Heisenberg Uncertainty Principle

Quantum Physics

Operating instructions

Never Stand Still | Science | School of Physics

Contents

1 Safety

1.1 Personal safety

During the experiment it is your responsibility to observe rules for safe handling of lasers.

Warning!

- Do not look directly into the laser beam or its reflection in a mirror. Be particularly careful to avoid the reflex to 'look along' the beam line when aligning. Always stay above the beam plane.
- Do not wear reflective jewellery or a watch when doing this experiment.
- Do not point the laser beam towards other people. Always know where your beam and its reflections are pointing. It is your experiment, and you are responsible for any 'thrown beams'.
- If leaving the experiment unattended for a significant period of time, please turn off the laser using the key-switch on the side.

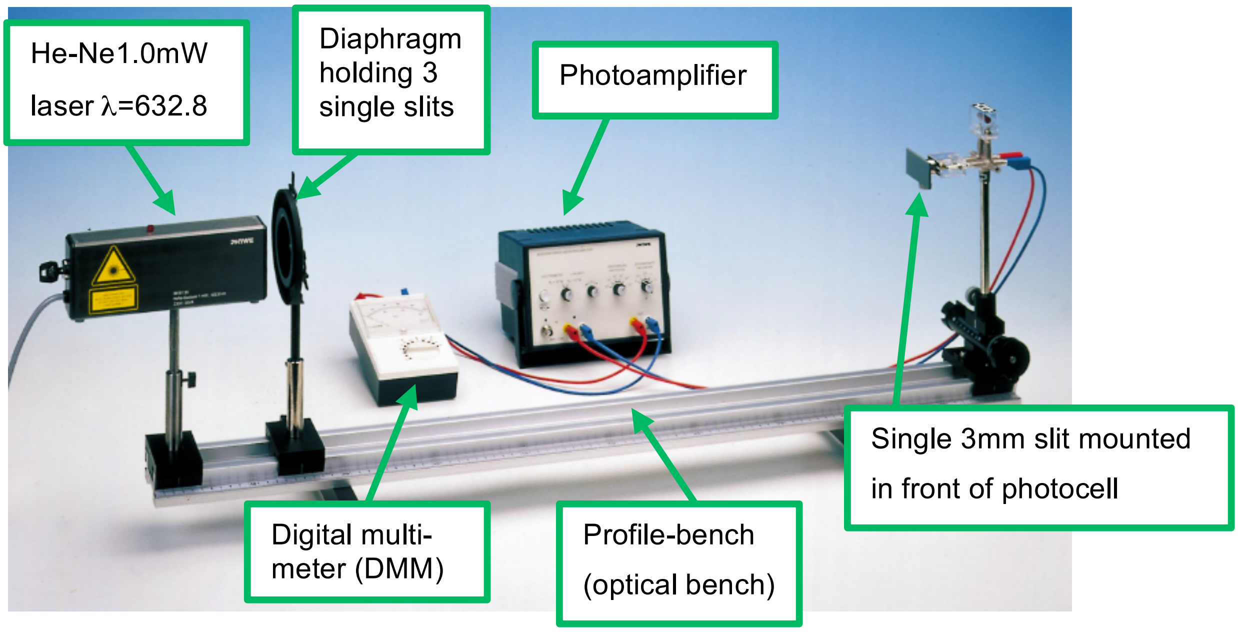
1.2 Responsible equipment use

This equipment has optical components that are easily damaged if not handled carefully:

- Avoid touching optical surfaces with your (greasy) fingers. If you do accidentally fingerprint an optical element, please see your lab demonstrator for how to clean it properly. Rubbing it with tissue, your t-shirt, etc. will ruin the optic.

2 Operating instructions

2.1 Equipment overview



An overview of the experimental set-up from the equipment manufacturer's literature is shown above. The main optical components are mounted on stands on a 1500 mm profile-bench (aka an optical bench) and are, on the left of the figure, the He-Ne laser and on a separated stand in front of this the diaphragm holding 3 single slits (0.1 mm, 0.2 mm and 0.4 mm wide slits). On the right-hand end of the bench a 0.3 mm wide slit mounted in front of a photocell detects the intensity of the diffraction pattern. Behind the profile-bench and connected by the blue-red cables are a photoamplifier connected to the output of the photocell and a digital multimeter (DMM) reading the output of the photoamplifier.

2.2 Measurement overview

Single slits with width 0.1 mm, 0.2 mm or 0.4 mm are positioned, alternately, in front of the laser to produce a single-slit diffraction pattern at the photocell on the right-hand end of the bench. The output signal of the photocell is amplified by the photoamplifier and the voltage output read on the digital voltmeter. A single slit of width 0.3 mm mounted in front of the photocell illuminates the cell. The output voltage of photodetector should not exceed 5 V in the principal maximum of the diffraction pattern. If the voltage is above 5V, then the slit diaphragm has to be adjusted to reduce the amount of light going to the detector (by shifting the slit diaphragm to the left or right on the diaphragm support).

Further details of individual components

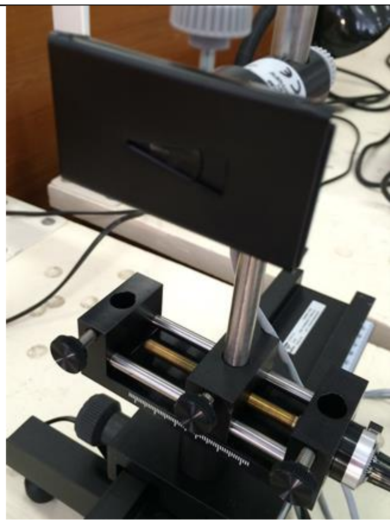
More detail follows below of the individual component parts of the set-up.

2.2.1 Laser and single slit array

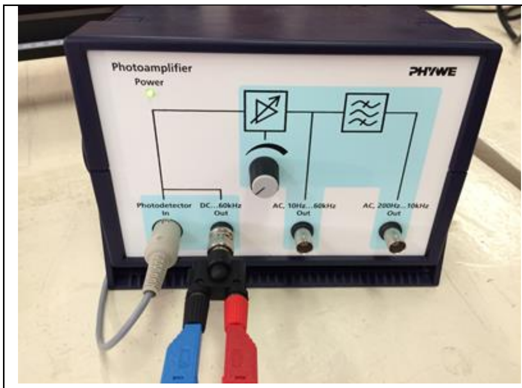
The figure at right shows a close-up of the laser with the single slits mounted in a standard 35mm slide holder that is held in place in front of the laser by a spring clamp. Individual slits are selected by moving the slide holder laterally into position in front of the beam.

CAUTION: remember not to look directly into the laser beam whilst making adjustments!

Below (left), is a view along the profile-bench towards the laser and diffracting slits from the photoelement end of the bench. **Below (centre)** image shows the single ~0.3mm slit which is mounted in front of the photoelement. This slit has been adjusted for optimum illumination of the photoelement. **Below (right)** shows the 0.3mm slit mounted in front of the photoelement.



2.2.2 Measurement electronics



3.0 Acquiring data

Brief instructions for acquiring the required data set follow below.

3.1 Warm up

IMPORTANT: The He-Ne laser intensity is sufficiently stable for precise measurement only following a warm-up period of ~30mins. Use the time to plan your measurements and take trial readings.

3.2 Taking the readings

1. Select a single slit mounted in front of the laser by appropriately positioning the slide holder containing the three single slits. The slide holder is held in place by a spring clamp – gentle force only is required to shift the slide holder to the desired position.
2. At the photoelement end inspect the multi-turn dial counter (see figure below, left, and close-up of multi-turn dial counter below, right) used to translate the 0.3 mm slit laterally in front of the photocell.
3. Confirm the calibration of dial counter: how does the reading on the counter's scale relate to lateral distance moved, in millimetres for example?
4. Check to see if there is any 'backlash'† in lateral translation movement. If so it will be necessary to take data by moving continuously in one direction when translating the 0.3 mm measurement slit, thus collecting a full series of readings in a single 'sweep' across the diffraction pattern for each of the three individual slits. This means you should be careful if you need to go back to check a previous reading in the series which would introduce an offset in the readings and limit overall precision. If you are unsure about this, ask your demonstrator for advice.

†Backlash is a mechanical design limitation common is experimental apparatuses that rely on a screw thread to make calibrated translational movements. Movement with precision is achieved if the translation is made by movement in one direction, thus advancing the screw thread continuously in one direction, in acquiring a data set. Reversal of the translational movement during the measurement of a data set can lead to an offset in the readings and a reduction in precision as this can cause the screw mechanism to shift with respect to the multi-turn dial counter such that there is an uncalibrated change (offset) in the assumed relationship between multi-turn dial counter and screw mechanism – this can spoil a data set by limiting the measurement precision of that particular data set containing the backlash offset.

(a) View of the multi-turn dial counter used to translate laterally the 0.3mm measurement slit across the diffraction pattern.

(b) Close-up of the multi-turn dial counter shown at the base of the stand in figure (a).