Dynamics of relativistic electrons interacting with whistler mode chorus emissions in the outer radiation belt

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Nonlinear whistler mode wave-particle interaction is one of the processes to generate energetic electrons in the Earth's outer radiation belt. Applying test particle simulations with a large number of electrons and a pair of whistler mode chorus emissions generated at the magnetic equator, we traced the electrons in various initial energies, pitch angles, gyrophases, and locations along a L=4.5 magnetic field line to build a set of Green's functions to analyze the electron distribution functions in a kinetic energy and pitch angle phase space. Setting up the initial distribution function and then employing convolution integral, we can track the evolution of the electrons as interacting with consecutive chorus emissions. We compare the simulation results among three wave models. The first one is a pure parallel wave model. The others are oblique wave models with gradually increased wave normal angles and the maximum wave normal angles are 20 degree and 60 degree. Multiple resonances result in higher probability of nonlinear trapping of electrons and the different tendency of pitch angle scattering. Hence the trapped electrons for the oblique cases are scattered to a wider range of pitch angles than those for the parallel case. In addition, owing to the subpacket structure of the waves, a single electron has a chance to be trapped by different resonances during the lifetime of an oblique wave. Oblique chorus emissions can accelerate 10-30 keV electrons to MeV level rapidly in a few wave cycles, which is much faster than that of the parallel emission. In case of larger time scale, the pure parallel wave can accelerate electrons to more than 6 MeV. However, electrons with energy greater than 3 MeV cannot receive much energy from the oblique waves neither via cyclotron resonance nor Landau resonance. Therefore, when electrons reach MeV level, the acceleration rate becomes much slower, and the electrons only reach about 4 MeV after hundred cycles interacting with the oblique waves. This study first shows evolution of the radiation belt electron flux through nonlinear interactions with oblique chorus emissions.