コーラス放射バンド構造の生成機構と高エネルギー電子の非線形加速

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Generation of lower-band and upper-band chorus emissions and associated acceleration of energetic electrons

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Whistler-mode chorus emissions characteristically occur in two distinct frequency ranges, a lower band and an upper band, separated at half the electron cyclotron frequency. In the source region of chorus emissions near the magnetic equator, a wide-band rising-tone emission is generated without any gap at the half the cyclotron frequency. As the chorus wave packet propagates away from the equator, the wave normal angle gradually deviates from the parallel direction, and there occurs nonlinear trapping of electrons via Landau resonance. Electrons trapped by Landau resonance gain energies from waves. The Landau resonance velocity becomes very close to the group velocity of nearly parallel whistler mode waves at frequencies around half the electron gyrofrequency, resulting in a long time of wave-particle interactions and wave damping.

We perform test particle simulations with parameters at L = 5 and a small wave normal angle to study the wave-particle interactions via the Landau resonance. Analyzing the wave electric fields and the resonant currents formed by electrons undergoing Landau and cyclotron resonances, we find that effective wave damping and resonant electron acceleration occurs near half the electron gyrofrequency. This nonlinear wave damping is contributed by Landau resonance rather than cyclotron resonance.

Furthermore, we confirm that this damping and associated electron acceleration is dominated by perpendicular components of wave electric field and perpendicular resonant currents [Hsieh and Omura, 2018]. The simulation results indicate that nonlinear damping via Landau resonance can divide chorus emissions into the upper band and the lower band. Another mechanism enhancing the separation of the lower and upper bands is a significant difference of propagation characteristics in these bands. The Gendrin angle, at which the oblique waves propagate parallel to the magnetic field, does not exist in the upper band. Therefore, the wave packet of the upper band chorus propagates away from the original magnetic field line, being observed as an independent wave packet entirely separated from the lower band.

Reference:

Hsieh, Y.-K. and Y. Omura, Nonlinear damping of oblique whistler mode waves via Landau resonance, submitted to J. Geophy. Res. Space Physics, 2018.