フォーリングトーンコーラスの生成領域

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Source location of falling tone chorus

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Chorus is characterized by the fine structure consisting rising or falling tones [e.g., Burtis and Helliwell, 1969, Santolik et al., 2003] believed to result from nonlinear wave-particle interactions [Nunn 1974, Omura et al., 1991, Trakhtengerts, 1999]. Using the THEMIS observations, Li et al. [2011] investigated typical properties of rising and falling tone chorus and showed that rising tones are typically field aligned, whereas falling tones are highly oblique and have much small magnetic amplitudes compared with rising tones. Based on the results, Li et al. [2011] suggested that two separate excitation mechanisms might be responsible for the generation mechanism of rising and falling tone chorus. Most of theoretical models of chorus generation have assumed that the waves propagate parallel to the ambient magnetic field and their source is located at the magnetic equator [e.g., Nunn et al., 1997, 2009; Katoh and Omura, 2007; Hikishima et al., 2009]. The models have successfully reproduced rising tone elements, while falling tone chorus elements are produced by only few studies [Nunn et al., 1997; Nunn et al., 2009]. It is important to investigate the propagation characteristics and source location of falling tone chorus to construct a precise generation model. In this study, using the waveform data obtained from the THEMIS spacecraft, a spatial survey of the propagation characteristics of falling tone chorus is conducted. The periods for which falling tone chorus is detected are selected from the waveform data set (one set lasting ~8second) based on the criteria used by Li et al. [2011]. The wave normal angle and the Poynting vector are computed on each falling tone chorus event, and the propagation directions respect to the ambient magnetic field are determined. The result shows that the falling tone chorus observed by THEMIS generally propagates away from the magnetic equator, suggesting that the source location of the falling tone chorus is located at the magnetic equator. Recent studies on comparison of theory with simulation and observation of rising tone chorus show that the rising tone chorus is generated at the magnetic equator [Hikishima et al., 2009; Katoh and Omura, 2011; Cully et al., 20011]. Our result suggests that the different properties between rising and falling tone chorus are originated from its generation process rather than source region. The falling tone chorus emissions observed by the THEMIS spacecraft often emerge from quasi-electrostatic (highly oblique) whistler-mode waves. Based on the theoretical models, a whistler-mode wave propagating in the field aligned direction contributes to formation of the resonant current through the nonlinear cyclotron resonant trapping, which results in the nonlinear amplification and frequency variation of a chorus element [e.g., Omura et al., 1991]. For whistler-mode waves propagating in the field aligned direction, only the lowest resonant wave-particle interaction is effective. While, higher order resonant interactions and the Landau resonance can occur for obliquely propagating whistler-mode waves, resulting in increase in resonant electrons [Kennel, 1966]. It is supposed that the dynamics of resonant electrons in the wave phase space caused by highly oblique whistlers are quite different from the nonlinear cyclotron resonant trapping by field-aligned whistlers. Thus, falling tone chorus would not be a simple inverse version of rising tone chorus. The THEMIS observations suggest that the existing models cannot directly apply to explain the generation of the falling tone chorus since the assumptions adopted to construct the existing models are invalid. Models for falling tone chorus generation should be account for the nonlinear resonant interactions with oblique whistler-mode waves.