§17. Triggering Mechanism of Collisionless Driven Reconnection in Three Dimensions

Horiuchi, R., Sato, T.

We have clarified from three-dimensional particle simulation that two different types of plasma instabilities are excited in a collisionless current layer in the absence of an external driving source. 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 in a late period as a result of the nonlinear deformation of the current sheet by the LHDI. A reconnection electric field grows at the neutral sheet in accordance with the excitation of the DKI.

In order to examine how collisionless reconnection evolve in three dimensions in the presence of an external driving source, we carry out the full particle simulation on a 128 × 64 × 64 point grid by making use of 24 million particles. Figure 1 shows the simulation result for the case of the driving field $E_0 = -0.02B_0$. The Poynting flux, which is supplied into the simulation domain from the exterior region, moves towards the current layer together with the convergent plasma flow, while compressing the current profile. The compression by the convergent plasma flow increases the growth rate of the DKI. Because most of ions inside the current layer is unmagnetized, the electric field or the Poynting flux, which is carried by the convergent plasma motion, penetrates into the current layer due to the particle kinetic effect. When the Poynting flux reaches the neutral sheet, collisionless reconnection is triggered by the convective electric field.

Once magnetic reconnection takes place, a generated fast plasma flow carries away the plasma near the reconnection point towards the downstream. After the reconnection electric field reaches its saturation level, the amplitude of the DKI decreases and the width of the current layer increases (see Fig. 1). These phenomena indicate that the reconnection flow carries away the plasmas faster than the flux is accumulated at the reconnection point by the input flow. Consequently, the current profile is flattened in the vicinity of the reconnection point and the DKI becomes stable there. Thus, we cannot see any modification of the current sheet by the DKI in the vicinity of reconnection point (midline), although there appears the $n = 1$ modification of the current sheet along the vertical axis in the downstream region (see Fig.2). It is concluded that the drift kink instability is not a primary cause of collisionless reconnection in the presence of an external driving source.

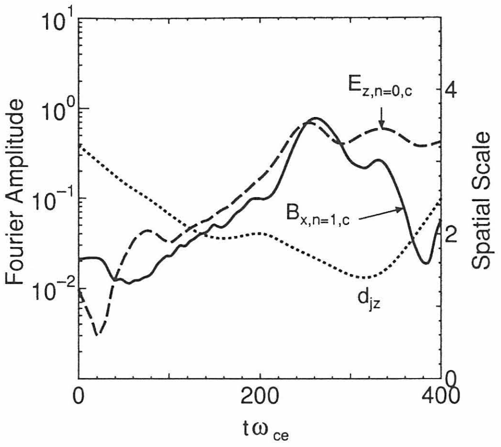

Figure 1: Time-evolutions of the drift kink mode (solid), the reconnection electric field (dashed), and the half-width of current layer (dotted).

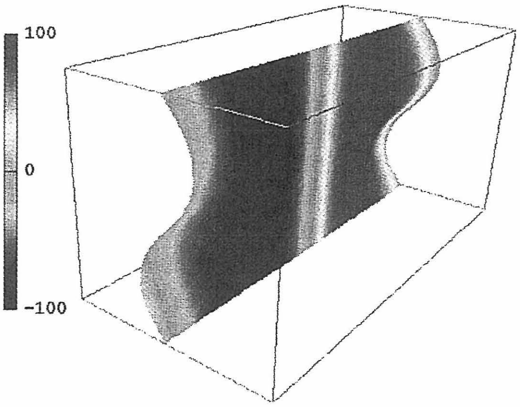

Figure 2: Perspective views of the current sheet at $t\omega_{ce} = 408$ for the same case as Fig. 1 where the current sheet is defined by the condition $B_x = 0$.

References

1) R. Horiuchi and T. Sato, Phys. Plasma **1**, 3587 (1994); **4**, 277 (1997); **6**, 4565 (1999).