EXPERIMENT 6

Introduction to Interferometry

THE MICHELSON-MORLEY AND FABRY-PEROT INTERFEROMETERS

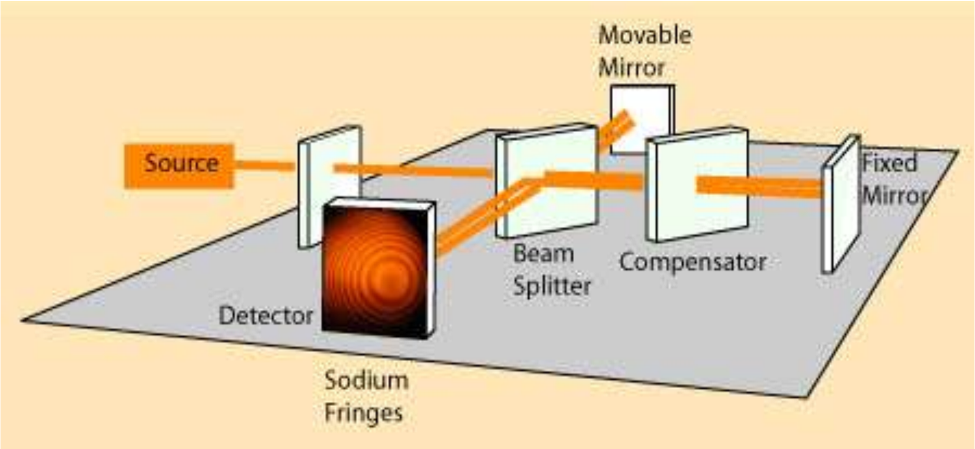
AIM: Calculating the wavelength λ of an unknown light source

APPARATUS: 0.6328 µm for a standard helium-neon laser, Laser Bench Adjustable Mirror, Movable Mirror, Beam Splitter, Compensator Plate, Viewing Screen, Lens, 18 mm Focal Length, base of Michelson and Morley interferometer.

METHODOLOGY:

The Michelson and Morley interferometer is primarily used to measure wavelengths of unknown monochromatic light sources. The method lies in firing the light sample as illustrated in Figure 6.1 and observing the resultant fringe pattern. While it is being observed, the movable mirror is adjusted backwards. That is until a fringe pattern change of exactly one is observed. This means that the mirror has been moved one-quarter of its wavelength; this is because the path length of the light has changed one-half of its wavelength (because it goes both to and from the mirror) and this change in path length shifts the interference pattern by precisely one fringe.

A schematic representation of the Michelson and Morley interferometer using a sodium light source



Precise distance measurements can be made with the Michelson interferometer by moving the mirror and counting the interference fringes which move by a reference point. The distance **d** associated with **m** fringes is

$$2d = 2\left(L_f - L_m\right) = m\lambda \quad (6.1)$$

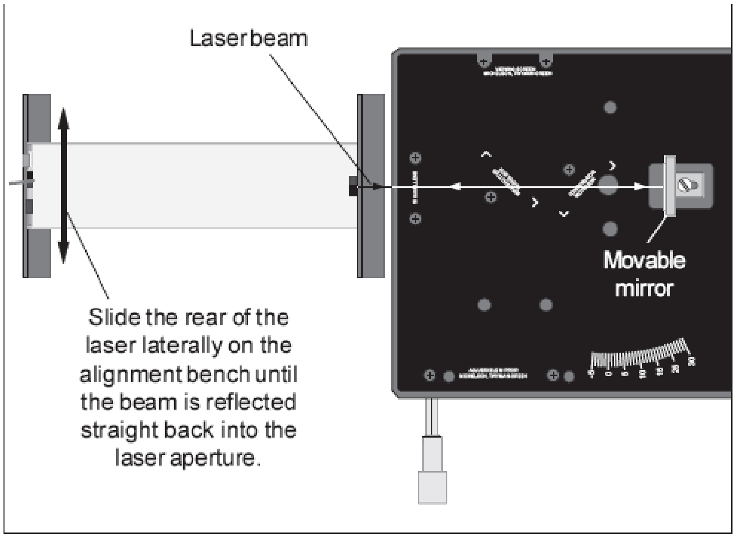
Part1: The Michelson Mode

PROCEDURE:

STEP A: Setup and Operation

Laser Alignment:

Adjust your laser so that the beam is approximately 4 cm above the table top. Then align the beam as in steps 4 and 5, below.



Slide the rear of the laser laterally on the alignment bench until the beam is reflected straight back into the laser aperture.

Figure 6.1. Aligning the Laser

Michelson Mode:

1. Align the laser and interferometer base as previously described. The laser beam should be approximately parallel with the top of the base, should strike the center of the movable mirror, and should be reflected directly back into the laser aperture.
2. Mount the adjustable mirror on the interferometer base. Position one component holder in front of the laser. see figure 6.2.

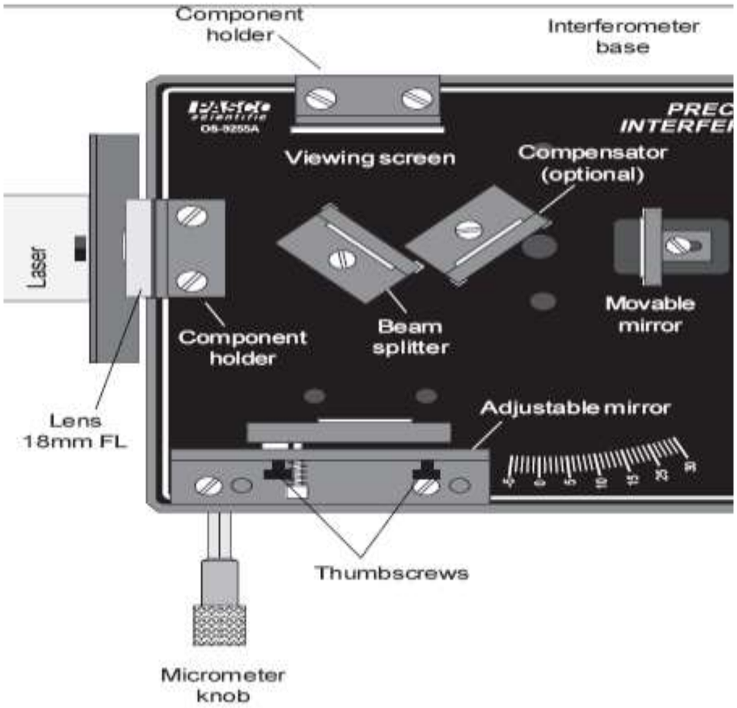


Figure 6.2. Michelson Mode Setup

3. Position the beam-splitter at a 45 degree angle to the laser beam, within the crop marks, so that the beam is reflected to the fixed mirror. 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 or wall ; one set comes from the fixed mirror and the other comes from the movable mirror. Adjust the angle of the beam-splitter again until the two sets of dots are as close together as possible.
5. Using the thumbscrews on the back of the adjustable mirror, adjust the mirror's tilt until the two sets of dots on the viewing screen coincide.
6. The compensator is not needed for producing interference fringes when using a laser light source. why?
7. Attach the 18 mm FL lens to the magnetic backing of the component holder in front of the laser, as shown ,and adjust its position until the diverging beam is centered on the beam-splitter. You should now see circular fringes on the viewing screen. If not, carefully adjust the tilt of the adjustable mirror until the fringes appear.

StepB:

1. Align the laser and interferometer in the Michelson mode, so an interference pattern is clearly visible on your wall.

2. Rotate the micrometer knob slowly counterclockwise. Count the fringes as they pass your reference mark. Continue until some predetermined number of fringes have passed your mark (count *at least* 20 fringes). Record the final reading of the micrometer dial *x* in the table 1.

3. Repeat the operation previous several times until you complete table 1.

NOTE: Knowing that each small division on the micrometer knob corresponds to one µm (10^{-6} meters) of mirror movement find d_0 the ratio of path difference (twice the distance of mirror movement) to Δx. due to $d_0 = .1$.

n	Number of fringes	X(mm)
1	0	
2	20	
3	40	
	.	
.	180	

Table.1

5. Draw a graph of X as a function of m, and find the slope $=\lambda/2d_0$, then find wavelength of laser, where d_0=.1, and compare by the real λ=633nm.

Part2: The Fabry-Perot Mode

PROCEDURE:

STEP A: Setup and Operation

1. Mount the adjustable mirror where indicated on the interferometer base and one component holder in front of the movable mirror. See Figure 6.3.

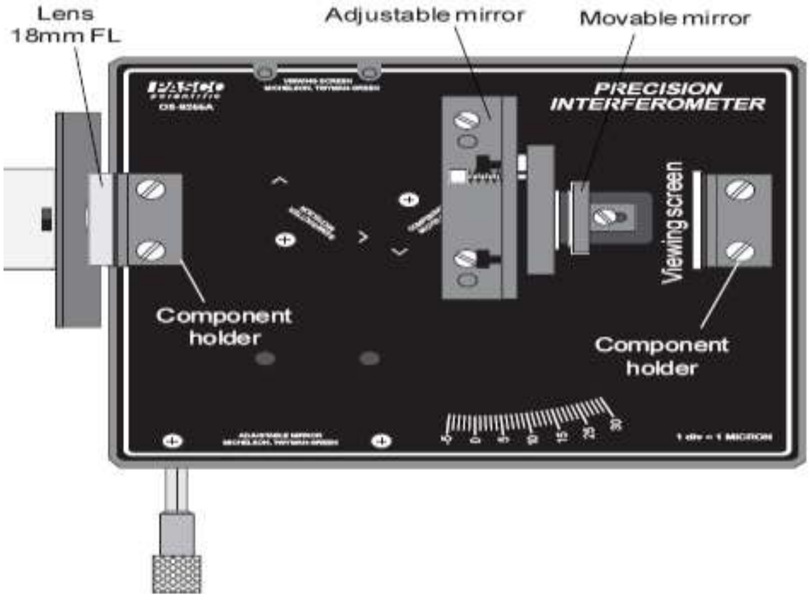


Figure 6.3. Fabry-Perot Mode Setup

2. Place the other component holder behind the movable mirror. You should see several images of the laser beam on wall.
3. Using the thumbscrews, adjust the tilt of the adjustable mirror until there is only one bright dot on the wall.
4. Now mount the 18 mm FL lens on the front component holder. A clear sharp interference pattern should be visible on wall.

STEP B: Procedure for Wavelength by using the ***Fabry-Perot Mode:***

1. Repeat step 1and 2 as in the first part**.** Record x in table 2.
2. Record $\mathbf{d_m}$, the distance that the movable mirror moved toward the beam-splitter according to your readings of the micrometer knob using $d_m=d_0*\Delta x$, where $d_0=0.1$.

n	Number of fringes	x (mm)	$\Delta x=(x_{n+1}-x_n)$ (mm)	$d_m=d_0*\Delta x$(mm)	$\lambda = 2d_m/20$
1	0				
2	20				
3	40				
	.				
.	180				

Table 2

3. For each trial, calculate the wavelength independently for that data. The same formula applies, then average your results and compare by the real λ=633nm.