Hello everyone and welcome to my presentation for PHYS 437 A – Measuring the Quantum Beat

Before we continue, just wanted to give a short summary of contents

* I begin with the premise and motivation behind the project speaking about particle distinguishability and a plan of attack to help determine this
* Next, I will collect the building blocks necessary to help me determine particle distinguishability, by defining the object being tested, how it will be tested, and the methodology used to analyze the results of assessment
* I will then assemble these blocks in such a way to detect the quantum beat, and find the likelihood of measuring a coincidence count
* I will conclude with a summary of these results and future considerations

Without further ado: Particle Indistinguishability

Looking at this picture, can we determine the outcome of this collision? We would probably say that the blue one will deflect up while the red will deflect down. Now suppose I strip it of colour? Can we still talk about the trajectory of the particles? I suppose I could then speak about the left and right particles. But what if they were quantum particles? According to Heisenberg’s uncertainty principle, position has very little meaning outside the time of measurement. This inability to differentiate between particles is quantum phenomenon called Indistinguishability. This seems like a simple thought experiment; however this can have large effects on experimental data as well.

Due to the nature of optical quantum computing; it often requires the generation of entangled photon pairs that are indistinguishable. But how do we know that this is the case? In this experiment I aim to demonstrate that the Hong-Ou Mandel experiment can be used to determine the distinguishability of photons.

Motivated by “Time- Resolved Two-Photon Interference” by Legero, Wilk, Kuhn, and Rempe I seek to do the following:

* + Demonstrate Quantum Beat
  + Compare Probability Distribution found with Idealized HOM Probability Distribution

I do this by following the process outlined in “Signatures of Hong-Ou-Mandel Interference at Microwave Frequencies

* + Perform Hung-0u-Mandel Experiment on Incident Photons
  + Determine the associated second order Correlation Function
  + Integrate Second-order correlation function over all possible detection times

In order to carry out this plan successfully, I need the following 3 Mathematical descriptions, which I seek to outline in my next slides

Photon generation and destruction falls naturally under the framework of the quantum harmonic oscillator, especially when considering that the electromagnetic field quantization recovers a form that looks like the harmonic oscillator. However, the quantization of electromagnetic field uses solutions of the electromagnetic field that are polarization dependent. How do we involve frequency?

Through the combined efforts of Glauber and Titulaer, a relationship between the inverse of photon lifetime and spectrum of frequency that a photon contains. Given this, a spatio-temporal definition for a photon was made possible. In this project we will be using the function defined by Legero, Wilk, Kuhn, and Rempe. With the following variable definitions

We have now established the mathematical shape of the photon, let us find a framework for the Hong-Ou-Mandel experiment

First demonstrated by Chung Ki Hong, Zheyu Ou, and Leonard Mandel in 1987. This experiment is a landmark experiment in quantum optics. Though it holds such a large place in the field its implementation is deceptively simple. Two photons are incident upon a beam splitter

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Now that we’ve collected our blocks, let us build them in such a way that we can demonstrate particle distinguishability