Bayesian Spectral Analysis of Chorus Sub-Elements

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We develop a Bayesian spectral analysis technique that calculates the probability distribution functions of a superposition of wave-modes each described by a linear growth rate, a frequency and a chirp rate. The Bayesian framework has a number of advantages, including 1) reducing the parameter space by integrating over the amplitude and phase of the wave, 2) incorporating the data from each channel to determine the model parameters such as frequency which leads to high resolution results in frequency and time, 3) the ability to consider the superposition of waves where the wave-parameters are closely spaced, 4) the ability to directly calculate the expectation value of wave parameters without resorting to ensemble averages, 5) the ability to calculate error bars on model parameters. We examine one rising-tone chorus element in detail from a disturbed time on November 14, 2012 using burst mode waveform data of the three components of the electric and magnetic field from the EMFISIS instrument on board NASA's Van Allen Probes. The results of the analysis demonstrate that whistler mode chorus sub-elements are composed of almost linear waves that are nearly parallel propagating with continuously changing wave parameters such as frequency and wave-vector. The change of wave-vector as a function of time is a three-dimensional phenomenon suggesting that 2D simulations may not accurately represent chorus. The initial parts of the sub-elements are in good agreement with the analytical theory of Omura *et al.* 2008. However, between sub-elements the wave parameters of the dominant mode undergo discrete changes in frequency and wave-vector. Near the boundary of sub-elements multiple waves are observed such that the evolution of the waves is reminiscent of wave-wave processes such as parametric decay or induced scattering by particles. These nonlinear processes are signatures of weak turbulence and may affect the saturation of the whistler-mode chorus instability.