[redacted]

UNPUBLISHED PRELIMINARY DATA

ENERGY LOSS OF CHARGED PARTICLES IN PLASMAS

FACILITY FORM 602

N65-35288 (ACCESSION NUMBER) | (THRU)

6 (PAGES) | 1 (CODE)

CR 58470 (NASA CR OR TMX OR AD NUMBER) | 25 (CATEGORY)

Status Report to
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Grant No. NsG-169-61

Period: January 1, 1964 to June 30, 1964

GPO PRICE $ ________

CSFTI PRICE(S) $ ________

Hard copy (HC) 1.00

Microfiche (MF) .50

ff 653 July 65

Sr. Investigator: Professor Werner Brandt

NEW YORK UNIVERSITY

DEPARTMENT OF PHYSICS

REPORTS CONTROL No. 3

ENERGY LOSS OF CHARGED PARTICLES IN PLASMAS

Introduction

Our main objective during this period was the further study of the response of an atom to an external field in collaboration with Professor Stig Lundqvist, Sweden. Professor Lundqvist and one of his associates, Dr. Lars Hedin, visited our laboratory for an extended period of time during the spring to continue this research. We derived a comprehensive formula for the polarizability, $\alpha(\omega)$, of atoms taking into account the coupling between single-particle excitations in the correspondence limit. From it, the dipole photoabsorption cross section $\sigma(\omega)$ was derived and its properties discussed in different ranges of atomic frequencies.

With these results, we can now formulate the theory of atomic excitations for the statistical model of the atom. The resulting photoabsorption cross section of the atom, in the framework of this model, aside from its inherent interest, should find many applications in astrophysics, plasma physics and in problems of radiative transfer generally.

Summary of Results to Date

Most of our work was reviewed in previous status reports. More detailed accounts are contained in the papers listed in the last section of this report. Briefly, one may summarize the results to date as follows.

1. Atoms with more than one electron never are excited at the frequencies expected from a single-particle picture. The mutual interaction between the electrons always cause a collective shift to higher frequencies. The shifts may be small for excitations from the outer or the innermost atomic shells but are significant for all other excitations.

2. Collective effects usually manifest themselves strongly in the actual frequency distribution of the photoabsorption cross section. The coupling between the electrons in an atom reduces the absorption of low frequencies and enhances the absorption at high frequencies proportionally such that the total absorption over all frequencies remain constant. In short, collective effects shift the absorption to higher frequencies.

3. Our theory predicts that new atomic resonances may occur in the frequency range of order (atomic number) x rydberg, which are essentially collective in nature. The question whether or not these resonances of atoms as a whole have large absorption cross sections is still under investigation.

4. The methods developed for and employed in gaining new insight in the dynamics of atoms lend themselves to the study of many-body problems of even greater complexity. The methodological advances and their application to systems of atoms is currently under study.

Outlook

Our main effort currently is centered about the third of the results mentioned in the previous section. For a detailed study of the atomic resonances each atom in the periodic system would have to be subjected to a separate analysis which for the moment appears to be a prohibitive task.

It is more promising at this time to treat the statistical model of the atom in which all the characteristic differences between atomic structures are averaged out and only the gross trends within the periodic system are retained in such a manner that all atomic properties are scaled to the atomic number Z. One may first ask for the photoabsorption cross section of the statistical atom in a single particle-type approximation. We have calculated such cross sections. The next task is to couple these excitations such that we retrieve the response of the atom as a whole. It is this problem we intend to undertake during the coming year. Since then the photoabsorption cross section and its frequency dependence is scaled only via the parameter Z, the resulting curve may be called a universal photoabsorption cross section valid, within the framework of the statistical model, for all atoms and all frequencies.

Such a universal cross section is desirable for two reasons: First, if collective resonances of the atoms occur as a general phenomenon it should appear prominently in this curve. Secondly, such a curve would be of immediate practical importance for many applications in physics, chemistry, and astronomy.

Reports and Papers

NASA Status Reports

July 1, 1961 - December 31, 1961

January 1, 1962 - June 30, 1962

July 1, 1962 - December 31, 1962

January 1, 1963 - June 30, 1963

July 1, 1963 - December 31, 1963

January 1, 1964 - June 30, 1964

1. Werner Brandt and Stig Lundqvist, "Possible New Atomic Resonances," Phys. Letters 4, 47 (1963)

2. Werner Brandt and Stig Lundqvist, "Atomic Response Function," Phys. Rev. 132, 2135 (1963)

3. Werner Brandt and Stig Lundqvist, "Collective Effects in Atomic Spectra," J. Quant. Spectroscopy and Radiative Transfer, (1964) (in press)

4. Werner Brandt and Stig Lundqvist, "Many-electron Effects in the Dipolar Spectra of Closed-Shell Atoms," Arkiv för Fysik, (in press)

5. Werner Brandt and Stig Lundqvist, "Atomic Oscillations in the Statistical Approximation," July 1964