§14. 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[2)] investigated the roles of microscopic plasma instabilities on the violation of the frozen-in condition by examining the force balance equation based on explicit electromagnetic particle simulation for an ion-scale current sheet, and concluded that the growth of drift kink instability (DKI) can create anomalous resistivity leading to the excitation of collisionless reconnection. They estimated the effective resistivity based on the particle simulation data.

We perform substorm simulation by using the global MHD code developed by Tanaka[3)] with this anomalous resistivity obtained in microscopic approach[2)] as follows:

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

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, 0.5, 45. 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 reconnection time and the onset time for two resistivity models.

Time evolution of the velocity in the x-direction is presented in Fig. 2. The color contour indicates the magnitude of the velocity. The magnitude of the velocity starts to vary at $t \sim 48$ min and two direction, toward the earth and toward the tail, stream appears at $t \sim 58$ min, which are seen in four models. Boundary between the blue and red colors, indicating the reconnection point, moves toward the tail in the lower panel, on the other hand, the reconnection point does not move largely in the upper panels. Namely retreat of the reconnection point occurs for a=45 and the constant resistivity model, and it does not for a=0.02 and a=0.5 model. This means that the flux rope is not connected to the IMF. We promote further analysis of the value of the resistivity in substorm phenomena.

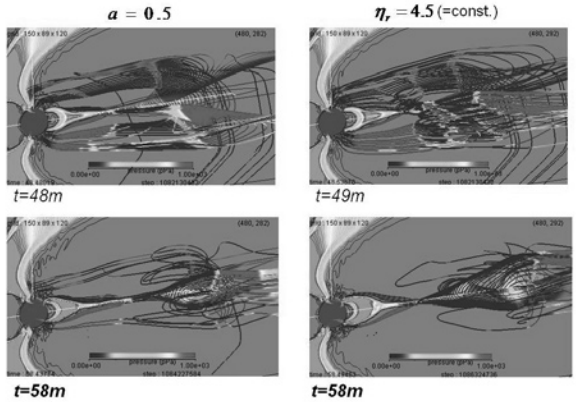

Fig. 1. The snapshot at the reconnection and the onset time for a=0.5 and the constant resistivity model, $\eta_r = 4.5$. The color contour represents the pressure, the color lines are the magnetic field in the magnetosphere and the color on those lines represents the intensity of B_z.

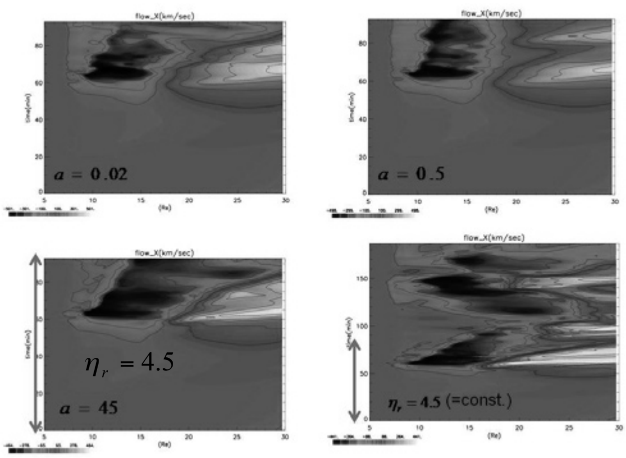

Fig. 2. Time evolution of the velocity in the x-direction for four models. The upper left panel is for a=0.02 model, the upper right panel is for a=0.5 model, the lower left panel is for a=45, and the lower right panel is for the constant resistivity model. The color contour indicates the intensity of the velocity. It should be noted that time scale is different between the constant resistivity model and the other three models.

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