Diffraction at a narrow obstacle (plate) (Babinet's Principle)

Task and equipment

Information for teachers

Additional Information

In this experiment the students should come to realize that in the shadow area behind a narrow obstacle regular patterns of brightness will be found which are formed by diffraction at the edges of the obstacle.
By comparing the diffraction pattern with that created by diffraction at a slit having the same width as the obstacle, they should gain an understanding of Babinet's Principle and find it confirmed.
Babinet's Principle states that diffraction phenomena behind complementary screens are identical. This diaphragm employed has a slit and a plate (narrow obstacle) of identical size; they act as screens which are complementary to each other, i.e. together they bring about total extinction. Therefore, in the observation plane the amplitudes of the waves which interfere following diffraction at a slit or obstacle, must be identical but phase displaced by 180°.

Suggestions for Set-up and Performance

This experiment can be performed under almost normal lighting conditions. This makes setup and performance comparatively simple.
Which operational light voltage is chosen − 12 V~ or 6 V~ − depends on the selected width of the light aperture and the subjective sensitivity to brightness of each investigator.

Remarks

This experiment can be further elaborated by gradually altering the distance from the narrow obstacle to the observation plane. This will enable the students to observe, e.g. as the distance decreases, how alternating light and dark fringes filter into the shadow area from the outside.
We have not attempted to take measurements or carry out a mathematical analysis of this phenomenon because our main objective in this experiment is to gain an understanding of Babinet's Principle and this can be done on the basis of semi-quantified statements. Measurements and calculations, e.g. of the wavelength of red light, are much better carried out on the basis of diffraction at a double slit or at a grating.

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Task

What sort of shadow is created behind a narrow obstacle?

Direct a narrow pencil of light onto a slender obstacle so that part of the beam grazes the side. Observe the shadow thus created and compare it with the diffraction pattern formed when the light beam strikes a slit of the same width as the obstacle.

Student's Sheet

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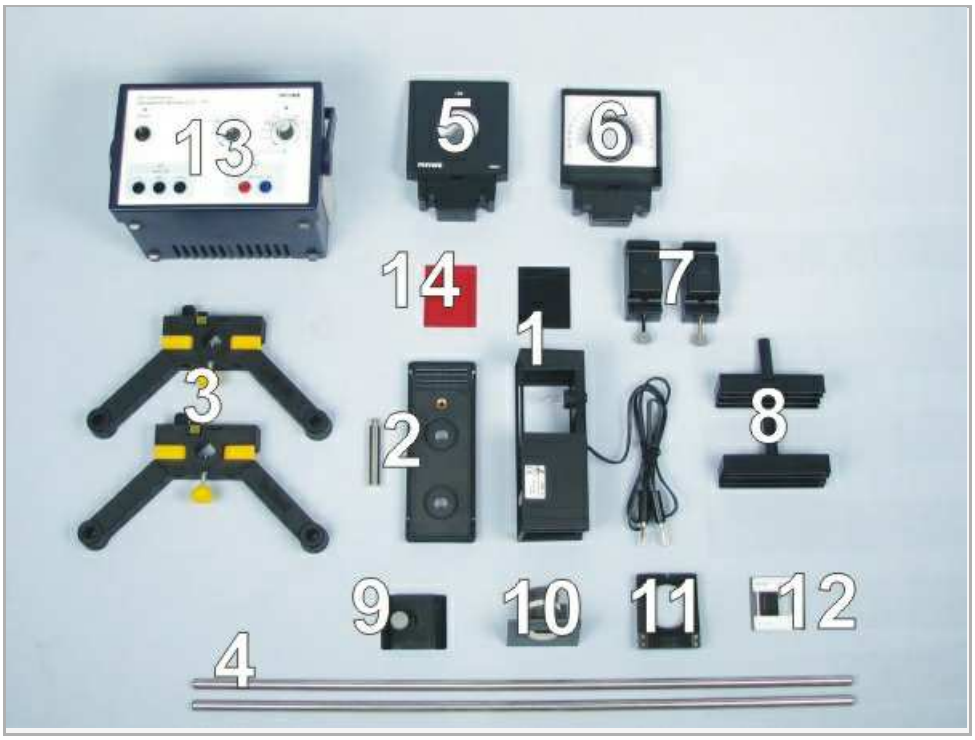
Equipment



Position No.	Material	Order No.	Quantity
1	Light box, halogen 12V/20 W	09801-00	1
2	Bottom with stem for light box	09802-10	1
3	Support base, variable	02001-00	1
4	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	2
5	Lens on slide mount, f=+50mm	09820-01	1
6	Mount with scale on slide mount	09823-00	1
7	Slide mount for optical bench	09822-00	2
8	Plate mount f.3 objects	09830-00	2
9	Slit, adjustable.up to 1 mm	11604-07	1
10	Measuring magnifier	09831-00	1
11	Diaphragm holder, attachable	11604-09	1
12	Diaphragm with single slit, bar and edge	08521-00	1
13	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
14	Colour filter set, additive (red, blue, green)	09807-00	red filter
-	Cardboards 200x300mm,black,10 pcs	06306-01	1

Set-up and procedure

Set-up

- Set up the optic bench with the two support rods and the support base and place the scale in position (Fig. 1 and Fig. 2).

Fig. 1

Fig. 2

- Assemble the light box according to Figures 3 and 4 and clamp it into the left part of the support base with the lens end pointing away from the optic bench (Fig. 5). Insert a tight fitting cover in front of the lens (Fig. 6).

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Fig. 3

Fig. 4

Fig. 5

Fig. 6

- Position the lens with f = +50 mm right next to the light box on the optic bench (Fig. 7).

Fig. 7

- Insert the adjustable slit (light aperture) into the diaphragm holder (Fig. 8, Fig. 9) and attach this to the mount with scale (Fig. 10). Then, place the mount with scale directly next to the lens (Fig. 11).

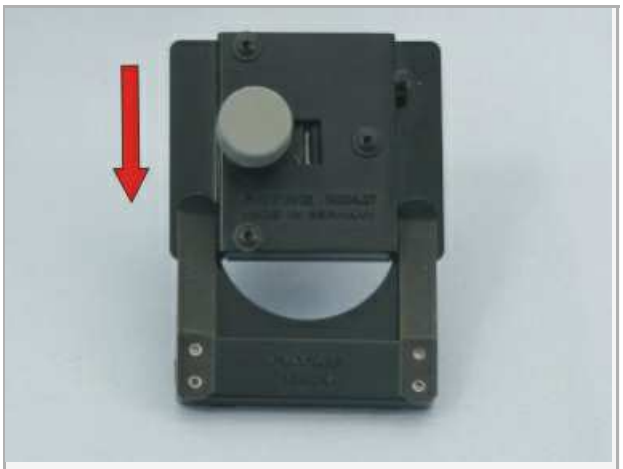

Fig. 8

Fig. 9

Fig. 10

Fig. 11

- Position a slide mount with plate mount at the end of the optic bench (Fig. 12).

Fig. 12

Procedure

- Connect the light box to the power supply (12 V~) (Fig. 13) and switch it on.

Fig. 13

- Slightly open the adjustable slit (light aperture).
- Attach the diaphragm with slit and plate (narrow obstacle) (Fig. 14) to the plate mount (Fig. 15) so that the light strikes the **obstacle** symmetrically; cover the slit with a light-tight diaphragm (Fig. 16).

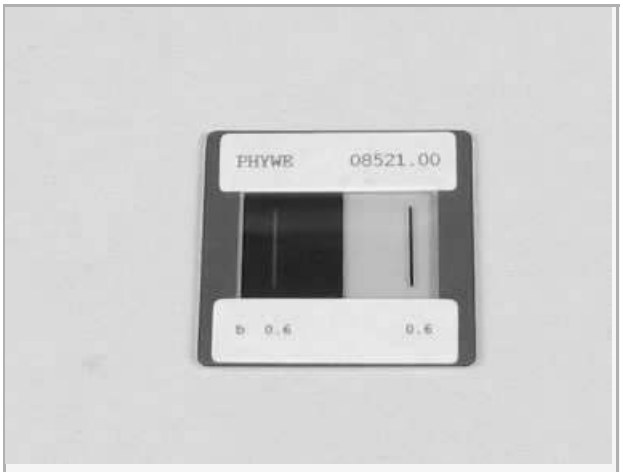

Fig. 14

Fig. 15

Fig. 16

- Position the slide mount with the other plate mount holding the measuring magnifier in the light path at a distance of approx. 20 to 30 cm from the narrow obstacle (Fig. 17).

Fig. 17

- Observe the shadow of the narrow obstacle through the measuring magnifier; if necessary, readjust the following aspects: parallel alignment of light aperture and obstacle, symmetrical incidence of light and obstacle, optimum width of light aperture, possibly connect the light box to the 6 V~ plugs of the power supply to prevent glare (comp. Fig. 13).
- Insert the red filter into the well of the light box (Fig. 18).

Fig. 18

- Observe the ensuing pattern through the measuring magnifier. Describe your observations before and after inserting the red filter and note them in the report, "Result – Observations 1".
- Set up the measuring magnifier about 80 cm away from the narrow obstacle.
- Again observe the shadow area and write down your observations in the report, "Result – Observations 2".
- Now, place the **slit** in the light path and cover the obstacle (plate) with the light-tight diaphragm. Observe and describe the diffraction pattern in the report, "Result – Observations 3".
- Move the measuring magnifier back to its starting position (20 to 30 cm away from the slit / obstacle); again observe and describe the diffraction pattern in the report, "Result – Observations 4".
- Remove the light-tight diaphragm and shine the light simultaneously on both slit and obstacle (of identical width).
- Alternate between the slit and the narrow obstacle by moving the measuring magnifier from side to side to observe the diffraction patterns behind them. Compare your observations and note your results in the report, "Result – Observations 5".

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Report: Diffraction at a narrow obstacle (plate) (Babinet's Principle)

Result – Observations 1

Describe your observations before and after inserting the red filter:

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Result – Observations 2

Describe your observations through the measuring magnifier about 80 cm away from the narrow obstacle:

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Result – Observations 3

Describe your observation with the placed slit:

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Result – Observations 4

Describe your observations through the measuring magnifier in its starting position:

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Result – Observations 5

Alternate between the slit and the narrow obstacle by moving the measuring magnifier from side to side.

Describe the diffraction patterns:

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Evaluation – Question 1

Summarize your observations that you noted under "Result - Observations 1" to "Result - Observations 5":

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Evaluation – Question 2

What conclusions can be drawn from the observations?

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Evaluation – Question 3

Attempt to explain how the phenomenon observed during the experiment comes about.

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