WAVES ON A PLASMA COLUMN.

The Display and Measurement of Space Charge Waves on the Positive Column of a Mercury Vapour Discharge

by

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CONTENTS.

Summary

The experimental work to be described was part of a general investigation on resonances excited in the plasma of a discharge column. It was concerned with some of the problems of launching, maintaining and detecting surface waves on plasma columns and in particular the effects on propagation of varying axial and radial electron densities.

It is known that there exist for space-charge waves in plasmas which partially fill waveguides, both symmetric and dipole surface modes and the theoretical dispersion curves for these modes have been verified experimentally. The methods used in this work were an attempt to determine the conditions for launching these waves and their subsequent history over a large range of frequencies and plasma densities.

The method used the afterglow of a pulsed plasma or a current modulated plasma column as a vehicle for the wave, together with a bridge detection of probe response and photographic recording of successive oscilloscope traces. The photographs were either measured for point by point readings to determine wavelength and attenuation, or alternatively interpreted three dimensionally so as to give an overall picture of the various waves propagating along the plasma column. The number density regions for which propagation is difficult are very evident and an application of these waves to diagnostics of the modulated positive column is described. The alternative method also reveals some of the warm plasma waves which perturb the surface modes and enables the approximate dispersion curves for these modes to be calculated.

The use of a reflection external probe for the presentation of Tonks-Dattner resonances is also described and the geometrical precision and rapidity of this method is of value in following number density changes along a plasma column.

Chapter I is a review of plasma definitions and properties together with a discussion of the Langmuir-Tonks oscillations and the dielectric properties of

a plasma. The Tonks-Dattner resonances, which are closely allied to, and have influenced much of, the work on plasma-microwave interaction, are also introduced.

In the second Chapter the dispersion relations for waves in an unbounded plasma are derived and the idea of Landau damping introduced.

The third Chapter discusses resonances and waves in finite structures and summarises the fairly complete treatment of resonances developed by recent workers. An analysis of space charge waves on a plasma column in a coaxial waveguide follows, and a survey of the relations between these waves for both magnetised and unmagnetised plasma by geometrical methods similar to those of the Clemmow-Mullaly-Allis diagram is given.

Chapter V is concerned with a brief survey of those properties of the low pressure arc column which are apposite to the experiments.

The final Chapter gives a detailed account of the experimental work to which reference has been made and discussed the interpretation of the results and the implications they have for maintaining waves on fluctuating plasmas. The work ends with some suggestions for further experimental work and applications of the methods to other areas.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any other University and, to the best of my knowledge and belief, it contains no material previously published or written by another person, except when due reference is made in the text.