Diffraction at a double slit

Task and equipment

Information for teachers

Additional Information

The object of this experiment is to prepare the ground for understanding the structure and function of optical transmission gratings.
Normally it would not be necessary to take measurements in order to gain an understanding of the interrelationships between slit spacing and slit width on the one hand, and spacing brightness and definition of the interference fringes on the other hand. However, we do suggest measuring the fringe gaps because this automatically draws the students' attention to the accuracy of the test results.

Suggestion for Set-up and Performance

Adjustments to the experimental setup must be performed in a darkened room. When taking measurements with the measuring magnifier, somewhat increase the light level sufficiently to read the scale.
Adjusting the setup will not pose any particular problems providing that the students are well aware of the fact that the light aperture and the double slit must be positioned parallel to one another and in the optical axis, and that both slits of the double slit are evenly illuminated. It is also important to find the optimum width adjustment of the light aperture.
In order to observe the brightness and definition of the diffraction patterns, the students will have to make several comparisons of the diffraction patterns created by the various double slits.

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Task

How do slit spacing and slit width affect the interference pattern when working with double slits?

Investigate how the interference pattern varies according to slit width *b* and slit spacing *g* when light is diffracted at a double slit. Then determine the wavelength of red light.

Student's Sheet

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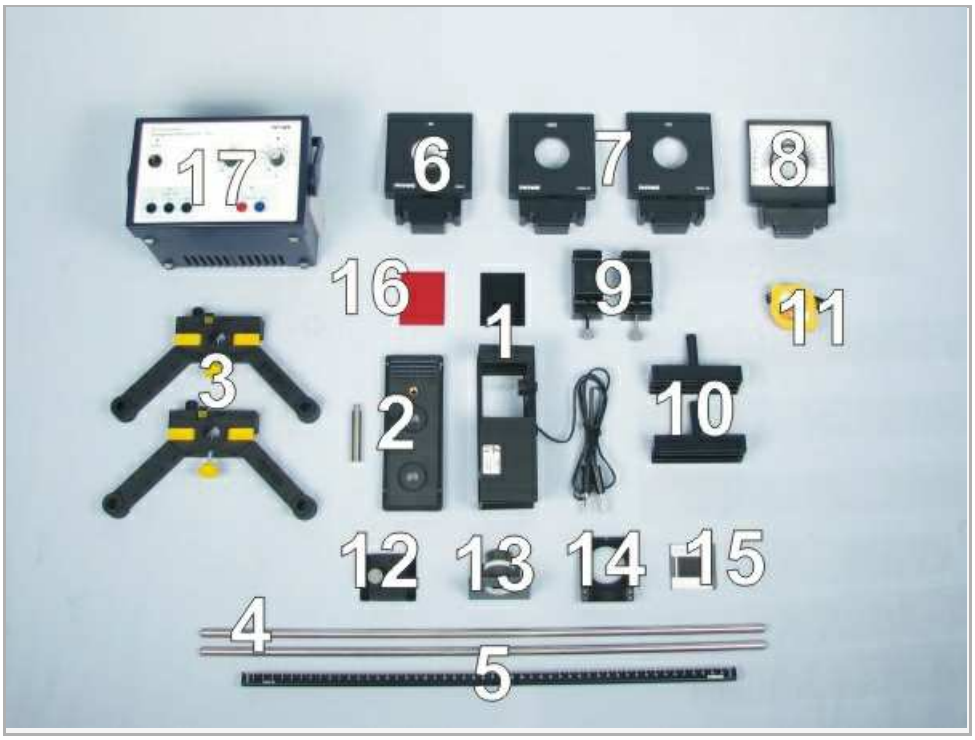
Equipment



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	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	Measuring tape, l = 2 m	09936-00	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, 4 double slits	08523-00	1
16	Colour filter set, additive (red, blue, green)	09807-00	red filter
17	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
-	Cardboards 200x300mm,black,10 pcs	06306-01	(1)

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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).

Fig. 3

Fig. 4

Fig. 5

Fig. 6

- Insert the adjustable slit (light aperture) into the diaphragm holder (Fig. 7, Fig. 8) and attach this to the mount with scale (Fig. 9).

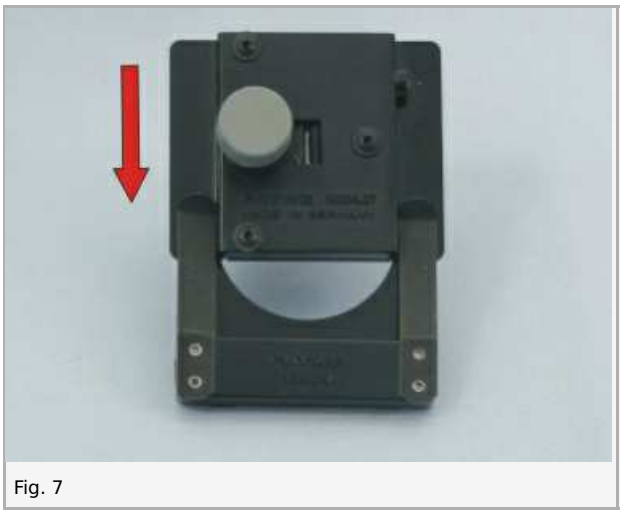

Fig. 7

Fig. 8

Fig. 9

- Position the lens with f = +50 mm at about 6 cm on the optic bench and the mount with scale at about 9.5 cm (Fig. 10).

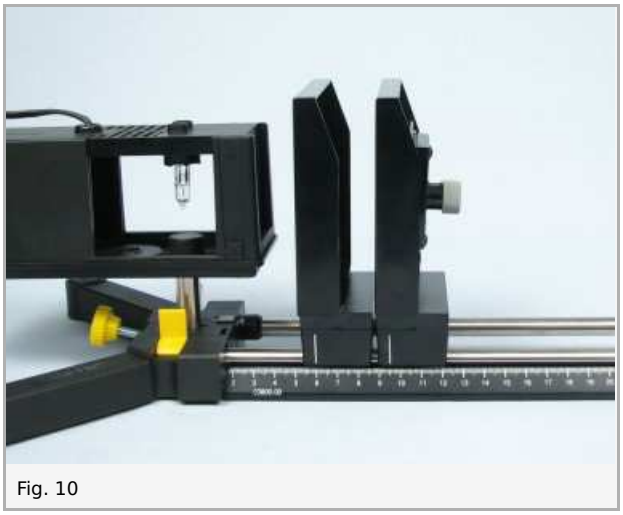

Fig. 10

- Place one of the lenses with f = +300 mm at about 40 cm and the other lens with f = +300 mm at the right-hand end of the optic bench. Just in front of the second lens position a slide mount holding a plate mount (Fig. 11).

Fig. 11

- Position the other slide mount with plate mount holding the measuring magnifier approx. 30 cm to the right of the optic bench (Fig. 12).

Fig. 12

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

Fig. 13

- Move the measuring magnifier along the optical axis until the light aperture (adjustable slit) is sharply focussed on the observation plane.
- Attach the diaphragm with 4 double slits to the right-hand mounting of the plate mount between the two lenses (Fig. 14).

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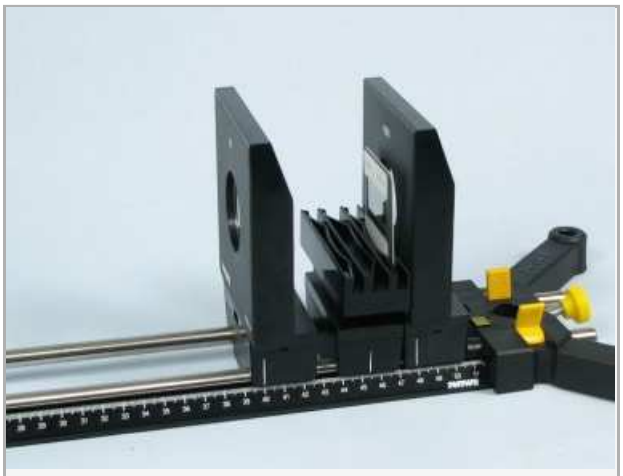

Fig. 14

Procedure

1. Spacing of the interference fringes

- Position the double slit with b = 0.2 mm and g = 0.25 mm in the optical axis and cover the other slits with a light-tight diaphragm (Fig. 15).

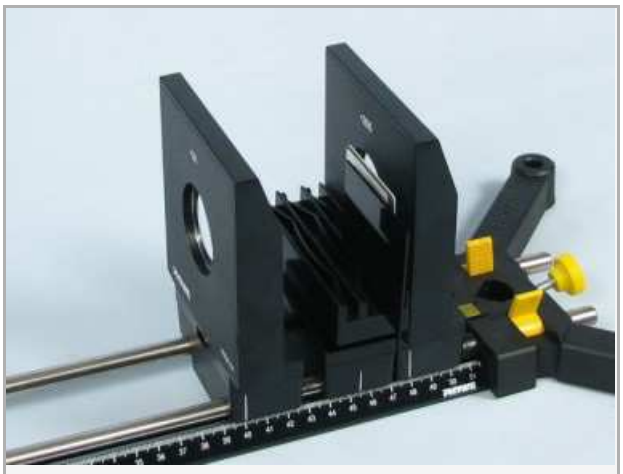

Fig. 15

- If necessary, readjust the arrangement to ensure that the light aperture and double slit are parallel, that the double slit is evenly illuminated and that the light aperture is adapted so that the diffraction pattern is sufficiently bright but not glaring.
- Insert the red filter into the light well (Fig. 16).

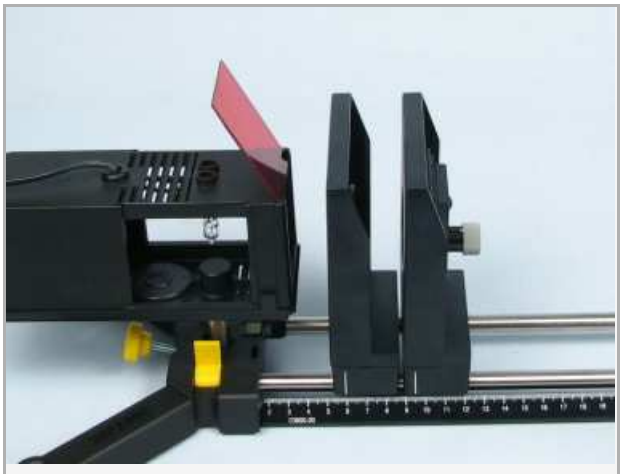

Fig. 16

- Look through the measuring magnifier and measure the distance *d* between the interference fringes; enter the value for *d* in table 1 in the report.
- Measure the distance *e* between the measuring magnifier and the right-hand lens (Fig. 17) and note your result in the report.

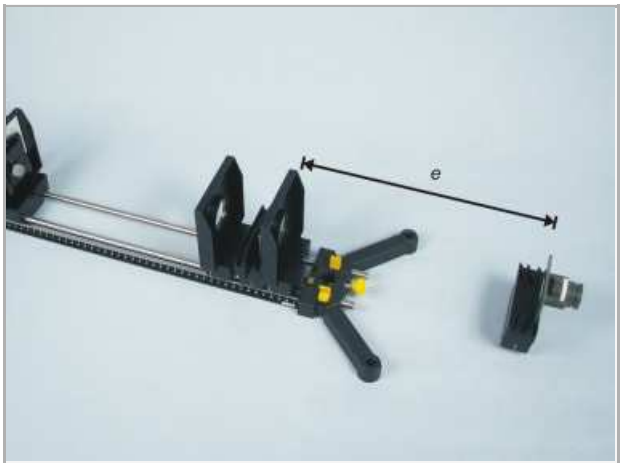

Fig. 17

- Set up the other 3 double slits consecutively in the light path; in each case measure the distance *d* between the interference fringes and enter your results in table 1 in the report.

2. Brightness and definition of the interference fringes

- First, place the double slit with $b = 0.2$ mm and $g = 0.25$ mm in the light path and then the double slit with $b = 0.1$ mm and $g = 0.25$ mm. Compare the ensuing interference patterns.
- Describe the brightness and definition (width) of the interference fringes and note your observation in the report.
- Place the double slits with $b = 0.1$ mm and $g = 0.5$ mm and $g = 1.0$ mm respectively in the light path.
- Again, describe the brightness and definition of the fringes and note your results in the report.

- Switch off the power supply.

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Report: Diffraction at a double slit

Result – Observations 1

Specify the value:

e = ... cm

Result – Table 1

1. Note down your measured values.
2. From Fig. 18 we can derive the equation $\lambda = g \times d_n / (n \times e)$ for calculating the wavelength λ when light is diffracted at a double slit.
   Calculate the values for the wavelength of red light which you arrive at on the basis of your measurements using 4 double slits; enter your results in the table.

b in mm	g in mm	d in mm	λ in nm
0,2	0,25	$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$
0,1	0,25	$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$
0,1	0,50	$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$
0,1	1,00	$\frac{1}{\pm 0}$	$\frac{1}{\pm 0}$

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Result – Observations 2

Compare the double slits with b = 0.2 mm, g = 0.25 mm and b = 0.1 mm, g = 0.25 mm.

Then compare the double slits with b = 0.1 mm and g = 0.5 mm and g = 1.0 mm respectively.

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Evaluation – Question 1

Compare the 4 resulting wavelengths. Explain the deviations and estimate the relative error which must be taken into account for λ.

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Evaluation – Question 2

What correlation exists between the slit width *b* and slit distance *g* on the one hand and the width, brightness and definition of the interference fringes on the other hand?

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