§12. Damping of Toroidal Ion Temperature Gradient Modes

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The temporal evolution of linear toroidal ion temperature gradient (ITG) modes is studied based on a gyrokinetic integral equation including an initial condition [1]. It is shown how to evaluate the analytic continuation of the integral kernel as a function of a complex-valued frequency, which is useful for investigating the asymptotic damping behavior of the ITG mode. In the presence of the toroidal magnetic drift, the potential perturbation consists of normal modes and a continuum mode, which correspond to contributions from poles and from an integral along a branch cut, respectively, of the Laplace-transformed potential function of the frequency [1,2]. The normal modes have exponential time dependence while the continuum mode, which has a ballooning structure, shows a power law decay $\propto t^{-2}$, where t is the time variable. Therefore, the continuum mode dominantly describes the long-time asymptotic behavior of the perturbation for the stable system.

Most of conventional linear analyses of the microinstabilities have shown the dispersion relation only for the case of positive growth rates partly because calculation of negative growth rates is sometimes more complicated due to treatment of analytic continuation in the complex-frequency plane. In the present work, by performing proper analytic continuation for the dispersion relation, the normal modes' growth rate, real frequency, and eigenfunction are numerically obtained for both stable and unstable cases, and the critical condition for the marginal stability is determined accurately. The normalized growth rate $\gamma k_\theta \rho_s/\omega_{*e}$ of the toroidal ITG mode for the large aspect ratio tokamak case is shown as a function of $\eta_i \equiv d\ln T_i/d\ln n$ in Fig.1 where we can clearly identify the critical values of η_i where the growth rate vanishes. In Fig.2(a), the normalized growth rate γ/ω_{*e} and real frequency ω_r/ω_{*e} as a function of the magnetic shear parameter $\hat{s} \equiv (r/q)(dq/dr)$. In this case, the growth rate has a peak at $\hat{s} \simeq 0.4$. The eigenfunctions $\phi(\theta)$ for $\hat{s} = \pm 0.8$ are shown in Fig.5(b).

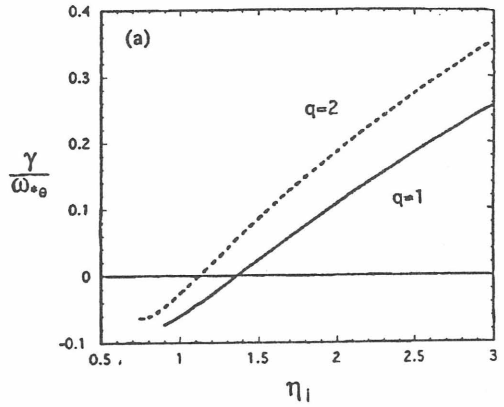

Fig.1. Normalized growth rate γ/ω_{*e} as a function of η_i for $k_\theta\rho_s = 0.75$, $T_e/T_i = 1$, $L_n/R = 0.2$, $\hat{s} = 1$, $\theta_k = 0$, and $q = 1, 2$.

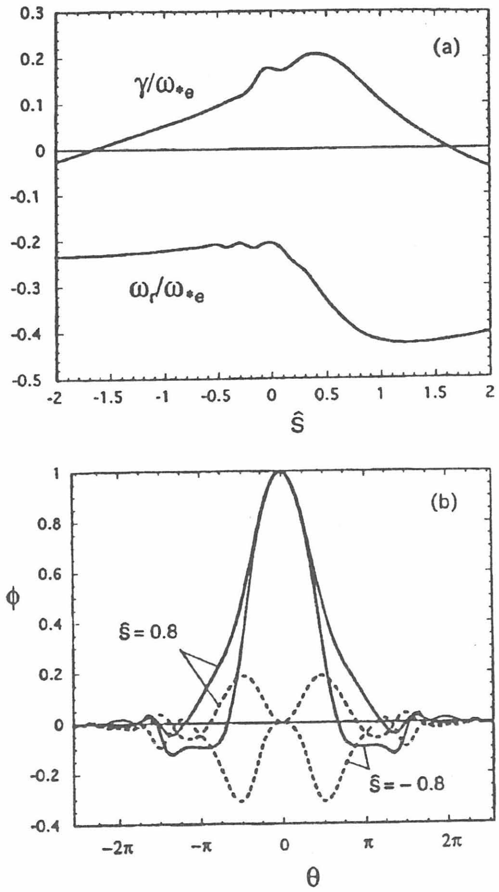

Fig.2. (a) Normalized growth rate γ/ω_{*e} and real frequency ω_r/ω_{*e} as a function of $\hat{s} \equiv (r/q)(dq/dr)$ for $T_e/T_i = 1$, $L_n/R = 0.2$, $\eta_i = 2$, $k_\theta\rho_s = 0.75$, $\theta_k = 0$, and $q = 1$. (b) Eigenfunctions $\phi(\theta)$ for $\hat{s} = \pm 0.8$. The real and imaginary parts of the eigenfunction are shown by the solid and dotted lines, respectively.

References

1) Sugama, H. : Phys. Plasmas **6** (1999) 3527.
2) Kuroda, T., Sugama, H., Kanno, R., Okamoto, M., and Horton, W. : J. Phys. Soc. Jpn. **67** (1998) 3787.