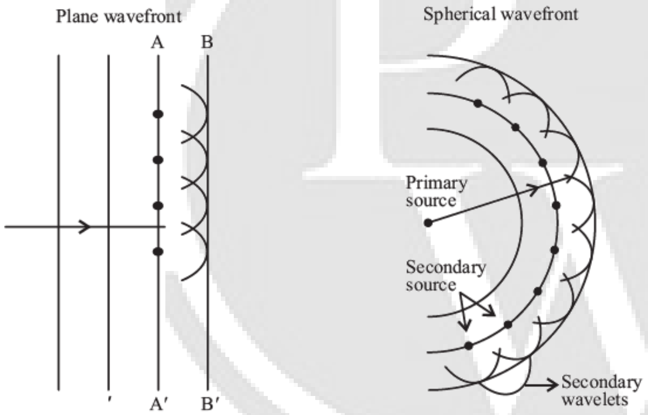
2024 – 25

Wave Optics

Recall what did you study in previous class

Huygen's Wave Theory

- Each point source of light is a center of disturbance from which waves are emitted in all directions. The locus of all the particles of the medium oscillating in the same phase at a given instant is called a wavefront.
- Each point on a wave front is a source of new disturbance, called secondary wavelets. These wavelets are spherical and travel with speed of light in that medium
- The forward envelope of the secondary wavelets at any instant gives the position of the new wavefront.
- In homogeneous medium, the wave front is always perpendicular to the direction of wave propagation



Coherent Sources

- Two sources are coherent if and only if they produce waves of same frequency (and hence wavelength) and have a constant initial phase difference.

Incoherent sources

- Two sources are said to be incoherent if they have different frequency or initial phase difference varies with time.

Interference: YDSE

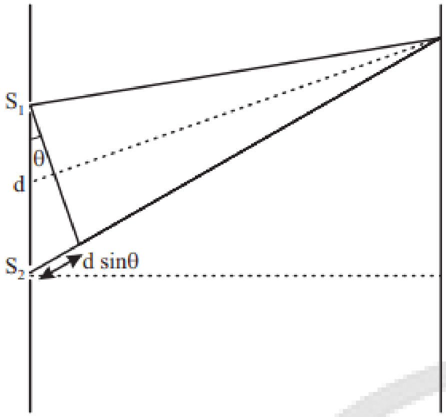
- Resultant intensity for coherent sources
- $I = I_1 + I_2 + \sqrt{I_1 I_2}\cos\phi_0$
- Resultant intensity for incoherent sources $I = I_1 + I_2$
- Intensity ∝ width of slit ∝ (amplitude)^2

$$\Rightarrow \frac{I_1}{I_2} = \frac{W_1}{W_2} = \frac{A_1^2}{A_2^2} \Rightarrow \frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2}{\left(\sqrt{I_1}-\sqrt{I_2}\right)^2} = \left(\frac{A_1+A_2}{A_1-A_2}\right)^2$$

- Distance of n^{th} bright fringe $y_n = \frac{n\lambda D}{d}$

  Path difference= $n\lambda$

  where n = 0, 1, 2, 3, ...



- Distance of m^{th} dark fringe
- $y_m = \frac{(2m-1)\lambda D}{2d}$
- Path difference = (2m – 1) 2 $\frac{\lambda}{2}$ where m = 1, 2, 3,.....
- Fringe width $\beta = \frac{D}{d}$
- Angular fringe width = $\frac{\beta}{D} = \frac{\lambda}{d}$
- If a transparent sheet of refractive index m and thickness t is introduced in one of the paths of interfering waves, optical path will become 'μt' instead of 't'. Entire fringe pattern shifts by $\frac{D[(\mu-1)t]}{d} = \frac{\beta}{\lambda}(\mu-1)t$ towards the side in which the thin sheet is introduced without any change in fringe width.

  $I = 4I_0 \cos^2\left(\frac{\phi}{2}\right)$

Diffraction

- In Fraunhofer diffraction
- For minima $a \sin\theta_n = n\lambda$
- For maxima $a \sin\theta_n = (2n + 1) \frac{\lambda}{2}$
- Linear width of central maxima $W = \frac{2\lambda D}{a}$
- Angular width of central maxima $W_\theta = \frac{2\lambda}{a}$

Polarization

Brewster's law

- $\mu = \tan\theta_p \Rightarrow \theta_p = \tan^{-1}\mu$
- $\theta_p \longrightarrow$ polarization or Brewster's angle
- Here reflecting and refracting rays are perpendicular to each other.

Malus law

- $I = I_0\cos^2\theta$
- $I_0 \rightarrow$ intensity of incident polarized light