

Contents

PREFACE	ix
ACKNOWLEDGEMENTS	xi
NOTES REGARDING SECTIONS, EQUATIONS, REFERENCES, AND NOTATION	xiii
Chapter 1. Historical Development and Basic Principles of Gas Lasers	1
1.1. Introduction	1
1.2. Chronology of Major Advances and Knowledge Gained of Important Basic Selective Excitation Processes	3
1.3. Fundamental Processes	6
1.3.1. Mean free paths and collision cross-sections	9
1.3.2. Velocity and electron-energy distributions	12
1.3.3. Types of collisions (first and second kind)	16
1.4. The Interaction of Radiation with Matter	20
1.5. Oscillation Conditions	23
1.5.1. Dependence of gain on wavelength	24
References	26
Chapter 2. Selective Excitation Processes in Gas Discharges	29
2.1. Theoretical Considerations	29
2.1.1. Transitional probabilities	30
2.1.2. Selective excitation mechanisms	32
2.2. Resonant Excitation-energy Transfer	33
2.2.1. Excitation transfer (atom–atom)	33
2.2.2. Vibrational energy transfer (molecule–molecule)	40
2.3. Charge Transfer	42
2.4. Penning Ionization	49
2.5. Dissociative Excitation Transfer	51
2.6. Electron Impact	54
2.7. Charge Neutralization	56
2.7.1. Dissociative recombination	56
2.7.2. Mutual neutralization	57
2.8. Line Absorption and Molecular Photodissociation	58
2.9. Radiative Cascade-pumping	58
References	58
Chapter 3. Gas Discharge Processes	61
3.1. Introduction	61
3.2. The Glow Discharge	61
3.2.1. The negative glow	62
3.2.2. The positive column	67

CONTENTS

3.3. RF-Discharges	74
3.3.1. General considerations	75
3.3.2. Properties determined by the pressure and frequency of the field	76
3.3.3. Limits of the diffusion theory	77
3.3.4. Average electron energy in the RF-discharge	78
3.3.5. Translation discharges	79
3.4. The Hollow-cathode Discharge (HCD)	79
3.4.1. General considerations	80
3.4.2. Electron energy distribution in the HCD	83
3.4.3. Excitation theories	85
3.4.4. Sputtering action	85
3.4.5. Use as a spectroscopic source	86
3.4.6. Excited-states population in the HCD	87
3.4.7. Electrical properties of the HCD	90
3.5. Pulsed Discharges	91
3.5.1. Excitation processes at breakdown	91
3.5.2. Excitation processes in the afterglow	92
References	98
 Chapter 4. Specific Neutral Laser Systems	 102
Introduction	102
4.1. Resonant Excitation-energy Transfer (atom-atom) Lasers	102
4.1.1. Helium-neon	102
4.1.2. 3.067- μm chlorine	149
4.2. Dissociative Excitation-transfer Lasers	152
4.2.1. Neon-oxygen	152
4.2.2. Argon-oxygen	156
4.2.3. Helium-fluorine	158
4.3. Electron-impact-excited Lasers	163
4.3.1. CW, noble-gas	163
4.3.2. Transient noble-gas and metal-vapor	171
4.3.3. Dissociative, molecular metal-vapor type	176
4.4. Miscellaneous Lasers	178
4.4.1. Charge neutralization lasers; sodium-hydrogen, potassium-hydrogen, pure oxygen, and neon-helium and argon-helium	178
4.4.2. Line-absorption and molecular-photodissociation lasers; cesium, neon, and 1.315- μm iodine	179
4.4.3. Radiative cascade-pumped lasers; helium-neon, and neon	180
References	181
 Chapter 5. Specific Ionized Laser Systems	 186
Introduction	186
5.1. Resonant Excitation-energy Transfer Lasers	186
5.1.1. Helium-krypton	187
5.1.2. Neon-xenon	189
5.2. Charge-transfer Lasers	191
5.2.1. Helium-mercury	192
5.2.2. Helium-cadmium	202
5.2.3. Helium-zinc and helium-neon-zinc	206
5.2.4. Helium-iodine	209
5.2.5. Helium-selenium	213
5.2.6. Helium- or neon-tellurium	218
5.3. Penning-reaction Lasers	222
5.3.1. Helium-cadmium	223

CONTENTS

5.3.2. Helium-zinc	233
5.3.3. Helium-magnesium	237
5.4. Electron-impact-excited Lasers	239
5.4.1. Noble-gas (argon) lasers	241
5.4.2. Pulsed oscillation behavior	245
5.4.3. CW-oscillation behavior	249
5.4.4. Spectroscopy of ion lasers	257
References	259
Chapter 6. Specific Molecular Laser Systems	263
Introduction	263
6.1. Resonant Excitation-energy Transfer (molecule-molecule) Lasers	264
6.1.1. Nitrogen-carbon dioxide	264
6.1.2. "Pure" carbon dioxide	295
6.1.3. Nitrous oxide-nitrogen	301
6.2. Electron-impact-excited Lasers	304
6.2.1. Hydrogen, deuterated-hydrogen, and deuterium (near-infrared and vacuum-UV)	305
6.2.2. Carbon monoxide (infrared, visible, and vacuum-UV)	313
6.2.3. Nitrogen (UV and near-infrared)	342
6.2.4. Noble gas	363
6.2.5. Far-infrared H ₂ O	364
6.3. Line Absorption Lasers	368
6.3.1. 10.6-μm CO ₂ , HBr-laser pumped	369
6.3.2. 81.48-μm NH ₃ , N ₂ O-laser pumped (far-infrared and submillimeter)	371
6.3.3. Iodine vapor, frequency-doubled, YAG-laser pumped (visible and near-infrared)	372
6.4. Radiative Cascade Lasers	373
6.4.1. Hydrogen cyanide, deuterium cyanide (submillimeter)	374
6.4.2. Far-infrared SO ₂	382
References	383
APPENDIX	390
Electron Temperatures in Mixtures of the Noble Gases for Various Values of pD: Figs. A.1 to A.9	390
(see Fig. 3.7 for He-Ne mixture)	
Partial Energy-level Diagrams showing Laser Transitions: Figs. A.10 to A.25	395
Laser Transitions in Atomic Species: Tables 1 to 46	405
References	455
Laser Transitions in Molecular Species: Tables 47 to 85	463
References	515
INDEX	519
OTHER TITLES IN THE SERIES	527