Lab Setup for Physics 312 March 18th

Lab 7: Michelson Interferometer

Goals: Using a Michelson interferometer 1) measure the wavelength λ of a He-Ne laser 2) measure the index of refraction of air n and 3) (optional) study interference between orthogonally polarized light.

A simplified version of the Michelson interferometer is shown in Figure 1. The basic idea is to split a beam of light into two beams; delay one with respect to the other, and then recombine them to observe their interference. An excellent tutorial can be found here: https://www.youtube.com/watch?v=j-u3IEgcTiQ.

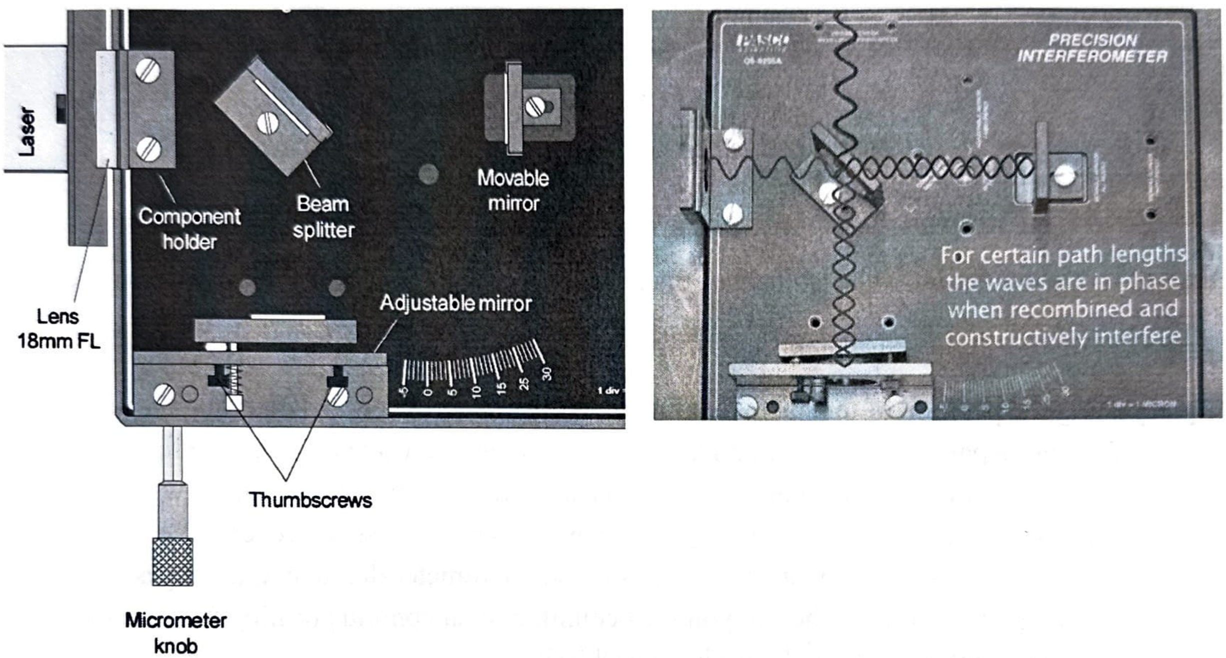


Figure 1: *Left:* A top view of the experimental set-up with components labeled. Note: Turning the micrometer dial clockwise moves the movable mirror toward the right. Turning the dial counter-clockwise moves the mirror towards the left. *Right:* The same but with the two beams shown. The interference pattern can be seen on a far-off viewing screen (not shown) as a set of concentric rings.

0.Before you begin: aligning the Michelson Interferometer

Before the experiments, the beams must be aligned in order to produce an interference pattern. To begin with the laser beam must be aligned to hit the middle of the movable mirror and to be perpendicular to its surface; see Fig. 2. The lens should not be in place for this step. The beam splitter should then be added to the set-up, as shown in Fig. 1, and its angle adjusted until the reflected beam hits the adjustable mirror (the one that has thumbscrews). There should be two bright spots on the viewing screen, one from each mirror; other, less bright, spots are due to multiple reflections. The thumbscrews on the fixed mirror can then be used to make the spots overlap. Interference between the beams can be observed as twinkling. Slide the lens into the set-up and look for circular fringes on the viewing screen. The diverging beam from the laser should be roughly centered on the beam splitter. The adjustable mirror's tilt may need to be finely readjusted to create the fringes.

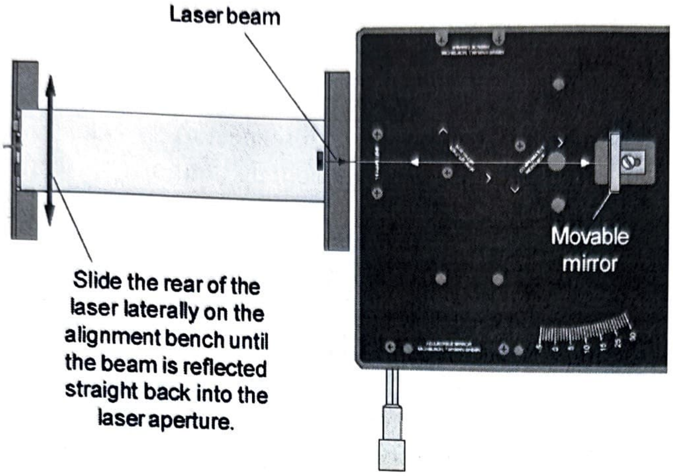


Figure 2. The laser beam, while hitting the center of the movable mirror, should reflect back on itself.

1. Measuring the laser wavelength

By adjusting the position of the movable mirror with the micrometer, and counting the number of fringes that move past a certain point on the viewing screen, the wavelength of the light can be measured. Count at least 20 fringes. Backlash must be avoided in order to not skew the measurements. Backlash is a slight slippage that always occurs when you reverse the direction of motion in a mechanical instrument. When turning the micrometer dial to count fringes, always turn it one complete revolution before you start counting, then continue turning it in the same direction while counting. This will eliminate backlash.

2. Measuring the index of refraction of air

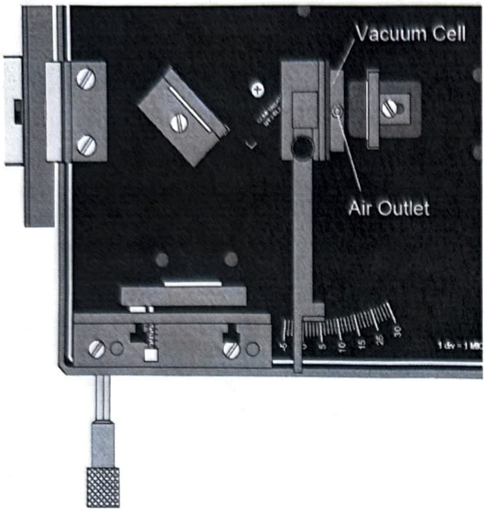
To measure the index of refraction of air, a vacuum cell of width L will be added to the set-up as shown in Fig. 3. As the air pressure is reduced from pressure P_0 to P_f the cell with a hand pump, the fringe pattern on the view screen will shift by N fringes. If n is linear in P as shown in Fig. 4, the index of refraction at P_0 can be calculated through

$$n(P_0) - 1 = [\lambda N / (2L)]\,[P_0/(P_0 - P_f)],$$

as derived in homework. The accepted value of n-1 for 1 atmosphere at 20 C is 2.73×10^{-4}.

3. Polarization studies.

Place one linear polarizer in front of the movable mirror and one in front of the adjustable mirror. Rotate the polarizer and observe what happens to the interference pattern. What can be concluded about the interference of two beams which are polarized 90 degrees with respect to each other?



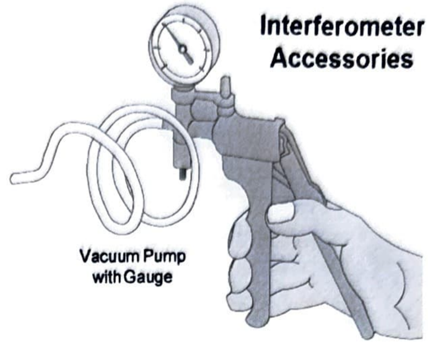


Figure 3. *Left.* A vacuum cell, with L = 3.0 cm, is placed in one of the branches of the interferometer. *Right.* The vacuum pump will be used to evacuate the cell from an initial pressure P_0 down to a final pressure P_f.

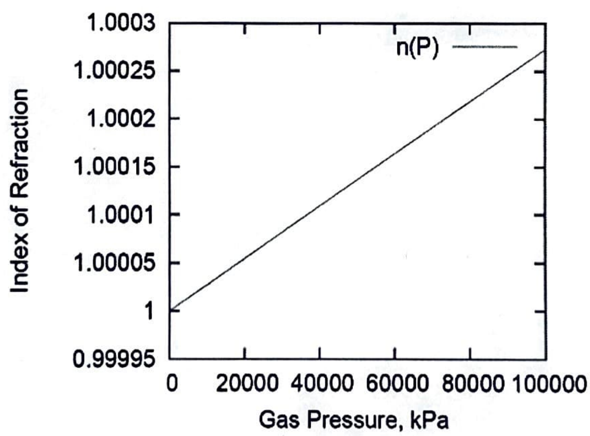


Figure 4. The linear relationship between n and gas pressure is shown for air.