Existence of the Region1 field-aligned current system for zero interplanetary magnetic field

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The interaction between the solar wind and the magnetosphere for southward interplanetary magnetic field (IMF) is manifested in the development of the region 1 field-aligned current system and equivalently in the formation of ionospheric two-cell convection. Recent research indicates that the energy source of the region 1 current system is the high-pressure plasma in the magnetospheric cusp. Thus, understanding the cusp formation process is one critical issue in magnetospheric physics. On the other hand, solar activity has been modulating anomalously since solar cycle 23. In particular, a prolongation of the minimum period and a decrease of the maximum have been reported. If this trend continues, the IMF intensity is expected to become very small in the future. Therefore, investigating the cusp for infinitesimal IMF (for which reconnection effects are minimal) in comparison with the 'normal' cusp for southward IMF, contributes significantly not only to better understanding of the solar wind-magnetosphere interaction but also to future prediction of the global environment. For this purpose, we reproduced the magnetosphere under very small IMF using the Reproduce Plasma Universe (REPPU) code [Tanaka, 2015]. In the simulation, a quasi-steady state magnetosphere was produced under the solar wind and IMF conditions of density = 5cm^{-3}, Vx = -370km/s, Bx = 0.0nT, By = -0.05nT, Bz = 0.086nT (total intensity B = 0.1nT and clock angle θ = 30°), and temperature = 340,000K. The simulation reproduced the observed field-aligned current system for small IMF(-0.5nT < Bz < 1.5nT,|By| < 1.5nT) [Watanabe et al,1998]. There exists a clear difference between the cusp for infinitesimal IMF and the cusp for southward IMF. Normally, the cusp consists of the equatorward "load" in which electromagnetic energy is converted to thermal energy and the poleward "dynamo" in which thermal energy is converted to electromagnetic energy. The dynamo on the high latitude side is the energy source for the region 1 current system. Although this structure does not change even for infinitesimal IMF, a salient feature for infinitesimal IMF is the imbalance between the load and the dynamo. In the normal cusp, the load and the dynamo are almost balanced. However, in the cusp for infinitesimal IMF, the load is much smaller than the dynamo. This imbalance implies the existence of more than one energy supply route to the cusp dynamo, with one of them emerging solely for infinitesimal IMF. In the presentation, we report the detailed analysis of the simulation data and discuss the role of the cusp from the point of view of the functional aspect in the solar wind-magnetosphere interaction.

Keywords: field-aligned current, cusp