RECENT RESEARCH ACTIVITIES

Simulations and Modeling of Geospace Environment

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Recent observations of plasmaspheric hiss emissions by the Van Allen Probes show that broadband hiss emissions in the plasmasphere comprise short-time coherent elements with rising and falling tone frequencies. Based on nonlinear wave growth theory of whistler mode chorus emissions, we have examined the applicability of the nonlinear theory to the coherent hiss emissions. We have generalized the derivation of the optimum wave amplitude for triggering rising tone chorus emissions to the cases of both rising and falling tone hiss elements. The amplitude profiles of the hiss emissions are well approximated by the optimum wave amplitudes for triggering rising or falling tones. Using the theory, we can infer properties of energetic electrons generating hiss emissions in the equatorial region of the plasmasphere.

We perform test particle simulations of energetic electrons interacting with whistler mode chorus emissions. We compute trajectories of a large number of electrons forming a delta function with the same energy and equatorial pitch angle. The electrons are launched at different locations along the magnetic field line and different timings with respect to a pair of chorus emissions generated at the magnetic equator. We follow the evolution of the delta function and obtain a distribution function in energy and equatorial pitch angle, which is a numerical Green's function for one cycle of chorus wave-particle interaction. By taking the convolution integral of the Green's functions with the distribution function of the injected electrons repeatedly, we follow a long-time evolution of the distribution function. We find the rapid formation of a dumbbell distribution of highly relativistic electrons within a few minutes after the onset of the continuous injection of 10–30 keV electrons.

Sudden brightening of aurora can be seen in the polar region at night. This phenomenon is called auroral breakup, and is a visible manifestation of a substorm. When the substorm takes place, the near-Earth space environment is severely disturbed. For example, energetic particles are injected into the near-Earth space, which can be a seed of radiation belt electrons. Large-scale current system is also developed, which can induce electric current in the power grid system on the ground. The substorm has been a challenging problem since the definition of a substorm was made in 1964. We utilized a global magnetohydrodynamics (MHD) simulation, and suggested the generation mechanism. The mechanism is quite different from previously suggested ones, but can explain many related phenomena reasonably (Figure 1) throughout the substorm from quiet time to substorm expansion [3][4][5]. Large-scale redistribution of the state of the magnetosphere and the magnetosphere-ionosphere coupling are found to be essential to cause the substorm.

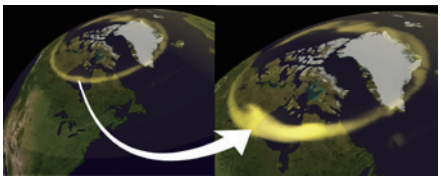

Figure 1. Simulated auroral breakup.

References

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