

1. READING:

Styer, *The Strange World of Quantum Mechanics*

Chapters 8, 9 - 11

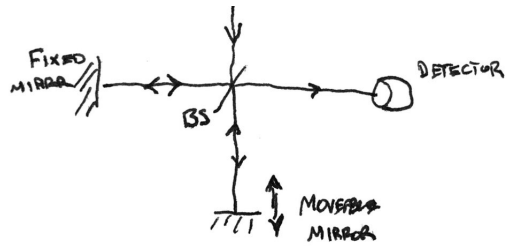
So far we have also discussed material in 12.2 and Chapter 14

Optional: Chapter 7 - we used the Hardy experiment (a.k.a quantum cakes) instead the GHZ experiment discussed in this chapter

Optional: Appendix A, on the history of quantum mechanics; Appendix B, on putting the weirdness to work

2. QUESTIONS: DUE THURSDAY DECEMBER 4, AT 11 PM

- (1) Consider the experiment 6.1 (the non-switching EPRB experiment).
 - (a) Explain why it is not possible to send a message instantaneously using this experiment.
 - (b) If the world followed the local realist/deterministic scheme, and the experimental results were explained by the instruction sets we used, would Alice be able to send an instantaneous communication to Bob?
- (2) 6.2
- (3) 6.3
- (4) 6.4 Feel free to use the notation we used in class, “+” for “R” and “-” for “G” etc.
- (5) 8.1
- (6) 9.2
- (7) 9.3
- (8) 10.3
- (9) 11.1
- (10) 11.2
- (11) On campus we have a setup for single photon interference using a Michelson interferometer with one beam splitter (BS) and as shown in this sketch

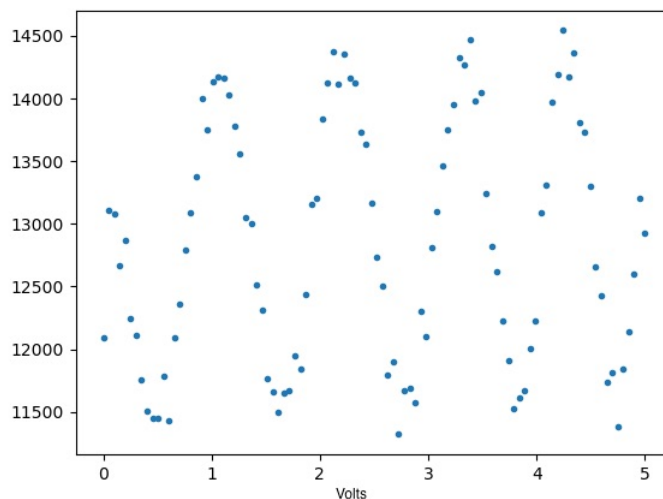


The source of light is at the top of the sketch. The light comes from a green laser with wavelength 523 nm ($1 \text{ nm} = 1 \times 10^{-9} \text{ m}$). The amplitude for a single photon at this wavelength rotates once as the photon travels one wavelength, or about 1910 times every mm.

- (a) If a photon moves exactly 1 cm how far does the amplitude rotate?
- (b) Consider two photons traveling in the two paths of the interferometer. Let the paths of the interferometer be set so that the amplitudes for each path point in the same direction when we add them together.

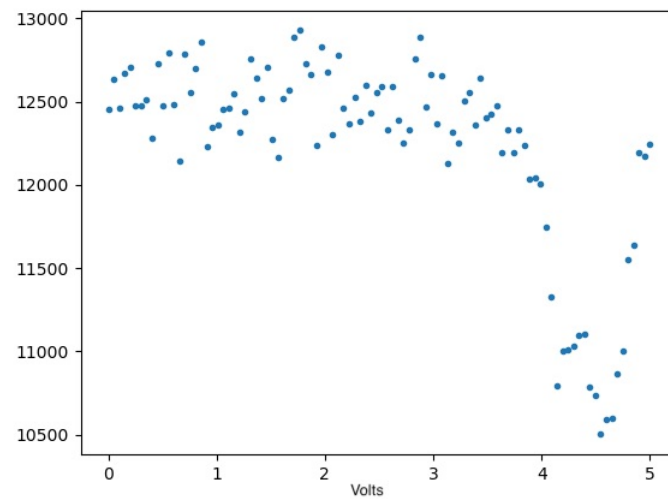
The mirror on one arm of the interferometer moves forward $1.18 \mu\text{m}$ ($= 1.18 \times 10^{-6}$) how many fringes or dark bands do you see pass by? Hint: For every change in the mirror's position the path length changes by twice as much.

- (c) Sketch the interference pattern and label the peaks and valleys with sketches of the amplitudes for the two arms.
- (d) In the experiment filters are added to reduce the amount of light intensity so that photons are separated by 200 m on average. Here is the data:



The horizontal axis (in volts) is proportional to the distance the mirror moves - a total displacement of $1.18 \mu\text{m}$. On the vertical are counts of individual photons. Given filters and the pattern you see in the data, what can we conclude about the single photons?

- (e) When one path of the interferometer is blocked the pattern changed to this:



Why did the interference pattern go away?