Course: BSO 203 Instructor: S. Raychaudhuri

SESSION 2002-2003, SEMESTER I

QUIZ III

1. What was the outcome of the Franck-Hertz experiment? **(1)**

   Answer: The outcome of the Franck-Hertz experiment was to show that in a collision with high-velocity electron, atoms can absorb mechanical energy only in discrete packets of characteristic size, indicating that there are discrete energy levels inside the atom.

2. In an low-energy electron diffraction experiment, show that the direction of the principal diffraction peak obeys the formula

$$\cos\theta \propto \frac{1}{\sqrt{E}}$$

   where E is the energy of the electron beam. **(2)**

   Answer: Diffraction peaks from a crystal are given by Bragg's law $2D\cos\theta_n = n\lambda$, where D is the spacing between lattice planes. For the principal diffraction peak $n = 1$, so that

$$\begin{aligned}
\cos\theta_1 &= \frac{\lambda}{2D} \\
&= \frac{h}{2Dp} \text{ using the de Broglie relation} \\
&= \frac{1}{2D\sqrt{2mE}} \text{ using } E = p^2/2m \\
i.e.\ \cos\theta_1 &\propto \frac{1}{\sqrt{E}}
\end{aligned}$$

3. Calculate the Fourier transform of $f(x) = \cos ax$. **(2)**

   Answer: Given $f(x) = \cos ax$, we write the Fourier transform as

$$\begin{aligned}
g(k) &= \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} dx\ f(x)\ e^{-ikx} \\
&= \frac{1}{2\sqrt{2\pi}} \int_{-\infty}^{\infty} dx\ \left[e^{iax} + e^{-iax}\right]\ e^{-ikx} \\
&= \frac{1}{2\sqrt{2\pi}} \int_{-\infty}^{\infty} dx\ \left[e^{i(a-k)x} + e^{-i(a+k)x}\right] \\
&= \frac{1}{2\sqrt{2\pi}} \left[2\pi\delta(a-k) + 2\pi\delta(a+k)\right] \\
&= \sqrt{\frac{2}{\pi}} \left[\delta(a-k) + \delta(a+k)\right]
\end{aligned}$$