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LABORATORY INVESTIGATION OF NONLINEAR CHARACTERISTICS OF WHISTLER WAVES*

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Many interesting in situ and laboratory observations of whistler wave propagation and stimulated emissions have been made over the past few decades. For example, in the space environment, observations of artificially stimulated emissions from the magnetosphere triggered by whistler modes launched from VLF transmitters have been reported by *Stiles and Helliwell* [1]. The emission radiation is assumed to come from the temporary phase bunching of particles by the constant frequency triggering signal. In the laboratory, *Stenzel* [2] reported on the self-ducting of large-amplitude whistler waves. Those experiments showed that with increasing driving amplitude, the radiation pattern from a small dipole antenna becomes increasingly narrow, and ultimately forms a duct with diameter of the order of the parallel wavelength. The ducted waves were observed to propagate virtually undamped along the length of the plasma column.

Observations such as these have prompted an NRL Space Physics Simulation Chamber investigation of nonlinear whistler wave dynamics [3]. The ultimate goals of the experiments are to understand and quantify ducting, self-focusing, and amplification of whistler waves, to investigate nonlinear whistler-plasma interactions, and to study the secondary emission of whistler waves. In parallel to the investigations of nonlinear whistler wave properties, the radiation resistance and radiation patterns of various whistler wave antenna configurations are being examined.

In the initial experiments, transmitting and receiving magnetic loop antennas and crossed electric field dipole receiving antennas have been fabricated and tested. Electromagnetic modes launched in the Space Chamber plasma have been identified as whistler waves due to the correspondence of the wave properties with theoretical predictions. Preliminary investigations into the nonlinear properties of whistlers have provided indication of whistler wave ducting. Space Chamber experiments are also being performed to characterize the radiation resistance of different whistler wave antenna geometries, beginning with an investigation of the radiation characteristics of a spherical capacitive probe. The RF region of interest for these experiments is much lower than frequencies necessary for electromagnetic radiation and therefore the usual definition of antenna radiation resistance does not apply. From a measurement of the ratio of reflected to incident power we characterize plasma impedance as a function of the probe driving frequency, which is much lower than frequencies for detectable electromagnetic radiation. Initial results from these experiments confirm the accuracy and performance of the plasma diagnostics by identification of the electron plasma frequency. Observations of the plasma sheath resonance agree with the model proposed by *Harp and Crawford* [4] and give a sheath width of approximately 4.5 Debye lengths. Simplified plasma models have been employed to help guide the experimental effort.

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