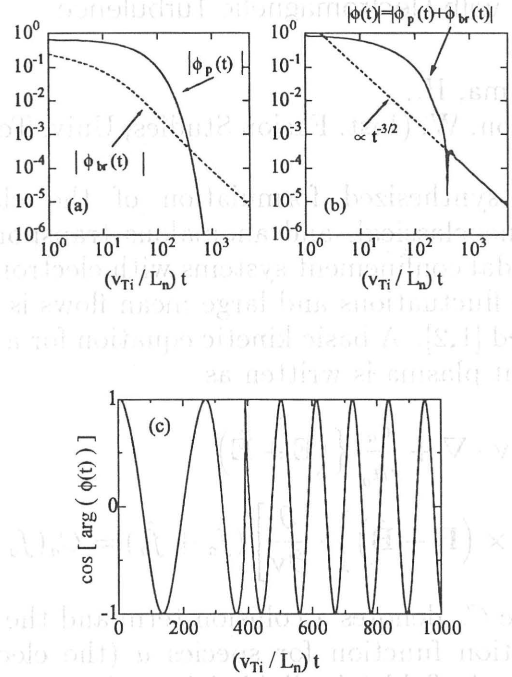

Figure 1: (a) The potential amplitudes of the normal mode $\phi_p(t)$ (a solid curve) and the continuum mode $\phi_{br}(t)$ (a dotted curve), (b) The total potential $\phi(t) = \phi_p(t) + \phi_{br}(t)$ normalized by the initial value $\phi(t=0)$, (c) The cosine of the phase of the potential $\phi(t)$, for the stable case. Here the eigenfrequency of the normal mode and the branch frequency are given by $L_n\omega_n/v_{Ti} = 0.024 - 0.019i$ and $L_n\omega_{br}/v_{Ti} = 0.056$, where $1/L_n = |d\ln n/dr|$. The dashed line in (b) represents the analytical asymptotic result.

References

[1] P. Similon *et al* : J. Comput. Phys.**54** (1984) 260.
[2] J. Y. Kim *et al* : Phys. Plasmas **1** (1994) 927.
[3] T. Kuroda *et al* : submitted to J. Phys. Soc. Jpn.