This experiment consists of three part-experiments:

Experiment 1: Diffraction at a small obstruction and at a narrow slit
Experiment 2: Diffraction at an edge
Experiment 3: Diffraction and interference at a wide slit.

If plane waves hit an obstruction or a narrow slit with dimensions which are small compared to the wavelength, circular waves are emanated from the obstruction or slit. If they hit an edge they are diffracted and a circular wave (elementary wave) is emitted from this edge into the geometric shadow area.
A characteristic interference pattern can be observed in the diffraction area of a slit whose width is larger than the wavelength. Interference of the diffracted wave trains can also be observed in the geometric shadow area behind a wide obstruction.

Materials
from the accessory set of 11260-99

1 Holder for plane wave generator
1 Plane wave generator
1 Barrier l = 30 mm
2 Barrier l = 71 mm
1 Rubber plug

Method

Experiment 1:

Plane waves are generated in the wave tray. Diffraction at a small obstruction and at a narrow slit is demonstrated with continuous wave trains. Short wave trains are generated (pulse mode) to show that circular waves are also emitted from the obstruction in the direction of the wave generator. In this way the disruptive superimposition of the waves emitted from the exciter (wave generator) with the waves reflected by the obstruction is avoided.

Experiment 2:

The diffraction at an edge is demonstrated with the help of plane waves which hit an obstruction oriented parallel to the wave front. Short wave trains are generated to show here too that an elementary wave (circular wave) propagates in all directions from the edge.

Experiment 3:

Plane waves perpendicularly hit a slit whose width is larger than the wavelength. The interference pattern that can be observed behind the slit is examined.

In the second part of this experiment an obstruction with approximately the same size is placed in the wave field instead of the slit. The obstruction is oriented parallel to the wave front (Fig. 5).

Experiment 1 – diffraction at the obstruction and narrow slit

Setup

The plane wave generator is fixed to the internal exciter unit and is moved to the bottom edge of the wave tray. For the first part-experiment the rubber plugs are placed in the wave tank as shown in Fig. 1.

The two 71 mm barriers are used to make a roughly 10 mm wide slit as shown in Fig. 2 to demonstrate diffraction at a narrow slit.

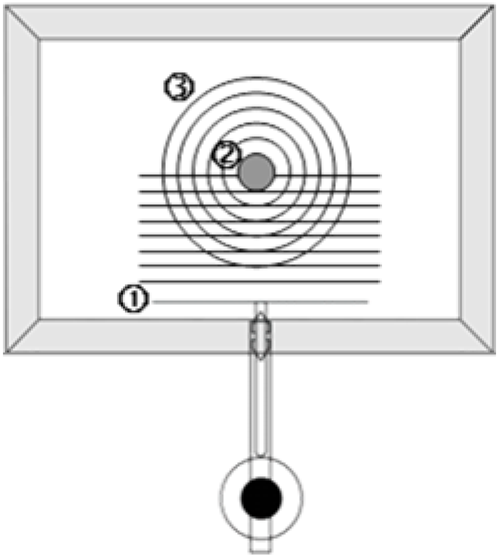

Figure 1: Arrangement for diffraction at an obstruction. The wave front ① produced by the planar wave generator hits the small obstruction ② (rubber plug), from which circular waves propagate in all directions ③.

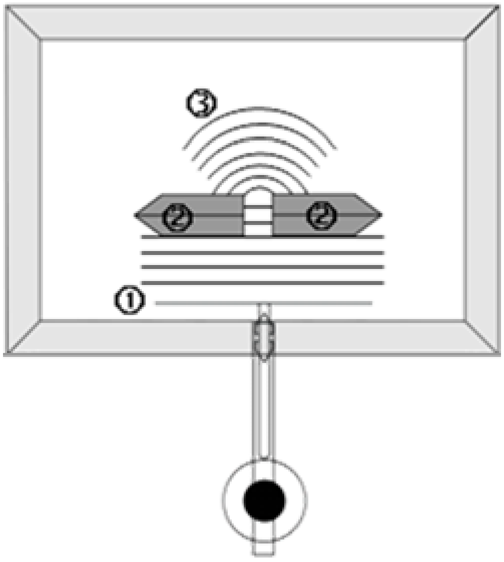

Figure 2: Arrangement for diffraction at a narrow slit. The wave front ① produced by the planar wave generator hits the 10 mm slit ② formed by the two barriers. Circular waves emanate from this slit ③.

Procedure

The wave generator is carefully adjusted and a frequency between 18 Hz and 25 Hz is set at the ripple tank.

a) Diffraction at an obstruction:
Initially the wave pattern is observed with continuous wave generation, whereby the exciter amplitude is set so that a clear wave pattern results. The "pulse" mode is then used to produce short wave trains and the waves emanating from the obstruction are observed.

b) Diffraction at a slit:
The wave pattern is observed with continuous wave generation. The exciter amplitude is set so that the plane waves in front of the obstruction can be clearly recognised. The amplitude is then increased until the diffracted waves behind the slit are clearly visible.

Experiment 2 - diffraction at an edge

Setup

The planar wave generator is adjusted as in experiment 1 and the 71 mm barrier is placed in the wave tank as shown in Fig. 3.

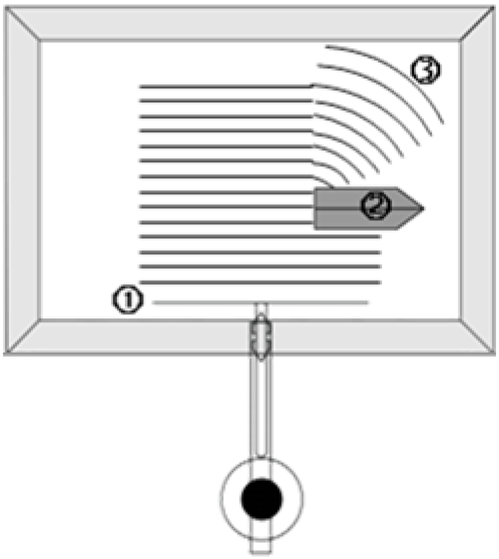

Figure 3: Experiment arrangement for diffraction at an edge. The wave front ① produced by the planar wave generator hits the barrier ②, which acts as an edge here. Circular waves are emanated from here, which penetrate the geometric shadow area ③.

Procedure

The exciter frequency from the first experiment is retained and the exciter amplitude is selected so that a clear wave pattern results. After the wave pattern has been observed the experiment is repeated with short wave trains generated in the "pulse" mode.

Experiment 3 – diffraction and interference at the wide slit

Setup

The two 71 mm barriers are used to form an approx. 3 cm slit in the wave tank as shown in Fig. 4.

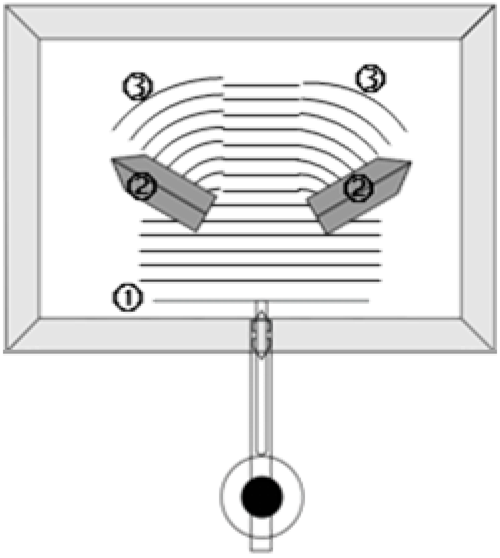

Figure 4: Arrangement for diffraction at a wide slit. The wave front ① produced by the planar wave generator hits the 3 cm wide slit formed by the two barriers ②. The wave front is diffracted there; circular waves emanate from the barriers and propagate in the geometric shadow area ③.

Procedure

exciter frequency is again between 18 Hz and 25 Hz and the exciter amplitude should be selected so that a clear wave pattern results in front of and behind the slit. The interference pattern resulting behind the slit is observed.

The two 71 mm barriers are then removed and the 30 mm barrier is placed in the position where the slit was previously (Fig. 5). The interference pattern recognisable behind the barrier is compared with the pattern seen behind the slit in the first part of this experiment.

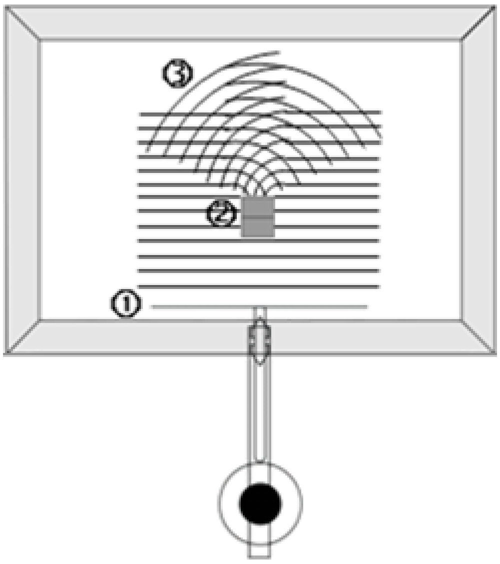

Figure 5:
Arrangement for diffraction and interference at the 30 mm barrier. The wave front ① produced by the planar wave generator hits the barrier ②. Circular waves are emitted from this, which interfere behind the barrier ③.

Experiment 1 – diffraction at the obstruction and narrow slit

Results

Circular waves emanate from the obstruction (Fig. 6) as well as from the slit (Fig. 7). In the case of the obstruction, these circular waves interfere with the incoming plane waves. These interferences can be prevented in the area in front of the obstruction by generating short wave trains instead of continuous waves. However, an instantaneous snapshot (photo) with short wave trains is hardly possible, which is why interference can be seen on the photo. In addition, it can be seen that the waves continue in the geometric shadow area of the obstruction.

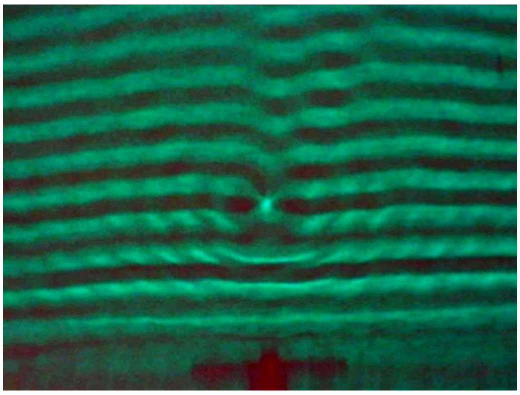

Figure 6: Snapshot as shown in Fig. 1. The circular waves emanating from the obstruction and penetrating its geometric shadow area can be clearly seen. The resulting interference of these circular waves with the incoming plane waves can be prevented by using short wave trains (pulse mode), however this can no longer be shown on a photo.

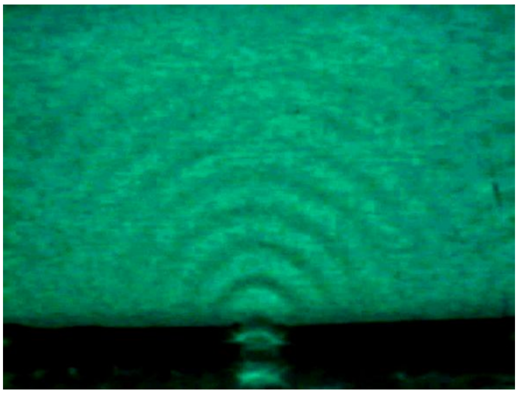

Figure 7: Snapshot as shown in Fig. 2. The circular waves emanating from the slit can be clearly recognised and it is also possible to see how they propagate in the geometric shadow area of the barriers.

Interpretation

The analogous experiment with light waves is always performed with an obstruction whose diameter is substantially larger than the wavelength. In this case an interference figure can be observed in the shadow area.

The narrow slit opposite the wavelength also becomes the starting point for an elementary wave. The diffraction is observed in a pure form, i.e. without a superimposed interference pattern. When performing the analogous experiment with light waves a slit whose width is larger than the wavelength must be used in order to achieve adequate image brightness. In this case an interference pattern is observed which superimposes the intensity distribution of pure diffraction.

Experiments 2 and 3 – diffraction and interference at edge and wide slit

Results

Experiment 2:

The plane waves pass the obstruction without hindrance. A circular wave moves from the edge of the barrier into its geometric shadow area (Fig. 8). The part of the plane waves that hits the obstruction is reflected so that a standing wave results in front of the obstruction.
When working with short wave trains it can be seen that the circular wave emanating from the edge of the barrier propagates in all directions.

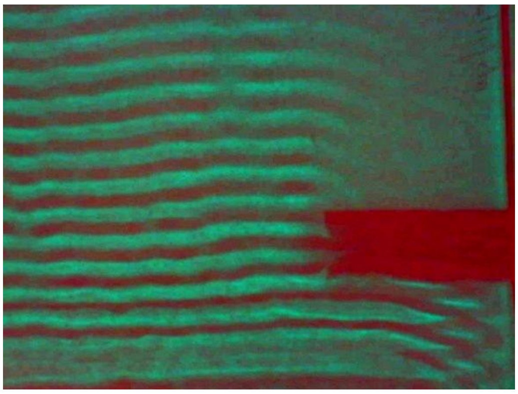

Figure 8: Single snapshot image as shown in Fig. 3. The circular wave emanating from the barrier can be clearly recognised in the shadow area of the barrier.

Experiment 3:

An interference pattern can be seen behind the slit. The zeroth interference order is substantially wider than the higher orders (Fig. 9). A similar interference pattern to that behind the slit can be seen behind the obstruction (shadow zone).

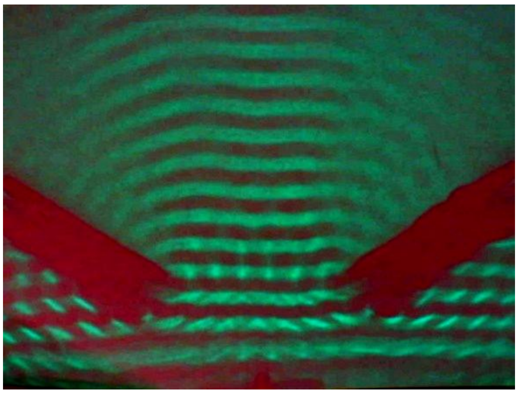

Figure 9: Snapshot as shown in Fig. 4. An interference pattern can be seen behind the slit whose zeroth interference order is substantially wider than the higher orders.

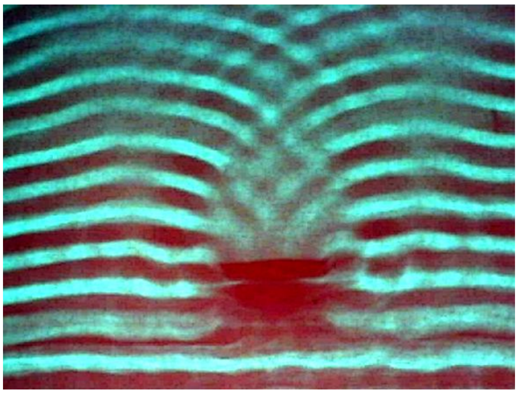

Figure 10: Snapshot as shown in Fig. 5. The circular waves emanating from the barrier interfere behind it. These interferences are similar to the interferences seen in the shadow area of the slit in Fig. 9.

Experiment 2 and 3

Interpretation

The results of both experiments can be explained with the help of Huygen's principle. This states that circular elementary waves emanate from each point in a wave field. While an infinite number of such elementary waves are superimposed in the undisturbed wave field to form a plane wave field, the elementary wave emanating from the edge in experiment 2 into the shadow area of the obstruction does not superimpose with other waves and can be directly observed there.

In experiment 3 the slit opening can be considered to be a location with an infinite number of point generators. The elementary waves emanating from these generators interfere behind the slit to form a characteristic pattern as seen in Fig. 9.

Note:
The interference pattern of the wide single slit differs from that of a double slit in a characteristic way. At a large distance from the single slit the zeroth interference order is twice as wide as the higher orders. In the case of the double slit the same widths result there for all orders.

