URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

Generation Mechanisms of Whistler-mode Chorus and Electromagnetic Ion Cyclotron Rising-tone Emissions

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We give a brief review of the nonlinear wave growth theory of whistler-mode chorus emissions [1, 2]. We describe the nonlinear dynamics of resonant electrons, and the formation of the electromagnetic electron "hole" that results in resonant currents generating rising-tone emissions. We have theoretically derived threshold and optimum wave amplitudes for the nonlinear wave growth of rising-tone emissions. There occurs nonlinear wave growth as an absolute instability above the threshold amplitude near the equator, and the wave grows rapidly along with frequency increase. The nonlinear wave growth saturate around the optimum amplitude, and the wave amplitude damps to the level of the threshold amplitude. The nonlinear wave growth process is repeated, resulting in a rising-tone chorus element with subpacket structures. As the wave packet propagates away from the equator, it undergoes nonlinear convective growth. The profiles of these wave amplitudes as functions of frequencies agree well with those from observations and simulations. As the wave packet propagates away from the equator, it undergoes efficient nonlinear convective growth. The wave normal angle gradually deviate from the parallel direction, and there occurs nonlinear wave damping at half the cyclotron frequency, separating the chorus element into lower-band and upper-band emissions [3].

The nonlinear wave growth theory of chorus emissions can be applied to the generation mechanism of electromagnetic ion cyclotron (EMIC) wave emissions [4]. Hybrid code simulations have confirmed that coherent rising-tone emissions are generated by energetic protons at frequencies below the proton cyclotron frequency through formation of electromagnetic ion holes [5].

Both chorus and EMIC emissions are generated near the magnetic equator, and they propagate along the magnetic field to the ground. Characteristics of these wave spectra are not affected much through propagation to the ground. The ground observations of these wave spectra can give us important clues for remote sensing of plasma conditions in the equatorial magnetosphere.

Acknowledgements

This work was supported by JSPS KAKENHI grant 17H06140.

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