Single/Double Slit Experiments

M. Lane and Alex J. Harsell.

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Abstract

Particle wave duality is one of the most perplexing concepts in modern physics. This apparent paradox seems to defy intuition, which is built upon common experience. In this experiment the double and single slit experiments are performed one photon at a time. It is shown that a single photon experiences wave interference in both the single and double slit cases. In this sense the particle and wave natures of light are shown simultaneously, which motivates the paradox of duality in an undeniable way.

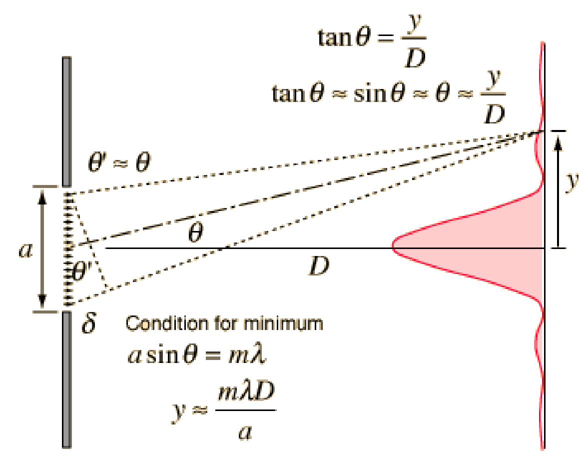

Figure 1: Replace picture with correct variables or picture in notes

1 Introduction

Introduced by Albert Michelson in 1881, the Michelson Interferometer was instrumental in ushering in the era of modern physics; most notably, it validated Einstein's theory of special relativity and dismissed the omnipresence of an ether through which light was thoughtto have propagated. It's applications, however, are varied and can be used to discern wavelengths given precise measurements of distance or vice versa.[2] In addition, the Michelson Interferometer can determine the separation of wavelengths of non monochromatic light. If two wavelengths are present, they will "beat" in the same way that two closely separated audio waves beat. Intuitively, the interference patterns for each wavelgength present in the extended source superimposes and will thus rotate in phase and out of phase as the path lengths are altered. Superposition in this manner is true for arbitrarily contiguous light sources. The final application demonstrated in this study is the present of white light fringes which should exist in theory since there is a point where all waves intefere, irrespective of wavelength.[2]

2 Theory

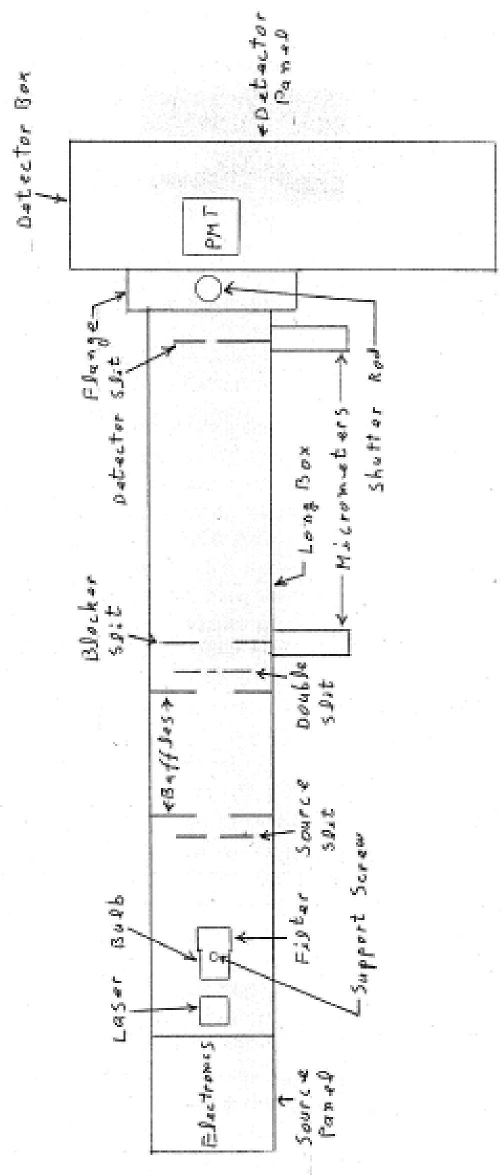

Figure 2: Not to scale.

Figure 2: Results for Two Slit with Laser

Interference is one of the many significant consequences of the wave nature of light. Fortunately, these efeffects are also accessible, many of them are presented in an introductory physics course. The Michelson Interferometer is a practical way of superimposing two light sources to observe interference. A schematic from Guenther's Modern Optics is shown in figure 1.[1] After passage through a beam splitter the primary ray of light moves along two orthogonal paths (the arms of the interferometer) before rejoining to produce an inteference pattern observed at the detector. M_O^2 is the location of the virtual image

3 Analysis

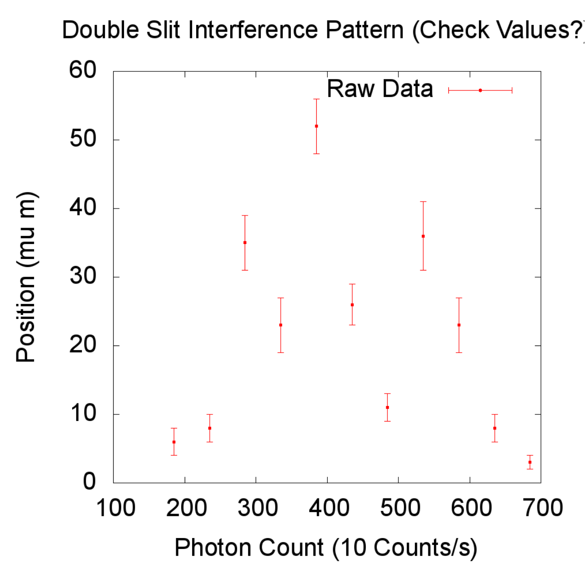

Figure 3: Results for Two Slit with Laser

th Quantum Electrodynamics, and hence applies equally well to any other type of matter[5,3]. It is a fundamental property of nature. Upon seeing the above result, one may be curious how all of the photons moving through the apparatus add together when one can switch from single slit interference to double

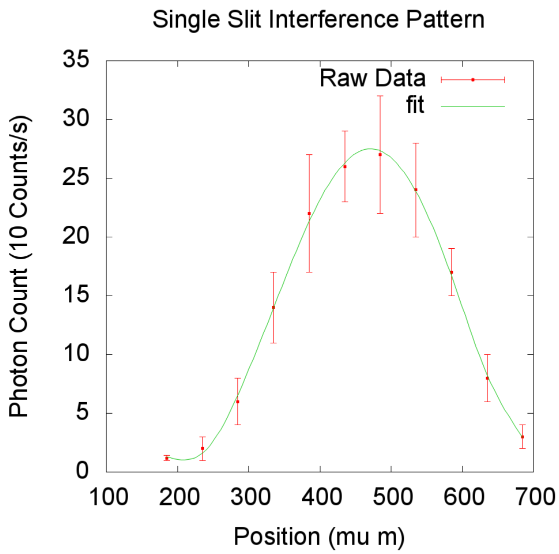

Figure 4: Results for One Slit with Laser

4 Extra Biography

[1] M. Sobel, Light (The University of Chicago Press, 1987), pp. 8-15. [2] P. Tipler, R. Llewellyn Modern Physics (W.H. Freeman Company 1999,2003), pp. 141-143. [3] R. Feynman, The Character of Physical Law (MIT Press 1967) pp. 128. [4] D. Halliday, R. Resnick, J. Walker, Fundamental of Physics Volume 2 (John Wiley and Sons, Inc., 2005), pp 996-1003. [5] R. Feynman, Quantum Electrodynamics (Oxford University Press, 1988), pp. 78.