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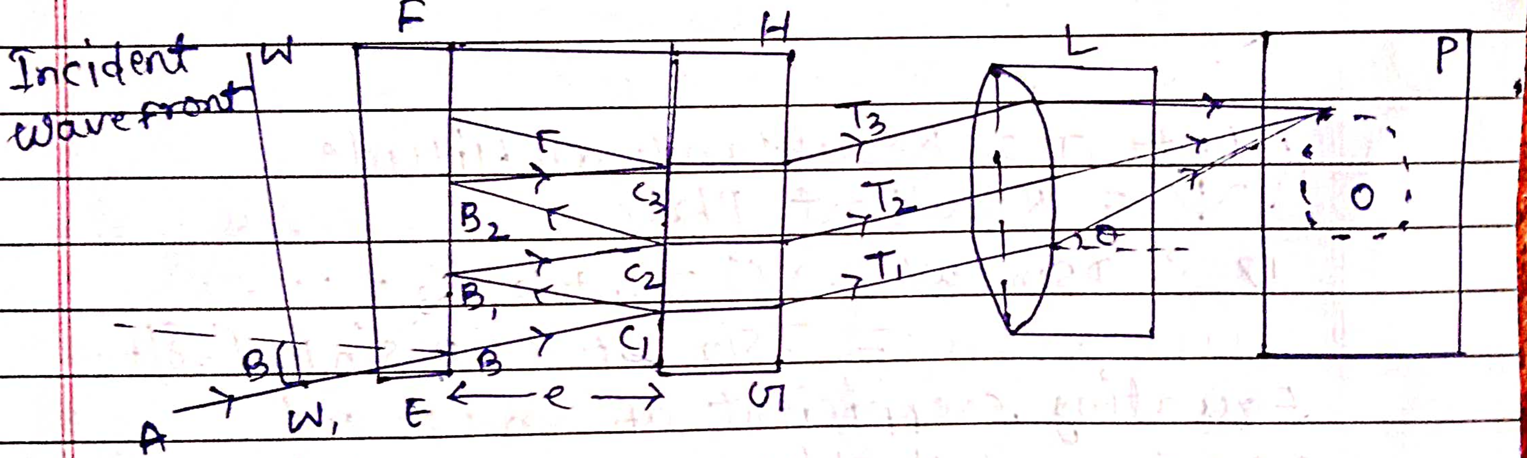
The formation of fringes in a Fabry – perot interferometer → Fabry – perot interferometer consists of two parallel high quality glass plates having silver coating in their inner surfaces. Let a monochromatic plane polarised light ray AB be incident on glass plate EF. The amplitude of light wave in one. After partial reflections and refractions between two plates, parallel rays C_1T_1, C_2T_2, C_3T_3 .... emerge. These rays are coherent and are brought to focus at p on the focal plane of the lens L.



Let, T = Intensity coefficient of emergent ray

R = Intensity coefficient of reflected ray.

Thus their amplitude coefficents will be $\sqrt{T}$ and $\sqrt{R}$ respectively. Since amplitude of incident ray is one hence amplitude of $BC_1 = \sqrt{T}$ for C_1B_1 is $\sqrt{RT}$ for C_1T_1 is T, for B_1C_2 is $R\sqrt{T}$, for C_2T_2 is TR and so on.

Thus phase difference between two consecutive emergent rays will be —

$$\delta = \frac{2\pi}{\lambda} \cdot 2e\cos\theta \quad (\text{Fig.} - 1)$$

Let incident ray AB is represented by —

$Y = \sin \omega t$ [Amplitude = 1]

Hence emergent rays are represented by

$$Y_1 = T\sin\omega t$$
$$Y_2 = TR\sin(\omega t - \delta)$$
$$Y_3 = TR^2\sin(\omega t - 2\delta)$$

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Let D = Resultant amplitude

ψ = Resultant Phase

$\therefore D\sin(\omega t - \psi) = Y_1 + Y_2 + Y_3 + \cdots$

$= T\sin\omega t + TR\sin(\omega t - \delta) + \cdots$

Equating coefficient of $\sin\omega t$ and $\cos\omega t$ on both sides —

$$D\cos\psi = T + TR\cos\delta + TR^2\cos 2\delta + \cdots$$
$$D\sin\psi = TR\sin\delta + TR^2\sin 2\delta + \cdots$$

$\therefore$ Resultant amplitude.

$$I = D^2 = (D\cos\psi + iD\sin\psi)(D\cos\psi - iD\sin\psi)$$

where $i = \sqrt{-1}$

Here, $D\cos\psi + iD\sin\psi = T(1 + Re^{i\delta} + R^2e^{i2\delta} + \cdots)$

$$= \frac{T}{1 - Re^{-i\delta}}$$

and $D\cos\psi - iD\sin\psi = T(1 + Re^{-i\delta} + R^2e^{-i2\delta} + \cdots)$

$$= \frac{T}{1 - Re^{-i\delta}}$$

$$\therefore I = \frac{T^2}{(1-Re^{i\delta})(1-Re^{-i\delta})} = \frac{T^2}{1+R^2-2R\cos\delta}$$

$$= \frac{T^2}{(1-R)^2+4R\sin^2\delta/2} = \frac{T^2}{(1-R^2)\left[1+\frac{4R}{(1-R)^2}\sin^2\delta/2\right]} \quad \text{---} (1)$$

for constructive interference

$$2e\cos\theta = n\lambda$$

And for Destructive interference --- (2)

$$2e\cos\theta = (n+\tfrac{1}{2})\lambda \quad \text{where, } n = 0,1,2,3 \ldots$$

putting equation (2) in equation (1)

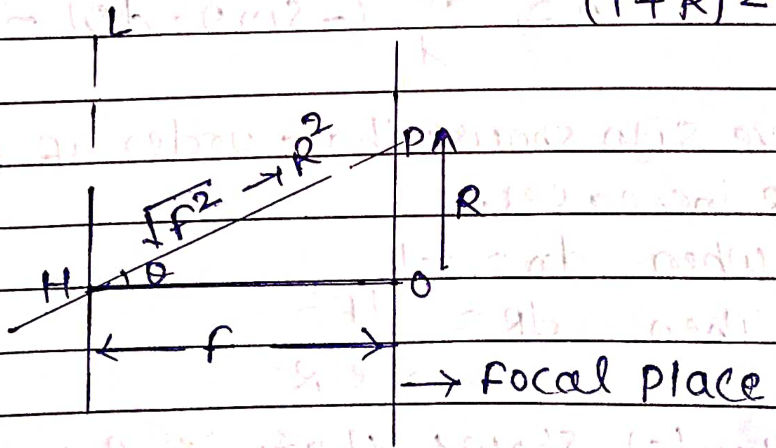
Maximum intensity, $I_m = \frac{T^2}{(1-R)^2}$

Maximum intensity, $I_n = \frac{T^2}{(1+R)^2}$ --- (3)

If light is not absorbed any where, then,

$$T = 1-R$$

$$\therefore I_m = 1 \text{ and } I_n = \frac{(1-R)^2}{(1+R)^2}$$



Formation of fringes: Now path differences between two consecutive emergent rays.

$$2e\cos\theta = n\lambda \quad \text{....} (4)$$

Equation (4) says that for given value of e, λ and n, the circle passing through point P and having radius OP = r, has same value of θ.

Fig.-2 says that sevral bright concentric circular fringes having centre O will be formed. Each bright fringe is followed by a dark fringe.

Now, $\cos\theta = \frac{f}{\sqrt{f^2 + R^2}}$

f = Focal length of lens L.

$\therefore \cos\theta = \frac{1}{\sqrt{1 + \frac{R^2}{f^2}}} = \left(1 + \frac{R^2}{f^2}\right)^{-1/2}$

$= 1 - \frac{1}{2}\frac{R^2}{f^2}$

Now from equation (4)

$$n = \frac{2e}{\lambda}\cos\theta = \frac{2e}{\lambda}\left(1 - \frac{R^2}{2f^2}\right) \quad \text{.....(5)}$$

Differenciating:

$$dn = \frac{2e}{\lambda}(-\sin\theta \cdot d\theta) = -\frac{2e}{\lambda}\frac{R}{f^2} \cdot dR$$

Negative sign shows that order of fringe decreases when R increases.

When, $dn = -1$

Then, $dR = \frac{\lambda f^2}{2e \cdot R}$

Equation (6) shows that if R increase then distance between fringes descreases. For large value of e the distances between fringes is large.

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"To measure wave length (λ) :
Fabry perot interferometer is arranged to form circular fringes. Now rotating mirror attached to the interferometer is moved from position x_1 to x_2 and number of bright fringes (N) that has passed is counted.

Now, $\frac{1}{2} N\lambda = x_2 - x_1$

This equation gives value of λ.