Homework 5

Wave-particle duality

Due Friday February 22 at 5pm

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1. Red laser in a physics lab
Q4B.4 *from Chpt 4 of Unit Q, 3rd Edition*

2. Radio station
Q4B.13 *from Chpt 4 of Unit Q, 3rd Edition*

3. Stars visible to the naked eye
Q4R.1 *from Chpt 4 of Unit Q, 3rd Edition*

4. deBroglie wavelength
Q5B.3 *from Chpt 5 of Unit Q, 3rd Edition*

5. Gamma radiation
Gamma radiation is a form of electromagnetic radiation with a photon energy greater than 100 keV. Gamma radiation is emitted by the radioactive decay of atomic nuclei. It is also emitted by supernova and the merger of neutron stars (see the research of Prof. Lazzati at Oregon State).

a) Calculate the wavelength of gamma radiation when the photon energy is 1 MeV.

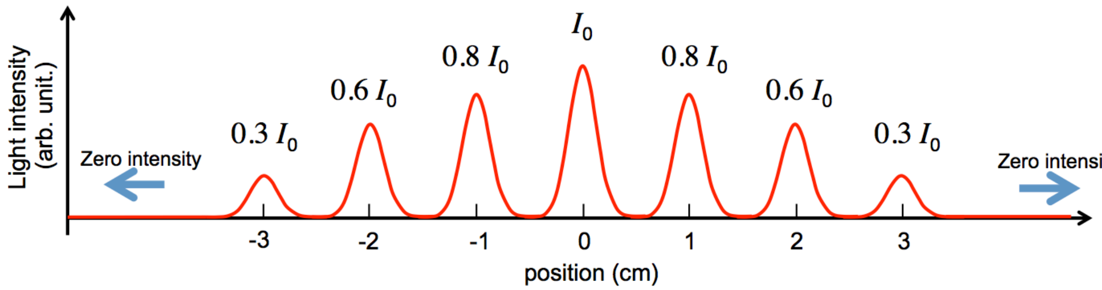
b) Do you expect the language of particles, or waves, to be used more often when describing gamma radiation?

6. An experiment with helium atoms
Q5M.6 *from Chpt 5 of Unit Q, 3rd Edition*

(Question 7 is on the next page)

7. Randomness and Probability in Quantum Mechanics

Consider an interference pattern that is formed on a screen using a bright laser:



The interference pattern has 7 distinct peaks. The peak shapes are Gaussian. Each distinct peak has the same full width at half maximum (FWHM = 0.3 cm). The maximum intensity is labeled for each peak. For $x > 3.5$ cm, and $x < -3.5$ cm, the light intensity drops to zero.

The brightness of the laser is now drastically reduced so that photons hit the screen one at time. Nothing else is changed. Answer the following questions by applying the quantum-classical correspondence principle.

a) What is the probability that the next photon to hit the screen will arrive at a position -0.5 cm < x < 0.5 cm?

b) What is the probability that the next photon to hit the screen will arrive at a position 2.5 cm < x < 3.5 cm?

Useful result:
The area under a Gaussian peak is equal to 1.06*(FWHM)*(Peak height)