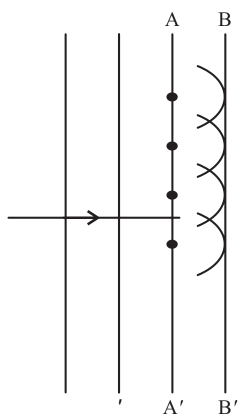
CHAPTER 10

Wave Optics

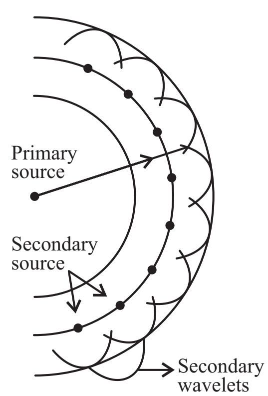
Huygen's Wave Theory

- 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.

Plane wavefront



Spherical wavefront



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

  $I = I_1 + I_2 + \sqrt{I_1 I_2}\cos\phi_0$

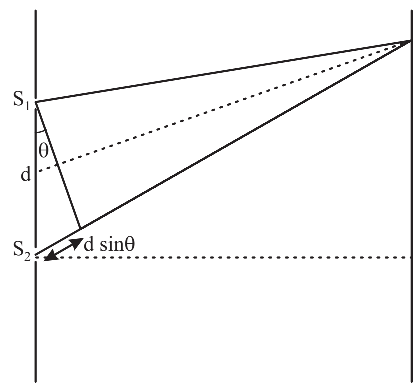
- Resultant intensity for incoherent sources $I = I_1 + I_2$
- Intensity $\propto$ width of slit $\propto$ (amplitude)^2

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

- 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 = $(2m - 1)\frac{\lambda}{2}$ 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 μ 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 $\frac{D\left[(\mu-1)t\right]}{d} = \frac{\beta}{\lambda}(\mu-1)t$ 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 $a \sin\theta_n = (2n + 1)\dfrac{\lambda}{2}$
  - Linear width of central maxima $W = \dfrac{2\lambda D}{a}$
  - Angular width of central maxima $W_\theta = \dfrac{2\lambda}{a}$

Polarization

Brewster's law

$\mu = \tan\theta_p \Rightarrow \theta_p = \tan^{-1}\mu$

$\theta_p \rightarrow$ 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.