



Contents

Abstract	v
Kurzzusammenfassung	vii
1 Astrochemistry	1
1.1 Spectroscopy and radioastronomy: symbiotic sciences	1
1.1.1 Interstellar molecules	2
1.2 New radio and far-infrared observatories	4
1.3 Necessity of laboratory data	7
1.4 This thesis	8
2 Theoretical Considerations	11
2.1 Introduction	11
2.2 Rotational motion of a molecule	12
2.3 Diatomic molecules - CO ⁺	14
2.3.1 Dunham's solution	14
2.3.2 Spectra of radicals and ions	16
2.3.3 Hund's case b for ² Σ molecules, the fine structure of CO ⁺ .	16
2.3.4 The hyperfine structure of CO ⁺	18

2.4 Asymmetric tops - cyclic and linear C ₃ H ₂	19
2.4.1 Nuclear spin statistics : <i>ortho</i> and <i>para</i> states in C ₃ H ₂ and C ₃ D ₂	21
3 Experimental Setup	23
3.1 Introduction	23
3.2 Radiation sources	23
3.3 Detector	26
3.4 High Resolution Spectroscopy of Molecular Ions	26
3.5 Overview of different techniques	28
3.5.1 Hollow cathode	30
3.5.2 Extended negative glow	31
3.5.3 Velocity modulation	31
3.6 Old experiment	31
3.7 Development of the new discharge cell	34
3.8 Characterization of the new discharge cell	38
3.8.1 Production of ions	39
3.8.2 Less power or less ions	40
3.8.3 Counting ions	42
3.9 Discussion and future developments	44
4 Accurate Rest Frequencies for CO⁺, ideal tracer for Photon-Dominated Regions	47
4.1 Introduction	47
4.2 Previous work	48
4.3 Experimental details	49

4.4	Analysis	52
4.5	Discussion	55
4.5.1	Bond length	56
4.6	Conclusions	57
4.7	Perspectives	58
5	First Interstellar Detection of <i>c</i>-C₃D₂	59
5.1	Introduction	59
5.1.1	Deuterium chemistry in the interstellar medium	60
5.1.2	Cyclopropenylidene	61
5.1.3	Doubly deuterated cyclopropenylidene in the laboratory	62
5.1.4	Doubly deuterated cyclopropenylidene in space	64
5.2	Observations	65
5.3	Results	68
5.3.1	Column density and optical depth	70
5.4	Discussion	73
5.4.1	Modeling the observed abundances with MAPLE	74
5.4.2	Perspectives	78
6	Tentative Detection of <i>l</i>-C₃HD	81
6.1	Introduction	81
6.1.1	Linear C ₃ H ₂ in the laboratory	81
6.1.2	Linear C ₃ H ₂ in space	82
6.1.3	Previous laboratory studies on <i>l</i> -C ₃ HD	83
6.2	Linear C ₃ HD in space	83

6.2.1 Extreme deuteration	85
6.3 New laboratory measurements for <i>l</i> -C ₃ HD	87
6.4 Proposal for the IRAM 30 m telescope	88
6.4.1 Additional noise	92
6.5 Perspectives	93
 A MAPLE mini model	 97
 Bibliography	 101
 Acknowledgements	 115
 Erklärung	 117
 Lebenslauf	 119