# Abstract

In this thesis we sought to methodically confirm the quantum nature of the quantum dot, for which our mode of confirmation was not the usual entanglement, but rather in the detection of Rabi oscillations. Motivated by the statistical description of photons and the mechanism and structure behind the quantum dot a rationale for expecting Rabi oscillations is developed, along with a theoretical understanding for Rabi oscillations which include a model used at present. Furthermore, we wished to fine tune this model, by including dampening mechanisms detailed by Huber et. al. in Coherence and Degree of Time-Bin Entanglement from Quantum Dots. The suggested Linblad Master Equation implemented in QuTiP using the master equation solver program. Ground, exciton, and biexciton populations modelled with dephasing present, all three populations oscillating about the 35% population probability. Quantum nature of the quantum dot confirmed, with considerations for further research suggested in the conclusion.

Table of Contents

[Chapter 1 – Introduction 1](#_Toc124162456)

[Chapter 2 – Experimental and Theoretical Context 4](#_Toc124162457)

[2.1 What is Modelled - Rabi Oscillations 4](#_Toc124162458)

[2.1.1 General Intuition 4](#_Toc124162459)

[2.1.2 The Idealized Scenario **8**](#_Toc124162460)

[2.1.3 Approaching the Real World 9](#_Toc124162461)

[2.2 Object Studied – The Photon 11](#_Toc124162462)

[2.2.1 The Toy Model 12](#_Toc124162463)

[2.3 Production of Object – The Quantum Dot 15](#_Toc124162464)

[2.3.1 Quantum Dot Structure and Mechanism – Core-Shell Quantum Dot 16](#_Toc124162465)

[2.3.2 Quantum Dot Used in Thesis 20](#_Toc124162466)

[2.4 Lindblad Master Equation 21](#_Toc124162467)

[Chapter 3 – Methodology, Findings, and Analysis 25](#_Toc124162468)

[3.1 General Methodology 25](#_Toc124162469)

[3.1.1. Motivation 26](#_Toc124162470)

[3.1.2 General QuTiP Implementation 28](#_Toc124162471)

[3.2 Implementation, Findings, and Analysis 29](#_Toc124162472)

[3.2.1 Challenges 29](#_Toc124162473)

[3.2.2 Results and their Analysis 33](#_Toc124162474)

[Chapter 4 – Conclusions and Future Considerations 35](#_Toc124162475)

[Acknowledgements 38](#_Toc124162476)

[Bibliography 39](#_Toc124162477)

# Table of Figures

[Figure 1 – 1.1 Spontaneous Parametric Down Conversion [17] 2](#_Toc113029576)

[Figure 2 – 2.1.1 Two State System 5](#_Toc113029577)

[Figure 3 – 2.2.1 Toy Model 12](#_Toc113029578)

[Figure 4 – 2.2.2 Classifying light](#_Toc113029579) 14

[Figure 5 – 2.2.3 Classifying Sub-Poissonian Light](#_Toc113029580) 15

[Figure 6 – 2.3.1 Bandgap](#_Toc113029581) 16

[Figure 7 – 2.3.2 Core-Shell Quantum Dot](#_Toc113029582) 17

[Figure 8 – 2.3.3 Radiative Recombination 17](#_Toc113029583)

[Figure 9 – 2.3.4 Biexciton-Exciton Cascade [1] 1](#_Toc113029576)7

[Figure 10 – 2.3.5 Reimer Group Quantum Dot [1] 2](#_Toc113029577)0

[Figure 11 – 2.4.1 Hilbert Spaces 21](#_Toc113029578)

[Figure 12 – 3.1.1 Pennacchietti Experimental Data and Fit](#_Toc113029579) 25

[Figure 13 – 3.2.1 Initial Curve](#_Toc113029580) 32

[Figure 14 – 3.2.2.1-3 Results of Model (ground, exciton and biexciton respectively)](#_Toc113029581) 34