

CONTENTS

I. ATOMS IN STRONG FIELDS: PHOTOIONIZATION AND CHAOS

by P. W. MILONNI and B. SUNDARAM

§ 1. INTRODUCTION	3
§ 2. CLASSICAL PHENOMENOLOGICAL THEORY OF GAS BREAKDOWN BY A LASER	4
§ 3. PERTURBATION THEORY OF MULTIPHOTON IONIZATION	7
3.1. One-photon ionization (the photoelectric effect)	9
3.2. Multiphoton ionization	11
3.3. Computation of multiphoton ionization rates	14
3.4. Field statistics	17
§ 4. BEYOND LOWEST-ORDER PERTURBATION THEORY: INTERMEDIATE RESONANCES	18
§ 5. VOLKOV STATES	22
§ 6. THE KELDYSH APPROXIMATION	25
6.1. Digression on the form of the interaction Hamiltonian	26
6.2. Strong-field perturbation theory	30
6.3. Limitations of the Keldysh theory	36
§ 7. ABOVE-THRESHOLD IONIZATION: EXPERIMENTS	39
§ 8. ABOVE-THRESHOLD IONIZATION: THEORY	45
8.1. Predictions of Keldysh–Reiss theory: ATI peaks and polarization effects	46
8.2. The ponderomotive potential	51
8.3. Numerical experiments on simplified models	56
§ 9. HIGH-ORDER HARMONIC GENERATION	61
§ 10. DISCUSSION	69
§ 11. WHAT IS CHAOS?	74
11.1. Preliminary notions	75
11.2. Hamiltonian systems	78
11.3. Integrability, tori and quasiperiodicity	80
11.4. The KAM theorem	84
11.5. Resonance overlap	85
11.6. Resonance overlap in driven systems	91
§ 12. QUESTIONS OF CHAOS IN ATOMIC PHYSICS	96
12.1. Is there any quantum chaos?	96
12.2. Regular and irregular spectra	102
12.3. Quantum systems can mimic classical chaos	103
§ 13. MICROWAVE IONIZATION OF HYDROGEN: EXPERIMENTS AND CLASSICAL THEORY	109
13.1. Ionization experiments	109
13.2. Resonance overlap for the classical, one-dimensional hydrogen atom	114
13.3. Comparison of classical theory with ionization experiments	118
13.4. Remarks	122
§ 14. MICROWAVE IONIZATION OF HYDROGEN: QUANTUM THEORY	124
§ 15. SUMMARY AND OPEN QUESTIONS	132
ACKNOWLEDGEMENTS	133
REFERENCES	133

II. LIGHT DIFFRACTION BY RELIEF GRATINGS: A MACROSCOPIC AND MICROSCOPIC VIEW

by E. POPOV (SOFIA, BULGARIA)

§ 1.	INTRODUCTION	141
1.1.	Grating anomalies	141
1.2.	Grating properties and physical intuition	142
1.3.	Theoretical approaches to grating properties	145
§ 2.	QUASIPERIODICITY: A FUNDAMENTAL PROPERTY OF GRATINGS	147
2.1.	Statement of the problem	147
2.2.	Reflection grating supporting two diffraction orders	149
2.2.1.	Littrow mount	149
2.2.2.	Non-Littrow mount	151
2.2.3.	Surface waves on corrugated metallic surfaces	152
2.3.	Grating supporting a single diffraction order	153
2.3.1.	Perfectly conducting grating	153
2.3.2.	Total absorption of light by metallic gratings	154
2.4.	Dielectric gratings	156
§ 3.	PHENOMENOLOGICAL APPROACH: A STEP TOWARD THE PHYSICAL INTERPRETATION OF GRATING PROPERTIES	158
3.1.	Resonance anomalies	159
3.2.	Nonresonance anomalies	164
§ 4.	MICROSCOPIC PROPERTIES OF LIGHT DIFFRACTED BY RELIEF GRATINGS	168
4.1.	Perfectly conducting grating in Littrow mount	169
4.1.1.	Flat surfaces	169
4.1.2.	Shallow gratings	170
4.1.3.	Perfect blazing in Littrow mount	172
4.1.4.	Antiblazing of gratings	173
4.1.5.	Very deep gratings	173
4.2.	Perfectly conducting grating supporting a single diffraction order	174
4.3.	Plasmon surface wave along a metallic grating	174
4.4.	Resonant total absorption of light by metallic gratings	176
4.5.	Nonresonant total absorption of light	181
4.6.	Total internal reflection by dielectric gratings	182
4.7.	Light refraction by deep transmission gratings	184
ACKNOWLEDGEMENTS		185
REFERENCES		185

III. OPTICAL AMPLIFIERS

by N. K. DUTTA and J. R. SIMPSON (MURRAY HILL, USA)

§ 1.	INTRODUCTION	191
§ 2.	SEMICONDUCTOR OPTICAL AMPLIFIERS	191
2.1.	Impact of facet reflectivity	194
2.2.	Amplifier designs	196
2.2.1.	Low-reflectivity coatings	196
2.2.2.	Buried-facet amplifiers	197
2.2.3.	Tilted-facet amplifiers	202

2.3. Multiquantum well amplifiers	204
2.4. Integrated laser amplifier	205
§ 3. FIBER AMPLIFIERS	207
3.1. Energy levels	207
3.2. Fiber design and fabrication	210
3.2.1. Fiber fabrication	210
3.2.2. Amplifier design	211
3.3. Fiber amplifier performance	212
3.3.1. Characteristics	212
3.3.2. Commercial erbium fiber amplifiers	215
§ 4. LIGHTWAVE TRANSMISSION SYSTEM STUDIES	216
4.1. Direct-detection transmission	216
4.2. Coherent transmission	216
4.3. Soliton transmission	219
4.4. Video transmission	222
REFERENCES	222

IV. ADAPTIVE MULTILAYER OPTICAL NETWORKS

by D. PSALTIS and Y. QIAO (PASADENA, CA, USA)

§ 1. INTRODUCTION	229
§ 2. OPTICAL MULTILAYER NETWORK	231
2.1. System architecture	232
2.2. Character recognition application	236
2.3. Experimental results	240
§ 3. IMPLEMENTATION OF FULLY ADAPTIVE LEARNING ALGORITHMS	243
3.1. Anti-Hebbian local learning algorithm	245
3.2. Weight decay and hologram copying	248
3.3. Phase coherence of the holographic gratings	250
3.3.1. Temporal response derivation	251
3.3.2. Experimental demonstration	255
3.3.3. Multiple reference beams	258
§ 4. DISCUSSION AND CONCLUSIONS	259
ACKNOWLEDGEMENTS	260
REFERENCES	260

V. OPTICAL ATOMS

by R. J. C. SPREEUW and J. P. WOERDMAN (LEIDEN, THE NETHERLANDS)

§ 1. INTRODUCTION	265
§ 2. TWO-LEVEL SYSTEMS WITH CONSTANT COUPLING	266
2.1. Avoided optical crossings	267
2.2. Coupled modes and two-level systems	270
2.3. Eigenstates	271
2.4. The pseudospin picture	274
2.5. Conservative and dissipative coupling	277
§ 3. OPTICAL BAND STRUCTURE	279

§ 4. FOUR-LEVEL SYSTEMS	280
§ 5. DYNAMICAL BEHAVIOR OF THE OPTICAL ATOM	283
5.1. Rabi oscillation in the rotating-wave approximation	284
5.1.1. Rabi experiments in the time domain	287
5.1.2. Rabi experiments in the frequency domain	289
5.2. Violation of the rotating-wave approximation	290
5.2.1. Distorted Rabi oscillation	290
5.2.2. Bloch-Siegert shifts and multiphoton transitions	292
5.2.3. The optical atom beyond the rotating-wave approximation	294
5.3. Landau-Zener dynamics	297
5.3.1. Adiabatic limit	297
5.3.2. Multiphoton resonances	300
5.3.3. Diabatic limit	301
5.4. Passive and active ring cavities	302
5.5. Two-level atoms and electric-dipole coupling	303
§ 6. THE DRIVEN OPTICAL RING RESONATOR AS A MODEL FOR MICROSCOPIC SYSTEMS	307
6.1. Can one simulate spontaneous decay of the optical atom?	307
6.2. Landau-Zener crossing problems	309
6.3. Jaynes-Cummings model	310
6.4. Driven top	313
6.5. Quantum limit of the driven top	314
6.6. Hybrid nonlinear optics	316
§ 7. CONCLUSIONS	317
ACKNOWLEDGEMENTS	317
REFERENCES	318

VI. THEORY OF COMPTON FREE ELECTRON LASERS

by G. DATTOLI, L. GIANNESI, A. RENIERI and A. TORRE (ROME, ITALY)

§ 1. INTRODUCTION	323
§ 2. SPONTANEOUS EMISSION BY RELATIVISTIC ELECTRONS MOVING IN AN UNDULATOR MAGNET	333
2.1. Qualitative introduction	334
2.2. Spectral brightness calculation of undulator magnet radiation	340
2.3. Inhomogeneous broadening	346
§ 3. THE FEL GAIN	350
3.1. Low-gain regime	350
3.2. High-gain regime	354
3.3. Very high gain regime	359
3.4. Gain degradation induced by inhomogeneous broadening	360
§ 4. TRANSVERSE MODE DYNAMICS	364
4.1. Analytical approach	364
4.2. Numerical results for a transversally uniform electron beam	369
§ 5. LONGITUDINAL DYNAMICS	370
§ 6. FEL OSCILLATOR REGIME AND THE PULSE PROPAGATION PROBLEM	376
6.1. Preliminary considerations	376
6.2. Quantitative analysis	379
§ 7. FEL SATURATION	387
§ 8. A SIMPLIFIED VIEW OF FEL STORAGE RING DYNAMICS	393
§ 9. CONCLUSION	396

CONTENTS

XIX

APPENDIX A. OPTICAL CAVITY FOR THE FEL	396
A.1. Ray matrix and stability condition	398
A.2. Modes of a stable resonator free of diffraction losses	402
A.3. Diffraction integral and ray matrix	405
APPENDIX B. UNDULATOR MAGNETS FOR THE FEL	406
REFERENCES	411
AUTHOR INDEX	413
SUBJECT INDEX	423
CUMULATIVE INDEX, VOLUMES I-XXXI	427