Single-Photon Interference

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Abstract

Multiple studies of light have confirmed that has both wave-like and particle-like properties. It is unlawful to try and assign a single classification to light, particularly if we design an experiment where it is behaving like a wave and a particle- at the same time! We performed the Single-Photon Interference Experiment, a version of Young's Double Slit Experiment where the incident beam of green photons is so dim that we can be sure, within some probability, that there is only one single photon going through the slits at once. Considering the photon to be a particle, one might expect the resultant pattern (from the photon traveling through two slits) to be two bright lines parallel to the two slits. However, even with the confirmation of a single photon in flight at any time, we still observe interference fringes. We can say that the photon 'interferes with itself' and displays at once a wavelike nature and particle-like nature. In this paper, we explore the single-photon interference experiment and the resulting fringes. We compare them to the Fraunhofer and Fresnel models for photon interference and discuss the advantages and disadvantages of each.

I. INTRODUCTION

Talk about discovery of light- Maxwell wave Talk about discovery of light as particle- Young double slit

Talk about single photon situation, what is expected

Talk about models/equations here? If not, in analysis.

II. METHODS

We used the Teach-Spin "2-Slit Interference One Photon at a Time" Apparatus for this experiment. The apparatus comes with a long black box containing an adjustable light source (with green filter to restrict wavelength and intensity), a 670nm laser source for alignment, four magnetic slit-holders along the length of the box for adding slits in the path of the light, and two detector options at the end: a photodiode (for laser light) and a photomultiplier tube (for lightbulb illumination). We placed a single columnating slit in the first holder to focus the light from the lightbulb. This created vertical a single-slit diffraction pattern, which we centered on the next set of slits. In the second slit holder, in the middle of the box, we placed the double-slit, and immediately following that we placed the slit blocker (a wide single-slit) so we could choose to allow light through one slit, both slits, or neither. At the far end of the box we placed a single slit for the detector slit - by moving this slit holder lengthwise across the channel we could "scan" the interference pattern and measure photon counts at regular intervals.

Behind the detector slit was a photomultiplier tube (PMT). A PMT generates an electrical current

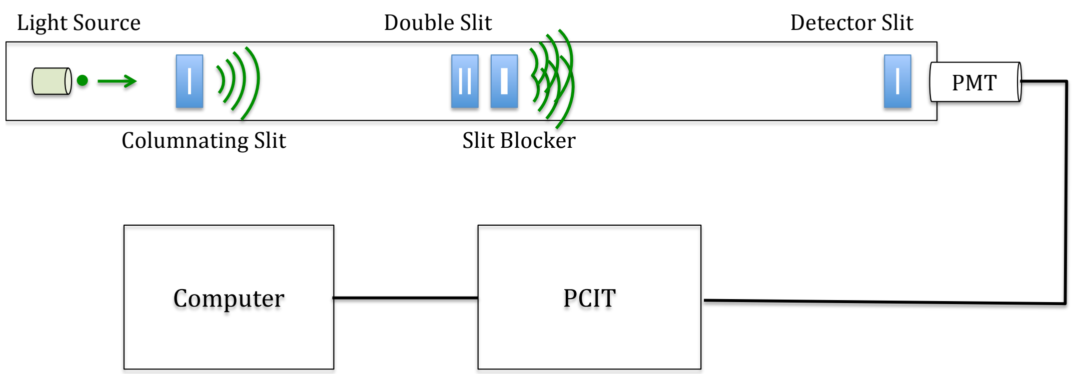

FIG. 1. Teach-Spin apparatus to measure quantum interference: a 1m-long black box containing an adjustable light source (450nm), columnating single slit, double slit, slit blocker, detector slit, and photomultiplier tube (PMT) detector. We sent the PMT output to a pulse-counter interval timer (PCIT), and from there to the computer.

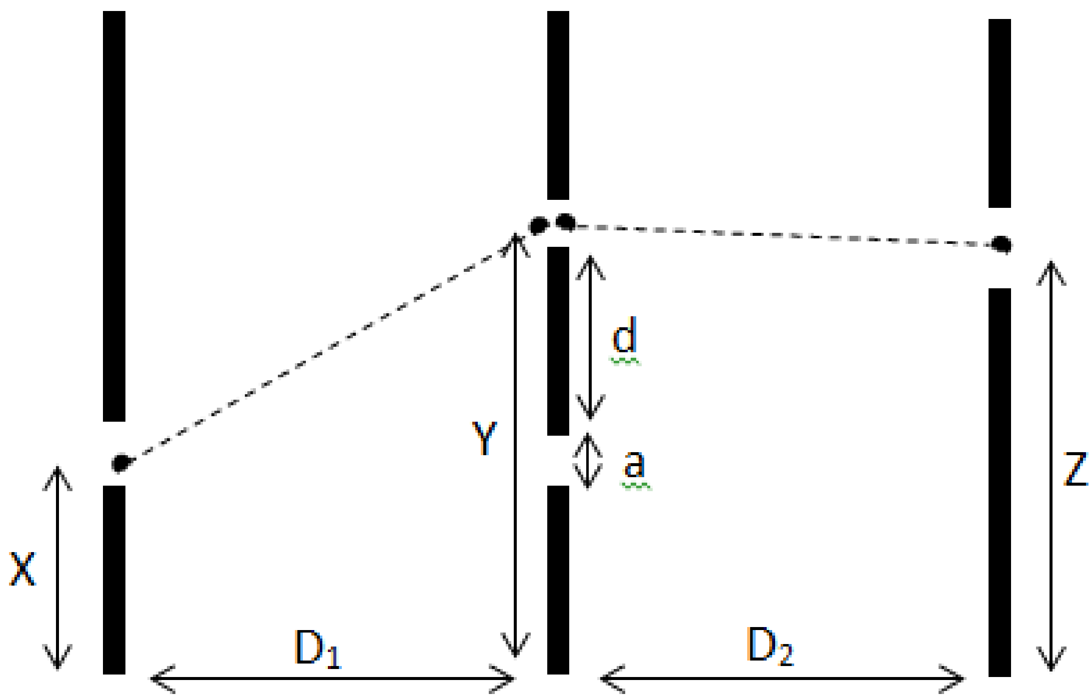

FIG. 2. The set-up and variables used in the Fresnel Approximation. Note that the variable "Z" in the fresnel formula is what we've been calling "X" in our other calculations - the position of the detector slit.

III. RESULTS

IV. ANALYSIS

V. DISCUSSION

VI. CONCLUSION

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