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Roles of interaction between the ULF waves and energetic particles in acceleration of relativistic electrons in the Earth's inner magnetosphere

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The geospace storm, or magnetic storm, stands for the largest disturbance of the near-Earth space (geospace). During the geospace storms, various plasma processes facilitate dynamic variations of the geospace environment resulting in major space weather phenomena such as active aurora and drastic decrease and/or increase of relativistic electrons in the Earth's radiation belts. Understanding of dynamic variation of the relativistic electrons consisting of the Earth's outer radiation belt is one of the important problems in the space physics. The Earth's intrinsic magnetic field in the inner magnetosphere is dominated by the dipole component and relativistic electrons are trapped in the magnetic field forming the radiation belts. Typical energy of the source electrons in the magnetotail plasma sheet is several keV, and effective acceleration of the electrons up to the radiation belt energies ~1 MeV is needed. While the radial diffusion of the electrons driven by ULF (Ultra Low Frequency) waves in Pc5 frequency range (1.67-6.67 mHz) has been considered as one of the candidate mechanisms, it is pointed out that the radial transport of relativistic electrons by ULF waves is not necessarily reach the radial diffusion limit and collective motion of the outer belt electrons can exhibit large deviations from the radial diffusion [1]. Particularly, efficiency of the mechanism under realistic ULF distribution in the inner magnetosphere is far from understood because of the lack of the global model to capture both the 3-D distribution of the ULF waves and their interaction with the energetic ions and electrons. Thus it is important to understand the form of radial transport of electrons under realistic ULF distribution in the inner magnetosphere.

In order to overcome the problem, we have developed numerical models of the inner magnetosphere with association of the geospace exploration satellite mission, Arase [2]. The GEMSIS-RC (ring current) model is a self-consistent numerical simulation code solving the five-dimensional collisionless drift-kinetic equation for the ring-current ions in the inner-magnetosphere coupled with Maxwell equations [3]. In order to investigate the characteristics of radial transport of relativistic electrons, we then use the global magnetic and electric fields variation obtained by the GEMNIS-RC model as input field models for the test particle simulations of radiation belt electrons (GEMSIS-RB) [4]. There are three quasi-periodic motions of high-energy charged particles in the inner magnetosphere, i.e., the cyclotron motion around the local magnetic field, bounce motion between northern and southern hemisphere, and drift motion around the Earth by the magnetic drift. The adiabatic invariant corresponding to the first periodic motion is the magnetic moment, and its conservation in the course of the radial transport driven by ULF is assumed in both GEMSIS-RC and RB models.

We first applied the GEMSIS-RC model for simulation of global distribution of ULF Pc5 waves both for externally [5] and internally [6] driven waves. In order to give realistic boundary conditions, we have also developed a one-way model coupling method between a global MHD simulation of the solar wind-magnetosphere interaction, BATS-R-US+CIMI, and GEMSIS-RC [7]. Then the electric and magnetic field variations obtained with GEMSIS-RC is used as inputs to the GEMSIS-RB model to investigate Roles of interaction between the ULF waves and energetic particles in acceleration of relativistic electrons in the Earth's inner magnetosphere. In this presentation, we review our recent results about interaction between the ULF waves and energetic ions and electrons in the Earth's inner magnetosphere.

References

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