The Formation of Substorm Aurora in the Solar Wind-Magnetosphere-Ionosphere Coupling System

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Magnetospheric substorms have often been referred to as auroral substorms. Understanding the formation of substorm auroras, the evolution of their morphological structures, and the explosive nature of the aurora displays during the expansion phase is a key unsolved question in substorm study.

A necessary condition for the development of substorms is the accumulation of free magnetic energy in the magnetotail. Thus the question how this energy can be released and converted into accelerated particle energy causing the explosive enhancement of the aurora needs to be answered. We pointed out that a decrease in momentum transfer from the solar wind into the magnetosphere due to, for example, an IMF northward turning, will start a preconditioning stage, and cause force imbalance, producing a net earthward body force acting on the magnetotail. This huge earthward force can cause a large scale movement of the tail towards a more dipole-like configuration, producing disturbances in the tail, such as bursty bulk flows and dipolarization fronts.

We suggest that electrostatic fields are the most efficient and powerful means for auroral particle acceleration during substorm. We will elucidate the generation of parallel electrostatic fields by Alfvenic interaction in the inhomogenous Solar Wind-Magnetosphere-Ionosphere coupling system. The generation of parallel electrostatic fields in the auroral acceleration region and the resulting formation of low-density cavities is a positive feedback process. The continuous large energy supply from Poynting flux during the expansion phase can support long-lasting strong parallel electrostatic fields and create explosive auroral displays.

Keywords: Auroral substorm, Auroral particle acceleration , Generation of electric fields

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