FABRY- PEROT INTERFEROMETER

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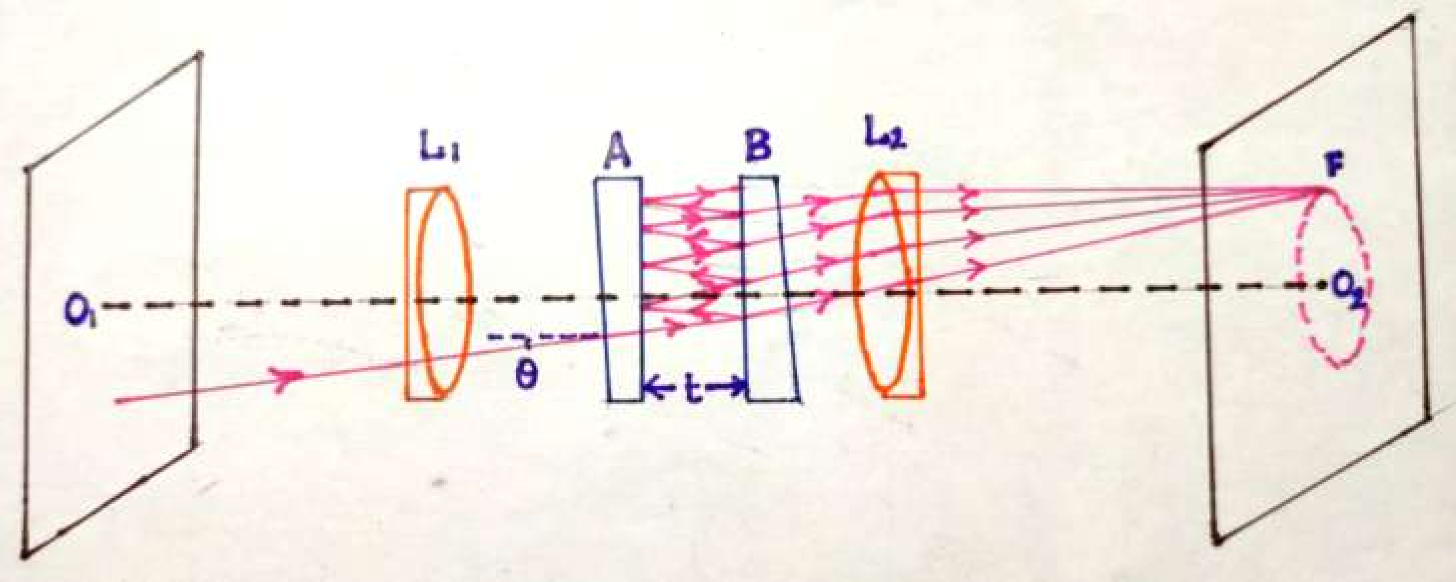
CONSTRUCTION

Fabry-Perot interferometer consists of two glass plates A and B separated by a distance. The inner surfaces of the plates are optically plane, exactly parallel and thin silvered so that about 70% of incident light gets reflected. The outer faces of the plates are also parallel to each other, but inclined to their respective inner faces.



If θ is the angle of incidence on the silvered face of A,then, the path difference between successive rays is

$$2\mu t\cos\theta = 2\,t\cos\theta \text{ as } \mu = 1 \text{ for air}$$

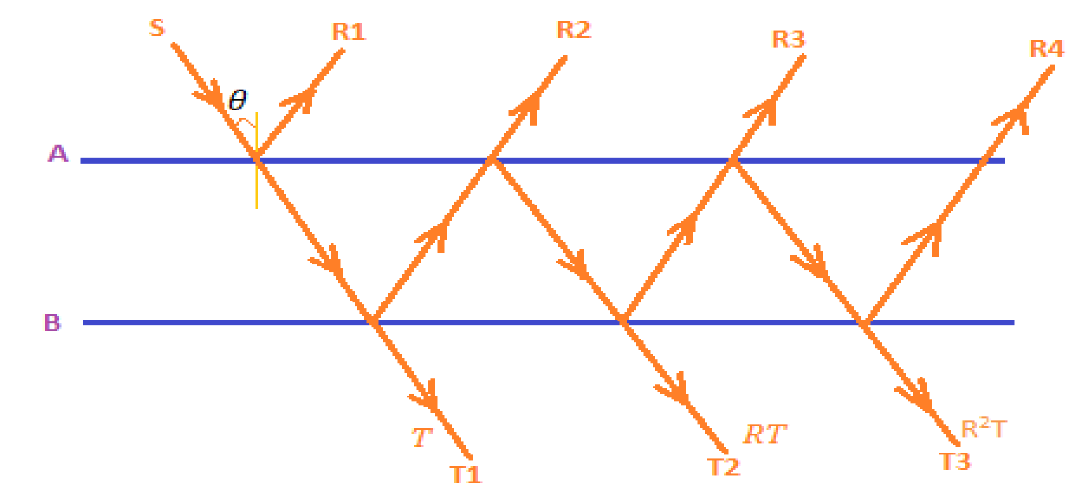
For bright fringe

$$2\,t\cos\theta = n\lambda,\ n = 0, 1, 2, 3, 4,.....$$

For all points passing through F with centre at O_2 on the axis $O_1\ O_2$

When t is decreased, the ring shrinks and disappears at the centre. For a decrease of λ/2 , one ring disappear at the centre.

Consider a plane wave of unit amplitude incident at an angle θ on the glass plate.
Due to multiple reflections , a set of parallel reflected rays A_1R_1, A_2R_2, A_3R_3,…., and a set of parallel transmitted rays B_1T_1,B_2T_2,B_3T_3, ….are produced.
The amplitudes of B_1T_1,B_2T_2,B_3T_3,….are T, RT, R^2T,R^3T, ….respectively.



Neglecting the small phase change due to reflection from silvered surfaces, the phase difference between two consecutive transmitted rays

$$\delta = \frac{2\pi}{\lambda} \times 2t\cos\theta = \frac{4\pi t\cos\theta}{\lambda}$$

Let the incident wave be represented by

$$y = a\sin\omega t = \sin\omega t \quad \text{(a is assumed to be unity)}$$

So, the transmitted rays can be represented as

$$y_1 = T\sin\omega t$$
$$y_2 = RT\sin(\omega t - \delta)$$
$$y_3 = R^2 T\sin(\omega t - 2\delta), \text{ and so on}$$

From the superposition principle

$$Y = y_1 + y_2 + y_3 + \cdots.$$

If A be the resultant amplitude of these rays and ϕ be the phase difference, then we may write

$$A\sin(\omega t - \phi) = T\sin\omega t + RT\sin(\omega t - \delta) + R^2 T\sin(\omega t - 2\delta) + \ldots \ldots\ldots$$

A sin ωt cos ϕ – A cos ωt sinϕ = T sin ωt + R T sin ωt cos δ – RT cos ωt sinδ + $R^2T \sin\omega t \cos 2\delta$ + $R^2T \cos\omega t \sin 2\delta$ + ...

Equating the coefficients of sinωt and cos ωt on both sides, we get
A cos ϕ = T + RT cos δ + $R^2T\cos 2\delta$ + ...
A sin ϕ = RT sin δ + R^2 T sin 2δ +....

The resultant intensity

$$I = A^2 = (A\cos\phi + iA\sin\phi) \times (A\cos\phi - iA\sin\phi)$$

A cos ϕ+ iA sinϕ = T + RT(cos δ+i sin δ) + $R^2T(\cos 2\delta + i\sin 2\delta)$ + ...

Which in terms of exponential can be put as

$$A\cos\phi + iA\sin\phi = T + RT\,e^{i\delta} + R^2T\,e^{2i\delta} + \dots$$
$$= T(1 + Re^{i\delta} + R^2e^{2i\delta} + \dots)$$
$$= \frac{T}{1 - Re^{i\delta}}$$

Similarly,

$$A\cos\phi - iA\sin\phi = \frac{T}{1 - Re^{-i\delta}}$$

The resultant intensity,

$$I = A^2 = \frac{T}{1-Re^{i\delta}} \times \frac{T}{1-Re^{-i\delta}}$$

$$= \frac{T^2}{1+R^2-2R\cos\delta}$$

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

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

$$= \frac{T^2}{(1-R)^2+4R\sin^2\delta/2}$$

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

This expression is known as Airy's formula, shows that the resultant intensity depends upon the properties of the silver coating and δ.