Pitch Angle Scattering of Energetic Electrons by Plasmaspheric Hiss Emissions

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We study scattering of energetic electrons in pitch angles and kinetic energies through their resonance with plasmaspheric hiss emissions consisting of many coherent discrete whistler-mode wave packets with rising and falling frequencies. Using test particle simulations, we evaluate the efficiency of scattering, which depends on the inhomogeneity ratio S of whistler mode wave-particle interaction. The value of S is determined by the wave amplitude, frequency sweep rate, and the gradient of the background magnetic field. We first modulate those parameters and observe variations of pitch angles and kinetic energies of electrons with a single wave under various S values so as to obtain basic understanding. We then include many waves into the system to simulate plasmaspheric hiss emissions. As the wave packets propagate away from the magnetic equator, the nonlinear trapping potential at the resonance velocity is deformed, making a channel of gyrophase for untrapped electrons to cross the resonance velocity, and causing modulations in their pitch angles and kinetic energies. We find efficient scattering of pitch angles and kinetic energies because of coherent nonlinear wave-particle interaction, resulting in electron precipitations into the polar atmosphere. We compare the results with the bounce averaged pitch angle diffusion coefficient D_{aa} based on quasi-linear theory, and show that the nonlinear wave model with many coherent packets can cause scattering of resonant electrons much faster than the quasi-linear diffusion process.