Ionospheric plasma sheet isolation during northward interplanetary magnetic field periods reproduced by numerical magnetohydrodynamic modeling

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During periods of northward interplanetary magnetic field (IMF), for the case of IMF $B_y<0$, the dawnside plasma sheet expands poleward in the northern ionosphere, while in the southern ionosphere the duskside plasma sheet expands poleward. At the same time, auroral arcs aligned to the auroral oval are often observed at dawnside high latitudes in the northern hemisphere and at duskside high latitudes in the southern hemisphere. The above-mentioned dawn-dusk relation reverses for the case of IMF $B_y>0$. Although the oval-aligned arcs at high latitudes may simply be an intensification of the poleward boundary of the plasma sheet, an alternative explanation is the plasma sheet “fragments” that have been detached from the main body of the plasma sheet. For the latter case, an open magnetic flux is intruding into the closed flux region on the flankside in the ionosphere, implying an unknown topological structure in the magnetosphere that differs from the basic 2-null, 2-separator topology. We call this ionospheric configuration “plasma sheet isolation.” The purpose of this study is to investigate such plasma sheet isolation by numerical magnetohydrodynamic modeling. Using the REPPU (Reproduce Plasma Universe) code, we unintentionally found a plasma sheet isolation event for the following solar wind and IMF conditions. We first made a steady state magnetosphere with a total IMF intensity of B=6 nT and a clock angle of $\theta=45^\circ$ ($B_y<0$). The solar wind parameters were N=10/cc (density), V=370 km/s (speed), and T=100,000 K (temperature). We then changed the IMF abruptly to B=13 nT and $\theta=70^\circ$ without changing the B_y sign. The figure below shows the polar caps about 70 min after the IMF change. The gray area represents the open magnetic flux region, while the white area shows the closed magnetic flux region. The thin solid lines indicate the contours of electric potentials every 1 kV. Plasma sheet isolation is seen on the dawnside in the northern hemisphere and on the duskside in the southern hemisphere. The plasma sheet isolation started about 50 min after the IMF change and lasted about 40 min. The plasma sheet fragments on the two hemispheres are magnetically conjugate. In the magnetotail, the closed lines threading these fragments are stuck by IMF lines, exhibiting a tangling of field lines. We discuss the origin of such a topological structure in terms of magnetic reconnection. The plasma sheet isolation is a consequence of Dungey-type “crossover reconnection” in the tail plasma sheet that is prohibited in the basic 2-null, 2-separator structure.

Keywords: Plasma sheet isolation, Magnetohydrodynamics, Magnetic field topology

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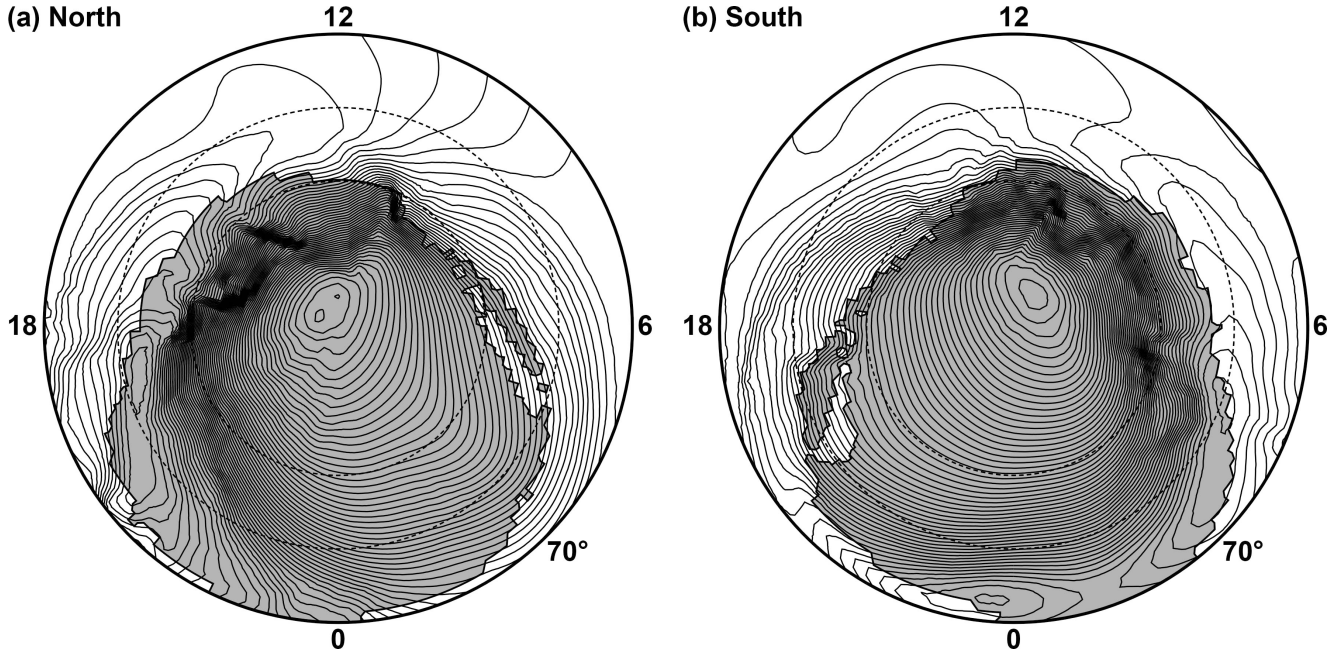

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