Diffraction at a stripe - Babinet's theorem

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 at a bar.

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/6492abe81411df0002871ad2

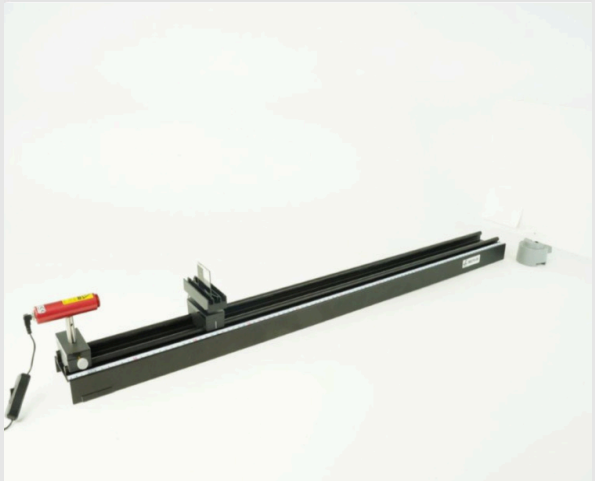
PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

PHYWE

General information

Application

PHYWE



Experimental setup

When light falls on a slit or a bar, the light rays at the edge of these objects are bent and interference occurs.

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

Babinet's theorem is mainly used in electrodynamics. There, for example, it can be used to determine the electric field in a hole in an infinitely large conducting plane. To do this, the hole and the plane are interchanged, as they behave the same according to Babinet's theorem.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Other information (1/2)

PHYWE

Prior knowledge

To understand this experiment, more basic experiments on diffraction phenomena should already have been carried out, such as the experiment "Determination of the wavelength of a laser with an optical grating".

Principle

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

Thus, the interference patterns of equally wide columns and ridges differ only in the first maximum, where the actual object is imaged.

Other information (2/2)

PHYWE

Learning objective

Diffraction also takes place at a bar, so that an interference pattern can be seen. Babinet's theorem states that the interference patterns of ridges and columns 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

- Observing the interference patterns
- Interpret and explain the results

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

PHYWE

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

If the bent edge rays overlap somewhere in the central axis of the shadow space, they always meet there in phase because of their same path, i.e. there is always brightness on the central 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, brightness maxima and minima can now be observed alternately on a screen.

If the bar is replaced by a slit of the same width, the same interference pattern is 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

Equipment

Position	Material	Item No.	Quantity
1	Optical profile-bench, l = 1000 mm	08370-00	1
2	Slide mount for optical bench	09822-00	3
3	Plate mount for three objects	09830-00	1
4	Diaphragm with single slit, bar and edge	08521-00	1
5	Screen, metal, 300 x 300 mm	08062-00	1
6	Barrel base expert	02004-00	1
7	Measuring tape, l = 2 m	09936-00	1
8	Diodelaser, red, 1 mW, 635 nm	08761-99	1

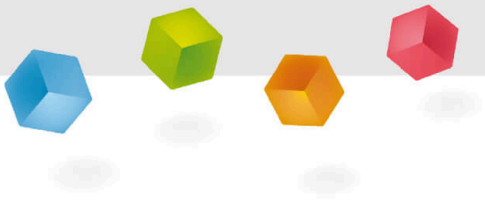
PHYWE
Robert-Bosch-Breite 10
37079 Göttingen
Tel.: 0551 604 - 0
Fax: 0551 604 - 107
info@phywe.de
www.phywe.de

Equipment

PHYWE

Position	Equipment	Quantity
1	Sellotape	1
2	Sheet of paper	1

PHYWE



Set-up and Procedure

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Set-up

PHYWE

The set-up is as shown in the illustration.

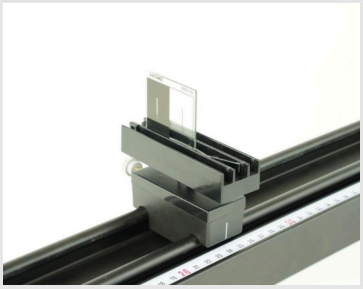
The diode laser stands at the head end of the optical bench.

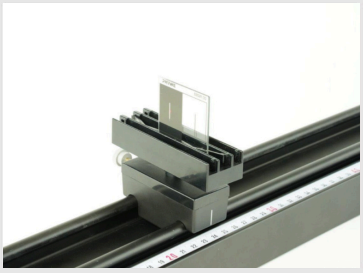
Close behind is the plate holder with the aperture containing the diffraction objects.

The screen is fixed in the barrel base and placed approx. 4 - 5m away from the screen.

Procedure

PHYWE





A sheet of paper is attached to the screen with its surface normal pointing in the direction of the optical axis using adhesive tape.

The aperture with the diffraction objects is moved in the plate mount so that the bar is evenly illuminated by the laser light. Mark the positions of the minima of several diffraction orders with a pencil.

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 diaphragm 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

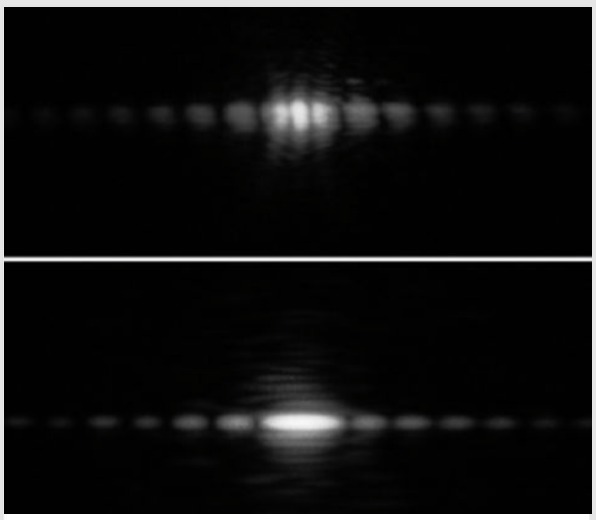
info@phywe.de
www.phywe.de

PHYWE

Evaluation

Evaluation (1/3)

PHYWE



Diffraction patterns

The upper figure shows the interference pattern created by diffraction of the laser beam at a ridge of width 0.6mm. The comparison with the corresponding diffraction pattern of the complementary slit in the lower figure shows that both diffraction patterns are identical except for the central maximum. In contrast to the central maximum of the slit pattern, however, that of the bar is interspersed with two additional minima.

If you move the screen, the diffraction pattern of the bar in the centre of the geometric shadow always shows an intensity-rich maximum, the so-called Poisson's spot.

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Evaluation (2/3)

PHYWE

What distinguishes the diffraction patterns of a bar and a slit of the same width?

- [ ] The first maximum is tripartite for the bar, but not for the gap.
- [ ] The minima are located in different places.
- [ ] The diffraction pattern of the slit is brighter.

Check

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

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

Evaluation (3/3)

PHYWE

Where could the interference at the bridge 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 see the _____ spot where the object should actually be.

Poisson's | microscope | diffraction | small

Check

PHYWE

Robert-Bosch-Breite 10
37079 Göttingen

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

info@phywe.de
www.phywe.de

Slide	Score / Total
Slide 14: Multiple tasks	0/4
Slide 15: Diffraction at the bar	0/4

Total score 0 / 8

Show solutions Repeat

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