Geophysical Research Abstracts, Vol. 7, 10508, 2005
SRef-ID: 1607-7962/gra/EGU05-A-10508

Topology, symmetry-breaking, and dissipative structures of magnetosphere

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The energy transfers from the solar wind to the Earth magnetosphere, and the cause of magnetic storm have been mysteries for decades. Axford proposed that the reconnection of magnetic field at the dayside magnetopause is one of the candidates to explain the huge energy transfer from the solar wind to the Earth magnetic field. However, the mechanism of reconnection has not been understood well in magnetospheric physics. Using a 3D full electromagnetic particle model (EMPM), we have investigated the structural stability of the Earth magnetosphere at the dayside magnetopause with a time-varying southward IMF. The distance between the magnetopause and the Earth, R_{mp} was measured with varying southward IMF step by step slowly. Suppose that the Earth magnetic field evolves according to the time-dependent equation in the general form $B_t = G(B_t, \lambda)$. Solutions of $G(B_t, \lambda) = 0$ represent steady magnetic fields we have been considering. When the parameter (IMF B_z) is varied, one mean magnetic field may persist, but become unstable to small perturbations as crosses a critical value. At such a transition point, a new magnetic field may bifurcate with breaking symmetry, which shows dissipative structures. The hysteresis in the IMF B_z - R_{mp} plot indicates that the energy transfer system from the solar wind to the magnetosphere is dissipative, which is caused by the subcritical bifurcation. The differences of local and global steady reconnections are discussed with three-dimensional magnetic field topology.