

## Equipment Set for Wave Optics with Laser 1003053

### Instruction sheet

06/18 Alf



### 1. Safety instructions

The laser emits visible radiation at a wavelength of 635 nm with a maximum power of less than 1 mW, thus conforming to class 2 regulations as specified in DIN EN 60825-1 "Safety of lasers", i.e. the human eye can be protected by the instinctive reaction to turn away and blink.

- Do not look straight into the laser beam or any reflected beam.
- Lasers should only be operated by trained and authorised personnel.
- All those people participating in or observing an experiment must have been informed of the dangers inherent in laser radiation and educated regarding protective measures.
- Experiments may only be performed using the minimum power output required in each specific instance.
- Ensure that the beam is not directed at eye level.
- Use suitable screening to isolate the area around the laser and avoid unwanted reflections.

- Any rooms in which laser experiments take place should be labelled with warning signs.
- Observe the regulations valid in the respective country where the experiment is being performed, e.g. Germany's health and safety regulations BGV B2 "Laser radiation", and any stipulations set by the relevant ministry.

Safe operation of the laser is guaranteed, provided it is used correctly. However, there is no guarantee of safety if the equipment is used in an inappropriate or careless manner. If it is deemed that the equipment can no longer be operated without risk (e.g. visible damage has occurred), the laser should be switched off immediately and secured against any unintended use.

- Before putting the equipment into operation, check for any signs of damage. In the event of any malfunction or visible damage, turn off the laser and put it away so that it cannot be used unintentionally.
- Never open the housing.

## 2. Description

Equipment set for demonstrating fundamental phenomena in wave optics by means of practical experiments.

### Experiment topics:

Refraction and interference at the surfaces of a glass block, apertured diaphragm, square diaphragm, grating with slits, cross grating.

Michelson interferometer

Reconstruction of a hologram

Investigation of linearly polarized light

Absorption of light

The light source is provided by a partially polarized diode laser with adjustable mount. Power is supplied from a plug-in power supply (included) or from batteries. The components are magnetic and can be placed horizontally or vertically on the included metal board, according to the set-up required for the various experiments.

All components are stored in a case with shaped foam inlay.

## 3. Contents

- 1 Diode laser with adjustable mounting
- 1 Plug-in power supply
- 1 Battery holder (without batteries)
- 2 Mirrors with adjustable mounting
- 1 Half-silvered mirror
- 1 Screen, white
- 1 Screen, frosted glass
- 1 Convex lens
- 1 Polarization filter
- 1 Holder for lens and filter
- 3 Colour filters in slide frames (red, green, blue)
- 2 Apertured diaphragms in slide frames
- 2 Square diaphragms in slide frames
- 3 Gratings with slits in slide frames
- 1 Cross grating in slide frame
- 1 Glass plate in slide frame
- 1 Holder for slide frames
- 1 Hologram
- 1 Metal board with removable strut
- 4 Rubber feet for metal board
- 1 Storage case
- 1 Experiment guide

## 4. Technical data

Diode laser:	laser safety class II, max. 1 mW
Wavelength:	635 nm
Plug-in power supply:	primary 100 – 240 V AC secondary 3 V DC, 300 mA
Battery holder:	for 2x1.5 V AA batteries (batteries not included)
Metal board:	600 mm x 450 mm

## 5. Sample experiments

### 5.1 Light interference

#### 5.1.1 Light interference on a thin glass plate

- Place the laser without the lens in the corner of metal board, the laser beam should be parallel to the longer side of the board (see Fig. 1).
- Place the holder with the glass plate in the other corner of the board. The laser beam spot should be visible on the plate. The vertical position of the beam spot can be adjusted by turning the nut in the laser holder.
- Position the ground screen in the corner diagonal to the glass plate.
- Rotate the glass plate holder until the beam spot is in the centre of the ground screen.
- Place the lens holder with lens directly in front of the laser or place the lens without holder in contact with the laser to produce a diverging beam.

The diameter of the beam should not be greater than the diameter of the glass plate, to maximise light utilisation.

- Observe the interference pattern on the ground screen. Adjust its position to see the best interference pattern.

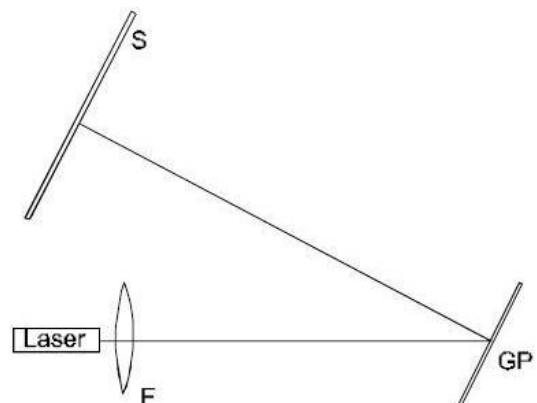


Fig.1 Experimental set-up (F = lens, GP = glass plate, S = ground screen)

### 5.1.2 Michelson interferometer

- Position the laser half way along the longer side of the metal board (Fig. 2) and adjust the laser beam parallel to the ground plate (see Notes).
- Position mirror M2 on the opposite side of the board, ensuring that the side without the screw is facing the laser. Direct the beam back to the laser by adjusting the screws on the laser holder and the mirror holder.
- Position the semi-transparent mirror between the laser and mirror M2 as shown in Figure 2. The angle between the semi-transparent mirror plane and the axis of the laser beam should be  $45^\circ$ . Correct positioning is vital.
- Position the ground screen as shown in Figure 2, on the shorter side of the board. The beam spot should appear in the centre of the screen.
- Place mirror M1 opposite the ground screen on the other side of the board.
- Merge the spots on the screen by moving mirror M1 slightly and adjusting the screw on the mirror holder and place the spots on the same height as the laser source (see Notes).
- Position the lens between the semi-transparent mirror and the laser. This causes a typical interference pattern to appear.

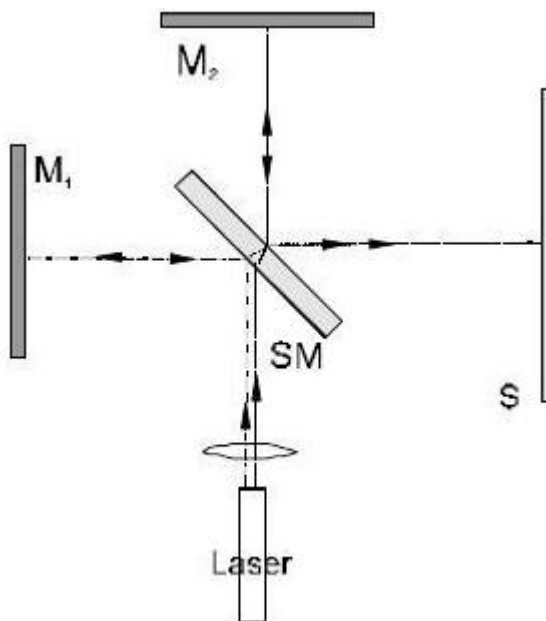


Fig. 2 Experimental set-up Michelson's interferometer. (M1, M2 = mirrors, SM = semitransparent mirror, S = ground screen)

### Notes:

Before the beginning of the experiment clean the lens, so that no parasite interference on dust particles attached to lens surface occur. You can easily identify such parasite interference as a number of concentric circles. An interference of beams coming from only one of the mirrors M1 or M2 can occur. This interference is easy to identify as occurring even by covering of one the mirrors M1 or M2.

By adjusting the set up according to Figure 2 it is very important that the interfering spherical waves are containing only a small angle (see Figure 3a), then we can observe the interference in the area I. If the spherical waves contain too big an angle (Figure 3b) the interference can not be observed. Therefore it is important to adjust the laser beam parallel to the ground plate and try to keep it parallel after reflection from mirrors M1 and M2.

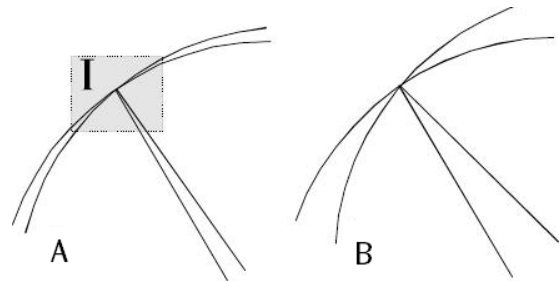


Fig. 3 Interference of two spherical waves

After placing and adjusting the mirrors observe two images of laser beams on the screen. By adjusting the mirrors and the laser place these two images in the same height as the laser source and on the same place on the screen. This way it is secured that the beam axis will be parallel to the ground plate and will intersect the image screen. It is better to carry out this adjustment without the lens placed.

It is very helpful to adjust the mirrors by positioning the laser very close to the semitransparent mirror. The mirror images should be nearly of the same shape and position. After finding the interference image we can move the laser source freely, without affecting the success of the interference.

In accordance to the high sensibility of the Michelson interferometer is it very important to place the base plate very stable and resistant to shake disruption. Touch the whole set up very carefully during adjustments.

If there is no interference image on the screen, remove the lens and ensure that the interfering beams are parallel to the ground plate and are hitting the screen at the same place. If that's correct and there is still no interference image, move one of the mirrors on the optical axis back or forward about 1 mm.

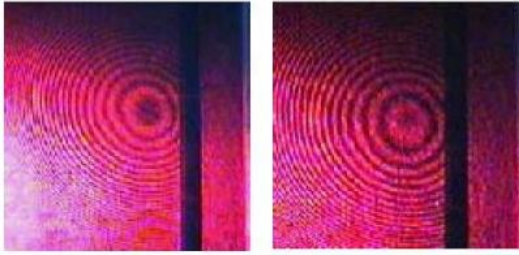


Fig. 4 The interference pattern of two spherical waves when the axes of the beams are overlaid or form a small angle

## 5.2 Light diffraction

### 5.2.1 Light diffraction on a square and a circle aperture

- Attach the square or circular aperture slide to the magnetic stand.
- Position the stand between the laser and the screen. The distance between the aperture and the screen should be at least 50 cm.
- Observe the diffraction patterns by using different apertures.

The equation for diffraction through a circular aperture

$$\sin\varphi = k \frac{\lambda}{D}$$

where  $\varphi$  = diffraction angle,  $k$  = diffraction order (0, 1, 2, ...),  $\lambda$  = wavelength of light,  $D$  = diameter of aperture.

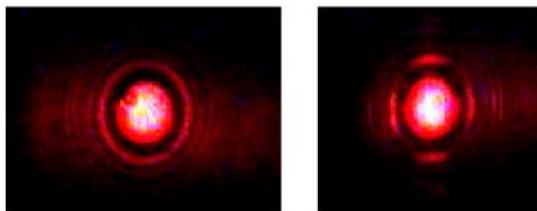


Fig. 5 Patterns produced when light is diffracted through circular and square apertures

### 5.2.2 Light diffraction on a grating

- Position the laser and the ground screen opposite and as far as possible from each other on the metal board (see Fig. 6).
- Position the grating between the laser and the screen. The distance between grating and the screen should be at least 50 cm.
- Observe the diffraction pattern (see Fig. 7).

The equation for diffraction maxima can be written as

$$\sin\varphi = m \frac{\lambda}{d}$$

where  $\varphi$  = diffraction angle,  $m$  = diffraction order (0, 1, 2, ...),  $\lambda$  = wavelength of light,  $d$  = grating constant

- Observe the diffraction on gratings of different types (G1, G2, G3, G4).

- Try to insert two gratings into the set-up at once, one behind the other.
- Observe the diffraction pattern.

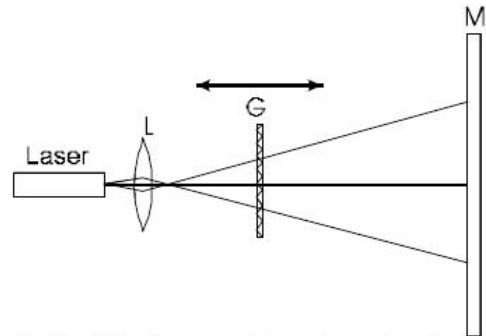


Fig. 6 Diffraction set-up [G = diffraction medium (square aperture, circle aperture, grating,), M = ground screen, L = lens]

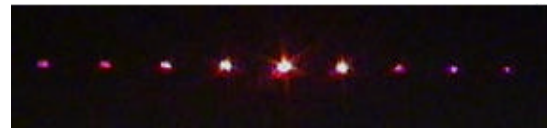


Fig. 7 The diffraction pattern of a linear grating

## 5.3 Hologram reconstruction

- Arrange the components on the metal board as shown in Figure 8. The lens should be in direct contact with the laser and the hologram should be positioned as far as possible from the laser and turned with the red spot to the laser.

The larger the area of the illuminated hologram, the more visible is the reconstructed image.

- Observe the hologram at an angle of approximately 30°. Rotate the hologram plate slowly until a holographic image appears.
- If you cannot locate the image, try turning the hologram 180°, or move your head slightly (observation at 30° can be achieved from two different positions).

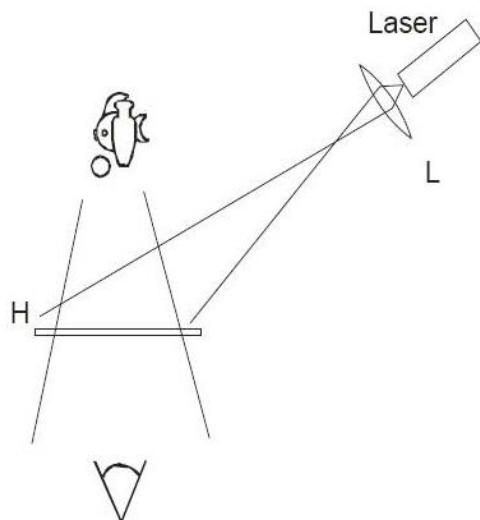


Fig. 8 Set-up for hologram reconstruction (L = lens, H = hologram)

#### 5.4 Polarisation of light

- Set up the experiment as shown in Figure 9.
- Rotate the polarization filter around the optical axis.
- Observe the changes of intensity of the laser beam spot on the screen.

#### Caution

No light is visible on the screen due to the perpendicular direction of the polarizer axis and the E vector of laser light. However this does not mean that your eyes are protected from the laser beam. Direct eye contact with the laser beam can permanently damage your sight.

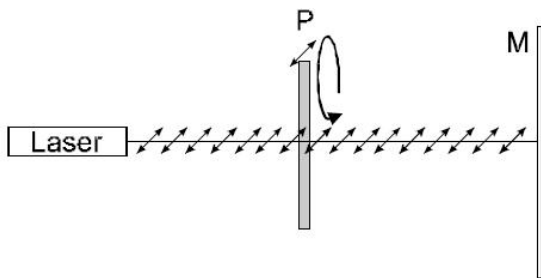


Fig. 9 Demonstration of the polarizing properties of light (P = polarization filter, M = ground screen)

#### 5.5 Absorption of light

- Set up the experiment as shown in Figure 10.
- By using different colour filters observe the changes in beam spot intensity.

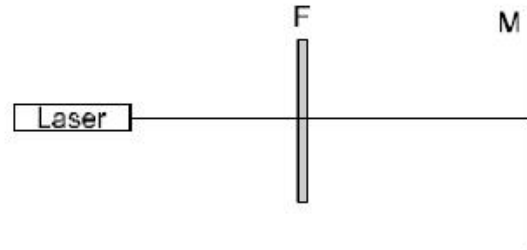


Fig. 10 Demonstration of light absorption with colour filters (F =colour filter, M = ground screen)

