WHISTLER WAVE RADIATION FROM A MODULATED ELECTRON BEAM INJECTED IN A COLLISIONAL DENSITY DUCT IN A MAGNETOPLASMA

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ABSTRACT

A study is made of the coherent spontaneous emission of whistler waves from a thin modulated electron beam of finite length injected parallel to an external magnetic field in a magnetic-field-aligned cylindrical density duct located in a uniform collisional magnetoplasma modeled upon the Earth's ionosphere. The beam-excited field and the power emitted from the beam at the modulation frequency have been determined. It is shown that in the presence of an enhanced-density duct, the emitted power can increase due to Čerenkov resonance excitation of the whistler modes guided by the duct.

FORMULATION

Recent active experiments in the Earth's ionosphere demonstrate that nonlinear effects due to intense electromagnetic fields excited by antennas on board spacecraft can result in the formation of artificial density ducts aligned with the geomagnetic field [1]. In this paper, we consider coherent spontaneous emission of whistler waves from a modulated electron beam injected parallel to the axis of a field-aligned collisional cylindrical duct under conditions of such active experiments. To elucidate the key aspects of the problem, we assume that the beam is given, as is done in numerous previous works on the whistler wave radiation arising from modulated beams in a homogeneous unbounded magnetoplasma [e.g., 2].

RESULTS

We have revealed a significant difference between the features of whistler wave emission from modulated beams in the presence of a duct (Fig. 1a) and in the case of a homogeneous background plasma (Fig. 1b). It is found that in the presence of an enhanced-density duct, the average power lost by the beam at the modulation frequency can increase noticeably due to Čerenkov resonance excitation of the whistler modes guided by the duct.

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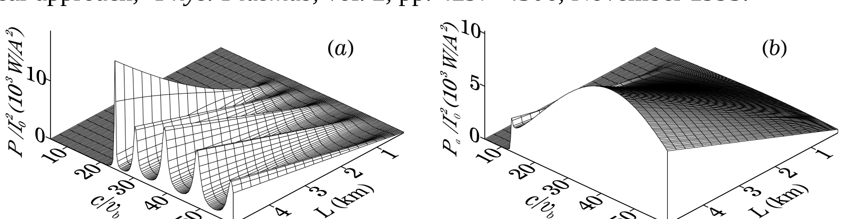

Fig. 1. Average emitted power normalized to the squared beam current as a function of beam length L and parameter c/v_b (c is the velocity of light in free space and v_b is the beam velocity) for beam modulation frequency $\omega/2\pi = 120$ kHz, beam radius $b = 1.5$ m, external magnetic-field strength $B_0 = 0.5$ G, background plasma density $N_0 = 10^6$ cm^{-3}, electron collision frequency $\nu = 10^{-3}\omega$, duct radius $a = 10$ m, and plasma density inside the duct $N = 3N_0$. The maxima on plot (a) correspond to the Čerenkov resonance condition for the beam and the guided modes