Quantum (PHYS 290): Week 2

Fall 2025 v1.5

Intro:

This week we connect the mathematics of wave phasor addition to the sum of quantum amplitudes - it's essentially the same math! We'll also explore single photon interferometry. In the lab we'll devise an experiment to determine whether polarization is source-dependent.

Reading: ("T" stands for Townsend's text)

- T: Chapter 1 Section 3 - We discussed light as a photon on Wednesday and Friday last week
- T: Chapter 1 Section 4 - This is the big development for the week. Likely this will be in Wednesday's class
- T: by the end of the week we'll be done with Chapter 1
- Looking ahead - Chapter 2 sections 1 and 2 with more interferometry (for matter). The discussion of Schrödinger's equation starts in section 3, which we'll probably get to late in the week.

Problems: Due Friday, September 12 at the beginning of class

(1) In figure 1.31 (b) Townsend shows the geometry of phasors for infinitely narrow double slits. Let's modify the calculation to account for single slit diffraction:

  (a) Carefully redraw the diagram adding the phasors and geometry for finite width single slits as we did in class. Assume both slits have the same width.

  (b) Using Townsend's phasor notation using complex numbers write down the addition of the Huygens' source phasors to obtain an expression for the phasor z_s for one single slit. Hint: This is one equation with a sum over N terms. Feel free to use $\ldots$ in your equation.

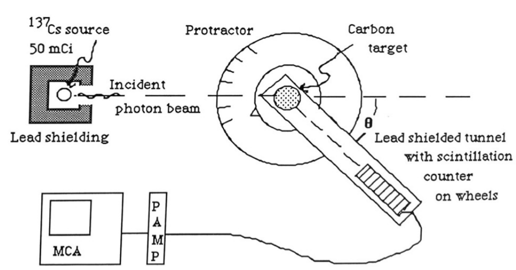
  (c) **Optional (0.1 pt)** Find the magnitude squared of the phasor $z_P^* z_P$, which is proportional to the intensity we found in class. (Townsend has an analogous treatment for multiple slits in problem 1.38.)

(2) 1.28 Double slit calculations

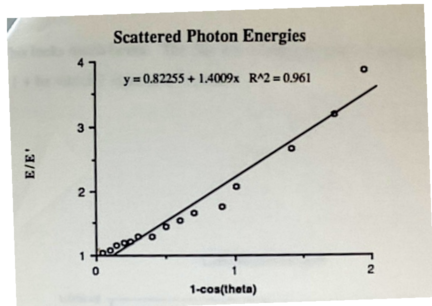
(3) 1.9 Photoelectric effect

(4) 1.10 Finding h using Millikan's data

(5) Long ago I helped run a Compton scattering experiment using a cesium source and carbon target. Here's the schematic of the experiment



Photons with energy $E_\gamma = 0.66165$ MeV scattered off the target, loosing energy due to the recoil of the electrons. Here's data from that experiment (like what I mentioned in class on Friday September 5)



(a) Using the Compton formula in equation (1.28) show that the ratio of energies can be written as

$$\frac{E_\gamma}{E_{\gamma'}} = 1 + \frac{E_\gamma}{m_e c^2}\,(1 - \cos\theta)$$

(b) Using the fit to the data, find the experimental and theoretical ($\lambda_C = h/m_e c$) Compton wavelengths of an electron.

(c) Based on your calculations and the data in the plot discuss the level of agreement between the theoretical and experimental wavelengths.

(6) 1.17 Radiation safety. Add this part (b) Explain the situation for the photons used in the Compton experiment in problem 5. Were they dangerous?

(7) 1.22 Rotating phasors

(8) (2 pts.) 1.24 Phasors in thin films

(9) 1.45 On quantum and classical probabilities