Self-consistent particle simulation of falling tone emissions via nonlinear wave-particle interactions

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We perform one-dimensional electromagnetic particle simulations, to study fundamental processes of whistler-mode wave propagation from the equator and their interaction with energetic electrons. Approximating the dipole magnetic field by a parabolic magnetic field, we assume a cylindrical model for particle dynamics with a parabolic magnetic field taken along the axis of the cylinder, while we solve Maxwell's equations including Poisson's equation on the axis. The parallel electrostatic field, which has been neglected in most studies on whistler-mode chorus emissions, is included in the simulation. We put an antenna perpendicular to the background magnetic field, and oscillate the antenna current at fixed frequencies with different duration.

We observe falling tone emissions for a short triggering pulse with a frequency close to half the electron cyclotron frequency. We also find rising tone emissions is generated with a long triggering pulse. Through the process of falling tone emissions, we find entrapped particles generates the resonant current parallel to the wave magnetic field, which decreases the frequency of the seed waves near the equator. By changing the wave frequency and the length of the triggering wave packet, we can control the occurrence of rising and falling tone emissions.