§3. Influence of Strong Guide Magnetic Field on Collisionless Reconnection

Horiuchi, R., Usami, S., Ohtani, H.
Ono, Y., Inoue, S. (Univ. Tokyo)

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 several simulation runs with different guide fields while keeping other simulation parameters the same [1], using "PASMO" code [2,3].

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:

$$B_z = B_{z0},\ B_x = B_0 \tanh(y/L),$$
$$P = P_0 + \frac{B_0^{\ 2}}{8\pi} \mathrm{sech}^2(y/L),$$

where P_0, B_{z0} and B_0 are constant, and $L(=2.1\rho_{i0}, \rho_{i0}$: ion Larmor radius evaluated using B_0) 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. Figure 1 shows the spatial profiles of the z-components of ideal and non-ideal terms for electrons along the y axis at quasi-steady state for the case of $B_{z0} = 2.0B_0$. The off-diagonal pressure tensor term becomes dominant within a particle meandering scale (l_{me}) in the vicinity of reconnection point ($y=0$) and sustains the reconnection electric field. These results are the same as those in the previous simulations with no guide field. This result suggests that the meandering orbit effect plays a key role in triggering collisionless reconnection even for a strong guide field.

Figure 2 shows the temporal evolutions of energy conversion rates to ions and electrons for no and strong guide fields. As soon as magnetic reconnection sets in (at $\omega_{ce}t$=600), the electromagnetic (EM) energy is rapidly converted to both ion and electron energies. In the presence of the guide field, the energy conversion rates is suppressed to a lower level both for ions and electrons. This result corresponds to the fact that the dissipation region shrinks and the number of the unmagnetized particles decrease in proportion to the meandering scales as the guide field is amplified. Furthermore, it is interesting to note that the EM energy is dominantly converted to the ion energy regardless of guide field, which rate is 2-3 of the conversion rate to electrons.

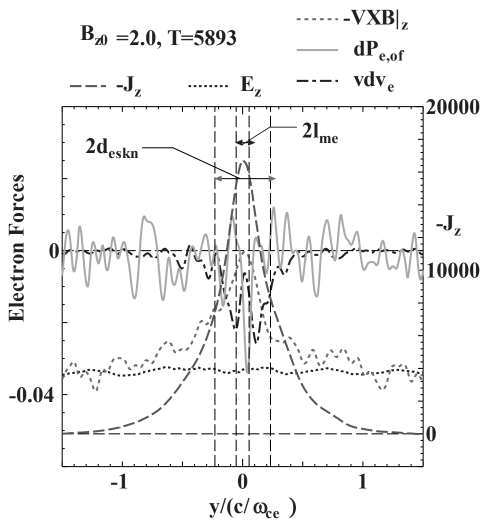

Fig. 1. Spatial profiles of the z-components of ideal and non-ideal terms in force balance equations for electrons at a quasi-steady state.

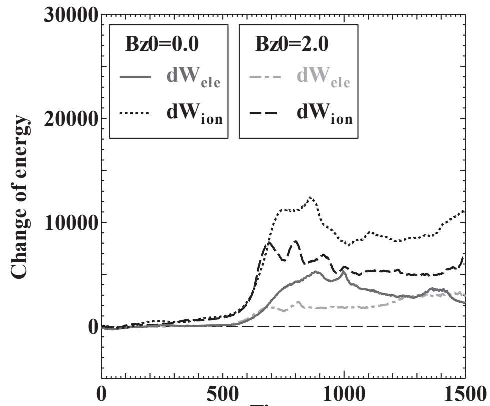

Fig. 2. Temporal evolutions of energy conversion rates to ions and electrons for no and strong guide fields.

[1] R. Horiuchi , S. Usami and H. Ohtani, Plasma and Fusion Research, **9** (2014) 1401092.

[2] W. Pei, R. Horiuchi and T. Sato, Phys. Plasmas, **8** (2001) 3251.

[3] H. Ohtani, and R. Horiuchi, Plasma and Fusion research, **4** (2009) 024.