Michelson's Interferometer

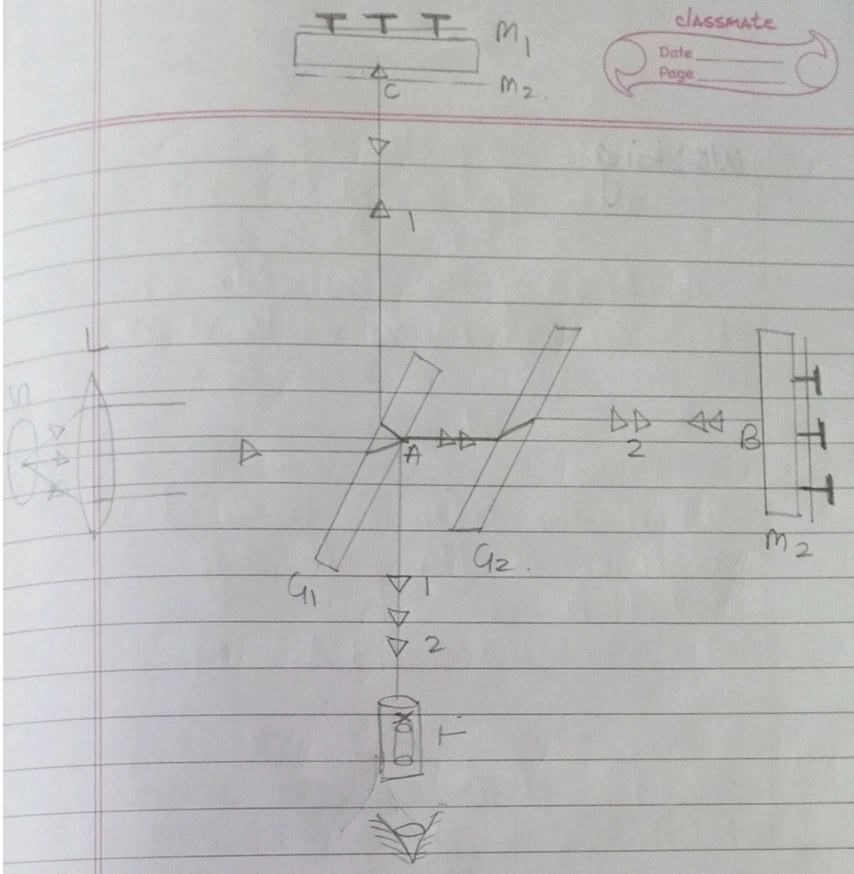
An interferometer is an instrument in which the phenomenon of interference is used to precise measurements of wavelengths or distances.

Principle

1) A beam of light from extended source splits into two coherent beams of equal intensities by partial reflection or ~~&~~ refraction
2) These beams travel in two mutually ⊥ dirⁿs & meet after reflection from plane mirrors
3) The beams overlap on each other to form interference fringes
4) exactly ⊥ mirrors → circular
small angle inclination → straight

Construction

1) It has two plane mirrors M_1 & M_2
2) Beam splitter G_1 → partially silvered plane ∥ glass plate
→ transmits half the incident light & reflects back the rest.
3) compensating plate G_2 → simple plane ∥ glass plate having thickness same as G_1



4) G_1 & G_2 are $\parallel$ to each other & inclined at an angle 45° to mirror M_2.

5) M_1 is mounted on the carriage & can be moved exactly $\parallel$ to itself with micrometer screws.

6) M_1 distance can be moved with help of graduated drum attached to the screw.

7) M_1 & M_2 can be made exactly $\perp$ with help of fine screws attached to it. & interference bands are observed in the fields of view of telescope T.

$AB = \frac{y}{2}$

Path difference calc.

Path of wave 1

$AM_1AT + \frac{\lambda}{2} + \frac{\lambda}{2} = AM_1AT + \lambda$

$= AM_1A + \lambda = 2x_1 + \lambda \rightarrow (1)$

Path of wave 2

$AM_2AT + \frac{\lambda}{2} + \frac{\lambda}{2} = AM_2AT + \lambda$

$= AM_2A + \lambda = 2x_2 + \lambda \rightarrow (2)$

$\therefore$ path diff b/w 2 waves eq^n

$(2) - (1)$

$S = 2(x_2 - x_1)$

When it is viewed like a thin ||
film, then the reflected waves are

causing a path diff
since $x_2 - x_1 = d$
$\Downarrow$

thickness of the thin film i.e. distance b/w mirror M_1 & virtual M_2'

$\therefore \; \delta = 2d$

When the film is viewed at an angle of θ the path diff can be written as

$$\delta = 2d\cos\theta + \frac{\lambda}{2}$$

case(i) $d = 0$

$\therefore \; \delta = \frac{\lambda}{2}$

for constructive $\Rightarrow \delta = n\lambda$

for destructive $\Rightarrow \delta = (2n+1)\frac{\lambda}{2}$

case(ii) distance b/w $M_1 M_2' = \frac{\lambda}{4}$

$$\delta = \frac{\lambda}{2} + \left(\frac{\lambda}{4} + \frac{\lambda}{4}\right) = \frac{\lambda}{2} + \frac{\lambda}{2} = \lambda$$

$\therefore$ This should be result in bright fringe case(iii) increase distance with $\lambda/4$

$$\delta = \frac{\lambda}{2} + \left(\frac{\lambda}{4} + \frac{\lambda}{4}\right) + \left(\frac{\lambda}{4} + \frac{\lambda}{4}\right)$$

$$\delta = \frac{\lambda}{2} + \left(\frac{\lambda}{2}\right) + \left(\frac{\lambda}{2}\right)$$

$$\delta = \frac{3\lambda}{2}$$

which results in dark fringe.

Applications of Interferometer

1) To determine wavelength of incident light.

A monochromatic source of light is placed at the position of the source 'S' whose wavelength needs to be determined. Let d_1 be the distance b/w the source and mirror M_1 for reading distance of micrometer of position M_1. Now change the position of M_1 to get M_1. d_2 is the micrometer reading for d_2. The no. of fringes disappering during the same time is taken as N. Therefore wavelength of the incident light can be determined by

$$\lambda = \frac{2(d_2 - d_1)}{N}$$

2) Difference b/w the wavelengths of two spectral lines which are close to each other.

Determining the avg wavelength of the two spectral lines, the diff. b/w wavelengths ~~is given~~ of the two lines is given by

$$\Delta\lambda = \frac{\lambda^2}{2d}$$

d = distance b/w M_1 & M_2'

3) Thickness of a thin transparent sheet.

For 'N' no. of fringes displaced in a fringe system, when insertions of thin transparent sheets takes place in the path of one of the interfering beams then thickness is given by

$$t = \frac{N\lambda}{2(\mu - 1)}$$

μ = RI of the sheet.