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TITLE OF RESEARCH:

Properties of Simple Atoms and Ions

PERIOD:

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SUBMITTED BY:

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Degrees Awarded

None.

Publications

S. Dworetsky, R. Novick, W. W. Smith, and N. Tolk, "Electron Bombardment Ion Source for Low Energy Beams," Rev. Sci Instr. 39, 1721-1723 (November 1968).

R. Miller, W. Fastie, and R. Isler, "Rocket Studies of Far-Ultraviolet Radiation in an Aurora," J. Geophys. Res. 73, 3353-3365 (1 June 1968).

Lectures

C. J. Artura, R. Novick, and N. Tolk, "He^{+}(2S)-He Inelastic Collisions," 21st Gaseous Electronics Conference, University of Colorado, Boulder, Colorado, 16-18 October, 1968; Bull. Am. Phys. Soc. II, 14, 265 (February 1969).

Reports

Columbia Radiation Laboratory Progress Report No. 18 to the Joint Services Technical Advisory Committee (U. S. Army, U. S. Navy, and U. S. Air Force) under Contract DA-28-043 AMC-00099(E), October 31, 1968, pp. 3-10, 23-29, 34-36.

Description of Research

OPTICAL EXCITATION WITH LOW-ENERGY IONS

Our program of investigation of excitation in low-energy He^+-He collisions has, during the past half year, focused attention on excitation of the lowest excited states of He I. Radiation emitted by the decay of such states lies in the far ultraviolet. Recent attempts to explain our previous results theoretically have led to this course of study.

We have previously observed strong oscillatory structure in the dependence of excitation of higher excited states ($n = 2$, 3, 4, 5) on bombarding beam energy.[1] This as well as other phenomena in our data has been explained in terms of a ground-state molecular pseudocrossing occurring at a certain He^+-He internuclear separation R_x.[1] It was felt that the observed oscillatory structure was due to a phase difference developed during the evolution of the system in a quantum-mechanical superposition of states when $R < R_x$. Quantitative analysis showed that this would not account for the observed structure.[2] Calculations now indicate that a second crossing between two excited states exists at $R_s > R_x$.[2] Initial calculations show that the phase difference developed between R_x and R_s can account for our experimental results. More extensive calculations are now being carried out on the final state interaction. At this point, accurate calculations seem possible only for the lowest-lying excited states.

In conjunction with these calculations, an experimental effort was initiated to study the excitation of the low-lying 2^1P state during the He^+-He collision. This state emits 584-Å radiation when it decays to the ground state and would be amenable to accurate calculation. Numerous technological difficulties

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1. M. Lipeles, R. Novick, and N. Tolk, Phys. Rev. Letters **15**, 815 (1965); S. Dworetsky, R. Novick, W. W. Smith, and N. Tolk, Phys. Rev. Letters **18**, 939 (1967).

2. H. Foley and H. Rosenthal, private communication.

associated with the resonant nature of this radiation have been met and overcome. Our experimental apparatus now includes (1) a McPherson 1-meter normal incidence vacuum uv spectrometer to select the radiation emitted at 584 Å, (2) a collodion film ≈ 500 Å thick to separate the spectrometer and target chamber and thereby minimize the trapping effect normally present in observing resonant radiation, and (3) an EMI open-face particle multiplier to detect the 584-Å photons. During the past half year a signal was observed and was studied both as a function of beam energy and target pressure. By extending the range of measurable target pressure, the trapping effect will be studied further during the next period. We also plan to study this line when He^3 is used as a collision partner. Such work will help us analyze this process of phase development.

It has been recently brought to our attention that this collision work might be useful to workers in the field of MPD flows of propulsion interest.[3] Specifically, the velocity components of the propellant as a function of pressure must be consistent with, and might be better understood in terms of, collision processes of the kind which we are now studying. Active communication is being established with these groups so that better use might be made of our results. We hope also to obtain suggestions which might give us added direction so that our work could better aid the development of such devices.

THE DECAY OF THE METASTABLE HELIUM ION

We have completed our study of the spectral distribution of the two-photon emission from the metastable $2^2S_{1/2}$ state of singly ionized helium. The two-photon coincidence counting rates that we have observed experimentally agree with the coincidence counting rates calculated from the theoretically

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3. U. Kogelschatz, AIAA Paper 69-110, January, 1969; A. C. Malliaris and D. R. Libby, AIAA Paper 69-109, January, 1969.

predicted spectral distribution of the two-photon emission. While we have not been able to provide a critical test of the theory in the sense that other spectral distributions are also consistent with our observations, we have certainly shown that the coincidence spectrum is continuous. We have also shown that the theoretically null "soft"-"soft" coincidence counting rate is less than 1/60 of the "hard"-"soft" coincidence counting rate. The residual coincidence counting rate is due only to statistical fluctuations in the chance coincidence background. A publication describing our work is in preparation and will be submitted at an early date to the Astrophysical Journal.

RELAXATION OF EXCITED ATOMS

The optical pumping method described previously[4] has been used to measure the quenching rates of excited alkali atoms in various buffer gases. The rates of atomic excitation and fluorescent decay as a function of buffer gas pressure are measured by monitoring the transmitted and scattered beams, respectively. By periodically saturating the ground-state magnetic resonance transitions, differential changes in intensity can be observed by lock-in techniques, thereby eliminating the problem of instrumental scattering.

Results have been obtained for quenching of the first excited-state doublet of rubidium by nitrogen. The quenching cross sections at room temperature for the $^2P_{1/2}$ and $^2P_{3/2}$ states are identical to within experimental error (5%) and equal to 80 $Å^2$. The rates for transfer between the doublet components have been observed and appear to be small, but no precise measurements have yet been made. For hydrogen and deuterium, preliminary work has shown that the rates for transfer between the components of the P doublet are comparable to the quenching rates out of them.

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4. Columbia Radiation Laboratory Semiannual Report No. 11 to the National Aeronautics and Space Administration for Grant NsG-360/33-008-009, October, 1968.