

Table of Contents

Part I Trapped Ions and Cavity QED

Generation of Fock States in the One-Atom Maser

<i>H. Walther</i>	3
1 Introduction	3
2 The One-Atom Maser and the Generation of Fock-States Using Trapping States	4
3 Dynamical Preparation of Number States in a Cavity	7
4 Preparation of Fock States on Demand	9
5 Conclusion	12
References	13

Coherent Manipulation of Two Trapped Ions with Bichromatic Light

<i>E. Solano, R.L. de Matos Filho, N. Zagury</i>	14
1 Introduction	14
2 Dispersive Interaction	15
2.1 The model	15
2.2 Bell states	18
2.3 Reliable teleportation	19
2.4 Wigner function of the collective motion	21
3 Selective Interaction	22
4 Resonant Interaction	25
4.1 Conditional vibrational displacement	25
4.2 Motional Schrödinger's cat states	26
4.3 Motional squeezed states	27
5 Conclusions	27
6 Acknowledgments	27
References	28

Quantum Nondemolition Measurement and Quantum State Manipulation in Two Dimensional Trapped Ion

<i>W. Kaige, S. Maniscalco, A. Napoli, A. Messina</i>	29
---	----

1	Introduction	29
2	Description of the Model	31
3	Properties of the Model	32
4	QND Measurement of Vibrational Quanta	35
5	Quantum State Manipulation	36
	5.1 Generation of a bimodal Fock state	36
	5.2 Generation of entangled superposition of Fock states	38
	5.3 Generation of a pair coherent state	39
6	Conclusion	41
	References	41

Phonon-Photon Translation with a Trapped Ion in a Cavity

<i>E. Massoni, M. Orszag</i>	43	
1	Introduction	43
2	The Model for a Phonon-Photon Translator	44
3	Information Transfer	46
4	Numerical Simulation	49
5	Discussion	52
6	The Model for an Ion Trap Laser Producing Transfer of Squeezing	53
7	Semiclassical Approximation	56
8	Numerical Results	58
	References	61

Part II Quantum Interference, Entanglement, Decoherence and Quantum Computing

Decoherence, Pointer Engineering and Quantum State Protection

<i>A.R.R. Carvalho, P. Milman, R.L. de Matos Filho, L. Davidovich</i>	65	
1	Introduction	65
2	Strategy for Quantum State Protection	66
3	Application to a Trapped Ion	67
	3.1 Hamiltonian of the system	67
	3.2 Master equation for the center-of-mass motion	68
	3.3 Effect of random fields	70
	3.4 Protection of superpositions of Fock states	72
	3.5 Protection of a qubit	73
	3.6 Protection of approximate phase eigenstates	74
	3.7 Superpositions of coherent states	74
	3.8 Protection of squeezed states	76
4	Conclusion	76
	References	78

High Efficiency in Detection of Photonic Qubits

<i>K.M. Gheri, C. Saavedra</i>	80
1 Introduction	80
2 Mode Structure of a System of Two-Cavities	81
3 Photon Wavepacket Absorption	84
4 Generation of Photonic Qubits with Three-Level Λ Atoms	87
5 Summary and Further Applications	92
References	94

Macroscopic Entanglement and Relative Phase

<i>G. Nienhuis</i>	95
1 Introduction	95
2 Single Histories with Arbitrary Detection Efficiency	96
2.1 Perfect detection efficiency	96
2.2 Imperfect detection efficiency	98
3 Single Boson Mode	98
3.1 Arbitrary state	98
3.2 Fixed amplitude	100
4 Master Equation for Two Boson Modes	101
4.1 Two representations	101
4.2 Correlations created by observation	102
5 Initial States with Fixed Amplitudes	103
5.1 Separation of total number and relative phase	103
5.2 Coherent states	105
5.3 Uniform phase distribution	105
6 Conclusions	108
References	109

Decoherence Effects of Motion-Induced Radiation

<i>P.A. Maia Neto, D.A.R. Dalvit</i>	110
1 Introduction and Brief Summary of Decoherence Theory	110
2 Dynamical Casimir Effect	114
3 Decoherence and the Casimir Effect	116
4 Conclusion	122
References	123

Control of Cold Atomic Collisions by Multiparticle Entanglement and a Modified Vacuum in Cavity QED

<i>J.I. Kim, R.B.B. Santos, P. Nussenzweig</i>	125
1 Introduction	125
2 Cold Collisions and Cavity QED	126
2.1 Radiative escape collisions	126

2.2	Cavity QED	128
3	Collisional Dynamics in a Cavity	129
3.1	Multiparticle entanglement	129
3.2	Control of cold collisions by a modified vacuum	131
3.3	Collective decay rate	132
3.4	Trap-loss probabilities	134
3.5	Orders of magnitude	135
4	Conclusion	136
	References	136

Decoherence Evolution of a Harmonic Oscillator

	<i>J.C. Retamal</i>	138
1	Introduction	138
2	Stable Quantum States	139
3	The Onset of Unstabilities	141
4	Analytical Solutions for the Linear Entropy	145
4.1	A reservoir at a finite temperature	150
4.2	Finite temperature entropy for a coherent state	151
4.3	Finite temperature entropy for a Schrodinger cat	153
5	Conclusions	155
6	Acknowledgments	156
	References	156

Part III Non-linear Optics, Matter Waves

Atomic Squeezing and Entanglement from Bose–Einstein Condensates

	<i>H. Pu, M.G. Moore, P. Meystre</i>	161
1	Introduction	161
2	Entangled Atomic Beams	162
3	Dicke States	167
4	Atom-Photon Entanglement	171
5	Conclusion	175
	References	176

Atomic Coherence Effects in Doppler-Broadened Three-Level Systems with Standing-Wave Drive

	<i>F. Silva, J. Mompart, V. Ahufinger, R. Corbalán</i>	177
1	Introduction	177
2	Semiclassical Density Matrix Analysis	180
3	Dressed-Atom Analysis	182
4	Electromagnetically Induced Transparency	185

5	Amplification Without Inversion	188
	References	193

Frequency Up-Conversion to the Vacuum Ultra-Violet in Coherently Prepared Media

	<i>J.P. Marangos, I. Kuçukkara, M. Anscombe</i>	195
1	Introduction	195
2	Review of Previous Work on EIT Enhanced Non-linear Mixing	199
3	Theoretical Treatment of EIT Enhanced Four-Wave Mixing in Kr	201
4	Experimental Investigation of EIT Enhanced Four-Wave Mixing in Kr	203
	4.1 Experimental system and results	203
	4.2 Discussion	206
5	Further Developments and Conclusion	209
	References	210

Optical Lattice Dynamics and Scattering Processes Resulting from Dipole-Dipole Interaction

	<i>A. Guzmán, J. Zapata</i>	212
1	Introduction	212
2	Atomic States in Optical Lattices	213
3	The Dipole-Dipole Interaction in an Optical Lattice	217
4	Hopping Within the Wannier Representation	219
5	Atom-Atom Diffraction in 1D Optical Lattices	220
6	Summary and Conclusions	225
	References	225

Part IV Quantum Optics and Applications

Time Delay and Tunneling

	<i>H.M. Nussenzweig</i>	229
1	Introduction	229
2	The Eisenbud-Wigner Time Delay	229
3	Tunneling Time as Group Delay	230
	3.1 Critique of tunneling time as group delay	231
4	The Larmor Times	231
5	Stationary Dwell Time	232
	5.1 Remarks	233
6	Other Approaches to Tunneling Time	233
	6.1 Modulation of the barrier or of the incident wave	233
	6.2 Conditional dwell time	233
	6.3 Path integrals	234
	6.4 Critique of the “Feynman” approach	234

7	Average Wave Packet Dwell Time	235
8	One-Dimensional Quantum Scattering Theory	236
	8.1 The time delay matrix.....	237
	8.2 New basis functions	237
9	The Average One-Dimensional Wave Packet Dwell Time	238
	9.1 Average one-dimensional dwell time for a symmetric potential ...	239
10	Rectangular Potential.....	240
	10.1 Average dwell time in tunneling	240
11	Main Problems with Previous Treatments	241
12	Ten Good Features of the Average Dwell Time	241
	References	242

Giant Intensity-Intensity Correlations and Quantum Interference in a Driven Three-Level Atom

	<i>S. Swain, Z. Ficek</i>	244
1	Introduction	244
2	The Three-Level Model: Both Transitions Excited	246
	2.1 Second-order correlation functions	247
	2.2 Distinguishable photons	249
	2.3 Indistinguishable photons	250
	2.4 Interpretation of the results	251
3	Single-Transition Excitation	253
	3.1 Superposition dressed states.....	255
4	Conclusions.....	259
	References	259

A Cavity QED Test of Quantum Mechanics

	<i>Z. Ficek, S. Swain</i>	262
1	Introduction	262
2	The Eigenstructure of the Driven Two-Level Atom in a Cavity	264
3	Master Equation of the System.....	266
4	The Autler-Townes Absorption Spectrum.....	268
	4.1 Population of the undriven level	268
	4.2 Population of the dressed states	270
5	Autler-Townes Spectra	271
	5.1 Fixed number of photons	271
	5.2 Numerical results	273
6	Summary.....	277
	References	277

The Method of Quantum Jumps and Quantum White

	<i>W. von Waldenfels</i>	279
1	Introduction	279

2	The Master Equation	281
3	The Quantum Jump Method	281
4	Quantum White Noise Integrals	285
5	The Two Level Atom	286
6	The Oscillator in an Atomic Heat Bath	290
	References	293

Quantum Orbits in Intense-Laser Atom Physics

	<i>R. Kopold, W. Becker</i>	294
1	Introduction	294
2	The S Matrix for Ionization	296
	2.1 General formalism	296
	2.2 Approximation by quantum orbits	299
	2.3 Quantum orbits and the simple-man model	300
3	Results	302
	3.1 Spectra for linear polarization	302
	3.2 Spectra for elliptical polarization	302
	3.3 Angular distributions for elliptical polarization	303
4	Comparison to Experimental Data and Conclusions	307
	References	308

Micromaser Dynamics

Beyond the Rotating-Wave Approximation

	<i>F. De Zela</i>	310
1	Introduction and Background	310
2	The Micromaser	316
3	The Rotating and the Counter-rotating Wave Approximations	321
4	Diagonalization of the Rabi Hamiltonian by Continued Fractions	323
5	Transition Probabilities	325
6	The Steady-State Photon Distribution	327
7	The Atomic Inversion	329
8	Trapping States	332
9	Conclusions	335
	References	335

What Is a Quantized Mode of a Leaky Cavity?

	<i>S.M. Dutra, G. Nienhuis</i>	338
1	Introduction	338
2	Open Systems in Quantum Mechanics	339
	2.1 Quantum dissipation and the classical limit	340
3	What Is a Mode of a Leaky Cavity?	342
	3.1 The classical answer	342
	3.2 Quasimodes in the quantum theory	344

4	A Simple Model of a Leaky Cavity	346
5	Fox-Li Modes as Natural Modes	347
5.1	Sturm-Liouville with a Twist	348
6	Quantum Theory	350
7	Conclusions	351
	References	352

The Quantum Jumps Approach for Infinitely Many States

	<i>D. Spehner, J. Bellissard</i>	355
1	Introduction	355
2	The Model	358
2.1	The stochastic scheme	358
2.2	Examples	360
3	Case of Infinitely Many States	362
4	Equivalence with the Master Equation	366
4.1	Decomposition of the generator \mathcal{L} into a jump and a damping parts	366
4.2	Average over quantum trajectories	367
4.3	Comments	369
5	Stochastic Hamiltonians	369
6	Comparison with Other Stochastic Schemes	371
6.1	Quantum jump schemes	371
6.2	Quantum diffusion schemes	373
6.3	Comparison with the model of Sect. 2	374
7	Conclusion	374
	References	375

Part V Short Contributions

**Coherent Population Trapping and Resonance Fluorescence
in a Closed Four-Level System**

	<i>M.L. Ladrón de Guevara</i>	379
1	Introduction	379
2	Model	380
3	Results.....	380
	References	383

**Dynamics of Bose–Einstein Condensation
for Negative Scattering Length**

	<i>V.S. Filho, A. Gammal, L. Tomio, T. Frederico</i>	384
	References	388

Quantum Gates with a Selective Interaction

<i>E. Solano, M. França Santos, P. Milman</i>	389
References	393

Measuring Entanglement Through the Wigner Function

<i>M. França Santos, L. Davidovich</i>	394
1 Introduction	394
2 Entanglement in the Two-Mode Wigner Function.....	395
3 Conclusions	397
References	397

Reflection of a Slow Atom by a Cavity

<i>A. Delgado, L. Roa, C. Saavedra</i>	399
1 Introduction	399
2 The Model	400
3 Summary.....	404
References	405