§6. Influence of a Guide Field on Microscopic Kinetic Processes of Collisionless Driven Reconnection

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Magnetic reconnection is one of basic plasma processes commonly observed in various natural systems such as solar corona, earth magnetosphere, fusion devices, and so on. It is widely believed that magnetic reconnection in each system is controlled by common and/or similar physical processes, regardless of big differences in magnetic configuration and temporal-spatial scales. Although there exists strong guide fields in fusion devices, which is consider to alter microscopic physical processes, its role in magnetic reconnection is not clear. In order to clarify the influence of a guide field on collisionless driven reconnection, we have carried out three simulation runs with different guide fields while keeping other simulation parameters the same [1], using "PASMO" code [2].

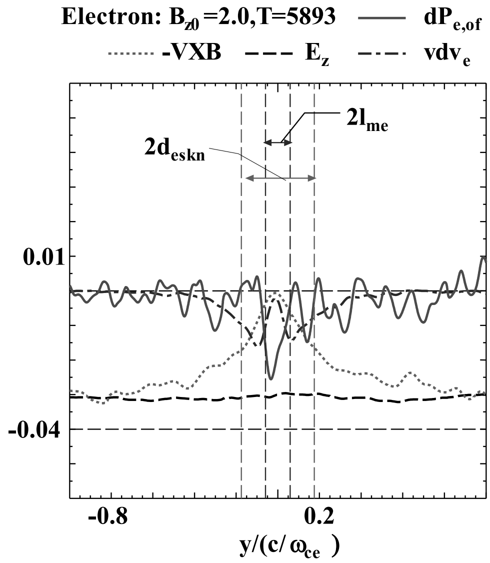
An initial condition is one-dimensional equilibrium with an antiparallel magnetic field along the x-axis and a uniform guide field along the z-axis as:

$$B_z = B_{z0},\ B_x = B_0 \tanh(y/L),$$

$$P = P_0 + \frac{B_0^{\ 2}}{8\pi}\operatorname{sech}^2(y/L),$$

where P_0, B_{z0} and B_0 are constant, and $L(=2.1\rho_{i0})$ is a scale height. An external driving flow supplied from upstream boundaries compresses the current sheet. When the current layer width becomes as thin as ion kinetic scale, magnetic reconnection occurs and reconnected magnetic flux is carried away towards the downstream region by fast reconnection outflow. As the guide field is intensified, the starting period of magnetic reconnection is delayed. The reconnection current density evolves locally in the narrow electron kinetic region in which unmagnetized electrons exist, and the dissipation of magnetic energy predominantly occurs there. As the guide field is intensified, both the thickness of the current layer and the number of the unmagnetized electrons decrease in proportion to the electron meandering scale.

Figure 1 shows the spatial profiles of the z-components of ideal and non-ideal terms in force balance equations for electrons (top) and ions (bottom) at a quasi-steady state for the case of $B_{z0}=2B_0$. The force terms associated with the off-diagonal pressure tensor term (solid curve) becomes dominant within a particle meandering scale (l_{mi} or l_{me}) in the vicinity of reconnection point ($y=0$) and sustains the reconnection electric field (dashed curve) for both electrons and ions. Since the off-diagonal components of pressure tensor terms originate from the meandering motion in the vicinity of a reconnection point, we conclude that the particle kinetic effect due to the meandering motion plays a key role in breaking the plasma frozen-in condition even when a strong guide field exists.



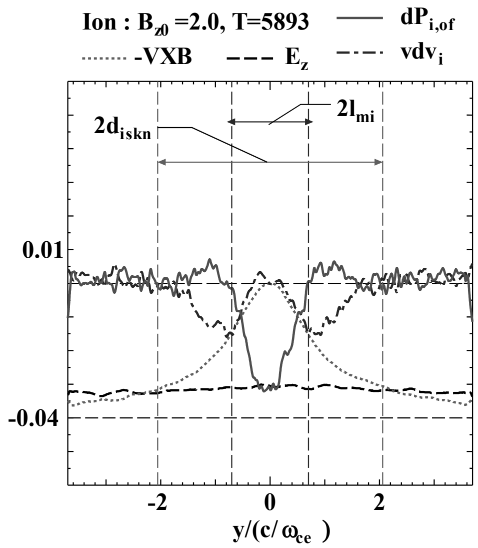


Fig. 1 Spatial profiles of the z-components of ideal and non-ideal terms in force balance equations for electrons (top) and ions (bottom) at a quasi-steady state.

[1] R. Horiuchi , S. Usami and H. Ohtani, Plasma and Fusion Research, in press (2014).
[2] H. Ohtani, and R. Horiuchi, Plasma and Fusion research, Vol. 4 , (2009) 024-1 - 024-14.