Test particle simulation of interactions between relativistic electrons and obliquely propagating whistler-mode waves

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We carry out test particle simulations of relativistic electrons interacting with large-amplitude and obliquely propagating whistler-mode waves in the Earth's inner magnetosphere. Recent observation shows that large-amplitude whistler-mode waves propagating obliquely with respect to the ambient magnetic field may be responsible for energizing radiation belt electrons to relativistic energies (MeV) within a time scale shorter than a second [Cattell et al., 2008]. By referring observation results of large-amplitude whistler-mode waves in the magnetosphere, we study the acceleration mechanism of relativistic electrons through the resonant interactions. We expect that the cyclotron resonance plays important roles for interactions between energetic electrons and whistler-mode waves propagating parallel to the background magnetic field, while the Landau resonance becomes important in the interaction with obliquely propagating whistler-mode waves.

For the study of resonant interactions, we develop a test particle simulation code to solve motion of energetic electrons in the presence of whistler-mode waves. We first assume a monochromatic whistler-mode wave of frequency of 0.2 fce, where fce is the electron gyrofrequency. The wave amplitude is assumed to be 1 % of the intensity of the background magnetic field. We assume relativistic electrons having the initial kinetic energy of 0.66 MeV with various initial pitch angles. For the case of monochromatic whistler-mode waves propagating purely parallel to the background magnetic field, a part of resonant electrons are trapped by the waves and are oscillate in the velocity space. The oscillation can be estimated by the trapping velocity and is typically less than 0.01% of its initial velocity under the condition assumed in the present study. Next, we assume a finite wave normal angle for the whistler-mode waves in the simulation system, in which Landau resonance with the longitudinal wave component occurs simultaneously. By assuming various properties of whistler-mode waves such as wave frequency, wave normal angle, and wave amplitude, we quantitatively evaluate the effect of wave characteristics on the resonant interaction process between energetic electrons and obliquely propagating whistler-mode waves.