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Nonlinear Whistler Wave Physics in the Laboratory and in the Radiation Belts

Chris Crabtree[1], Gurudas Ganguli[1], Erik Tejero[1]
[1] U.S. Naval Research Laboratory
e-mail: chris.crabtree@nrl.navy.mil

Recent experiments in the Space Physics Simulation Chamber at NRL on the interaction of electron beams with whistler waves revealed interesting new wave dynamics such as (1) large sub-packet amplitude modulations, (2) discrete changes in frequency between sub-packets, (3) multiple chirping waves at nearby frequencies, and (4) parametric decay of chirping whistlers. These experiments inspired a reanalysis of high time resolution waveform data from the Van Allen Probes of whistler mode chorus in the Earth's outer radiation belts. In this analysis, we developed a Bayesian spectral analysis technique that takes into account the fact that waveforms are not stationary by developing time-domain models for the waves. It uses all six channels of data to make precise spectral determinations. The results of this analysis revealed many features of chorus that are seen in laboratory data. Using lessons learned from both laboratory and space observations a new finite-dimensional self-consistent Hamiltonian model was developed in which solutions that exhibit sub-packet structuring were found. These solutions exhibit not a single island forming in phase space but a pair of islands. The self-consistent rotation in phase space of the two islands leads to the dramatic amplitude modulations that form sub-packets. These models are tractable enough to incorporate into waveform models of observed time-series to test the validity of the underlying physical assumptions and further the development of a self-consistent theory of nonlinear wave-particle interactions.

References

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