WAVE DISPERSIONS IN A WARM ELECTRON BEAM

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A dispersion equation is derived for three-dimensional waves in a warm constant-density cylindrical electron beam confined in a uniform magnetic field [1]. The transverse temperature decreases with radius, from a maximum on axis to zero at the beam edge in a manner that results in rigid-rotor equilibria [2]. The model introduces both an axial thermal parameter TAXN and a transverse thermal parameter TEQ.

The derivation follows that for a cold constant-density beam [2]. Small perturbation terms are introduced into fluid variables and only linear combinations of these terms are kept. The perturbed pressure terms are eliminated by using thermodynamics equations and the ideal gas law. The perturbed velocity terms are eliminated by substitutions into the continuity equation.

Significant simplification results by ignoring terms containing the derivative of the density perturbation. This approximation is expected to constrain most useful results to those for perturbations that resemble surface waves on cold beams where space charge extends beyond the equilibrium radius without much change in density.

Elimination of the perturbed density from Poisson's equation results in an equation formally identical to that for the cold beam. The sharp beam edge, where boundary conditions on the RF potential function can be fulfilled, enables a warm beam dispersion equation to result from following the cold beam derivation procedure [2]. Figure 1 shows axisymmetric wave dispersions for a beam emitted from a shielded cathode.

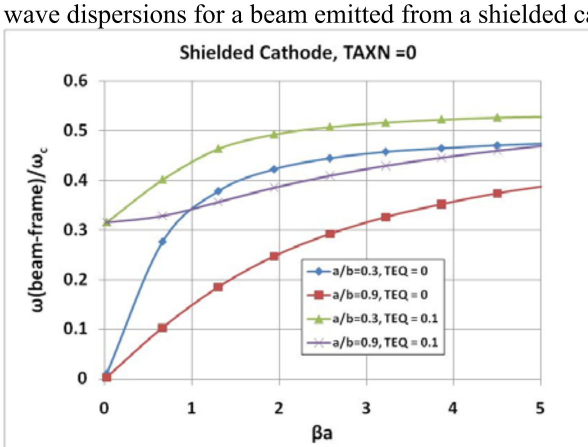

Fig. 1. Dispersions for axisymmetric waves on beams with and without transverse temperature emitted from a magnetically shielded cathode. (ω_c is the electron-cyclotron angular frequency, β is the axial wavenumber, a is the beam radius and b is the tunnel radius.)

1. R. C. Davidson, *Theory of Nonneutral Plasmas,* Reading, Massachusetts, W. A. Benjamin, 1974, Section 3.2.
2. Ibid, Section 2.7.