Plasma fluid and electron-hybrid cross-reference simulations for the study of the resonant scattering of auroral electrons by whistler-mode chorus emissions

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It has been widely accepted that whistler-mode chorus emissions play important roles in scattering energetic electrons into the loss cone in the magnetosphere. Recent studies suggest that the periodicities of pulsating aurora can be explained by the characteristic time scale of chorus. For the quantitative study of the relation between chorus and auroral activities, numerical experiments enable us to simulate realistic properties of precipitation and resultant auroral emissions in the polar ionosphere.

In the present study, we have been developing a simulation code combining a plasma fluid code and a plasma particle code for the investigation of the temporal and spatial variations of auroral emissions due to energetic electrons precipitated from the magnetosphere through the resonant interaction with whistler-mode chorus emissions. For the resonant scattering process of energetic electrons by chorus, we use simulation results of whistler-mode chorus by an electron hybrid code [e.g, Katoh and Omura, 2007] and a plasma fluid code [Katoh, 2014]. The simulation results demonstrate that chorus emissions propagate parallel to the magnetic field line around the equator and become oblique during the propagation in the region away from the equator. The spectral and propagation properties of chorus govern the resonant scattering of energetic electrons in the magnetosphere and therefore should control the time scale and the flux of the energetic electron precipitation. In particular, results of our recent study revealed the importance of the mirror force acting on resonant particles in wave-particle interactions in the magnetosphere. In this paper we reort the current status of the development of the combination simulation code of a plasma fluid code and a plasma particle code. The plasma fluid code is used for the propagation of whistler-mode chorus in the meridional plane of the inner magnetophsere. We solve the motion of energeitc electrons by the plasma particle code, where we apply the method used in the simulation of the chorus generation process [e.g., Katoh and Omura, 2007] in order to treat the mirror force acting on the precipitating electrons, which enables us to solve the variation of the pitch angle of the electrons during their precipitation. We also employ a module computing the altitude distribution of the auroral emissions by precipitating energetic electrons in the polar ionosphere. We use the Monte Carlo method to derive the ionization rate by the precipitating electrons, as has been used in previous studies [e.g., Hiraki and Tao, 2008]. By combining the developed module and the chorus simulations, we study the time scale and intensity of auroral emissions due to the energetic electron precipitation by chorus emissions.

Furthermore, we have started to develop the framework for cross-reference simulations using different types of simulation codes. Since the chorus simulations require much computational resources, we need to carry out simulations on supercomputers but we have to overcome difficulties related to the data exchange between the simulations running on the different CPU/memory space. We present the developing framework which enables us to realize the data exchange among the simulations and its initial results using both electron hybrid and fluid code simulations.

References

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