Gyro-averaging method for simulation of whistler-mode wave-particle interactions at oblique angles

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Whistler-mode chorus waves propagating with oblique normal angles have been observed by many satellite missions in the Earth' inner magnetosphere. In this study, we have analyzed the propagation condition of an obliquely propagating coherent wave, and have developed a wave model with the whistler-mode dispersion relation. Solving the equations of motion of relativistic electrons interacting with the wave, we perform test particle simulations of energetic electrons along the Earth's inner magnetosphere field line to reveal the interactions between oblique whistler-mode waves and energetic electrons. By confirming that the Poynting vector of oblique whistler-mode wave is nearly parallel to the background magnetic field, we apply gyro-averaging method, which just treat particle motion as its guiding center motion to simplify the complicated cyclotron motion and reduce the simulation system from 2 dimension to 1 dimension. This method was successfully examinated in a recent study [1]. We can achieve higher numerical efficiency through this gyro-averaging method than the method which we directly solved the 2 dimensional equations of motion. In the simulation, the energetic electrons undergo multiple cyclotron resonances. The simulation result shows the validity of gyro-averaging method, how the waves trap and accelerate the energetic electrons, and how the waves develop after the interactions.

Reference:

[1] Nunn and Omura (2015), A computational and theoretical investigation of nonlinear wave-particle interactions in oblique whistlers, J. Geophys. Res. Space Physics, 120, doi:10.1002/2014JA020898.