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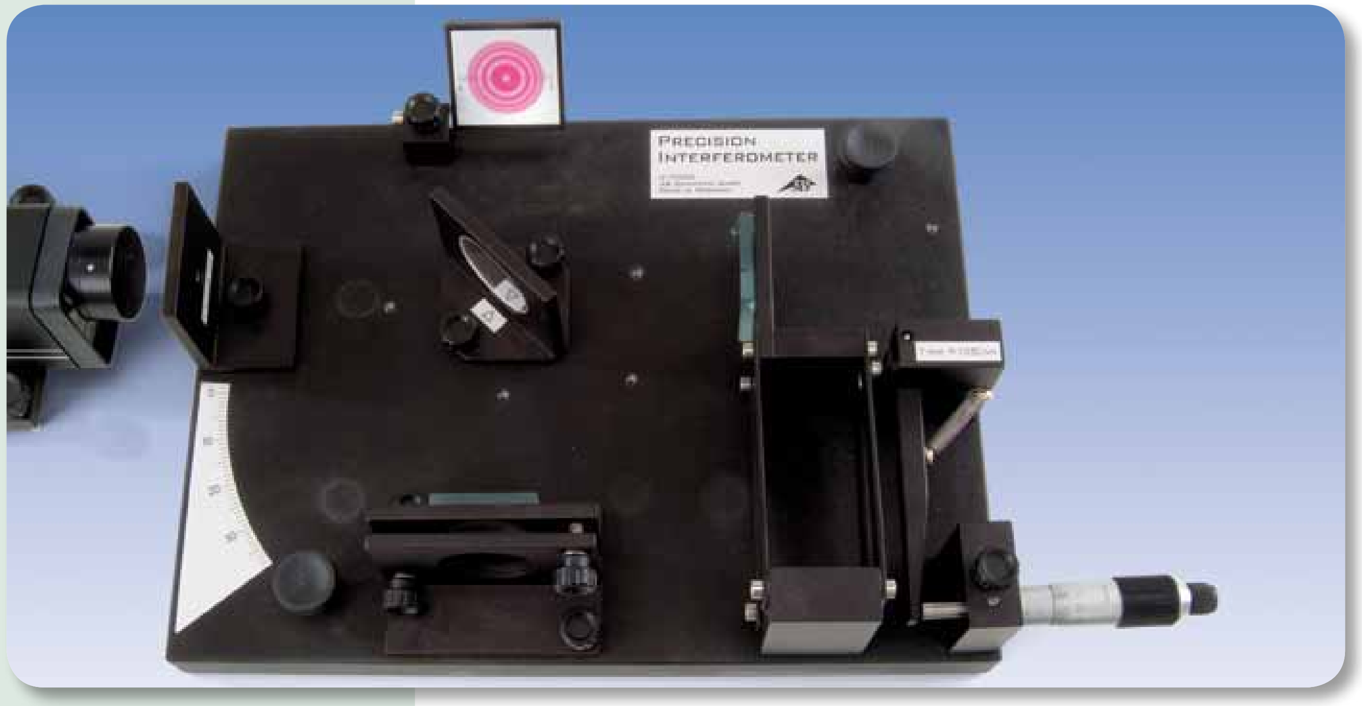
MICHELSON INTERFEROMETER



EXPERIMENT PROCEDURE

- **Determine the wavelength of laser light.**
- **Determine the refractive index of air as a function of pressure.**
- **Determine the refractive index of glass.**
- **Determine the quality of the surface of a strip of adhesive tape.**

OBJECTIVE

Demonstrate and investigate how a Michelson interferometer works.

SUMMARY

In a Michelson interferometer a coherent light beam is separated into two rays travelling in different directions by inserting a half-silvered mirror in the path. The separated beams are reflected back along themselves and then recombined. The viewing screen then exhibits an interference pattern that changes perceptibly when the optical path lengths for each of the split beams are changed by fractions of the wavelength of light.

REQUIRED APPARATUS

Quantity	Description	Number
1	Interferometer	**1002651**
1	Accessory Set for the Interferometer	**1002652**
1	He-Ne Laser	**1003165**
1	Vacuum Hand Pump	**1012856**
1	Tubing, Silicone 6 mm	**1002622**

Glass plate in the beam path of the Michelson-interferometer.

Vacuum chamber in the beam path of the Michelson-interferometer.

2

UE4030410

BASIC PRINCIPLES

The Michelson interferometer was invented by *A. A. Michelson* originally to demonstrate whether the Earth could be observed to be in motion through an ether in which light was once thought to propagate. His design (see Fig. 1) has nevertheless proved crucial for making interferometric measurements, e.g. of changes in length, thickness of layers or refractive indices.

A divergent light beam is split into two by a half-silvered mirror and the two resulting beams travel along differing paths. They are then reflected back on themselves and recombined so that interference patterns can be viewed on a screen. The resulting pattern is highly sensitive to any differences in the optical paths covered by the split beams. If the refractive index remains constant the degree of change in the geometric paths can be calculated, e.g. changes in size of various materials due to thermal expansion. If by contrast the geometry is maintained, then refractive indices or changes in them due to pressure, temperature or density variations may be determined.

Depending on whether the optical paths are increased or decreased in length, interference lines may appear or disappear in the centre of the pattern. The relationship between the change Δs in the optical paths and the wavelength λ is as follows

(1) $$2 \cdot \Delta s = z \cdot \lambda$$

The number z is a positive or negative integer corresponding to the number of interference lines appearing or disappearing on the screen.

If the wavelength of light in air is to be measured by moving one of the two mirrors by a carefully defined distance Δx by means of a fine adjustment mechanism, the refractive index can be assumed to be $n = 1$ to a good approximation. The change in the optical path is thus:

(2) $$\Delta s = \Delta x$$

The situation is different if an evacuated chamber of length d is inserted into only one of the split beams. By allowing air to pass into the vessel until the pressure rises to a value p, the optical path changes as follows

(3) $$\Delta s = \left(n\left(p\right) - 1\right) \cdot d = A \cdot p \cdot d$$

This is because the refractive index of air at constant temperature varies with pressure in a fashion that can be represented in the following form:

(4) $$n\left(p\right) = 1 + A \cdot p$$

NOTE

The supplementary kit contains a glass plate. This can be placed in the path of one light beam and rotated to a specific angle so that the portion of the optical path that passes through the glass increases while that portion of the path outside the glass decreases. The resulting change in the optical path allows the refractive index of glass to be determined. It is also possible to demonstrate the surface quality of a strip of adhesive tape attached to the glass. In practice such experiments are performed using a *Twyman-Green*-interferometer, which is a variant of the Michelson-interferometer.

EVALUATION

Solving Equations (1) and (2) for wavelength gives an equation for the wavelength that depends on the change in position of the mirror:

$$\lambda = \frac{2 \cdot \Delta x}{z}$$

Determining the refractive index of air: The coefficient A that appears in Equation (4) can be calculated using the following equation

$$A = \frac{z \cdot \lambda}{2 \cdot d \cdot p}$$

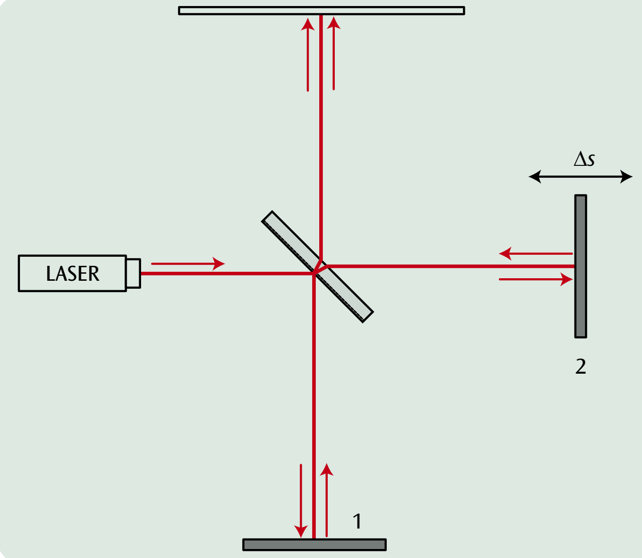


Fig. 1: Optical paths in a Michelson interferometer with a movable mirror.

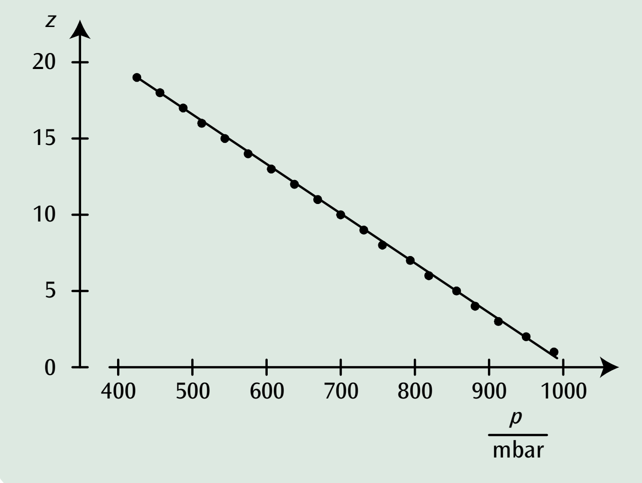


Fig. 2: Number of interference lines as a function of air pressure.