Coherency Requirement

Task and equipment

Information for teachers

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Task

What condition must be fulfilled so that diffracted light of a particular wavelength λ can be brought to interference?

1. When red light is diffracted from a triple slit, investigate the critical width *d* of the light aperture at which secondary interference maxima just occur or disappear.
2. After that, find out whether green or blue light is brought to interference at the established aperture width *d*.

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	1
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	2
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	Diaphragm, 4 multiple slits	08526-00	1
15	Slit, adjustable.up to 1 mm	11604-07	1
16	Diaphragm holder, attachable	11604-09	1
17	Measuring tape, l = 2 m	09936-00	1
18	PHYWE power supply DC: 0...12 V, 2 A / AC: 6 V, 12 V, 5 A	13506-93	1
19	Cardboards 200x300mm,black,10 pcs	06306-01	(1)
Additional material			
20	Scissors		1

Set-up and procedure

Set-up and procedure 1

Experiment 1

- 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

- Insert the red filter into the other light well (Fig. 7).

Fig. 7

- Set up the lens with *f* = +50 mm at 6 cm on the optic bench (Fig. 8).

Fig. 8

- Set up the mount with the scale at approx. 9.5 cm and attach the diaphragm holder with the adjustable slit to the mount (Fig. 9).

Fig. 9

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

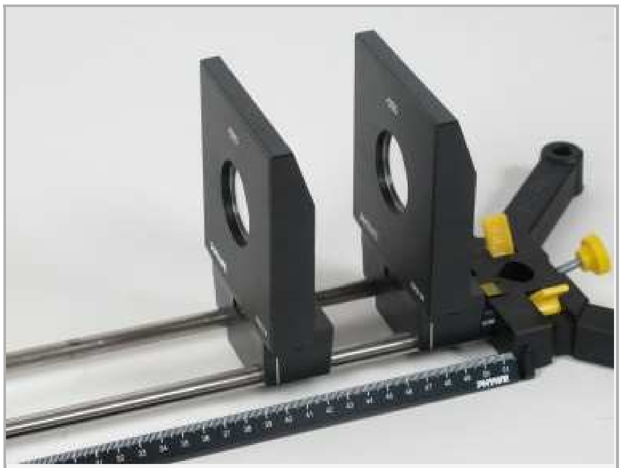

Fig. 10

- Place a slide mount with plate mount between these two lenses (Fig. 11).

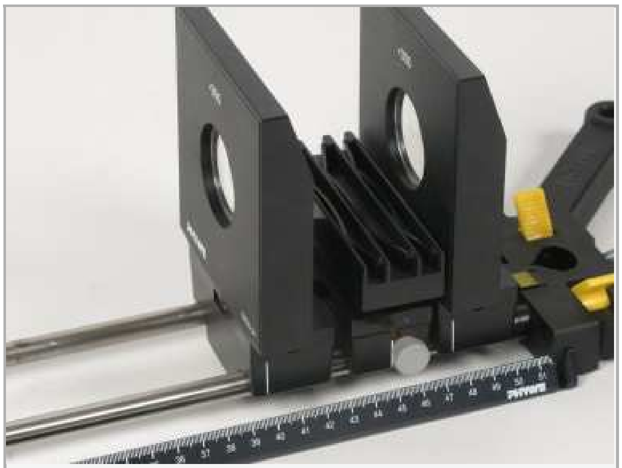

Fig. 11

- Place the second slide mount with plate mount and the observation lens on the table about 30 cm away from the outside, right-hand lens (Fig. 12).

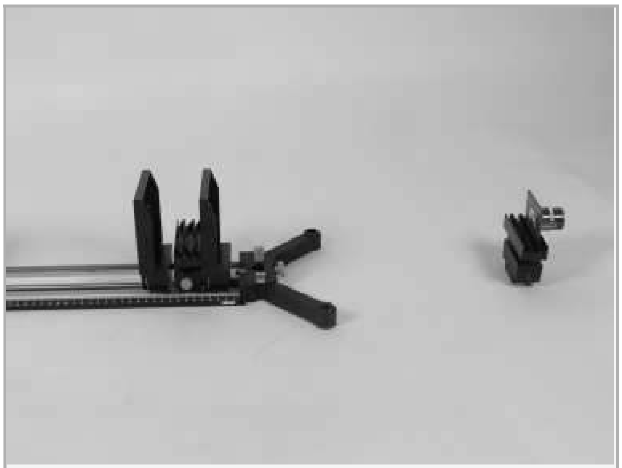

Fig. 12

- Connect the light to the power supply (12 V~) and swith on the power supply (Fig. 13).

Fig. 13

- Slide the observation lens along the optical axis until the image of the light aperture is sharply focused; if necessary, reduce the light voltage briefly to 6 V in order to avoid glare when focussing the image.
- Attach the diaphragm with multiple slits to an attachment of the plate mount located between the two lenses with *f* = +300 mm (Fig. 14).

Fig. 14

- Move the triple slit (*n* = 3) into the optical axis and cover the other multiple slits with black card.
- Shut the light aperture.
- Observe through the observation lens the diffraction patterns which occur as the light aperture is slowly opened; above all watch the secondary peaks (one at a time) visible between the primary peak of the 0th order and the primary peaks of the 1st order (comp. Fig. 15).

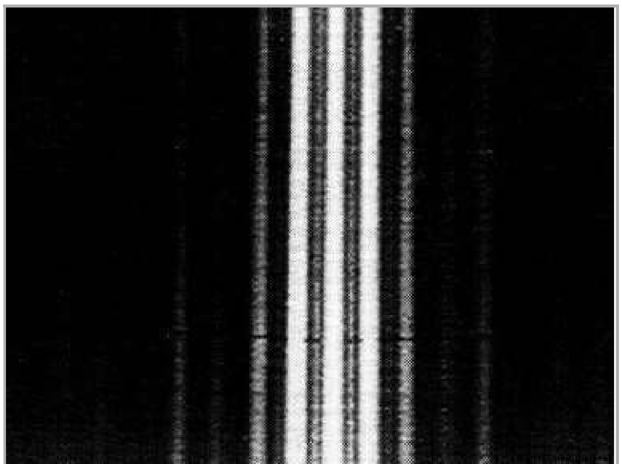

Fig. 15

- If necessary, readjust the arrangement: light aperture parallel to the triple slit; even illumination of the triple slit (i.e. symmetrical to the optical axis).
- Open the light aperture further until the secondary peaks have **just** disappeared.
- *Remark:* To gain more accuracy in establishing the width *d* of the light aperture at which the secondary peaks have just disappeared - or are not yet visible -, it is advisable to slightly reduce *d* and then increase it once more.
- Repeat this procedure several times.
- From now on, do not alter slit width *d* or position of the observation lens.
- Measure and note the distance *a* of the light aperture from the first lens with *f* = +300 mm.
- To ascertain the slit width d alter the arrangement as follows:
  Remove both lenses with *f* = +300 mm and the plate mount with the multiple slits; set up the lens with *f* = +100 mm at approx. 22 cm (Fig. 16).


Fig. 16

- Move the lens with *f* = +100 mm until a sharply focused image of the light aperture appears in the observation plane of the measuring lens.
- Measure the width *d*' of the slit image and note down the measurement.
- Measure and note down the image distance *b* (distance image lens - observation plane) and the object distance *g* (distance slit - image lens) under "Result - Observations 1" in the report.
- Switch off the power supply.

Set-up and procedure 2

Experiment 2

- Rearrange the apparatus as the beginning of Experiment 1.
- Switch on the power supply and check whether the image of the light aperture is in focus.
- Adjust the triple slit as in Experiment 1 and regulate the light aperture so that the secondary maxima are **still just** visible.
- Insert the green filter in place of the red filter and watch the secondary maxima in the diffraction pattern; note your observation under "Result - Observations 2" in the report.
- Insert the blue filter in place of the green filter; observe the diffraction pattern and note your observation "Result - Observations 3" in the report.

Report: Coherency Requirement

Result – Observations 1

Record all the measured values:

a = ... mm

d' = ... mm

b = ... mm

g = ... mm

Result – Observations 2

Note down your observations during the first part of the experiment:

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Result – Observations 3

Note down your observations during the second part of the experiment:

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Evaluation – Question 1

The equation for magnification of images at lenses is:

$V = B/G = b/g$ and hence also

$V = d'/d = b/g$.

Using this equation calculate the width *d* of the light aperture at which the 1st secondary maxima had just become invisible (or were not quite visible).

Evaluation – Question 2

For light waves which when superimposed are expected to interfere, the coherency requirement

$d \times \sin \varepsilon << \lambda$ or $d \times D/a << \lambda$

must be fulfilled (comp. Fig. below which illustrates this requirement for a double slit).

On the basis of your measurements check whether this requirement was fulfilled in the experiment; you may assume that the wavelength for red light is approx. 620 mm.

Evaluation – Question 3

Summarize the results of the Experiments 1 and 2.

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