EXCITATION AND PROPAGATION OF WHISTLERS IN THERMALLY GENERATED DUCTS
(Theory and Experimental Results)

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Abstract. A study is made of the excitation and propagation of whistler waves in space magnetoplasma containing magnetic-field-aligned density ducts. The thermal-diffusion formation of ducts caused by Joule heating of the electrons in the near-zone field of current loop is considered.

Introduction A study is made of the excitation and propagation of whistler waves in magnetoplasma containing magnetic-field-aligned cylindrical density ducts. The such artificial density ducts can be formed in the vicinity of antennas due to different nonlinear effects. The interest has been sprurred by the desire a new technique which uses artificial ducts for improving the antenna coupling into VLF waves propagating below the electron gyrofrequency in space and laboratory plasmas.

Experimental and theoretical results We considered two cases of ducts formation due to electron heating in the quasistatic near field of the source. When the characteristic dimension of the heating source in the transverse direction is small compared with the transverse heat-conduction scale of the electrons, the thermal diffusion process creates a duct within which the density is diminished. Usually, such density depletion is surrounded by an annulus with density enhancements. If the heating source possesses the transverse dimension comparable to the radial electron heat-conduction length, the duct with enhanced density in its core is created. We have presented a theoretical description of the duct formation and have demonstrated (by the numerical computations) that the agreement between theoretical results and direct measurements of the density distribution is good. We investigated, experimentaly and theoretically, not only creation of ducts, but generation and guiding properties of VLF waves in such thermally generated ducts.

The experiments were performed in a large plasma device. The argon plasma was created by RF discharge in 120 cm long, 100 cm diameter vacuum chamber. Detailed measurements of the excited field by current sources and the plasma density distribution inside ducts will be reported. With the use of the full wave formulation [1], the total source-excited field is calculated and compared with the experimental data. Excellent agreement is found between the measured and calculated wave patterns.

Conclusion The results obtained in this work can be of importance both to linear and nonlinear whistler wave phenomena taking place in the laboratory and magnetosheric space plasma.

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References

1. Kondrat'ev, I. G., Kudrin, A. V., and Zaboronkova, T. M., "Electrodynamics of Density Ducts in Magnetized Plasmas" (Gordon and Breach, Amsterdam 1999), 288 p.