MEASUREMENT OF ELECTRON-ATOM SCATTERING CROSS SECTIONS AT LOW ENERGIES BY PHOTOELECTRON SPECTROSCOPY

by

K.P. SUBRAMANIAN

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PHYSICAL RESEARCH LABORATORY
AHMEDABAD 380 009
INDIA

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To

My Parents

CERTIFICATE

I hereby declare that the work presented in this thesis is original and has not formed the basis for the award of any degree or diploma by any University or Institution.

K.P. Subramanian

Certified by:

Vijay Kumar
Ahmedabad.

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STATEMENT

The basic aim of the work presented in this thesis is to measure the electron scattering cross-sections for noble atoms at low electron energies.In this energy region,new theoretical models for calculating the electron-atom scattering cross-section accurately are now available in literature with the result that a direct comparison of the experimental data is now possible.Experimentally,low energy electron scattering studies are difficult and somewhat challanging. Not much data are available in this electron energy region. An experiment has been designed and fabricated in the laboratory to measure absolute total electron-atom scattering cross-sections using a photoelectron source. This is the first time when such a study has been carried out using the powerful technique of photoelectron spectroscopy. The electron scattering cross-sections have been carried out for helium,neon,argon, krypton and xenon a seventeen electron energies ranging from 0.7 to 10 eV with an accuracy of ± 2.7%.

Basic experimental set-up consists of a monochromatic VUV photon source, beam-splitter, photoionising/scattering cell, electron energy analyser, electron detector and data acquisition system. VUV photons from strong emission lines are allowed to interact with source gas kept at low pressure inside the ionising region. Noble gas atoms (argon, krypton and xenon) - are used as source gas for the production of photoelectrons. Photoionisation of source gas leads to the production of electrons with two energies, corresponding to $^2P_{1/2}$ and $^2P_{3/2}$ state of the ion thus produced. Using various combinations of of photon energies and source gases, seventeen energy points could be generated in the electron energy region ranging from 0.7 to 10 eV. Photoelectrons thus produced are allowed to undergo scattering in the cell where target gas is introduced. The photoelectrons are then energy analysed and the intensities of photoelectron peaks are monitored as a function of target gas pressure. Sometimes source and target gas are one and the same. Total scattering cross-sections are derived from these observations. the experimental set-up has been described in detail in chapter 2 of the thesis whereas the subject of electron scattering at low energies has been introduced in chapter 1.

An analytical method has been developed to compute the scattering cross-sections from the observations for attenuations of photoelectron peaks due to the introduction of target gas in the scattering region. Two methods for data analysis have been developed when source and target atoms are the same and when these are different. These methods have been discussed in chapter 3 of the thesis.

The major errors taken into account are errors from pressure maesurement, thermal transpiration effects, scattering in the accelerating region of the energy analyser, uncertainty in the scattering path length,counting statistics, forward scattering of electrons,gas impurities etc. Coherent sum of all these errors acted as upper limit to the actual error and it came out to be $\pm5.3\%$.The incoherent sum of all these errors represent the most probable error which is $\pm2.7\%$ in this experiment.All errors and their estimated magnitudes have been discussed in detail in chapter 4 of the thesis.

The total electron scattering cross-sections for helium as measured in the present experiment are comparable with those reported by other investigators using transmission techniques and time-of-flight measurements and using variational methods to express helium ground-state wave function. The electron-neon scattering cross-sections also compare well with the measurements made other investigators and theoretical calculations using adiabatic exchange approximations and R-matrix theory.In the case of argon,the scattering cross-sections reported in the present work compare well those measured by transmission techniques but disagree in some limitted energy regions with measurements obtained by time-of-flight technique. There is a good agreement between our results and those reported by R-matrix calculations. Electron scattering cross-sections for krypton and xenon obtained in the present work at electron energies upto 5 eV compare well with the values given by other investigators using transmission technique but at higher energies, there is a discrepancy between different set of experimental data. Unfortunately, at electron energies above 2 eV, the results reported using different theoretical models for both krypton and xenon disagree to a large extent with the results obtained by different experimental techniques. The results for the present experiment have been discussed in detail in chapter 5 of the thesis whereas conclusion and scope for future work has been taken up in chapter 6.

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(K.P. Subramanian)

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CHAPTER TWO : EXPERIMENTAL SET-UP