B.Sc Part II (Physics Hons) ①
Dr Satyadeo Narayan Singh
S.B. College Ara

Question: Describe Michelson's interferometer and Explain how it can be used to obtain circular fringes with monochromatic light.

OR

How will you use it to determine the wavelength of monochromatic light

Answer: **Michelson Interferometer :→**

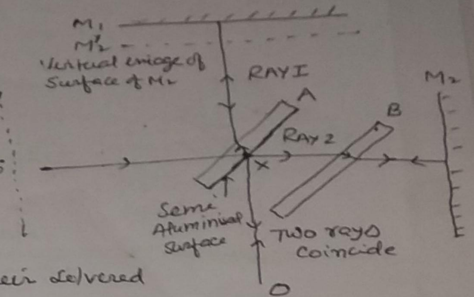
It is an apparatus with which interference fringes are produced by reflection at an air film.

Construction :→

S → an extended Source which gives a parallel incident beam

A → accurately plane parallel plate of homogeneous glass set at 45° to the axis of incident beam. It is half silvered on the face nearer to B.

B → a transparent plate (identical with A) Kept parallel with A



M_1, M_2 → Two plane mirrors with their silvered faces vertical and ⊥ to each other. The mirror M_2 is mounted on a carriage which can be moved parallel to itself by means of a screw. The displacement of M_2 can be accurately determined by a linear scale and a circular scale.

O → Observing Telescope

Working :→ Light from an extended source is made parallel and allowed to fall on A. A ray of light incident on A is partly reflected and partly transmitted. The reflected ray 1, and the transmitted ray 2 travel to M_1 and M_2 respectively. After reflection at M_1 and M_2 the two rays recombine at the partially silvered surface and enter the observing Telescope O. Since the rays entering the telescope are derived from the same incident ray, they are coherent and hence produces interference fringes which can be seen in the telescope.

In absence of B, the paths of ray ① & ray ② in glass are not equal. To equalise paths, a glass plate

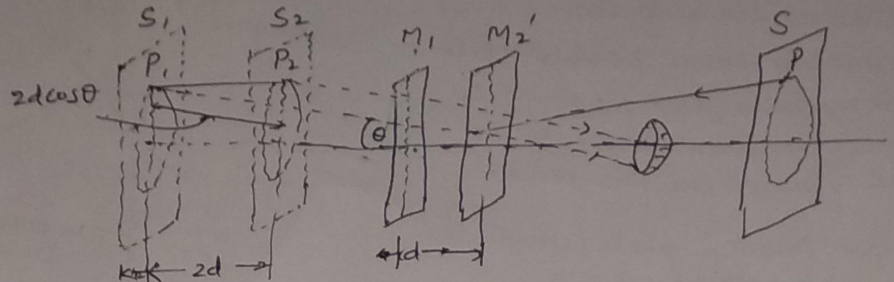
B, which has the same thickness as A is placed parallel to A. Hence B is called the compensating plate.

FORMATION OF FRINGES:→

M_2' is the image of M_2 formed by reflection at the semi silvered surface of A so that $XM_2' = XM_2$. The interference fringes are formed by light reflected from the surface of M_1 and M_2' respectively. This is equivalent to an air film enclosed between the reflecting surfaces M_1 & M_2'.

(I) CIRCULAR FRINGES:→

When M_1 is exactly ⊥ to M_2, the air film M_1M_2' is uniform thickness which gives circular fringes localised at ∞.



M_1 and M_2' are parallel reflectors. The actual source is replaced by virtual source S' formed by ~~reflector~~ reflection in A. S' forms two virtual images S_1 and S_2 in M_1 & M_2' respectively. The light from a point P on the extended source appears to come from P_1 and P_2 on S_1 and S_2. If $M_1M_2' = d$ and $S_1S_2 = 2d$. The path difference between the rays entering the eye is $2d\cos\theta$. Now

P appears bright if $2d\cos\theta = n\lambda$ and

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

The focus of the points of the source making same angle at the axis is a circle, hence a series of bright and dark circular fringes is seen. Fringes are at ∞ because interfering rays are parallel.

With white light a few curved and coloured localised fringes are obtained if the thickness of the film is small. The fringes corresponding to $d=0$

is perfectly straight and achromatic. For large thickness of the film uniform illumination is obtained.

DETERMINATION OF WAWELENGTH OF MONOCHROMATC LIGHT:-

The interferometer is adjusted for circular fringes. M_2 is adjusted to obtain a bright spot at the centre of ~~film~~ field of view. If 'd' be the thickness of the film, then for n^{th} order of spot, we have

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

At the centre $\theta = 0^\circ$, $\cos 0^\circ = 1$

$$\therefore 2d = n\lambda \quad \text{------------} \quad (1)$$

If M_2 is moved away from M_1 by half wavelength then $2d$ increases by λ and hence $(n+1)$ replaces n in eq^n (1), Hence $(n+1)^{th}$ bright spot appears at the centre. Then each time M_2 moves by $\lambda/2$, next bright spot appears at the centre.

Let D = Displacement of M_2 and

N = nos of ~~few~~ new fringes appearing at centre

$$\therefore D = N \cdot \frac{\lambda}{2}$$

$$\therefore \lambda = \frac{2D}{N}$$

The distance D is measured with the help of the micrometer screw and N is counted visually. Hence λ can be easily calculated.