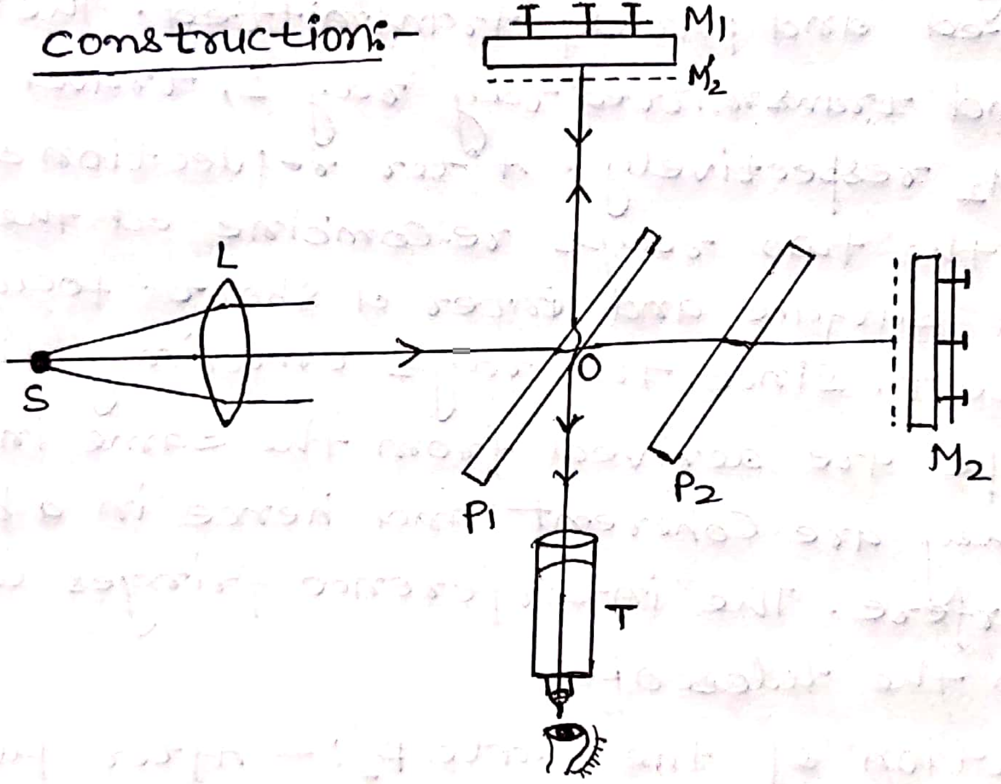
prof. vidya Sagar
Department of physics
B.Sc (part-II) Hons

paper-III

Formation of fringes in Michelson interferometer illuminated by monochromatic light.

Michelson's Interferometer is an excellent device to obtain interference fringes of various shapes which have a number of applications in optics.

Construction:-



It main optical parts are two plane mirrors M_1 and M_2 and to similar optically-plane, parallel glass plates P_1 and P_2. The plane mirror M_1 and M_2 are silvered on their front surfaces and are mountained vertically on two arms at right angles to each other. Their planes Can be slightly tilted about vertical an horizontal axes by adjusting screws at their backs.

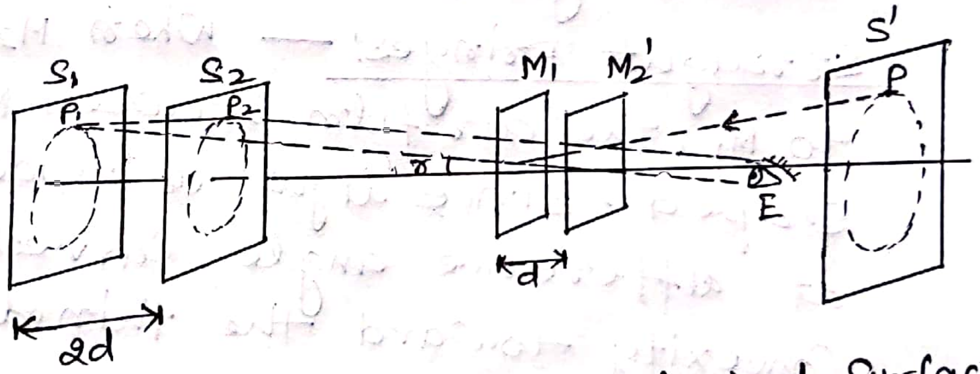
The mirror M_1 mounted on a Carriage provided with a very accurate and fine Screw and Can be moved in the direction of the arrow. The palate P_1 and P_2 are mounted exactly parallel to each other and inclined at 45° to M_1 and M_2. The Surface of P_1 towards P_2 is partially silvered.

Working!— Light from an extended monochromatic source S, rendred nearly parallel by a Lens L_1 fall on P_1. A ray of light incident on the partially-silvered surface of P_1 is partly reflected and partly transmitted. The reflected ray 1 and transmitted ~~ray~~ ray 2, travel to M_1 and M_2 respectively. After reflection at M_2 and M_2 the two rays re-combine at the partly silvered surface and enter a short-focus telescope T. Since the rays entering the telescope are derived from the same incident ray, they are Coherent and hence in a position to interfere. The interference fringes can be seen in the telescope.

Function of the plate P_2!— After partial reflection and transmission at O, the ray 1 travels through the glass plate P_1 twice, while ray 2 does not do so even once. Thus in the absence of P_2; the paths of rays 1 and 2 in glass are not equal. To equalise these paths a glass plate P_2 which has the Same thickness as P_1, is placed parallel to P_1. P_2 is called the, Compensating plate.

Form of Fringes!— The form of the fringes depends on the inclination of M_1 and M_2. Let M_2' be the image of M_2 formed by reflection at the Semi-Silvered surface of P_1 So that $OM_2' = OM_2$. The interference fringes may be regarded to the formed by light reflected from the surface of M_1 and M_2' respectively. Thus the arrangement is equivalent to an air-film enclosed between the reflecting surface M_1 and M_2'.

circular Fringes!— When M_2 is exactly perpendicular to M_1 the film M_1M_2' is of uniform thickness and we obtain circular fringes localised at the Infinity.



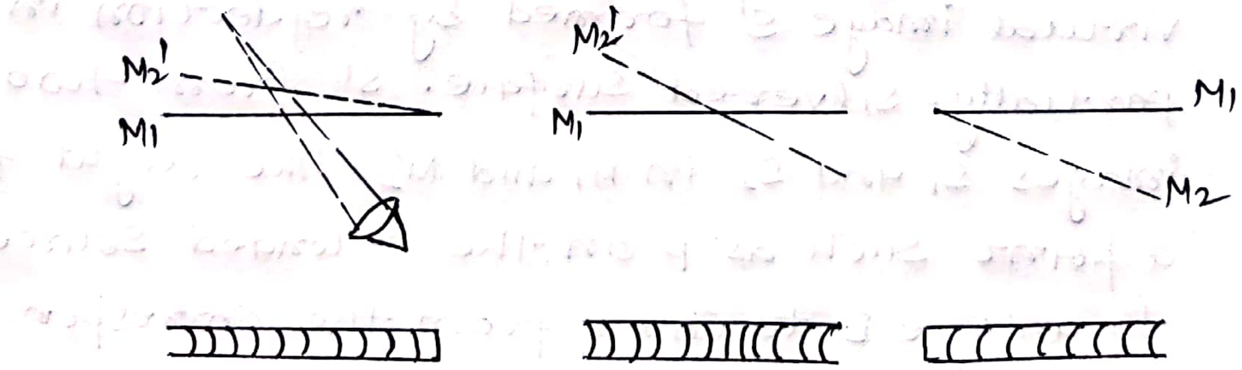
M_1 and M_2 are the parallel reflected Surface. The actual Source has been replaced by its virtual image S' formed by reflection in the partially-Silvered Surface. S' from two virtual images S_1 and S_2 in M_1 and M_2'. The light from a point Such as P on the extended Source appear to an eye E to Come from the Corresponding coherent points P_1 and P_2 on S_1 and S_2. If d is the sepration between M_1 and M_2', then 2d is the separation between S_1 and S_2. The path difference between the rays entering the eye is clearly, $2d\cos r$

If $2d\cos r = n\lambda$ (P appears bright)

and $2d\cos r = (2n+1)\lambda/2$ (P appears dark)

The focus of points on the source which subtend the same angle r at the axis is a circle passing through P with its centre on the axis. Thus a series of bright and dark circular fringes is seen. The order of the fringes decreases as r increases i.e. we move away from the centre. Since the interfering rays are parallel these fringes are formed at infinity.

Straight Fringes!— When M_2 is not perpendicular to M_1, the air film between M_1 and M_2' is wadge-shaped. Since light is incident on the film at difference angle, curved fringes with convexity toward the thin edge of the wedge are obtained.



If the thickness of the film is very small, the fringes are practically straight.

The fringe corresponding to ~~to~~ t=0 is perfectly straight. These fringes are formed near the film and are visible upto path differences comparatively much smaller than that in case of circular fringes.

White light fringes!— If in the case monochromatic light is replaced by white light and if the thickness of the film is small, a few curved and coloured localised fringes are obtained, the fringe of zero thickness of the film uniform illumination is obtained.

Measurement of wavelength!— The interferometer is adjusted for circular fringes and the position of M_1 is adjusted to obtain a bright spot at the Centre of the field of view. If d be the thickness of the film and n the order of the spot obtained we have

$$2d\cos r = n\lambda \quad \text{——} ①$$

At the Centre, $r=0$, so that $\cos r = 1$

$$\therefore 2d = n\lambda \quad \text{——} ②$$

If now M_1 be moved away from M_2 by $\lambda/2$ then 2d increases by λ. Thus $(n+1)$ replaces n in equation ①

Hence $(n+1)$ bright spot now appear

the Centre. Thus each time M_1 moves through a distance $\lambda/2$, next bright spot appears at the Centre. Let us suppose that during the movement of M_1 through a distance x, N new fringes appear at the centre of the field.

$$\therefore x = N \cdot \lambda/2$$

$$\text{or, } \boxed{\lambda = \frac{2x}{N}}$$

Thus measuring the distance x with the micrometer Screw and Counting the Number N, the value of λ Can be obtained.

The determination of λ by this method is most accurate because x Can be measured to an accuracy of 10^{-4}mm, and the value of N Can be Sufficiently increased, as the circular fringes Can be obtained upto large path difference.