§8. An Anomalous Resistivity in Collisionless Driven Reconnection and its Role in Multi-hierarchy System

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Many particle simulation studies [1,2] have revealed that frozen-in condition is broken due to particle kinetic effects and collisionless reconnection is triggered when current sheet is compressed as thin as ion kinetic scales under the influence of external driving flow. A reconnection system evolves into a quasi-steady state after an initial transient phase if the driving flow satisfies some condition [1]. In the steady state, reconnection electric field generated by microscopic physics evolves inside ion meandering scale so as to balance the flux inflow rate at the inflow boundary, which is controlled by macroscopic physics. That is, effective resistivity generated through this process can be expressed by balance equation between micro and macro physics. Based on the above discussion we introduce the simple effective resistivity model as

$$\begin{aligned}\mathbf{E} &= -\mathbf{v}\times\mathbf{B} + (\text{all kinetic term})\\ &= -\mathbf{v}\times\mathbf{B} + \eta_{anorm}\mathbf{J}\\ &= \mathbf{const}. \qquad \text{for } \rho_i|\mathbf{J}|/|\mathbf{B}| \geq 1\\ \Rightarrow \eta_{anorm} &\approx |\mathbf{v}\times\mathbf{B}|_{periphery} / |\mathbf{J}|_{center}\end{aligned}$$

where ρ_i is a local ion Larmor radius. Figure 1 illustrates a schematic diagram of the effective resistivity model in which reconnection electric field (red curve) is assumed to be generated inside ion meandering scale so as to balance the flux inflow rate (E_d) from the outside of the current layer.

On the other hand, because such a microscopic kinetic system is always imbedded in a global microscopic system and its location varies in both time and space, it is very important to locate a kinetic regime in a dynamically evolving macroscopic system and clarify the role of kinetic effect in the global reconnection phenomena through the interaction between macro and micro physics.

For this purpose we apply this effective resistivity model to magnetic reconnection phenomena in the Earth magnetosphere as a typical multi-hierarchy system. A wide kinetic region appears near equatorial plane in night-site region of Earth magnetosphere, and its structure is complex and three-dimensional, as shown in Figure2. However, the ratio of the kinetic region ($\rho_i|J/B|> 0.5$) to the whole simulation volume remains around 0.001. Generated anomalous resistivity in a kinetic region is nearly 0.01 in normalized unit. In case of southward solar wind magnetic field with an oblique component, intermittent plasmoid ejection was also observed in the night-site region of the magnetosphere as a result of magnetic reconnection around 10-20 of the earth radius.

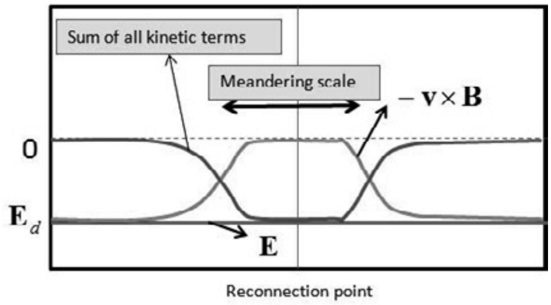

Fig.1 Schematic diagram of an effective resistivity model.

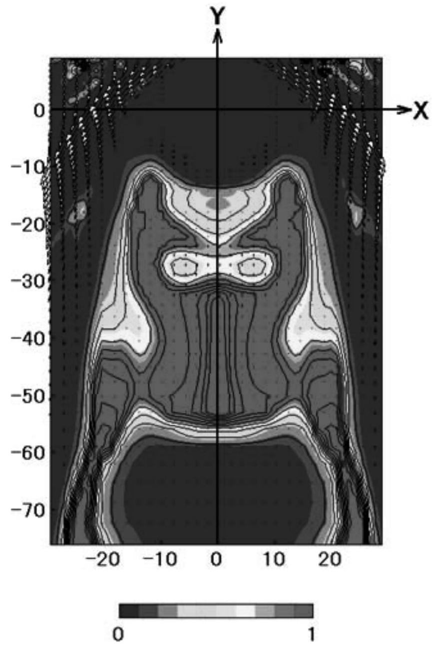

Fig.2 Kinetic region in the earth equatorial plane where color map stands for the value of $\rho_i|J/B|$.

[1] W. Pei, R. Horiuchi, and T. Sato, Physics of Plasmas,Vol. **8** (2001), pp. 3251-3257.
[2] A. Ishizawa, and R. Horiuchi, Phys. Rev. Lett., Vol. **95**, 045003 (2005).