Nalanda Open University

B.Sc Part-II

Course – Physics

Paper – III

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Topic: Fabry-Perot interferometer and formation of fringes in it:

Fabry **-** Perot interferometer is formed by a pair of mirror aligned parallel to each other at a distance d, as presented in figure (1) forming a reflective cavity.

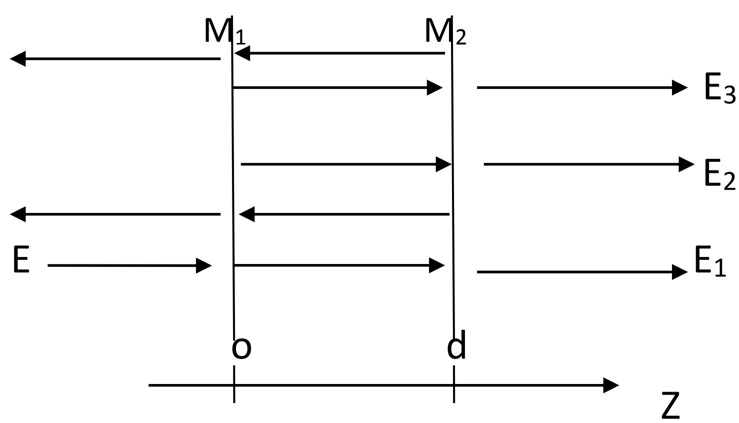

Figure-(1) Fabry Perot Interferometer

When irradiated by a monochromatic light (a laser) of wave length ƛ at an angle of incidence ϴ (Theta), multiple reflections takes place inside the cavity. The fringes in a Fabry-Perot interferometer are formed with light incident nearly normally (ϴ=0) on the air film bounded between the parallel inner faces of a pair of glass plate because the separation between the successive fringes is maximum for normal incidence . Part of light is transmitted each time the light reaches the second reflecting surface. All such transmitted light rays interfere with each other to give rise to a maxima or minima depending on the path difference between them. Then the optical path difference between two neighbouring rays is

$$\Delta = 2\, n\, d \cos\Theta \qquad \text{.........(i)}$$

Then the phase difference is given by $\delta = (2\pi/\lambda)\,\Delta$ ....(ii)

In the figure (2) calculation of path difference is shown for a general cavity is shown where $\dot{\alpha}$ and β are the angle of incidence and refraction, respectively.

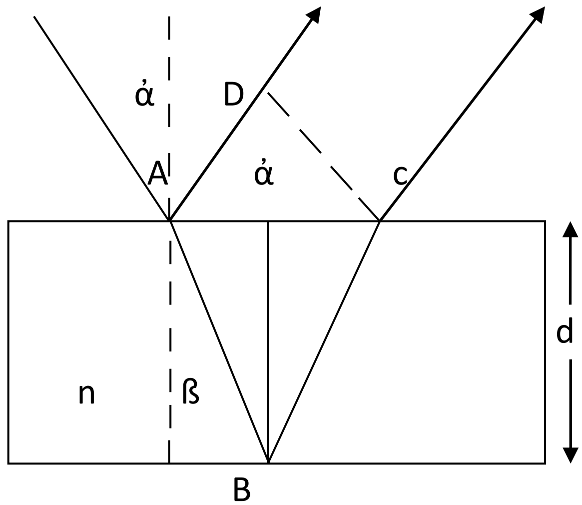

Figure- (2)

Optical path length difference ,

$$\Delta = n\,(AB + BC) - AD$$

$$AB = d/\cos\beta \qquad AD = (2d\tan\beta)\sin\dot{\alpha}$$

$$AD = 2d\tan\beta(n\sin\beta)$$

Collecting terms ,

$$\Delta = 2\,nd\,[\,1/\cos\beta - \tan\beta\sin\beta] = 2\,nd\,[1 - \sin^2\beta/\cos\beta] = 2\,nd\cos\beta$$

Thus, the resultant transmitted light intensity I_T is

$$I_T = I_0 \frac{1}{1 + \frac{4R}{(1-R)^2}\sin^2 \delta/2} \qquad \text{..........(iii)}$$

Where, I_0 is the incident intensity, R is the reflectivity of the mirrors. It can be noticed that I_T varies with δ.

I_T is maximum when $\Delta = m\lambda$ (m=0, 1, 2...)or $\delta = 2m\pi$ ....(iv)

and I_T minimum when

$$\Delta = (2m+1)\lambda/2 \qquad (m= 0, 1, 2...) \text{ or } \delta = (2m+1)\pi \text{ ......(v)}$$

The complete interference pattern appears as a set of concentric rings. The sharpness of the rings depends on a parameter called coefficient of fines.

F , defined as $F = \frac{4R}{(1-R)^2}$

Measurement of wavelength(λ)of light : Using the relation (i) and (iv) or (v) wavelength of the incident light can be determined accurately. Let the initial separation between the mirrors is d_1 . If one counts the number of fringes (say maxima) appearing or disappearing at the centre ($\Theta = 0$) by varying the distance between the mirrors to d_2. Then X can be measured as follows :

$2d_1 = m_1x$, $2d_2 = m_2x$, $m_2 - m_1 =$ number of maxima to be counted

Therefore , $\lambda = 2(d_2-d_1)/m_2-m_1$ ....(vi)