§7. Collisionless Driven Reconnection in Three Dimensions

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Particle simulation studies [1,2] have disclosed that there exist two types of triggering mechanisms which break the frozen-in condition of magnetic field and lead to magnetic reconnection in a collisionless plasma. One is due to the wave-particle interaction which is a cause of anomalous resistivity. The other is due to the particle kinetic effect which becomes significant in a particle scale such as collisionless skin depth and Larmor radius.

The lower hybrid drift (LHD) instability is observed to grow with a large rate in the periphery of current layer, but it cannot penetrate into a high beta region in the vicinity of the neutral sheet. Instead, a low frequency electromagnetic (EM) instability is excited there after the saturation of the LHD wave. The detailed examination indicates that the new instability is deeply related to the meandering motion of ions in the current sheet[2].

Particle kinetic effect in collisionless reconnection is examined for the case where the system is subject to an external driving flow[1]. Collisionless driven reconnection develops in two steps in accordance with the formation of two current layers, i.e., ion current layer in which ion kinetic effect is dominant, and electron current layer in which electron kinetic effect is dominant. The ions are anomaly heated through the ambipolar interaction by an electrostatic field generated in the downstream.

We have developed three-dimensional particle simulation code in order to clarify the relationship between two mechanisms associated with the wave-particle interaction and the particle kinetic effect. The periodic condition is adopted at the boundaries of x-axis and z-axis, while an electric field to generate an inward plasma flow is assumed at the boundary of y-axis. Figures 1 and 2 show the typical examples of the simulation results. The LHD instability is excited in the periphery of current layer in the early phase (Fig. 1), and after then the EM instability grow to modify the current sheet (Fig. 2), in the same way as the two-dimensional simulation.

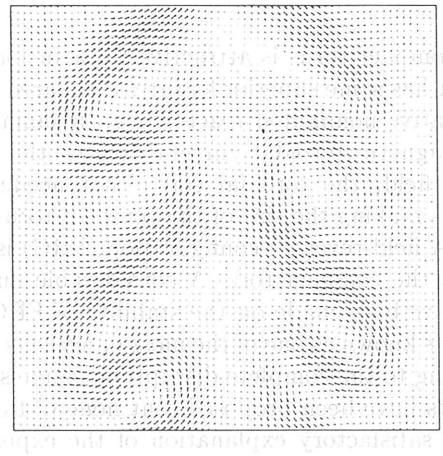

Figure 1: Vector plots of electric field in the (y, z) plane at $t = 251\omega_{ce}^{-1}$.

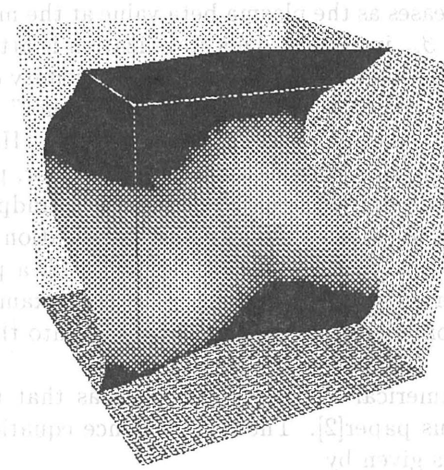

Figure 2: Perspective view of current sheet at $t = 352\omega_{ce}^{-1}$.

References

1) R. Horiuchi and T. Sato, Phys. Plasmas **1**, 3587(1994): **4**, 277(1997).

2) M. Ozaki, T. Sato, R. Horiuchi, et al., Phys. Plasmas **3**, 2265(1996).