コーラス放射との共鳴散乱による降下電子とオーロラ発光についての計算機実験

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Simulation study of the auroral electron precipitation by whistler-mode chorus in the magnetosphere and resultant auroral emissions

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By plasma particle code simulations, we study 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. It has been widely accepted that whistler-mode chorus emissions play important roles in scattering energetic electrons into the loss cone in the magnetosphere and that the energetic electrons precipitated into the polar ionosphere generate diffuse aurora. Recent studies suggest that the periodicities of pulsating aurora can be explained by the characteristic time scale of whistler-mode chorus emissions observed in the inner magnetosphere. For the quantitative study of the relation betweeen chorus emissions and auroral activities, numerical experiments enable us to simulate realistic properties of energetic electron precipitation and resultant auroral emissions in the polar ionosphere. In the present study, we conduct plasma particle code simulations for both the resonant scattering process between whistler-mode chorus and energetic electrons and the computation of auroral emissions by energetic electrons precipitated into the polar ionosphere.

For the resonant scattering process of energetic electrons by chorus, we use simulation results of whistler-mode chorus by electron hybrid code [e.g, Katoh and Omura, 2007] and electron fluid code [Katoh, 2014]. In the electron fluid code, we assume the spatially two-dimensional simulation system in a meridional plane of the magnetosphere and reproduced the propagation properties of chorus, such as the wave normal angle and wave amplitude. The simulation results demonstrate that chorus emissions propagate parallel to the magnetic field line around the eqautor and become oblique during the propagation in the region away from the equator. We also reproduced the duct propagation of chorus emissions along a field line of the local density enhancement or depletion of cold plasma. The wave spectra obtained in the simulation results show subpacket-like fine structures, whose characteristics varied significantly depending on the density distribution of cold plasma. The spectral 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. We solve the motion of energetic electrons in the simulation results of Katoh [2014] and study the resonant scattering process quantitatively.

In addition, we develop a module computing the altitude distribution of the auroral emissions by precipitating energetic electrons in the polar ionosphere. In the developed module, we consider the mirror force acting on the precipitating electrons by the method used in the simulation of the chorus generation process [e.g., Katoh and Omura, 2007] and thereby the variation of the pitch angle of the electrons during their precipitation. 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 whistler-mode chorus emissions.

References

Hiraki, Y. and C. Tao, Parametrization of ionization rate by auroral electron precipitation in Jupiter, Ann. Geophys., 26, 77-86, 2008.

Katoh, Y., A simulation study of the propagation of whistler-mode chorus in the Earth's inner magnetosphere, Earth Planets Space, 66, 6, 2014.

Katoh, Y. and Y. Omura, Computer simulation of chorus wave generation in the Earth's inner magnetosphere, Geophys. Res. Lett., 34, L03102, 2007.