§24. Magnetic Reconnection and Global Structure of Substorm in Magnetosphere

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Magnetic reconnection is considered to play an important role in space phenomena such as substorm in the Earth's magnetosphere. Recently, Tanaka and Fujita[1] reproduced substorm evolution process by numerical simulation with the global MHD code. In the MHD framework, the dissipation model is introduced for modeling of the kinetic effects. They found that the normalized reconnection viscosity, one of the dissipation model employed there, gave a large effect for the dipolarization, central phenomenon in the substorm development process, though that viscosity was assumed to be a constant parameter. On the other hand, Horiuchi and his corroborators investigated the dissipation mechanism of the magnetic field as process of the violation of the frozen-in condition.[2],[3] They proposed two mechanisms: anomalous resistivity created by the growth of drift kink instability (DKI) and meandering motion of particles around the neutral sheet. They estimated the effective resistivity based on the particle simulation data for DKI studies (wave particle interaction) and on behavior of the reconnection electric field for meandering motion analyses using macro variables for two mechanisms.

We perform substorm simulation by using the global MHD code developed by Tanaka[4] with two resistivity models obtained in microscopic approach as described above. Model A: use the resistivity model based on the wave particle interaction,

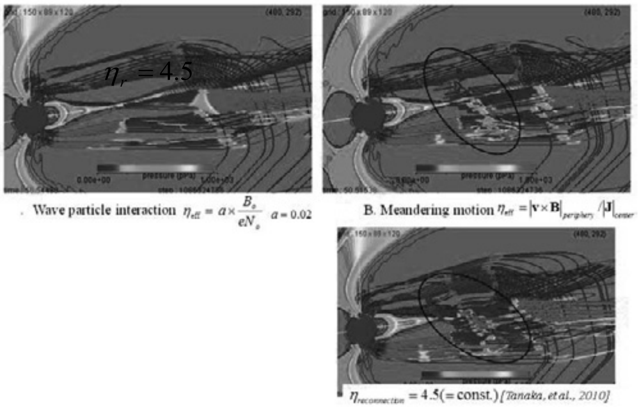
$$\eta_{\mathrm{eff}} = a \times \eta_{\mathrm{Hall}} = a \times \frac{B_o}{eN_o} \qquad (1)$$

where B_o and N_o are constant magnetic field and the density at the neutral sheet used in the initial profile in [2] respectively. The coefficient a evolves as $a = 0.02 \sim 0.1$ according to the growth of the DKI and we show the result in case of a=0.02 since simulation results for the above region of a are almost same. Model B: use the resistivity model based on meandering motion analyses,

$$\eta_{\mathrm{eff}} = \left|\mathbf{v} \times \mathbf{B}\right|_{periphery} / \left|\mathbf{J}\right|_{center} \qquad (2)$$

where v and J are the fluid velocity and the current respectively, and periphery and center mean the region apart from the reconnection point and the reconnection point respectively.

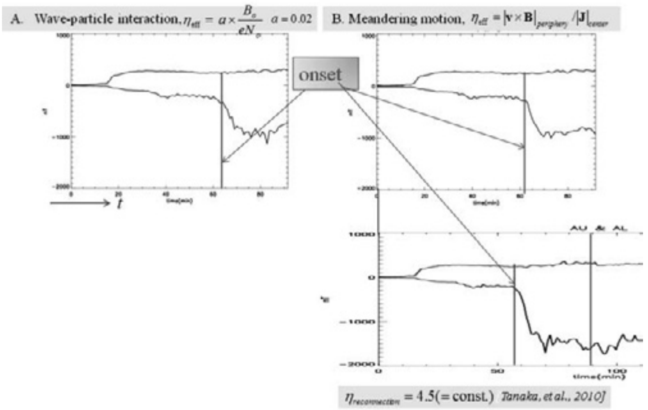
We compare that with the result described in [1], in which the resistivity for reconnection, η_r is constant and its value is 4.5. Figure 1 shows the pressure and the magnetic field at the time when flux rope is formed in Model B and the constant resistivity model [1]. The flux rope does not appear in Model A. Figure 2 presents the AE indices, in which sudden decrease indicates the onset of substorm. The onset time is similar for three models, which means that time may be determined by the solar wind conditions, although the intensity of the AE indices and the way to decrease are different in those models. Analyses are in progress.



Wave particle interaction $\eta_{eff} = a \times \frac{B_o}{eN_o}$ $a = 0.02$ B. Meandering motion $\eta_{eff} = |\mathbf{v}\times\mathbf{B}|_{periphery} / |\mathbf{J}|_{center}$

$\eta_{reconnection} = 4.5(= \mathrm{const.})$ [Tanaka, et al., 2010]

Fig. 1. The snapshot at the time when flux rope is formed in Model B and the constant resistivity model [1]. Left upper panel is for Model A, right one is for Model B, and right lower panel is for constant resistivity model [1]. The color contour represents the pressure, the color lines are the magnetic field in the magnetosphere and the color on those lines represents the intensity of B_z.



A. Wave-particle interaction, $\eta_{eff} = a \times \frac{B_o}{eN_o}$ $a = 0.02$ B. Meandering motion, $\eta_{eff} = |\mathbf{v}\times\mathbf{B}|_{periphery} / |\mathbf{J}|_{center}$

$\eta_{reconnection} = 4.5(= \mathrm{const.})$ Tanaka, et al., 2010]

Fig. 2 The AE indices are plotted. Correspondence between models and panels is same as Fig. 1.

1) Tanaka, T., et al, J. Geophys. Res. **115,** (2010) A05220.

2) Moritaka, T., Horiuchi, R., and Ohtani, H.: Physics of Plasmas **14** (2007) 102109 1

3) Ishizawa, A. and Horiuchi, R., Phys. Rev. Lett., **95** (2005) 045003.

4) Tanaka, T., J. Comp. Physics **111** (1994) 381