RECENT RESEARCH ACTIVITIES

Simulations and Modeling of Geospace Environment

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The Earth is surrounded by the radiation belts that consist of relativistic electrons. The growth and decay of the radiation belts come from the competition between generation and loss processes of energetic electrons. We conducted test particle simulations with a large number of relativistic electrons interacting with electromagnetic ion cyclotron (EMIC) triggered emissions. A substantial amount of relativistic electrons is trapped by the EMIC wave, and guided to lower pitch angles within a short time scale. We demonstrated that the relativistic electrons are efficiently precipitated into the atmosphere, resulting in a rapid loss of the radiation belt [1]. The coherent EMIC triggered emissions are well reproduced by energetic protons with large temperature anisotropy. The optimum wave amplitude and the transition from a linear stage to a nonlinear stage are in a good agreement with theory. A subpacket structure appears because of a new triggering wave [2]. The EMIC waves are found in the deep inner magnetosphere at L=2.5 − 5, based on observations by the Akebono satellite. The mode conversion and rising tone structures are clearly identified, which are consistent with theory [3].

Plasma circulates in the magnetosphere, which is called a magnetospheric convection. As a consequence, hot plasma is transported from the plasma sheet on the nightside into the inner region, resulting in the formation of the ring current and the seed of the radiation belt. A substorm, which is one of the most severe disturbances in the magnetosphere, is known to rapidly supply the hot plasma into the inner magnetosphere. During the interval of a substorm, magnetic field lines are shortened. This is called dipolarization. We found that the dipolarization process does not proceed smoothly during a substorm, and that the electric field oscillates with a period of 2–3 min, resulting in multiple enhancements of low-energy electrons in the course of a substorm [4]. The characteristics of the multiple enhancements of electrons are consistent with observations, and found to be a natural consequence of the force imbalance, not simply due to multiple injections. We also demonstrated for the first time that the direction of the convection electric field is reversed just after a substorm. General tendency of ground magnetic disturbances from pole to equator is similar to that observed. This implies that a substorm is not a simple element of magnetic storms as was suggested about a half century ago because the reversal of the convection impedes transportation of hot plasma from the nightside plasma sheet. The reversal of the convection results from the mutual coupling between the magnetosphere and the ionosphere.

References

[1] Omura, Y. and Q. Zhao, Relativistic electron microbursts due to nonlinear pitch-angle scattering by EMIC triggered emissions, J. Geophys. Res., 118, 5008–5020, doi: 10.1002/jgra.50477, 2013.

[2] Shoji, M. and Y. Omura, Triggering process of electromagnetic ion cyclotron rising tone emissions in the inner magnetosphere, J. Geophys. Res., 118, 5553–5561, doi:10.1002/jgra.50523, 2013.

[3] Sakaguchi, K., Y. Kasahara, M. Shoji, Y. Omura, Y. Miyoshi, T. Nagatsuma, A. Kumamoto and A. Matsuoka, Akebono observations of EMIC waves in the slot region of the radiation belts, Geophys. Res. Lett., 40, doi: 10.1002/2013GL058258, 2013.

[4] Ebihara, Y. and T. Tanaka, Fundamental properties of substorm-time energetic electrons in the inner magnetosphere, J. Geophys. Res., 118, 1589-1603, DOI: 10.1002/jgra.50115, 2013.