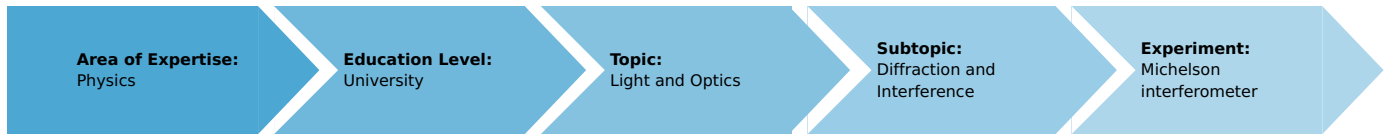


Michelson interferometer (Item No.: P2220500)

Curricular Relevance



Difficulty



Difficult

Preparation Time



1 Hour

Execution Time



2 Hours

Recommended Group Size



2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Interference, wavelength, refractive index, velocity of light, phase, virtual light source

Introduction

Overview

In the Michelson arrangement interference will occur by the use of 2 mirrors. The wavelength is determined by displacing one mirror using the micrometer screw.



Fig. 1: Experimental set-up for measuring wavelengths with the Michelson interferometer.

Equipment

Position No.	Material	Order No.	Quantity
1	Michelson interferometer	08557-00	1
2	Laser, He-Ne 1.0 mW, 220 V AC	08181-93	1
3	Swinging arm	08256-00	1
4	Lens, mounted, $f = +20$ mm	08018-01	1
5	Lens holder	08012-00	1
6	Slide mount f. opt. pr.-bench, $h = 30$ mm	08286-01	3
7	Optical profile bench $l = 60$ cm	08283-00	1
8	Base f. opt. profile-bench, adjust.	08284-00	2
9	Screen, metal, 300x300 mm	08062-00	1
10	Barrel base -PASS-	02006-55	1

Task

Determination of the wavelength of the light of the used laser.

Set-up and procedure

The experimental set up is as shown in Fig. 1. In order to obtain the largest possible number of interference fringes, the two mirrors of the interferometer are first of all adjusted; to do this, the lens is first of all removed. The laser beam strikes the half-silvered mirror at an angle of 45° splitting the beam. The resulting two beams are reflected by the mirror and impinge on the screen. By means of the two adjusting screws fitted to one of the mirrors, both points of light are made to coincide. If the lens is placed in the light beam, the points of light are enlarged and the interference patterns are observed on the screen (bands, circles). By careful readjustment, an interference image of concentric circles will be obtained.

To measure the wavelength, the micrometer screw is turned to any initial position at which the centre of the circles is dark. The micrometer screws is now further turned in the same direction and the light-dark per ods thus produced are counted. The distance travelled by the mirror must be read off on the micrometer screw and divided by ten (lever reduction 1:10). Should the central point of the circles move outside the light spot area a readjustment has to be performed.

Caution: Never look directly into a non attenuated laser beam

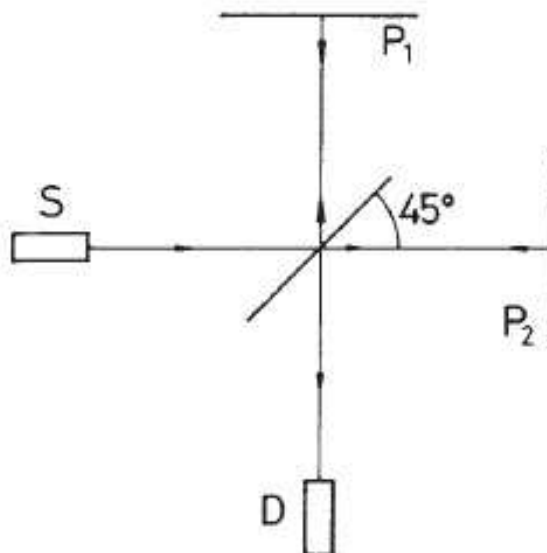


Fig. 2: Michelson interferometer set up.

Theory and evaluation

If 2 waves of the same frequency ω but of different amplitude and different phase impinge on one point they are superimposed, or interfere, so that:

$$y = a_1 \sin(\omega t - \alpha_1) + a_2 \sin(\omega t - \alpha_2)$$

The resulting wave can be described as

$$y = A \sin(\omega t - \alpha)$$

with the amplitude

$$A^2 = a_1^2 + a_2^2 + 2a_1 a_2 \cos \delta \tag{1}$$

and the phase difference

$$\delta = \alpha_1 - \alpha_2$$

In a Michelson interferometer, light is split up into two beams by a half-silvered glass plate (amplitude splitting), reflected by two mirrors, and passed again through the glass plate to produce interference phenomena behind it.

A lens is inserted between the light beam and the glass plate so that the light source lies at the focal point, since only enlarged light spots can exhibit interference rings.

If the actual mirror M_1 is replaced by its virtual image $M_1 = M_2$ which is formed by reflection at the glass plate, a point P of the real light source is formed as the points P' and P'' of the virtual light sources L_1 and L_2 .

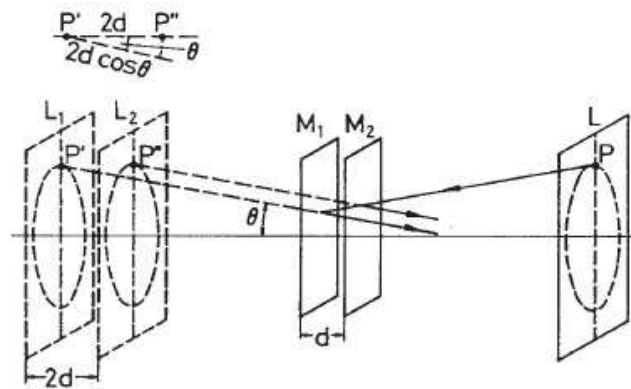


Fig. 3: Formation of circles on interference.

Based on the different light paths, the phase difference, using the symbols of Fig. 3, is:

$$\delta = \frac{2\pi}{\lambda} 2d \cos \Theta \tag{2}$$

where λ is the wavelength of the light used in the experiment.

The intensity distribution $a_1 = a_2 = a$ for according to (1) is:

$$I \sim A^2 = 4a^2 \cos^2 \frac{\delta}{2} \tag{3}$$

Maxima thus occur if δ is a multiple of 2π , i.e. from equation (2), if

$$2d \cos \Theta = m\lambda ; m = 1, 2, \dots \tag{4}$$

i.e. circles are produced for a fixed value of m and d since Θ remains constant (see Fig. 3).

If the position of the movable mirror M_1 is changed so that d for example decreases then, according to equation (4), the diameter of the ring will also decrease since m is fixed for this ring. A ring thus disappears each time d is reduced by $\lambda/2$. The ring pattern disappears if $d = 0$.

If M_1 and M_2 are not parallel, curved bands are obtained which are converted to straight bands when $d = 0$.

To measure the wavelength of the light, 500 ring changes were counted. A $158 \mu\text{m}$ displacement of the mirror was measured. From this, the wavelength was obtained as:

$$\lambda = 632 \text{ nm}$$