PROGRESS REPORT

FOR

RESEARCH GRANT NO. NsG-220-62

ON

PLASMAS AND SPACE PHYSICS

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by the

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University of Maryland
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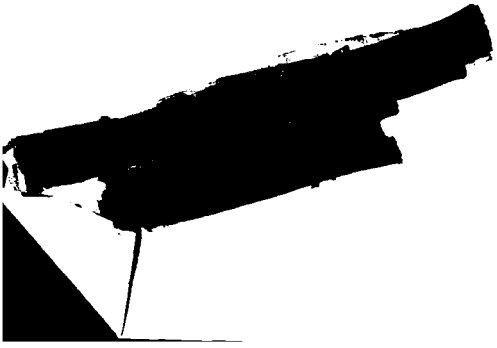

I. INTRODUCTION

The research work described in this report is supported by Grant No. NsG-220-62. We shall outline briefly the work that has been carried out in the six month period from August 1st, 1965 to January 31st, 1966 of the above Grant. The research supported at the University of Maryland by this Grant is in the field of basic theoretical Plasma Physics with applications to problems in Space Physics.

II. PROGRESS REPORT OF CURRENT RESEARCH PROGRAMS

In the above six month period the various members of our group have made the following research contributions:

Enhanced Fluctuations in Plasmas, D. A. Tidman, Tech. Note BN-426 (1965).

This paper is to be published in the proceedings of the Symposium on the Dynamics of Fluids and Plasmas held at the University of Maryland in October 1965. The Symposium was dedicated to Professor Burgers and the proceedings will be published by Academic Press.

Most plasmas, whether they are produced in the laboratory or naturally occurring, are far from thermal equilibrium. One consequence of this is that they are very "noisy", i.e., various modes of the plasma are highly excited to more than the energy of KT/2 per propagating mode appropriate to thermal equilibrium. This excited wave spectrum may take the form of macroscopic turbulence excited externally or by instabilities, or at a lower amplitude level is continually present in the form of the natural fluctuations of a many-body system. Such

turbulent motion plays an important role in the processes of scattering and emission of electromagnetic radiation by a plasma, and also contributes to transport processes such as the rapid diffusion of plasma across a magnetic field through wave-particle scattering. Some of these effects are discussed in the paper.

The Role of Electrostatic Plasma Oscillations in Electron Scattering in the Earth's Outer Magnetosphere, Aharon Eviatar (communicated to Journal of Geophys. Res., 1966).

The scattering of electrons in a spatially homogeneous magnetic field-free stable plasma by ion and electron plasma waves excited by suprathermal particles is considered using a test-particle approach. A previously derived theory is modified and extended to the case of ion-waves propagating in a current bearing plasma. The results are applied to electrons in the Earth's magnetosphere and in the transition zone between the magnetosphere and the interplanetary medium, where the geomagnetic field is weak in the sense that $\Omega^2 \ll \omega_{pe}^2$ ($\Omega = \frac{eB}{mc}$; $\omega_{pe}^2 = \frac{4\pi ne^2}{m}$) . It is found that interaction with electron plasma oscillations is competitive with whistlers in scattering suprathermal electrons and that ion waves are the dominant mechanism for the diffusion of subthermal electrons across the magnetopause and the shock wave.

Enhanced Bremsstrahlung from Plasmas Containing Nonthermal Electrons, D. A. Tidman and T. H. Dupree, Phys. Fluids 8, 1860 (1965)

We have calculated the bremsstrahlung emitted from thermal plasmas which co-exist with a flux of energetic (suprathermal) electrons. We find that under some circumstances the radiation emitted can be greatly increased compared

to the emission from a Maxwellian plasma with no energetic particles present. The enhanced emission occurs at the fundamental and second harmonic of the electron plasma frequency.

Scattering of a Test-Particle by Enhanced Plasma Fluctuations, D. A. Tidman and A. Eviatar, Phys. Fluids 8, 2059 (1965).

The scattering of a test-particle by enhanced electric field fluctuations in a plasma containing nonthermal electrons is considered, together with some characteristic times for wave-particle scattering in such a plasma. The calculations are based on the Balescu-Lenard equation.

Propagation of Correlations in a Boltzmann Gas, E. A. Frieman (Princeton) and R. Goldman (Maryland), 1966 (this is being rewritten as a Princeton Tech. Note).

New results are obtained on the propagation of correlations in a Boltzmann Gas on the scale of the mean free path and the collisional time scale. This appears to support a conjecture of Green's* on this subject.

* M. Green, Physica 24, 393 (1958).

An Asymptotic Kinetic Equation for Inhomogeneous Plasma, R. Guernsey (to be communicated to Canadian Journal of Physics, 1966).

A kinetic equation is derived which is a generalization of the Balescu-Lenard equation and applicable to weakly inhomogeneous plasmas.

Plasma Radiation and Solar Radio Outbursts

This paper is in the course of preparation by D. Tidman, T. Birmingham (NASA Goddard) and H. Stainer, and will be communicated to the Astrophysical Journal. It contains a calculation of the splitting of the harmonics of plasma

radiation near ω_e and $2\omega_e$ due to a weak magnetic field. It provides a satisfactory explanation of the observed splitting of the two bands of radiation emitted in Type II solar radio outbursts.

Correlation Velocities, K. Suchy, communicated to Annalen der Physik, Leipzig (1966).

With the coefficients of a Taylor expansion of the correlation function $C(\vec{\xi},\tau)$ up to the second order in $\vec{\xi},\tau$, three (or four) velocities can be defined to describe the space-time behaviour in a satisfying manner. They have a simple geometrical relationship among each other. The necessary measurements for the computation of these coefficients are discussed.

III. GENERAL COMMENTS

Both Mr. A. Eviatar and Mr. H. Stainer are in the course of writing their Ph.D. theses and should finish this activity sometime this Spring. Mr. Eviatar's work has dealt with the role of electrostatic plasma oscillations in electron scattering in the earth's outer magnetosphere. Mr. Stainer has carried out calculations on the line splitting of plasma radiation due to weak magnetic fields.

Various members of our group have contributed papers and seminars to meetings and research institutions in the six month period covered by this progress report. Among these was an invited paper entitled "Mechanisms for Type II Solar Outbursts" by D. Tidman at the APS Plasma Division meeting in San Francisco. Dr. Tidman also gave colloquia on "Enhanced Bremsstrahlung and Solar Radio Noise" at Chicago (November 1965) and Columbia (December 1965) universities.