Unit-12　Michelson Interferometer II

Objective：

Use Michelson Interferometer to measure the refraction index of the glass.

Apparatus：

Michelson interferometer (include lens, beam splitter and mirror), He-Ne laser, glass, screen

Principle：

The speed of light in vacuum, commonly denoted $c = \nu\lambda$. Its exact value is 3×10^{8} m/s. That ν is frequency and λ_0 is wavelength. When the light propagates through materials, the wavelength will be change. It can be expressed as $\lambda = \lambda_0/n$.

A glass plate in one of the arms is rotated through a small measured angle, the path of light will be changed, and the number of fringes corresponding to this change may be counted. The exact method of performing this experiment will be described in a later paragraph. As shown in figure 1.

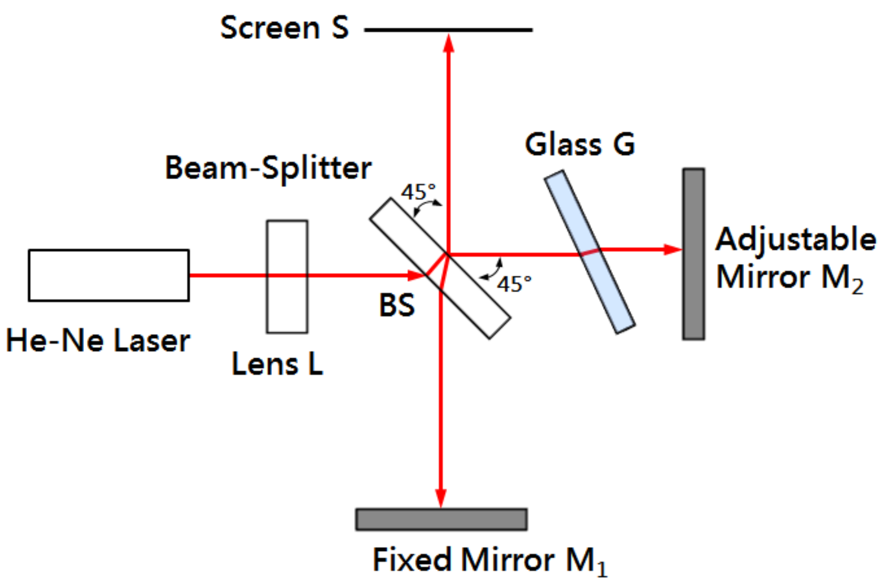

Figure 1. Experiment set-up

By Michelson Interferometer experiment 1, Δl is optic path length and Δm is the change number of fringes. Then,

$$2\Delta l = \lambda \Delta m \tag{1}$$

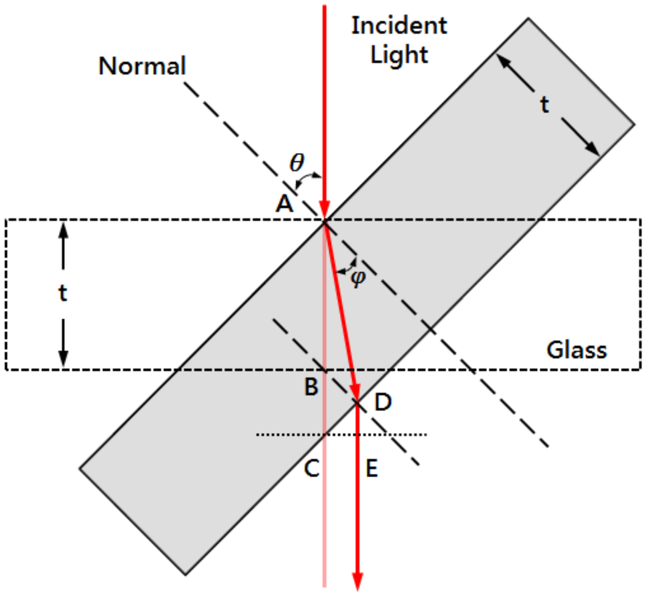

Figure 2. Optic path schematic

Using Snell's law

$$n_0 \sin \theta = n \sin \varphi$$

That, n is the index of refraction of glass, n_0 is the index of refraction of air (n_0=1)

The index of refraction of glass is

$$n = \frac{\sin \theta}{\sin \varphi}$$

As shown in figure 2. The total optical path between A and C for the light going in one direction is

$$n\overline{AB} + \overline{BC} \tag{2}$$

After the glass is rotated through an angle θ, this optical path has been increased to

$$n\overline{AD} + \overline{DE} \tag{3}$$

By equation (2) and (3), that the total optical path is

$$\Delta l = \left(n\overline{AD} + \overline{DE}\right) - \left(n\overline{AB} + \overline{BC}\right) \tag{4}$$

Substitute equation (4) into equation (1)

$$2\left(n\overline{AD} + \overline{DE} - n\overline{AB} - \overline{BC}\right) = \lambda \Delta m$$

When $\overline{AB} = t$, $\overline{AD} = \dfrac{t}{\cos\varphi}$, $\overline{BC} = \dfrac{t}{\cos\theta} - t$, $\overline{DE} = \overline{CE}\tan\theta = \dfrac{t\sin(\theta-\varphi)\sin\theta}{\cos\varphi\cos\theta}$

That the index of refraction of glass is

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

Remarks：

1. Do not look directly at an operating laser; it will cause serious eye injury.
2. Do not touch the mirror of optical element or switch on and off the laser repeatedly.
3. Make sure your laser beam won`t hurt anyone else. If you need move laser, please block the beam or turn it off first in case of any possible hazards.
4. Do not let laser emit out of your table.
5. When the experiment is conducted, do not walk beside the table in case of vibration.
6. If the fringes are not perfectly circular, it would not influence the measurement of number *n*.

Procedure：

1. Adjusts Michelson interferometer to make the interference fringes on the screen.
2. Place the rotating table between the beam-splitter *BS* and adjustable mirror M_2
3. Position the pointer so that its□0° on the Vernier scale is lined up with the zero on the degree scale on the interferometer base.
4. Slowly rotate the table by moving the lever arm.
5. Count the number of fringe transitions Δm that occur as you rotate the table from 0 degrees to an angle θ.
6. Calculate the index of refraction of glass.

7. Repeat above steps.
   [Note] t is the thickness of glass and λ is the wavelength of the laser.

Questions：

1. If we do not turn the glass to be measured but to change the relative position of the moving mirror, whether the glass can still be measured refractive index? Please explain.
2. Is it possible to obtain the refractive index of air at atmospheric pressure using a Michelson interferometer? Please explain.