§25. Electron/ion Mass Dependency in Current Sheet Instabilities

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Collisionless magnetic reconnection is widely believed to play an important role in energetically active phenomena in the solar corona, the Earth's magnetosphere, fusion devices and so on. Anomalous resistivity due to current sheet instabilities at the reconnection region[1] is one of the candidates of the trigger mechanism of the collisionless magnetic reconnection. We have investigated the roles of ion and electron dynamics in the destabilization of current sheet instabilities and the resulting generation of anomalous resistivity by means of 2.5D explicit particle simulation.

Under the effects of lower hybrid drift instability (LHDI), two types kink modes become unstable at the neutral sheet in Harris-type field reserved equilibrium. Upper two panels of Fig.1 show the spatial profiles of the magnetic field when the shorter (panel A) and the longer (panel B) wavelength modes grow dominantly. The dependences of the linear growth rate of these kink modes on the effective electron and ion masses are given in Fig.1(C) and (D), respectively. It is clearly shown that the growth rate of the longer wavelength mode is constant independent of electron mass while that of the shorter wavelength mode is independent of ion mass in the high mass ratio cases. Figure 2 shows the time evolutions of DC electric field at the neutral sheet in different electron mass cases. The electric field reaches the same order of magnitude $10^{-(1\sim2)}V_aB_0$ independently of electron mass when the longer wavelength mode grows dominantly, where V_a and B_0 are Alfven speed and the outside magnetic field, respectively. This value is roughly consistent with the reconnection rate expected from the experimental and satellite observations[2]. These results suggest that the generation of the electric field due to the longer wavelength mode is characterized only by the ion dynamics and can play an important role in magnetic reconnection even for the real mass ratio in ion-scale current sheets, which are commonly observed in the magnetosphere and laboratories.

The shorter kink mode, which grows dependently on the electron mass, can grow effectively only in an electron-scale current sheet. This mode may have some impact on driven reconnection processes because the electron-scale profiles of electron current density are formed due to the plasma inflow from the external region[3]. Three dimensional treatment including the equilibrium current and the plasma inflow directions is needed to clarify such a destabilization mechanism of the shorter wavelength kink mode.

1)T.Moritaka, etal, Phys.Plasmas, **15**,092114(2008)
2) M.Yamada, Phys.Plasmas, **14**,058192(2006)
3) R.Horiuchi etal, Phys.Plasmas, **4**,277(1996)

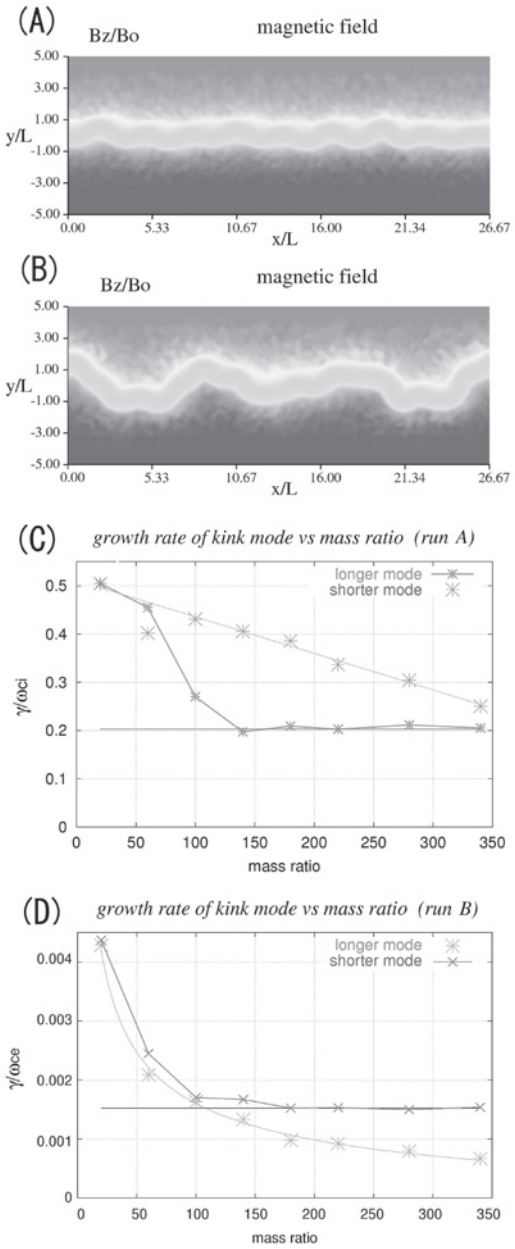

Fig. 1: (A), (B): Magnetic field profiles $B_z(x, y)$ at (A) $t\omega_{ci} = 1.743 \times 10^1$ and (B) $t\omega_{ci} = 3.139 \times 10^1$. (C),(D):Mass ratio dependences of growth rate in varying effective (C) electron mass and (D) ion mass.

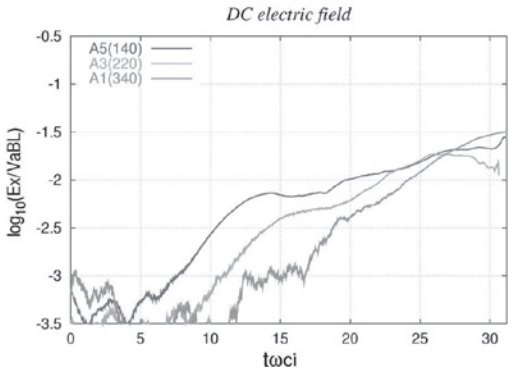

Fig. 2: Time evolutions of DC electric field at the neutral sheet for mass ratios 140, 220 and 340 in varying effective electron mass.