Lecture-23 7/10/2023

* Wave aspect of particles :⇒

de Broglie's Hypothesis (Matter wave) :⇒

In 1923 de Broglie suggested that the wave-particle dulaty is not restricted to radiation, but it must be universal.

All material particles should also display a dual wave-particle behaviour.

for photon $\begin{cases} E = h\nu \\ p = \frac{h\nu}{c} = \frac{h}{\lambda} \end{cases}$

Each material particle of momentum $\bar{p}$ behaves as a group of waves (matter waves) whose wavelength λ & wavevector $\bar{k}$ will be -

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

$$\bar{k} = \frac{\bar{p}}{\hbar}$$

where, $\hbar = \frac{h}{2\pi}$

This is de Broglie relation. It connect the momentum of a particle with the wavelength & wave vector of the wave corresponding to this particle.

Homework

Q :⇒ Calculate the de Broglie wavelength for

(a) :⇒ A proton of K.E. 70 MeV. &

(b) :⇒ A 100g bullet moving at 900 m/sec.

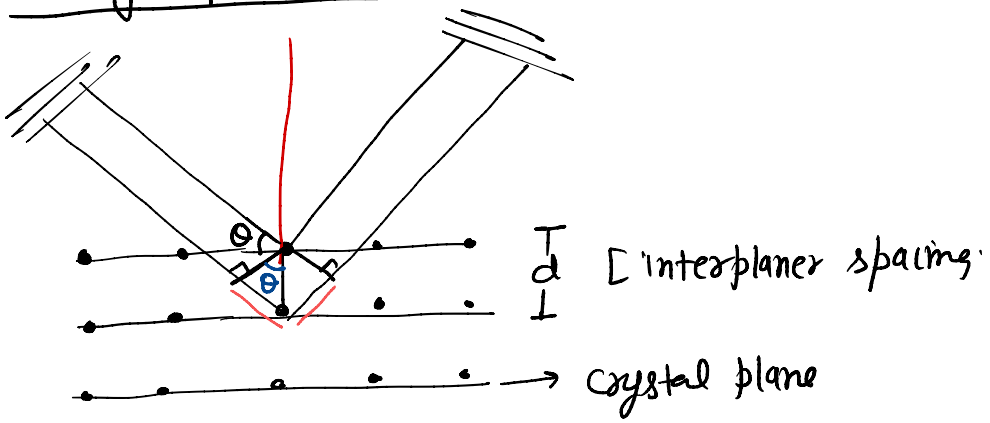
Ans :⇒ (a) :⇒ 3.4×10^{-15} m

(b) :⇒ 7.4×10^{-36} m

Davisson- Germer Experiment ⇒

This experiment confirmed the existence of de Broglie waves.

* X-ray diffraction ⇒



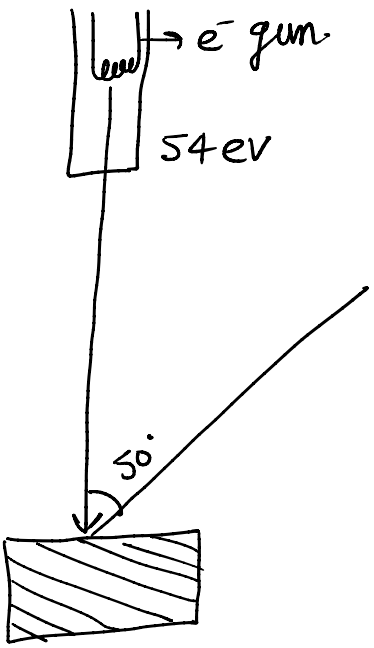
path diff $= d\sin\theta + d\sin\theta$

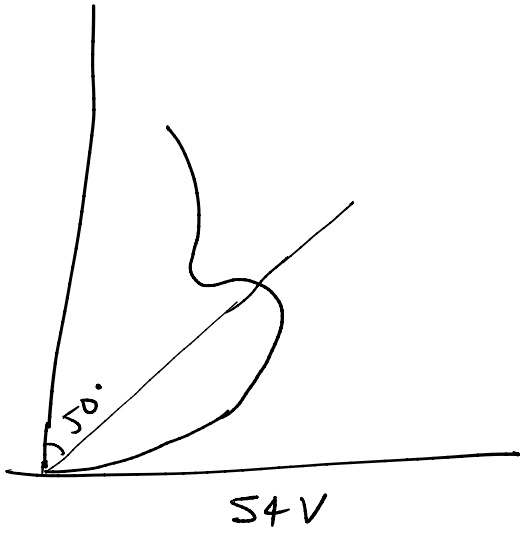
$$2d\sin\theta = n\lambda$$

n is order of diffraction.

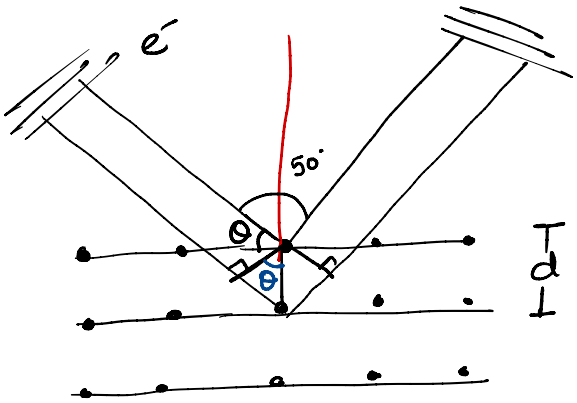
Cond^n for constructive interference, Bragg's law.

*





* In the exp., energy of e⁻, angle of incident & angle of detector could all be varied.



$\theta = 90 - 25^\circ$
$= 65^\circ$

* The spacing of the planes measured by the x ray technique $d = 0.091$ nm.

$\lambda = 2 \times .91 \times \sin 65^\circ = 0.165$ nm ——— ①

* Now if we use de Broglie formula to calculate the wavelength of e^-.

$\lambda = \frac{h}{mv}$

$K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$

$p = \sqrt{2mK}$.

$= \sqrt{2 \times 9.1 \times 10^{-31} \times 54 \times 1.6 \times 10^{-19}}$

$= 4 \times 10^{-24}$ kgm/sec.

$\lambda = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{4 \times 10^{-24}} = 1.66 \times 10^{-10}$ m $= .166$ nm ——— ②

Homework

Double-slit experiment with quantum particles like e^- ⇒

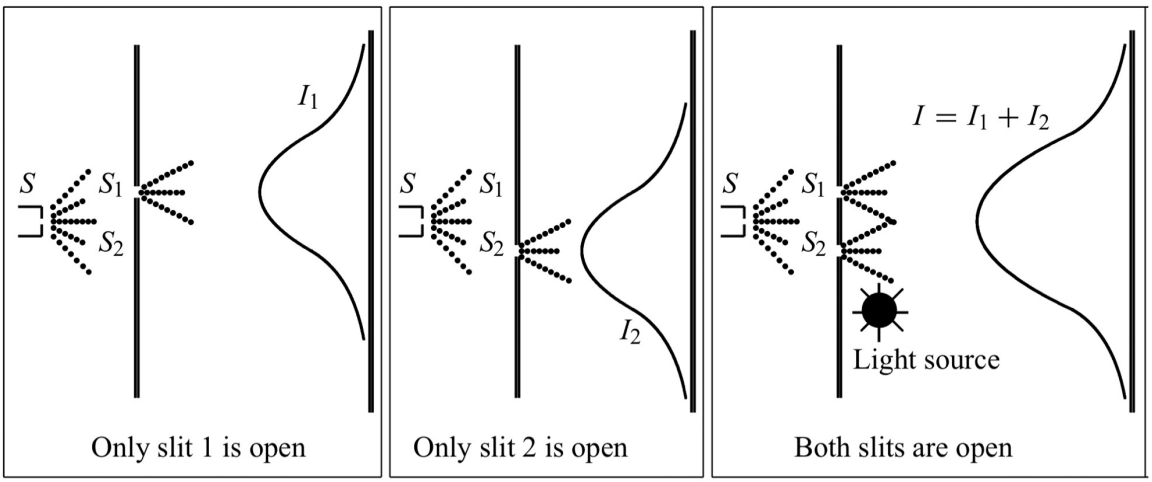


Figure 1.11 The double-slit experiment: S is a source of *electrons*. *A light source* is placed behind the wall containing S_1 and S_2. When both slits are open, the interference pattern is destroyed and the total intensity is $I = I_1 + I_2$.