Nalanda Open University
B.Sc Part- II

Course: Physics
Paper- III

Prepared by: Dr. Amiya Kumar – Ganga Devi Mahila College, Patna

Topic- Construction of Michelson's Interferometer

Construction of Michelson's Interferometer: A schematic diagram of a Michelson's interferometer is shown in the figure- (1)

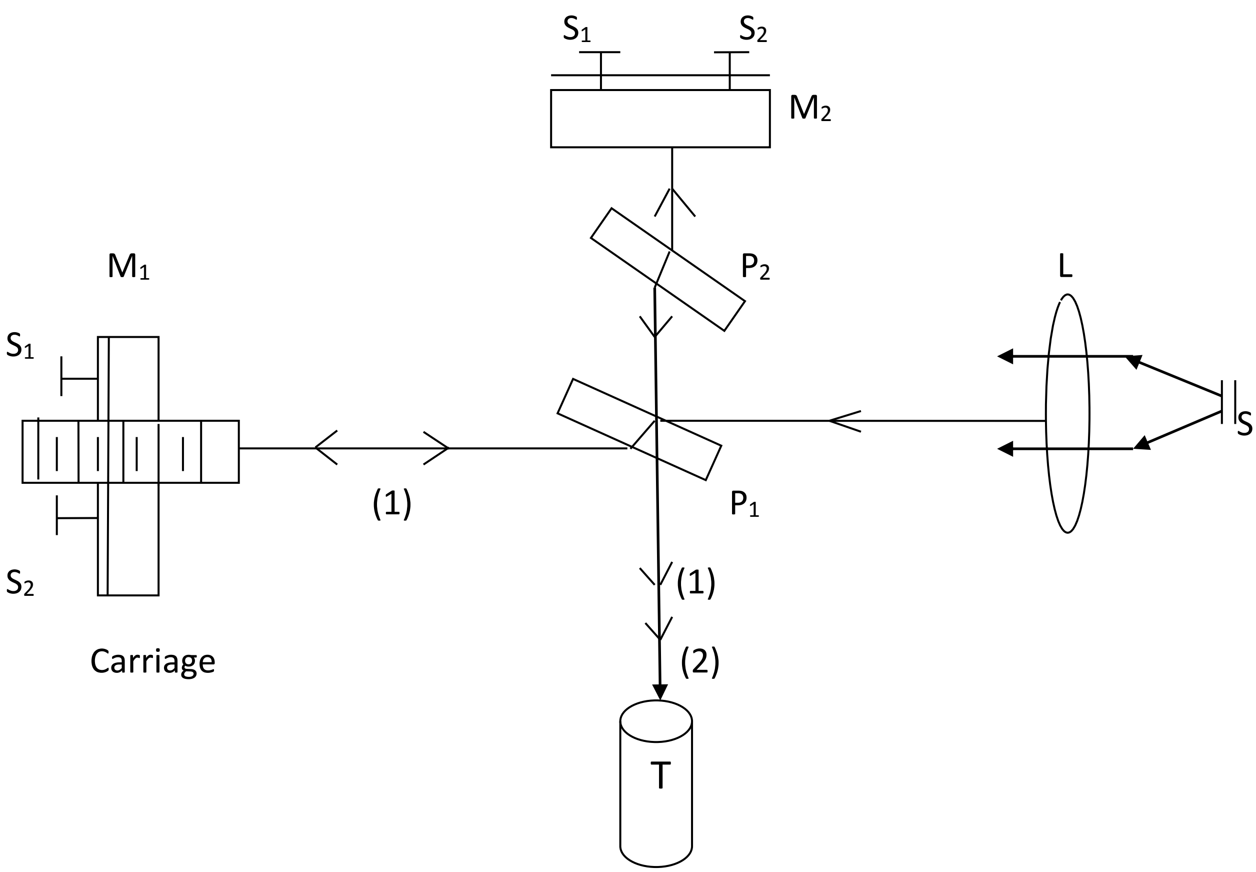

Figure – (1)

M_1 and M_2 are the two highly polished optically plane mirrors whose front surfaces are thickly polished with high-quality polishing material. Mirror M_2 is fixed while M_1 is mounted on a carriage which can be moved along the direction of the arrow through a fine screw capable of measuring as small as 10^{-5} cm.

S_1 and S_2 are the adjusting screws fitted at the back of M_1 and M_2 respectively. Then screws are adjusted to align the planes of the mirror M_1, M_2 along vertical and horizontal lines respectively.

P_1 is an optically plane glass plate, which is thinly silvered towards M_2. It is inclined at 45^0 with the mirrors M_1 and M_2. The thin silvering applied on the plate P_1 divides the incident amplitude in two. These divided portions of the amplitudes are propagated towards M_1 and M_2 respectively. P_2 is another optically plane glass plate known as a compensating plate. P_2 is exactly similar to P_1 and is placed in between P_1 and M_2, keeping parallel to P_1.

S is a broad source of light which may be monochromatic or white depending upon the use. L is a lens used for reading the rays parallel for the source S is situated at the focus of the lens L.

T is a telescope to observe the interference fringes.

Working:- Any ray of light incident on P_1 first is divided into two partially refracted rays no.1 and no.2. Ray no. 1 is reflected at M_1 and then thinly silvered surfaced of P, towards T. Ray no.2 passes through P_2 and is reflected by M_2 and after passing through P_2 and P_1, it is directed towards T.

The presence of P_2 is significant. In the absence of plate P_2, ray no.2 travel once through the glass plate P_1 only while ray no.1 does so thrice. To make their paths exactly equal in glass, the compensating plate P_2 is placed. It is very necessary to use plate P_2 while using the white light source for obtaining the fringes.

Adjustment- To observe the fringes certain adjustments are to be made. They are:-

1. The distance of M_1 and M_2 is made equal to P_1.
2. The planes of M_1 and M_2 must be normal to each other.
3. The glass plate P_1 should be inclined at an angle 45^0 with either M_1 or M_2.

In order to complete the adjustment, a diaphragm carrying a pin hole is kept in between L and P_1. In the field of view, through telescope we see two pairs of images. By adjusting the screw S_1 and S_2 provided at the back of M_1 and M_2, the two pairs are made to coincide with each other, ensuring the adjustment of the above adjustment.

Measurement of the difference in wave length of D- line of sodium light by using Michelson's interferometer : The interferometer is adjusted so as to get circular fringes. For this, the distance of M_1 and P_1 must be same and the planes of M_1 and M_2 must be mutually perpendicular to each other, so that we can have a parallel thick film between M_1 and M_2 be t , then

$$2\,t = 2n_1 \lambda_1 / 2 \qquad \text{....................(i)}$$

$$2t = 2n_2 \lambda_2 / 2 \qquad \text{....................(ii)}$$

from these conditions it is clear the n_1^{th} maxima due to λ_1 is coinciding with the n_2^{th} maxima due to λ_2 , thus getting the pattern of maximum visibility. Now the mirror M_1 is moved so as to increase the thickness t of the film. The visibility of pattern will go in decreasing, at one stage it will be minima, clearly, the maxima due to one wave length is superposing on the minima due to other wave length, with the result we are getting the poor visibility of the pattern. If the motion of M_1 is continued in the same direction. Again a position of maximum visibility will arrive, suppose we have to move M_1 by d , then

$$2\,(t+d) = 2(n_1 + N)\, \lambda_1 / 2 \qquad \text{...................(iii)}$$

$$2\,(t+d) = 2(n_2 + N + 1)\lambda_2 / 2 \qquad \text{...................(iv)}$$

(since $\lambda_1 > \lambda_2$)

With the help of (iii) and (iv) , we get

$$2\,d = 2\,N\,\lambda_1 / 2$$

With the help of (ii) and (iv) , we get

$$2\,d = 2\,(N + 1)\,\lambda_2 / 2$$

Also , $N = \frac{2d}{\lambda_1}$

and, $N+1 = \frac{2d}{\lambda_2}$

on subtraction

$$1 = \left(\frac{2d}{\lambda_2} - \frac{2d}{\lambda_1}\right) = \frac{2d(\lambda_1 - \lambda_2)}{\lambda_1\,\lambda_2}$$

Or, $\lambda_1 - \lambda_2 = \frac{\lambda_1\,\lambda_2}{2d}$

$$(\lambda_1 - \lambda_2) = \frac{\lambda^2}{2d}$$

Where $\lambda = (\lambda_1\,\lambda_2)^{1/2}$

= mean wavelength

Knowing mean wavelength λ and the distance ; through which mirror M_1 is moved to get next position of maximum visibility, $(\lambda_1 - \lambda_2)$ can be calculated.