Physics 313-Fall 2023 9

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Due 5:00 pm Nov. 8, 2023

1. (3 pts) (Heisenberg Uncertainty) The speed of an electron is measured to within an uncertainty of 2.0×10^4 m/s. What is the size of the smallest region in which it can be confined?

Solution:

Using let $v_e = \alpha \pm 2.0 \times 10^4$; using $\Delta x \Delta p \geq \frac{\hbar}{2}$:

$$\begin{aligned} \Delta x(2.0 \times 10^4) &\geq \frac{\hbar}{2} \\ \implies \Delta x &\geq \frac{\hbar}{4 \times 10^4} \end{aligned}$$

This implies that the smallest region in which the electron can be confined is $\frac{\hbar}{4 \times 10^4}$ m.

2. (3 pts) Doors are about 1 m wide, and human beings are very roughly 160 lbs. How slow would a person have to be moving through a doorway in order for that person to diffract?

Solution:

The De Broglie wavelength of a human being is $\frac{h}{p}$, and destructive interference occurs when $a \sin(\theta) = m\lambda$. Therefore, for a human to diffract, both sides of the equation would need to be proportional.

$$\begin{aligned} a = \lambda \to a &\sim \frac{h}{mv} \\ \implies v &\sim \frac{h}{ma} \\ &\sim 9.135 \times 10^{-36} \text{m/s} \end{aligned}$$

3. (4 pts) Consider two waves $\cos(2\pi x/\lambda_1)$ and $\cos(2\pi x/\lambda_2)$ where $\lambda_1 = 1$ m and $\lambda_2 = 1.1$ m. In your favorite plotting program, plot each wave separately and then plot the addition of the waves assuming equal amplitude. Do it over the range -15 m $< x < 15$ m. Do you see beats when you add them together?

Plot:

The beats are clearly defined in the plot below: