View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NASA Technical Reports Server

GENERAL ATOMIC DIVISION
GENERAL DYNAMICS CORPORATION

John Jay Hopkins Laboratory for Pure and Applied Science
P.O. Box 608, San Diego 12, California

GPO PRICE $ ______
OTS PRICE(S) $ ______
Hard copy (HC) $1.00
Microfiche (MF) $0.50

GACD-5716

Copy No.

EXPERIMENTAL INVESTIGATION OF THE FUNDAMENTAL MODES OF A COLLISIONLESS PLASMA

QUARTERLY REPORT NO. 2
June 11, 1964 through September 10, 1964

Work done by:

W. E. Drummond
J. H. Malmberg
C. B. Wharton

Report written by:

J. H. Malmberg

N65-19896 (ACCESSION NUMBER)
5 (PAGES)
CR-57432 (NASA CR OR TMX OR AD NUMBER)
1 (THRU)
(CODE)
25 (CATEGORY)
FACILITY FORM 602

Contract No. NAS7-275
National Aeronautics and Space Administration
Western Operations Office
150 Pico Boulevard
Santa Monica, California
General Atomic Project No. 407

September 22, 1964

INTRODUCTION

During the current period we have made a preliminary measurement of the dispersion relation of a wave near the electron cyclotron frequency. Such a measurement is one of the primary objectives of this research program. At the time of this writing, these measurements are still in progress.

Special Antenna

We have designed an antenna in the shape of a helix surrounding the plasma column. This antenna acts as a slow wave structure for the transmitter signal. This geometry should couple preferentially to plasma waves of short wave length. The helix is mounted on the ion trap and carefully shielded by a waveguide-beyond-cutoff structure. The receiving probe is a small diameter transverse wire also shielded by waveguide-beyond-cutoff structure.

Dispersion Relation

The dispersion relation we observed for waves near electron cyclotron frequency is shown in Fig. 1. The plasma frequency in this case is less than the electron cyclotron frequency but not terribly small compared to it. The low frequency branch of the curve, which we have investigated extensively for another program, is also given in Fig. 1. The upper branch of the dispersion curve may be represented by the formula $f-f_c = \pm v_p/\lambda$, where f is the transmitter frequency, f_c is the electron cyclotron frequency, λ is the wave length of the transmitted wave, and for the case exhibited in Fig. 1, $v_p = 3.5 \times 10^8$ cm/sec. We have as yet made only a preliminary theoretical interpretation of this result. However, a wave with this dispersion is expected if the plasma distribution function has two electron beams out on the tail, one going in each direction at a speed equal to v_p. This has now been experimentally confirmed by injecting a controlled beam into the plasma. Preliminary analysis indicates that instabilities may result in such a beam-plasma system when the beam wave resonates with the cyclotron frequency. Work is in progress to analyze this situation. Positive identification of the wave will depend on further experimental and theoretical work.

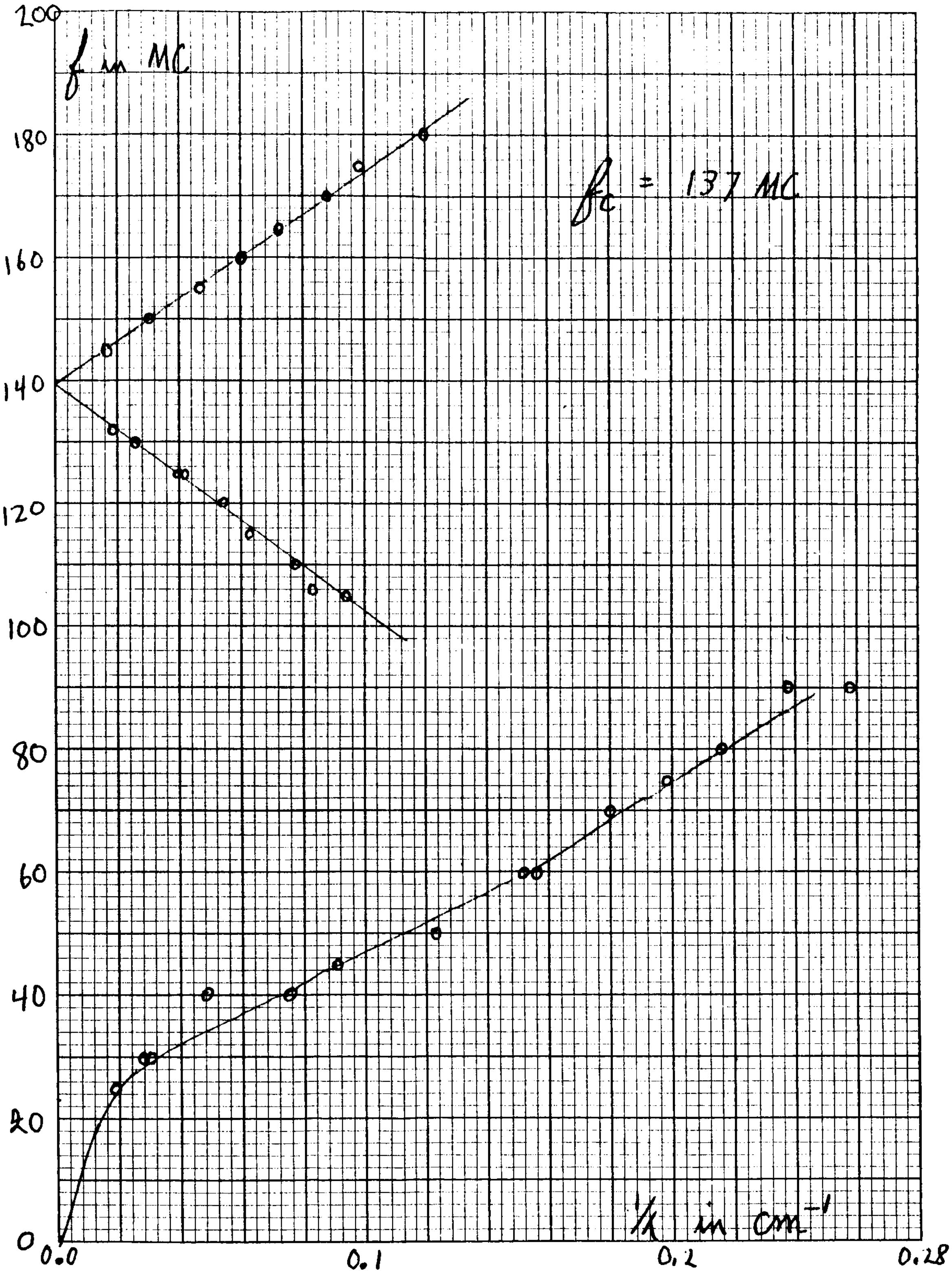

Fig. 1--Dispersion Relation

Wave Damping

The wave observed near the electron cyclotron frequency is heavily attenuated and disappears in a few wave lengths. Detailed measurements of the wave damping have not been made as yet.

Publications

A talk on the dispersion data will be given at the New York meeting of the American Physical Society. The abstract of this talk is given in Appendix A.

Financial

Approximately $37,000 has been expended or committed on this project to date.

APPENDIX A

CYCLOTRON WAVES IN A COLLISIONLESS PLASMA

C. B. Wharton and J. H. Malmberg

The propagation characteristics of spacecharge waves in a long collisionless plasma column[1] have been studied over the frequency range 90 to 520 Mc. The collisionless damping of these waves has previously been reported[2]. Recently the growth of the wave amplitudes in space, due to an injected electron beam having a velocity spread[3], has been investigated.

In this paper we report the appearance of a wave at frequencies slightly above the cyclotron frequency ω_b. The wave appears to be longitudinal, with velocities ranging from 3×10^8 to 10^{10} cm/sec over the frequency range. There is also a wave at frequencies slightly below ω_b, that seems to be directed by the plasma column and which may be a whistler.

---

[1] Malmberg, J. H., et al, A collisionless plasma for wave propagation studies. Proc. VI Intern. Conf. on Ionization Phen. in Gases, Paris, 1963.

[2] Malmberg, J. H. and C. B. Wharton, Collisionless damping of electrostatic plasma waves, Phys. Rev. Lett. 13, (6), 184 (1964).

[3] Drummond, W. E., Spatially growing electrostatic turbulence, Phys. Fluids, 7, 816 (1964), also General Atomic Report GA-3809, (Sept. 1963).