# Magnetic reconnection associated with a kink-type instability

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Magnetic reconnection is one of the key processes playing an important role in the magnetospheric substorm and solar flares. It facilitates the fast conversion of energy stored in a compressed magnetic field into plasma kinetic and thermal energies. However, many of detailed processes around the diffusion region, where the reconnection and energy conversion take place, are poorly understood.

One of the main issues is the mechanism to quickly initiate reconnection. Although the onset of reconnection has been attributed to the tearing instability, it is known that the tearing instability saturates at low levels even in the thin current sheet with thickness of the order of the ion skin depth, before fast reconnection is triggered. Thus it is difficult for the tearing instability alone to trigger the onset of fast reconnection. Recently, it has been suggested that the lower hybrid drift instability (LHDI) intensifies the current density in the center of the current sheet, so that the growth rate of the tearing instability is enhanced in three-dimensional (3-D) systems. Previous two-dimensional (2-D) simulations in the non-tearing plane (orthogonal to the magnetic field) have also revealed that the current sheet modifications due to the LHDI lead to the evolution of a kink-type instability (e.g., Kelvin-Helmholtz, ion-ion kink, or drift kink instabilities). Furthermore, recent observations by the Cluster spacecraft also suggested the existence of the kink-type structure in the current sheet, which is consistent with the simulation results in terms of wavelength, period, and phase velocity. And magnetic reconnection is sometimes observed in the kinking current sheet. However, it is still an open question how the kink mode has an impact on the tearing instability.

In this study, we considered the behavior of the tearing instability in the system where the kink-type instability evolves. Our simulations are performed in 3-D system including the fully kinetic effects of plasma. The code employs the adaptive mesh refinement (AMR) technique, which subdivides computational cells locally in space and dynamically in time, and facilitates high-resolution simulations of the current sheet. We found that the nonlinear evolution of the kink mode does not enhance the reconnection processes in the present system where the tearing instability evolves in the same time scale as the kink-type instability. However, the kink mode completely deforms the structure of the diffusion region, which makes the reconnection processes three-dimensional. Most electrons enter the diffusion region from the ridge of the kinking current sheet and exit from the trough. The significant difference from the 2-D reconnection is in the electron acceleration mechanism. The electrons ejected from the diffusion region tend to return into the inflow region because of the ambient electric field imposed by the kink mode, and are repeatedly accelerated by the reconnection field. Consequently, the electrons gain much more energy in the 3-D system than in the 2-D system. We suppose that the energy source for the secondary electron acceleration originates from the drift energy of the ions.

In this paper, we will show the 3-D picture of the reconnection processes in the system where both the tearing and kink instabilities evolve, and discuss the new acceleration mechanism of electrons.