Diffraction at a crossed grating

Task and equipment

Information for teachers

Additional Information

A crossed grating consists of two systems of diffraction slits positioned at right angles to each other. This can best be accomplished by crossing two line gratings.
When light is diffracted from a crossed grating, it produces interference patterns with a reticular structure. If the crossed gratings have the same grating constant, the mesh shape will be square, and if not it will be rectangular. In the experiment the two gratings employed have grating constants in the ratio of 1 : 2; hence diffraction patterns with rectangular mesh holes are produced, the sides of which are in the ration of 2 : 1.
Working first with white and then with red light, the students should in the course of the experiment become acquainted with this kind of meshed diffraction pattern.

Suggestions for Set-up and Performance

The laboratory should be darkened, but still light enough to read the scale of the observation lens.

Remarks

We have not bothered with a mathematical analysis of diffraction from a crossed grating because it is not generally a school requirement.
The mirror box (order no. 09832-00) cannot be utilised in this experiment because the mirror is not surface coated and would therefore produce multiple reflections (which cause no problems with unidimensional diffraction objects arranged vertically).

Robert-Bosch-Breite 10
D - 37079 Göttingen
Tel: +49 551 604 - 0
Fax: +49 551 604 - 107
info@phywe.de
www.phywe.com

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Task

What kind of interference patterns are found when light is diffracted from a crossed grating?

Direct a parallel, narrow beam of light onto two line gratings positioned crosswise to each other, and investigate the ensuing interference patterns.

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	Support base, variable	02001-00	1
3	Support rod, stainless steel, l = 600 mm, d = 10 mm	02037-00	2
4	Meter scale for optical bench	09800-00	1
5	Lens on slide mount, f=+50mm	09820-01	1
6	Mount with scale on slide mount	09823-00	2
7	Diaphragm holder, attachable	11604-09	2
8	Aperture, d 0.4mm	08206-04	1
9	Diffraction grating, 4 lines/mm	08532-00	1
10	Diffraction grating, 8 lines/mm	08534-00	1
11	Lens on slide mount, f=+300mm	09820-04	2
12	Bottom with stem for light box	09802-10	1
13	Plate mount f.3 objects	09830-00	1
14	Measuring magnifier	09831-00	1
15	Colour filter set, additive (red, blue, green)	09807-00	1
16	Slide mount for optical bench	09822-00	1
17	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

- 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).

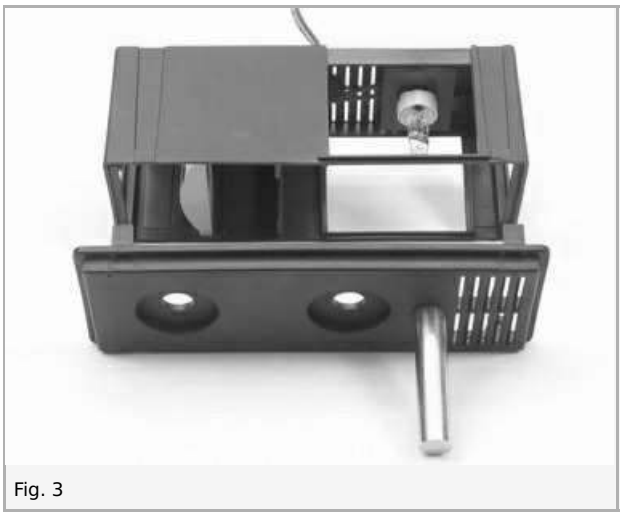

Fig. 3

Fig. 4

Fig. 5

Fig. 6

- Set up the lens with f = +50 mm close to the light (Fig. 7).

Fig. 7

- Attach the diaphragm holder with the aperture diaphragm (d = 0.4 mm) to the mount (Fig. 8) and set up the mount with scale at approx. 9.5 cm (Fig. 9).

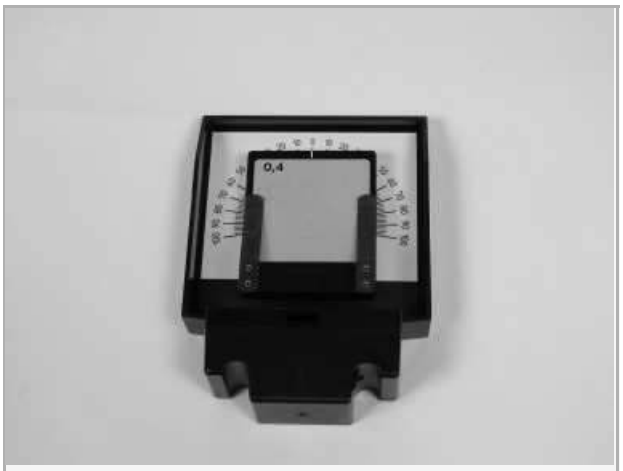

Fig. 8

Fig. 9

- Position one lens with f = +300 mm at 40 cm and the other at the end of the optic bench (Fig. 10).

Fig. 10

- Place the second mount with the scale between these two lenses (Fig. 11).

Fig. 11

- Position the second slide mount with the plate mount and the observation lens about 30 cm to the right of the optic bench (Fig. 12).

Fig. 12

Procedure

- Plug the light into the power supply (12 V~) (Fig. 13) and switch on the power supply.

Fig. 13

- Slide the observation lens along the optical axis until the image of the diaphragm aperture is sharply focused in the observation plane.
- Adjust the observation lens horizontally and vertically until the image of the diaphragm aperture is in the centre of your field of vision.
- Attach the diaphragm holder with the two crossed gratings to the scale mount at position approx. 44 cm (Fig. 14).

Fig. 14

- Observe and describe the diffraction patterns in the report.

- Insert the red filter into the light well (Fig. 15).

Fig. 15

- Observe and describe the diffraction patternsin the report.
- Vertically adjust the observation lens so that the centre of the diffraction pattern is positioned just above the scale.
- Measure and note the distance d_1 between the ring segments arrayed on a horizontal straight line.
- *Remark:* We recommend measuring the distance across several ring segments and dividing the measured value by the corresponding number.
- Now measure the distance d_2 between the ring segments arrayed vertically; to do this, turn the plate holder with the crossed gratings through 90° around the optical axis. Note the results.
- Switch off the power supply.
- Check which grating was last positioned with its lines aligned vertically and assign the distance d_2 to this grating. Assign the distance d_1 to the other grating.

Robert-Bosch-Breite 10
D - 37079 Göttingen
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Report: Diffraction at a crossed grating

Result – Observations 1

Describe the diffraction patterns:

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Result – Observations 2

Describe the diffraction patterns with red filter:

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Result – Observations 3

Enter the values:

d_1 = ... mm; refers to grating with ..... lines/mm

d_2 = ... mm; refers to grating with ..... lines/mm

Evaluation – Question 1

Account for the configuration of the diffraction pattern created by a crossed grating, or rather crossed gratings.

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Evaluation – Question 2

The following is true for the distance d_1 (distance between interference fringes created by diffraction at a line grating):

$d \sim 1/g$, where g stands for the grating constant (distance between two adjacent slit centres).

Hence, it must also be true that $d \times g$ = constant.

Check whether your experimental results confirm this hypothesis.

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