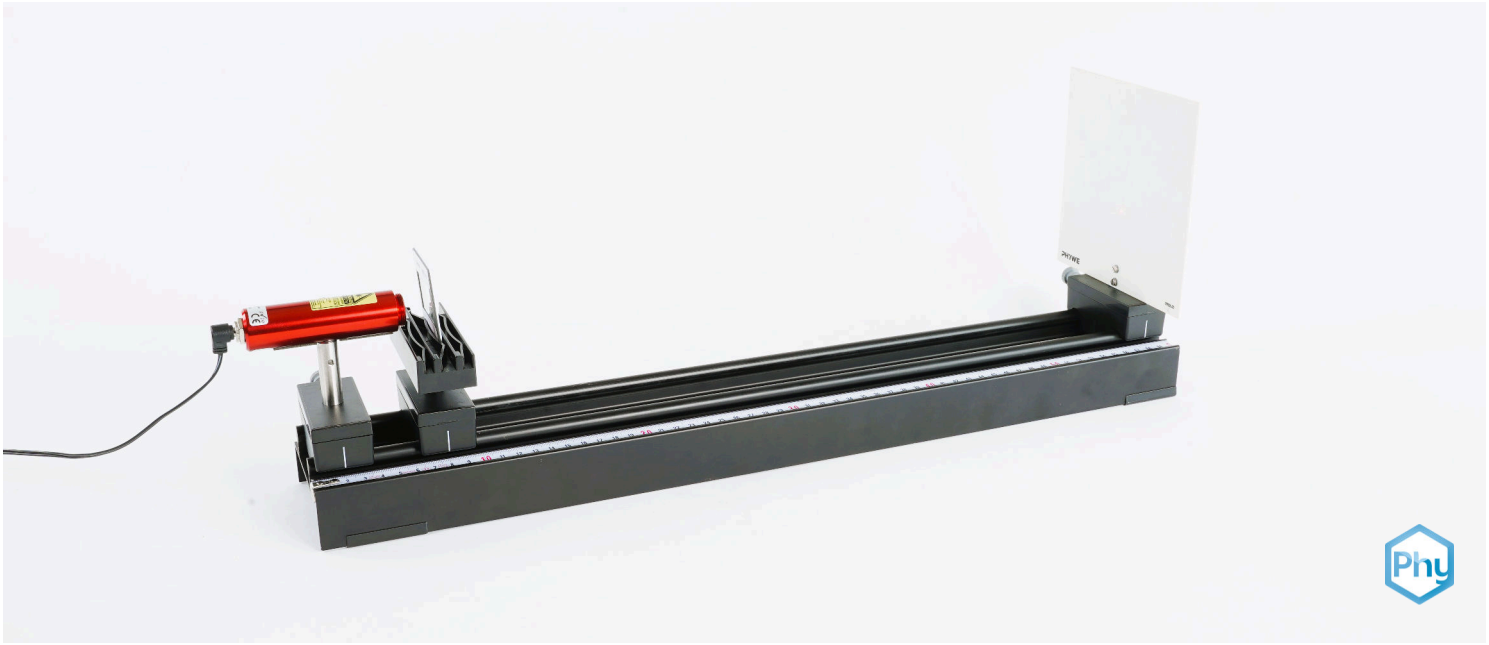
Diffraction at a narrow obstacle with laser



Babinet's theorem states that complementary objects (slit bar or wire) provide diffraction patterns that are identical outside the central maximum. In this experiment, Babinet's theorem is investigated by diffraction from a bar.

Physics > Light & Optics > Diffraction & interference

Difficulty level	Group size	Preparation time	Execution time
easy	-	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/6729fb8b26998c000267a30f

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

PHYWE

Teacher information

Application

Experimental setup

If light falls on a slit or a stripe, the light rays are bent at the edge of these objects and interference occurs. In everyday life, the diffraction at the bridge becomes visible when you look at the sun behind a tree trunk.

Babinet's theorem states that the interference patterns of a slit and a stripe of the same thickness are identical except for the first maximum.

When light falls through a door gap, it casts a shadow. The edges of this shadow are often blurred, as with a street lamp. This is due to diffraction effects.

PHYWE

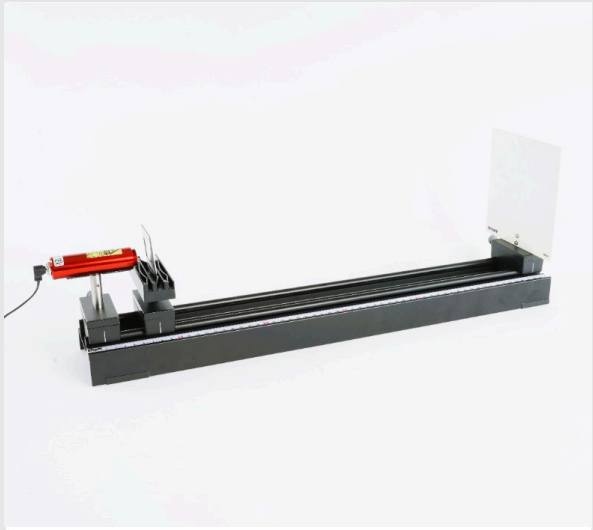
Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Application

PHYWE



Experimental setup

If light falls on a slit or a stripe, the light rays are bent at the edge of these objects and interference occurs. In everyday life, the diffraction at the bridge becomes visible when you look at the sun behind a tree trunk.

Babinet's theorem states that the interference patterns of a slit and a stripe of the same thickness are identical except for the first maximum.

When light falls through a door gap, it casts a shadow. The edges of this shadow are often blurred, as with a street lamp. This is due to diffraction effects.

Other teacher information (1/3)

PHYWE

Prior knowledge

In order to understand this experiment, more fundamental experiments on diffraction phenomena should already have been carried out, such as the experiment "Determining the wavelength of a laser with an optical grating".

Principle

If light falls on a diffraction object such as a stripe or a slit, the edges of this object are the starting points of elementary waves that interfere with each other. Only the distance between these sources plays a role in the interference pattern, not what lies between them.

This means that the interference patterns of columns and srtpes of the same width only differ in the first maximum, where the actual object is depicted.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Other teacher information (2/3)

PHYWE

Learning objective

Diffraction also takes place at a stripe, so that an interference pattern can be seen. Babinet's theorem states that the interference patterns of stripes and slits of the same width are identical except for the first maximum. This is because the edges of the diffraction object are always the starting points of the elementary waves that interfere.

Tasks

- Observe the interference patterns of the stripe and slit of the same width
- Interpreting and explaining the results

Other teacher information (3/3)

PHYWE

If a parallel beam of light falls on a stripe of width d the edge rays are diffracted at the edges of the obstacle according to Huygens' principle. As the rays emanate from the same light source, they penetrate the area of the geometric shadow as two wave systems in phase.

If the diffracted edge rays overlap somewhere in the centre axis of the shadow space, they always meet there in phase due to their identical path, i.e. there is always brightness on the centre axis of the shadow space. If the rays have a path difference of half a wavelength or an odd multiple thereof, they cancel each other out. Depending on the path difference, alternating brightness maxima and minima can now be observed on a screen.

If the bar is replaced by a slit of the same width, the same interference pattern can be observed except for the central brightness maximum.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

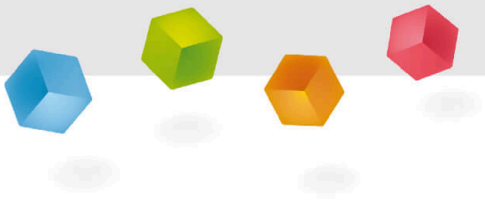
Safety instructions

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.

PHYWE



Student information

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Motivation

PHYWE

Diffraction of light on a dandelion

Light refers to the range of the electromagnetic spectrum that is visible to humans. Diffraction objects, such as a bar, can be used to observe a special phenomenon of light - the ability to interfere - which indicates the wave character of light.

Diffraction can be observed in everyday life when the sun is behind objects such as the stem of a dandelion: The stem appears slightly blurred at the edges.

This experiment shows which physical laws underlie this phenomenon and what a resulting diffraction pattern looks like.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Equipment

Position	Equipment	Item no.	Quantity
1	Optical profile bench for student experiments, l = 600 mm	08376-00	1
2	Rider for optical profile bench	09822-00	3
3	Plate holder for 3 objects	09830-00	1
4	Cover with gap, bar and edge	08521-00	1
5	Shade, white, 150 mm x 150 mm	09826-00	1
6	Diode laser, 1 mW, 635 nm (red-3V) with short stem, l = 75 mm	08771-99	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	Equipment	Item no.	Quantity
1	Optical profile bench for student experiments, l = 600 mm	08376-00	1
2	Rider for optical profile bench	09822-00	3
3	Plate holder for 3 objects	09830-00	1
4	Cover with gap, bar and edge	08521-00	1
5	Shade, white, 150 mm x 150 mm	09826-00	1
6	Diode laser, 1 mW, 635 nm (red-3V) with short stem, l = 75 mm	08771-99	1

Additional equipment

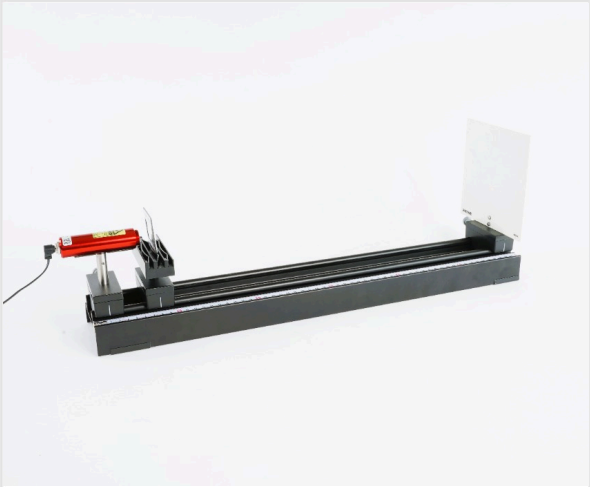
PHYWE

Position	Equipment	Quantity
1	Sellotape	1
2	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

Setup

PHYWE



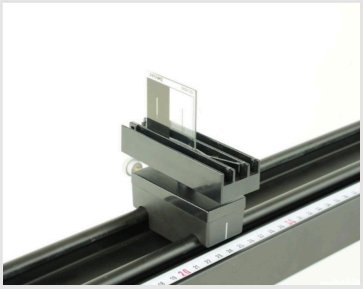
The experimental setup

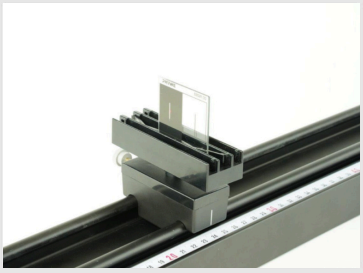
The screen is set up as shown in the illustration, with the screen positioned behind the profile bench.

- The diode laser is positioned at the head end of the optical bench (mark at $2\ \mathrm{cm}$).
- Close behind it is the plate holder with the aperture with the diffraction objects (mark at $8\ \mathrm{cm}$).
- The screen is fixed in the holder and positioned $1.5\ \mathrm{m}$ away from the aperture. A sheet of paper is attached to the screen with the surface normal pointing in the direction of the optical axis using adhesive tape.

Procedure

PHYWE





The aperture with the diffraction objects is moved in the plate holder so that the stripe is evenly illuminated by the laser light. Use a pencil to mark the positions of the minima of several diffraction orders.

Without changing the distance between the diaphragm and the screen, the slit is now pushed into the beam path. The positions of the minima are marked again.

Finally, the bar is illuminated again. The distance between the aperture and the screen is now changed by moving the screen. The interference pattern can be observed.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

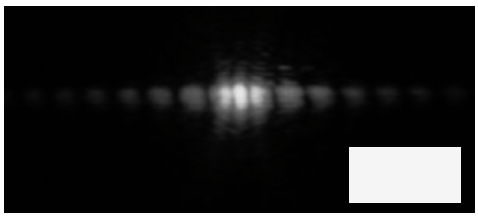
PHYWE

Report

Task 1

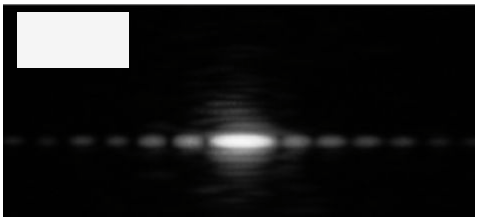
PHYWE

Assign the correct diffraction object to the interference patterns.



Stripe

Slit



After solving all tasks and clicking on "Show solutions" (last slide), additional information is displayed on this slide!

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Task 2 and 3

PHYWE

What is the difference between the diffraction patterns of a stripe and a slit of the same width?

- [ ] The diffraction pattern of the slit is brighter.
- [ ] The first maximum is divided into three parts for the stripe, but not for the slit.
- [ ] The minima are located in different places.

Check

Light falls on a diffraction object. What does the distance between the interference maxima depend on?

- From the material of the diffraction object.
- From the width of the diffraction object.
- From the type of diffraction object (slit or stripe).

Task 4

PHYWE

Where could the interference at the stripe lead to problems?

If you want to look at very small things with a _____, you have to illuminate them. If the objects are _____ enough, _____ will also take place on these objects so that you can see the _____ spot where the object should actually be.

diffraction | microscope | Poisson's | small

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de