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拡張磁気流体モデルを用いたテアリング不安定性に対する二流体・有限ラーマー半径・熱流束の効果の解析

Analysis of two-fluid, finite Larmor radius and heat flux effects on tearing instability based on extended MHD models

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Extended MHD models are used to study small scale effects such as two-fluid and finite Larmor radius (FLR) effects on macroscopic instability. The extended MHD equations includes the Hall current and the electron pressure gradient as two-fluid effects and the gyroviscosity as FLR effects for ions. For low collisionality plasmas, the terms with parallel heat flux to the magnetic field included in the gyroviscosity derived from the fluid moment of the kinetic equation [1,2] cannot be neglected. This study is motivated to examine the effects of parallel heat flux in the ion gyroviscosity on tearing instability based on extended MHD models.

To study linear stability of tearing modes, the linearized extended MHD equations including parallel heat flux in gyroviscosity are simplified by taking only the first-order terms in the MHD ordering,

$$v \sim v_{th}, \quad v_d \sim \delta v_{th}, \quad \delta \ll 1, \quad p_{e\parallel} = p_{e\perp}.$$

We solve the resulting linear eigenmode equations for the tearing mode numerically. In order to examine in a wide range of parameters, we first consider two-fluid tearing instability [3] as a benchmark. By changing both plasma beta value and ion skin depth, three regimes with different algebraic scaling law, weak-Hall, strong-Hall with high beta and strong-Hall with low beta regimes, have been reproduced for three different values of resistivity. Figure 1 (a) shows the transition of the growth rate as a function of resistivity from weak-Hall to strong-Hall with high beta regimes by increasing the ion skin depth d_i with the wavenumber k=1 for the beta value β=0.05 while (b) shows that from strong-Hall with high beta to low beta regimes by decreasing the beta value for kd_i=2.0.

Based on the results for the parameter dependence of two-fluid tearing instability, we will examine the effects of gyroviscosity with parallel heat flux.

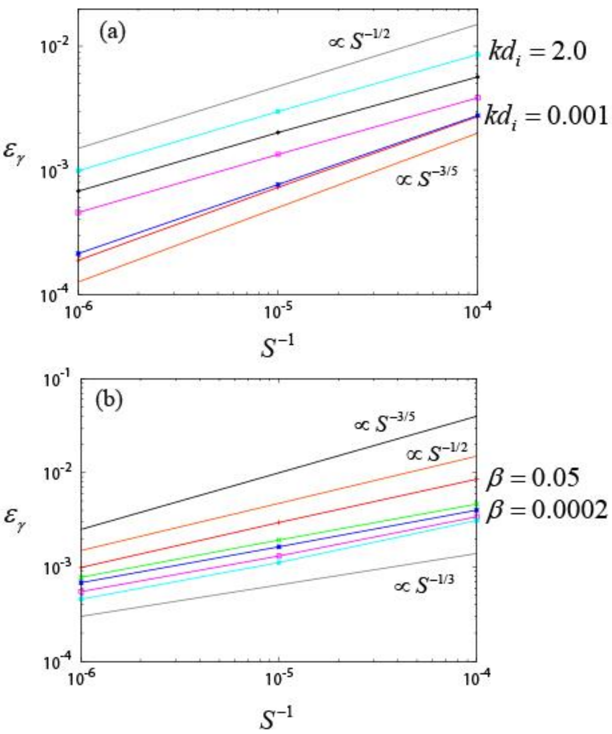

Fig. 1

References

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