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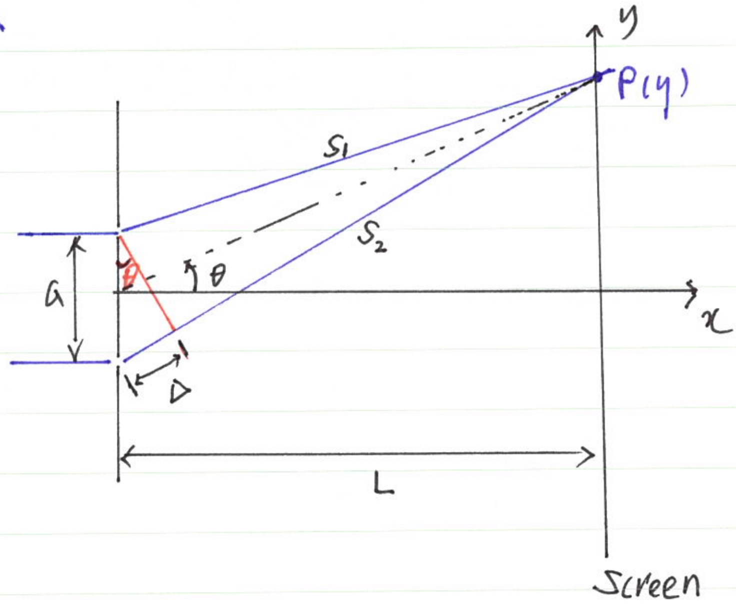
7-2 Young's double-slit exp

In 1802, the exp was performed.

→ Wave nature of light

(cf. particle nature of light : photoelectric effect
by A. Einstein in 1905.)



· path length difference Δ,

$$\Delta = s_2 - s_1 \fallingdotseq a\sin\theta \qquad (\theta \ll 1)$$

(i) For constructive interference,

$$\Delta = m\lambda$$

(ii) For distructive interference,

$$\Delta = \left(m+\tfrac{1}{2}\right)\lambda \sim a\sin\theta \sim a\tan\theta \sim \frac{ay}{L}$$

$$\therefore\ y_m = \frac{L\lambda}{a}\left(m+\tfrac{1}{2}\right), \quad m = 0, \pm1, \pm2, \ldots$$

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· phase difference δ,

$$\delta = k\Delta = \frac{2\pi}{\lambda}\Delta = \frac{2\pi}{\lambda} a\sin\theta \sim \frac{2\pi a y}{\lambda L} \quad (1)$$

From the two ~~photon~~ field interference in Eq. (7-18)

$$I = 4I_0\cos^2\left(\frac{\delta}{2}\right) = 4I_0\cos^2\left(\frac{\pi a y}{\lambda L}\right)$$

For the minima,

$$\frac{\cancel{\pi} a y_m}{\lambda L} = \left(m+\frac{1}{2}\right)\cancel{\pi}$$

$$\therefore\ y_m = \frac{\lambda L}{a}\left(m+\frac{1}{2}\right), \quad m = 0, \pm1, \pm2, \cdots$$

For the maxima,

$$\frac{\cancel{\pi} a y_m}{\lambda L} = m\cancel{\pi}$$

$$\therefore\ y_m = \frac{\lambda L}{a} m, \quad m = 0, \pm1, \pm2, \cdots$$

$$\rightarrow\ y_{m+1} - y_m \equiv \Delta y = \boxed{\frac{\lambda L}{a}} \quad \text{(fringe separation)}$$

(i) $\lambda\uparrow$, $\Delta y\uparrow$ ⇒ Diffraction is better for long waves.

(ii) $a\uparrow$, $\Delta y\downarrow$ ⇒ Diffraction is better for small slit.

A. Think about mobile communications for

(i) 2 GHz & (ii) 200 GHz

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B. Think about a particle case for Young's double slit exp?

Condition ex)

(i) An atom (^4He) is sent to the slit at each time

(ii) Repeat (i) for N times under the condition of no mutual coherence.

→ Action A & Action B are independent.