Using diffraction at a grating to determine wavelength

Task and equipment

Information for teachers

Additional Information

The main objective of these experimenst is to practise finding wavelengths on the basis of diffraction optical transmission gratings.
Furthermore, they will help students to gain an understanding of the magnitude of wavelegths to the visible part of the spectrum and to realise that it is often necessary to allow a considerable tolerance when determining the wavelegth of filter light, unless it is possible to use costly special filters for defining wavelengths.

Suggestions for Set-up and Performance

These experiments can be set up and performed in a semi-darkened room. In order to avoid dissolution of the diffraction spectra the power supply may be reduced to 6 V~ and the light aperture adjusted to an appropriately narrow width.

Remarks

It can happen - as in the current example - that in the experiment the upper limit of the transmission range of the red filter is found to be above the upper critical wavelength of visible light. This apparently contradictory phenomenon is due to the fact that, when taking measurements in the complete spectrum of white light, the outer visible red is dissolved in the brightness of the spectrum. If the students arrive at similar results, they should switch the power supply on again and observe the diffraction pattern alternately with and whithout the red filter.
If an experimental lamb (order no. 11615-05), a spectral lamb (e.g. Hg, order no. 08120-14) and a power supply for spectral lamb (order no. 13662-93) are available, it will be possible to determine the wavelengths of specific spectral lines using basically the same experimental setup.

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Task

In which range are the wavelengths of visible light and of light transmitted by a colour filter to be found?

Using diffraction from a transmission grating, find out the critical wavelengths for the colours od the visible spectrum and the transmission range for the red the blue and the green filter.

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	red, blue and green filter
7	Lens on slide mount, f=+50mm	09820-01	1
8	Lens on slide mount, f=+100mm	09820-02	1
9	Lens on slide mount, f=+300mm	09820-04	1
10	Slide mount for optical bench	09822-00	2
11	Mount with scale on slide mount	09823-00	1
12	Plate mount f.3 objects	09830-00	2
13	Measuring magnifier	09831-00	1
14	Grating, 80 lines/mm	09827-00	1
15	Slit, adjustable.up to 1 mm	11604-07	1
16	Diaphragm holder, attachable	11604-09	1
17	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13505-93	1
Additional material			
	Ruler (approx. 30 cm)		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).

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Fig. 3

Fig. 4

Fig. 5

Fig. 6

- Position the lens with *f* = +50 mm at 6 cm on the optic bench (Fig. 7).

Fig. 7

- Attach the diaphragm holder with adjustable slit (light aperture) to the mount with scale and position the mount at 9.5 cm (Fig. 8).

Fig. 8

- Position one lens with *f* = +300 mm at approx. 40 cm and the other one at the very end of the optic bench (Fig. 9).
- Position one lens with *f* = +100 mm on the far right-hand side so that its front edge points away, i.e. to the right, of the optic bench (Fig. 10).

Fig. 9

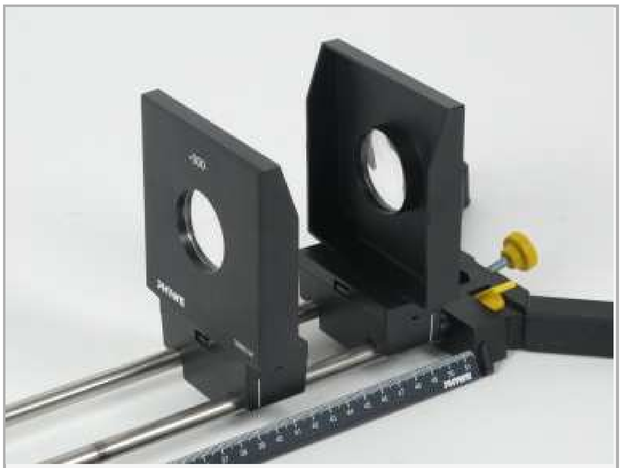

Fig. 10

- Place a slide mount with plate mount just to the left of the lens with *f* = +100 mm with the springs pointing towards the lens. This will enable you later on to attach the grating as close to this lens as possible (Fig. 11).

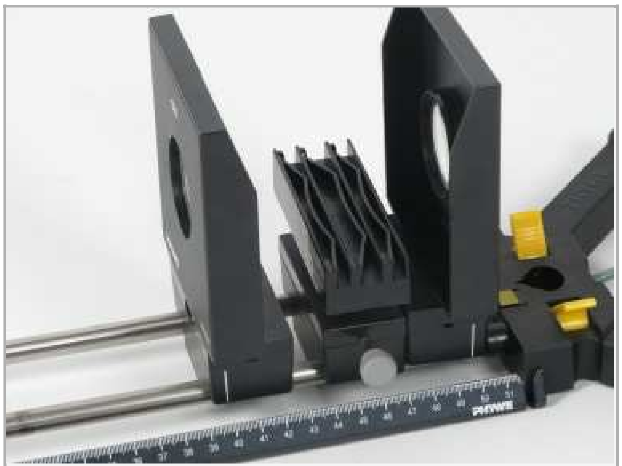

Fig. 11

- Position slide mount with plate mount holding observation lens as close as possible to and on the right of the optic bench (Fig. 12); to do this, screw the thumbscrew on the right side of the support base in as far as it will go (Fig. 16).

Fig. 12

Procedure

- Connect the light box to 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 light aperture is sharply focussed in the observation plane.
- Attach grating with 80 lines/mm (g = 0.0125 mm) to the right-hand attachment of the plate mount in front of the lens with f = +100 mm (Fig. 14).

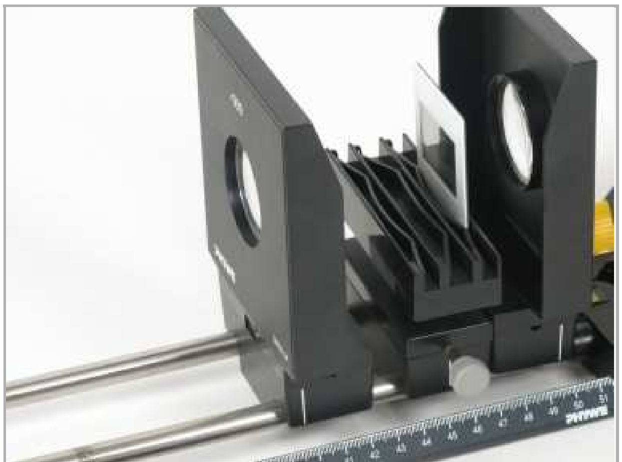

Fig. 14

- Adjust the arrangement: light aperture parallel to the grating lines; optimum width of light aperture to ensure that interference pattern is sharply focused and bright enough without dissolving.
- With the aid of the observation lens measure the distance d_{max} of the just visible red and d_{min} of the just visible violet

away from the brightness peak of the 0th order (Fig. 15).

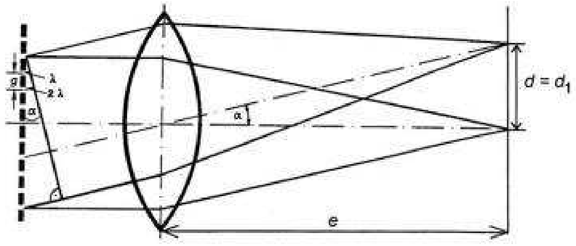

Fig. 15

- Mesure distance *e* between the centre of the lens with *f* = +100 mm and the observation plane (Fig. 15)
- Note down your results in table 1 in the report.
- Insert red filter into light well (Fig. 16).

Fig. 16

- Using the observations lens measure the distance d_{max} of the outer and d_{min} of the inner edge of the 1st-order diffraction fringe away from the brightness peak of the 0th order.
- Describe colour image and note down values in table 1.
- Proceed in the same manner for the blue and green filters.
- Switch off power supply.

Report: Using diffraction at a grating to determine wavelength

Result – Observations

Note down the distance lens - observation plane:

e = ... mm

Result – Table 1

1. Enter the measured values in the table.
2. From Fig. 15 you can derive the equation: $\lambda = g \cdot d/e$ (g = 0.0125 mm). Calculate with this equation and on the basis of your measurements the critical wavelengths λ_{min} and λ_{max} of visible light and enter the values in the table.
3. Calculate with the equation $\lambda = g \cdot d/e$ the critical wavelengths λ_{min} and λ_{max} of the light transmitted by the color filters and enter these values in the table.

	Distance		Color	Wavelength	
	d_{min} in mm	d_{max} in mm	from ... to	λ_{min} in nm	λ_{max} in nm
White light	1 ±0	1 ±0	violet ... dark red 1	1 ±0	1 ±0
Red filter	1 ±0	1 ±0	yellow green ... dark red 1	1 ±0	1 ±0
Green filter	1 ±0	1 ±0	blue ... orange 1	1 ±0	1 ±0
Blue filter	1 ±0	1 ±0	blue ... green 1	1 ±0	1 ±0
Blue filter 2	1 ±0	1 ±0	blue ... red 1	1 ±0	1 ±0

Evaluation – Question 1

Give rounded values for the range of visible light and for the transmission ranges of the filters.

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