§26. Strong Electron Outflow and its Influence on the Downstream Structure of the Electron Dissipation Region in the Steady Collisionless Driven Reconnection

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The electron dynamics in the steady collisionless driven reconnection is investigated by using the electromagnetic particle simulation code ("PASMO") developed for a microscopic open system which is surrounded by an external macroscopic system [1,2,3,4]. In the previous study [5], the generation of strong electron outflow was discussed. The analysis of the present study is focus on the relation between this strong electron outflow and the structure of the electron dissipation region along the downstream..

The electron dissipation region appears in the central region of the current layer where electron frozen-in condition is broken through electron kinetic effects and the electron current density grows largely. Figure.1 shows that the electron dissipation region has a two-scale structure along the x direction [6].

The regions in blue and in red correspond to the inner and outer structure of the electron dissipation region, respectively. The difference in color between two regions lies in the difference of the value of the term $(E+v_e\times B)_z$, which is smaller than zero in the inner structure and is larger than zero in the outer structure.

In the steady state of driven recoonection, the driven electric field is constant throughout the simulation domain [1,2,3,4,5]. So the variation of the term $(E+v_e\times B)_z$ mainly comes from cross product of the term $(v_e\times B)_z$. Actually, the main contribution of the $(v_e\times B)_z$ comes from the outflow velocity v_{xe} and the reconnected magnetic field B_y [5].

Figure 2 shows spatial profiles of three physical quantities along the downstream, in which can be seen that $(E+v_e\times B)_z\approx 0$ around $|x|\approx 6$, and the reconnected magnetic field B_y becomes flat there. It is expected that if electron outflow keeps its value for $|x|>6$, electron frozen-in region will be extended further in downstream direction.

However, electron outflow speed continues to increase until it reaches its maximum value around $|x|\approx 12$, while the value of B_y is nearly a constant. As a consequence, the value of the term $(E+v_e\times B)_z$ is smaller than zero, and the outer region of electron dissipation region is formed as shown in Fig.1.

It is shown that the magnitude of the term $(v_e\times B)_z$ increases with the distance away from the reconnection point due to strong electron outflow, the quantity $(E+v_e\times B)_z$ changes its sign from negative to positive in downstream direction. In this sense, it is easy to infer that the generation of the outer structure of the electron dissipation region is deeply related with the strong electron outflow.

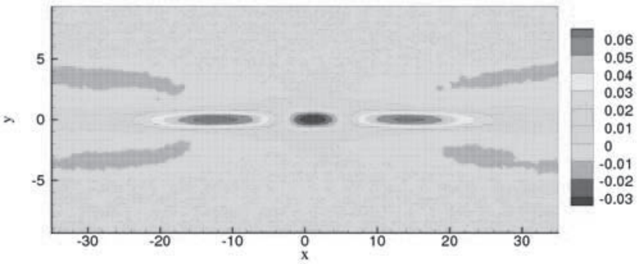

Fig. 1. Contour plots of the electron dissipation region in the (x,y) plane in the steady state. The color in the figure indicates the value of the term $(E+v_e\times B)_z$.

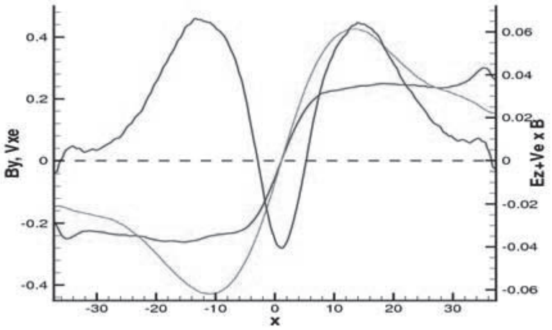

Fig. 2. Spatial profiles of physical quantities passing through the reconnection point along downstream in the steady state for the same case as Fig.1. Electron outflow velocity v_{xe}, reconnected magnetic field B_y, and quantity $(E+v_e\times B)_z$ are indicated in green, red, and blue, respectively.

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