Diffraction at a slit

Task and equipment

Information for teachers

Diffraction at a slit

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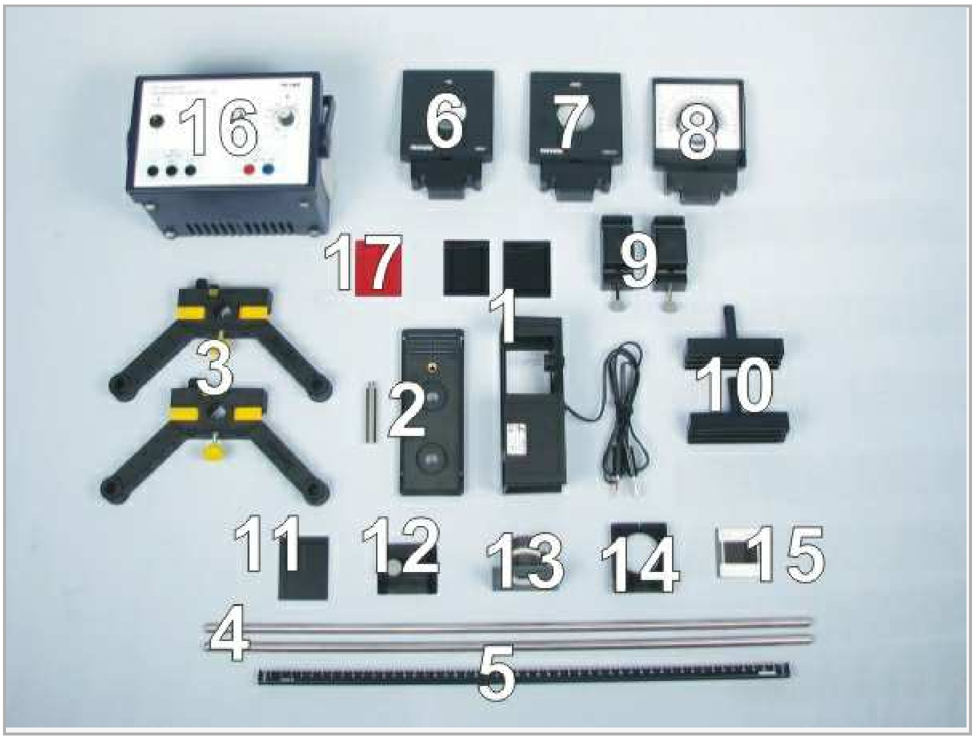
Task

What happens to a beam of light when it passes through a narrow slit?

1. Direct a narrow pencil of light onto a slit of variable width, and observe the slit images which are created when the slit width is gradually reduced.
2. Find out what correlation exists between the slit width *b* and the distance *d* between the interference minima created.

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	Meter scale for optical bench	09800-00	1
6	Lens on slide mount, f=+50mm	09820-01	1
7	Lens on slide mount, f=+300mm	09820-04	2
8	Mount with scale on slide mount	09823-00	1
9	Slide mount for optical bench	09822-00	2
10	Plate mount f.3 objects	09830-00	2
11	Diaphragm, 3 single slits	08522-00	1
12	Slit, adjustable.up to 1 mm	11604-07	1
13	Measuring magnifier	09831-00	1
14	Diaphragm holder, attachable	11604-09	1
15	Diaphragm with slit	09816-02	1
16	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
17	Colour filter set, additive (red, blue, green)	09807-00	red filter
-	Cardboards 200x300mm,black,10 pcs	06306-01	1 piece

Set-up and procedure

Set-up and procedure 1

Experiment 1

- 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 the light-tight diaphragm in front of the lens (Fig. 6).

Fig. 3

Fig. 4

Fig. 5

Fig. 6

- Insert the red filter (Fig. 7) and the slit diaphragm with d = 1 mm (Fig. 8) into the well of the light box.

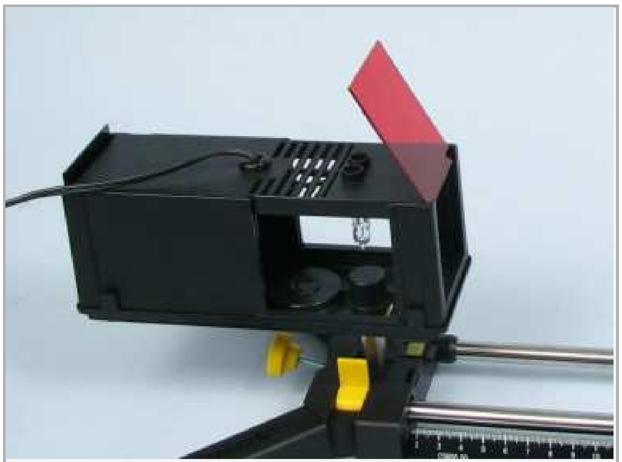


Fig. 7

Fig. 8

- Attach the diaphragm holder with adjustable slit (light aperture) to the mount with scale (Fig. 9 - 11) and place it in the centre of the optic bench (Fig. 12).

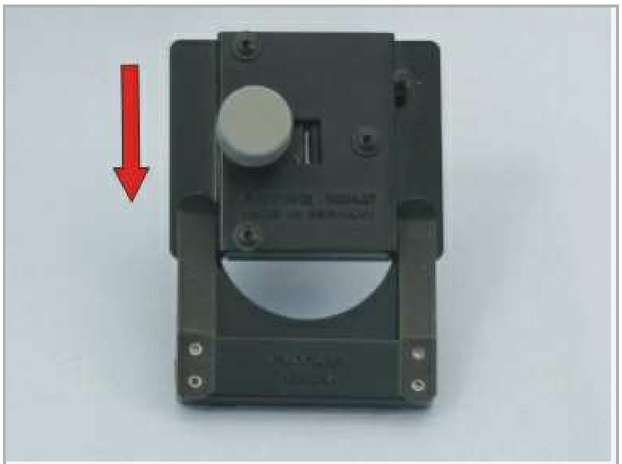


Fig. 9

Fig. 10

Fig. 11

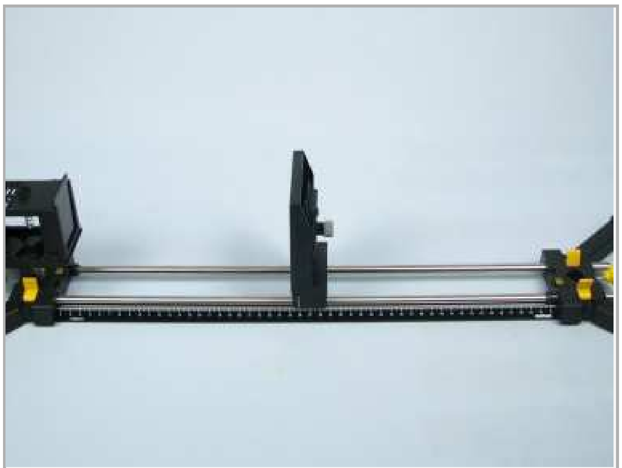


Fig. 12

- Position the lens with *f* = +50 mm at the right-hand end of the optic bench (Fig. 13).

Fig. 13

- Connect the light box to the power supply (12 V~) and switch it on (Fig. 14).

Fig. 14

- If necessary, slightly turn the adjustable slit until it is aligned parallel to the slit diaphragm in front of the light box.
- Adjust the slit to its maximum width.
- Look through the lens towards the light beam and gradually reduce the width of the adjustable slit in small steps; observe the ensuing phenomenon closely.
- Choose a narrow slit width and observe the patterns when the red filter is removed.
- Vary the slit width several times and note your observations in the report.
- Switch off the power supply.

Set-up and procedure 2

Experiment 2

- Leave the optic bench arrangement with scale and light box as in the first experiment, just remove the slit diaphragm and the red filter.
- Place lens with *f* = +50 mm at 6 cm and mount with scale with diaphragm holder and adjustable slit at approx. 9.5 cm (Fig. 15).

Fig. 15

- Set up one lens with *f* = +300 mm at 40 cm, and the second one at the end of the optic bench with a slide mount with plate mount in-between (Fig. 16).

Fig. 16

- Place the other slide mount with plate mount holding the measuring magnifier about 30 cm away from the lens at the end of the optic bench (Fig. 17) and switch on the power supply.

Fig. 17

- Slide the measuring magnifier along the optical axis until the slit is sharply focussed in the observation plane.
- Attach the diaphragm with 3 single slits to the plate mount between the lenses with *f* = +300 mm (Fig. 18).

Fig. 18

- Move the diaphragm so that the slit with width *b* = 0.4 mm (comp. Fig. 19) is positioned in the optical axis; cover the other slits with a light-tight diaphragm (Fig. 20).

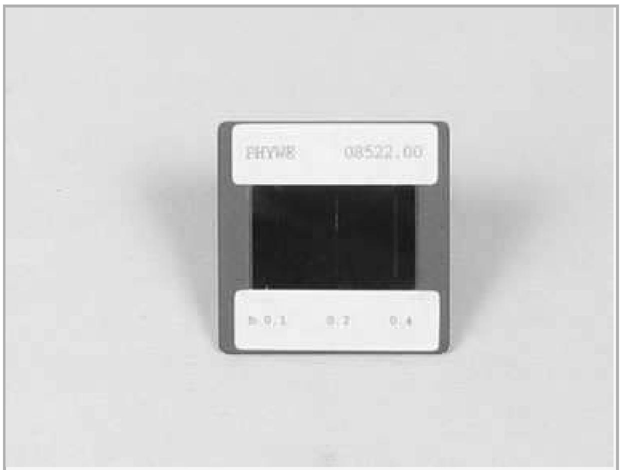


Fig. 19

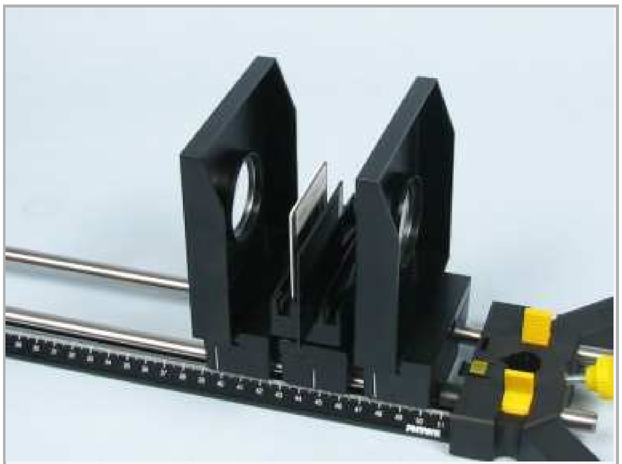


Fig. 20

- Look through the measuring magnifier and observe the diffraction pattern. If necessary, readjust the following aspects of the arrangement: parallel alignment of light aperture and diffraction slit, even (symmetrical) illumination of the diffraction slit, optimum width of the light aperture.
- Describe the diffraction pattern and note your description in the report.
- Insert the red filter into the well of the light box (Fig. 21).

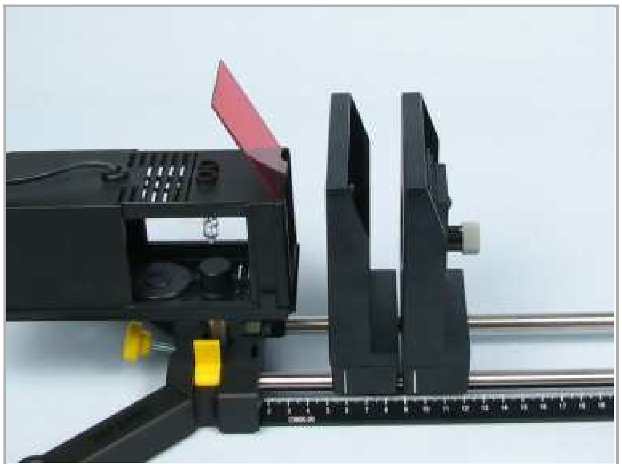


Fig. 21

- Measure the distance d_n of the nth intensity minimum (dark fringe) from the centre (0th intensity maximum). To do this, maximize $_n$ and measure the distance $2d_n$ from the nth minimum on the left to the nth minimum on the right. Divide your measured value by 2 and enter the result in table 1 in the report.
- Now, move the slit with b = 0.2 mm into the optical axis. Cover the other slits again with light-tight diaphragms. Measure the distance dn the same way as above and note your result in table 1, too.
- Repeat this procedure with the third slit (b = 0.1 mm).
- Switch off the power supply.

Report: Diffraction at a slit

Result – Observations 1

Note down your observations made during the first experiment:

Result – Observations 2

Note down your observations made during the second experiment:

Result – Table 1

1. Record all your measured values in the table.
1. Calculate the products $b \times (d_n / n)$ and enter these in the last column of the table.

b in mm	n	d_n in mm	$b \times d_n/n$ in mm^2
0,4	1 ±0	1 ±0	1 ±0
0,2	1 ±0	1 ±0	1 ±0
0,1	1 ±0	1 ±0	1 ±0

Evaluation – Question 1

The phenomena you have observed are based on the diffraction of light. What colour has the light that is diffracted most and what colour has the light that is diffracted least?

Evaluation – Question 2

What correlation exists between slit width *b* and distance d_n of the nth intensity minimum from the 0th intensity maximum (comp. Fig. 22)?

Evaluation – Question 3

What correlation exists between *b* and d_n for a particular number *n*, e.g. $n = 1$? Calculate the products $b \times (d_n / n)$ and enter these in the last column of Table 1.

Evaluation – Question 4

On the basis of Fig. 22 (see Question 2) explain how, e.g., the 3rd intensity minimum comes about.

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