§ 10. Structure Formation Controlled by Three-Dimensional Collisionless Driven Reconnection

Horiuchi, R.

Three-dimensional electromagnetic particle simulation [1,2] has revealed that, when an external driving source does not exist, the lower hybrid drift instability (LHDI) is observed to grow in the periphery of current layer in an early period, while a drift-kink instability (DKI) is triggered at the neutral sheet as a second instability after the current sheet is modified through nonlinear evolution of the LHDI. Based on these results, we investigate the structure formation process controlled by three-dimensional reconnection in the presence of an external driving source. For this purpose we have developed a full electromagnetic particle simulation code for three-dimensional open system in which there exist input upstream boundaries and free downstream boundaries [2].

Figure 1 shows the spatiotemporal structure of the $n = 0$ (top) and $n = 8$ (bottom) modes of out-of-plane electric field E_z where magnetically neutral sheet corresponds to the midpoint of the space coordinate y. In the same way as non-driven case the LHDI is excited in the periphery (see the bottom panel). It is worthy of notice that this mode propagates into the central region in contrast to the non-driven case. The existence of the DC component $E_z^{(n=0)}$ is an indicator of magnetic reconnection at the neutral sheet. We adopt the external driving electric field at the input boundary. This field compresses the current sheet. After experiencing an intermediate quasi-steady state it penetrates into the current sheet in accordance with the propagation of the $n = 8$ wave. When the wave reaches the neutral sheet, the driving electric field fully penetrates inside the current sheet and balances with the reconnection field.

In three-dimensional case the spatial structure of current sheet is dynamically modified by plasma instabilities excited through wave-particle interaction [3]. Local island structures of plasmas are generated by tearing instability in the central current sheet and moves towards the downstream. The electric current density which is carried by fast reconnection flow accumulates inside the magnetic islands. When the current density exceeds some critical value, a kink-like instability is excited and the island structure is modified in a helical form, as is shown in Fig. 2. Finally, the island structure is destroyed and disappears from the system.

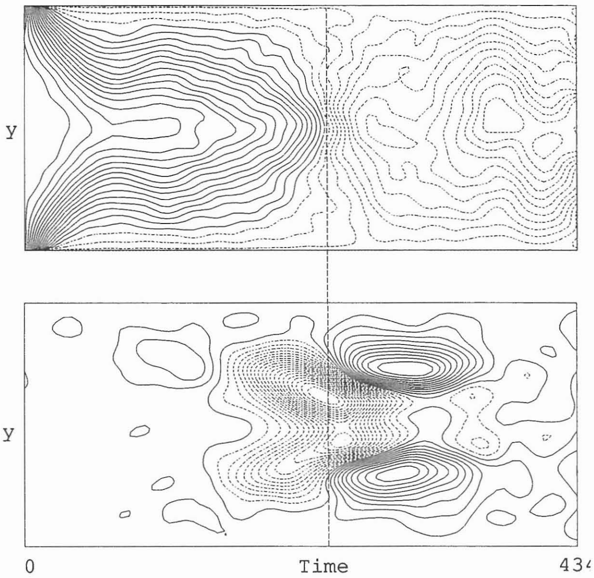

Figure 1: Spatiotemporal structure of the Fourier modes $E_z^{(n=0)}$ (top) and $E_z^{(n=8)}$ (bottom) in the (t,y) space.

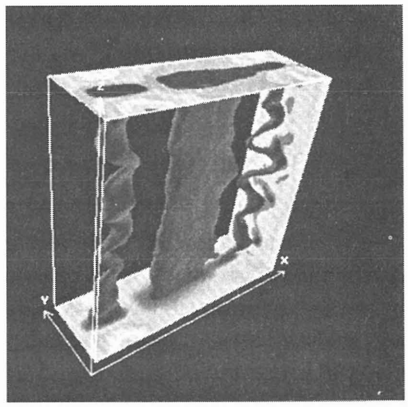

Figure 2: Perspective view of the magnetic field in the downstream where weak field region is plotted by an isosurface.

References
1) R. Horiuchi et al., Phys. Plasma **6**, 4565(1999).
2) R. Horiuchi et al., EPS, **53**, 439(2001).
3) R. Horiuchi, in the Proceeding of ICPP2002, (2002).