3D MHD Simulation on Nonlinear Evolution of Ballooning Instability

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Several substorm trigger mechanisms such as near-Earth neutral line model, current disruption model are proposed. In near-Earth neutral line model substorms occur from reconnection in the near-Earth magnetotail. In current disruption model substorms occur because cross-tail current is suppressed for some reason. A part of the current is converted to field-aligned current and flows into the Earth.

Ballooning instability is also one of the potential models as a trigger mechanism of substorms. Because of the ballooning instability which occurs due to cooperation between gradient of plasma pressure and curvature effect of magnetic field lines, irregular structure of plasma locally grows in perpendicular direction to the magnetic field line and gradient of plasma pressure in near-Earth tail. Due to the plasma structure (unevenness of plasma pressure and structure of magnetic field lines in the dawn-dusk direction), cross-tail current is suppressed and changes to the field-aligned current. Then substorms occur when a part of field-aligned current flows into polar ionosphere along the magnetic filed line.

Cheng and Zaharia (2002) performed linear analysis of ballooning instability and showed relation between ballooning instability and field-aligned current in the polar ionosphere.

In this study, we have investigated nonlinear behavior of ballooning instability by 3D magnetohydrodynamic (MHD) simulation starting from the initial condition by Cheng and Zaharia. We show the nonlinear evolution, saturation mechanism and distribution of the field-aligned current for ballooning instability.