Optical Properties of Gain incorporating Photonic Resonators

by

AHMAD BILAL

CIIT/FA15-BPH-019/ISB

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In

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In partial fulfillment

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Bachelor of Science in Physics

by

Ahmad Bilal
CUI/FA15-BPH-019/ISB

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II

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A Under Graduate Thesis submitted to the Department of Physics as partial fulfillment of the requirement for the award of Degree of BS (Physics).

Name	Registration Number
Ahmad Bilal	CUI/FA15-BPH-019/ISB

Supervisor:
Dr. Ahmer Naweed,
Associate Professor,
Department of Physics,
COMSATS University Islamabad (CUI),
January, 2019.

Final Approval

This thesis titled

Optical Properties of Gain incorporating Photonic Resonators

By
ar *Ahmad Bilal*
CIIT/FA15-BPH-019/ISB

Has been approved

For the COMSATS University Islamabad

External Examiner: _____

Supervisor: _____

Dr. Ahmer Naweed
Associate Professor, Dept. of Physics
COMSATS University Islamabad

HoD: _____

Dr. Sajid Qamar
Professor, Dept. of Physics
COMSATS University Islamabad

Declaration

I **Ahmad Bilal** (CIIT/FA15-BPH-019/ISB) hereby declare that this project neither as a whole nor as a part there of has been copied out from any source. It is further declared that I have developed this thesis and the accompanied report entirely on the basis of my personal efforts made under the sincere guidance of my supervisors. No portion of the work presented in this report has been submitted in support of any other degree of qualification of this or any other University or Institute of learning, if found I shall stand responsible.

Date:

Ahmad Bilal
CIIT/FA15-BPH-019/ISB

Certificate

It is certified that Ahmad Bilal (Registration No. CIIT/FA156-BPH-019/ISB) has carried out all the work related to this thesis under my supervision at the Department of Physics, COMSATS University Islamabad and the work fulfills the requirement for award of BS degree.

Date: Jan, 2019

Supervisor:

Dr. Ahmer Naweed
Associate Professor, Department of Physics

Head of Department:

Dr. Sajid Qamar
Department of Physics

Abstract

In this project, we extended the research on optical ring resonators for such mediums in which there is gain. First we studied normally the optical properties of passive resonators and measured the effects of EIT and EIA in them (details later discussed). Then we moved over focus on active resonators varrying different parameters to acheive EIT and EIA in gain incorporating photonic resonators which have extensive amount of applications. The main focus for this project was to model the characteristics and properties of active resonators and compare it with the results of passive resonators. Due to the gain property of active resonators, similar effects can be seen here as in passive resonators but without losses involved. The main idea was to establish a photonic device that could work efficiently as passive resonators and also have more output.

Dedication

This thesis is dedicated to my mother who brought me up all by herself and made me the gentleman I am today.

Indeed, in the creation of the heavens, and the earth and the alternation of the night and the day, are signs for those of understanding.

The Nobel Quran [3:190]

Ackowledgements

In the name of Allah, who is the most beneficient and merciful. I would like to thank all the

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Resonators

Most of the time, using mpmath is simply a matter of setting the desired precision and entering a formula. For verification purposes, a quite (but not always!) reliable technique is to calculate the same thing a second time at a higher precision and verifying that the results agree.

Explaination

To perform more advanced calculations, it is important to have some understanding of how mpmath works internally and what the possible sources of error are. This section gives an overview of arbitrary-precision binary floating-point arithmetic and some concepts from numerical analysis.Most of the time, using mpmath is simply a matter of setting the desired precision and entering a formula. For verification purposes, a quite (but not always!) reliable technique is to calculate the same thing a second time at a higher precision and verifying that the results agree.

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Fabry-Perot Resonators

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Ring Resonators

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All-Pass

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Add drop

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Coupled Ring

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Chapter 2

Area of Study

The Fabry-Perot Interferometer

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Theory of Fabry-Perot interferometer

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Gain incorporation in Resonators

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Beer's Law

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Gain medium

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Chapter 3

Coupled Resonators with Gain

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Gain element

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Coupling Regimes

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Chapter 4

Electromagnetically Induced Transparecy

EIT in Atoms

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Two level Atoms

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EIT in ring resonators

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Results

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Chapter 5

Electromagnetically Induced Absorbption

EIA concepts

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EIA in atoms

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EIA Quantum phenomena

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EIA in resonators

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Chapter 6

Conclusion

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Appendix A

Abrevations

EIT Electromagnetically Induced Transparency

EIA Electromagnetically Induced Absorption

CRIT Coupled Resonator Induced Transparency

CRIA Coupled Resonator Induced Absorption

FSR Free Spectral Range

MRR Micro Ring Resonator

MZI Mach Zehnder Interferometer

FWHM Full width at half maximum

CMT Coupled Mode Theory