Ions' acceleration in near earth plasma sheet during substorm

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Rapid enhancements of energetic ions during a substorm are one of the unsolved issues in the inner magnetospheric research. Previously, two distinct processes have been suggested to explain the enhancements. The first one is transport from the near-earth plasma sheet, and the other one is local acceleration. To test the latter process, we traced oxygen ions under the electric and magnetic fields that are self-consistently obtained by the global MHD simulation developed by Tanaka et al. (2010, JGR). We focus on acceleration of the oxygen ions that are initially situated at 8.5 Re at midnight in the magnetosphere. Our forward test particle simulation reveals that the ions are efficiently accelerated more than 200 keV in 10 minutes after the substorm onset. Just after the substorm onset, the magnetic field lines have a flux rope-like geometry at 8.5 Re because of presence of IMF B_y. The ions initially looking dawnward moves dawnward along a field line, and then scattered in the kink of a field line. At this first stage, the ions do not gain kinetic energy efficiently because there is no parallel electric potential in the MHD simulation. After scattering, the ions move tailward, then duskward. At this second stage, the ions gain kinetic energy rapidly because they traverse magnetic field lines perpendicularly and existence of the dawn-dusk electric field. The acceleration of the ions is primarily caused by gyro betatron, but drift betatron also participates in the acceleration. To understand the overall influence of the substorm on the magnetospheric energetic ions, we reconstruct the phase space density by tracing the trajectory backward in time until they reach appropriate boundary, namely, the ionosphere and the magnetopause. We will discuss the variation and mechanism.

References

Tanaka, T., A. Nakamizo, A. Yoshikawa, S Fujita, H. Shinagawa, H. Shimizu, T. Kikuchi, and K. K. Hashimoto (2010), Substorm convection and current system deduced from the global simulation, J. Geophys. Res. 115, A05220, doi:10.1029/JA014676.