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Gyrokinetic Simulations of Microtearing Mode in 2D Slab Model

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The microtearing mode (MTM) driven by electron temperature gradients is believed to be a cause of electron thermal transport in magnetized plasmas [1]. The original theoretical works predicted that the mode is a collisional mode. It was also shown that the instability is sensitive to collision models, namely, the energy dependent electron-ion collisions are necessary for the mode to be unstable [1-3]. Since then, many theoretical and numerical studies have been done for understanding the instability mechanism of MTM [1-7], yet it is still controversial. For instance, a recent theoretical study based on the reduced gyrokinetic model claims that the energy dependent collision model is not necessary to destabilize the mode [4]. Some gyrokinetic simulation studies suggest the existence of collisionless MTM in a toroidal geometry due to trapped particles[5], and even in a slab [6].

To clarify the fundamental destabilization mechanism of the mode, we perform linear gyrokinetic simulations of MTM in a slab geometry using AstroGK [8], which has been successfully utilized to study (normal) tearing mode reconnection [9,10]. We add electron temperature gradients to the simulation setup of the tearing mode. As a validation, we first compare our simulation results with the latest and the most comprehensive theory [4] in the low-beta regime for which the theoretical framework is developed.

Figure 1 shows ν_{ei} dependence of the linear microtearing growth rate γ. ν_{ei} and γ are normalized by the electron diamagnetic drift frequency ω_e^* . The energy dependent collision operator is used. γ/ω_e^* peaks at $\nu_{ei} \sim \omega_e^*$ and the mode is stable in both weakly and strongly collisional regimes, therefore it is a collisional mode. Figure 2 shows the parallel magnetic (top) and parallel current (bottom) fluctuations, respectively. The structures of the mode show a tearing parity (even parity) and the parallel current is localized within a narrow layer. The results show qualitative agreement with the previous theoretical studies [3, 4]. We have also performed the same simulation runs using the energy-independent collision model, and have confirmed the energy dependence is indispensable for the instability.

In the presentation, we discuss the detailed instability mechanism of MTM focusing mainly on electrons. We show how the out-of-plane electric field is generated in terms of electron dynamics in the current layer, and how the supporting mechanism of the reconnection electric field is affected by collision models.

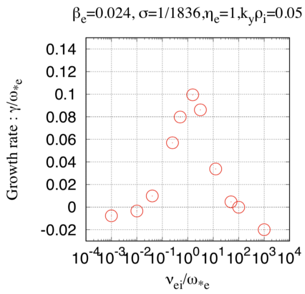

Figure 1 The linear growth rate of microtearing instability against electron-ion collision frequency.

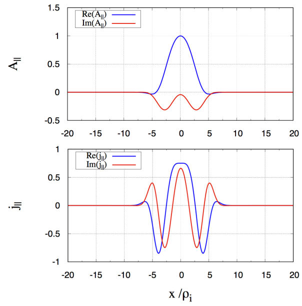

Figure 2 Real and complex part of eigenfunctions of microtearing mode ($\nu_{ei}/\omega_e^* = 1.56$). The top and bottom figures represent, respectively, the parallel magnetic and parallel current fluctuations around the singular point (x = 0).

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