

Dynamics of Cold Atoms in High Quality Cavities

A THESIS

**submitted for the Award of Ph.D degree of
Mohan Lal Sukhadia University
in the
Faculty of Science**

BY

R. Arun



Under the Supervision of

Professor G.S. Agarwal

Director, Physical Research Laboratory

DEPARTMENT OF LASER PHYSICS AND QUANTUM OPTICS
PHYSICAL RESEARCH LABORATORY, AHMEDABAD.

MOHANLAL SUKHAJIA UNIVERSITY, UDAIPUR

Year of submission: 2002

Contents

Acknowledgement	vi
Abstract	vii
1 Introduction	1
1.1 Interaction of Radiation with Matter	1
1.1.1 Field Quantization in a Cavity	1
1.1.2 Density Matrix Formalism	5
1.1.3 Interaction Hamiltonian	8
1.2 Atom-Field Interaction in a Cavity	9
1.2.1 Jaynes-Cummings Model	10
1.2.2 Micromaser	14
1.2.3 Mechanical Forces in Cavity QED	18
1.3 Ultracold Atoms in a Cavity - Quantization of the Atomic Motion	20
1.3.1 Atom-Field Interaction as a Scattering of a Wave packet	20
1.3.2 Reflection and Transmission	23
2 Tunneling Time of Ultracold Atoms Through Vacuum Induced Potential	26
2.1 Atom-Field Dynamics and Its Basic Equations	28
2.2 Phase Tunneling Time of a Gaussian Wave Packet	30
2.3 Time Dependence of the Wave Packet for Ultracold Atoms	34
2.4 Splitting of the Wave Packet	36
2.5 Summary	38
3 Resonant Tunneling of Ultracold Atoms Through Vacuum Induced Potentials	39
3.1 What is Resonant Tunneling ?	39
3.2 Model System	42
3.3 Quantum Interferences in Resonant Tunneling	45
3.4 Coupling of the Cavities	48
3.5 Summary	50

4 Generation of Correlated Fields in a Bimodal Cavity With Ultracold Atoms	51
4.1 A Three-level Atom Plus Bimodal Field	51
4.2 Buildup of the Cavity Field	58
4.3 Analytical Solution of Master Equation	61
4.4 Steady State Photon Statistics	64
4.5 Summary	69
5 Maser Operating on Two-Photon Transitions in Ultracold Atoms	70
5.1 One- and Two- Photon Processes	70
5.2 Basic Master Equation	79
5.3 Numerical Results of Photon Distribution in Steady State	81
5.4 Summary	86
Conclusions and Future Outlook	88
References	89
List of Publications	99

For Fulltext Please Contact:

library@prl.res.in