Whistler wave propagation in plasma with magnetic field duct

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Propagation of whistler waves in ducts (field-aligned plasma irregularities) plays a principal role in VLF signals transmission through magnetosphere. Traditionally only plasma density ducts are under investigation, but propagation of whistler waves can be strongly affected by duct-like magnetic field nonuniformities. In this paper we describe the first experiments performed on “Krot” facility, in which whistler propagation in appearance of magnetic field duct was modeled. The experiments were conducted in low-temperature (0.2 eV) uniform plasma with external magnetic field B = 35 G; to produce the duct-like magnetic irregularity we use compact wire solenoid (7 loops, 40 cm long, 7.5 cm in diameter) carrying current up to 100 A. Probe waves at frequencies f = 20 - 50 MHz were radiated and received from plasma by loop antennas located in different sections of vacuum chamber.

The experiments show trapping of a whistler wave in duct with increased magnetic field. It is essential, that at frequencies close to the half of the electron cyclotron frequency (approximately 50 MHz in our experiment) trapping is very effective even in case of week (about 10%) magnetic field perturbation. Detailed researches of RF field spatial structure versus frequency, plasma density, magnetic field, and current in solenoid were carried out, the results are presented.

The qualitative theoretical model is proposed, some mechanisms of magnetic field ducts formation in magnetosphere are discussed. Several principal distinctions between whistler wave trapping by density ducts and magnetic field ducts are indicated.

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