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Acceleration of energetic electrons by oblique whistler-mode chorus in the radiation belt

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We perform test particle simulations for relativistic electrons interacting with a whistler-mode chorus packet propagating at oblique angles. The properties of group velocity of obliquely propagating whistler mode waves are analyzed. The group velocity of lower band chorus is nearly parallel to the magnetic field, which justify the gyroaveraging method. In the gyroaveraging method, we calculate the equations of motion of electrons averaging the cyclotron motion at gyrocenter and reducing the simulation from two-dimensional system to one-dimensional system. In the simulations, we found that multiple resonances are essential in electron accelerations. We trace evolution of a delta function of relativistic electrons in a phase space of kinetic energy and equatorial pitch angle, and then obtain numerical Green's functions of the chorus wave-particle interactions. The efficiency of the MeV electron acceleration by the Landau resonance is confirmed by examining the Green's functions in a wide range of kinetic energies. We investigate the rate of energy gain of the cyclotron resonance acceleration and the Landau resonance acceleration, and find that the perpendicular component of wave electric field dominates both accelerations for MeV electrons. Furthermore, we find that the efficient acceleration of MeV electrons is contributed by the proximity between the parallel components of V_p and V_g of oblique whistler mode waves. The proximity makes the interaction time of the Landau resonance much longer than that of the cyclotron resonance, resulting in efficient acceleration of MeV electrons.

Keywords: Whistler mode waves, Relativistic electrons, Landau resonance

