Spacetime and the Quantum World: Guide 4

Fall 2025 v1.0

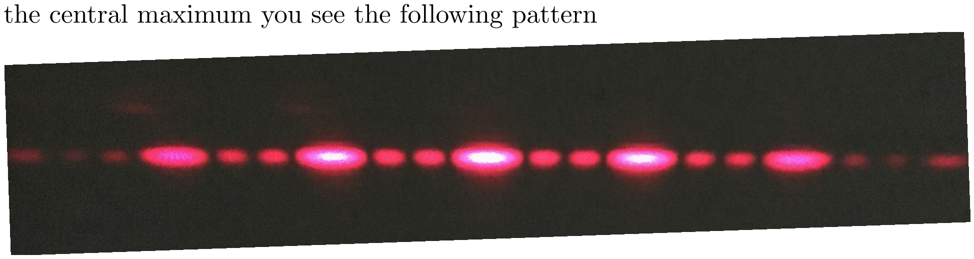
1. Reading:

Styer, *The Strange World of Quantum Mechanics*
Preface and Chapters 1 - 3

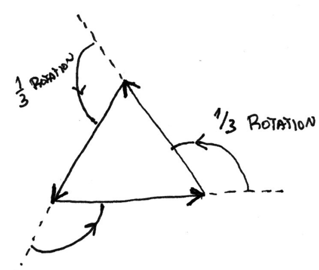
2. Questions: Due Thursday October 30, at 11 PM

All numbered questions are in Dan Styer's book, *The Strange Work of Quantum Mechanics*

(1) In our "light introduction to quantum mechanics" we discussed phasors or hands of an analog clock. Here we'll fill out the description for a 4 slit pattern:
  (a) In the central maximum you see the following pattern



Sketch the intensity of the pattern, using the saturation in the photo to scale the peaks in the pattern - sketch higher peaks for higher intensity.
  (b) On or near your sketch of the intensity add the phasor diagrams for the (i) central maximum, (ii) first minimum, (iii) second minimum, and (iv) third minimum. You only need to do this on one side of the pattern. *Hint: The analogous result for the first minimum of a 3 slit interference pattern is*



On or near your sketch of the intensity add the phasor diagrams for the two secondary maxima. As before one side is fine.

(2) 2.1

(3) 2.2

(4) 2.3

(5) 2.4

(6) 2.5

(7) 3.1

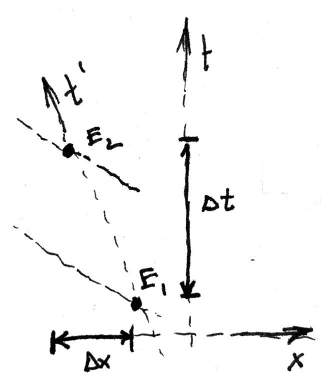
(8) 3.2

(9) (Optional but worth 1/2 an extra point) In the Preface of his book Styer quotes from someone on the hopelessness of popularizing quantum mechanics. Who is it? (I suspect this author now agrees with Dan Styer, for this author went on to do just that!)

(10) (Optional but worth 1 extra point) If you were to study special relativity elsewhere you would likely encounter the 'Lorentz transformations' which are general equations that relate spacetime coordinates (t, x) in one frame with another. Suppose we are studying two events E_1 and E_2. The time interval Δt and separation Δx between E_1 and E_2 in one frame and $\Delta t'$ and separation $\Delta x'$ in a relatively moving frame are related by

$$\begin{aligned} \Delta t &= \gamma\left(\Delta t' + \frac{v\Delta x'}{c^2}\right) \\ \Delta x &= \gamma\left(\Delta x' + v\Delta t'\right) \end{aligned} \tag{1}$$

These are the Lorentz transformations. Most of our results in special relativity are encoded in these relations.

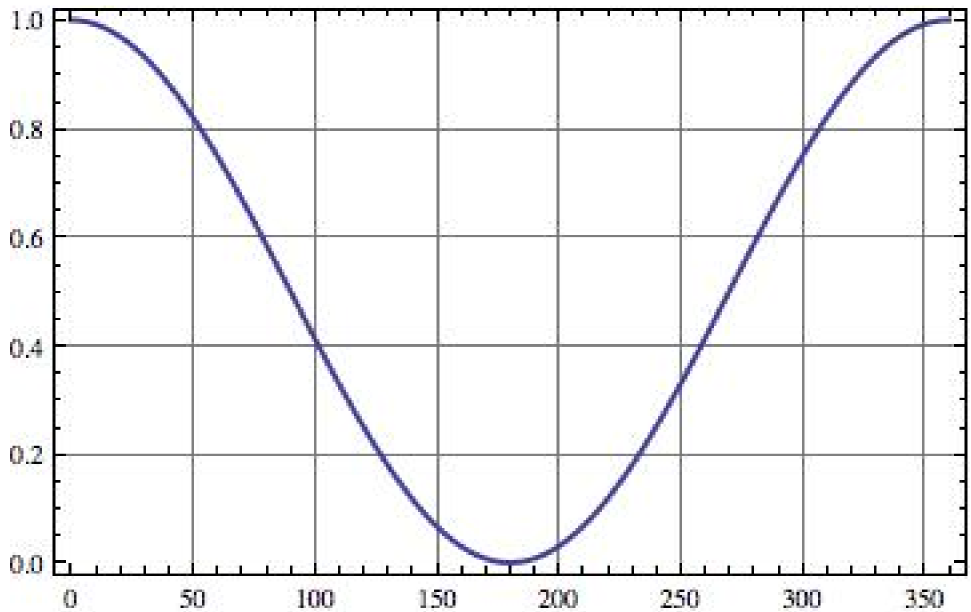


For instance, for events that occur in the same location ($\Delta x' = 0$) such as on the t' worldline as shown, we have from the first equation

$$\Delta t = \gamma\left(\Delta t' + 0\right) = \gamma \Delta t' \tag{2}$$

and so we recover time dilation.
(a) Where is length contraction encoded in these relations?
(b) Where is the slip in simultaneity in these relations?
It is helpful to reposition the events and redraw the diagram for these cases.

This plot of $\cos^2(\theta/2)$ is helpful for tilted Stern-Gerlach experiments.


1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150
200
250
300
350