



**PHOTOIONIZATION OF GASES
IN THE EXTREME ULTRAVIOLET**

MICHAEL JOSEPH HENNESSY , B.Sc. (HONS.)

**Thesis submitted for the degree of
Master of Science
in
The University of Adelaide
(Department of Physics & Mathematical Physics)**

October 1996

CONTENTS

	<u>Page</u>
Abstract	(iv)
Statement	(v)
Acknowledgments	(vi)
CHAPTER 1: Photoabsorption by gases	
1.1 Introduction	1
1.2 Atomic absorption	2
1.3 Quantum Mechanics	3
1.4 Atomic photoionization	8
1.5 Diatomic molecular absorption	13
1.6 Molecular photoionization	18
CHAPTER 2 : Light production	
2.1 EUV light sources	20
2.2 Gas discharge theory	21
2.2.1 Introduction	21
2.2.1a Gas discharge light production	21
2.2.2 Breakdown mechanisms	22
2.2.3 Glow discharge	28
2.2.3a Negative glow	29
2.2.4 Hollow cathode effect	30
2.2.5 Low pressure spark discharge	32
2.3 The experimental lamp	34
2.4 Lamp power supplies	35
2.4.1 Lamp operation	36
2.3c The Lamp spectra	38

CHAPTER 3 : Wavelength selection		
3.1	Diffraction grating theory	40
3.2	The monochromator	41
3.3	Operation of the monochromator	42
CHAPTER 4 : Ionization particle detectors		
4.1	Double ionization chamber theory	43
4.2	The experimental double ion chamber	46
4.3	Photoionization cross section measurements using the double ionization chamber	48
4.4	Metrology of the experimental ion chamber	49
4.4.1	Determination of ion collector length	49
4.4.2	Determination of the number density	50
4.4.2(a)	Temperature measurement	50
4.4.2(b)	Pressure measurement	51
4.4.2(c)	Target gas number density	52
CHAPTER 5 : Ion current measuring equipment		
5.1	Review of electrometer instrumentation	53
5.2	Experimental electrometer	54
5.2	Digitiser circuit	55
CHAPTER 6 : Data recording electronics		
6.1	Computer interface	57
6.2	Detector linearity	58
CHAPTER 7 : Data acquisition		
7.1	Experimental techniques	59
7.2	Operation of the double ionization chamber	61

CHAPTER 8 : Experimental Data

8.1	Introduction	63
8.2	Argon total photoionization cross section	63
8.3	Nitrogen total photoionization cross section	66
8.4	Oxygen total photoionization cross section	68

APPENDICES

Appendix I :	Systematic errors of the experimental double ion chamber	70
Appendix II :	CBM-interface program	74

BIBLIOGRAPHY		76
---------------------	--	----

ABSTRACT

The main goal of this thesis is the measurement of the total photoionization cross section of gases, principally Ar, O₂ and N₂, from approximately 200 to 600 Å, that is, in the Extreme Ultraviolet (EUV). The present aim is to reduce errors associated with the experimental acquisition of data and to achieve cross sectional results with total relative errors of less than $\pm 3\%$.

The emphasis of the experimental work was on the construction of a pulsed power supply capable of delivering peak currents of the order of a thousand amperes for use with a condensed spark discharge lamp, the design and implementation of an electrometer, built from discrete components, and a computer interface board.

Radiation from the lamp was dispersed by a grazing incidence monochromator before being passed into a double ionization chamber. The ion currents produced by the absorption of EUV radiation in the double ion chamber were grounded through their respective electrometers, whose readings used with other physical measurements, results in the total photoionization cross section being determined.

STATEMENT

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of the my knowledge and belief, contains no material previously published or written by any other person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

SIGNED:

.....**DATE:** 25/10/96

ACKNOWLEDGMENTS

To my supervisor, Dr. A. J. Blake, I wish to express my sincere gratitude for his limitless patience and easy accessibility whenever it was necessary to consult him for advice. I also thank Dr. D. G. McCoy for the many informative discussions on various experimental problems and, more importantly, their solutions. Also it would be remiss of me not to mention the technical staff for their extremely useful advice and hands-on help with many aspects of this work. Principally they were Messrs J. Wright and B. Nation, consecutive technicians with the UV Group, Messrs J. Smith and M. Shorthose from Electronic Services and Messrs P. Schebella, J. Schache and G. Eames from the department's Mechanical Workshop.

To my fellow students, especially those within my research group and in particular Messrs M. Panizza and A. L. Jones, I offer my gratitude for the time and assistance they freely gave. Also thanks to all fellow postgraduate students who offered a healthy social atmosphere outside the laboratory with various sporting activities and other not-so healthy social activities!

Lastly, but definitely not least, I thank Jennifer for her love, understanding and support above and beyond what can be reasonably expected. I truly hope that we both reap the rewards from what has been achieved here.