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Relativistic Electron Acceleration by Whistler-mode Chorus Emissions

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Energetic electrons in the energy range 10 - 100 keV are injected into the inner magnetosphere at times of magnetic disturbances such as magnetic storms and sub-storms. The electrons are trapped by the Earth's dipole magnetic field, and are primarily responsible for the generation of a special form of electron cyclotron waves called whistler-mode chorus emissions through the linear and nonlinear instabilities driven by the temperature anisotropy at the magnetic equator. It has been found that a fraction of the higher-energy electrons from a few hundred keV to a few MeV are effectively accelerated by chorus due to a nonlinear trapping process called relativistic turning acceleration (RTA). The MeV electrons are further accelerated by the nonlinear trapping moving in the same direction of the wave phase velocity, which is called ultra-relativistic acceleration (URA). The RTA and URA processes due to chorus emissions create a high-energy tail in the electron energy distribution function. The RTA and URA can accelerate electrons in a much shorter timescale than that estimated by quasi-linear diffusion theory, e.g., it typically takes tens of minutes to hours for a few hundred keV seed electrons to be accelerated to energies of a few MeV.

Keywords: whistler-mode wave, chorus emissions, relativistic electrons,
nonlinear wave-particle interaction, inner magnetosphere, cyclotron resonance