

Table of Contents

Acknowledgements	iv
Abstract	vi
Table of Contents	vii
List of Figures	x
List of Tables.....	ix
Chapter 1: Introduction.....	1
1.1 Historical Overview	1
1.1.1 Multiphoton Ionization	2
1.1.2 Multiphoton Detachment from Negative Ions	6
1.2 Multiphoton Detachment from H^-	8
1.2.1 Theoretical Interest in MPD of H^-	9
1.2.2 About the H^- MPD Experiment	10
Chapter 2: Basic Physics and Concepts.....	15
2.1 General Aspects	15
2.2 Consistency of Gauge, Operator, and State Vector.....	19
2.3 Perturbation Theory	22
2.4 Keldysh-Type Theories	26
2.4.1 Keldysh Ansatz.....	26

Table of Contents

2.4.2 A view on Keldysh-Type Theories	30
2.5 Floquet Theory.....	32
2.6 Relativistic Doppler Effects	34
2.7 A Heuristic Theory	36
Chapter 3: Features of Multiphoton Detachment in H⁻ : Theory .	37
3.1 Threshold Behavior and Laser Polarization	38
3.2 Zero-Range Potential- A Good Approximation for H ⁻	40
3.3 Roles of Laser Intensity, Frequency, and Polarization	41
3.3.1 Method of Calculation	41
3.3.2 Polarization Effects and Shifts in Threshold Energies	42
3.3.3 Channel Closing and Energy Shift of the Ground State	44
Chapter 4: Experiment.....	49
4.1 LAMPF, HIRAB, and the H ⁻ Beam	49
4.2 Limitations of the Experiment	54
4.3 Experimental Arrangement and Setup.....	57
4.4 Experimental Procedure	66
4.5 Calibration of Relative Signals	71
4.6 Measurement of Focal Region	73
Chapter 5: Results and Discussion	77
5.1 Summary of Experimental Conditions.....	78
5.2 Threshold Structures	79
5.3 Estimate of Absolute MPD Rates of H ⁻	83
5.4 Intensity Effects- Power Law Studies.....	85

Table of Contents

5.5 Comparison with Wigner Threshold Law	89
5.6 Averaging Effects of Laser Intensity Distribution	90
Chapter 6: Conclusion.....	96
6.1 Multiphoton Processes and Ponderomotive Effects.....	97
6.2 Outcome of the Experiment	98
6.3 Other Aspects of the Experiment	99
Appendix A: Integral Equations of the Wave Function	102
Appendix B: Fundamental Physics behind the Gauge Problem.....	106
B.1 Gauge-Invariant Physics	107
B.2 Work with Different Gauges.....	112
B.3 Physics behind the Gauge Problem.....	114
Appendix C: Floquet Eigenvalue Problem in a Zero-Range Potential	121
Appendix D: CO₂ Laser System.....	130
Appendix E: Optical Alignment	137
E.1 Laser alignment.....	137
E.2 Alignment in the Interaction Chamber	140
Appendix F: Multiphoton Detachment Rate and Cross Section	141
Appendix G: Calculation of MPD Rate and Energy Level Shift ...	144
Appendix H: MPD Data for Fig. 5.5	155
References.....	158

Table of Contents

List of Figures

Chapter 1.

1.1. Schematic Diagram of the Experiment.....	11
1.2. Preliminary Data of Relative MPD Cross Section.....	12
1.3. Temporal Profile of an Unsmoothed Laser pulse	13

Chapter 3.

3.1. Multiphoton Dipole Selection Rule	39
3.2. Dependence of MPD Rates on Photon Energy, Laser Intensity, and Polarization	43
3.3. Channel Closing and Transition of Dominant Orders	45
3.4. Same as Fig. 3.3, but on a semi-logarithmic scale.....	46
3.5. Energy Shifts of the Quasi-Bound H^-	47

Chapter 4.

4.1. The Experimental Areas at LAMPF.....	51
4.2. The Experimental Areas of the External Proton Beam.....	52
4.3. The Overall Experimental Arrangement	58
4.4. The Laser and Optical Arrangement	60
4.5. The HIRAB Beam-Line Arrangement in 1989	62
4.6a. A Side View of the Interaction Chamber	63
4.6b. A top View of the Interaction Chamber	64
4.7. A Scheme Separating Upstream Background from Signals.....	67
4.8. Relative Gain Calibration of the Electron Spectrometer.....	72
4.9. Setup for Focal Region Measurement.....	74
4.10. A Spatial Profile of the Focused Laser Beam	75

Table of Contents

4.11a. Variation of Laser Spot Sizes in the Focal Region (Amplifier off)	76
4.11b. Variation of Laser Spot Sizes (Amplifier on).....	76

Chapter 5.

5.1. Temporal Profile of a Smoothed Laser Pulse.....	78
5.2. A Photon Energy Scan across the 5-photon Region	80
5.3. Dependence of the MPD Yield on Photon Energy for 3 Laser Intensity Settings.....	82
5.4. Electron Pulse Height versus PMT Voltage Setting	84
5.5. Intensity-Averaged MPD rate versus Photon Energy.....	86
5.6. A Study of Laser Intensity Effects at Several Selected Photon Energies	87
5.7. A Fit to Wigner Threshold Law	89
5.8. Intensity weighting function for $\alpha = 25^\circ$	91
5.9. Direct Comparison of Intensity-Weighted Theoretical Results with Experimental Data.....	93
5.10. Complication of Signal by a Nonuniform Intensity Distribution ..	94

Appendix D.

D.1. Arrangement of the CO ₂ Laser System	131
D.2. Modification of CO ₂ Gain Profile with a Low-Pressure Gain Cell.	133
D.3. A Schematic Diagram of Triggering the CO ₂ Oscillator	134
D.4. A Schematic Diagram for the Amplifier Electrical Discharge System	136

Table of Contents

List of Tables

Chapter 2.

2.1. Relations between the E - and A -gauges	21
--	----

Chapter 5.

5.1. Results of Power Law Fitting	88
---	----

Appendix H.

H.1.– H.3. Data for Fig. 5.5.	155
------------------------------------	-----