1. Double slit interference

\[ dsin \theta = \frac{\lambda}{2} \]

\[ d_{best} = \frac{\lambda_{best}}{2 \sin \theta_{best}} = \frac{500 \text{ nm}}{2 \sin (6.5^\circ)} = 220.8 \text{ nm} \]

\[ 8d = \sqrt{\left(\frac{2d}{\sin \theta}\right)^2 + \left(\frac{\lambda \cos \theta}{2 \sin \theta}ight)^2} \]

\[ = \sqrt{\left(\frac{3 \lambda}{2 \sin \theta}\right)^2 + \left(\frac{\lambda \cos \theta}{2 \sin \theta}\right)^2} \]

\[ = 311.6 \text{ nm} \]

\[ d = 2200 \pm 300 \text{ nm} \]

2. \( \chi^2 \) fit

a) \[ \chi^2 = \sum \frac{(Y_i - f(x_i))^2}{\sigma^2} \]

\[ = \sum \frac{(Y_i - Bx_i)^2}{\sigma^2} \]

b) Best fit value for B: Minimize \( \chi^2 \) (error) with respect to B

\[ \frac{d\chi^2}{dB} = 0 \]

\[ 2\chi^2 = \sum \frac{2}{\sigma_i^2} (Y_i - Bx_i)(-x_i) \]

\[ 0 = \sum x_i Y_i - B \sum x_i^2 \]

\[ B = \frac{\sum x_i Y_i}{\sum x_i^2} \]

3. Counting Number Problem

a) In book def of Poisson distribution, \( P_n(n) = e^{-\mu} \frac{\mu^n}{n!} \), where \( \mu \) is the number of counts in some time interval \( T \) and \( \mu \) is the expected (average) number of counts in time \( T \). In this problem, \( \mu \) is given as an expected rate, so the expected \( n \) of counts in time \( T \) is \( \mu T \).

\[ P_{\mu T}(n) = e^{-\mu T} \frac{(\mu T)^n}{n!} \]

b) \( T = 4 \text{ min.} \)

\[ \text{expected counts} = 4, \mu = 4 \Rightarrow P = e^{-4} \cdot 4^4 / 4! = 0.195 \]

c) Poisson \( \rightarrow \) Gaussian when expected \( n \) counts is large (\( \mu T \gg 1 \))

d) mean \( \bar{x} = 8 \), s = 2, \( \sigma = \text{sqr} + (\text{mean}) = 9 \)

\[ P = \frac{1}{\sqrt{2\pi} \sigma} \int_{-\infty}^{\text{mean}} e^{-\frac{(x-\bar{x})^2}{2\sigma^2}} \text{d}x = \frac{1}{\sqrt{2\pi}} \int_{-2/2}^{1} e^{-z^2/2} \text{d}z \]
4. e/Me

a) Weighted average \( \frac{\langle e/Me \rangle}{\sigma_{\%}} = \frac{\langle e/Me \rangle}{\sigma} \)

\[
(\frac{e}{m})_{av} = \frac{\sum_i w_i \cdot (\frac{e}{m})_i}{\sum_i w_i}
\]

where \( w_i = \frac{1}{\sigma_i^2} \)

\[ (\frac{e}{m})_{av} = 1.75 \times 10^8 \text{ c/g} \]

b) \( \chi^2 \)

\[
E = 1.75 \times 10^8 \text{ c/g}
\]

\[
\chi^2 = \sum_k \frac{(O_k - E_k)^2}{\sigma_k^2}
\]

\[
= \frac{(1.76 - 1.75)^2}{0.2^2} + \frac{(1.90 - 1.75)^2}{0.4^2} + \frac{(1.36 - 1.75)^2}{0.9^2}
\]

\[ \chi^2 = 0.21 \]

c) \( \delta = n - c \)

\( n = 3 \) (3 independent trials)

\( c = 1 \) (calculated expected value from data)

\[ \therefore \delta = 2 \]

\[ \widetilde{\chi^2} = \frac{\chi^2}{\delta} \]

\[ \widetilde{\chi^2} = 0.11 \]

Data is consistent with hypothesis that \( \%m \) is a constant

since \( \chi^2 < 1 \).