Interference of Light Waves

BASIC DEFINITION OF COHERENT SOURCES.

CONDITIONS FOR COHERENT SOURCES.

INTERFERENCE.

YOUNG'S DOUBLE SLIT EXPERIMENT.

EXPRESSION FOR FRINGE WIDTH.

SUSTAINED INTERFERENCE:

CONDITIONS FOR SUSTAINED INTERFERECE

LOYD'S MIRROR

FRESNELL BIPRISM

Intereference

The phenomenon of redistribution of energy due to super position of light waves from two coherent sources is called interference.

CONSTRUCTIVE INTERFERENCE: In constructive interference the amplitude of the resultant wave is greater than that of either individual wave.

DESTRUCTIVE INTERFERENCE: In destructive interference the amplitude of the resultant wave is less than that of either individual wave.

Resultant Intereference Pattern

The light from the two slits forms a visible pattern on a screen.

- The pattern consists of a series of bright and dark parallel bands called fringes
- Constructive interference occurs where a bright fringe occurs.
- Destructive interference results in a dark fringe.

Mechanism to have sources coherent

- Division of Wave front
- Division of Amplitude

Division of Wave front

Under this category, the coherent sources are obtained by dividing the wavefront, originating from a common source, by employing mirrors, biprisms or lenses. This class of interference requires essentially a point source or a narrow slit source.

The instruments used to obtain interference by division of wavefront are the Fresnel biprism, Fresnel mirrors, Lloyd's mirror, lasers, etc

Division of Amplitude

In this method, the amplitude of the incident beam is divided into two or more parts either by partial reflection or refraction. Thus we have coherent beams produced by division of amplitude.

These beams travel different paths and are finally brought together to produce interference. The effects resulting from the superposition of two beams are referred to as two beam interference and those resulting from superposition of more than two beams are referred to as multiple beam interference. The interference in thin films, Newton's rings, and Michelson's interferometer are examples of two beam interference and Fabry-Perot's interferometer is an example of multiple beam interference.

Coherent Sources:

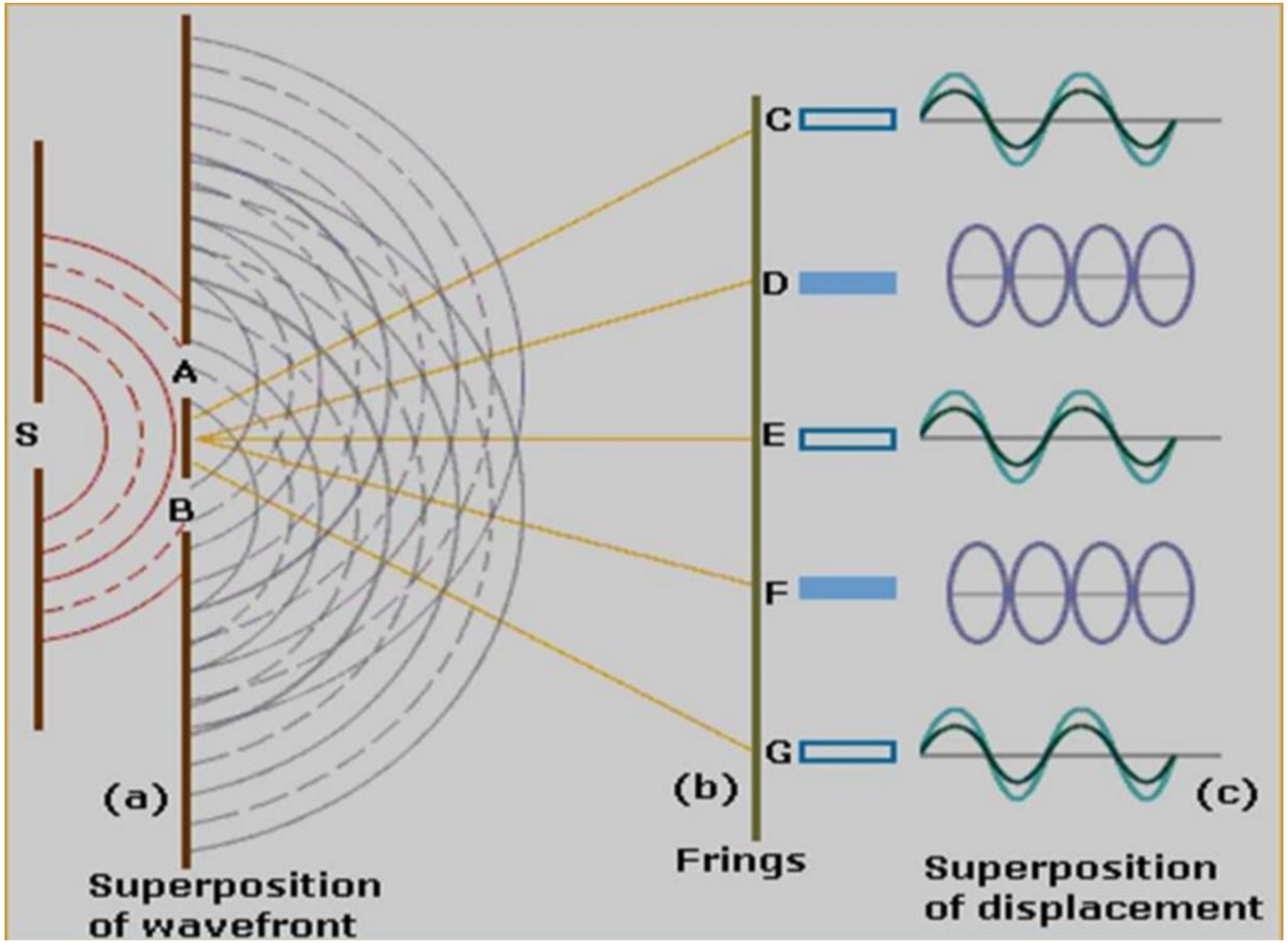
- Two waves are said to be coherent , if they emit same frequency or wave length and are in phase or constant phase difference.
- CONDITIONS FOR OBTAINING COHERENT SOURCE:
- Coherent sources are obtained from single source.
- The source must emit mono chromatic light.
- The path difference between light sources must be very small.

Young's Double Slit Experiment

Thomas Young first demonstrated interference in light waves from two sources in 1801.

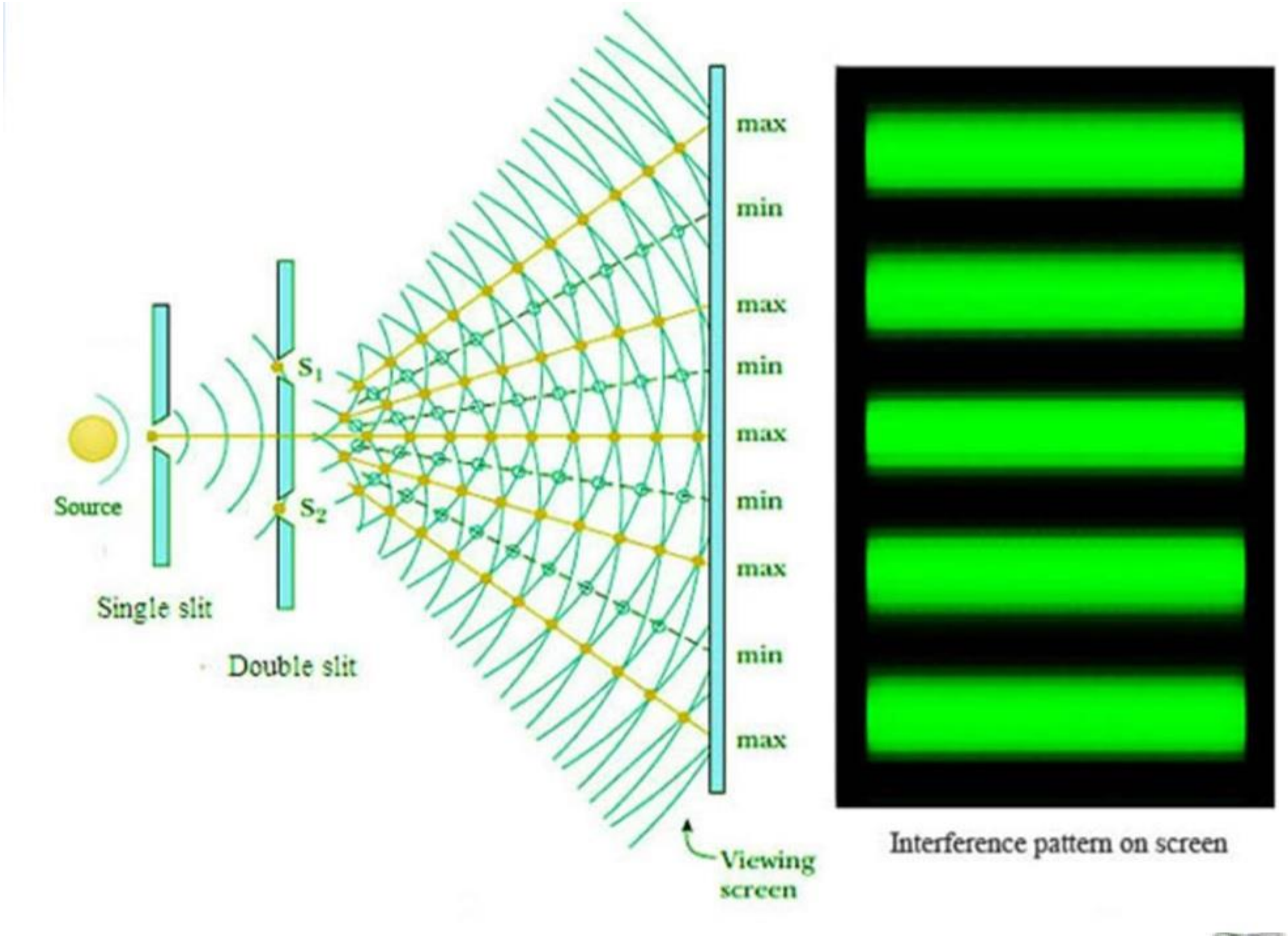
The narrow slits S_1 and S_2 act as sources of waves.

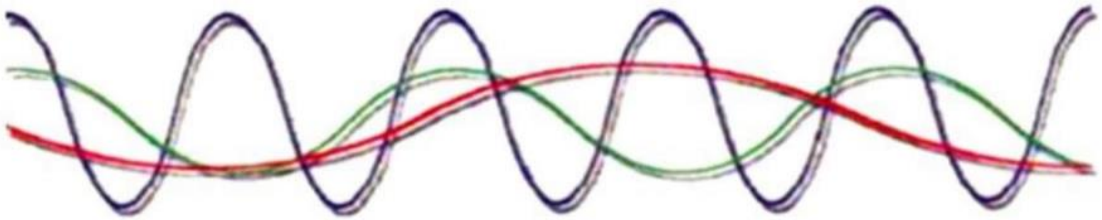
The waves emerging from the slits originate from the same wave front and therefore are always in phase.



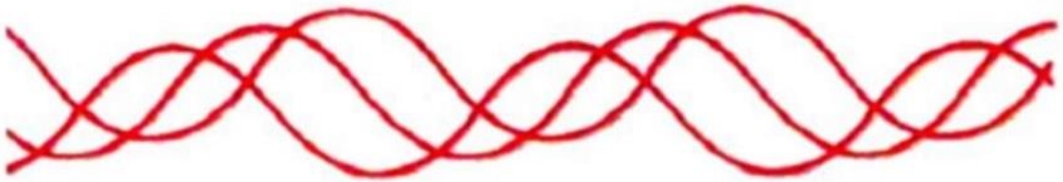
S
A
B
C
D
E
F
G
(a)
(b)
(c)
Superposition
of wavefront
Frings
Superposition
of displacement

Interference Pattern





Sunlight (many different colors)



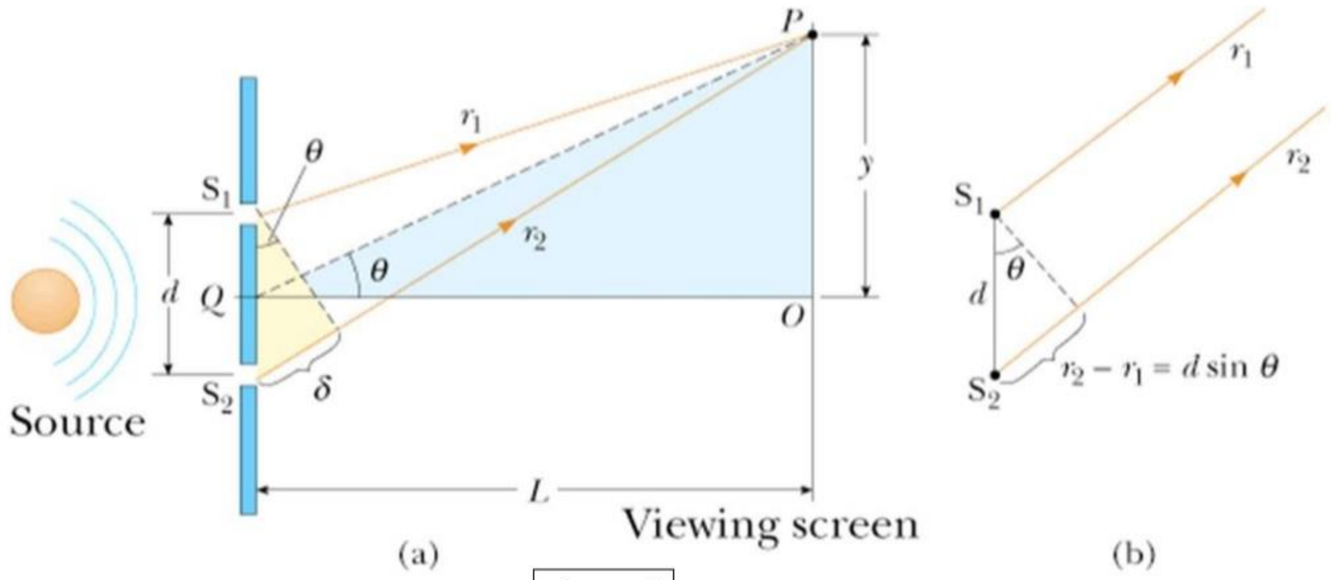
LED: one color (monochromatic) and waves not in phase (non-coherent)

LASER: One color (monochromatic) and waves in phase (coherent)

Why can’t two sources behave as coherent sources?

Two different sources can never produce waves of same phase because each source of light contains infinite number of atoms and the waves which are emitted by them will not be in phase. The atoms after absorbing energy go to excited states and emit radiations when fall back to ground state.

Ray Diagram



$$\delta = r_2 - r_1 = d \sin \theta$$

$d >> \lambda$, $L >> d$ → $\sin \theta \approx \tan \theta$ →

$$y = L \tan \theta \approx L \sin \theta$$

$$\delta = d \sin \theta = m\lambda$$

Constructive interference

$$y_{bright} = \frac{\lambda L}{d} m$$

$$\delta = d \sin \theta = \left(m + \frac{1}{2} \right) \lambda$$

Destructive interference

$$y_{dark} = \frac{\lambda L}{d} \left(m + \frac{1}{2} \right)$$

Fringe Width

The expression for fringe width is :

$\beta = \lambda L/d$

Where λ is wave length.

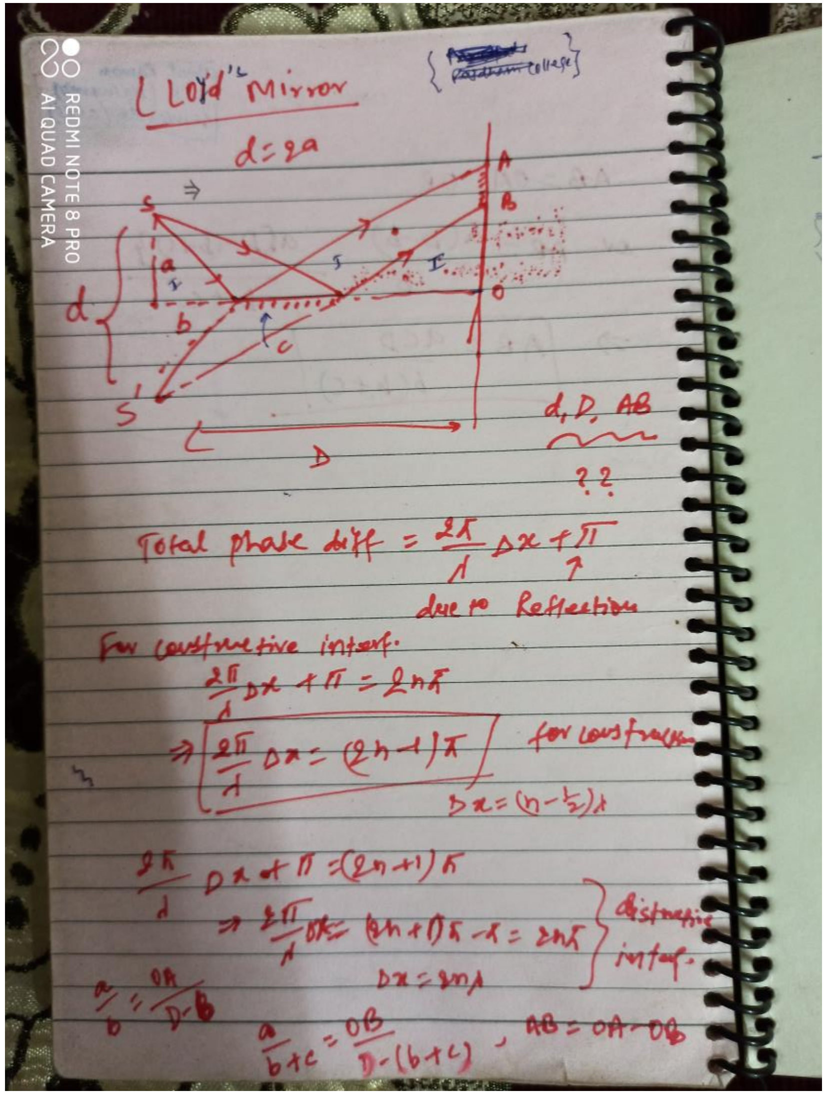
Sustained Intereference

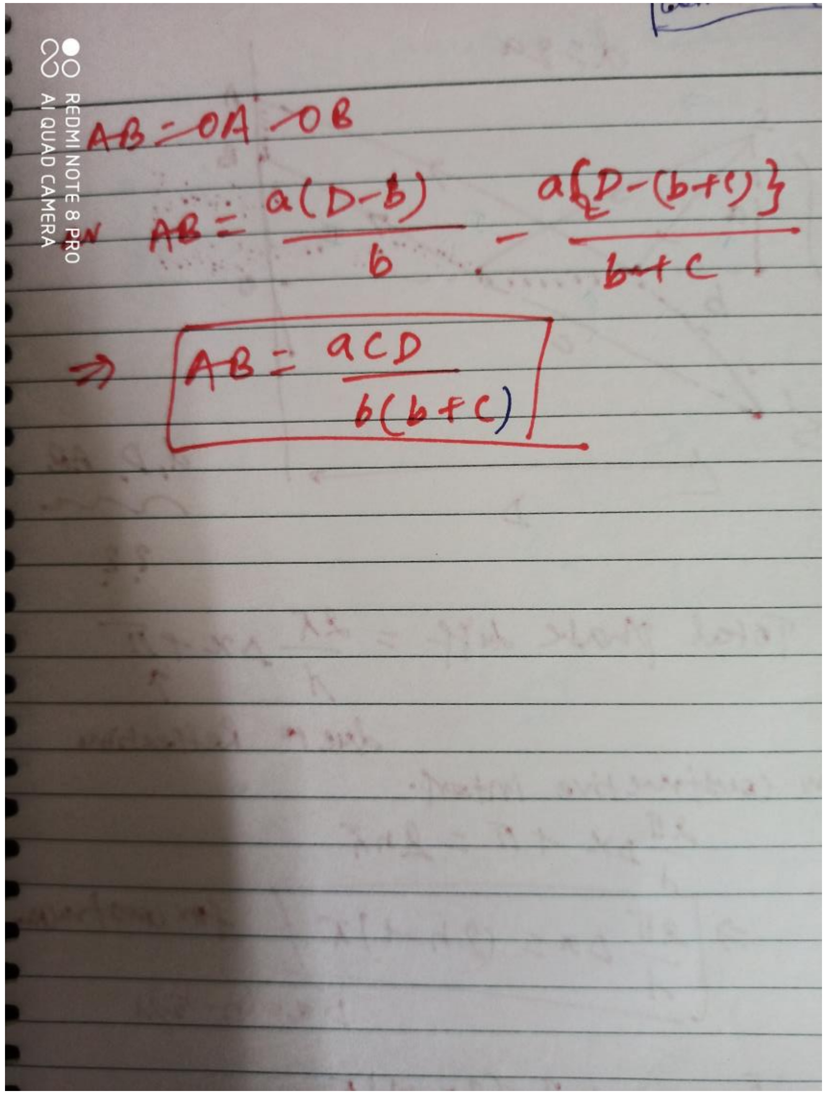
The interference pattern in which dark and bright fringes are positions are fixed on the screen is known as sustained interference.

CONDITONS FOR SUSTAINED INTERFERENCE:

- The sources must be mono chromatic.
- The two sources must be coherent.
- The two waves must travel with the same velocity.

Loyd’s Mirror





Fresnell biprism