Construct, Conduct & Comprehend Physics Experiments

LEOK-3-18 Constructing a Mach-Zehnder Interferometer and Measuring Refractive Index of Air

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

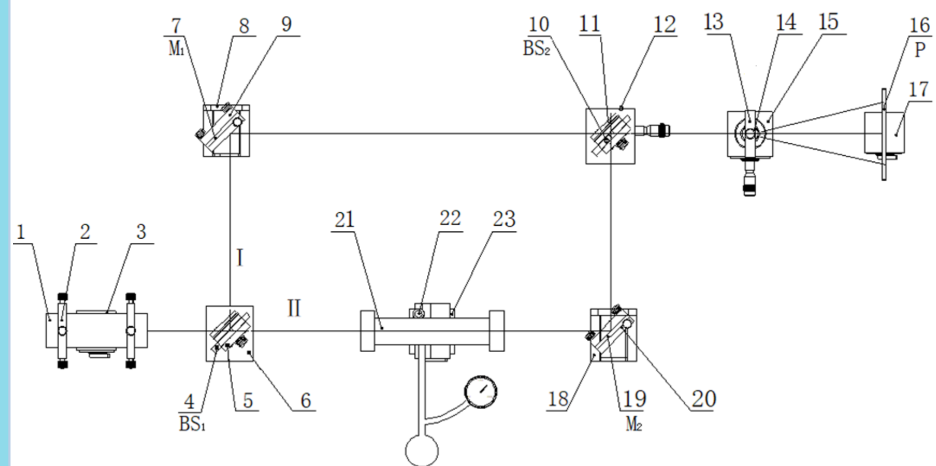

Figure 18-1 Schematic of experiment setup

1: He-Ne Laser L (LLL-2)	13: Lens Holder (SZ-08)
2: Laser Holder (SZ-42)	14: Beam Expender (*f'*=4.5 mm)
3: Magnetic Base (SZ-04)	15: Magnetic Base (SZ-04)
4: Beam Splitter (5:5, BS_1)	16: White Screen (SZ-13)
5: Plate Holder (SZ-12)	17: Magnetic Base (SZ-04)
6: Magnetic Base (SZ-04)	18: Magnetic Base (SZ-04)
7: Flat Mirror M_1	19: Flat Mirror M_2
8: Magnetic Base (SZ-04)	20: Two-axis Holder (SZ-07)
9: Two-axis Holder (SZ-07)	21: Air Chamber with Pump & Gauge
10: Beam Splitter (5:5, BS_2)	22: Bar Holder (SZ-19)
11: Plate Holder (SZ-12)	23: Magnetic Base (SZ-04)
12: Magnetic Base (SZ-04)	

Theory

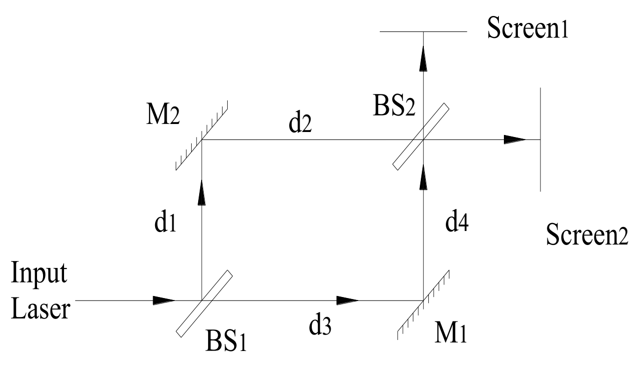

Figure 18-2 Schematic of Mach-Zehnder interferometer

Mach-Zehnder interferometer (MZI) is derived from the Michelson interferometer for studying the change in the wave front when the light wave passing through an object of interest. The schematic diagram of the Mach-Zehnder interferometer is shown in Figure 18-2.

The light beam from a He-Ne laser is divided by beam splitter BS_1 into two beams of equal intensity. After reflected by mirrors M_1 and M_2, the two beams are recombined via a second beam splitter (BS_2). Then the interference pattern can be observed on a viewing screen in either path, i.e. at location Screen1 or Screen2, and the intensity distributions of interference patterns at the two locations are complementary.

Experiment Procedures

A MZI is frequently used in the fields of plasma physics, aerodynamics, and heat transfer for the measurement of density, pressure, and temperature changes in gases. In this experiment, we will construct a MZI to measure the refractive index of air.

1. Refer to Figure 18-1, align all the components at same height on an optical table. At this moment, the beam expander and the air chamber should not be placed in the light path;
2. Adjust the output of the He-Ne laser to make it parallel to the surface of the optical table;
3. Adjust beam splitter BS_1 at an angle of 45° with respect to the beam axis, and adjust its tilt so that the two beams (transmission and reflection) are parallel to the table;
4. Adjust mirrors M_1 and M_2 until the light beams reflected by them parallel to the table surface and strike at the same position on BS_2;
5. Insert the beam expander in either path after BS_2, interference pattern should be observed on the screen (if not, repeat the above steps); depending on the situation of the intersection angle of the two interference beams, the pattern shape could be rings, partial rings or straight lines.
6. Finely adjust the tilt angle of M_2, observe the change in interference pattern;
7. For the measurement of air refractive index, insert the air chamber (mounted with SZ-19 and magnetic base) into one arm of the Mach-Zehnder setup, adjust the chamber parallel to optical path, pump air into the air chamber till the maximum permit pressure is reached (40 kPa or 300 mm Hg) and write as ΔP;
8. Slowly release the air valve, count the number N of interference rings changed in the center (or shifted across a fixed point in case of straight fringes) till air pressure falls to zero (using the provided hand tally counter);
9. Repeat steps 7 and 8 several times to obtain averaged data;
10. Calculate the refractive index of air according to theoretical formula $n_0 = 1 + \frac{N\lambda}{l} * \frac{P_0}{\Delta P}$. The standard atmospheric pressure, P_0, is 101.3 kPa or 760 mm Hg; l=200 mm, λ=632.8 nm.

   (Refer to previous experiment of “Construct a Michelson Interferometer and Measure Refractive Index of Air”. Use the same theory formula to calculate the refractive index of air except the light only passes through the air chamber once while passing through twice in Michelson interferometer.)

Optional experiments: Insert a glass sheet, or put a heating source to heat the air in one arm, observe the change in interference patterns. Knock the optical table and see any changes in the interference pattern.

Note:

1. Since the He-Ne laser source is polarized, may rotate the laser tube to adjust the polarization direction of the input beam to enabling the light intensities in the two arms as closer as possible.
2. For correctly using the beam splitter, please set the front surface of the beam splitter to face to the incident light and let the light reflected from the front surface.

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