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Nonlinear interaction between drift-tearing-modes and slab-ITG-modes

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In the realistic plasmas of fusion devices, both the macro-MHD instabilities and the micro-turbulence may coexist and interact with each other. However, due to the difficulties in the experimental diagnosis and the limits of the computing facilities, the multiscale interactions between macro-MHD instabilities and micro-turbulence transports are still a challenging topic. Recently, an electromagnetic Landau-fluid model is employed to study the nonlinear interplay between tearing modes (TM) and ion-temperature-gradient (ITG) turbulences [1-3]. Li *et al* found a kind of short wavelength ITG instability triggered by macroscale magnetic island in multiscale turbulence simulation [1]. Dual roles of shear flow, significantly suppressing microscale fluctuations and dramatically promoting macroscale fluctuations, are numerically verified in the multiscale simulation by Hu *et al*.[3]

In this work, basic features of the multiscale interaction between drift TMs and slab ITG modes are numerically studied. It is observed that the energy spectra with respect to wavenumbers become broader during the transition phase from ITG-dominated stage to TM-dominated stage, as shown in figure 1.

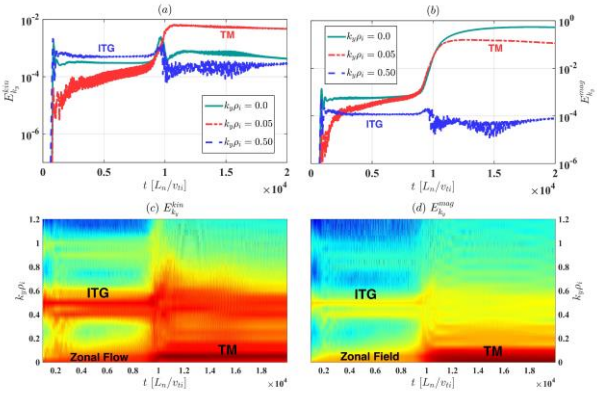

Figure 1. Time evolutions of the (a) kinetic and (b) magnetic energies. Instantaneous ky-spectra for the (c) kinetic and (d) magnetic energies.

Accompanied with the fast growth of magnetic island, the frequency of TM/ITG with long/short wavelength fluctuations in the electron/ion diamagnetic direction decreases/increases respectively, as shown in figure 2. The decrease of the TM frequency is identified to result from the effect of the profile flattening in the vicinity of magnetic island, while the increase of the frequencies of ITG fluctuations is mainly due to the eigenmode transition of ITG induced by the large scale zonal flow and zonal current related to the drift TM.

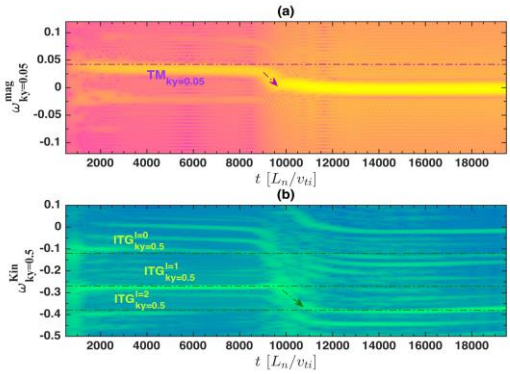

Figure 2. Frequency Spectra for the (a) long wavelength tearing mode and (b) short wavelength ITG modes.

Turbulent transport in the presence of magnetic island has received extensive attention in recent years. Thus, the transport feature near the island region is also discussed. In the ITG dominated stage with relatively weak magnetic perturbation, the turbulent transport is mainly contributed by the electrostatic perturbation. When TM grows up, magnetic island gradually splits the small-scale fluctuations. As shown in figure 3, the fluctuations are mainly localized near the magnetic separatrix. As the width of the magnetic island increases, the fluctuations are gradually squeezed to the X-point of the magnetic island. This structure is different from mode structure of the linear ITG mode in the presence of static magnetic island [4,5].

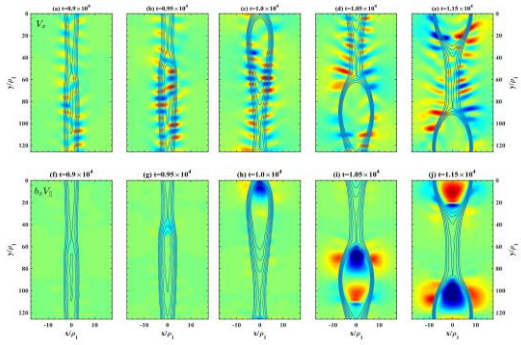

Figure 3. Snapshots of the velocity fluctuations during the transition phase.

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