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ON SOME PROPERTIES OF ANISOTROPIC PLASMAS

Lu Guan-Kang, Chen Zhi-Fan.
Fudan University, Shanghai.

I. ELECTROSTATIC SHIELDING

The problem of electrostatic shielding potential in a plasma with anisotropic kinetic temperatures is discussed in the first part of this paper. We suppose that the applied magnetic field is along the Z axis of Cartesian coordinates. The electron distribution function may be taken as

\[ f(e') = \frac{N}{2\pi} \text{det} \mathbf{A}^{1/2} \exp(-\mathbf{A} \cdot \mathbf{e}') \]  

(1)

where

\[ \mathbf{A} = \frac{m}{2} \begin{pmatrix} (KL)^T & 0 & 0 \\ 0 & 0 & (KL)^T \\ 0 & 0 & (KL)^T \end{pmatrix} \]  

(2)

\( T_n \) is the temperature along the main axis (Z axis) of tensor A and \( T_{\perp} \) is the temperature perpendicular to it, \( k \) is the Boltzmann constant, \( m \) and \( \mathbf{e}' \) are the electron mass and velocity respectively.

By using the integral transformation

\[ F(\omega) = \int e^{i\mathbf{A} \cdot \mathbf{e}} f(\mathbf{e}) \frac{d\mathbf{e}}{4\pi} \]  

we obtain the one dimensional distribution function

\[ F(\omega) = \frac{m}{4\pi} \exp(-m\omega^2/2\mathbf{T}) \]  

(3)

where

\[ \mathbf{T} = \left\{ (\mathbf{k}^2)_{\parallel} T_{\parallel}, (\mathbf{k}^2)_{\perp} T_{\perp} \right\} \]  

(4)

is the effective temperature along the \( \mathbf{k} \) direction, \( (\mathbf{k}^2)_{\parallel} \) and \( (\mathbf{k}^2)_{\perp} \) are the components of \( \mathbf{k} \) along and perpendicular to the Z axis respectively.

On the problem of positive charged test particle (coordinate \( \mathbf{R} = 0 \) and velocity \( \mathbf{v} = 0 \)) shielded by electron clouds, the Coulomb forces between particles are the chief interactions. The correction of shielding effect caused by magnetic force is neglected, in other words, it is assumed that the effect of applied magnetic field is only to maintain the anisotropic of electron velocity distribution.

In this case, we obtain that the electric potential function is given by

\[ V(\mathbf{R}) = \frac{Q}{2\pi} \int \frac{\mathbf{e}}{4\pi} \text{det} \mathbf{A}^{1/2} \exp(\mathbf{A} \cdot \mathbf{e}) d\mathbf{e} \]  

(5)

where \( Q \) is the electric charge of test particle, and \( \mathbf{e} \) is the electron plasma frequency.

When \( T_{\parallel} \neq T_{\perp} \), let

\[ \zeta = \frac{T_{\parallel}}{T_{\perp}} - 1 \]  

(6)

As \( |\zeta| < 1 \), integrating (7), we get

\[ V(\mathbf{R}) = \frac{Q}{2\pi} \int \frac{\mathbf{e}}{4\pi} \text{det} \mathbf{A}^{1/2} \exp(\mathbf{A} \cdot \mathbf{e}) d\mathbf{e} \]  

(7)

where \( Q \) is the electric charge of test particle, and \( \mathbf{e} \) is the electron plasma frequency.

When \( T_{\parallel} \neq T_{\perp} \), let

\[ \zeta = \frac{T_{\parallel}}{T_{\perp}} - 1 \]  

(8)

II. STRICT CRITERIONS OF KINETIC INSTABILITIES CAUSED BY INJECTED NEUTRAL PARTICLE BEAMS

A number of strict and general instability criterions may be obtained by analyzing the geometric properties of the dispersion relations of special plasma waves.

In the second part of this paper, Nyquist diagrams of cyclotron instabilities caused by plasma streams are analyzed. At first, the calculation method on instability criterions of \( n_i \) (the plasma stream density), \( n_s \) (the static plasma density), \( B \) (the applied magnetic field strength), \( \Phi \) (the weber number), \( V \) (the stream velocity) and \( T \) (the temperature) are obtained. The numerical results of Hydrogen plasma are obtained.

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Secondly, the cyclotron and electrostatic instabilities caused by two neutral plasma streams are also analysed. The numerical results of Hydrogen plasma are also given. Finally, an necessary condition of electromagnetic instabilities caused by plasma streams is derived.

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