Plasma turbulence at boundary layers of earth's magnetosphere with dipole tilt

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One of important problems in space plasma physics is to understand relationships among magnetic reconnection, initiation of substorm processes and magnetospheric dynamics when the IMF changes or rotates in earth's magnetosphere with a dipole tilt of intrinsic magnetic field. When the IMF is northward, a dipole-like magnetic field configuration is formed in a steady state and magnetic reconnection occurs in high latitude tail region. On the other hand, when it is southward, a tail-like configuration is formed and reconnection occurs at the dayside magnetopause and plasma sheet. When the IMF has a y-component as well as z-component in solar-magnetosphere coordinates, plasma sheet is inclined. The plasma sheet rotates in distant tail as the IMF rotates in y-z plane. Moreover the plasma sheet shifts from the equator and is warped for finite dipole tilt of intrinsic magnetic field. The reconnection sites shift to the magnetic equatorial region in the dayside magnetosphere and to central plasma sheet moved up-and-down from the equator in the tail for the southward IMF. Reconnection rate becomes weaker than that for no dipole tilt.

We studied the detail processes on magnetic reconnection in the plasma sheet and successive magnetospheric dynamics from a high-resolution and 3-dimensional global MHD simulation of interaction between the solar wind and earth's magnetosphere when the IMF turns from northward to southward and vice versa. As the results, the first reconnection occurs in closed field lines in the magnetotail and proceeds to full spread of reconnection line up to flank magnetopause and lobe reconnection in a few minutes, and then fast plasma flows appear in the plasma sheet. At the same time, a vortex turbulence appears flank magnetopouse and a streamer structure does in the plasma tail due to patchy and intermittent reconnection for large southward IMF. On the other hand, a regular vortex train is formed in the flank magnetopause due to Kelvin-Helmholtz instability for northward IMF.

When the intrinsic magnetic field is inclined, magnetospheric configuration has a north-south asymmetry, then reconnection sites deviate oppositely from the equator in dayside and nightside of magnetosphere and reconnection rate becomes somewhat weaker. From a high-resolution MHD simulation, we have studied plasma instabilities and formation of plasma turbulence at boundary layers, which could occur in different manners in north and south regions of magnetosphere, when the IMF rotates in y-z plane in the magnetosphere with dipole tilt. The configuration of magnetosphere does not have any symmetry when the IMF y-component and dipole tilt simultaneously exist. Moreover, plasma instabilities and their nonlinear evolutions distinguishly occur different manner in the north and south regions. We will demonstrate and discuss nonlinear processes of plasma instabilities.