

# Single-Photon Interference

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## Abstract

It has been understood since the 19th century that light displays both wavelike and particle-like properties. Light beams of differing phase interfere with each other and create observable light and dark fringes, as seen in Young's Double Slit experiment. At the same time, light can be seen as a particle: quanta of light, or photons, excite electrons to higher states of energy as seen in the photoelectric effect. It is unlawful to attempt to classify light as a single entity. We demonstrate the dual nature of light in the Single Photon Interference Experiment- a variation of Young's Double Slit Experiment. We use a beam of light and a double slit apparatus, however, in this case, we have confirmation that, within a certain probability, there is only a single photon in flight through the double slit device at any time. Considering light to be a particle, we would expect to see two single bright fringes projected onto a screen. However, we do actually see an interference pattern as seen in the Double Slit experiment. The photons 'interfered with themselves'- the light was both a wave and a particle at once! In this paper, we discuss the revolutionary implications of this result as well as how we might model these interference patterns. We fit the Fresnel and Fraunhofer models of interference to our data and discuss the advantages and disadvantages of each.

## I. INTRODUCTION

## 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

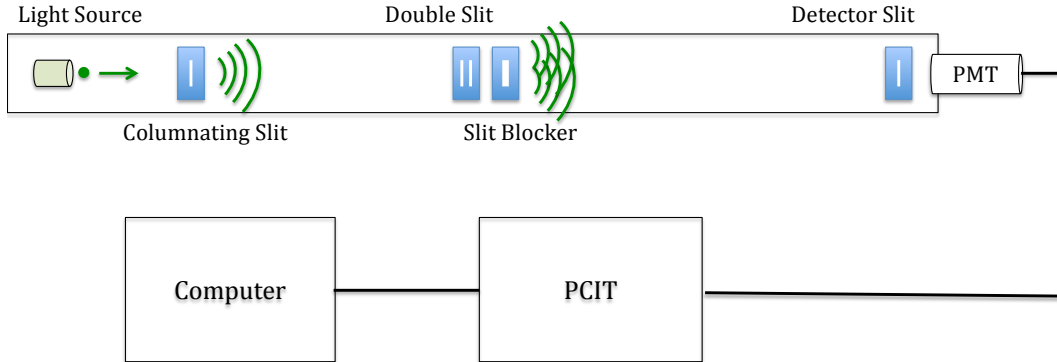


FIG. 1. Teach-Spin apparatus to measure quantum interference: a 1m-long black box containing an adjustable light source (450nm), columnating single slit, double slit, slit blocker, detector slit, and photomultiplier tube (PMT) detector. We sent the PMT output to a pulse-counter interval timer (PCIT),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

### III. RESULTS

### IV. ANALYSIS

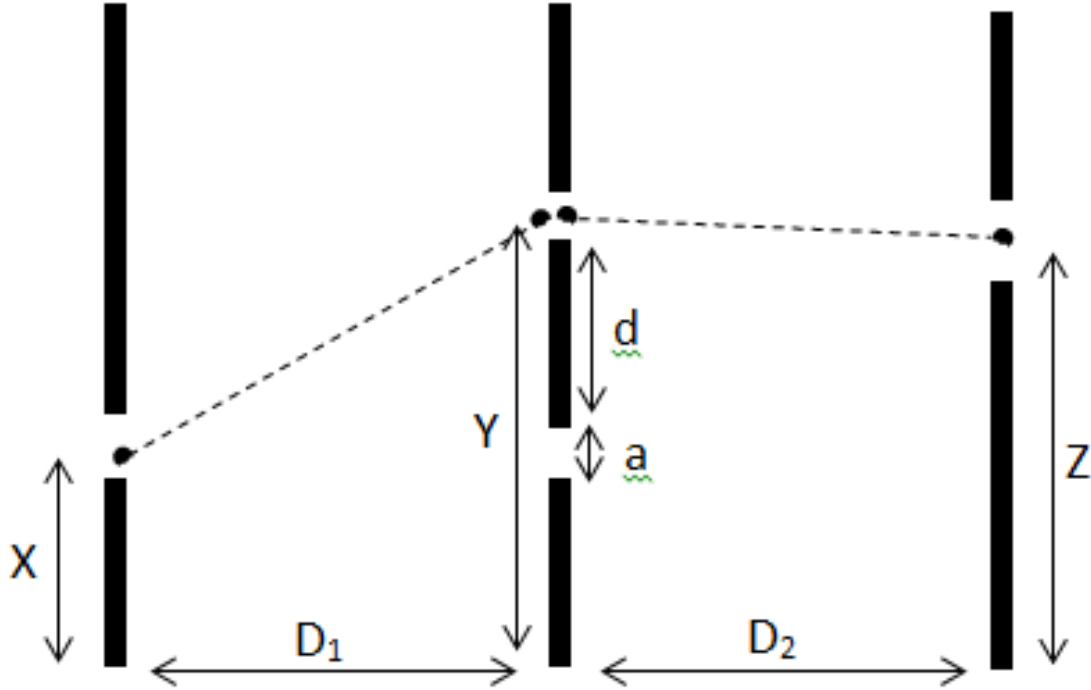


FIG. 2. The set-up and variables used in the Fresnel Approximation. Note that the variable " $Z$ " in the fresnel formula is what we've been calling " $X$ " in our other calculations - the position of the detector slit.

### V. DISCUSSION

### VI. CONCLUSION

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