Wave amplitude dependence of electron precipitation for pulsating aurora: Test-particle simulations

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Pulsating aurora is a kind of diffuse aurora with pulsation of a few Hz. The optical emission of pulsating aurora is due to intermittent electron precipitation into the atmosphere from the outer radiation belt of the earth's magnetosphere. Whistler mode chorus waves generated in the magnetosphere are a plausible candidate to scatter the trapped radiation belt electrons into the loss cone. The electrons in the loss cone precipitate into the atmosphere and cause the emission of the pulsating aurora. Miyoshi and Saito *et al.* (2015) found using the test-particle simulation that the electron precipitation by whistler chorus waves could produce the fine structure of the energy spectrum of precipitating electrons observed by the low-altitude Reimei satellite. Kasahara and Miyoshi *et al.* (2018) found the direct evidence of relationship between pulsating aurora and the electron flux enhancement inside the loss cone accompanied with whistler chorus emission from the Arase observations and the ground-based observations. It has been becoming clear that whistler mode chorus waves are a cause of pulsating aurora.

Quasi-linear diffusion theory by the cyclotron resonance suggests that higher wave amplitudes of whistler mode wave simply increase the electron precipitation flux before reaching the strong diffusion limit. However, Kitahara and Katoh (2019) propose that a Lorentz force by the finite amplitude magnetic fluctuation of whistler mode wave scatters electrons away from the loss cone. It indicates that the finite amplitude effect on the pitch angle scattering reduces the electron flux in the loss cone. The scattering model suggests the opposite effect on the electrons in the loss cone as proposed by quasi-linear diffusion model. Another scattering process of the electrons associated with the finite amplitude whistler mode wave is the nonlinear phase trapping process (Omura *et al*., 2007 and Bortnik *et al*., 2008). The phase trapping process increases electron kinetic energy with increasing pitch angle. Thus, the phase trapping process would contribute to the electron scattering away from the loss cone. However, the contribution of the phase trapping for the flux reduction in the loss cone has not yet been systematically examined and the important role of the phase trapping process for the electron precipitation is still unclear.

In this study, test-particle simulations by GEMSIS-RBW (Saito, Miyoshi, and Seki, 2012) are carried out to study the influence of the finite amplitude whistler chorus mode waves on energetic electrons precipitation. The simulations show that the electron flux close to the loss cone are reduced by scattering away from the loss cone when the whistler mode chorus waves nonlinearly trap the electrons in the wave phase. The trapped electrons increase their kinetic energy with increasing pitch angle. The parameter study as a function of the wave amplitude indicates that the nonlinear scattering process has an important role for the suppression of the electron precipitation. The amount of electron precipitation flux is not a linear function of the wave amplitude of whistler mode chorus waves. The high amplitude whistler mode chorus waves could reduce the electron precipitation flux and the emission of pulsating aurora.

References

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