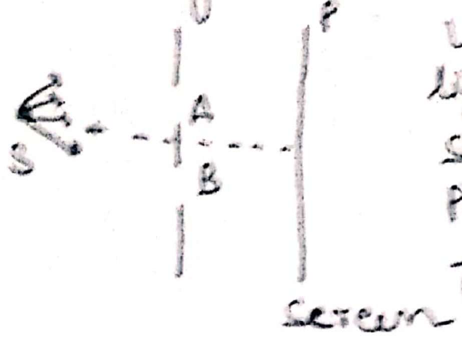
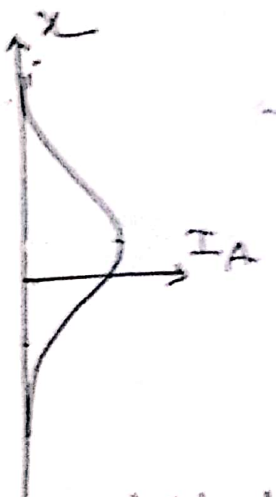
2.3 The Double slit Experiment

The double slit experiment is an excellent way of demonstrating the wave particle duality of radiation

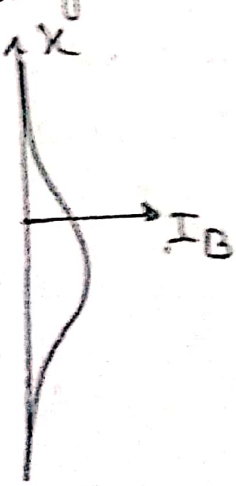


Let a monochromatic source of light is emitted from the source S on two slits A & B. After Passing through slit, the electron fall on the Screen P.

The Intensity I as a function of position on the screen. If the slit B is blocked, the pattern observed on screen is given by



similarly, If slit A is blocked, the Pattern observed on screen is only due to intensity of B (I_B)



The one should expect that If the both slit are opened the classical Intensity pattern would be given by

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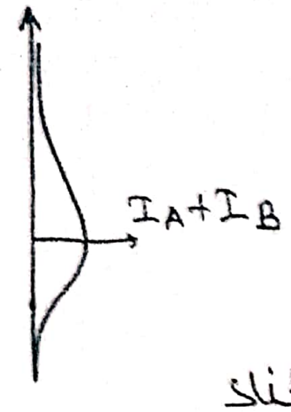
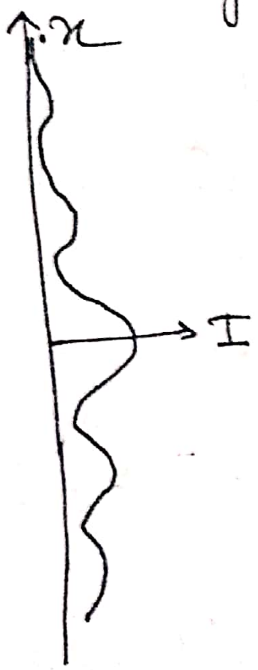


but it is found that when both slits are open, the pattern is an interference Patten which consist of maxima & minima. we might first think that the pattern is due to the interference between electron passing through the slits. But it is observed that if we fired one electron at a time, interference pattern was still produced. This is due to fact that interference does not occur between different electron but due to the wave associated with single electron. The actually pattern observed is like;



The electron behave like particle due detection but on the screen it form interference pattern which is property of wave.

3. <u>Wave function</u>

The result of double slit experiment reveals that each particle interfere itself. The Problem is that we have to consider the classical theory of waves for such explaination. According to it, the wave consists of amplitude and Intensity at a point is explained by $I = |\psi(x,t)|^2 = \psi^*(x,t)\,\psi(x,t)$

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Now according to Young's Double Slit experiment;
Suppose that ψ_1 & ψ_2 are the wave function at point corresponding to slit 1 & 2, respectively.
Then corresponding intensity,

$$I_1 = |\psi_1|^2 \ \& \ I_2 = |\psi_2|^2$$

when both slit open,

$$\psi = \psi_1 + \psi_2 \text{ and}$$

Intensity, $I = |\psi|^2 = |\psi_1 + \psi_2|^2$

consider

$$\psi_1 = |\psi_1| e^{i\alpha_1} \quad , \quad \psi_2 = |\psi_2| e^{i\alpha_2}$$

$$|\psi_1|^2 = \psi_1^* \psi_1 \quad , \quad |\psi_2|^2 = \psi_2^* \psi_2$$

$$I = (\psi_1 + \psi_2)^* (\psi_1 + \psi_2)$$

$$= \psi_1^* \psi_1 + \psi_2^* \psi_2 + \psi_1^* \psi_2 + \psi_1 \psi_2^*$$

$$= |\psi_1|^2 + |\psi_2|^2 + |\psi_1||\psi_2| \left(e^{-i(\alpha_1 - \alpha_2)} + e^{i(\alpha_1 - \alpha_2)}\right)$$

$$= |\psi_1|^2 + |\psi_2|^2 + 2|\psi_1||\psi_2| \cos(\alpha_1 - \alpha_2)$$

This shows that $I \neq I_1 + I_2$, The extra term is interference term.

If a particle is described in terms of wave function then probability $P(x)dx$ of finding the particle is given by

$$P(x) = |\psi(x,t)|^2 = \psi^*(x,t)\, \psi(x,t)$$

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