

الله لاله الا هو الحى القيوم
لاتأخذه سنة ولا نوم له ما فى
السموات وما فى الارض من ذا
الذى يشفع عنده الا باذنه يعلم
ما بين ايديهم وما خلفهم ولا يحيطون
بشئء من علمه الا بما شاء وسع
كرسيه السموات والارض ولا يؤده
حفظهما وهو العلى العظيم)

صدق الله العظيم

سورة البقره الايه (255)

Dedication

I Dedicate This Work:

To

My Father Soul.....

My Mother Soul.....

*I'm asking my god
to mercy upon them*

To

My Sisters and Brothers...

To

My Teachers...

My Colleagues & Friends...

Atifa

Acknowledgement

My great thanks to all those who supported me, guide me to right way and to do this work, to every one that advice me. I feel that I have been owed much to my supervisor and second mother:

Dr. Wafaa Salih Abd AL-Rahman

for her hard effort that she did to achieve this work in this way.

and special thanks to:

Dr. Gasim Al-Hitty

For his time that he spend to help me to complete this work

Also special thank to::

Dr. Osman Mustafa Mukhtar

Engineer: Gafar Abdo AL-Hamed

*And to all staff of the Institute of Laser in the Sudan
University of Science and Technology . And to Every One
pushed& helped and supported me to perform this Work*

Abstract

In this study linear and angular scattered intensity of different samples were measured also the reflectivity of samples as a mean of safety was determined. Samples were chosen according to the, availability and uses in laser clinics and laboratories. Samples under study were Aluminum with different coatings, glass, and ceramic.

Two types of lasers were used as a source of irradiation; He-Ne laser ($\lambda = 632.8\text{nm}$, $P = 1\text{mW}$), Diode laser ($\lambda = 808\text{nm}$, $P = 500\text{mW}$). The detection systems used were: photomultiplier for the former and I.R detector for the later.

The reflectivity of samples was determined for different materials at different incident angle (10° , 20° , 30°)

The values of linear scattered intensity was measured at scattering angle (10°), and the distance between detector and samples had been changed, this shows inverse relation due to the interaction of the scattered beam with air molecules.

In angular scattering the measurement was achieved using a chamber in two situations, before and after covering the chamber. The internal reflection increases the scattered intensity values, and covering of chamber by isolated material that eliminates the internal reflections.

In all samples the result of angular scatter shows a dependence of the scattering angle at a fixed incident angle. Al(2) shows higher values of scattered intensity compared with other samples because it's a polish surface, that means use of this sample in clinics and laboratories may be hazardous.

Also the reflectivity (R) was measured for all samples; reflectivity of aluminum samples is high compare with glass and ceramic.

Peak values of scattering intensity were obtained when the incidence and reflectance angle are equal.

The reflectivity of all samples varied with the incident angle the high value in Al(2).

الملخص

فى هذا البحث تم قياس التشتت الخطى والزواى لضوء الليزر فى انواع مختلفه من المواد، ايضا تم قياس الانعكاسيه لجميع العينات المستخدمه. لمعرفة مدى الامان فى استخدام هذه المواد، تم اختيار هذه المواد لتوفرها و كثرة استخدامها فى الغرف المخصصه لمصادر الليزر المختلفه المستخدمه فى العيادات للاغراض الطبيه وكذلك المستخدمه فى المعامل للبحث العلمى وهذه المواد هى (شرايح من الالمونيوم مطليه بالوان مختلفه، زجاج، وسيراميك).

تم استخدام مصادر ليزريه مختلفه مثل ليزر الهيليوم - نيون (بطول موجى = 632.8 نانومتر، وقدره 1ملى واط)، و ليزر الثنائى (طوله الموجى 808 نانومتر وقدره 500ملى واط). الكاشف الذى استخدم هو المضاعف الضوئى مع المصدر الاول وفى الحاله الثانيه تم استخدام كاشف الاشعه تحت الحمراء. تم قياس الانعكاسيه للعينات المستخدمه جميعها عند زوايا سقوط (10° و 20° و 30°).

عند قياس التشتت الخطى تم تغيير المسافه وكانت زاوية التشتت صغيره جدا وقيمتها ثابتة (10°)، كانت العلاقه عكسيه مع تغيير المسافه بين المصدر الليزرى والعيه، بزيادة المسافه قلت قيمة التشتت بسبب تاثير جزيئات الهواء فهى تعمل على توهين الاشعه.

اما فى حالة التشتت الزاوى تم استخدام خليه صممت خصيصا لتمكن من قياس التشتت خلال زوايا مختلفه صممت الخليه من نوع من انواع الحديد و تم تغليفها من الداخل باستخدام ماده عازله لتقليل الانعكاس الداخلى وبالتالي قلت قيمة التشتت بعد تغليف الخليه عن قبل تغليف الخليه.

التشتت المقاس خلال العينات المختلفه تختلف قيمه من عيئه لآخرى لكن سجلت اعلى القيم فى حالة الالمونيوم غير المطلى اللامع المشار اليه بالكود Al(2) مما يعنى ان استخدام هذا النوع من المواد قد يسبب بعض المخاطر. اعلى قيم للتشتت سجلت فى حالة عينات الالمونيوم مقارنه مع العينات الاخرى الزجاج والسيراميك

Contents

الايه	I
Dedication	II
Acknowledgement	III
Abstract English	IV
Abstract Arabic	V
List of Figures	XI
List of Table	XIII
Contents	VI

CHAPTER ONE

Introduction & Basic Concepts

1-1 Introduction	2
1-2 Electromagnetic Spectrum	3
1-3 Laser Physics	5
1-3-1 Interaction of Light with Matter	6
1-3-1-1 Induced Absorption of a Photon by Atom	6
1-3-1-2 Spontaneous Emission of a Photon	7
1-3-1-3 Induced Stimulated Emission	8
1-4 Population Inversion	8
1-5 Properties of Laser	10
1-5-1 Monochromatic	10
1-5-2 Collimated	11
1-5-3 Coherence	11
1-5-3-1 Temporal Coherence	12
1-5-3-2 Spatial Coherence	13
1-5-4 Brightness	13
1-5-5 Tunability	13
1-6 Elements of Laser	14
1-6-1 Excitation Mechanism	15
1-6-1-1 Three and Four –Level Schemes	15
1-6-2 Feedback Mechanism	17
1-6-3 Active Medium	17
1-7 Lasing Action	18
1-8 Types of Lasers	19

1-8-1 According to Active Medium	19
1-8-1-1 Solid State Laser	19
1-8-1-2 Gas Lasers	20
1-8-1-3 Liquid and Dye	22
1-8-1-4 Chemical Lasers	22
1-8-1-5 Semiconductor Lasers	23
1- 8 1- 6 Other Types of Lasers	24
1-9 Helium-Neon Laser	25
1-9-1 Excitation Mechanism of He-Ne laser	26
1-10 Diode Laser	26
1-11 Laser Hazards	27
1-11-1 Beam Hazard	27
1-11-1-1 Eye Hazards	27
1-11-1-2 Skin Hazards	29
1-12 Non beam Hazard	30
1-13 Classification of Laser Hazards	31
1-14 Optical Detection	32
1-14-1 Light Detectors	32
1-14-1-1 Photon Conductive	32
1-14-1-2 Photo Voltaic	32
1-14-1-3 Photoemissive	33
1-15 Detector Characteristics	33
1-15-1 Responsivity	33
1-15-2 Noise	33
1-15-3 Detectivity	34
1-15-4 Quantum Efficiency	34
1-15-5 Speed of the Detector	35
1-15-6 Linearity	35
1-16 Photon Detectors	35
1-16-1 Photomultipliers	35
1-17 Objectives of the Work	37

CHAPTER TWO

Theoretical Background

2-1 Introduction	39
2-2 Interaction of Light with Matter	39
2-2-1 Absorption	39
2-2-2 Refraction	40
2-2-3 Reflection	41
2-2-4 Reflectivity and Fresnel Equations	43
2-2-5 Diffraction	44
2-2-6 Scattering	44

2-3 Scattering Processes	46
2-3-1 Elastic Scattering	49
2-3-1-1 Rayleigh Scattering	49
2-3-1-2 Mie Scattering	51
2-3-2 Inelastic Scattering	51
2-3-2-1 Brillouin Scattering	52
2-3-2-2 Raman Scattering	52
2-3-2-3 Compton Scattering	53
2-4 Coherent Scattering	53
2-5 Differentiating Between Dynamic and Static Light	54

Scattering

2-6 Mie, Rayleigh, and Fraunhofer Light Scattering Theories	55
---	----

CHAPTER THREE

Experimental Work

3-1 Introduction	58
3-2 Experimental Set-Up	58
3-2-1 Chamber	59
3-2-2 Detector	60
3-2-2-1 Photomultiplier	60
3-2-3 Digital Multimeter	61
3-2-4 Laser Light Sources	61
3-2-4-1 Helium-Neon Laser	61
3 - 2-4-2 Diode Laser	62
3-2-5 Samples	62
3-3 Experimental Procedure	63
3-3-1 Measurement of Linear Scattering Using He-Ne	63
Laser	
3-3-2 Measurement of Angular Scattering Using He-Ne	63
Laser	
3-3-3 Measurement of Angular Scattering Using Diode	63
Laser	
3-3-4 Measurement the Reflectivity	64

Chapter Four

Result and Discussion

4-1 Introduction	66
4-2 Measurement of Linear Scattering by Using He-Ne laser	66
4-3 Angular Scattering Before and After Covering the	69

Chamber	
4-4 Measurement of Angular Scattering Intensity by Using Diode Laser	76
4-5 Reflectivity of Samples	79
4-6 Conclusion	86
4-7 Future work	87
4-8 References	88

List of Figures

1-1 Electromagnetic Spectrum	3
1-2 Light Wave	4
1-3 Induced Absorption of a Photon by an Atom	6
1-4 Spontaneous Emission of a Photon	7
1-5 Stimulated Emission of a Photon	8
1-6 Maxwell & Boltzman Distribution for an Atomic System in	9

	Thermal Equilibrium Condition	
	1-7 Monochromaticity Compared to the Conventional Light	10
	1- 8 Collimated Laser Beam Compared with the	11
U	Uncollimated Beam from a Flash Light	
	1-9 Coherent Laser Beams	12
	1-10 The Basic Components of a Laser	14
	1-11 Three and Four Level Scheme of an Active Material.	15
	1-12 Absorption of Visible and Near Infrared Radiation	29
	1-13 Basic Structure of the Photomultiplier Tube (PMT)	36
	2-1 Refraction Angles	40
	2-2 Reflection	42
	2-3 Image of Point Source	42
	2-4 Reflection from a Rough Surface	43
	2-5 Planes of Incidence and the Interface	44
	2-6 Scattering of Volume of Particles	48
	2-7 Elastic and Inelastic Scattering	48
	2-8 Rayleigh Scattering	51
	2-9 Interaction of Incident Light with Matter in the Raman	54
	Process	
	2- 10 Coherent Scattering	55
	3-1 Block Diagram of Experimental Set-up	58
	3-2 Photograph of Experiment Set-up System	59
	3-3 Photograph of Sample Inside Chamber	59
	4-1 Distance Between Detector and Samples V_s Scattered	68
	Intensity Using He-Ne laser	
	4-2 Scattering angle V_s Scattered Intensity Using He-Ne Laser at	74
	Distance (225.5mm) Before Covering the Chamber	
	4-3 Scattering angle V_s Scattered Intensity Using He-Ne Laser at	74
	Distance (291.5mm) Before Covering the Chamber	
	4-4 Scattering angle V_s Scattered Intensity Using He-Ne Laser at	75
	Distance (225.5mm) After Covering the Chamber	
	4-5 Scattering Angle V_s Scattered Intensity Using He-Ne Laser	75
	at Distance (291.5mm) After Covering the Chamber	
	4-6 Scattering Angle V_s Scattered Intensity Using Diode Laser	78
	4-7 Scattering Angle V_s Reflectivity Using He-Ne Laser	84
	at $\theta_i=10^\circ$	
	4-8 Scattering Angle V_s Reflectivity Using He-Ne Laser	84
	at $\theta_i=20^\circ$	

4-9 Scattering Angle V_s Reflectivity Using He-Ne Laser at $\theta_i=30^\circ$	85
4-10 Incident Angle V_s Reflectivity at Peak Values	85

List of Tables

1-1 Examples for Solid State Lasers	19
1-2 Examples for Gas Lasers	20
1-3 Examples for Liquid and Dye Lasers	21
1-4 Examples for Chemical Lasers	21
1-5 Examples for Semiconductor Lasers	22
1-6 Examples for other Types of Lasers	22
1-7 Classification of Laser Hazards	31
2-1 Elastic Scattering Process	49
2-2 Inelastic Scattering Process	49
3-1 Specification of Chamber	60
3-2 Specification of Photomultiplier	60
3-3 Specification of Digital Multimeter	61
3-4 Specification of He-Ne Laser Source	61
3-5 Specification of Diode Laser Source	62
3-6 Specification of Samples	62
4- 1 Linear Scattering of Laser Beam from Different Aluminum Surfaces Using He-Ne	67
4-2 Angular Scattering of Laser Beam Before Covering the Chamber Using He-Ne Source at Distance (225.5mm)	70
4-3 Angular Scattering of Laser Beam Before Covering the Chamber Using He-Ne Source at Distance (291.5mm)	71
4-4 Angular Scattering of Laser Beam After Covering the Chamber Using He-Ne Source at Distance (225.5 mm)	72
4-5 Angular Scattering of Laser Beam After Covering the Chamber Using He-Ne Source at Distance (291.5 mm)	73

4-6 Result of Scattering Intensity Using Diode Laser Source at Distance (145.5 mm)	77
4-7 Reflectivity at Incident Angle 10°	80
4-8 Reflectivity at Incident Angle 20°	81
4-9 Reflectivity at Incident Angle 30°	82
4-10 Reflectivity at Peak Value	83