§3. Role of Magnetic Reconnection in a Substorm Phenomenon 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. Tanaka and Fujita[1] have carried out a global MHD simulation by using the model resistivity and reconnection resistivity, which is a free parameter and is set at the nearest grid point to the reconnection point. 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. We perform substorm simulation by using the global MHD code developed by Tanaka[2] with the the resistivity model based on meandering motion analyses,

$$\eta_{\text{eff}} = \left|\mathbf{v}\times\mathbf{B}\right|_{periphery} / \left|\mathbf{J}\right|_{center} \quad (1)$$

where **B**, ***v*** and ***J*** are the magnetic field, the fluid velocity and the current respectively, and periphery and center mean the region apart from the reconnection point and the reconnection point respectively. Mechanism of this model is based on behavior of the reconnection electric field for meandering motion analyses [3].

Dipolarization of the magnetic field is one of typical phenomena, which is observed in the global structure of the magnetosphere at the substorm onset. Figure 1 illustrates the temporal development of the z component of magnetic field B_z at x=-7.0Re, y=z=0, about the geosynchronous orbit where Re is the earth radius. Panel (A) is simulated B_z with the present resistivity model, panel (B) shows simulated B_z with the constant resistivity model calculated by Tanaka[1]. Right panel (C) is observation data obtained by ETS-VIII satellite provided by JAXA, and this plot is made by Yumoto group at Kyushu University. Onset time is characterized by the sudden decrease in amplitude of B_z and vertical red lines in each panels indicate that time. The simulation results clearly show that the amplitude of B_z decreases suddenly in a several minutes at the substorm onset and recovers its value in the same time scales immediately, which is in good agreement with that in the observation. Furthermore, the simulated dipolarization for the resistivity model reproduces the observed data on the same level with that in the constant resistivity model, although any adjustable parameters are not included in the present model[4].

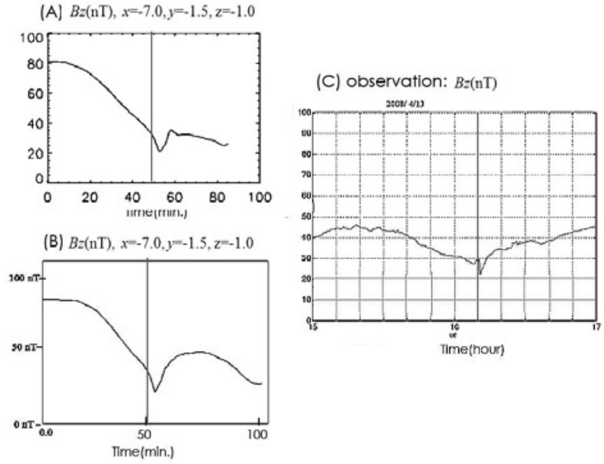

Fig. 1. (A) Time evolution of the north-south component of the magnetic field in the inner magnetosphere during substorm for the resistivity model given by eq. (1), (B) that for the constant resistivity model, and (C) the observation data. Red vertical lines indicate estimated onset time.

. Tanaka recently developed high resolution global MHD simulation code and simulated the activity on ionosphere during the substorm process. Figure 2 shows distributions of conductivity (color) and field aligned current (FAC, contour) in the polar ionosphere during the expansion phase of the substorm. Solid lines discribe downward FAC and dashed lines show upward FAC. The westward travelling surge (WTS) is reproduced in the evening side together with upward FAC concentrating at the head of WTS.

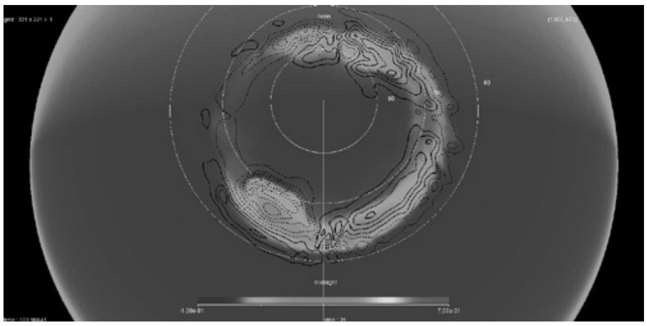

Fig. 2 Distributions of conductivity (color) and field aligned current (contour) in the polar ionosphere during the expansion phase of the substorm.

1) Tanaka, T., et al : J. Geophys. Res. **115,** (2010) A05220.
2) Tanaka, T. : J. Comp. Physics **111** (1994) 381
3) Ishizawa, A. and Horiuchi, R.: Phys. Rev. Lett., **95** (2005) 045003.
4) Horiuchi R. and Den M. et al.: Plasma Phys. Control. Fusion 55 (2012)