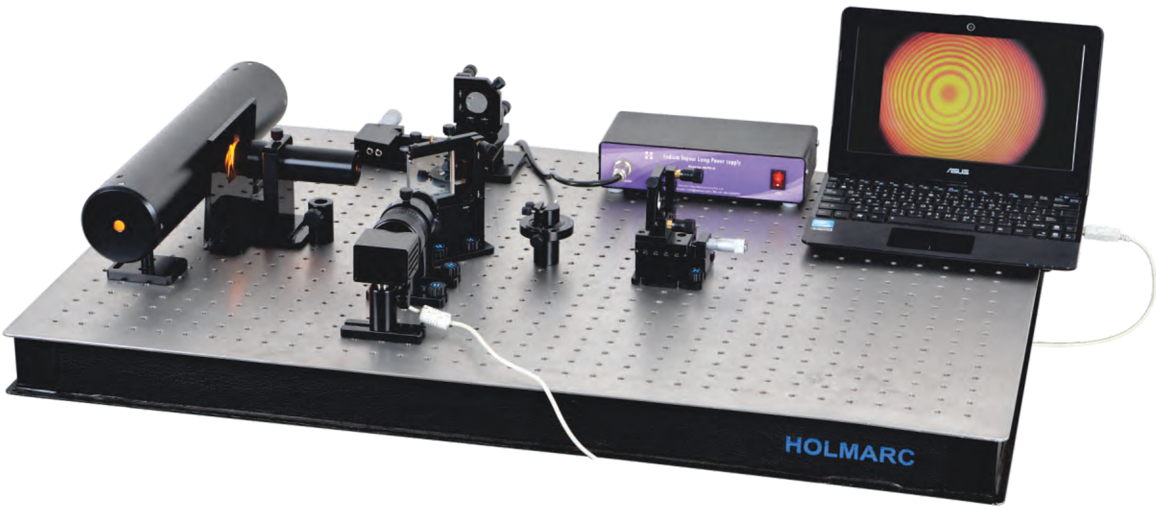
HOLMARC

Instruction Manual



Michelson Interferometer

Sodium D Lines

Model: HO-ED-INT-06 S

CONTENT Page

:: Product Features

In this Michelson interferometer sodium vapour lamp is used as light source instead of laser light. We are providing all the components in such a way that it can be assembled on an optical breadboard. Mirror mounts with kinematic adjustments as well as translation stages having coarse and fine adjustments are available with the product. Also we provide a laser source for setting up the interferometer and then it can be replaced by sodium vapour lamp. Instead of using microscope for viewing the fringe produced we provide CCD camera with USB 2.0 port so that it can be connected to a PC to view the fringes produced. Also using the translation stages provided one can measure the wavelength of sodium D - lines.

:: Getting Started

a. Quick Start

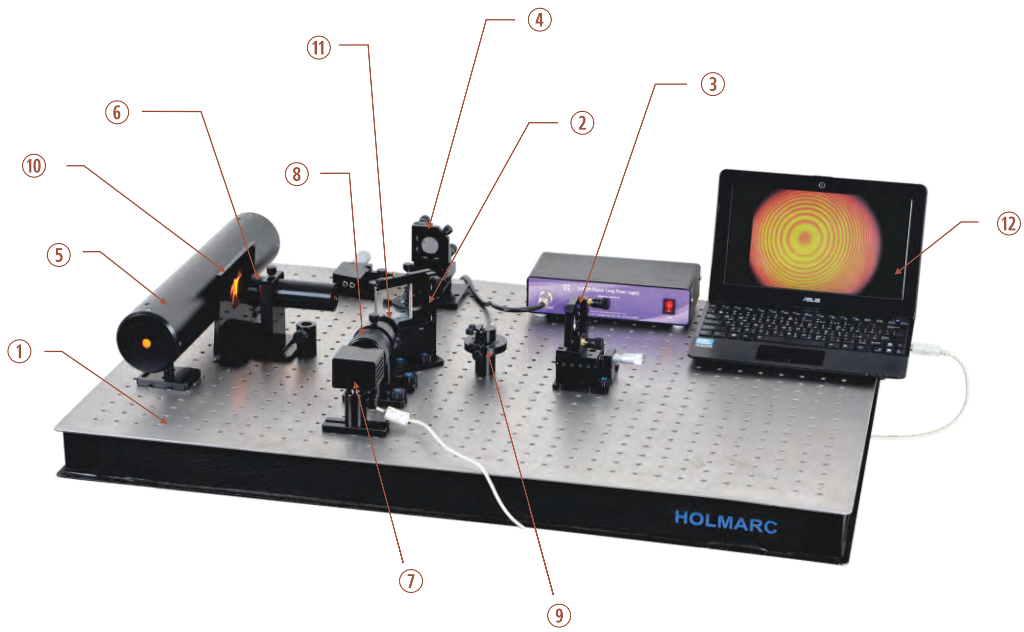
Please check whether the following items are present in the package delivered.

1. Optical Bread board with Rigid Support
2. Diode Laser with power supply
3. Sodium vapour lamp with power supply
4. Kinematic Laser mount
5. Beam splitter with mount
6. Front coated Mirrors with mount (2no.)
7. Rotation stage
8. Glass slide
9. CCD with mount
10. Screen
11. Thumb screws

b. Safety and Installation Instructions

- Laser radiation predominantly causes injury via thermal effects; avoid looking directly into the laser beam.
- It is best that students work in low light and dust free atmosphere.
- Care must be taken while handling the Optical components since this experiment uses high quality optical lenses and other components.
- Please don't put your fingers on the main optical surfaces but hold components by their edge.
- Always keep the equipment in a moisture and dust free atmosphere.

b. Parts Listing



1. Optical bread board
2. Beam splitter mount
3. Mirror mount with translation
4. Mirror mount with precision translation
5. Sodium vapour lamp with power supply
6. Collimator
7. CCD camera
8. Camera lens assembly
9. Rotation stage
10. Breadboard mountable slit
11. Variable aperture (breadboard mountable)
12. PC (Optional)

Note : PC not in the scope of supply

Items included with Specifications

1. Optical Bread Board with Rigid Support

Dimensions .... 800 mm x 600 mm

Material .... Stainless Steel

2. Kinematic Laser Mount

Fine adjustments .... Using 80 tpi leadscrews

Adjustment Range .... +/- 3 degrees

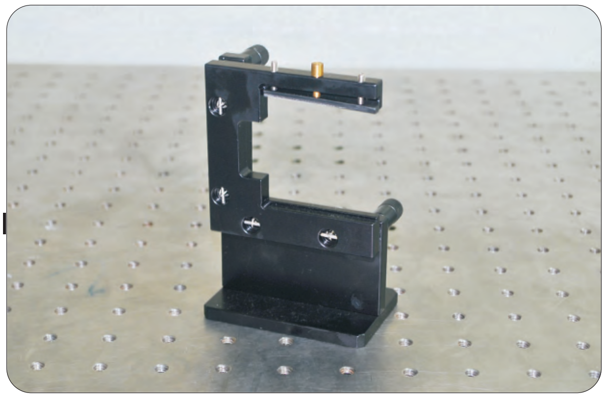
Material .... Black anodized Aluminum alloy

Sensitivity .... 20 arc second

Maximum laser module

Holder Diameter .... 25 mm

3. Beam splitter Mount



Angular Tip / Tilt .... +/- 3degree

Linear Resolution .... 0.25 mm

Sensitivity .... 4 arc sec.

Mounting Orientation .... Vertical & Horizontal

Material .... Aluminium

4. Mirror mount with translation (with Micrometer)

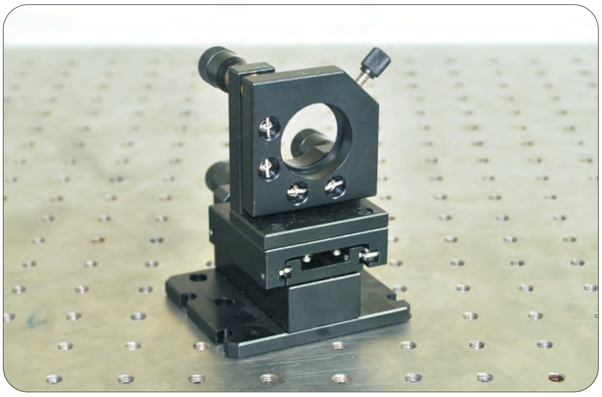
Angular Tip / Tilt .... +/- 3degree

Linear Resolution .... 0.25 mm

Sensitivity .... 4 arc sec.

Material .... Aluminium

Micrometer Least Count 0.01



5. Mirror Mount with Precision Translation

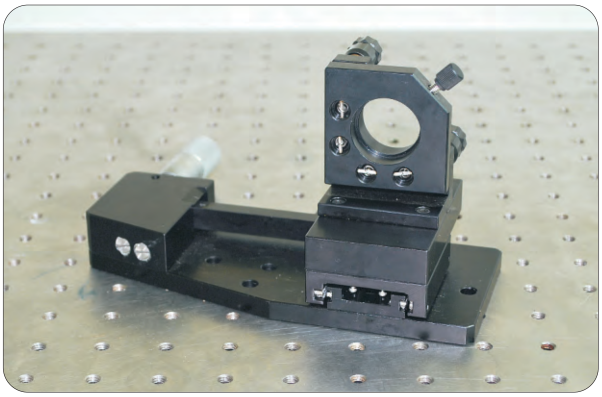
Angular Tip / Tilt .... +/- 3degree

Linear Resolution .... 0.25 mm

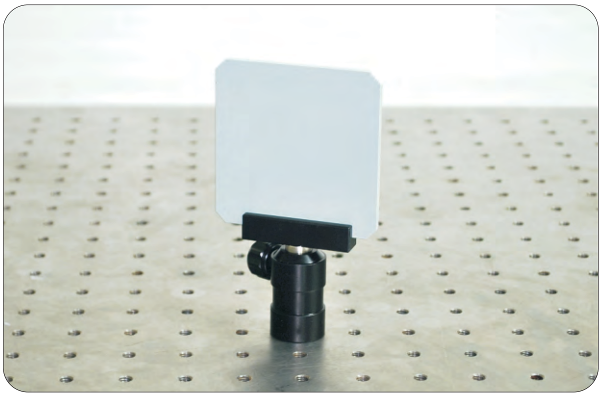
Sensitivity .... 4 arc sec.

Material .... Aluminium

Micrometer least count .... 0.01 mm



6. Screen with mount



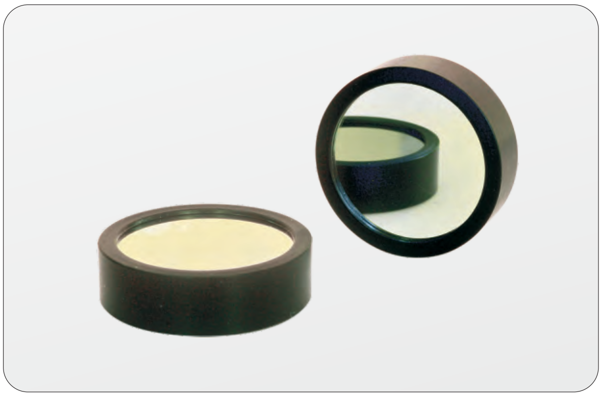
7. Front Coated Mirrors

Diameter .... 25 mm

Thickness .... 6 mm

Material .... Borofloat

Coating .... Protected Aluminum



8. Beam Splitter

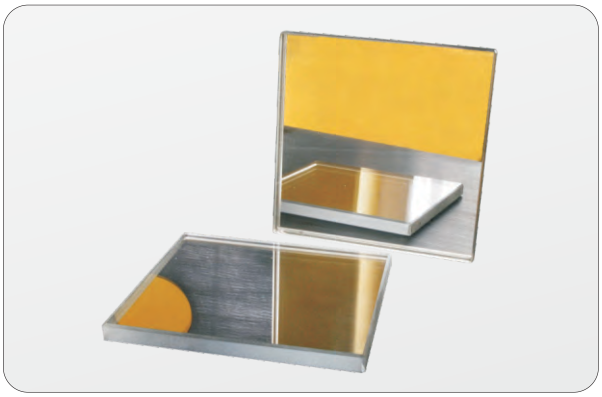
Dimension .... 50 mm X 50 mm

Thickness .... 4 mm

R/T ratio .... 50 / 50

Material Bk7

Coating .... Aluminum



9. Sodium vapour lamp with power supply

Power supply input .... 230V/50 Hz

10. Diode laser with power supply

Wave length .... 650 nm

Input .... 230V AC / 50 Hz

Optical power 5mw

Colour .... Red

11. CCD camera

Resolution .... Selectable (320-1280 pixels)

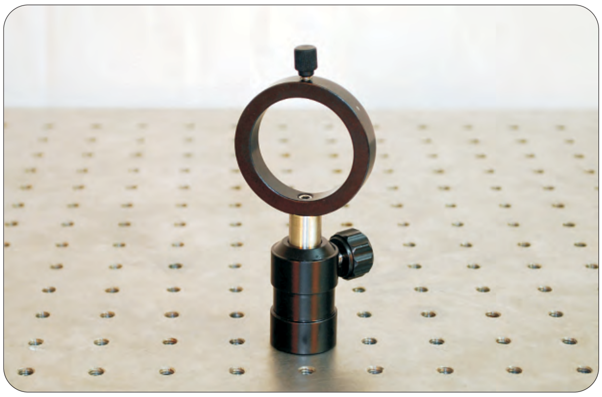
Connectivity .... USB 2.0

Focal length .... 60 mm

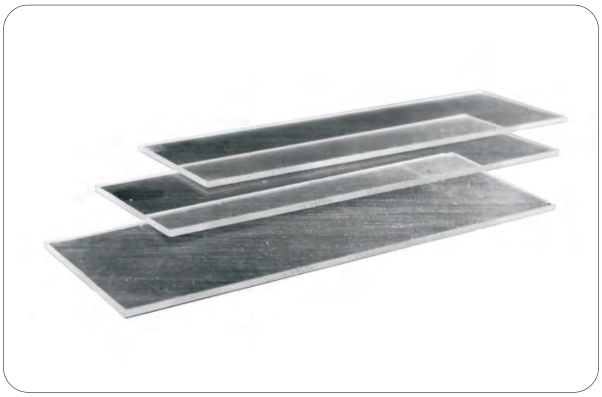
12. CCD camera mount

Diameter .... 50 mm

Material ... Black anodized Aluminium alloy



13. Microscopic glass slide



Dimension .... 75 mm x 25 mm

Material .... Float

Thickness .... 1 mm

14. Collimator

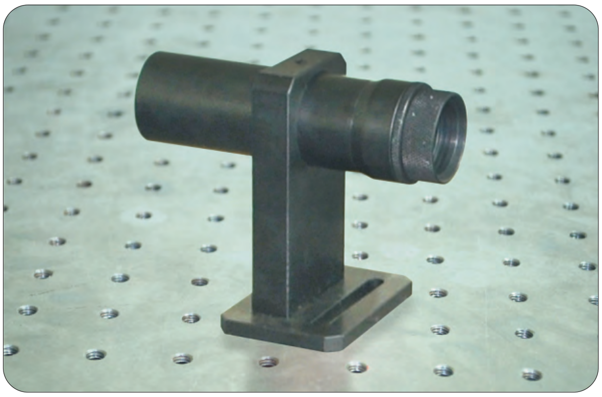
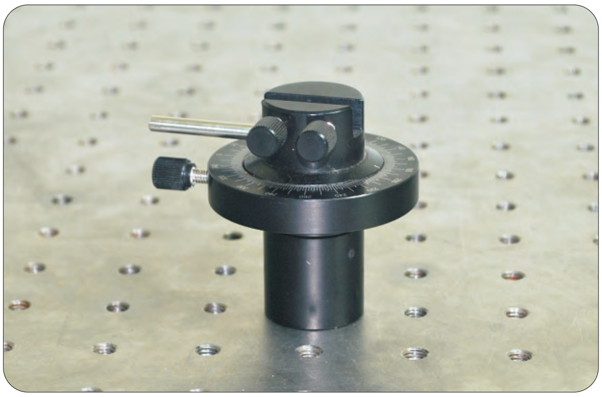


Plate Diameter .... 25 mm

Material .... Borofloat

15. Rotation stage



Resolution .... 2 degree

Material .... Black anodized aluminium alloy

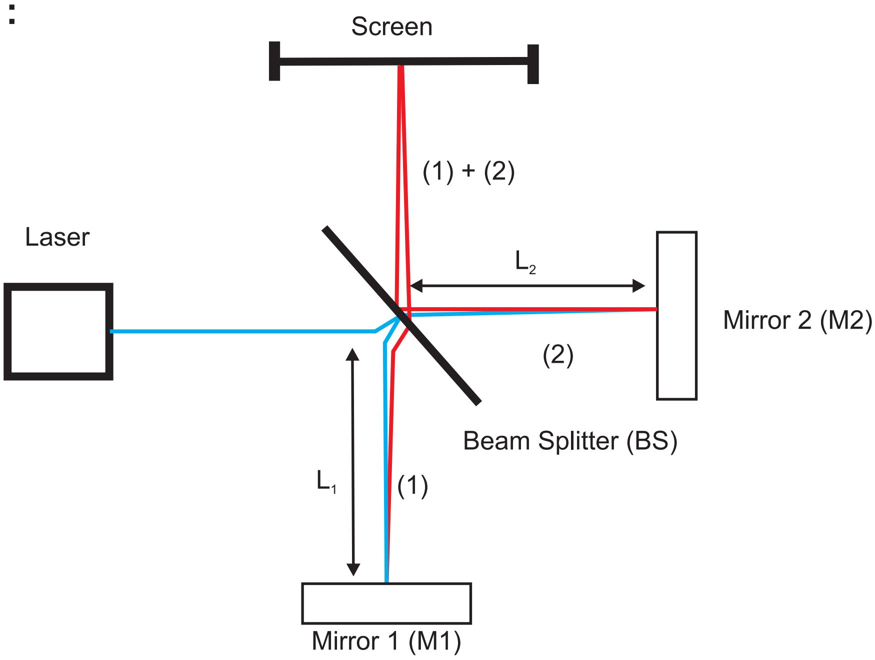
We also provide a bread board mountable slit made of acrylic in order to control the light coming out of the sodium vapour lamp. Also a variable aperture to be mounted in front of the camera to get a clear and precise fringe on screen.

Fundamentals

Aim :

1. To determine the wavelength of a monochromatic light.
2. To find the difference in wavelength of D1 and D2 lines of sodium light.
3. To find the refractive index of a transparent material.

Theory :



In the Michelson interferometer, coherent beams are obtained by splitting a beam of light that originates from a single source (a monochromatic source) with a partially reflecting mirror called a beam splitter (BS). The resulting reflected and transmitted waves are then re-directed by ordinary mirrors to a screen where they superimpose to create fringes. This is known as interference by division of amplitude.

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 on 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 M1 holder.

Light from a monochromatic source is allowed to fall on a beam splitter which is partially silvered and oriented at an angle 45^0 to the beam, producing two beams of equal intensity. One of them is transmitted to M_2 and the other is reflected to M_1, the light hitting on them is reflected back again to beam splitter. 50% of returning beam from M_2 is reflected by the beam splitter to the screen, and 50% from M_1 is transmitted by the beam splitter to the screen.

The two beams of a Michelson interferometer interfere constructively when the waves add in phase and destructively when they add out of phase, producing circular interference fringes as a result.

With sodium light as source the wavelength can be calculated from the equation,

$$\lambda = (2d / N)\,\Delta,$$

Where '*d*' is the change in position of micrometer after '*N*' fringes pass by, and Δ the calibration constant of micrometer.

The interference pattern observed with the sodium lamp contains two sets of fringe systems superimposed. For some mirror positions where path difference is integer number of wavelengths for both components the fringes will coincide for certain path length and looks sharp, in other positions of M_2 the maxima of one fringe system coincide with the minima of other and fringe visibility is minimum, that is, fringe disappear when the bright bands of one set are superimposed on the dark bands of the other. The wavelength separation of the sodium D - line doublet is easily determined by observing the successive coincidence of the two sets of fringe systems produced by the doublet of wavelengths (λ_1 and λ_2 with $\lambda_1 > \lambda_2$). As D is increased, the two systems gradually separate and the maximum discordance occurs when the rings of one system are set exactly halfway between those of the other system. The discordance positions are most clearly seen as minima in the contrast of the pattern. Then the wavelength separation $\lambda_1 - \lambda_2$ is given by,

$$\lambda_1 - \lambda_2 = \lambda_1 \lambda_2 / 2D$$

$$\lambda_1 - \lambda_2 \sim \lambda_2 / 2D$$

Where λ is the average wavelength of Sodium, D is the change in position of the micrometer for two successive discordance / coincidence.

If a glass plate of thickness 't' and refractive index 'n' is introduced in the path of two interfering beams of Michelson interferometer the path length of the beam changes to (n - 1) t. Since the beam traverses twice through the plate the total path difference $= 2\,(n - 1)\,t$.
So the refractive index of glass plate can be calculated from,

$$N\lambda = 2(n - 1)\,t$$

(The path difference is now increased due to the fact that the index of refraction of the solid is different from that of air, that's why we took the change in path length as (n - 1) t).

The refractive index of glass slide is,

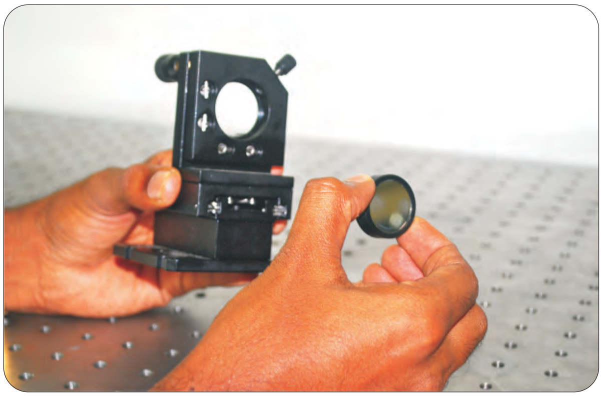
$$n = \frac{(2t - N\lambda)(1 - \cos\theta)}{2t(1 - \cos\theta) - N\lambda}$$

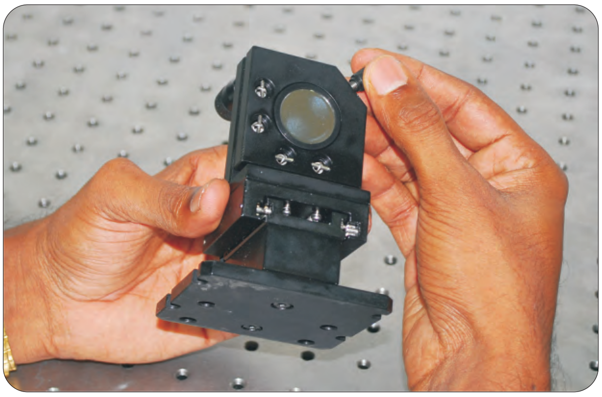
Where 'θ' is the angle turned for 'N' fringes.

Experimental Setup

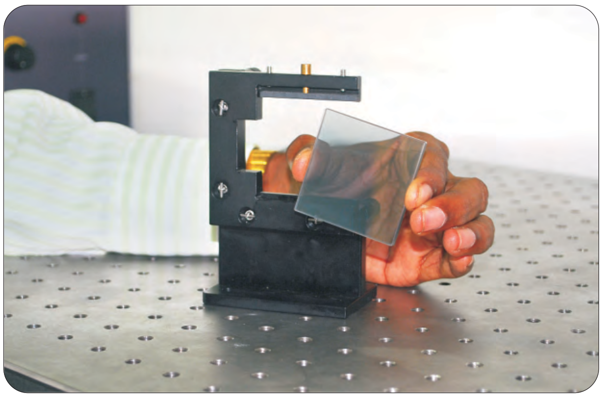
Making components ready for the Experiment

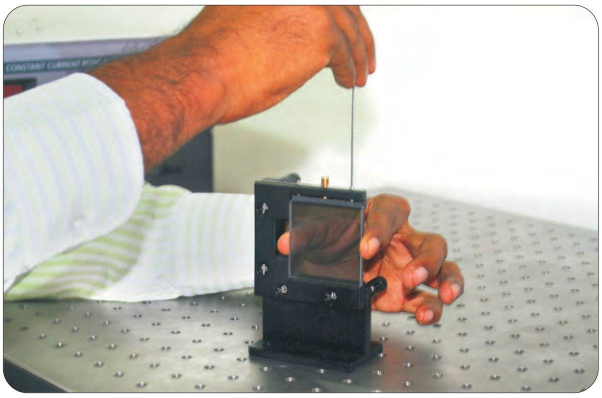
Insert mirrors into mirror mounts, Mirror mount with translation and mirror mount with precision translation. (insert it carefully without touching on polished faces).



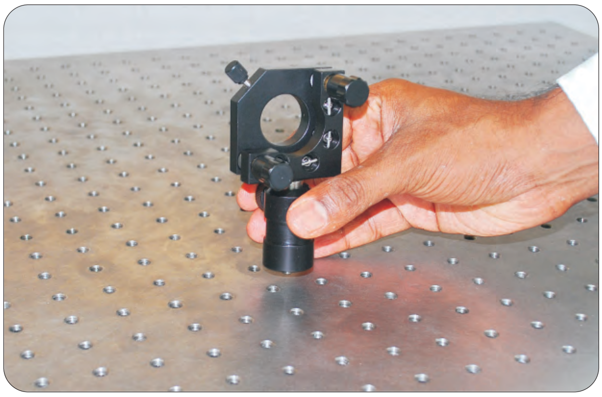


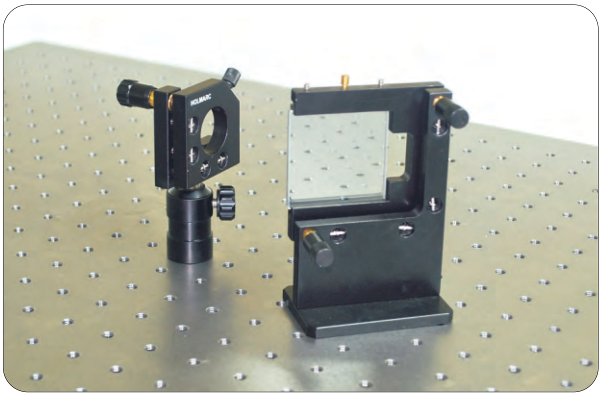
Insert beam splitter into the beam splitter mount, It should be inserted in a manner that the coated face of the beam splitter will come in front of the mount. (Must take care not to touch on the polished face).



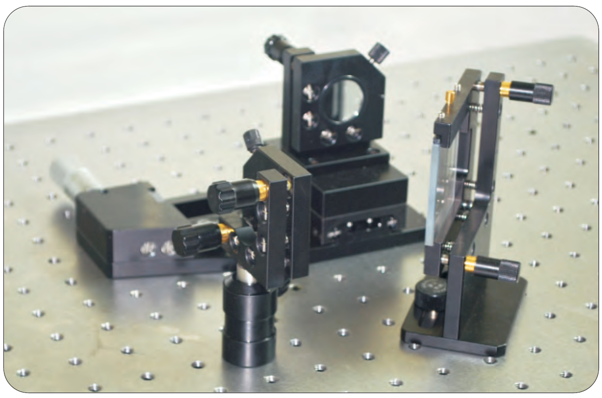


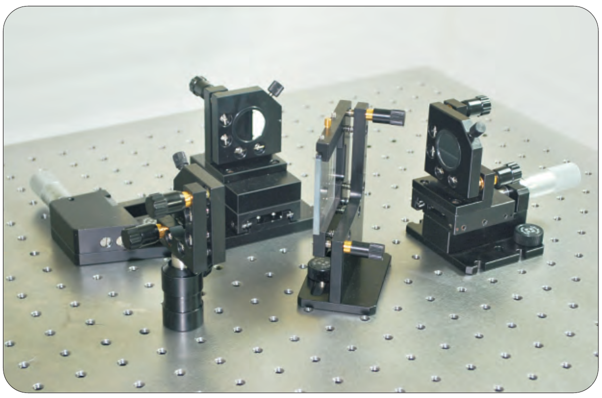
Start construction of Michelson interferometer. Fix the laser mount on the breadboard, also fix the beam splitter with an inclination of 45^0 to the mount.



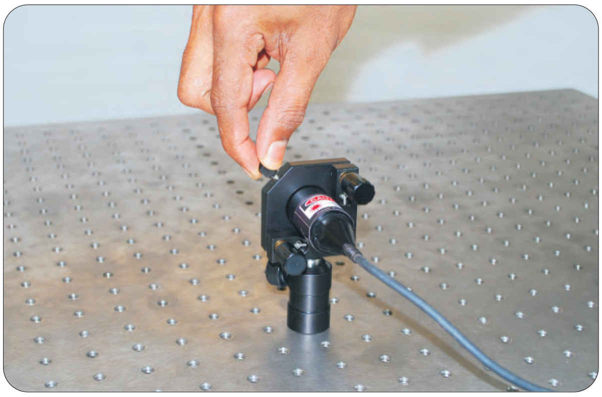


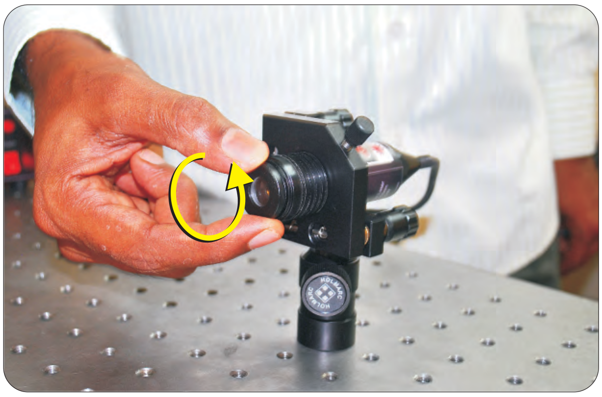
Fix the high precision mirror with translation stage (M_1) & mirror with translation (M_2) in equal distance from the beam splitter.(Both should be placed in such a way that they are perpendicular to each other, M_2 is placed in such a way that it faces the laser source and M_1 perpendicular to M_2.



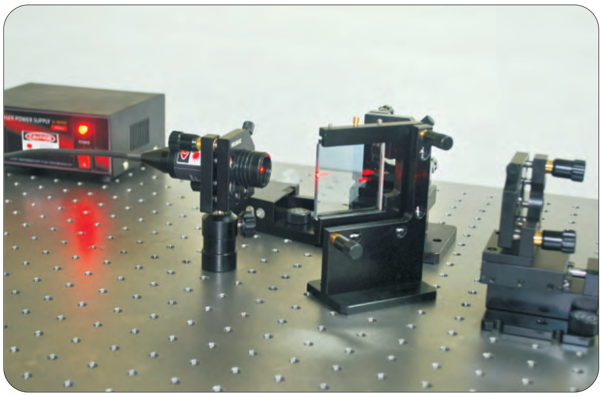


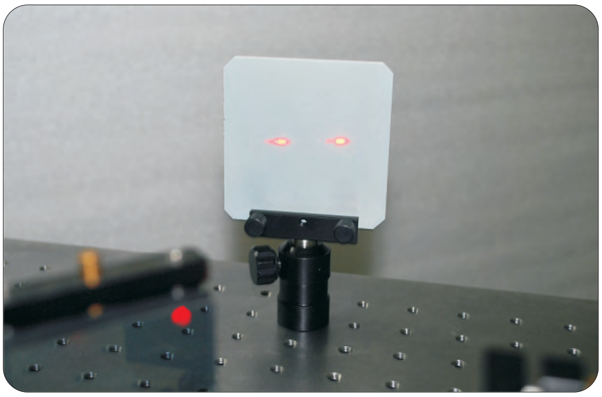
Insert laser module into the laser mount and remove the divergence lens in front of the laser module. Then fix the screen in a direction perpendicular to the laser source (directly opposite to mirror M_1) and switch on the Laser power supply.

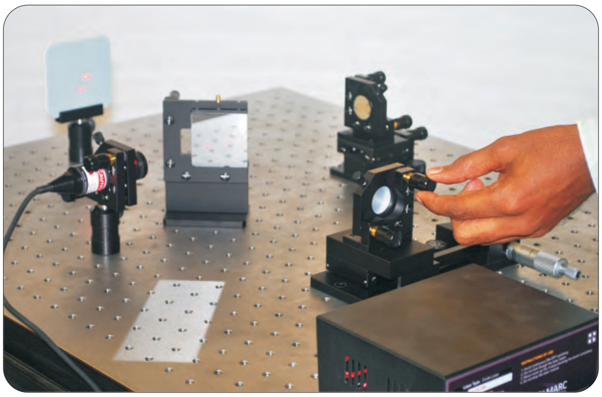


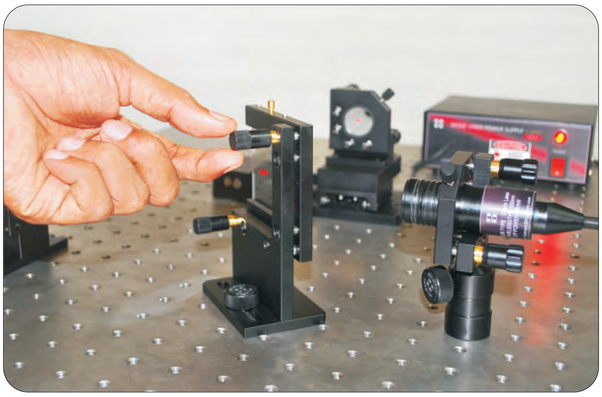


You can have two bright beam spots over the screen both reflected from M_1 , and M_2.Using the tilt adjustment of the beam splitter mount and mirror mounts try to coincide both beam spots.(If two beam spots are not obtained adjust the angle of beam splitter so that beam directly falls on the centre of both mirrors and reflects back directly into the beam splitter).

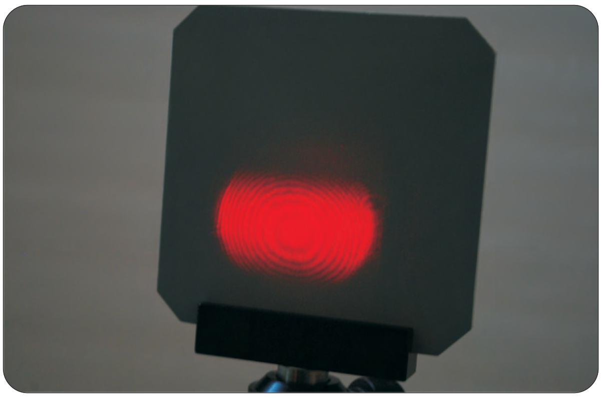




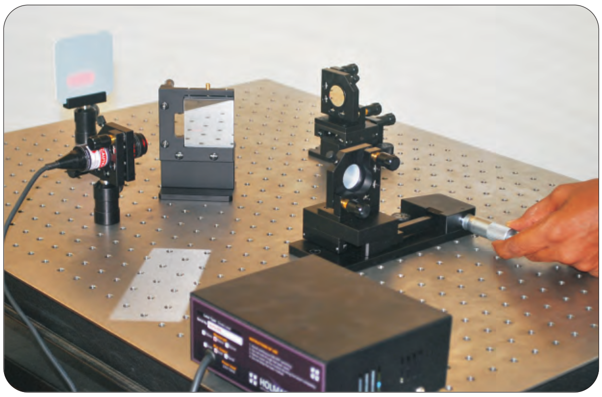


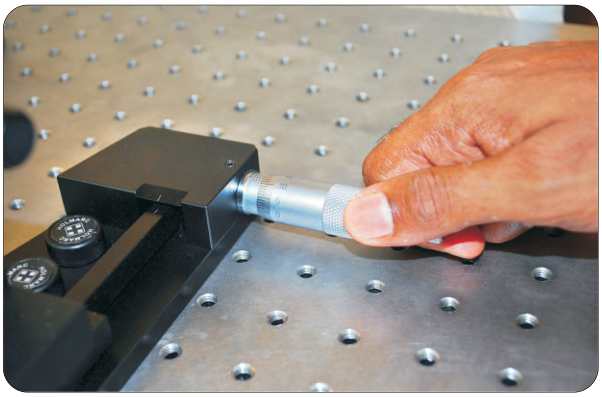


Insert the divergence lens back to the laser module, and observe the clear circular fringes on the screen.



This is the time for the calibration of micrometer, first of all make sure that the fringes moves when the micrometer screws are moved. Fix a position on the observing screen (either a dark or bright fringe) and note the micrometer reading.





Now start counting the number of fringes that move (either outward or inward) as the screw is turned (turn the screw with your hand and look at the screen, you must apply a steady pressure over it so that you could precisely count the fringes). Count at least 20 fringes that pass after the initial fixed position note this distance as ‘d’.

We know the wavelength of laser λ = 650 nm and N = 20 nos
So from equation

$$\lambda = (2d / N)\, \Delta$$

$$\Delta = \lambda / (2d / N)$$

So we can find the calibration constant.

Repeat the same to get precise calibration constant.

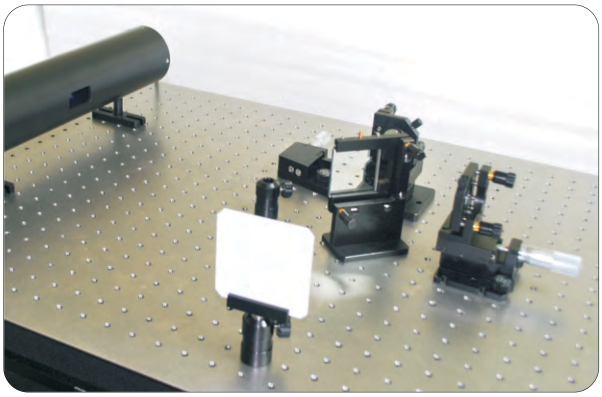
Observations :

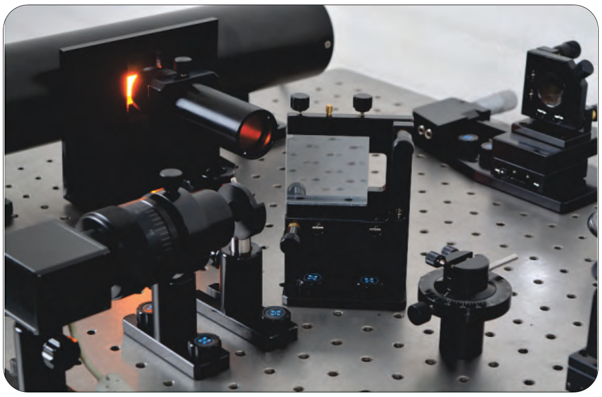
Trial No	No. of Fringes (N)	Micrometer reading		Distance Moved (d) mm	Calibration Constant $\Delta = (\lambda N / 2d)$
		Initial	Final		
1.					
2.					
3.					
4.					

Average calibration constant, Δ =

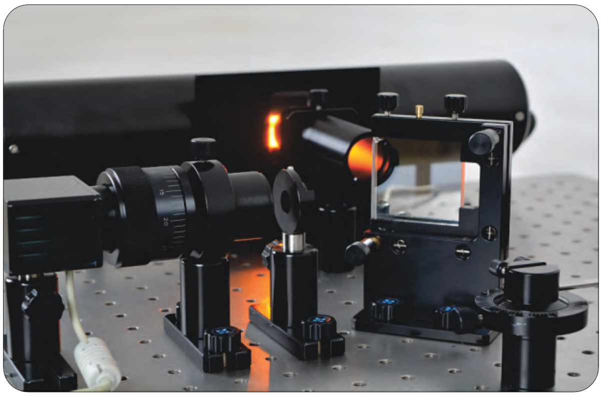
To find the wavelength of sodium light

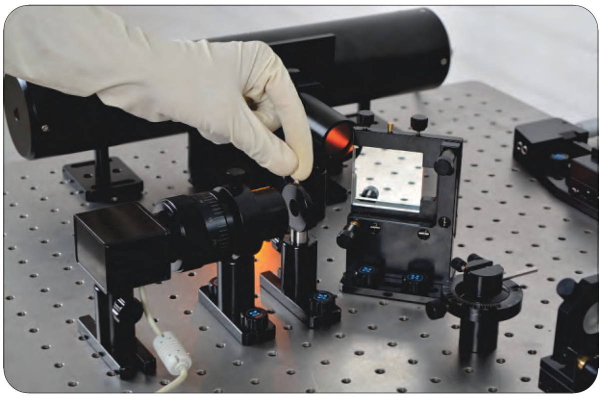
It is the time to find wavelength of sodium light, first of all replace the laser with Sodium lamp also insert a collimator in between sodium lamp and beam splitter so that the light get focussed, before falling on the beam splitter. (Remember to fix a bread board mountable slit in front of the sodium vapour lamp in order to control the light coming out of it).

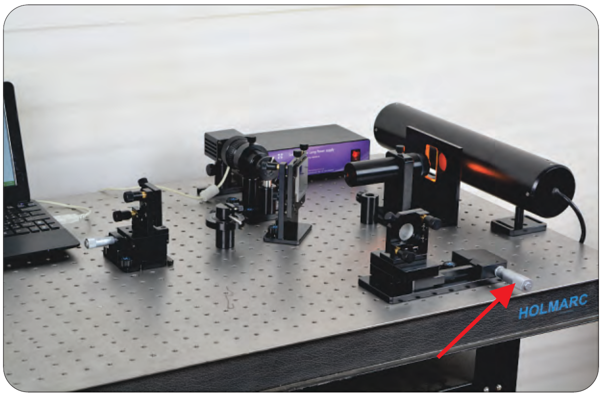


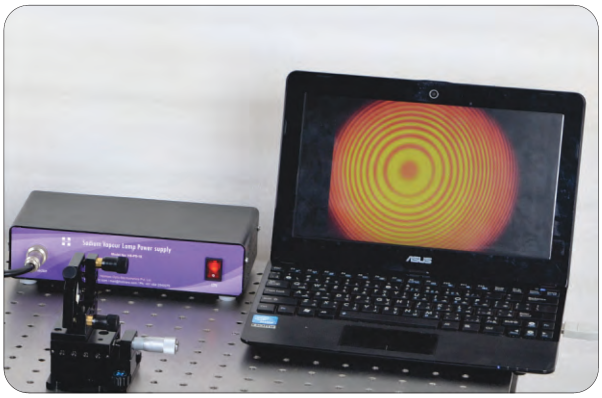


Also replace the screen with camera, (use camera lens assembly to focus the light) and connect it to the PC using the USB cable provided so that the fringes obtained can be observed on PC. Fix a variable aperture provided to mount in front of the camera, with you can adjust the clarity of the image obtained.





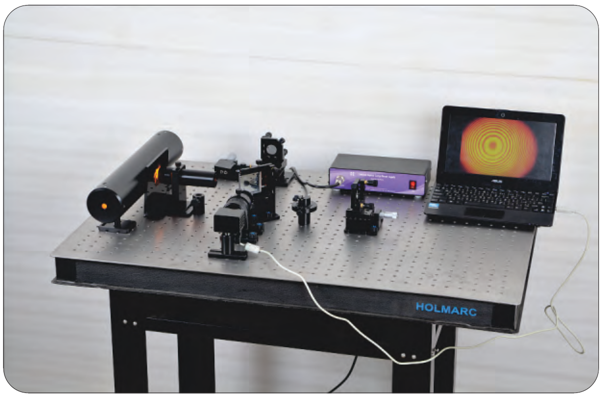




Adjust the mirror mounts, (using fine adjustment screws) as before and also the position of camera to get clear and sharp fringes.

As clear fringes are obtained rotate the micrometer of mirror M_1 so that the fringes move inward or outward (as we done above to find the calibration constant).

Note the initial micrometer reading, rotate the micrometer and count 20 fringes and measure the change in micrometer reading (take difference between initial and final readings of micrometer). The change in micrometer reading gives you ‘d’, the distance moved.



Knowing the wavelength of light and (λ = 650 nm) and number of fringes (N = 20) one can calculate the wavelength of the monochromatic light used using the equation

$$\Delta = \lambda / (2d / N)$$

then,

$$\lambda = (2d / N)\, \Delta$$

Try different trials to obtain an accurate value.

Observations :

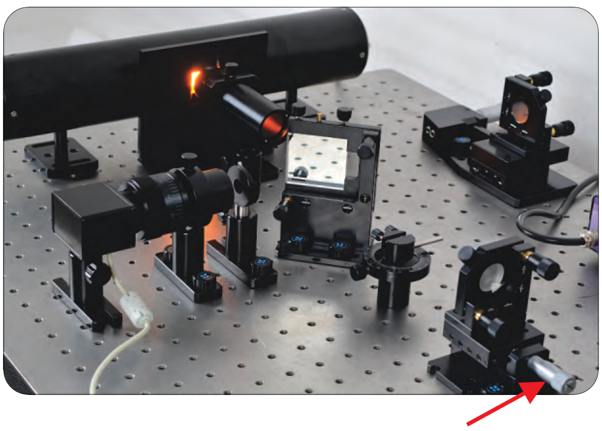
Trial No	No. of Fringes Counted, (N)	Micrometer reading		Distance Moved (d) mm	Wavelength $\lambda = (2d / N)\,\Delta$ nm
		Initial	Final		
1.					
2.					
3.					
4.					

Wavelength of sodium light = ... nm

To find the wavelength separation of D_1 and D_2 lines of sodium light

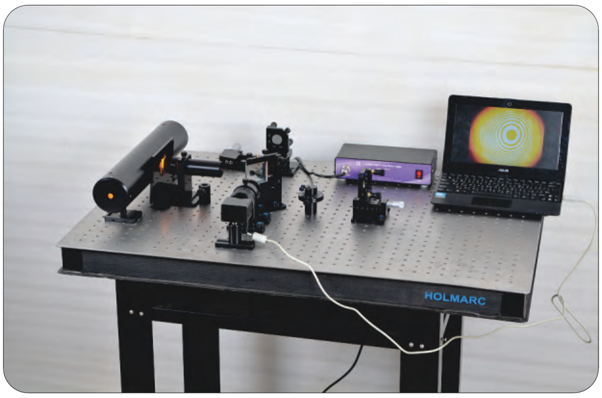
Now rotate the micrometer of translational stage provided with mirror M_2 and observe the changes occurring to the fringe pattern. You can see that at certain positions the fringes are clear, while at certain positions the whole fringe disappears.

{ When the sodium D lines are in phase together the fringes are clear and sharp. When they are out of phase the fringes gets disappeared }.



Start rotating the micrometer, as soon as the fringe disappears from screen note the reading. Repeat the process to get the same condition (no fringe condition) and note the reading again. As M_2 is moved the fringe visibility will go through alternate cycles of maximum and minimum visibility, and the wavelength difference $\Delta\lambda$ can be determined from the separation of these cycles.

Tabulate the readings from micrometer obtained when there are no fringes on the screen and find the difference between and name it as 'D' (change in position of micrometer for successive discordance). That is, distance to D_1 line to D_2 line.



Repeat different trials to obtain an accurate value.

The wavelength separation

$$\lambda_1 - \lambda_2 = \lambda^2 / 2D$$

where λ is the wavelength of the sodium light.

Observations :

Trial No	Micrometer reading		Distance Moved (D) mm	$\lambda_1 - \lambda_2 = \lambda^2 / 2D$ nm
	Initial	Final		

Average $\lambda_1 - \lambda_2$ = nm

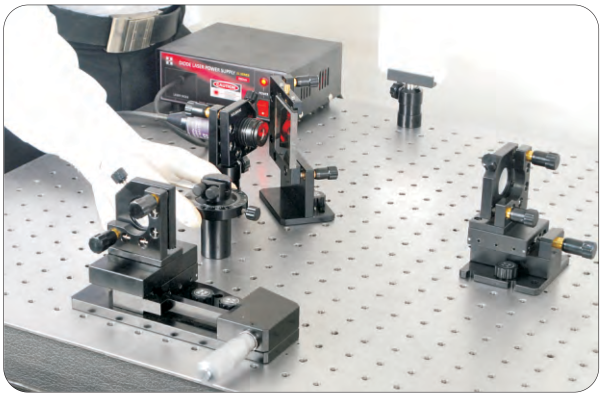
Result :

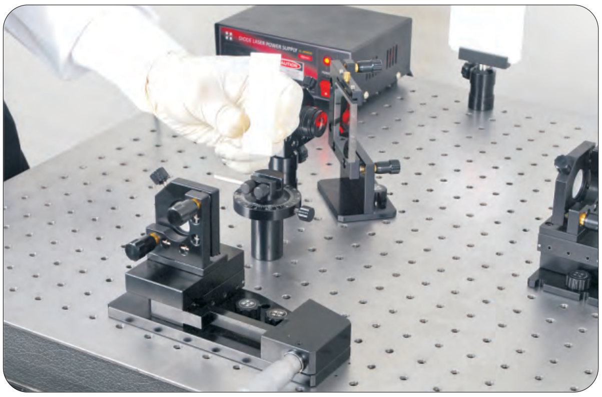
The wavelength separation of D_1 and D_2 lines of sodium is =

To find the refractive index of a transparent material

We are going to find the refractive index of glass slide using Laser beam replace the sodium source with Laser beam. Also replace the CCD with the screen (same set up of the first stage of experiment we made to find the calibration constant).

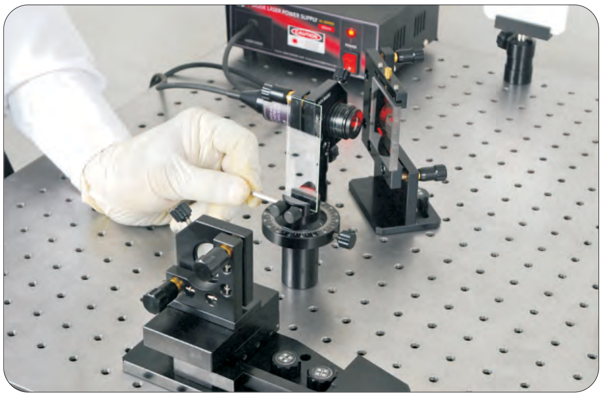
Introduce the rotational stage in one of the arms of the interferometer. Mount glass slide over the rotational stage.

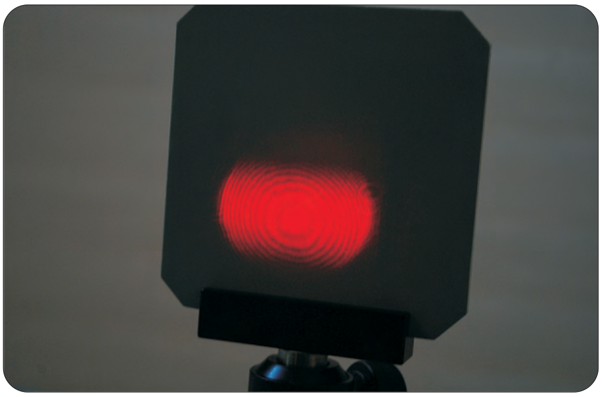




Note: *When glass plate is introduced in the optical path of Michelson interferometer, the fringe will be shifted & will become blur. To make the fringe sharp again, move mirror with translation to & fro till the clear set of fringes is achieved on the viewing screen.*

From the dial note the initial position of the glass slide, slowly rotate the rotational stage using hands and count the number of fringes that passes by (count at least 20 fringes). Note the final reading on the dial, the difference between the initial and final reading gives the angle of rotation **'θ'**. Measure the thickness, **t** of the glass plate using a screw gauge.





Observations :

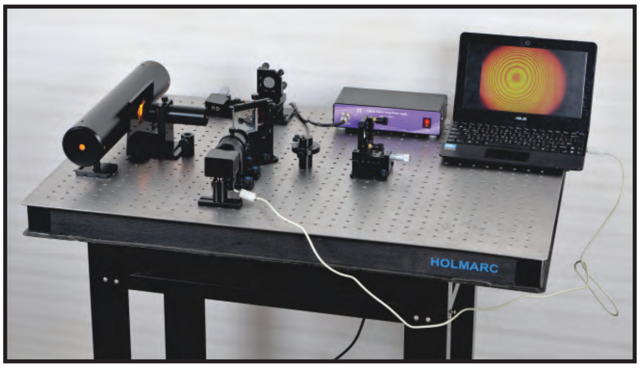
Least count of the rotational stage = ... mm

Thickness of glass plate = ... mm

Angle rotated, θ	No. of fringes moved(N)	Dial reading		Mean θ	Refractive index, n
		Initial	Final		
Left	20				
	20				
	20				
	20				
Right	20				
	20				
	20				
	20				

Mean value of refractive index, **n** =

Result : Refractive index of glass slide, **n** =



The sodium doublet is a product of a phenomenon called spin orbit interaction. Sodium lamps produce actually two dominant spectral lines very close together at 589.0 and 589.6 nm.

Experiment Example

To find the calibration constant

Least count of micrometer = 0.01 mm

Trial No	No. of Fringes (N)	Micrometer reading		Distance Moved (d) mm	Calibration Constant $\Delta = (\lambda N/2d)$
		Initial	Final		
1.	20	5.00	5.33	0.33	0.0197
2.	20	5.33	5.65	0.32	0.0203
3.	20	5.65	5.97	0.32	0.0203
4.	20	5.97	6.29	0.32	0.0203

Average calibration constant, Δ = 0.0203

Wavelength of sodium light

Trial No	No. of Fringes Counted, (N)	Micrometer reading		Distance Moved (d) mm	Wavelength $\lambda = (2d / N) \Delta$ nm
		Initial	Final		
1.	20	5.00	5.29	0.29	588.7
2.	20	5.29	5.58	0.29	588.7
3.	20	5.58	5.87	0.29	588.7
4.	20	5.87	6.18	0.29	588.7

Wavelength of sodium light = 588.7 nm

Finding wavelength separation

Trial No	Micrometer reading		Distance Moved (D) mm	$\lambda_1 - \lambda_2 = \lambda^2 / 2D$ nm
	Initial	Final		
1	2	30	0.28	0.618
2	2.5	31	0.285	0.608

Average $\lambda 1 - \lambda 2$ = (0.618 + 0.608) / 2 = 0.613 nm

Finding Refractive Index of Glass Plate

Thickness of glass plate = ...1... mm

Angle rotated, θ	No. of fringes moved(N)	Dial reading		Mean θ	Refractive index, n
		Initial	Final		
Left	20	5	9	5	1.405
	20	9	15		
	20	15	19		
	20	20	25		
Right	20	355	350	5	1.405
	20	350	345		
	20	345	340		
	20	340	335		

Refractive index of the glass plate, **n** = $$\frac{(2t - N\lambda)(1 - \cos\theta)}{2t(1 - \cos\theta) - N\lambda}$$

Mean refractive index is = (1.405 + 1.405) / 2 = 1.405

Maintenance Notes

- Always keep the equipment in moisture and dust free atmosphere.
- Switch on all the electronic devices used in this experiment at least once in a week.
- Do not touch on the polished faces of the mirrors and also on the beam splitter.
- Always be careful while using the CCD camera and also the camera lens assembly.

Technical Support

We have a state of the art laboratory for quality control and inspection. We have established a failsafe inspection procedure to make sure of quality standard of our products before shipment. If any problem occurs contact us; Before you call the HOLMARC technical Support staff, kindly gather the following information:

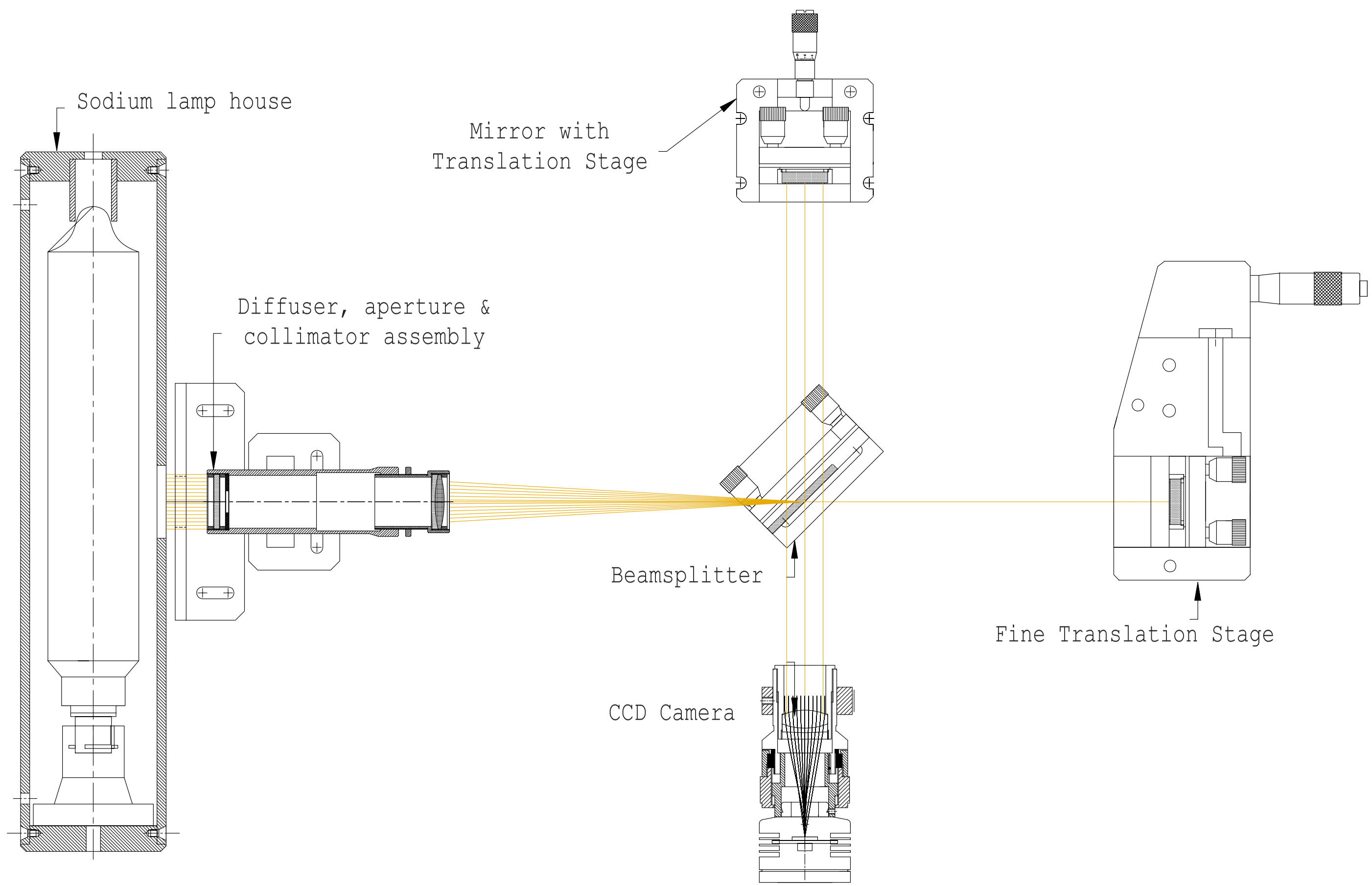
- Title and model number (usually listed on the label);
- Approximate age of apparatus;
- A detailed description of the problem/sequence of events.
- Have the manual in hand to discuss your questions

Feedback

If you have any comments regarding our product or manual, please let us know. If you have any suggestions on alternate experiments or find a problem in the manual, kindly inform us. HOLMARC appreciates any customer feedback. Your inputs help us evaluate and improve our product.

For technical support, contact us at
E-mail: sales@holmarc.com
Web: www.holmarc.com

:: Mechanical Drawing



Holmarc Limited Warranty

Every Holmarc Instruments and its accessories are warranted by HOLMARC OPTO-MECHATRONICS LTD for a period of ONE YEAR from the date of original purchase.

Holmarc will repair or replace a product, or part thereof, found by Holmarc to be defective, provided the defective part is returned to Holmarc, with proof of purchase.

This warranty applies to the original purchaser and our distributors and is non-transferable.

Each returned part or product must include a written statement detailing the nature of the claimed defect, as well as the end user's name, address, and phone number.

This warranty is not valid in cases where the product has been abused or mishandled, where unauthorized repairs have been attempted or performed, or where depreciation of the product is due to normal wear-and-tear.

Holmarc specifically disclaims special, indirect, or consequential damages or lost profit which may result from a breach of this warranty. Any implied warranties which cannot be disclaimed are hereby limited to a term of one year from the date of original retail purchase.

Holmarc reserves the right to change product specifications or to discontinue products without notice.

Please refer our commercial invoice for warranty claim.

(Authorized Signatory)