Electron acceleration by chorus emissions in the Earth's inner magnetosphere

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It has been reported that the fluxes of relativistic electrons in the Earth's inner magnetosphere are related to magnetic storms. Typically, for many storms the electron fluxes diminish rapidly during the main phase of the storm, and subsequently, during the recovery phase of the storm, fluxes increase to beyond prestorm levels and peak about 4 days after the initiation of the storm. It is becoming apparent that electrons are accelerated to relativistic energies in the inner magnetosphere. As a result of substorm activity, electrons with energies up to 300 keV are injected near geosynchronous orbit, and these electrons seem to be accelerated by whistler mode chorus emissions which are frequently observed during geomagnetic storms. However, any detailed understanding of such acceleration mechanism has not been obtained yet. Although some of the recent studies assume that the acceleration is due to a stochastic diffusion process by broadband whistler waves, close examination of whistler mode chorus emissions reveals that a chorus emission is a coherent monochromatic wave with a fast rising tone. The frequency of the emission increases rapidly along with growth of the wave amplitude. We first review past studies on the generation mechanism of whistler mode chorus emissions. The essential mechanism of the frequency change is critically related to the inhomogeneity of the geomagnetic field in the equatorial region. The rising tone emission is only possible, when the coherent wave propagates away from the equator interacting with counter-streaming resonant electrons. We performed test particle simulations where we solved relativistic equations of motion for high energy electrons under the electromagnetic fields of a coherent whistler mode wave and the dipole geomagnetic field. We find resonant trapping of high energy electrons by a whistler mode wave with a rising tone results in efficient acceleration of resonant particles to relativistic energy.