Diffraction object as described by Koppelmann

Task and equipment

Information for teachers

Additional Information

The experiment can be carried out in daylight because the diffraction pattern from a red LED can clearly be seen. However, the arrangement should not face into the light. It must be ensured that as far as possible only one Koppelmann pattern is always viewed with the eye.

Background to the Koppelmann patterns

In the top row the development from a single slit to a grating is shown. In the diffraction patterns the increasingly finer resolutions from a few to many lines can be seen. In the lower row two dimensional lattices and crystal structures are shown. The
diffraction patterns are accordingly more complex.

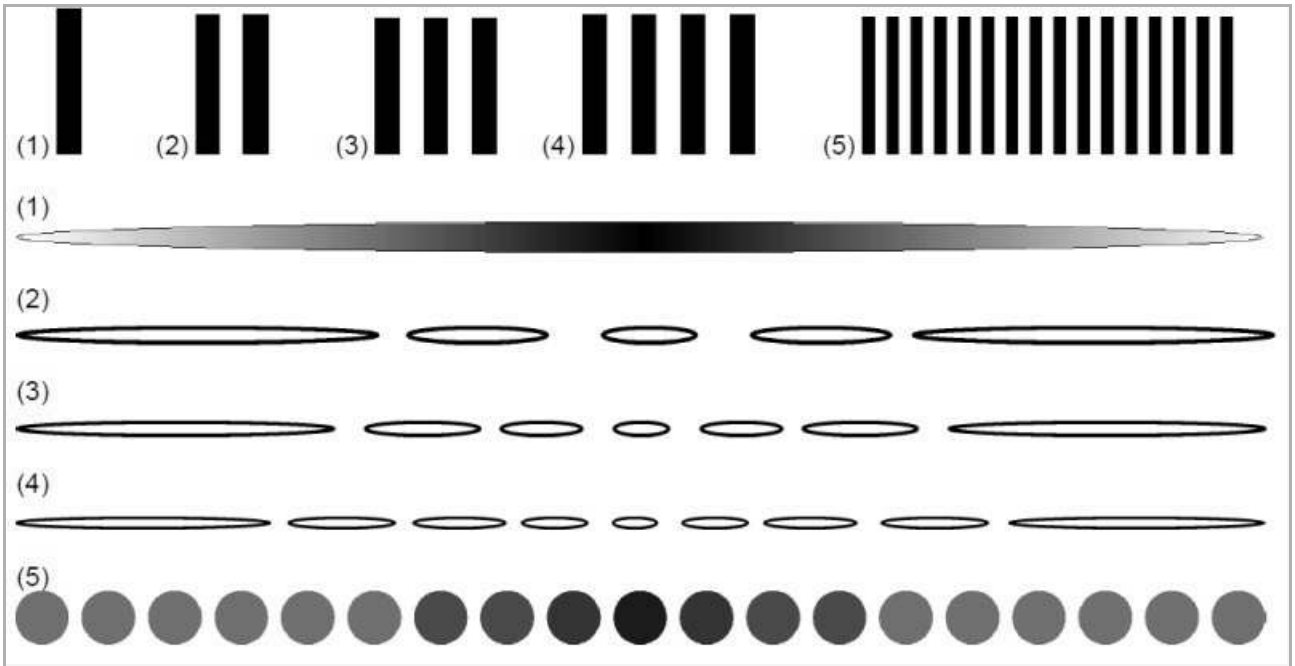

Fig. S1

The schematic diagram is of course not so impressive as the view through the slide, but it should give a first impression. The transition from a single slit to the grating can be discussed here. On account of the complexity of the remaining figures only 2 diffraction patterns are shown as drawings:

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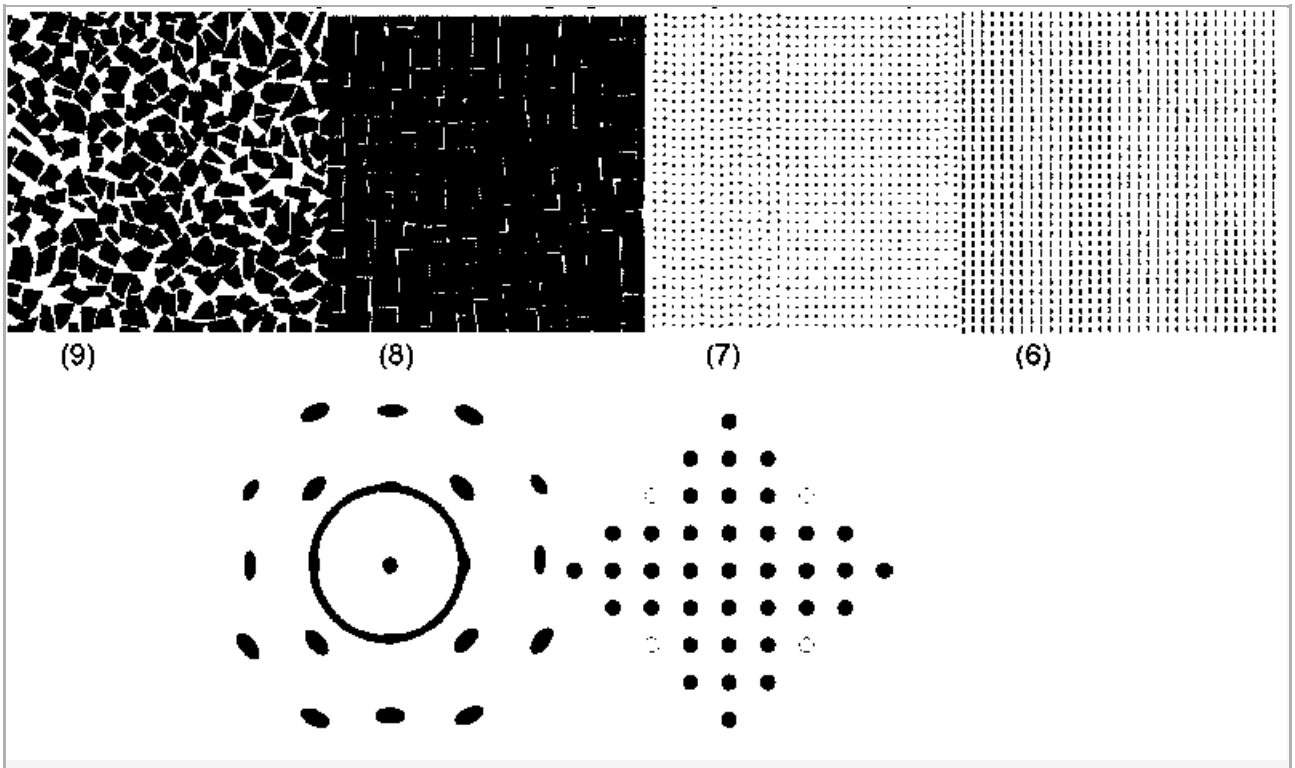

Fig. S2

For further clarification here is another view through the slide (of figure 8):

Fig. S3

From the figures it can be seen that diffraction patterns allow conclusions to be drwan about the starting structures. For example, diffraction pattern (8) is a typical example for a structural analysis of a crystal (Laue method - with the Laue method a single
crystal is analysed by means of x-ray radiation, with the Debey-Scherrer method, however, a powder made from crystallites is used).

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Task

What can be learned from diffraction patterns?

You are already familiar with the interference at a grating. This knowledge can be used to investigate and analyse structures of microscopic dimensions. In this experiment you will learn to draw conclusions about structures from their interference patterns.

Student's Sheet

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Equipment

Position No.	Material	Order No.	Quantity
1	LED - red, with series resistor and 4 mm plugs	09852-20	1
2	Slide mount without angle scale	09851-02	1
3	Diaphragm holder, attachable	11604-09	1
4	Lens on slide mount, f=+50mm	09820-01	1
5	Diffraction objects acc.Koppelmann, in slide frame, glassles	09851-15	1
6	Measuring tape, l = 2 m	09936-00	1
Additonal material			
7	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
8	School ruler (large)		1
	Connecting lead, red	07362-01	1
	Connecting lead, blue	07362-04	1

Set-up and procedure

Set-up

- Attach the LED with the aperture holder to the slide mount and stand it up. Other stands are not required for this experiment.

Fig. 1

Fig. 2

Fig. 3

- Connect the LED to the current source. Ensure that the poles are connected correctly.
- Set the power supply to 6 V.

Fig. 4

Fig. 5

Procedure

- At a distance of 3 - 4 m hold the slide with the Koppelmann figures directly in front of your eye and look at the various diffraction patterns occurring as you look at the LED.
- For each figure on the slide record the corresponding diffraction pattern together with a small sketch. Describe the diffraction pattern briefly.

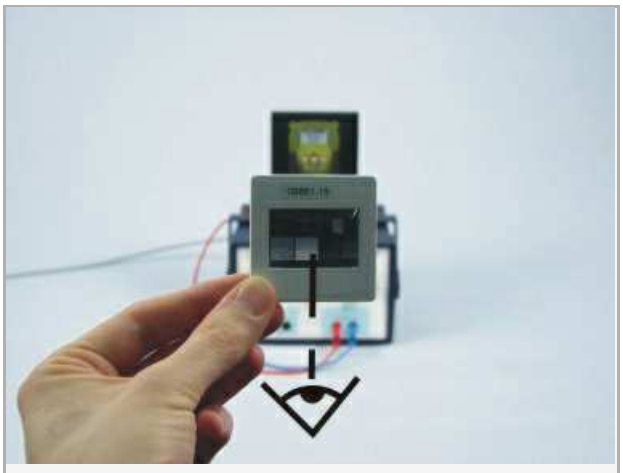

Fig. 6

- Use the lens as a magnifying glass and look carefully at the figures on the slide - draw the figures next to the diffraction patterns that you have noted down in the preceding step.

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Fig. 7

Fig. 8

Determine as an example the distance between the lines for the second figure from theright in the lower row. Place a large school ruler next to the LED and walk approx. 8 to 10 metres away. Vary your distance until an interference falls onto an easily read position
on the ruler and record your distance from the LED as l and the distance of the maximum from the middle as a.

Fig. 9

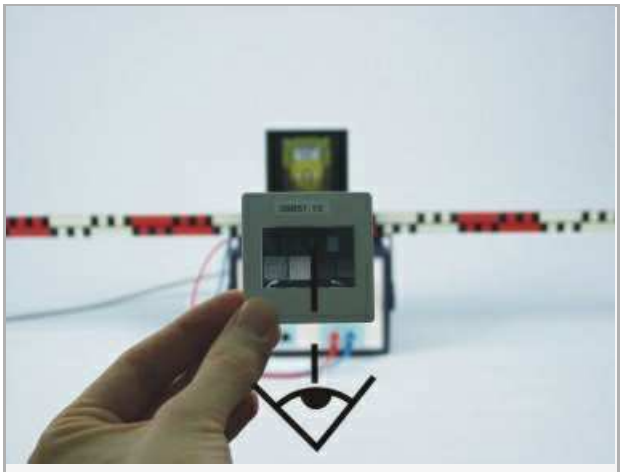

Fig. 10

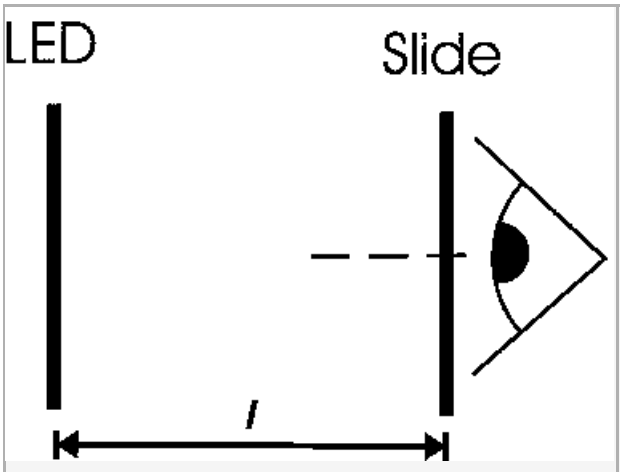

Fig. 11

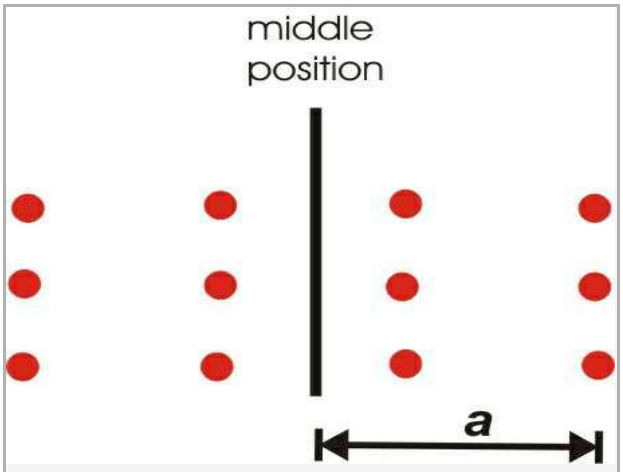

Fig. 12

Report: Diffraction object as described by Koppelmann

Result - Question 1

Outline the diffraction patterns and the associated object.

Sketches for object 1	
Diffraction pattern	Object

Sketches for object 2	
Diffraction pattern	Object

Sketches for object 3	
Diffraction pattern	Object

Student's Sheet

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Result - Question 2

Outline the diffraction patterns and the associated object.

Sketches for object 4	
Diffraction pattern	Object

Sketches for object 5	
Diffraction pattern	Object

Sketches for object 6	
Diffraction pattern	Object

Result - Question 3

Outline the diffraction patterns and the associated object.

Evaluation - Question 1

Describe in your own words the relationship between the diffraction figures and the original figures.

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Evaluation - Question 2

For determining the distance between the lines in the second part use these formulae: $\sin(\alpha_k) = k \times \lambda/g$ and $\tan(\alpha_k) = a_k/I$ with k being the order of the observed maximum. The wavelength λ is 631 nm for the red diode. Combine the two equations and solve to get g. Should you have any problems with the re-arranging use the following equation:

$$g = k \times \frac{\lambda}{\sin(\arctan(a_k/I))}$$