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Excitation of Electrostatic Oscillations In a Magnetic Field

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I. INTRODUCTION

1. Purpose of this report. The problem of electrostatic instabilities excited by electron beams has been treated theoretically by two groups of workers. On the one hand is a group of engineers whose ultimate motivation is the utilization of this phenomena in the practical generation of microwaves. On the other hand is a group of physicists whose ultimate goal is the understanding of the behavior of hot plasmas such as would be encountered in thermonuclear reactors. Because of the difference in emphasis, the approaches* of the two groups have been somewhat different. The physicists have for the most part worked with the linearized Boltzmann equation in order to discover effects connected with the finite energies of the individual particles. Their approach leads to equations of such complexity that it is difficult to take into account anything but the finite temperature. Although in principle any particular experimental case can be treated, these cases are so numerous that it does not in general pay for a theoretician to pursue the calculations to a point where they are experimentally interesting. On the other hand, the engineers have preferred to consider the plasma as an anisotropic dielectric medium, with a dielectric constant appropriate to the absence of thermal motions. Even in this greatly simplified approach, the equations are sufficiently complicated to necessitate certain approximations; but now it is possible to take into account the

finite size of the plasma and to prove certain useful theorems regarding the excitation of oscillations. However, all effects of finite temperature are lost.

In the first experiments performed to test the theory, it is likely that the engineers' approach would be the more useful, simply because cold plasmas are easier to produce than hot ones, and because small plasmas, in which boundary effects are important, are easier to produce than large ones. It is in fact a test of the experimentalist's skill to devise an experiment in which the theoretical results of the Boltzmann equation can be tested. This tract will, therefore, be concerned primarily with cold plasmas; the effects of finite temperature will be considered in later papers.

The purpose of this tract is twofold: first it is to assemble and condense the results of the cold-plasma approach and to present them in such a way that the approximations and physical ideas involved are made clear. This part of the report will not include much new material, however, the interpretation of known results may be novel. Second, it is to present a new calculation of the growth rates of various electrostatic interactions in the case of zero temperature, compare it with results obtained by others, and summarize the available results on this particular problem. The emphasis throughout will be on ideas and results of practical interest to an experimentalist.