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Hysteresis of Magnetospheric Structure Varying Southward IMF in Global Three-dimensional Electro-Magnetic Particle Simulation

D. Cai and B. Lembege
(1) University of Tsukuba, Japan, (2) CETP/UVSQ, Velizy, France

Using a three-dimensional full electromagnetic particle model (EMPM), we have performed global simulations of interaction between the solar wind and the magnetosphere, and have investigated the asymptotic stability of the solar wind magnetic flow. The distance between the dayside subsolar magnetopause and the earth center,R_{mp}, was measured varying the intensity of southward IMF step by step slowly. We obtain near-steady-state magnetic flows for each southward IMF value and measureR_{mp}. Suppose that the magnetic flow motion evolves according to the time-dependent equation in the general form$\mathrm{B}_t = G(\mathrm{B}, \lambda)$. Solutions of $G(\mathrm{B}, \lambda) = 0$ represent steady magnetic flows we have been considering. When the control parameter λ (for this case IMF $|\mathrm{B}_z|$) is varied slowly, one mean magnetic flow may persist, but become unstable to small perturbations as λ crosses a critical value. At such a transition point (the first-order phase transition), a new magnetic flow may bifurcate with breaking symmetry, which shows dissipative structures. The hysteresis in the IMF B_z vs 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 subcritical bifurcation always implies that the bifurcation flows will exhibits hysteresis effects.