



كلية الدراسات العليا

Sudan University of Science and Technology

College of Graduate Studies

**Computational Simulation of Laser Cooling and
Trapping of Radium Atoms.**

محاكاة حاسوبية لتبريد وإصطياد ذرات الراديوم بالليزر

**A thesis Submitted for Fulfillment of the Requirements for
the Degree of Doctor of Philosophy in Laser and its
Applications in Physics**

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الآية الكريمة

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DEDICATION

To

My mother,

My father's soul,

My kids, Abdurrahman and Fatimah,

My sisters and brothers,

My family,

My friends

To all who help me during my research.

ACKNOWLEDGMENT

شكر و عرفان

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ABSTRACT

This research aimed to study a model of laser cooling and trapping of radium atoms and developing a system of governing equations in similar way to the well-known four-levels Maxwell Bloch system, and to present computational results for special solutions of four levels system along with steps for how this system can be cooled by laser using MATLAB program.

The theory includes the mechanical light effect for atomic structure. The atomic decay time derived was determined according to the photon account. In this work MATLAB simulation of the atomic Liouville equation for spontaneous emissions was developed for laser cooling of radium atoms. The study followed the simulating solution of optical Bloch equations (OBEs) for four level system in an atom trap. Where the center of mass motion is described quantum mechanically.

The results showed that the laser cooling approach to Maxwell's law, the reduction of the velocity leads to new distribution of velocities and the atoms moving towards the light source will resonate the light field (crossing resonance).

In future, theoretical analysis shows that laser photons used for cooling atoms have velocity distribution that could be used to study many-body physics.

الخلاصة

يهدف هذا البحث إلى دراسة نموذج تقنية التبريد بالليزر واصطياد ذرات عنصر الراديوم وتوضيح النظام بمعادلات ماكسويل بلوخ ذي الأربع مستويات المعروفة، وتقديم نتائج حسابية لحلول معادلات بلوخ في المستويات الأربعة لليزر باستخدام برنامج الماتلاب.

تضمن الجانب النظري تأثير حركة الليزر وتأثيره على التركيب الذري للراديوم. تم تحديد وقت الاضمحلال الذري وفقاً لحساب عدد الفوتونات. وبينت الدراسة المحاكاة بواسطة برنامج الماتلاب بتطوير معادلات ليفويل للانبعاثات التلقائية. اتبعت الدراسة حل محاكاة معادلات بلوخ البصرية (OBES) لنظام أربعة مستويات في مصيدة الذرة. حيث يتم وصف مركز حركة الذرات ميكانيكياً. وأظهرت النتائج أن التبريد بالليزر لقانون ماكسويل، يؤدي تخفيض السرعة إلى توزيع جديد للسرعات، وتتحرك الذرات نحو مصدر ضوء الليزر يؤدي إلى (رنين).

في المستقبل، يُظهر التحليل النظري أن فوتونات الليزر المستخدمة لذرات التبريد لها توزيع سرعات يمكن استخدامه لدراسات كثيرة في عالم الفيزياء.

List of Contents

No	Title	Page no
1	الآية الكريمة	I
2	Dedication.	II
3	Acknowledgement.	III
4	Abstract English	IV
5	مستخلص البحث	V
6	List of contents	VI
7	List of figures	X
8	List of tables	XII
CHAPTER ONE, BASIC CONCEPTS		
1.1	Introduction	1-2
1.2	Aims of the work	2
1.3	Thesis layout	2-3
1.4	Laser cooling.	3-4
1.5	Maxwell's Boltzmann Distributions	5
1.6	Raman cooling	6
1.7	Phase Space Density	7
1.8	Fermions and Bosons	8
1.9	The principle of laser cooling	8-9
	1.9.1 Stimulated absorption	9
	1.9.2 Absorption and emission of near- resonant light.	10

1.10	The Doppler Effect	11
	1.10.1 Doppler cooling.	11
1.11	Zeeman Effect.	12
	1.11.1 Zeeman slowing	12
1.12	Laser trapping	13
1.13	Magnetic Trapping	13
1.14	Magneto-optical trapping (MOT)	13-14
1.15	Dipole moment:	15
	1.15.1 Optical dipole traps:	15
1.16	Evaporative Cooling	16
1.17	Applications of laser cooling and trapping of neutral atoms 1.17.1 Quantum degeneracy. 1.17.2 Bose-Einstein condensate (BEC).	17-18
CHAPTER TWO, LASER TRAPPING		
2.1	Introduction	19
2.2	Radiation pressure force.	19
	2.2.1 Characteristic time T_{ext}	20
	2.2.2 Approximations	20
2.3	wave function description	21-23

2.4	Optical Bloch Equations.	24
	2.4.1 Optical Bloch Equations for Four Level System	24-25
	2.4.2 The Hamiltonian:	25-26
	2.4.3 Density matrix	27-28
2.5	Atomic Matrices	29
	2.5.1 Stimulated emission rate	29
	2.5.2 Spontaneous emission rate	30
	2.5.3 Laser Detunings	30
	2.5.4 Laser Linewidths	31
	2.5.5 laser polarization	31
2.6	Literature review.	33-39
CHAPTER THREE, THE COMPUTER SIMULATION		
3.1	Introduction	40
3.2	Modeling method	40
3.3	Numerical simulation.	40
3.4	Matlab program	41
3.5	Periodic table	41
3.6	Alkaline earth elements.	42
3.7	Radium atom	42
	3.7.1 Structure of ^{225}Ra .	43

3.8	Lasers used in simulation.	43
	3.8.1 483 nm Laser	43
	3.8.2 1428 nm Lasers	44
	3.8.3 1488 nm Lasers	44
3.9	Simulation work.	44
	3.9.1 Program input	45
	3.9.2 Material Parameters	45
	3.9.3 Laser parameters	45
	3.9.4 Program out puts.	45
3.10	The program structure	45
	3.10.1 Liouville matrixequation.	46
	3.10.2. Cool Atom.m.	46
	3.10.3 Compute Velocity Final.	46
	3.10.4. Velocity Spectrum.	47
	3.10.5. Function Numbers (Maxwell's Boltzmann distribution), n atoms.	47
CHAPTER FOUR, RESULTS AND DISSICUTIONS		
4.1	Introduction	57
4.2	Results	57
4.3	Discussions	68

4.4	Conclusions	73
4.5	Recommendations	73
	References	75

List of Figures

<u>no</u>	Title of Figure	Page
FIG.1.1.	Graph of the atomic scattering rate versus laser frequency	4
FIG. 1.2	Maxwell' Boltzmann distribution	5
FIG.1.3	Temperature Landmark.	8
FIG 1.4	Absorption and emission of near-resonant light (Rabi Frequency)	10
FIG. 1.5	The momentum of the atom after absorbing a photon and then the spontaneous emission, P_A is the momentum of atom.	11
FIG 1.6	Zeeman slower apparatus	12
FIG.1.7	Schematic of the MOT. Lasers beams are incident from all six directions and have circular polarizations	14
FIG. 1.8	Zeeman split in inhomogeneous magnetic field	15
FIG. 1.9	The optical dipole potential calculated using the rotating waveapproximation (red) and keeping the counter rotating term (blue).	16
FIG. 3.1	Energy Levels of ^{225}Ra . Transition rates	44
FIG. 3.2	Flow chart for liouville script.	47
FIG. 3.3	Flow chart for cooling atom	48

FIG. 3.4	Flow chart for compute v final (final velocity)	49
FIG. 3.5	Flow chart for velocity spectrum	50
FIG. 3.6	Flow chart for Function Numbers (Maxwell's Boltzmann distribution)	52
FIG. 4.1	Final spectrum of velocity distributions.	59
FIG.4.2	The relation between the number of atoms and Rabi frequency.	61
FIG.4.3a	The Relation between velocity loss and time in microsecond.	63
FIG.4.3b	The Relation between velocity loss and time in microsecond.	64
FIG.4.3c	The Relation between velocity loss and time in microsecond.	65
FIG.4.4a	Relation between initial velocity in m/s and final velocity in m/s	66
FIG.4.4b	Relation between initial velocity in m/s and final velocity in m/s	67

List of Tables

<u>No of table</u>	Title of table	<u>Page no.</u>
Table 2.1	Parameters for radium atom needed in simulation.	26
Table 2.2	polarization s of light	32
Table 3.1	Periodic table for cooling atoms and trapping,	42
Table3.2	Atomic properties of the heavy alkaline-earth element radium.	43