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SIMPLIFYED THEORY OF GYRO-BWO WITH ZIGZAG QUASI-OPTICAL MICROWAVE SYSTEM *

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Recently, a microwave system in the form of a quasi-optical transmission line was proposed for electron cyclotron sources of short-wavelength coherent electromagnetic radiation [1]. The system consists of focusing mirrors, which are periodically located along the longitudinal axis of coordinates and ensure the transportation of a Gaussian wave beam along a zigzag trajectory (Fig. 1). The operating electron beam propagates along the same axis, so that the electron beam intersects the wave beam periodically. Electron-wave cyclotron interaction occurs in regions where the wave propagates strictly across the electron beam, which leads to gyrotron-type electron-wave interaction with minimal sensitivity to the velocity spread of particles in the beam. 3D PIC modeling demonstrates the attractiveness of this "zigzag" cyclotron maser for realizing gyrotron backward wave oscillators (gyro-BWOs) operating in the sub-THz frequency range with an octave band of frequency tuning.

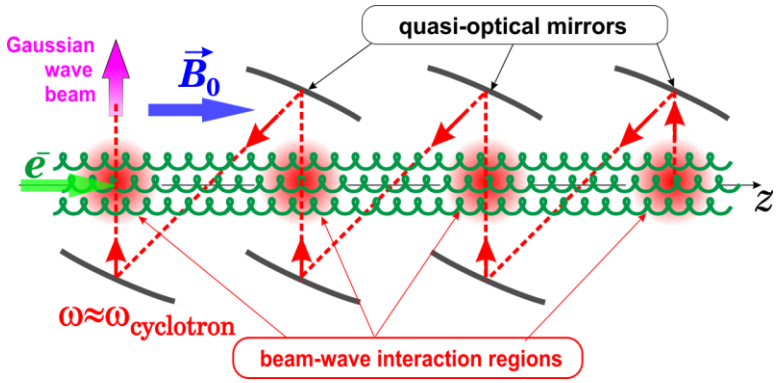

Fig.1. Schematic layout of a gyro-BWO with 3-period zigzag QO transmission line.

In this paper, we develop a quasi-analytical linear theory of such a gyro-BWO, as well as a simplified nonlinear space-time theory. These approaches explain the features of changing the operating frequency and output signal power in the process of broadband frequency tuning due to a change in the operating magnetic field. In particular, the complicated discrete-like nature of the dependence of the frequency of the excited wave on the cyclotron frequency with periodically occurring frequency “jumps” is explained, as well as various scenarios for changing the output power and generation frequency with a change in the external magnetic field or the initial energy of the particles. In addition, the nonlinear theory predicts the existence in this system of complex self-modulation regimes of generation, as well as regimes of superradiance of high-power short microwave pulses.

REFERENCES

[1] S.V. Samsonov, G.G. Denisov, A.A. Bogdashov, I. G. Gachev “Cyclotron Resonance Maser with Zigzag Quasi-Optical Transmission Line: Concept and Modeling”, IEEE Trans. Electron Dev., 2021, vol. 68, № 11, P. 5846-5850.

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