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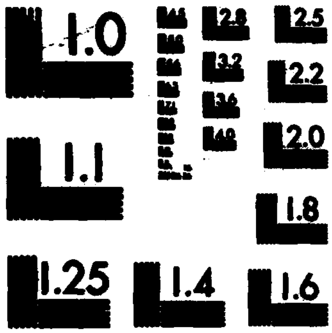

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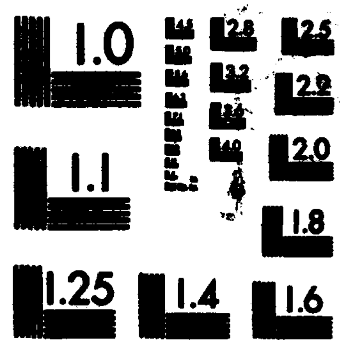

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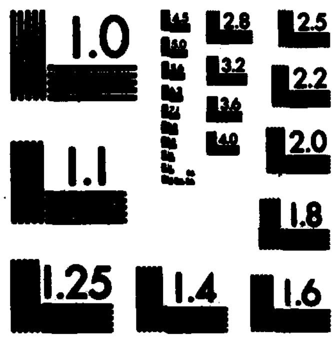

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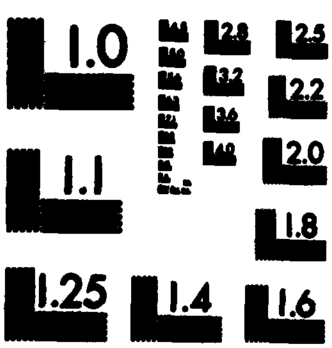

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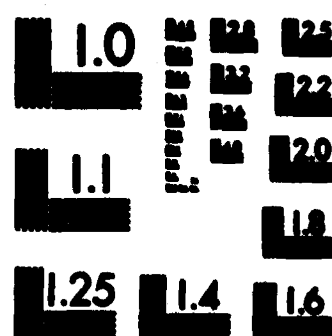

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The general objectives of this research project are to study collisional excitation of atoms and molecules and the radiation emitted by these excited atoms and molecules. For the 7/81-6/82 period our major efforts include (i) electron excitation of the xenon atom, (ii) electron excitation of the nitrogen molecules, (iii) a new technique for measuring electron excitation of metastable levels of atoms, (iv) excitation of sodium atom by negative-ion impact.

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Annual Technical Report: 1 July 1981 - 30 June 1982

Grant Number AFOSR-78-3649

Principal Investigator: Chun C. Lin

The general objectives of this research project are to study collisional excitation of atoms and molecules and the radiation of such excited atoms and molecules. During the period of 1 July 1981 - 30 June 1982, our major efforts were in the following areas:

(i) electron excitation of the xenon atom: We have measured absolute optical cross sections for some 100 emission lines of the xenon atom produced by electron-impact excitation for incident electron energies from threshold to 100 eV. From these optical data we are able to determine the direct excitation cross sections of all ten 2p levels (the $5p^5 6p$ configuration) as well as the apparent excitation cross sections of a number of levels from the $5p^5 ns$ and $5p^5 nd$ configurations. The excitation cross sections of the $2p_1$, $2p_2$, $2p_3$, and $2p_4$ levels are much smaller than those of the $2p_5, \ldots, 2p_{10}$ levels. This is an unusual feature of xenon excitation since the same kind of disparity in cross section was not found in argon and neon.

(ii) electron excitation of the N_2 molecule: Electron-impact excitation of the N_2 molecule plays a very important role in atmospheric physics and gas discharge. While the excitation cross sections of the $B^3\Pi_g$ and $C^3\Pi_u$ states have been studied extensively, much less is known about the electron excitation of the higher states. We have measured the optical emission cross sections for the $D^3\Sigma_u^+ \rightarrow B^3\Pi_g$ Fourth Positive band system of the nitrogen molecule excited by electron impact on ground-state N_2 molecules. Optical measurement for seven bands corresponding to $D^3\Sigma_u^+(v'=0) \rightarrow B^3\Pi_g(v''=0,1,2,3,4,5,6)$ has been made. The apparent cross section for the $v'=0$ level of the $D^3\Sigma_u^+$ state is 1.4×10^{-19} cm^2 at maximum. The excitation functions of all seven bands

studied show a principal maximum at 15.7 eV and a secondary maximum at 25 eV. This double-maximum feature is suggestive of singlet admixture in the $D^3\Sigma_u^+$ electronic wave function.

(iii) continuation of development of a new method for measuring electron excitation cross sections of metastable levels of atoms and molecules: In the usual optical method for studying electron excitation, one determines the electron excitation cross sections by measuring the radiation emitted by the atoms that are lifted to the excited levels of interest by electron impact. This procedure fails if the excited level is a metastable one as there is no radiative transition from this level. Our new method consists in pumping the metastable atoms (by a laser) to a higher level and observing the radiation emitted by this higher level. The rate of photon emission from this higher level as induced by laser pumping (the laser-induced fluorescence) is utilized to determine the excitation cross section of the metastable level. Recently we have varied the polarization of the pumping light (laser) and observed the variation in the polarization of the laser-induced fluorescence. This result enables us to determine separately the excitation cross section of each magnetic sublevel of the metastable state.

(iv) excitation of Na atoms to the 3p state by H^- ion impact: The cross sections (apparent) for the excitation of the Na atom from the ground level to the 3p level by H^- ions have been measured for incident ion energies in the range 1-25 keV. This was done by measuring the intensity of the $3p \rightarrow 3s$ emission produced by a H^- beam passing through a Na vapor target. The cross section rises from 1.4×10^{-15} cm^2 at 1 keV to a maximum of 3.8×10^{-15} cm^2 at 15 keV and then falls to 3.6×10^{-15} cm^2 at 25 keV. We interpret these cross sections in terms of a quasi-free electron model as follows. The H^-

ion consists of a proton, a tightly bound inner electron, and a loosely bound outer electron. The net excitation action of the neutral core (proton and the inner electron) is much smaller than the action of the outer electron since during collision the outer electron keeps the neutral core from coming into close contact with the Na atom so that the effect of the proton approximately cancel that of the inner electron. Thus we neglect the neutral core and consider only the outer electron. The outer electron is treated as being quasi-free with a distribution of velocities $F_v(v')$ given by the vectional sum of the H^- ion center of mass, v, plus the velocity distribution of the outer electron about the center of mass. A beam of H^- ions with a particular velocity, v, is treated as being equivalent to an electron beam with a distribution of velocities $F_v(v')$ which can be determined from the wave function of H^-. Using the <u>electron</u> excition cross sections for the 3p level of Na (measured in our laboratory recently) along with $F_v(v')$, we obtain the "theoretical" 3p excitation cross sections by H^--ion impact based on the quasi-free electron model. These "theoretical" cross sections are found to agree well with the measured values over the entire 1-25 keV range. The success of this quasi-free electron model indicates a direct correlation between electron-impact excitation and H^--ion-impact excitation, and the study of latter may provide important information about the former.

<u>Publications</u>

"Electron-Impact Excitation of the Sodium Atom", Physical Review A <u>24</u>, 1299 (1981).

"Electron Excitation Cross Sections for the $1s_2$ and $1s_4$ Levels in Ne", Physical Review A <u>25</u>, 1185 (1982).

"Production of Atomic Nitrogen Emission by Electron-Impact Dissociative Excitation of Nitrogen Molecules", Journal of Chemical Physics <u>76</u>, 3597 (1982).

"Excitation of the Na(3p) Level by H^- Ion Impact", submitted for publication.