Experiment using a Fresnel biprism

Task and equipment

Information for teachers

Additional Information

Along with the Fresnel double mirror experiment, this experiment with a Fresnel biprism is another one of historical significance which was performed in the 18th and 19th centuries to demonstrate the wave theory of light.
The surface of the Fresnel biprism strucked by the light emitted from a light aperture encompass an angle of almost 180°. If a diverging beam of light strikes the edge of the biprism, two diverging coherent light beams are created which appear to emerge from two virtual slits and interfere on the far side of the biprism. The students should first make themselves familiar with the general setup of the Fresnel experiment and describe the interference patterns.
In the second experiment, the wavelength of red light is to be determined. The students can use the other colour filters (e.g. in groupwork), to ascertain the wavelength of further colours.

Suggestions for Set-up and Performance

Remember that adjustments to the experimental setup must be carried out in a darkened room. In particular, make sure that the slit runs parallel to the blunt edge of the biprism facing towards it and that both incidence planes of the biprism are evenly illuminated.
During measurements with the measuring magnifier increase the light in the room sufficiently to read the scale of the measuring device. When the students are working with the measuring magnifier, remind them to make sure that their field of vision is evenly illuminated.

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Task

How can refraction bring about interference of light?

1. Direct a narrow beam of light onto the blunt edge of a Fresnel biprism and observe what happens.
2. Measure the distance between the virtual light sources and, using this and the interference pattern, determine the wavelength of red light.

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	1
8	Mount with scale on slide mount	09823-00	1
9	Slide mount for optical bench	09822-00	2
10	Screen, white, 150x150mm	09826-00	1
11	Plate mount f.3 objects	09830-00	2
12	Measuring tape, l = 2 m	09936-00	1
13	Diaphragm holder, attachable	11604-09	1
14	Measuring magnifier	09831-00	1
15	Slit, adjustable.up to 1 mm	11604-07	1
16	Colour filter set, additive (red, blue, green)	09807-00	1
17	Fresnel biprism	08556-00	1
18	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1

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

- Attach the diaphragm holder with adjustable slit (light aperture) to the mount with scale (Figs 7 - 9). Place the lens with *f* = +50 mm directly next to the light box and the mount with scale at approx. 8 cm on the optic bench (Fig. 10).

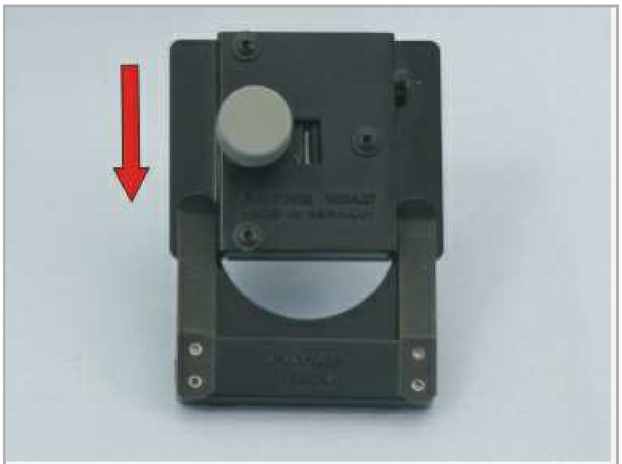

Fig. 7

Fig. 8

Fig. 9

Fig. 10

- Clamp the biprism onto a plate mount, attach this to a slide mount and place it at approx. 21 cm on the optic bench with the biprism's edge facing the slit (Fig. 11 and Fig. 12).

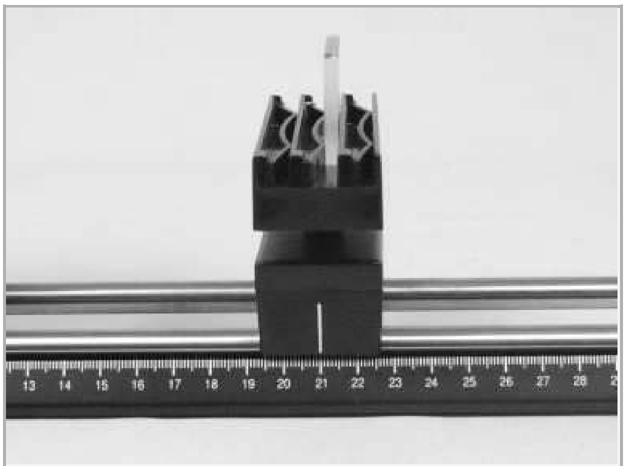

Fig. 11

Fig. 12

- Set up the screen with slide mount at approx. 90 cm (Fig. 13).

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Fig. 13

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

Fig. 14

- Observe the fringe patterns on the screen. If the fringes are not clearly visible, adjust the biprism laterally and, if necessary, slightly turn the slit diaphragm so that the light beam strikes the exact centre of the biprism and that the slit runs parallel to the blunt edge.
- Remove the screen and replace it by the second slide mount holding the measuring magnifier (Fig. 15).

Fig. 15

- Observe the interference pattern.
  Remark: If the fringes are not evenly distributed, carry out fine adjustment once again. To do this, place the slide mount with measuring magnifier on the optic bench. Now you can easily correct the position of the biprism and the slit observing the change in the interference fringes at the same time. Finally, re-position the measuring magnifier at 90 cm to monitor the interference fringes.

- Describe your observations and note them in the report.

Set-up and procedure 2

Experiment 2

- Leaving the general experimental setup unchanged, insert the red filter into the well of the light box (Fig. 16).

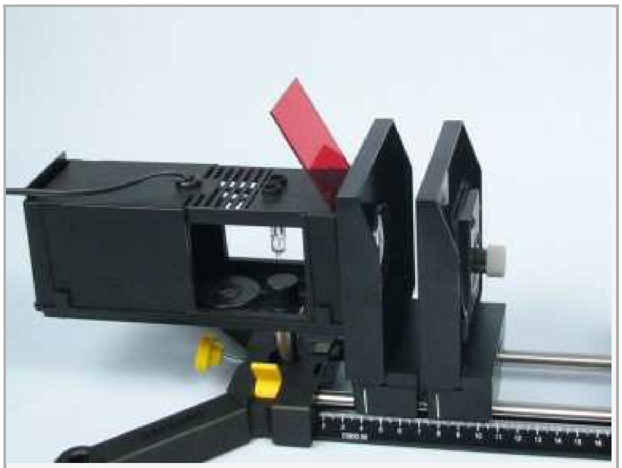

Fig. 16

- Using the measuring magnifier, measure the distance *d* between the red interference fringes. To do this, determine the distance between several fringes (d_n for (n + 1) fringes; comp. Fig. 17) and calculate the average value. Note your result in the report.

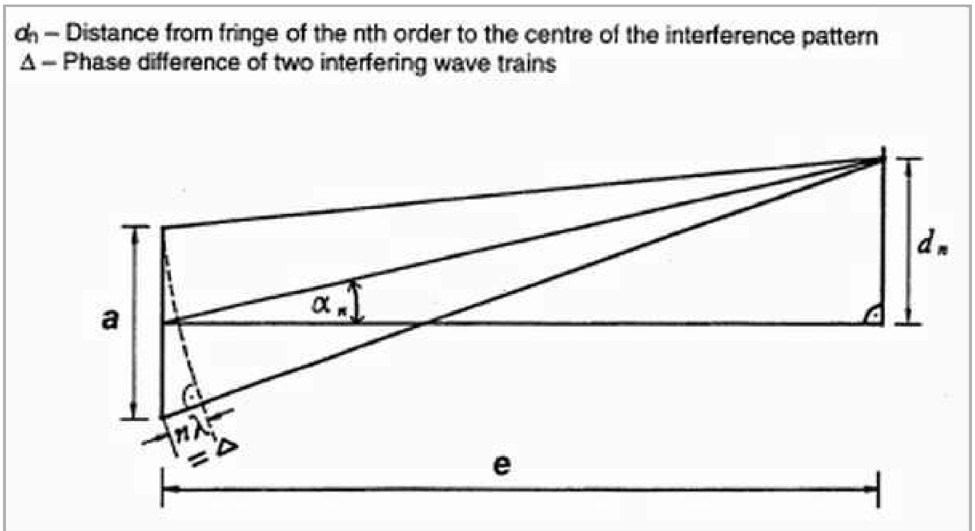

Fig. 17

- Measure the distance e between the slit and the measuring magnifier and also note your result in the report.
- To ascertain the distance between the two virtual light sources (slits), position the lens with *f* = +300 mm at the right-hand end of the optc bench (Fig. 18). Use the screen to find the point where the images from the virtual slits are sharply focussed.

Fig. 18

- Set up the measuring magnifier at the point where these images are focussed; measure the distance a' between the images (comp. Fig. 19) and make a note in the report.
- Measure the distance *g* between the adjustabe slit (i.e. virtual slits) and the lens with *f* = +300 mm as well as the distance *b* between the lens and the measuring magnifier (comp. Fig. 19).

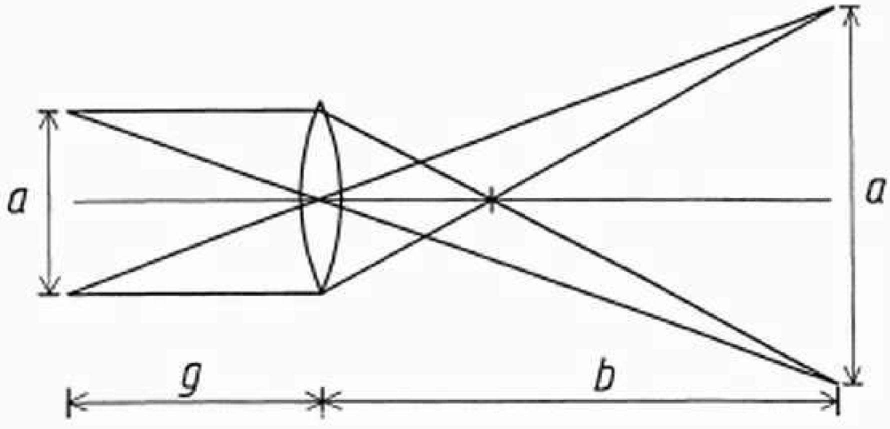

Fig. 19

- Switch off the power supply.

Report: Experiment using a Fresnel biprism

Result - Observations 1

Note down your observations during the first part of the experiment.

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Result - Observations 2

Enter the values:

Distance between (n + 1) red fringes: d_n = ...mm; n = ...

Distance slit − measuring magnifier: e = ...cm

Distance between images of the virtual slits: a' = ...mm

Distance slit − lens (f = +300 mm): g = ...cm

Distance lens − measuring magnifier: b = ...mm

Evaluation - Question 1

In Fig. 20 you can see the basic setup and the ray paths. On the basis of this figure explain how the interference fringes come about!

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Evaluation - Question 2

Fig. 18 (see Setup and Action Part 2) demonstrates how the nth bright fringe (fringe of the nth order) comes about. It also shows that the wavelength λ of monochromatic light which falls on the Fresnel biprism and interferes when reflected can be calculated with the formula: $\lambda = (a \times d_n) / (n \times e)$.
Derive this equation! Note that for small angles the sinus is equal to the tangent.

Evaluation - Question 3

Calculate the distance *a* between the two virtual slits using the equation $a / a' = g / b$ (comp. Fig. 19).

Evaluation - Question 4

Now calculate the wavelength λ of the red light used in the second experiment.

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