Ions acceleration and anistropy during the substorms

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Abstract

Observation showed that coherent and nonlinear characteristics of electromagnetic ion cyclotron (EMIC) waves in the magnetosphere. EMIC triggered emissions are excited near the magnetic equator by energetic ions from several keV to tens of keV injected into the inner magnetosphere. Ground and satellite observation reveal that EMIC wave cause precipitation of relativistic electrons. To investigate the region where EMIC excited is important for the understanding of the dynamic of radiation belt. The purpose of this study is to simulate the change of ion's anisotropy during the substorms and investigate the region where the EMIC wave are excited.

We performed test particle simulation under the electric and magnetic fields that are self-consistently obtained by the global MHD simulation developed by Tanaka et al. (2010, JGR). Ions are released in the lobe region with an interval of 1 minutes. The distribution function in the lobe is assumed to be drifting Maxwellian. The temperature is assumed to be 20 eV, the density is 10^5 cm^{-3}, and the parallel velocity is given by the MHD simulation. In total, a few hundreds of millions of particles are traced. Each test particle carries the real number of particles in accordance with the Liouville theorem. After tracing particles, we reconstruct 6-dimensional phase space density of the ions, as well as the directional differential number flux so as to be able to make a direct comparison with in-situ satellite observations. Just after a substorm onset, the differential flux of the ions is rapidly enhanced in the energy range from several keV to a few hundreds of keV on the nightside in the equatorial plane. The region of the enhanced flux propagates duskward, then to dayside because of grad-B and curvature drift of the ions. We also plotted energy versus time spectrograms of the differential flux at a fixed position to make a direct comparison with the CRRES satellite observation. At 7.2 Re and at 22.4 MLT, the ion flux is suddenly enhanced about 10 minutes after the onset. The enhancement appears first at ~100 keV, followed by lower energy as time proceeds. The energy-time dispersion is similar to that observed by CRRES [Fu et al., 2002]. The steepness of the energy-time dispersion depends on the source location of the ions. After a while, a high energy ion flux appears first, followed by that at lower energies. This is a called a drift echo, arising from the ions that encircled the Earth by the grad-B and curvature drift. In addition, we calculated anisotropy of the ions from the simulation result. The anisotropy of ions changes after the substorm onset. The change of anisotropy is due to the non-adiabatic acceleration and transport during substorm. Because the ion's non-adiabatic acceleration is triggered in the limited region, the anisotropy consist mainly of the ions preexisting in that region. We will discuss the generation mechanism of the ion's anisotropy in the course of acceleration and transport processes in more detail. .

Reference

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