THE EXCITATION OF A SURFACE WAVES IN A COAXIAL PLASMA WAVEGUIDE BY AN ELECTRON BEAM IN THE EXTERNAL MAGNETIC FIELD

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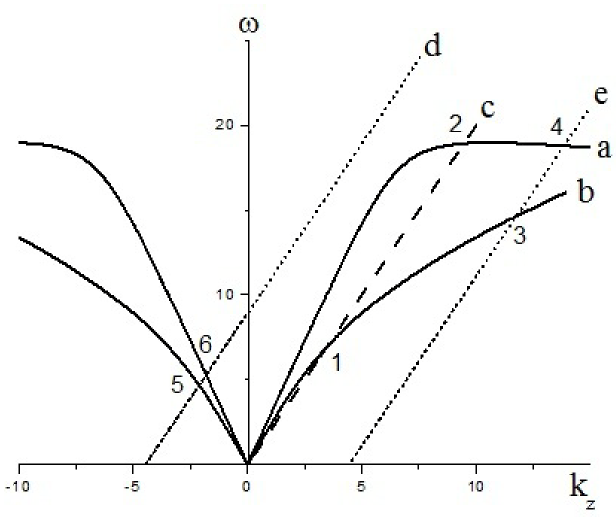
Let us consider the interaction of an annular relativistic electron beam with annular plasma in a coaxial metal waveguide in the presence of a finite external magnetic field. The main interest for applications in plasma microwave electronics is made up of electromagnetic interactions of slow surface waves (low-frequency and high-frequency plasma waves) of the coaxial plasma waveguide with surface waves of the electron beam [1].

There are six points of the resonant interaction of plasma waves with the electron beam (see Fig.). The dispersion curves of the high-frequency and low-frequency plasma waves intersect with the straight line $\omega = k_z u$ at points 1 and 2 (the Cherenkov resonance), the dispersion curves of the low-frequency and high-frequency plasma waves intersect with the straight line $\omega = k_z u - \Omega_e/\gamma$ in points 3 and 4 (the irregular Doppler resonance), and the dispersion curves of the low-frequency and high-frequency plasma waves intersect with straight line $\omega = k_z u + \Omega_e/\gamma$ at points 5 and 6 (the normal Doppler resonance). For example, the dispersion equation that describes instability near point 1 has the form:

$$\left(1-\delta_p\, r_p\, \chi_0^2 \frac{\omega_p^2}{\omega^2} G_p\right)\left(1-\delta_b\, r_b\, \chi_0^2 \frac{\omega_b^2\, \gamma^{-3}}{(\omega - k_z\, u)^2} G_b\right) = \delta_p\, r_p\, \chi_0^2 \frac{\omega_p^2}{\omega^2} G_p\, \delta_b\, r_b\, \chi_0^2 \frac{\omega_b^2\, \gamma^{-3}}{(\omega - k_z\, u)^2} G_b \Theta_1$$

where G_p, G_b - geometric factors, δ_p and r_p - radius and thickness of plasma, δ_b, r_b - of beam, Θ_1 - the coupling coefficient of plasma and beam waves.

The expressions for the instability increments in the described regimes are found by analyzing the dispersion equations.



In the case of single-particle Cherenkov Effect for the low-frequency wave near point 1 the expression for increment has the form:

$$\delta = \left(-\frac{1}{2} + \frac{i\sqrt{3}}{2}\right)\omega_0 \alpha^{1/3} \times (1 + k_{\perp p}^2 c^2/\omega_p^2)^{-1/3}\Theta_1^{1/3}$$

α - the parameter of the beam density,
ω_0 - coordinates of point 1 on plane (ω, k_z).

These results let us perform the comparison and establish the point at which instability developed more strongly.

References

[1] I. N. Kartashov, M. V. Kuzelev, and A. A. Rukhadze, Plasma Phys. Rep. 35, no. 2, 169 (2009).