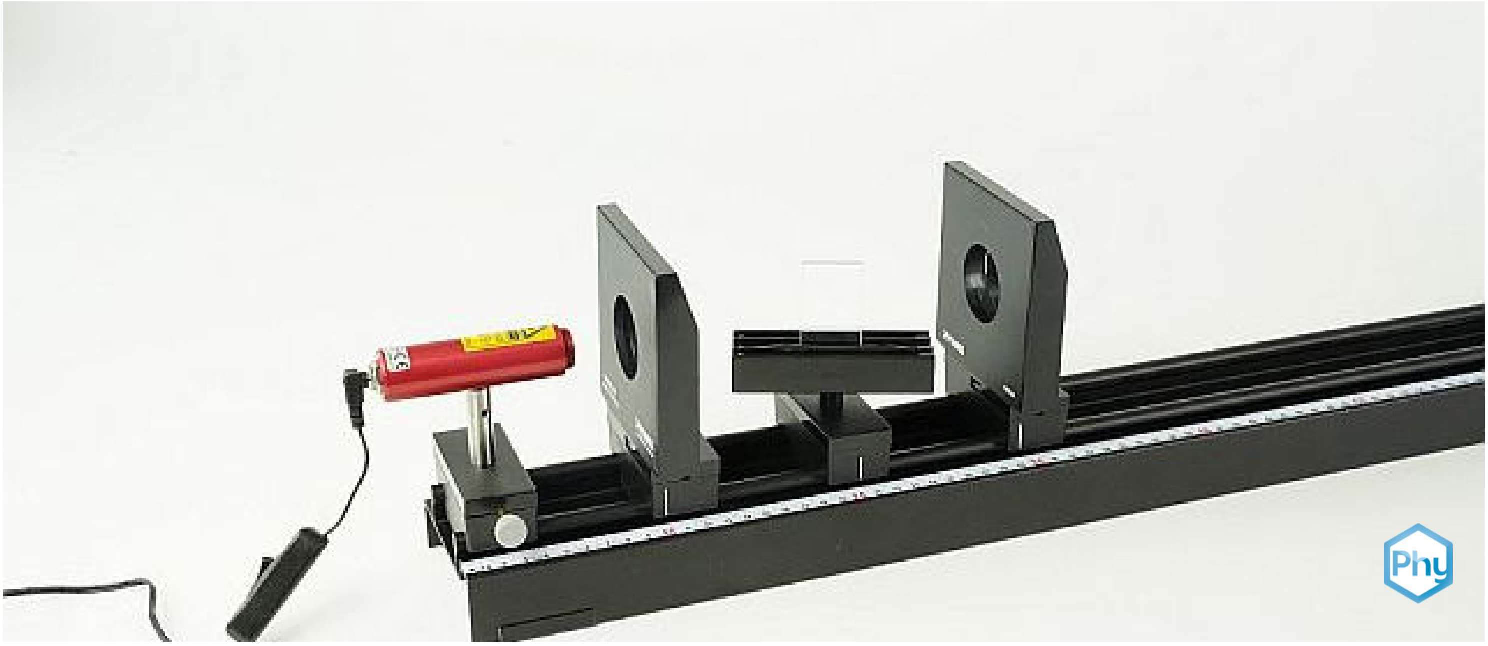
Generation of interferences with a Fresnel double mirror



If you let a widened laser beam fall on two plane mirrors that are slightly inclined towards each other by a small angle, you get two coherent light beams by reflection that interfere with each other in their overlapping area. An interference pattern of parallel light and dark stripes appears on a screen.

Physics | Light & Optics | Diffraction & interference

Difficulty level	Group size	Preparation time	Execution time
medium	-	10 minutes	20 minutes

This content can also be found online at:

http://localhost:1337/c/647c6b96fc0e690002ec71de

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

General information

Application

Experimental setup

If you let a widened laser beam fall on two plane mirrors that are slightly inclined towards each other by a small angle, you get two coherent light beams by reflection that interfere with each other in their overlapping area.

One screen shows an interference pattern of parallel light and dark stripes.

Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Other teacher information (1/2)

PHYWE

Prior knowledge

To understand this experiment, the students should already be familiar with the wave behaviour of light. For illustration purposes, it can be helpful to show interference of water waves beforehand.

Principle

When a divergent light beam hits a Fresnel double mirror, two waves are created that shine from two virtual coherent light sources.

If the two partial waves are projected onto a screen, interference fringes are visible in the area where the two reflected waves overlap.

Other teacher information (2/2)

PHYWE

Learning objective

Interference is also possible with the help of a Fresnel double mirror, as this creates two interfering light beams from one divergent light beam.

With the help of the distance between the k-ten and 0-The wavelength of the diode laser can be calculated by using the highest maximum on the screen and the distance between the two virtual sources.

Tasks

- Generation of interference with the aid of a Fresnel double mirror.
- Observing the interference pattern.
- Calculate the wavelength of the diode laser.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Safety instructions

PHYWE

It is essential to avoid looking directly into the laser light.

The general instructions for safe experimentation in science lessons apply to this experiment.

Theory (1/3)

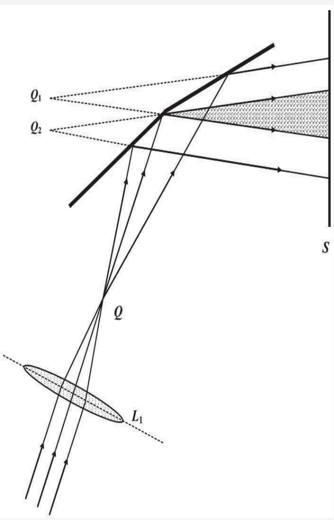


Fig. 1

To generate two light beams capable of interfering, a laser beam is made divergent with the help of a converging lens L_1. The divergent light beam hits a Fresnel double mirror and is reflected from there onto a screen S (Fig. 1).

In the overlapping area, the two light beams emanating from the virtual light sources Q_1 and Q_2 interfere.

If two rays emanating from the virtual sources should constructively interfere with each other on a screen at a distance r from the sources, their path difference Δl must be an integer multiple of the wavelength λ.

$$\Delta l = k * \lambda; k = \pm 1, \pm 2, \pm 3, \ldots \quad (1)$$

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Theory (1/3)

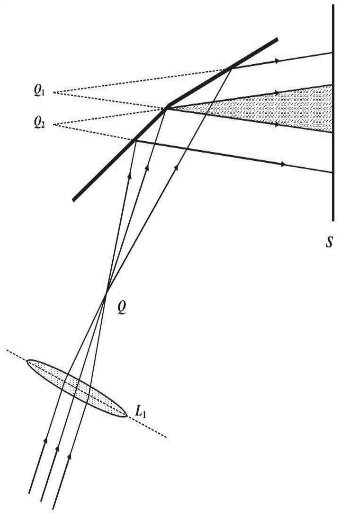


Fig. 1

To generate two light beams capable of interfering, a laser beam is made divergent with the help of a converging lens L_1. The divergent light beam hits a Fresnel double mirror and is reflected from there onto a screen S (Fig. 1).

In the overlapping area, the two light beams emanating from the virtual light sources Q_1 and Q_2 interfere.

If two rays emanating from the virtual sources should constructively interfere with each other on a screen at a distance r from the sources, their path difference Δl must be an integer multiple of the wavelength λ.

$$\Delta l = k * \lambda; k = \pm 1, \pm 2, \pm 3, \ldots \quad (1)$$

Theory (2/3)

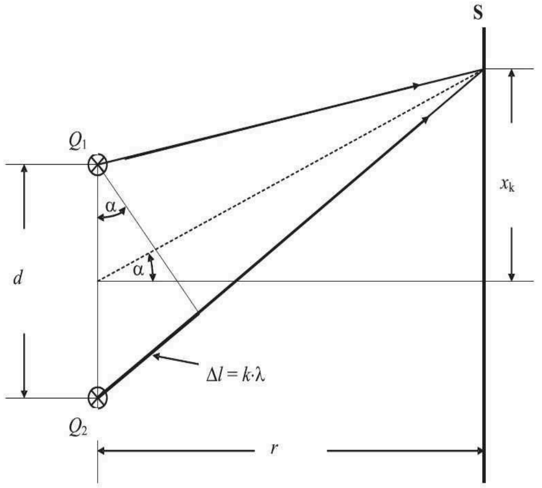


Fig. 2

Denoted by x_k the distance between the k-ten and 0-th maximum on the screen and is d is the distance between the two sources, then according to Fig. 2 for small angles α:

$$\Delta l = k * \lambda = d * \sin\alpha \cong d * \tan\alpha$$
$$\cong d * \frac{x_k}{r} \rightarrow \lambda = \frac{x_k}{k} * \frac{d}{r} \quad (2)$$

To determine the distance d of the virtual sources are collected by the latter with a second collecting lens. L_2 Two real images on the screen Q_1^* und Q_2^* generated, whose distance B can now be determined (see Fig. 3).

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Equipment

Position	Material	Item No.	Quantity
1	Optical profile-bench, l = 1000 mm	08370-00	1
2	Diodelaser 0.2/1 mW; 635 nm	08760-99	1
3	Fixing unit for diode laser	08384-00	1
4	Slide mount for optical bench	09822-00	1
5	Mount with scale on slide mount	09823-00	2
6	Lens, mounted, f +50 mm	08020-01	1
7	Lens, mounted, f +150 mm	08022-01	1
8	Fresnel mirror on plate	08561-00	1
9	Plate mount for three objects	09830-00	1
10	Screen, metal, 300 x 300 mm	08062-00	1
11	Barrel base expert	02004-00	1
12	Vernier calliper stainless steel 0-157mm, 1/20	03010-00	1
13	Measuring tape, l = 2 m	09936-00	1

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Equipment

PHYWE

Position	Material	Item No.	Quantity
1	Optical profile-bench, l = 1000 mm	08370-00	1
2	Diodelaser 0.2/1 mW; 635 nm	08760-99	1
3	Fixing unit for diode laser	08384-00	1
4	Slide mount for optical bench	09822-00	1
5	Mount with scale on slide mount	09823-00	2
6	Lens, mounted, f +50 mm	08020-01	1
7	Lens, mounted, f +150 mm	08022-01	1
8	Fresnel mirror on plate	08561-00	1
9	Plate mount for three objects	09830-00	1
10	Screen, metal, 300 x 300 mm	08062-00	1
11	Barrel base expert	02004-00	1
12	Vernier calliper stainless steel 0-157mm, 1/20	03010-00	1

Additional Equipment

PHYWE

Position	Equipment	Quantity
1	Sellotape	1
2	white sheet of paper	1

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Set-up and Procedure

Set-up

The experimental set-up is as shown in the figure, the tally marks of the tabs for holding the components have the following positions on the optical bench:

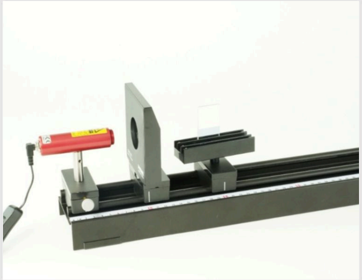
- Slider with diode laser at $2cm$
- Frame with scale and inserted lens $f = +50cm$ bei $13cm$
- Slider with plate holder for Fresnel mirror at $24cm$
- Frame with scale for lens $f = +150cm$ bei $36cm$

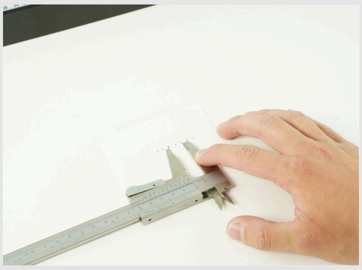
The barrel base with umbrella is located at a distance $r \leq 3m$ to the Fresnel mirror.

Structure incl. screen

Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Procedure (1/2)





The laser beam is aligned parallel to the optical axis. With the aid of the converging lens $L_1 (f = +50 mm)$ the laser beam is made divergent.

Insert the Fresnel mirror into one of the outer rails of the plate holder and turn the plate holder slightly until both parts of the mirror are hit by the expanded laser beam in approximately the same way.

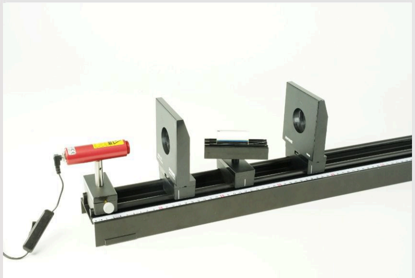
To determine the distance between the interference fringes, a white sheet of paper is previously attached to the screen with sellotape. With the help of a water-soluble felt-tip pen, the centres of the bright stripes are now marked at the same height and their distances are determined with the help of the calliper after removing the paper. To determine the distance between two maxima as accurately as possible, it is useful to measure 10 - 15 lines.

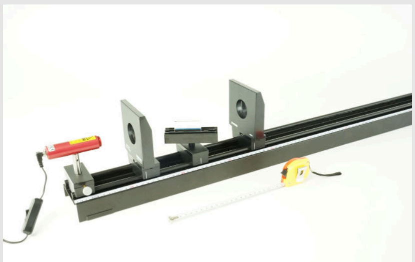
Procedure (2/2)

Finally, bring the converging lens $L_2 (f = +150 mm)$ into the beam path and sharply images the virtual light sources in the projection plane. A third pixel not to be considered is caused by the direct laser light passing the mirror.

To determine the wavelength of the laser light, the following distances must be determined at the end:

- Distance B of the pixels of the virtual sources
- Distance b From Collective Lens L_2 and screen S
- Distance $L_1 L_2$ of the collective lenses L_1 and L_2





PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

Tel.: 0551 604 - 0
Fax: 0551 604 - 107

info@phywe.de
www.phywe.de

Evaluation

Evaluation (1/2)

Maxima and minima always have the same distance?

- True
- False

Check

The evaluation of the experiment provides the following values:

$$x_k = 4,6cm$$

$$k = 14$$

$$L_1L_2 - f_1 = 18,0cm$$

$$B = 1,1cm$$

$$b = 316cm$$

This results in the wavelength of the diode laser:

$$\lambda = \frac{4,6}{14} * \frac{18*1,1}{316*(316+18)} cm = 6,16 * 10^{-5} cm = 616nm$$

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Evaluation (2/2)

What does constructive interference mean?

- Constructive interference is amplification and is characterised by the fact that the two superimposed waves constantly reinforce each other.
- Constructive interference is a cancellation and is characterised by the fact that the two superimposed waves constantly cancel each other out.

What does this stand for x_k?

- With x_k is the distance between the k-ten and 0-th minimum on the screen.
- With x_k is the distance between the k-ten and 0-th maximum on the screen.

PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de