電離圏での極冠分岐を生み出す磁気圏磁場トポロジー

Magnetic field topology of the magnetosphere evolving cap bifurcation in the ionosphere

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In a numerically simulated magnetosphere-ionosphere system for northward interplanetary magnetic field (IMF), it often occurs in the ionosphere that an island of open magnetic field lines appears within the dawnside or duskside auroral oval. Consequently, the polar cap looks as if it is divided into two parts. We call this configuration a bifurcated polar cap. The purpose of this study is to investigate magnetic field topology underlying the bifurcated polar cap. For this purpose, using the Reproduce Plasma Universe (REPPU) code, we examined magnetospheric and ionospheric responses for the following two cases and analyzed the magnetic field topology of the simulated magnetosphere.

(1) Response to solar wind or IMF disturbances without IMF By sign change
The disturbances include solar wind density change, IMF intensity change, IMF rotation without By sign change, and so forth. Before the disturbance arrival, the magnetic field topology consists of the basic 2-null, 2-separator structure. After the disturbance arrival, although the basic structure is sustained, each null point transmutes into a cluster of nulls with the same polarity. The null cluster can be regarded as one null point if one sees it on a much larger spatial scale than the cluster diameter (about 1Re). About 1 hour after the disturbance arrival, at the footpoint of the null cluster stemline (the field line connecting the ionosphere and the null), a region of open filed lines protrudes into the adjacent auroral oval with polar cap bifurcation evolving in the ionosphere.

(2) Response to IMF By reversal
In this case, it is well known both in observations and in simulations that a so-called theta aurora forms in the ionosphere. The magnetic topology in this situation consists of four nulls (two nulls corresponding to the old IMF and two nulls corresponding to the new IMF) and four separators connecting them. The bar of the theta aurora drifts across the polar cap from dawnside to duskside (or from duskside to dawnside, depending on the IMF By sign) in about 1 hour. During this transit, the footpoint of the stemline for the old IMF is located on the dayside tip of the drifting theta bar. The polarity of the old null is the same as that of the new null located in the opposite side of the polar cap. When the theta bar arrives at the opposite side auroral oval, the old stemline and the new stemline degenerate into one.

From observations above, the bifurcated polar cap in (1) and the final state in (2) are suggested to be topologically equivalent (homeomorphic). That is, the degeneracy of the four nulls in (2) corresponds to the null clusters in (1). Nearly the same timescale of the two phenomena (about 1 hour) also supports the close relation between the two topologies.

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