Diagnosing Parameters of Nonlinear Whistler Mode Growth in the Magnetosphere from Observations of Relative Phase of Sidebands of Triggered Emissions

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The Siple Station Antarctic Transmitter was operated in the years 1973-1988 to inject ELF/VLF waves into the Earth's magnetosphere to study whistler mode wave-particle interactions. Waves were injected into the magnetosphere from a ground based antenna 40 km long. The waves were subsequently observed at the conjugate point in Canada after propagating in the ducted mode in the magnetosphere and experiencing nonlinear growth and triggering of emissions driven by cyclotron resonance interactions with radiation belt electrons. Ina subset of the observations single frequency input waves were seen to trigger quasi-symmetric sidebands with 20-70 Hz separation from the injected frequency tone. While the amplitude of such magnetospherically generated sidebands has been treated before, little work has examined the relative phase of the sidebands. We analyze the sidebands using concepts from communication theory of amplitude (AM) and frequency (FM) modulation. We use a hybrid AM/FM model along with the MINUIT minimization package to quantify the relative phase of the observed sidebands and its evolution as the main input frequency undergoes nonlinear growth. The results are discussed in the context of the nonlinear whistler mode growth theory based on particle phase trapping and formation of an electron phase-space hole. Coherent oscillations of electrons in a phase-space trap are shown to generate sidebands similar to those in observations. Observations of sidebands can be used to put bounds on the collective inhomogeneity parameter and the degree of phase coherence in the phase-space trap.