

A Numerical Investigation of the Two Stream Instability and Resonant Heating of an Inhomogeneous, Axisymmetric Plasma Column

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The numerical simulation of an axisymmetric, inhomogeneous plasma column for two different problems (namely two stream instability and ion resonant heating) has been considered. In the first part we consider an inhomogeneous, cylindrically axisymmetric electron plasma confined electrostatically by immobile ions and with an external boundary surface. In this model the electron density profile is finite and continuous for all radii $\rho < a$ where a is a cut off radius, beyond which the electron contribution to the source terms in the field equations is negligible.

The ion density profile is also finite and continuous throughout, and its form will be consistent with maintaining the desired electron equilibrium, provided that form is not unphysical.

We transform the velocity dependence of $f(\rho, z, \theta, \vec{v}, t)$ in a Hermite series, the axial dependence in a Fourier series and use a radial grid. The partial derivative with respect to time then becomes a total derivative, enabling us to use standard forward-differenced integration procedures.

A two stream instability excited by axial counterstreaming is followed through limiting amplitude for one or two unstable wavenumbers. The results show that the limiting amplitude is largest for the wavenumber with largest growth rate, consistent with the one-dimensional result. In the case of multiple unstable waves, the first wave to reach limiting amplitude modifies the distribution functions and "turns off" the instability before the other waves reach the limiting amplitudes they would attain as isolated waves.

In the second part a background of electrons is assumed, on an ion plasma which is described by the equilibrium

$$f(\rho, V) = \frac{1}{(2\pi)^{\frac{3}{2}}} e^{-\rho^2/d^2} e^{-(V_\rho^2 + V_\theta^2 + V_z^2)/2}$$

in dimensionless units.

An electric field of the form $E = E_{zB}(1 - e^{-t/\tau}) \sin \omega t \hat{z}$ is applied on the boundary of the plasma along the axis of the cylinder. Power amplification through a thermonuclear fusion reaction is achieved by using the wave to speed up particles on the tail of the distribution function.

We find that the maximum power amplification occurs at a frequency $\omega = 1.3 \omega_p$. At this frequency the ratio of the output to input power raises above 1.0 at $T = 1.18$ keV, and peaks at a value of 136 for plasma temperature $T = 26$ keV.