Michelson Interferometer

Aim:- To calculate the wavlength of laser using Michelson interferometer.

Apparatus required: Breadboard, diode laser, laser mount, beamsplitter mount, mirror mount (2 numbers), screen.

Theory:

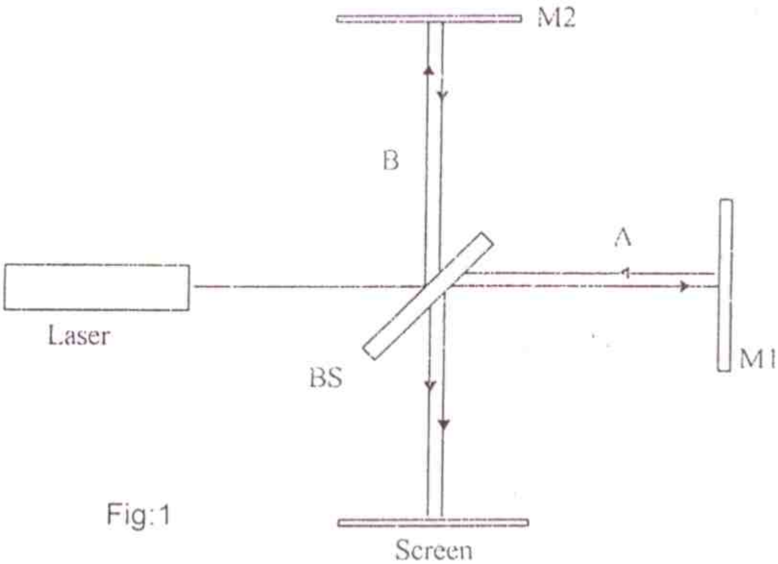


Fig:1

M_1 and M_2 are two plane mirrors silvered on the front surfaces. They are mounted vertically on two translation stages placed at the sides of an optical platform Screws are provided at the back of the holders, adjusting of which allows M_1 and M_2 to be tilted. M_1 can also be moved horizontally by a micrometer attached to the M_1 holder. BS the 50% -50% beam splitter, is a planar glass plate slightly silvered on one side. It is mounted vertically and at an angle 45° to the direction of the incident light.

When light from laser is allowed to fall on BS, one portion, calling it beam A, is transmitted through BS to M_2 and the other, calling it beam B, is reflected by BS to M_1. Beam A, returning from M_2, is reflected at the back of BS to reach the screen placed at E and beam B, after reflected from M_1 passes through BS to reach the screen.

The wavelength of laser is calculated by :

$$\lambda = 2D / n \qquad \text{.......................................(Eq: 1)}$$

where D is the change in position that occurs 'n' fringes to pass.

Procedure:

1. Attach the diode laser with mount, adjustable mirror and moveable mirror as in the illustration, but don't install the beam splitter yet. Attach the viewing screen to as in figure.
2. Align the laser so that the beam is parallel with the top of the base. The beam should strike the center of the moveable mirror and should be reflected directly back into the laser aperture.
3. Position the beam splitter so that the beam is reflected to the fixed mirror. Adjust the angle of the beam splitter as needed so that the reflected beam hits the fixed mirror near its center.
4. There should now be two sets of bright dots on the viewing screen; one set comes from the fixed mirror and the other from the moveable mirror. Each set of dots should include a bright dot with two or more dots of lesser brightness (due to multiple reflections in the thin film of the beam splitter). Adjust the angle of the beam splitter again until the two sets of dots are as close together as possible, then tighten the screws securing the beam splitter and mirror mounts.
5. Using the leadscrews on the back of the adjustable mirror, adjust the mirror's tilt until the two sets of dots on the viewing screen coincide.
7. Expand the laser beam slowly by rotating the collimating lens on front the diode laser.
8. As a rule a streaky interference pattern, resulting from a non-parallel alignment of the two mirrors, is now already to be seen. Carry out a sensitive re-adjustment with the adjusting screws to bring the interference pattern to the wanted concentric form (Fig 2).
9. After aligning the laser with the interferometer and making certain that the fringes you are looking at move when the micrometer screw is turned, fix a position on the observing screen and note the micrometer reading.
10. Count the fringes that move past the fixed point (either outward or inward) as the screw is turned. Count at least 15 fringes as they pass the fixed point of the viewing region. Begin the counting with a hand on the thimble and try to exert a steady pressure.
11. Begin the counting with a hand on the thimble and note the initial reading on the thimble. After 15 fringes pass, note the reading on the micrometer scale and compute the distance the mirror moved.
12 In the movable mirror mount, it is mounted in a translation stage. The micrometer shaft actuates a *lever arm* which pushes the translation stage carrying the mirror. Here 10 micron on the thimble (one divison) is equal to .35 micron on the translation stage. ie when we move one step on the micrometer, mirror is moved to .35 microns.
13. Repeat the procedure 3 or 4 times. Average the readings.
14. Substitute the readings in the equation (Eq:1) to obtain results.

Notes: To avoid backlash in the micrometer move micrometer to one direction only while doing repetitive experiments.

Before taking the readings, observe the fringe movement.

Avoid moving the micrometer in reverse direction while doing an experiment

Result: Observed the fringe pattern and calculated the wavelength of laser.

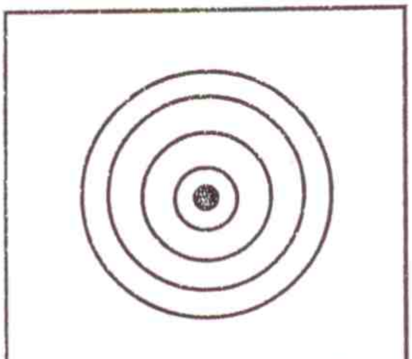
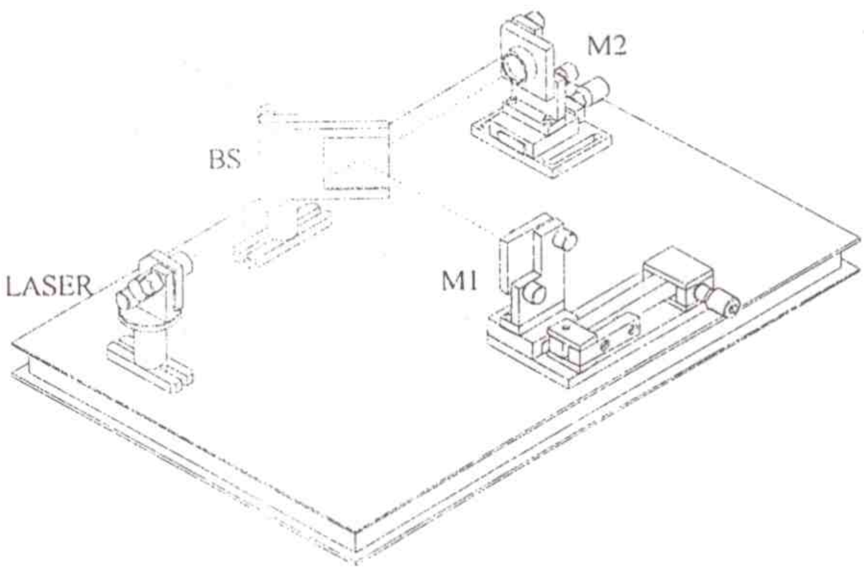


Fig 2



Calibrating the Micrometer

For even more accurate measurements of the mirror movement, you can use a laser to calibrate the micrometer.

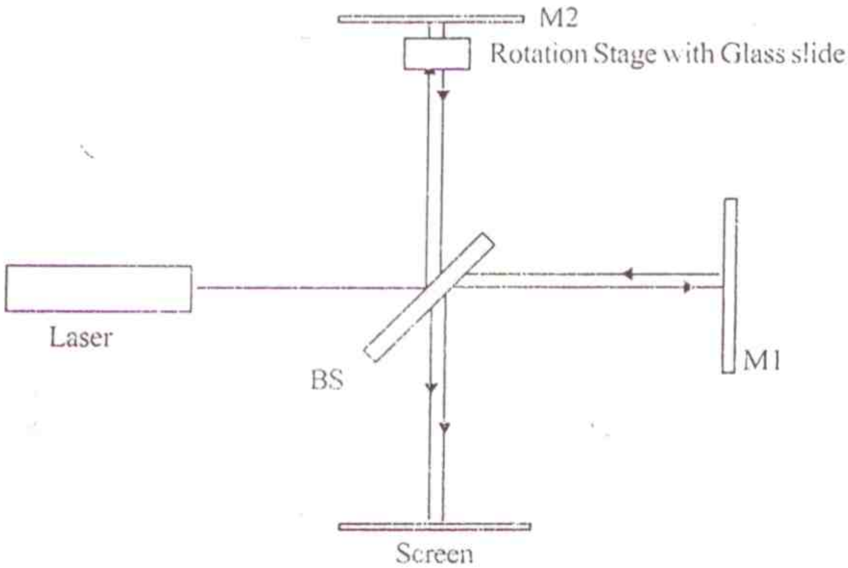
To do this, set up the interferometer in Michelson mode. Turn the micrometer knob as you count off at least 20 fringes. Carefully note the change in the micrometer reading, and record this value as d'. The actual mirror movement, d, is equal to $N\lambda/2$, where λ is the known wavelength of the light (0.6350 µm for our Diode Laser) and N is the number of fringes that were counted. In future measurements, multiply your micrometer readings by d/d' for a more accurate measurement.

Michelson Interferometer - Exp - 02

Aim:- To calculate the Index of Refraction of Glass using Michelson interferometer.

Apparatus required: Breadboard, diode laser, laser mount, beamsplitter mount, mirror mount (2 numbers), Screen & Rotation stage with Glass mounted.

Theory:



In principle, the method for calculating the index of refraction is relatively simple. The light passes through a greater length of glass as the plate is rotated. The general steps for measuring the index of refraction in such a case is as follows:

1. Determine the change in the path length of the light beam as the glass plate is rotated. Determine how much of the change in path length is through glass, $\mathbf{d}_g(\partial)$, and how much is through air, $\mathbf{d}_a(\partial)$.
2. Relate the change in path length to your measured fringe transitions with the following equation:

$$\frac{2n_a d_a(\theta) + 2n_g d_g(\theta)}{\lambda_0}$$

where $\mathbf{n}_a$ = the index of refraction of air , $\mathbf{n}_g$ = the index of refraction of the glass plate (as yet unknown), λ_0 = the wavelength of your light source in vacuum, and **N** = the number of fringe transitions that you counted.

Carrying out this analysis for the glass plate is rather complicated, so we'll leave you with the equation shown below for calculating the index of refraction based on your measurements. Nevertheless, we encourage you to attempt the analysis for yourself. It will greatly increase your understanding of the measurement and also of the complications inherent in the analysis.

$$\frac{(2t - N\lambda_0)(1 - \cos\theta)}{2t(1 - \cos\theta) - N\lambda_0}$$

where **t** = the thickness of the glass plate.

Procedure:

1. Align the laser and interferometer in the Michelson mode.
2. Place the rotation stage between the beam-splitter and movable mirror, perpendicular to the optical path.
3. Mount the glass plate on the rotation stage.
4. Position the stage & glass such that degree is 0 & glass slide is perpendicular to the optical path.
5. When glass plate is introduced in the optical path of Michelson interferrometer, the fringe will be shifted & will become blur. To make the fringe sharpen again, move the Mirror mount to & fro till the clear set of fringes is achieved on the viewing screen.
6 . Slowly rotate the rotaton stage. Count the number of fringe transitions that occur as you rotate the table from 0 degrees to an angle q (at least 10 degrees).

Calibrating the Micrometer

For even more accurate measurements of the mirror movement, you can use our laser to calibrate the micrometer.

To do this, set up the interferometer in Michelson mode. Turn the micrometer knob as you count off at least 20 fringes. Carefully note the change in the micrometer reading, and record this value as d'. The actual mirror movement, d, is equal to $N\lambda/2$, where λ is the known wavelength of the light (0.6350 µm for our Diode Laser) and N is the number of fringes that were counted. In future measurements, multiply your micrometer readings by d/d' for a more accurate measurement.