Diffraction at multiple slits

Diffraction objects with increasing numbers of slits are used to demonstrate the influence of the interaction of several slits on the resulting interference patterns.

Physics > Light & Optics > Diffraction & interference

Difficulty level	Group size	Preparation time	Execution time
medium	-	10 minutes	20 minutes

This content can also be found online at:

http://localhost:1337/c/64929aaa30fd2c00022dfe70

General information

Application

Experimental setup

When monochromatic light hits multiple slits, an interference pattern with intensity maxima and minima appears behind them on a screen.

As the number of slits increases, the brightness maxima become more intense and sharper, but their position remains independent of the number of slits.

Optical gratings are mainly used in spectral analysis for wavelength determinations.

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Other teacher information (1/2)

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Prior knowledge

To understand this experiment, students should already be familiar with the wave behaviour of light. For illustration purposes, it can be helpful to show interference of water waves beforehand.

Principle

A laser beam shines through an aperture with multiple slits and creates an interference pattern on a screen behind it.

Due to the interaction of the individual beams, sharply defined main maxima and less intense secondary maxima can be observed.

Other teacher information (2/2)

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Learning objective

With an increasing number of slits n the brightness maxima are more intense and sharper, but their position remains independent of the number of slits.

Additionally, there are $n-2$ secondary maxima and $n-1$ minima between two adjacent main maxima.

Tasks

- Observing the interference patterns on the screen.
- Determination of the influence of the interaction of several columns on the resulting interference patterns.

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Safety instructions

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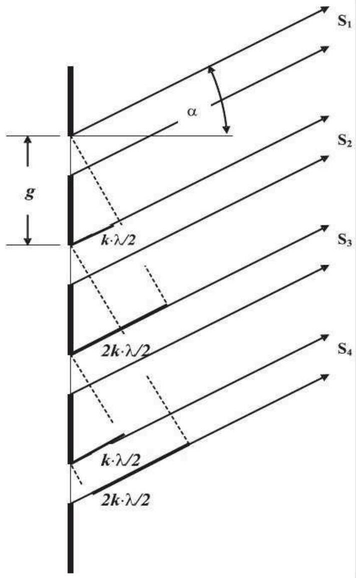
It is essential to ensure that you do not look directly into the laser beam.

The general instructions for safe experimentation in science lessons apply to this experiment.

Theory (1/2)



When light is diffracted at regularly arranged, identical slits, not only do the rays diffracted by an individual slit of the system interfere with one another, but also all the beams of rays diffracted at the other slits. The figure on the left illustrates the situation with a 4-fold slit as an example.

First consider the interference of the beams S_1/S_2 and S_3/S_4, which emanate from two adjacent slits, each of which corresponds to a double-slit system. Homologous rays of these diffracted bundles have a path difference. If this is $k * \lambda/2$, where k must be an even number, the result is brightness. On the other hand, darkness prevails when k is odd.

Now the bundles of rays S_1/S_3 and S_2/S_4 also interfere with each other.

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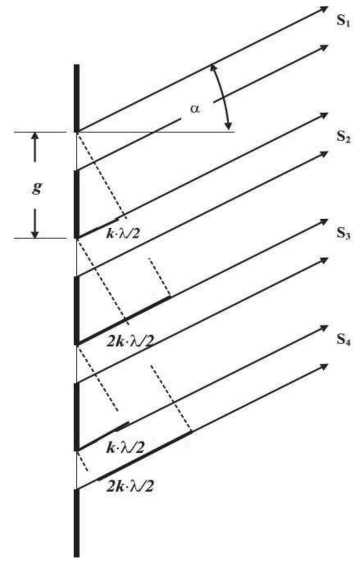
Theory (2/2)

These beams have a path difference of $2k * \lambda/2$.

They produce brightness when $2k * \lambda/2$ is an even multiple of half the wavelength. Accordingly, these rays cancel each other out when $2k$ is an odd number.

The interaction of all the beams leads to an interference pattern consisting of sharply defined main maxima, between each of which lie 2 secondary maxima of lower intensity.

In general, if a diffraction system consists of n slits, then between two adjacent main maxima there are $n - 2$ secondary maxima and $n - 1$ minima. If constructive n-rays of amplitude A are superimposed, the intensity of the corresponding brightness maximum is $(nA)^2$.



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Equipment

Position	Material	Item No.	Quantity
1	Optical profile-bench, l = 1000 mm	08370-00	1
2	Slide mount for optical bench	09822-00	3
3	Plate mount for three objects	09830-00	1
4	Diaphragm, 4 multiple slits	08526-00	1
5	Diffraction grating,10 lines/mm	08540-00	1
6	Screen, metal, 300 x 300 mm	08062-00	1
7	Barrel base expert	02004-00	1
8	Measuring tape, l = 2 m	09936-00	1
9	Diodelaser, red, 1 mW, 635 nm	08761-99	1

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Additional equipment

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Position	Equipment	Quantity
1	Cardboard strip	2

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Set-up and Procedure

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Set-up

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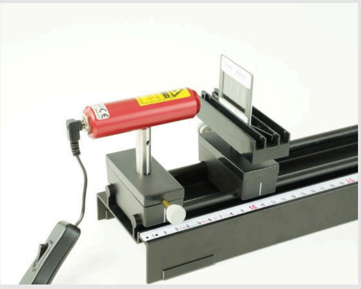
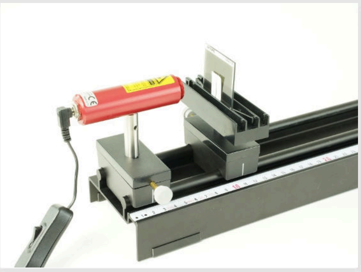
Fig. 1. shows the experimental setup. The diode laser is at the head end of the optical bench.

Close behind it is the plate mount in a tab. The screen is fixed in the barrel base and approx. $4m$ away from the aperture.

Fig. 1

Procedure





The aperture with multiple slits is inserted into the plate holder. One after the other, the multiple slits are pushed into the beam path so that the slits are fully illuminated. It may happen that the beam cross-section of a diode laser is not circular but oval, with the longitudinal axis of the oval vertical. In order to still be able to fully illuminate a multiple slit, in these cases the diaphragm is used with horizontally lying slits, which however has the consequence that the diffraction patterns run vertically in an unusual way.

Finally, the interference pattern of the grating is examined for comparison. To see the behaviour of different numbers of slits with the same grating constant, the cross-sectional area of the laser beam is changed with the help of two cardboard strips that are pushed in front of the grating in the plate holder.

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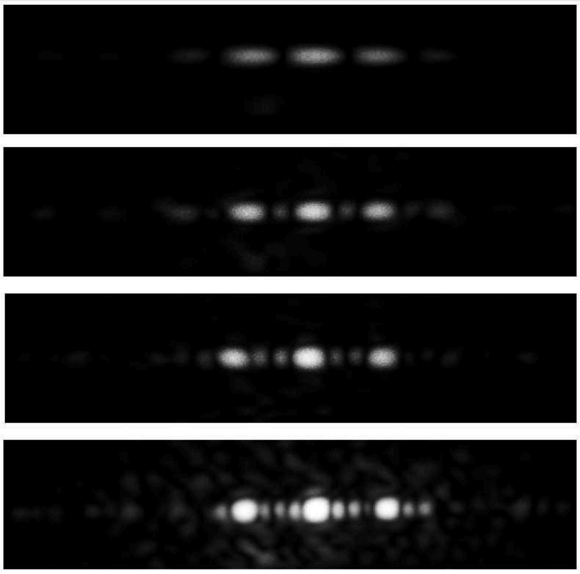
Evaluation

Evaluation (1/4)



The figure on the left shows the associated interference patterns for the slit systems $n = 2, 3, 4, 5$ with the number of slits.

It can be seen that with increasing n the brightness maxima become more intense and sharper, but their position is independent of the number of slits.

It is also confirmed that $n - 2$ secondary maxima and $n - 1$ minima lie between two adjacent main maxima (see table).

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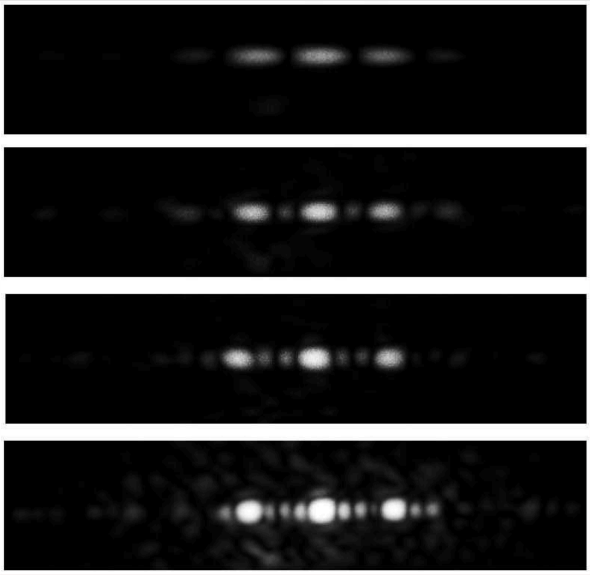
Evaluation (2/4)

Number n the column	Number of side maxima
2	0
3	1
4	2
5	3

Number n the column	Number of minor minima
2	1
3	2
4	3
5	4



The comparison with the grid provides an even clearer result.

As the width of the auxiliary slit increases, i.e. as the number of active but identical grating openings increases, the main maxima become sharper and sharper. At the maximum width of the auxiliary slit, sharp main maxima but almost no secondary maxima are visible.

Evaluation (3/4)

How many side maxima are there with $n = 10$ Columns?

- 8
- 9
- 6

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Evaluation (4/4)

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What makes it possible to show the main maxima very sharply and the secondary maxima very weakly?

- By maximising the width of the auxiliary gap.
- By changing the distances between the grating, screen and laser.
- By minimising the width of the auxiliary gap.

Is the position of the brightness maxima dependent on the number of slits?

- Yes, the position of the brightness maxima depends on the number of slits.
- No, the position of the brightness maxima is not dependent on the number of slits.

Slide	Score / Total
Slide 16: Secondary maxima	0/2
Slide 17: Multiple tasks	0/2

Total 0/4

Solutions Repeat

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