Construct, Conduct & Comprehend Physics Experiments

LEOK-3-17 Build a Michelson Interferometer & Measure Refractive Index of Air

- *Complete set*
- *Cost effective solution*
- *Detailed instructional manual*
- *Easy alignment*

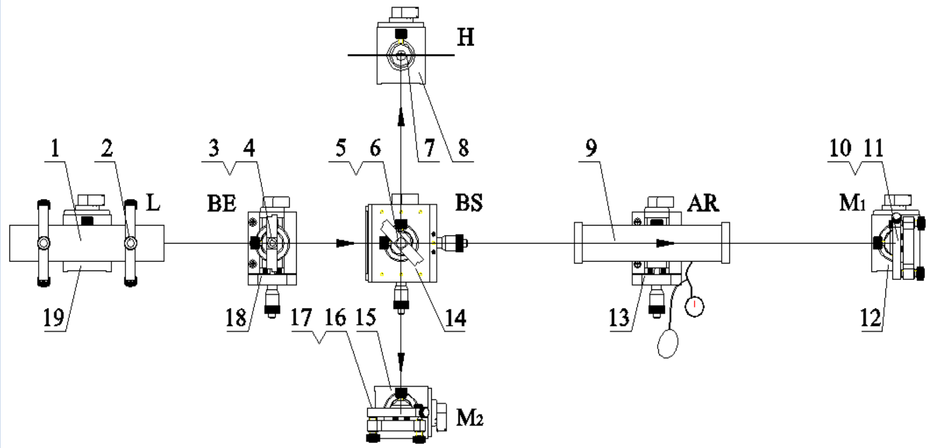


Figure 17-1 Schematic of experiment setup

1: He-Ne Laser L (LLL-2)	9: Air Chamber with Pump (*AR)*
2: Laser Holder (SZ-42)	10, 16: Kinematic Holder (SZ-07)
3,5: Lens Holder (SZ-08)	11, 17: Flat Mirror M_1, M_2
4: Beam Expander Lens L_1	8,12,13,14,19: Magnetic Base (SZ-04)
6: Beam Splitter *BS* (5:5)	15,18: Two-Axis Stage (SZ-02)
7: White Screen *H* (SZ-13)	

Theory

Figure 17-2 shows a schematic of a Michelson interferometer. A beam of light from the light source *S* strikes the beam-splitter *BS*, which reflects 50% of the incident light and transmits the other 50%. The incident beam is therefore split into two beams; one beam is transmitted toward the mirror M_1, the other is reflected toward the mirror M_2. The light reflected from M_1 transmits through the beam-splitter to the observer's eye *E*, and the other light reflected from M_2 is reflected by the beam-splitter *BS* to the observer's eye *E*.

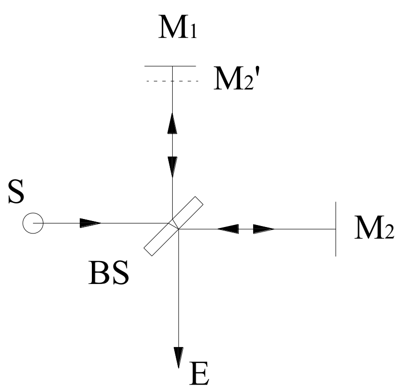


Figure 17-2 Schematic of Michelson interferometer

Since the beams are from the same light source, their phases are highly correlated. When a lens is placed between light source and beam-splitter, the light ray spreads out, and an interference pattern of dark and bright rings, called interference fringes, can be seen by observer.

If we place an air chamber in the light path between beam splitter and mirror M_2, and change the density of the air (by deflating or pumping the air in the air chamber), then the distance of light path will change by δ. It will generate a certain number of interference fringes. $\delta = 2\Delta n l = N\lambda$, so $\Delta n = N\lambda / 2l$ (17-1)

Where *l* is length of the air chamber λ is the wavelength of the light source, and *N* is the number of fringes counted. The refractive index of air *n* is dependent upon both temperature and pressure. If *n* is near unity, then *n*-1 is directly proportional to the density of the gas, ρ. For ideal gas, we get:

$$\frac{\rho}{\rho_0} = \frac{n-1}{n_0-1} \quad (17\text{-}2)$$

Therefore,

$$\frac{\rho}{\rho_0} = \frac{PT_0}{P_0T} \quad (17\text{-}3)$$

where T is the absolute temperature, P is the pressure. So we get

$$\frac{PT_0}{P_0T} = \frac{n-1}{n_0-1} \quad (17\text{-}4)$$

When temperature is constant, then

$$\Delta n = \frac{(n_0-1)}{P_0}\Delta P \quad (17\text{-}5)$$

Because $\Delta n = N\lambda / 2l$, we have

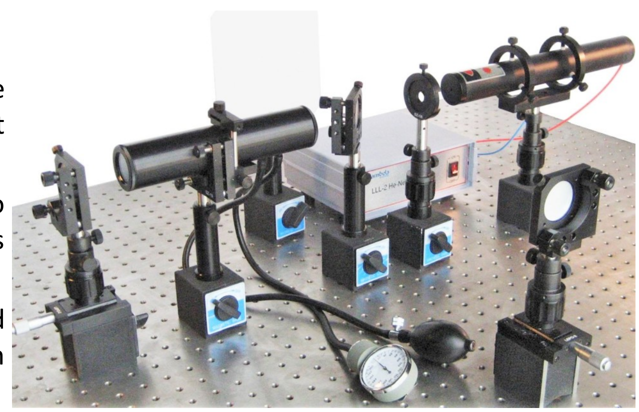
$$\frac{(n_0-1)}{P_0}\Delta P = N\lambda / 2l \quad (17\text{-}6)$$

Thus

$$n_0 = 1 + \frac{N\lambda}{2l} \times \frac{P_0}{\Delta P} \quad (17\text{-}7)$$

Note: the standard atmospheric pressure, P_0, is 101.3 kPa or 760 mm Hg; l = 200 mm.

Experiment Procedures



1. Refer to Figure 17-1, align all components in same height;
2. Adjust the output of the He-Ne laser to be parallel to the table surface (beam expander lens should not be inserted at this moment);
3. Put in a beam splitter *BS* at an angle of 45° with respect to beam axis, and adjust its tilt to make the two beams (transmission and reflection) parallel to table;
4. Adjust the tilt of mirrors M_1 and M_2 to make the reflected beams coincide with their incident paths, and the two beam spots on the screen *H* overlap together;
5. Insert a beam expander L_1, finely adjust beam splitter, M_1 and M_2, till concentric interference rings can be observed on the screen *H*;
6. Insert an air chamber between beam splitter and M_1, adjust it to be parallel to optical path, pump air into the air chamber till a maximum permit pressure (e.g. 40 kPa or 300 mm Hg) is reached and write as ΔP;
7. Slowly release the air valve, count the number of interference rings changed in the center till air pressure falls to zero (using the provided manual counter);
8. Repeat steps 6 and 7 several times to obtain averaged data;
9. Calculate the refractive index of air using equation (17-7).

Note: the optical path difference between the two interference beams should be proper to achieve a good viewing effect of the interference pattern.

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