Optical Properties of Gain incorporating Photonic Resonators

by

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CIIT/FA15-BPH-019/ISB

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January, 2019.

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Optical Properties of Gain incorporating Photonic Resonators

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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.

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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

Dedication

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

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.

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]

Ackowledgement

In the name of Allah, who is the most beneficient and merciful. I would start off this extensive documentation with a quote from Carl Sagan, one of the greatest science educator, who created enough enthusiasm and curiosity in me to persue my career in Physics. He said, *"Somewhere, something incredible is waiting to be known".* This is one of the reason I chose to be a student of physics, it inspires me to search for the unknown clues that are hidden in the very fabric of reality. Physics gave mankind the power to dominate his world and to use the best of nature for his benefit.

Since childhood, I was more into computers. Then in High School, I almost made the decision of joining the computer engineer. But the scientist inside me made me a star gazer and curious about how they get where they are, and what are they made of? These questions were those which made me switch my field to Physics which is a science of never-ending curiosity. In this process, a lot of people are included some directly and some indirectly, most of which are my family because of their never-ending support had made me persue my dreams.

I would personally like to thank my supervisor in BS project, Dr. A. Naweed. Who helped me through thick and thin to complete this project and who kept me motivated enough to continue my research in field of photonics. I would like to thank my batch counselor Dr. A. H. Mujtaba, who's support and teachings made us all work harder and harder for the progression of science. Also there is a big role of Ms. Zarqa in my motivation for this project. She not only recomended me to Dr. Naweed, but she is also my mental health counselor when I am in dire need of help. I would like to thank my peers in this, because the support and love I get from them is unmeasureable. Then again I would like to thank my family and especially my mother, who never asked me about my GPA and anything and always said, "if you love what you are studying, only then you can get true learning."

In the end, it is important to know that Knowledge is a never ending process, and Physics is such a beautiful field that every time I learn a new concept about the universe, it feels like I have been born again.

Ahmad B. Yousafzai

Islamabad, Jan 2019

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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 sec-

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Chapter 3

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Chapter 6

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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