plasma densities. For the case of an anisotropic Maxwellian velocity distribution, (1) simply becomes

$$\omega_c^2 > \frac{1}{2}\frac{\alpha_z^2}{c^2}\,\omega_p^2, \tag{2}$$

where α_z is the thermal velocity along $\mathbf{B}_0$.

Now, we consider an anisotropic Maxwellian velocity distribution with loss cones given by[3]

$$f_0 = \frac{1}{N\pi^{3/2}\alpha_\perp^2\alpha_z}\exp -\left[\left(\frac{v_\perp}{\alpha_\perp}\right)^2 + \left(\frac{v_z}{\alpha_z}\right)^2\right], \qquad v_\perp > \frac{|v_z|}{(R-1)^{1/2}}$$

$$= 0, \qquad v_\perp < \frac{|v_z|}{(R-1)^{1/2}}, \tag{3}$$

where $\alpha_\perp$ denotes the thermal velocity perpendicular to $\mathbf{B}_0$, R is the mirror ratio, and $\int f_0 d\mathbf{v} = 1$ so that $N = [(R-1)\theta/(R-1)\theta + 1]^{1/2}$ where $\theta \equiv (\alpha_\perp/\alpha_z)^2$. We find that for this distribution the condition for stability of the electromagnetic wave propagating perpendicular to $\mathbf{B}_0$ becomes

$$\omega_c^2 > \frac{1}{2}\frac{(R-1)\theta}{(R-1)\theta+1}\frac{\alpha_z^2}{c^2}\,\omega_p^2. \tag{4}$$

This differs from (2) by the factor $(R-1)\theta/(R-1)\cdot\theta + 1$ which is less than one for all finite values of R and θ. For $R = 1$, there is no instability since the dispersion relation is reduced to the cold plasma case where $\omega^2 = c^2k^2 + \omega_p^2$ ($R = 1$ means that particles with any motion along $\mathbf{B}_0$ will escape from the mirror configuration and the results of Hamasaki show that the instability is due to thermal motion along $\mathbf{B}_0$). For $R = \infty$, we simply regain (2) as this value of R means that all particles are confined in the mirror configuration.

Consequently, we have shown, from (4), that the loss cones of an anisotropic Maxwellian velocity distribution have a *stabilizing* influence on electromagnetic waves propagating perpendicular to an applied uniform magnetic field $\mathbf{B}_0$, when compared with an anisotropic Maxwellian without loss cones.

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[1] R. N. Sudan, Phys. Fluids **6**, 57 (1963).
[2] J. E. Scharer and A. W. Trivelpiece, Phys. Fluids **10**, 591 (1967).
[3] J. E. Scharer, Phys. Fluids **10**, 652 (1967).
[4] S. Hamasaki, Phys. Fluids **11**, 1173 (1968).

Comments

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Comment on "Oblique Incidence of an Electromagnetic Wave on a Plasma Layer"

VAUGHAN H. WESTON
Radiation Laboratory
Department of Electrical Engineering
The University of Michigan, Ann Arbor, Michigan
(Received 13 September 1968)

In the nonrelativistic analysis of a plane wave incident upon a warm plasma slab[1] and half-space,[2] a coupling term β defined as follows from Eq. (24)[2]:

$$\int \frac{f_0(\mathbf{v})v_t}{v_p - u}\,d\mathbf{v} = -i\pi\omega^2\lambda_D^2 n\beta$$

occurs, which was nonzero for the Maxwellian distribution function. It can be shown that this expression can be written in the reduced form

$$\beta(\omega^2\lambda_D^2 n) = -2\int_{-\infty}^{\infty} dv_y \int_{c/\sin\alpha}^{\infty} v_\rho f_0(\mathbf{v})\,dv_\rho,$$

where

$$v_\rho^2 = v_x^2 + v_z^2,$$

for an isotropic unperturbed distribution function. For a cutoff distribution function $f_0(\mathbf{v})$ which vanishes for $|\mathbf{v}| < v_0$, it follows that β vanishes if $v_0 > c/\sin\,\alpha$. Since nonrelativistic theory was employed,[1,2] it is more appropriate to use the cutoff distribution function where $v_0 = c$. In this case, β will vanish for $|\sin\,\alpha| < 1$, and should be neglected in the final results.[1,2] However, for the case $|\sin\,\alpha| > 1$, which would arise in the plane wave decomposition of the incident field produced by a source in the vicinity of the slab or interface, the term β may not necessarily vanish for the cutoff distribution function.

[1] J. J. Bowman and V. H. Weston, Phys. Fluids **11**, 601 (1968).
[2] V. H. Weston, Phys. Fluids **10**, 631 (1967).