

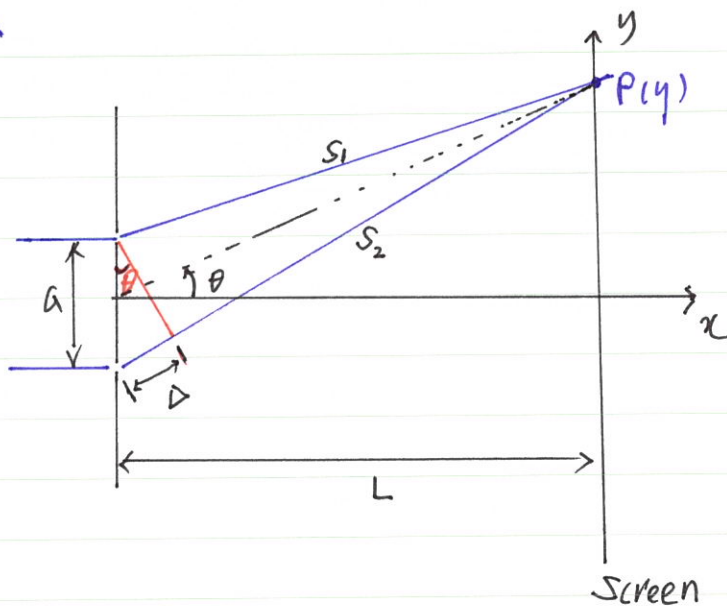
7-2 Young's double-slit exp

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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 ,

$$\Delta = S_2 - S_1 \doteq a \sin \theta \quad (\theta \ll 1)$$

(i) For constructive interference,

$$\Delta = m \lambda$$

(ii) For destructive interference,

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

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

• phase difference δ ,

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

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

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

For the minima,

$$\frac{\pi ay_m}{\lambda L} = (m + \frac{1}{2})\pi$$

$$\therefore y_m = \frac{\lambda L}{a} (m + \frac{1}{2}), \quad m = 0, \pm 1, \pm 2, \dots$$

For the maxima,

$$\frac{\pi ay_m}{\lambda L} = m\pi$$

$$\therefore y_m = \frac{\lambda L}{a} m, \quad m = 0, \pm 1, \pm 2, \dots$$

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

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

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

A. Think about mobile communications for

(i) 2 GHz & (ii) 200 GHz

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

Condition ex)

(i) An atom (${}^4\text{He}$) 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.