INTERFERENCE OF LIGHT

BRAIN MAP

CLASS XII

Interference of Light

When two light waves having same frequency and to nearly equal amplitude are moving in the same direction, superimpose each other at some point, then intensity of light is maximum at some point and it is minimum at some another point.

Conditions for Sustained Interference

1. *The two sources of light should be coherent.*
2. *Interfering waves must be in same state of polarisation.*
3. *Sources should be monochromatic otherwise fringes of different colour will overlap.*
4. *Distance between two coherent sources must be small.*

Addition of Coherent Waves

Intensity $\propto$ (Amplitude)^2

$I = KA^2$

Resultant intensity

$I = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$

Resultant amplitude

$A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}$

If intensity of both sources is same then

$I_1 = I_2 = I_0; I = 4I_0\cos^2\phi/2$

Intensity $\propto$ Width of slit

$$\left[\frac{I_1}{I_2} = \frac{W_1}{W_2} = \frac{a_1^2}{a_2^2}\right]$$

Interference Term
Depending upon $\cos\phi$

Phase difference $\phi = (2\pi/\lambda)\,\Delta$

Path difference $\Delta = (\lambda/2\pi)\,\phi$

$$\frac{\phi}{2\pi} = \frac{\Delta}{\lambda} = \frac{\text{Time difference}}{T}$$

Constructive Interference

Phase difference ϕ = 0, 2π, 4π, 6π ...

$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$

$A_{max} = a_1 + a_2$

For $I_1 = I_2 = I_0; I_{max} = 4I_0$

Destructive Interference

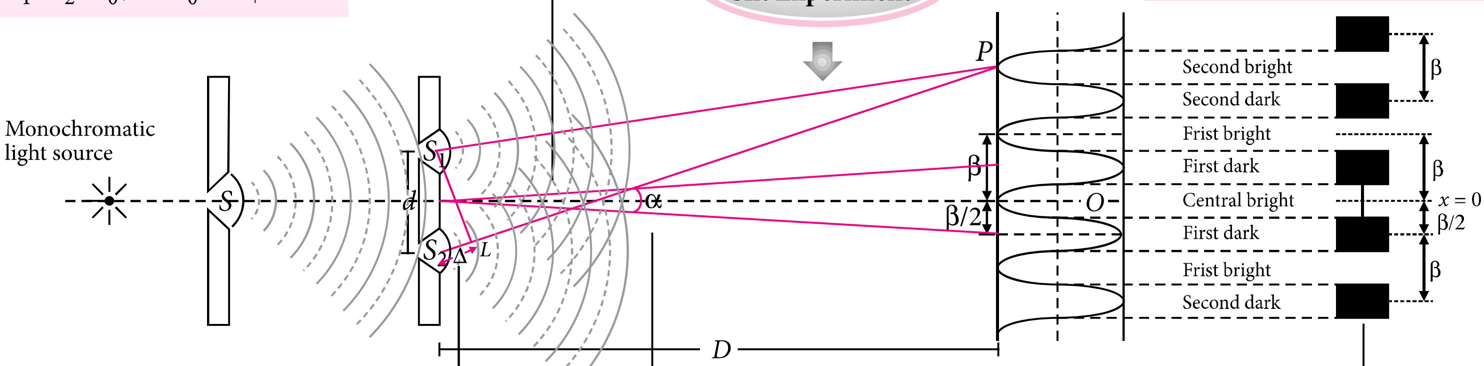
Phase difference ϕ = π, 3π, 5π ...

Resultant amplitude, $A_{min} = a_1 - a_2$

$I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$

For $I_1 = I_2 = I_0$; $I_{min} = 0$

Young's Double Slit Experiment



Path Difference

$\Delta = PS_2 - PS_1 = S_2L$

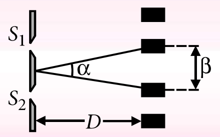
Path difference, $\Delta = xd/D$

$xd/D = n\lambda$ (Bright fringe)

$xd/D = (2n + 1)\,\lambda/2$ (Dark fringe)

Angular Fringe Width

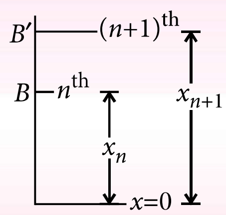
$$\alpha = \frac{\beta}{D} = \frac{\lambda}{d}$$



Fringe Width

The distance between two successive bright or dark fringe is known as fringe width.

$$\beta = x_{n+1} - x_n = \frac{D\lambda}{d}$$



Special Cases

- If two glass plates of R.I. μ_1 and μ_2 of same thickness t is placed in front of S_1 and S_2 then
  - Extra path difference $\Delta = (\mu_1 - \mu_2)t$
  - Shifting distance of central fringe $x = \beta(\mu_1 - \mu_2)t/\lambda$
- If a glass plate of thickness t and R.I. μ is placed in front of the slit then the central fringe shift towards that side in which glass plate is placed, because extra path difference is introduced by the glass plate.
  - Extra path difference $\Delta = (\mu - 1)t$
  - Shifting distance of central fringe $x = \beta(\mu - 1)t/\lambda$

INTERFERENCE IN THIN FILMS

- **For reflected Light**

  Maxima → $2\mu t\cos r = (2n + 1)\dfrac{\lambda}{2}$

  Minima → $2\mu t\cos r = n\lambda$

- **For transmitted light**

  Maxima → $2\mu t\cos r = n\lambda$

  Minima → $2\mu t\cos r = (2n + 1)\dfrac{\lambda}{2}$