Experiment using a Fresnel double mirror

Task and equipment

Information for teachers

Additional Information

This double mirror experiment devised by Fresnel in 1816 is one of a number of experiments of historical significance which were performed in the 18th and 19th century to demonstrate the wave theory of light. Using two plane mirrors set at an angle of almost 180° to each other, two virtual light sources are created by reflection of a diverging beam of light from which two divergent light beams appear to emerge. These are coherent and can thus interfere.
The students should first familiarize themselves with the general setup of the Fresnel experiment and describe the interference patterns. The angle of the two mirrors remains constant which simplifies the setup.
In the second experiment, the wavelength of red light is to be determined. You have the option of using the other colour filters to ascertain the wavelengths of further colours.

Suggestions for Setup 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 mirror planes.
First of all, three bright areas appear, one of which results from the passing light and the other two from the reflected light. Interference fringes can already be seen in the area of the passing light. They are brought about by diffraction at the front edge of the mirror, occur at uneven intervals and should not be confused with the interference fringes relevant to this experiment. The other two beams of light should be of approx. the same brightness. You can achieve this by moving the double mirror vertically to the light path, until the light strikes both halves of the mirror to the same extent. By rotating the mirror, the light should now be brought to superposition on the screen. In the bright area interference fringes now appear, which are at identical intervals to each other. The better the parallel alignment of slit and mirror planes, the better focussed these fringes will be.
When carrying out measurements with the observation lens, increase the light in the room sufficiently to read the scale of the measuring device.

Remarks

The Fresnel mirror, also known as the Fresnel double mirror, is made of surface-polished glass. The surface should not come in contact with fingers. If necessary, clean only with a soft brush, cotton wool, etc.

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Task

How can reflection bring about interference of light?

1. Let a narrow beam of light shine onto a Fresnel double mirror and observe what happens.
2. Determine the distance between the virtual light sources and, using this and the interference pattern, find out 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	Colour filter set, additive (red, blue, green)	09807-00	1
7	Lens on slide mount, f=+50mm	09820-01	1
8	Lens on slide mount, f=+300mm	09820-04	1
9	Slide mount for optical bench	09822-00	2
10	Mount with scale on slide mount	09823-00	1
11	Screen, white, 150x150mm	09826-00	1
12	Plate mount f.3 objects	09830-00	2
13	Measuring magnifier	09831-00	1
14	Slit, adjustable.up to 1 mm	11604-07	1
15	Diaphragm holder, attachable	11604-09	1
16	Measuring tape, l = 2 m	09936-00	1
17	Fresnel mirror on plate	08561-00	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 a light-tight diaphragm into the well in front of the lens (Fig. 6).

Fig. 3

Fig. 4

Fig. 5

Fig. 6

- Place a lens with *f* = +50 mm onto the optic bench directly next to the light (Fig. 7).

Fig. 7

- Fix the diaphragm holder with the adjustable slit onto the scale mount and place these on the optic bench at approx. 8 cm (Fig. 8).

Fig. 8

- Position the slide mount with the plate holder and the Fresnel mirror at approx. 20 cm inbetween the support rods (Fig. 9).

Fig. 9

- Connect the light to the power supply (12 V~) and swith on the power supply (Fig. 10).

Fig. 10

- Adjust the slit diaphragm and the Fresnel mirror so that part of the light emanating from the slit grazes both halves of the double mirror evenly, and the rest shines past the mirror.
- Position the screen on a slide mount in the ray path at approx. 180 cm and adjust the double mirror by rotating it around its own axis and sliding it vertically to the optical axis until the light emanating directly from the slit is about 2 cm away from two equally bright stripes created by the two virtual light sources as a result of reflection.
- Carry out final adjustments to the mirror position by carefully turning it until the two light beams reflected from the mirror are superimposed on it.

- Remove the screen from the slide mount and replace it by the plate holder with the observation lens (Fig. 11).

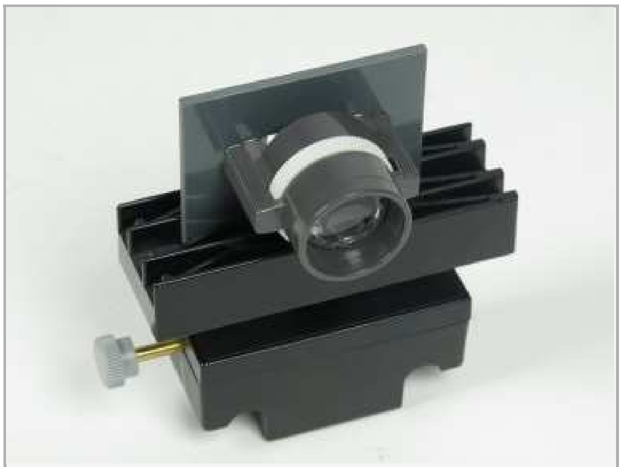

Fig. 11

- Position the observation lens on the optic bench at approx. 48 cm (Fig. 12) and, if necessary, slightly turn the slit with its support until the interference fringes are focussed (slit must be parallel to the mirror planes)
- Vary the width of the slit and slithly readjust the mirror if necessary.

Fig. 12

- Replace the observation lens in the ray path at approx. 180 cm.
- Observe the interference fringes; to do so, look into the observation lens, making sure that your field of vision is evenly illuminated.
- Describe your observations at (1) in the report.

Set-up and procedure 2

Experiment 2

- Keeping the same general setup of the experiment, insert the red filter into the well of the light box (Fig. 13).

Fig. 13

- Using the observation lens measure the distance *d* between the red interference fringes. To do this, determine the distance between e.g. 6 fringes (i.e., d_5 in Figure 14) and calculate the average value.

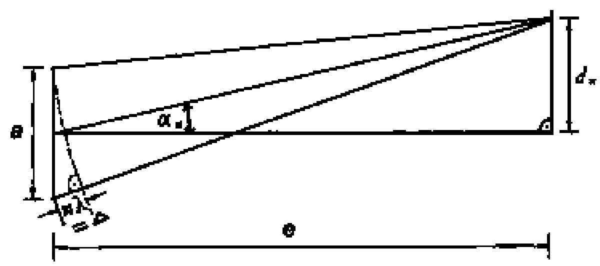

Fig. 14

d_n - Distance from fringe of the nth order to the centre of the interference pattern
Δ - Phase difference between two interfering wave trains

- Make a note of the result in (2) in the report.
- Measure the distance e between the slit and the observation lens, and note it in the report.
- To ascertain the distance between the two virtual light sources (slits), position the lens with *f* = +300 mm on the optic bench at approx. 48 cm (Fig. 14). Hold the screen in the light path and slide it horizontally until the virtual slits are sharply focused on it.
- Replace the screen by the observation lens; measure the distance a' between the images (comp. Fig. 15).

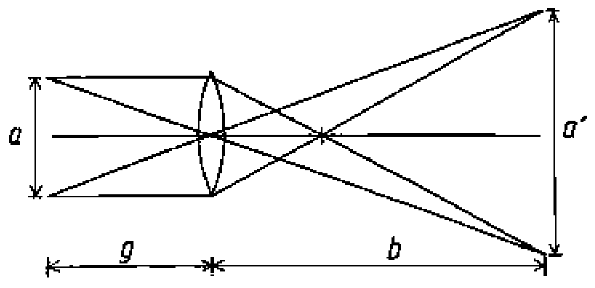

Fig. 15

- Measure the distange g between the adjustable slit (i.e. the virtual slits) and the lens with f = +300 mm and then the distance b between the lens and the observation lens.
- Switch off the power supply.

Report: Experiment using a Fresnel double mirror

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 - observation lens: *e* = ... cm

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

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

Distance lens - observation lens: *b* = ... cm

Evaluation - Question 1

In Fig. 16 you can see the basic setup of the experiment and the ray paths.
On the basis of this figure, explain how the interference fringes come about.

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Evaluation - Question 2

Figure 14 demonstrates how the nth bright fringe (fringe of the nth order) comes about.
Hence, the following formula is true for the wavelength: $\lambda = a \times d_n / (n \times e)$.

Derive this equation. Note that for small angles the sinus is equal to the tangent.

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Evaluation - Question 3

Calculate the distance *a* between the two virtual slits using the equation $a / a' = g / b$ (comp. Fig. 15).

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Evaluation - Question 4

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

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