Semi-Annual Status Report

for

Investigation of Energy Levels in

Foil Excited Atomic Beams

NASA Grant NGR 30-002-018

This report is not in final scientific form but is a progress review of our present activities. Therefore, it is requested that its distribution be restricted to the National Aeronautics and Space Administration for administrative purposes only.

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Prepared by

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and

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INTRODUCTION

This report represents the activity on the subject grant during the six month period beginning February 1, 1966 and ending July 31, 1966. The purpose of the experiment as described in the grant proposal is summarized below.

The purpose of this experiment is to study the relative population and mean lifetimes of some levels in atomic beams of hydrogen and helium using the foil method of excitation. The atomic beams are obtained by passing high velocity H_2^+ and He^{3+} ions from a Van de Graaff accelerator through a thin carbon foil ($20 \pm 5\ \mu g/cm^2$). The ions are either excited as they pass through the foil, or else pick up an electron to become an excited atom; thus, the emerging beam is luminous due to de-excitation of either the excited ions or atoms in the beam. Information about the lifetimes and relative populations of the atomic states are obtained by studying the intensity of the atomic beam as a function of distance from the point of initial excitation.

An additional aim of this program is the investigation of the inelastic scattering of electrons from atomic energy states. Feasibility of this type of experiment is under investigation both experimentally and theoretically.

II. UNH PROGRAM

1) Determine the spectra produced by the foil method of excitation.
2) Determine the lifetimes of the corresponding excited states.
3) Determine the number distribution of excited states populated by the foil method of excitation.
4) Investigate the feasibility of measuring inelastic electron scattering cross-sections from atoms and ions in known energy states.

III. SUMMARY OF PROGRESS

We have measured the fall-off in intensity of several spectral lines as a function of time from the point of initial state population. The lines investigated up to this date are the 4861Å and 1215Å lines of HI and the 4859A, 3889A, 4686A lines of HeI and HeII. An EMI "red sensitive" photomultiplier has been ordered so that we may extend our measurements to the longer wavelengths and further work is currently being done on helium in the visible and ultraviolet.

Our main concern at the present is the analysis of the data already accumulated. This is being done with an IBM 360 curve fitting program which fits the data to a function of the form:

$$y = \sum_{i=1}^{n} a_i e^{-\beta_i t}$$

where the a_i's are related to the initial state populations and the β_i's are the transition probabilities between the states in question. The generalized curve fitting program which uses the maximum likelihood method was developed by F. Grard, [Univ. of Calif., Radiation Lab. Report, CRL-10153, T.L.D.-4500, 17th ed. (unpublished)]. In our case, since we are assuming a normal distribution of errors, the technique simplifies to the method of least squares. This program, called "Malik" has been used by A.S. Goodman and D.J. Donahue [Phys. Rev. <u>141</u>, 1 (1966)] and W.S. Bickel and A.S. Goodman [Phys. Rev. <u>148</u>, 1 (1966)] to fit data similar to ours. It is interesting to note, however, in the paper by Bickel and Goodman they find that the best fit to their lyman α data is of the form:

$$y = a_1 e^{-\beta_1 t} + k$$

where k is a constant. Their explanation for this choice of fit is that, even though the effect of repopulation of the 2p state of HI from higher states is evident in their data, the lifetimes of these higher states are so long that the program cannot detect their exponential decay; and it therefore treats their contribution to repopulation of the 2p state as a constant.

In preliminary analysis of our Lyman α data, we have found that the best fit to the data is at least the sum of two exponentials. We are in the process of testing the goodness of fit to the data of a function composed of the sum of three exponentials.

It is also interesting that we find no abrupt change in intensity in our intensity versus time data for the HeII system which is in contradiction with the results reported by S. Bashkin and G. Beauchemin [To be published, Canadian J. of Phys.]. They explain this effect by referring to an earlier experiment [S. Bashkin, et. al., Phys. Rev. Letters 15, 284 (1965)] in which they saw a similar result when an electric field was applied perpendicular to the direction of the motion of the atomic beam. It was concluded in this experiment that this abrupt change in intensity was due to the Stark effect. Since we were limited in spectral range by our photomultiplier detector, we were only able to investigate this reported effect in the 4859A line and in the 4686A line which was over-exposed in the Bashkin data. (They were unable to conclude that this effect was present in the 4686 line due to the over-exposure; however, they assumed that they would have observed it in the 4686 line had not the plate been over-exposed).

With respect to the proposed electron scattering experiment we have been concentrating on obtaining good results from our electron gun. (It's design is similar to that used by J.A. Simpson)[Rev. Sci. Instr., 34, 265 (1962)]. We have purchased a diffusion pump and mechanical pump and have fabricated a chamber for this scattering experiment. With the electron gun in this chamber, we have been striving to obtain the desired high current (~100 μa) monoenergetic (~30 eV) electron beam. Up to this date our success has only been moderate and at the present time, we are experimenting with some minor modifications to the basic design.

IV. PROPOSED WORK DURING THE NEXT REPORTING INTERVAL

1) We propose to extend our work to longer wavelengths when we receive the "red-sensitive" photomultiplier previously ordered.

2) We will continue the analysis of our data with "Malik", the IBM 360 program, as long as funds remain. (The UNH Computation Center charges $180.00 per hour.)

3) Work will continue on the proposed electron scattering experiment. In particular, we will obtain maximum efficiency from the electron gun and test the gun and electrostatic analyzer system for the effect of electron scattering from residual gas atoms in the chamber.