THEORETICAL STUDY OF POSITRON - EXCITED ALKALI ATOM COLLISIONS

Thesis

Submitted for Partial Fulfillment of the Requirements for M.Sc. Degree in Physics

By

Khadija Ali Mohamed Ali
(B.Sc., 7th October University - Libya)

To

Physics Department, Faculty of Science,
Ain Shams University, Cairo-Egypt

2012

THEORETICAL STUDY OF POSITRON - EXCITED ALKALI ATOM COLLISIONS

By

Khadija Ali Mohamed Ali

B.Sc. (Physics)

Faculty of science, 7th October University, Libya

Thesis Advisors *Approved*

Prof. Dr. Salah Yaseen El-Bakry -----

Prof. of Theoretical Physics,
Faculty of Science, Ain Shams University

Dr. El-Sayed A. El-Dahshan -----

Assist. Prof. of Computational Physics,
Faculty of Science, Ain Shams University

Dr. Mahsan Mahsoup -----

Lecturer of Theoretical Physics,
Faculty of Science, Ain Shams University

2012

دراسة نظرية لتصادم البوزيترونات
مع ذرات قلوية مثارة

رسالة تكميلية

مقدمة للحصول على درجة الماجستير
فى العلوم فى الفيزياء

مقدمة من

خديجة علي محمد علي

بكالوريوس العلوم – جامعة ٧ أكتوبر – ليبيا

قسم الفيزياء – كلية العلوم

جامعة عين شمس

٢٠١٢

CONTENTS

CONTENTS (Cont...)

LIST OF TABLES

LIST OF TABLES (Cont...)

LIST OF TABLES (Cont...)

LIST OF TABLES (Cont...)

LIST OF FIGURES (Cont...)

LIST OF FIGURES (Cont...)

Fig. No.	Title	Page No.

Acknowledgement

I wish to express my sincere appreciation to professor **Dr. Salah Yaseen El-Bakry,** Professor of Theoretical Physics and Head of Theoretical Physics Group, Physics Department, Faculty of Science, Ain Shams University, and the major advisor, for suggesting the topics of this work and for his continuous guidance, encouragement, confidence and patience which gave me added incentive throughout the development of this manuscript.

Sincere thanks are extended to **Dr. El-Sayed A. El-Dahshan,** Assist. Prof. of Computational Physics, Physics Department, Faculty of Science, Ain Shams University, for the helpful guidance in progress of this work and help during the preparation of the computer codes of my work.

I would also like to extend my appreciation to **Dr. Mahasen Mahsoup,** Lecture of Theoretical Physics, Physics Department, Faculty of Science, Ain Shams University, for her fruitful help during the preparation of our programs.

I would like to express my gratitudes to **Prof. Dr. Adel Abdel Sattar El-Saadany,** Head of the Physics Department, for his help and encouragement

My very warm gratitudes go to **Dr. M. S. Al-Kotb** and the members of the Theoretical Group at the Physics Department, Faculty of Science, Ain Shams University, for many fruitful discussion as well as for their kind supports.

On a person notice, I am indebted to my family for their support and encouragement over all these years.

ABSTRACT

The inelastic scattering of positrons by excited lithium alkali atoms $\mathrm{Li}^*(2\mathrm{p})$ have been investigated within the frame work of the coupled – static and frozen – core approximations with the assumption that the elastic and rearrangement channels are open. In the present work, a rather complicated computer code is developed based on the coupled – static, frozen – core and Green's function partial wave expansion technique. The partial and total elastic and positronium (Ps) formation cross sections of $e^+ - \mathrm{Li}^*(2\mathrm{p})$ are calculated through a wide range of incident energy of positrons ranging from 0.3 eV to 1000 eV. Also, we have calculated the partial and total elastic and rearrangement (reversal of the Ps formation) cross sections of Ps – Li^+ collisions through the low, intermediate and high energy regions.

The effect of polarization potential of the Ps atom is taken into our consideration. The total cross sections which corresponding to twelve partial cross sections (calculated at twelve values of the total angular momentu $l = 0$ to $l = 11$) are calculated for each channel. Our calculated total positronium formation cross sections are compared with experimental results and those calculated by other authors. The present calculations encourage the experimental physicists to carry out positron – lithium experiments by taking the excited lithium target into accounts in order to obtain more positronium especially in the low and intermediate energy regions.

Keywords: Positrons; Positronium formation; Alkali atoms; Collisions; Inelastic scattering; Cross-sections; Lithium; Polarization potential.

Chapter 1

INTRODUCTION

1.1 The importance of scattering

Atomic scattering (collision) is a very wide topic. The field of atomic scattering has a venerable history, since it was central to the development of quantum mechanics, and nuclear physics. Atomic scattering are the basic means for probing the atomic structure of matter. Almost every thing we know about nuclei and elementary particles has been discovered in scattering experiments, from Rutherford's surprise at finding that atoms have their mass and positive charge concentrated in almost point - like nuclei, to the more recent discoveries, on a far smaller length scale, that protons and neutrons are themselves made up of apparently point - like quarks. More generally, the methods that we have to probe the properties of condensed matter systems rely fundamental on the notion of scattering. Study of scattering processes is the main source of information about strong, electromagnetic and weak interactions [Burke].

The interaction of antimatter with matter is an interesting and active field of study. Positron interactions with matter play important roles in many physical processes of interest. Examples include the origin of astrophysical sources of annihilation radiation, the use of positron in medicine (e.g, positron emission tomography); the characterization of materials; and the formation of antihydrogen, which is the simplest of stable, neutral antimatter [Marler].