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Evaluation of nonlinear growth of chorus emissions observed by Geotail

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We analyze the generation and propagation of chorus emissions observed by the wave form capture onboard the Geotail spacecraft. The specific relationship between amplitude variation and frequency shift has been predicted by the nonlinear growth theory [1]. Such relationship has been observed for the chorus emissions reproduced by simulations [2][3]. We examine if any observational evidence of the nonlinear growth of chorus emissions is found in Geotail chorus data.

We analyze the wave form data of the chorus emissions observed by Geotail mainly in the Earth's dayside outer magnetosphere (L from 9 to 10) to analyze the relationship between "amplitude multiplied by frequency" and "frequency sweep rate," of each chorus element predicted by the nonlinear growth theory. We apply Analytic Signal Method (ASM) to calculate the instantaneous amplitude and frequency of the chorus emissions, and a band pass filter with the center frequency dynamically adapted to the frequency variation to extract each chorus element for filtering out the background noise. As a result, we find positive correlation between "amplitude multiplied by frequency" and "frequency sweep rate," which is consistent with that predicted by the nonlinear growth theory.

We also investigate the propagation of chorus emissions from their generation region to the spacecraft. We have found a chorus event with a clear gap at around half of the gyrofrequency. We assume that the upper cutoff of the lower band element indicates the half-grofrequency at the generation region, while the lower cutoff of the upper band element indicates the value at the observation point. Then, we calculate the variation of gyrofrequency with the geomagnetic latitude by using the Tsyganenko geomagnetic field model. The minimum-B region is found at 25 degrees northward of the geomagnetic equator, where the half-gyrofrequency coincides with the upper cutoff of the observed lower-band chorus element. Furthermore, we evaluate the expected amplitude of the chorus element in the generation region, as well as the nonlinear growth during propagation toward the spacecraft, which are found to be consistent with those predicted by the nonlinear growth theory [2][3]. Additionally we show that the half-gyrofrequency damping of chorus emissions would be possible based on the observed amplitude of the chorus emissions [4].

Thus, we demonstrate that the observed chorus emissions in the Earth's magnetosphere exhibit the nonlinear growth features consistent with the nonlinear growth theory.

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Keywords: Geotail spacecraft, Chorus emission, Nonlinear growth, Amplitude, Frequency sweep rate, Generation and propagation