コーラス放射によるオーロラ降下電子のピッチ角散乱と
オーロラ発光高度でのピッチ角分布について

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Study of the resonant scattering of auroral electrons by whistler-mode chorus emissions and the pitch angle distribution at an alitude of auroral emissions

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We have been developing a simulation code by combining a plasma particle code with a Monte Carlo module of electron-neutral collisions. The main purpose of the present study is 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. It has been widely accepted that 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.

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 an electron 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 focus on the effect of the mirror force on the motion of precipitating electrons in the altitude range lower than 300 km. We have been developing a module computing the altitude distribution of the auroral emissions by precipitating energetic electrons in the polar ionosphere. In the developed module, we employ 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 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]. We carry out a series of simulations for altitude profiles of the ionization rate for different pitch angle distributions of precipitating electrons at an altitude of 300 km, where the loss cone angle becomes ~70 degree. In a case that the pitch angle distribution of precipitating electrons is uniformly distributed from 0 to 90 degree, the peak altitude of the ionization rate is found at 120 km. On the other hand, in a case that electrons are only distributed in the pitch angle range larger than the loss cone (70 degree at 300 km), the peak altitude of the ionization rate shifts at 130 km, because most of particles did not reach the lower altitude region due to the presence of the mirror force. 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

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