P73.36 ENS LYON

# Demo setup for PHY11 & PHY12

## Contents

# 1 Safety Instructions

Please consider the safety and operation instructions contained in the SC600 operating manual.

## 1.1 Laser modules

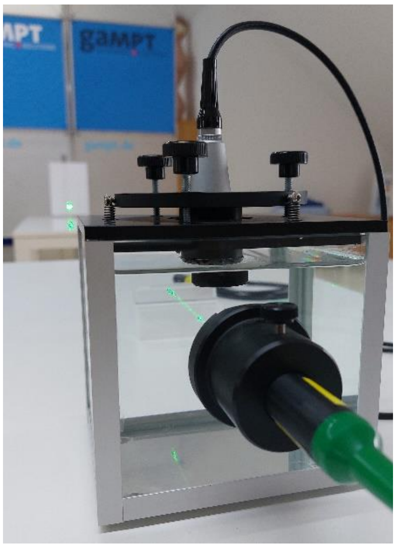
- The supplied green and red laser modules are equipped with laser diodes of the laser class 3R (EN 60825-1) with a performance of ≤ 5 mW. Before using them, find out about the necessary protective measures.
- Do not switch on a laser module connected to the output LASER of the SC600 if there is a person in the direction of the beam. Do not look into the laser beam and do not direct the laser at other people or animals.

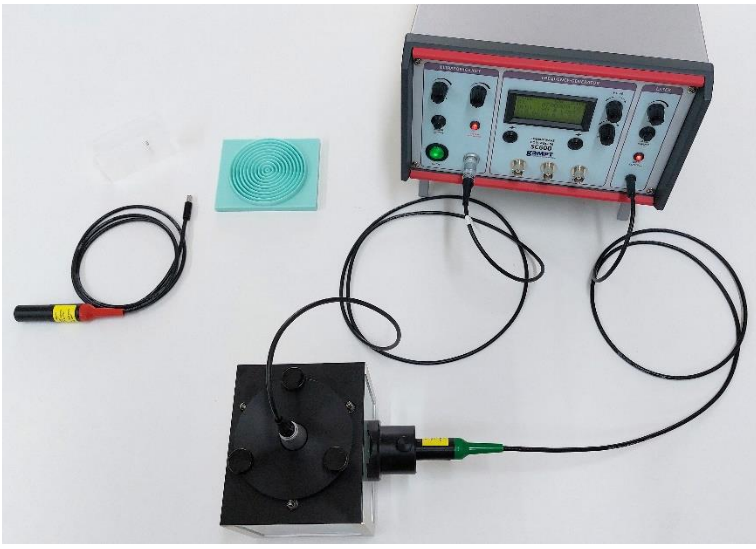
## 1.2 Ultrasonic multifrequency probe

- Only connect the ultrasonic transducer supplied by the company GAMPT mbH to the output of the ULTRASONIC unit marked PROBE. Be careful, there are voltages of up to 50 V and currents of up to 1000 mA.
- Switch off the output PROBE of the SC600 if the ultrasonic probe is not connected or not needed.
- Do not operate the connected ultrasonic transducer without contact with a liquid, because it can lead to overheating and thus to the destruction of the transducer.
- The surface of the ultrasonic probe must be free of bubbles.

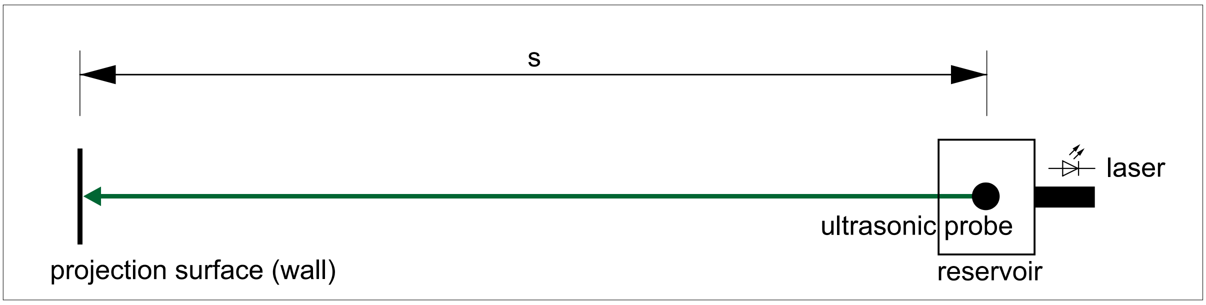
# 2 Setup

## 2.1 General setup

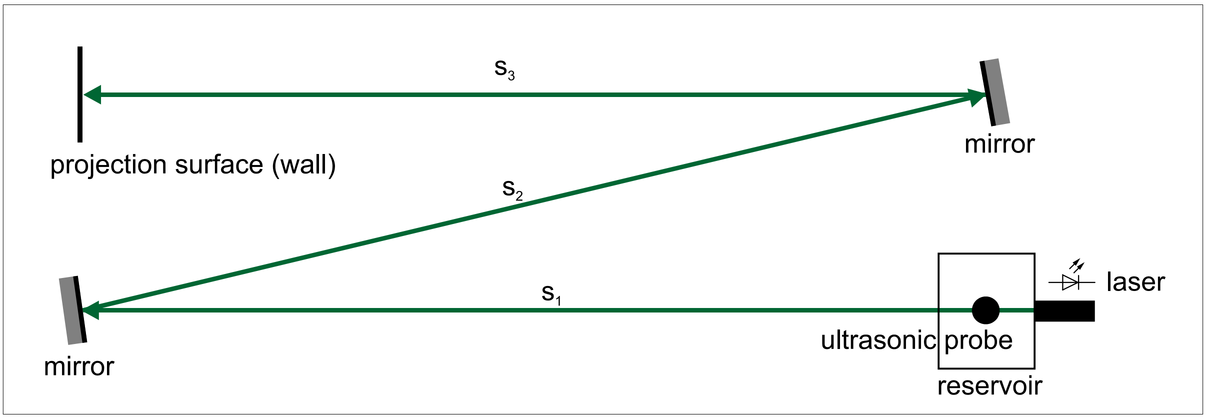




Demo setup on a table. Ultrasonic probe and green laser module are connected to the SC600 and switched on. PHY11 and PHY12 are performed with the same general setup.




The laser beam is directed onto a projection surface, e.g. a wall, canvas, ground glass screen etc. The path length **s** of the laser beam should be at least 3 meters (the longer the better), because the distances between the diffraction orders (PHY11) or brightness maxima (PHY12) are proportional to the path length **s** of the laser beam from the ultrasonic standing wave to the projection surface. If there is not enough space, mirrors (GAMPT order no. 20302, included in Set 8) can be used to redirect and extend the path of the laser beam (see the example below: $\mathbf{s} = \mathbf{s_1} + \mathbf{s_2} + \mathbf{s_3}$).



## 2.2 Settings on the SC600

Before using the SC600, read its manual to learn how to operate the instrument (see in particular chapter 3.4 Operation of the SC600).

After switching on the SC600, the outputs on the ultrasonic and laser unit of the device should be switched off (status LEDs are not lit). The outputs should generally only be switched on when ultrasonic probe and laser module are connected and in use.

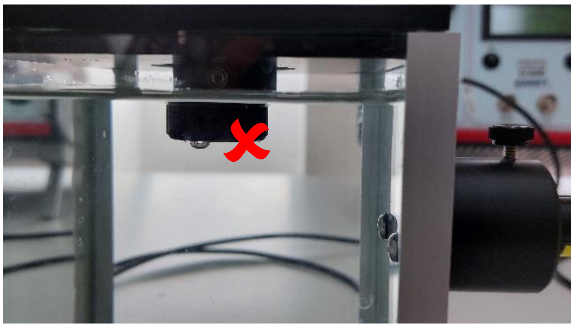
To use the ultrasonic probe, the current and voltage regulators at the ultrasonic unit of the device are set to maximum.

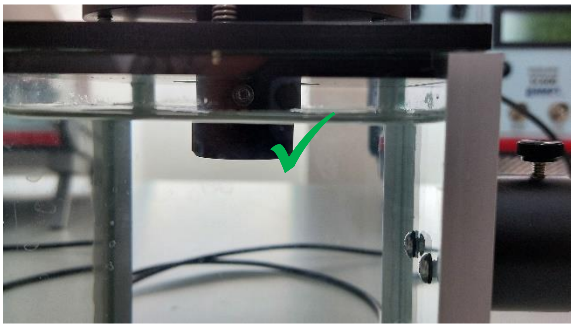
To use the laser modules, the voltage regulator at the laser unit of the device is set to about 3 volt.


## 2.3 Adjusting the ultrasonic standing wave

Switch on the laser output and direct the laser beam at the projection surface.

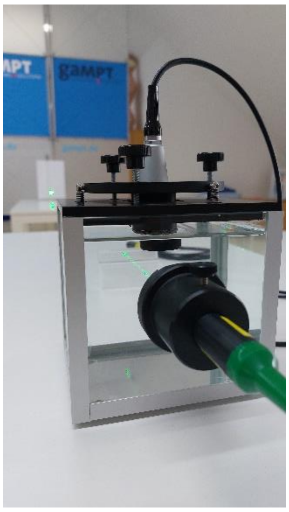
Check if the head of the ultrasonic probe is in water. There should be no air bubbles at the sound transmitting surface of the ultrasonic probe.



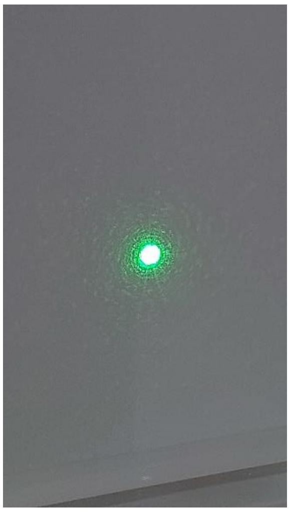


Select a frequency of about 5-6 MHz at the SC600 and turn on the ultrasound output at the ultrasonic unit of the SC600. Vary the ultrasound frequency in steps of 0.1 MHz or lower to find a resonance frequency generating a diffraction pattern with a lot of diffraction orders. Use the three-point adjustment of the probe support of the water reservoir to align the sound axis for an optimally adjusted ultrasonic standing wave.

**Resulting diffraction pattern (example):**

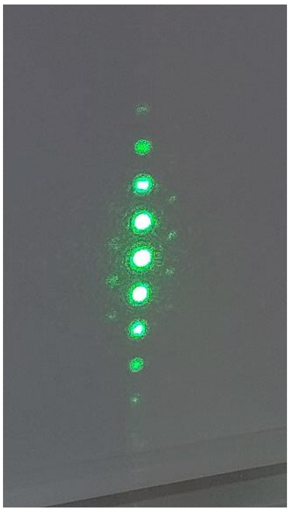


Laser beam directed to a simple paper sheet
Path length of laser beam about 3 m



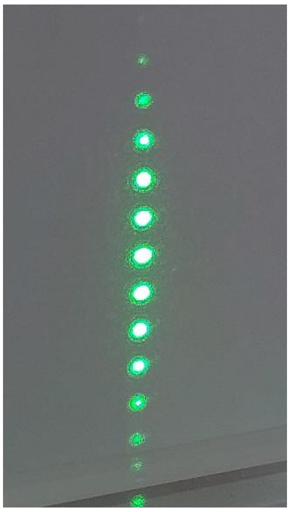
Step 1:

Laser on
Ultrasonic probe off



Step 2:

Ultrasonic probe on
Sound frequency set to 5.6 MHz



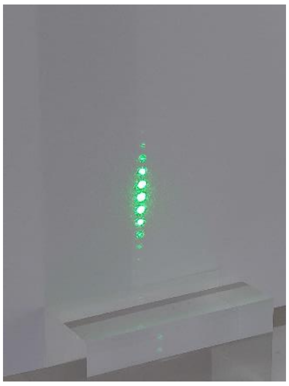
Step 3:

Ultrasonic standing wave adjusted

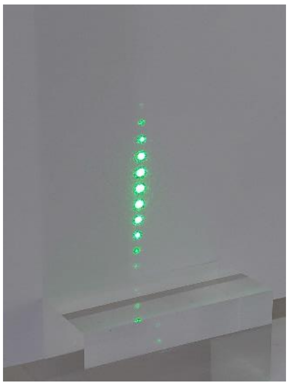
# 3 Debye-Sears effect

The effect describes the phenomenon of diffraction of parallel light crossing a standing or travelling ultrasonic wave. The ultrasonic wave acts like an optical diffraction grating where the grating constant corresponds to the wavelength of the ultrasonic wave. The distance between two diffraction orders is proportional to the sound frequency and inversely proportional to the wave length. (For a detailed description and discussion see the detailed experimental instructions.)

**Examples of diffraction patterns at different sound frequencies (s = 3 m):**



4 MHz



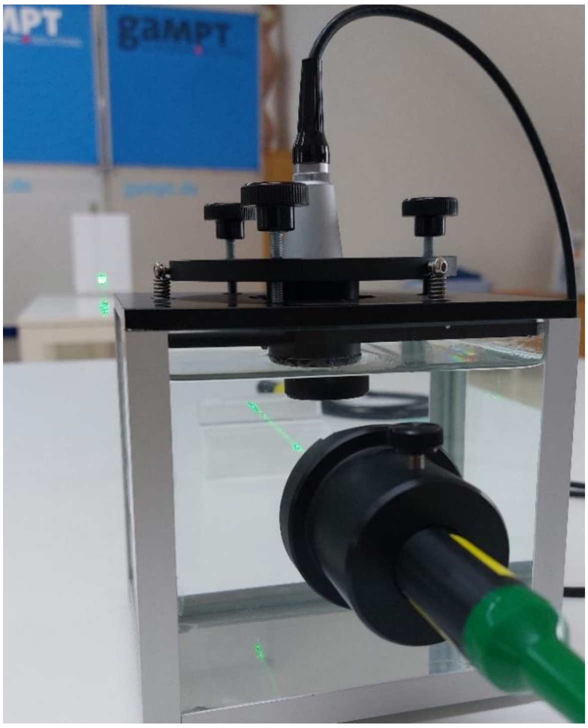
5 MHz

6 MHz

7 MHz

# 4 Projection of standing waves

A standing ultrasonic wave can be imaged by means of non-parallel light. Non-parallel light can be generated by placing a projection lens into the optical path.



Setup without projection lens

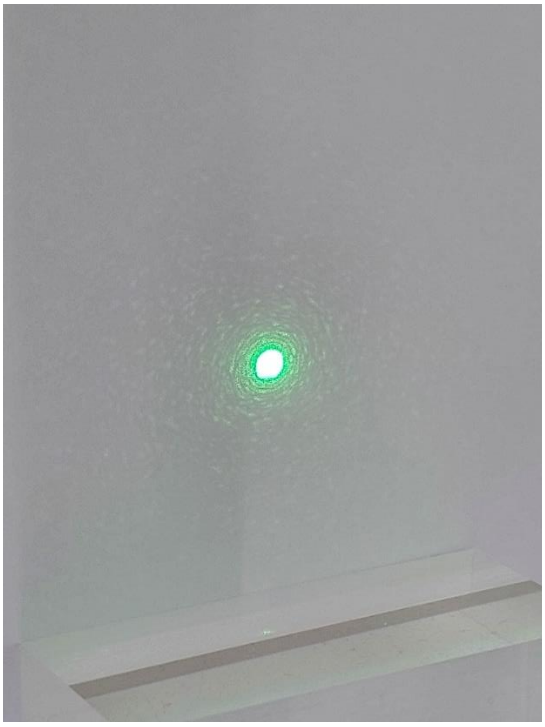
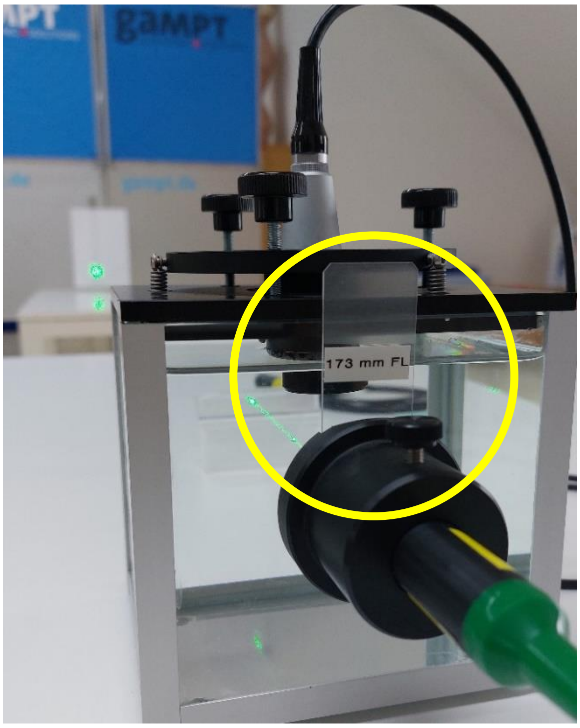


Image of parallel laser light
(no ultrasound)




Setup with projection lens

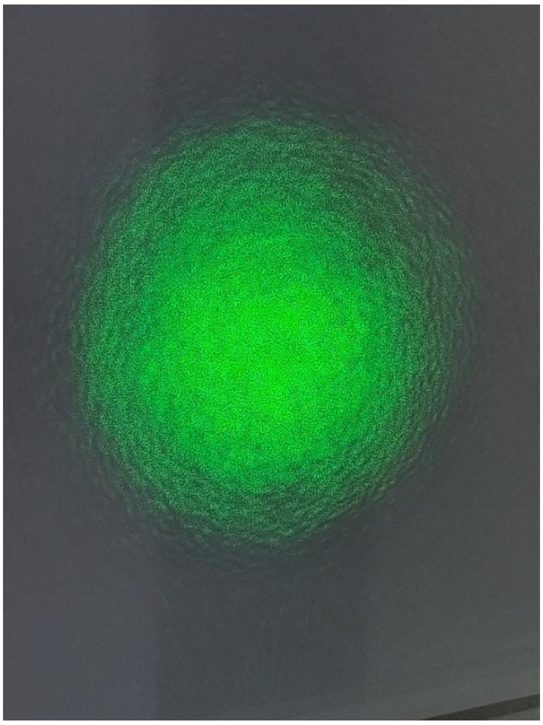
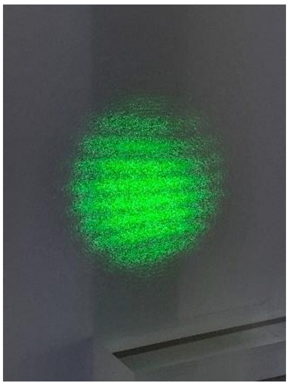


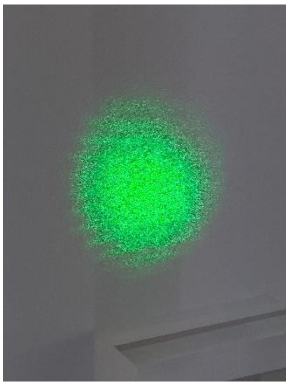
Image of non-parallel laser light
(no ultrasound)

The standing ultrasonic wave produces localized pressure differences in the liquid along the sound beam axis that result in periodically repeated refraction indices along the sound beam axis. Using monochromatic light, the projection of the standing wave therefore shows a light-dark modulation with periodically repeating brightness maxima which correspond to the density differences. The distance between two brightness maxima is inversely proportional to the sound frequency and proportional to the wave length. (For a detailed description and discussion see the detailed experimental instructions.)

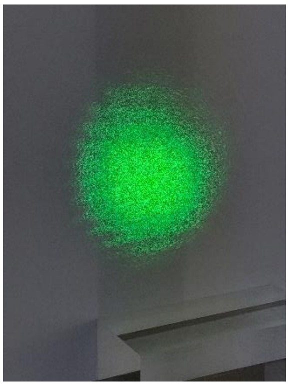
**Examples of brightness maxima at different sound frequencies (s = 3 m):**



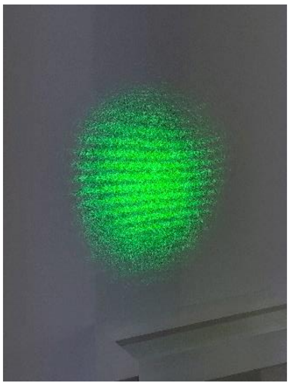
3 MHz



4 MHz



5 MHz

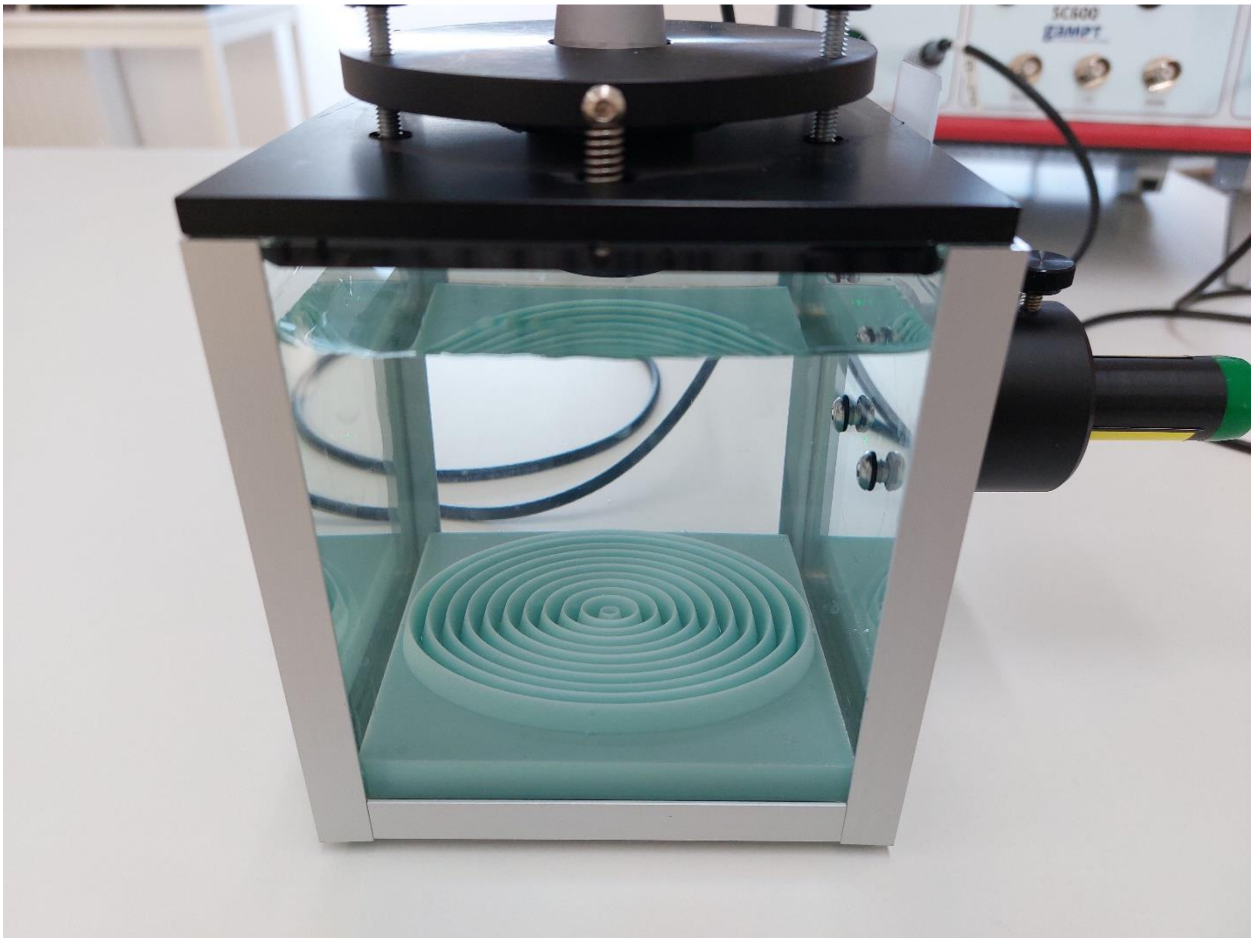


6 MHz

# 5 Travelling waves

An ultrasonic standing wave forms a locally fixed but temporally variable grating allowing both projection (as result of refraction) and diffraction.

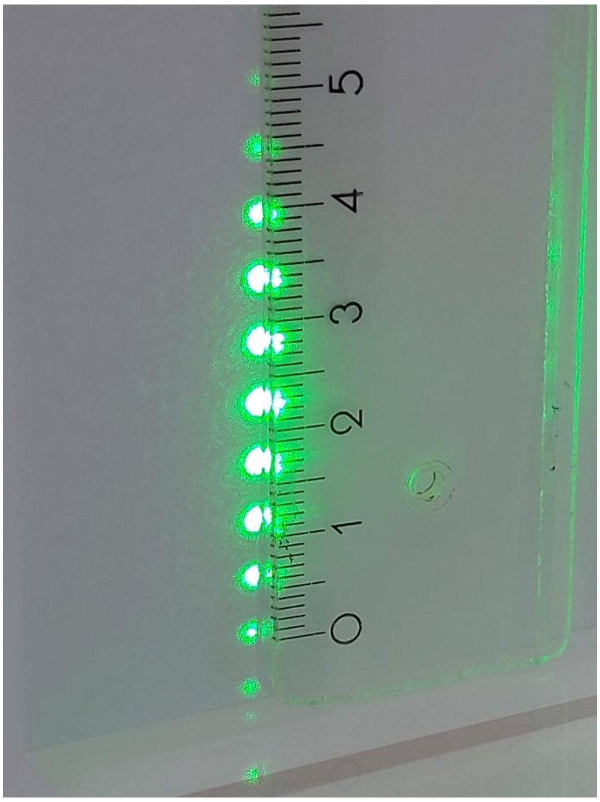
The use of an ultrasonic absorber prevents reflection at the bottom of the reservoir, i.e. the formation of a standing wave.

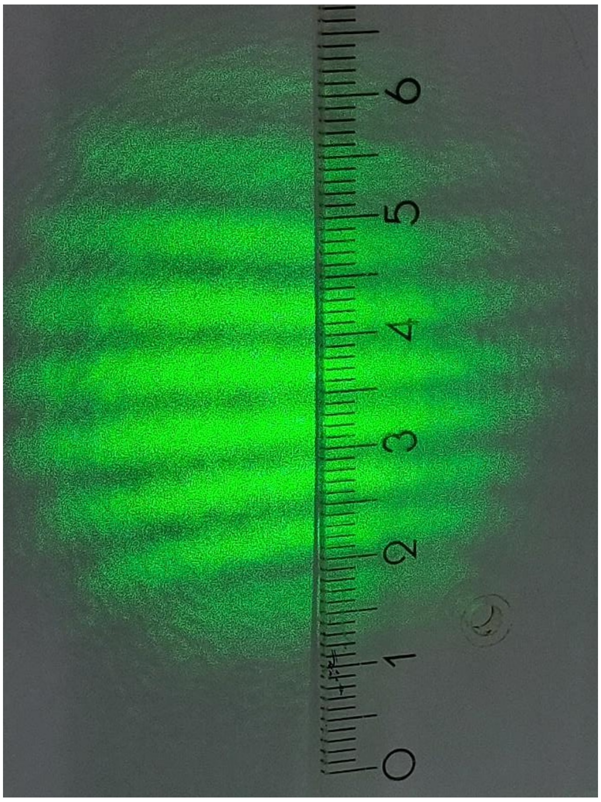


The grating caused by a travelling wave moves progressively with the speed of sound in the medium. The projection in form of the light-dark pattern using non-parallel light and the amplitude modulation of parallel light (see PHY17) are no longer observed.

# 6 Measuring the diffraction and projection patterns

To measure distances between different diffraction orders or brightness maxima, a ruler can be used.





Another simple way is to project the diffraction or light-dark patterns on a sheet of paper and mark them with a pencil to measure them afterwards.