SOURCE-EXCITED WHISTLER MODE WAVES IN COLLISIONAL DUCTS WITH ENHANCED PLASMA DENSITY

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ABSTRACT

The effect of collisional losses on the excitation and propagation of whistler waves in magnetic-field-aligned cylindrical ducts with enhanced density in a magnetoplasma is studied. It is shown that small collisional losses can significantly affect the dispersion properties and the field structures of whistler modes guided by such density enhancements. The cases are revealed where the change in the field structure of particular guided modes due to collisions is accompanied by an increase in the power emitted to these modes by a loop antenna located inside the duct.

FORMULATION

Magnetic-field-aligned cylindrical enhancements of plasma density can arise near antennas in a magnetoplasma due to ionization or thermal-diffusion effects. Such plasma structures, commonly known as density ducts, are capable of guiding whistler mode waves at frequencies below the electron gyrofrequency. In the case where the wave frequency ω is higher than the lower hybrid frequency $\omega_{\rm LH}$, the total field of a whistler mode guided along a density enhancement comprises a large-scale electromagnetic whistler mode wave and a fine-scale quasielectrostatic wave [1]. It is the purpose of the present paper to study how collisional losses in plasma affect the excitation and propagation of whistler mode waves launched from a loop antenna located inside a cylindrical duct with enhanced plasma density.

RESULTS

We have found that for ducts observed under conditions of active ionospheric and model laboratory experiments, comparatively small collisional losses can reduce significantly the relative contribution of a quasielectrostatic wave to the total field of particular weakly attenuated modes (see Fig. 1), which results in the nonmonotonic dependence of the mode attenuation constants on the effective electron-collision frequency ν_e. Using the rigorous representation of the source-excited field in the form of an eigenfunction expansion comprising both the discrete and continuous wave terms [1], we have calculated the full field excited by a loop antenna immersed in the duct. It is shown that such a change in the field structure due to collisional losses leads to a pronounced increase in the efficiency of excitation of the dominant weakly attenuated whistler modes.

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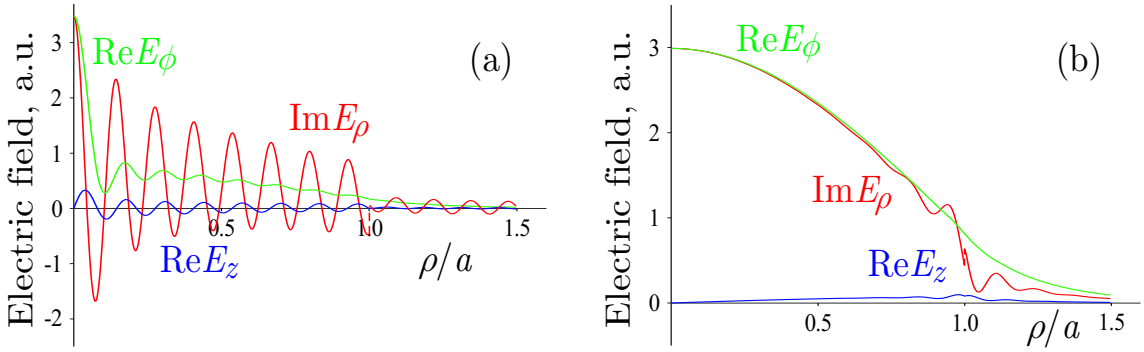

Fig. 1. The electric field of weakly attenuated modes with the azimuthal index $m = 1$ (a) in a collisionless plasma and (b) in the presence of collisions ($\nu_e/\omega = 0.25$) for $\omega = 8.8 \times 10^5$ s^{-1}. The chosen duct parameters are typical of conditions of active experiments in the Earth's ionosphere: background plasma density $N_0 = 8 \times 10^5$ cm^{-3}, external magnetic-field strength $B_0 = 0.5$ G, $\omega_{\rm LH} = 3.8 \times 10^4$ s^{-1}, density inside the duct $N = 1.44 N_0$, and duct radius $a = 85$ m