Diffraction at multiple slits with laser

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

Physics > Light & Optics > Diffraction & interference

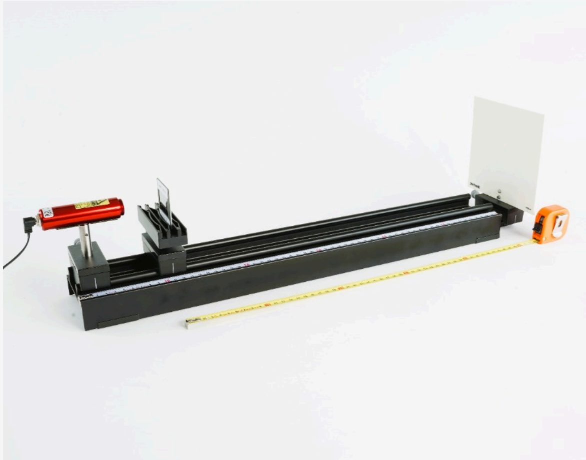
Difficulty level	Group size	Preparation time	Execution time
easy	-	10 minutes	10 minutes

This content can also be found online at:

http://localhost:1337/c/6729fb9926998c000267a33f

Teacher information

Application



The experimental setup

If 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.

Multiple slits (optical gratings) are mainly used in spectral analysis to determine wavelengths. An everyday example of diffraction at gratings are light reflections that occur on a CD.

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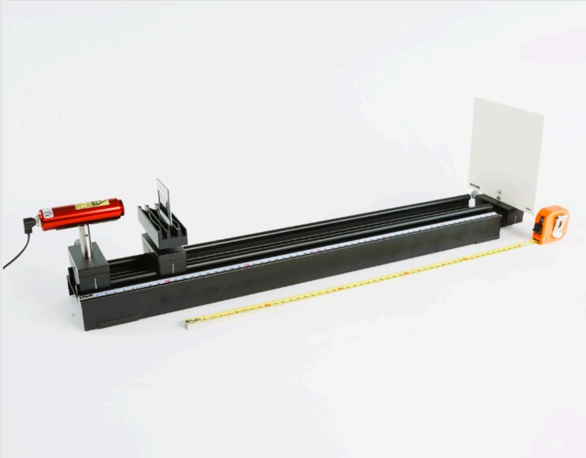
Application



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Other teacher information (1/4)

Prior knowledge

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

Principle

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

Due to the interaction of the individual beam bundles, sharply defined main maxima and secondary maxima of weaker intensity can be observed.

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Other teacher information (2/4)

Learning objective

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

In addition, between two neighbouring main maxima there are $n-2$ Secondary maxima and $n-1$ Minima.

Tasks

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

Other teacher information (2/4)

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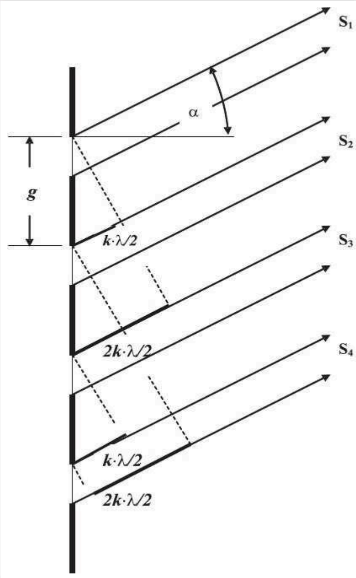
Other teacher information (3/4)



When light is diffracted at regularly arranged, identical slits, not only the beams diffracted by a single slit in the system interfere with each other, but also all the beams diffracted at the other slits. The figure on the left illustrates the situation at a 4-fold slit.

Firstly, the interference of the beams S_1/S_2 and S_3/S_4 is considered which emanate from two neighbouring slits, each of which corresponds to a double slit system. Homologous beams of these diffracted bundles have a path difference. If this is $k \cdot \lambda/2$ where k must be an even number, the result is lightness. On the other hand, there is darkness if k is odd.

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

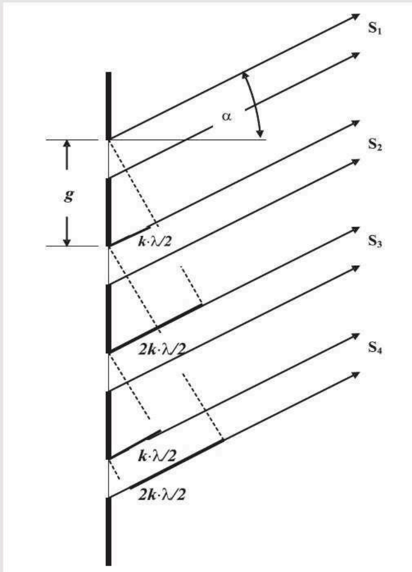
Other teacher information (4/4)

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

They interfere constructively and generate bright points of light when $2k$ is an even multiple of half the wavelength and are cancelled if $2k$ is an odd number.

The interaction of all the beams results in an interference pattern consisting of sharply defined main maxima, between each of which there are 2 lower-intensity secondary maxima.

The following generally applies: If a diffraction system consists of n-columns, then between two neighbouring main maxima there are $n-2$ Secondary maxima and $n-1$ Minima. Overlap constructively n-beams of the amplitude A the intensity of the corresponding maximum brightness is $(nA)^2$.



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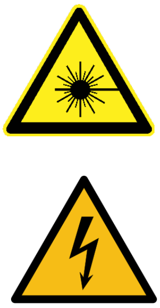
Safety instructions



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.

Student information

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Equipment

Position	Equipment	Item no.	Quantity
1	Optical profile bench for student experiments, l = 600 mm	08376-00	1
2	Rider for optical profile bench	09822-00	3
3	Plate holder for 3 objects	09830-00	1
4	Aperture with 4 multiple columns	08526-00	1
5	Shade, white, 150 mm x 150 mm	09826-00	1
6	Measuring tape, l = 2 m	09936-00	1
7	Diode laser, 1 mW, 635 nm (red-3V) with short stem, l = 75 mm	08771-99	1
8	Power supply unit for 08761-99, 6V, 0.3A	08761-00	1

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Tasks

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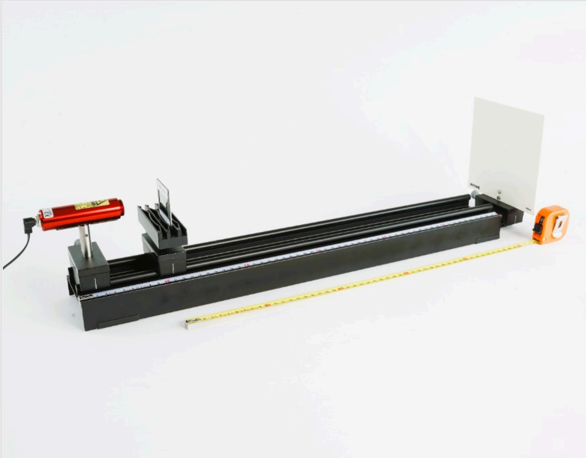

The experimental setup

1. Examine the diffraction patterns generated by 2, 3, 4 or 5 equally wide slits (multiple slits).
2. Compare the diffraction pattern of a grating with the diffraction patterns of the multiple column.

Equipment

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1	Optical profile bench for student experiments, l = 600 mm	08376-00	1
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Additional equipment

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Position	Equipment	Quantity
1	Cardboard strips	2

Setup

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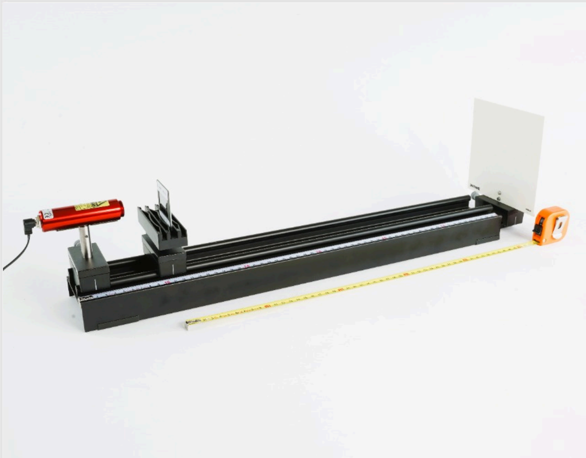

The experimental setup

The experiment is set up is as shown in the figure.

The line marks of the tabs for holding the components have the following positions on the optical bench:

- Rider with diode laser at 2 cm
- Rider with panel holder and inserted panel with multiple slits at 10 cm

The barrel base with screen is located at a distance of r = 1.5 m to the double slit.

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Procedure (1/4)

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Detailed view

Insert the aperture with multiple slits into the plate holder. Switch on the laser power supply.

The multiple slits are pushed into the beam path one after the other so that the slits are fully illuminated (see next page). It can happen that the beam cross-section of a diode laser is not circular but oval, whereby the longitudinal axis of the oval is vertical. In order to be able to fully illuminate a multiple slit, the aperture with horizontal slits is used in these cases, which, however, results in the diffraction patterns running vertically in an unusual way.

Procedure (2/4)

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Mark the main and side maxima

- Examine the diffraction patterns in relation to possible interference patterns. **Side** maxima and minima that occur between the brightness maxima, which are known as **main** maxima.
- Count the **main** maxima, the **side** maxima and the minima and enter the results in a table. Label the intensity as high, medium, low or very low and also enter this in the table.

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Procedure (3/4)

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Experimental setup with inserted piece of cardboard

Finally, the interference pattern of the grating is analysed for comparison. In order to recognise the behaviour of different numbers of slits with the same grating constant, the cross-sectional area of the laser beam is changed with the aid of two cardboard strips, which are pushed in front of the grating in the plate holder.

- Cover the grid with the two opaque cardboard strips so that initially a wide area of the grid remains uncovered symmetrically to the optical axis.

Procedure (4/4)

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Experimental setup with inserted piece of cardboard

- Move the two opaque cardboard strips evenly to the optical axis and thus reduce the area used by the grating. This reduces the number of illuminated diffraction slits.
- Describe the changes in the diffraction pattern in writing. Finally, switch off the power supply unit.

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Report

Task 1

Assign the correct slit system to the interference patterns with $n = 2, 3, 4$ and 5.

$n = 2$ $n = 3$ $n = 4$ $n = 5$

Check

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Task 2

How many secondary maxima are there for $n = 10$ slit columns?

- 6
- 8
- 9

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