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MICHELSON INTERFEROMETER:-

This instrument is of great historical importance because it was used to detect the relative motion between the light beam and the stationary hypothetical medium 'ether' in the form Michelson Morley experiment. Secondly, the instrument was employed to calibrate metre in terms of wave length of red Cadmium line.

CONSTRUCTION:-

It consists two plane mirrors M_1 and M_2 and two similar optically-plane, parallel glass plates G_1 and G_2 as shown in fig. (1) The plane mirror M_1 and M_2 are silvered on their front Surfaces and are mounted vertically on two arms at right angles to each other. Their planes can be slightly tilted about vertical and horizontal axes by adjusting screws at their backs. The mirror M_1 is mounted on a Carriage provided with a very accurate and fine Screw and can be moved in the direction of the arrows. The plates G_1 and G_2 are mounted exactly parallel to each other and inclined at $45°$ to M_1 and M_2. The Surface of G_1 towards G_2 is partially silvered.

WORKING:-

Light from an extended monochromatic source S Shown in fig. (1) rendered parallel by the Condensing lens L is incident on the Semi-silvered plate G_1. Thus SO is one of the rays of the light beam. It is refracted in the plate G_1 to the point A where it is pratially reflected and partially transmitted. Thus the ray SO is amplitude divided into two rays of equal intensity, I and 2. These rays proceed towards M_1 and M_2 respectively, are reflected normally from their front silvered surface, and reunite at the point A of the plate G_1. How at the point A, a part of the amplitude of the ray from M_2 is reflected while a part of that from M_1 is transmitted along AT 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.
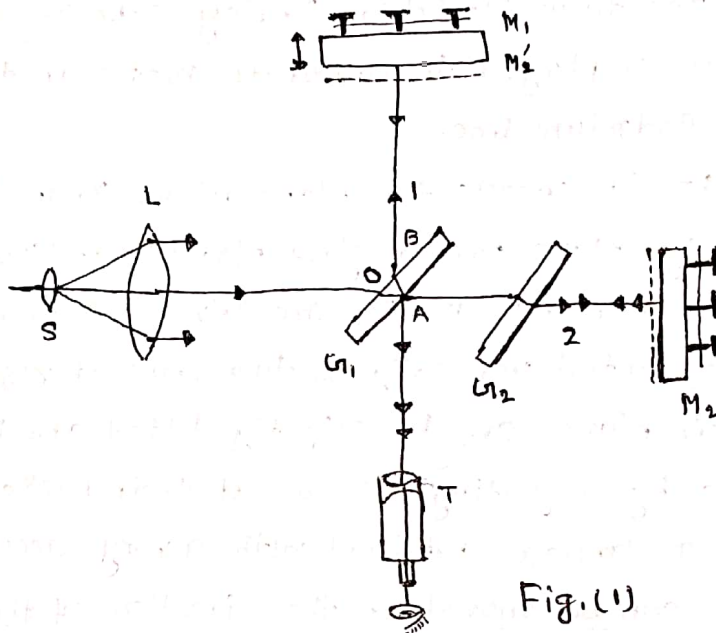

Fig.(1)

Function of the Plate G_2:— After partial reflection and transmission at A, the ray 1 travels through the glass plate G_1 twice, while ray 2 does not do so even once. Thus in the absence of G_2, the paths of rays 1 and 2 in glass are not equal. To equalise these paths the glass plate G_2 which has the same thickness as G_1 is placed parallel to G_1. 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 G_1 so that $AM_2'=OM_2$. The interference fringes may be regarded to be 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 $M_1 M_2'$ is of uniform thickness, and we obtain circular fringes localized at infinity.

In fig.(2) M_1 and M_2' are the parallel reflecting surfaces. The actual source has been replaced by its virtual image s' formed by reflection in the partially-silvered surface. s' forms 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 appears to the eye to come from the corresponding coherent points P_1 and P_2 on S_1 and S_2. If d is the separation between M_1 and M_2', then 2d is the separation between the virtual sources S_1 and S_2. Therefore the path difference between the two parallel

Fig.(2)
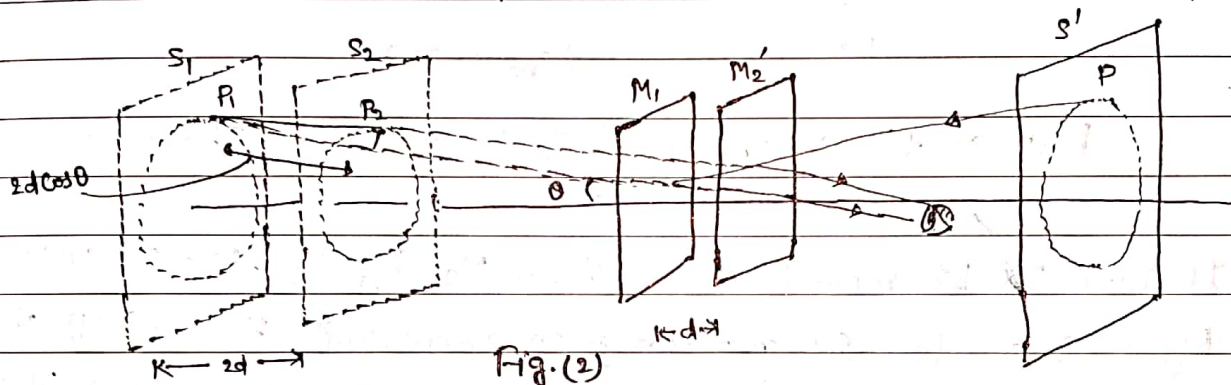
rays coming from the corresponding points P_1 and P_2 at the eye (or telescope) is equal to $2d \cos\theta$. When the telescope is focussed to receive parallel rays, the rays will reinforce each other to produce maxima for the those angles θ which satisfy the relation
$$2d \cos\theta = n\lambda.$$

Now, for a given n, λ and d, angle θ is constant and the locus of points on the source which subtend the same angle θ at the axis is a circle passing through P with its centre on the axis. Hence the fringes are concentric circles and are called the fringes of constant inclination. They are situated at infinity. The order of the fringes decreases as θ increases i.e as we move away from the centre of the pattern where the order is a maximum.

Teacher's Signature : _____

Now, the mirror M_1 is moved so that d is decreased steadily, then, in view of the relation $2d\cos\theta = n\lambda$, θ decreases more and more rapidly for a given fringe. The fringes therefore shrink and vanish of the centre, and at the same time they become more widely spaced. When d becomes zero (M_1 and M_2' coincident), the central fringe spreads out to cover the entire field of view which becomes uniform in intensity. If the mirror M_1, M_1 is moved further to increase d, the widely spaced fringes reappear from the centre of the pattern and diverge across the field of view. With further increase of d, the fringes become gradually more and closely spaced.

Determination of Wave length :—

We have $2d\cos\theta = n\lambda$

But at the centre $\theta = 0°$, so that $\cos\theta = 1$, There fore

$$2d = n\lambda$$

If now M_1 be moved away from M_2' by $\frac{\lambda}{2}$, the 2d increases by λ, There fore (n+1) replaces n in above equⁿ, Hence (n+1) is bright spot now appears at the centre. Thus each time M_1 moves through a distance $\frac{\lambda}{2}$, next bright spot appears at the centre.

Suppose that during the movement of M_1 through a distance x, N new fringes appear at the centre of the field, then we have

$$x = N\frac{\lambda}{2}$$

$$\therefore \boxed{\lambda = \frac{2x}{N}}$$

———— X ————