Diffraction and interference of microwaves (Item No.: P2460903)

Curricular Relevance

Area of Expertise:	Education Level:	Topic:	Subtopic:	Experiment:
Physics	University	Electricity and Magnetism	Maxwell's Equations, Magnetism, Electromagnetic Waves	Diffraction and interference of microwaves

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	30 Minutes	20 Minutes	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Microwaves, electromagnetic waves, Huygens-Fresnel principle, double-slit, interference

Introduction

Overview

When a wave reaches an obstacle, in which a slit slightly wider than the wavelength is made, the phenomenon of diffraction occurs. When the obstacle has two slits, the radiation diffracted by each of them will interfere with each other.

Fig. 1: Set-up for the diffraction experiment (double-slit).

Equipment

Position No.	Material	Order No.	Quantity
1	Microwave set II, 110...240 V	11743-99	1

Overview of the parts of the microwave set.

Tasks

First, familiarise yourself with the phenomenon of diffraction through a single-slit. Then, perform the experiment with the double-slit (Young's experiment) to observe the different phenomena occuring compared to the single-slit.

Set-up and procedure

Diffraction through a single slit

Set the experiment up as shown in Fig. 2.

Fig. 2: Single-slit in the microwave beam.

Connect the microwave transmitter, receiver, and loudspeaker to the power supply via the three ways cable, and connect the receiver and the loudspeaker with the receiver - loudspeaker connection cable (Fig. 3).

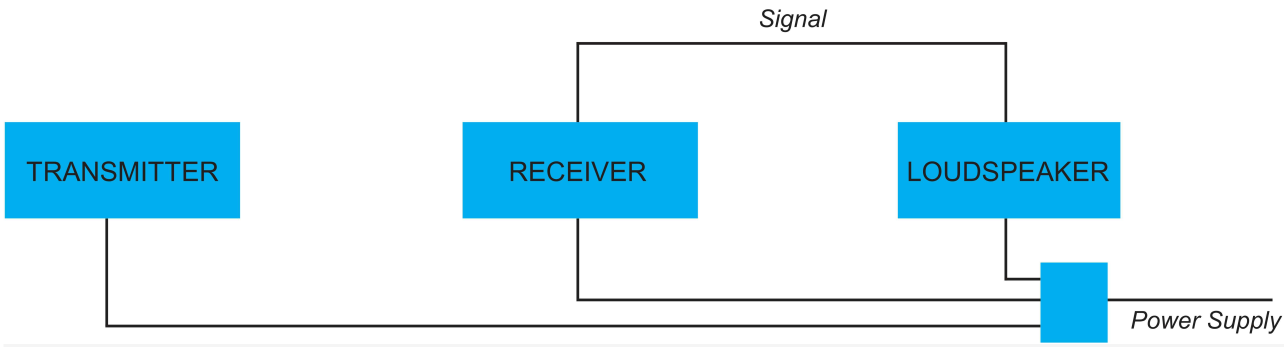

Fig. 3: Set-up of the experiment connections.

To assemble the articulated track with protractor, (1) first hook the short arm (having connection flange) to the long one (having pivot). (2) Then put the washer in the pivot. (3) Insert the protractor on the pivot at 0°, and (4) screw the black PVC yoke onto the pin (Fig. 4).

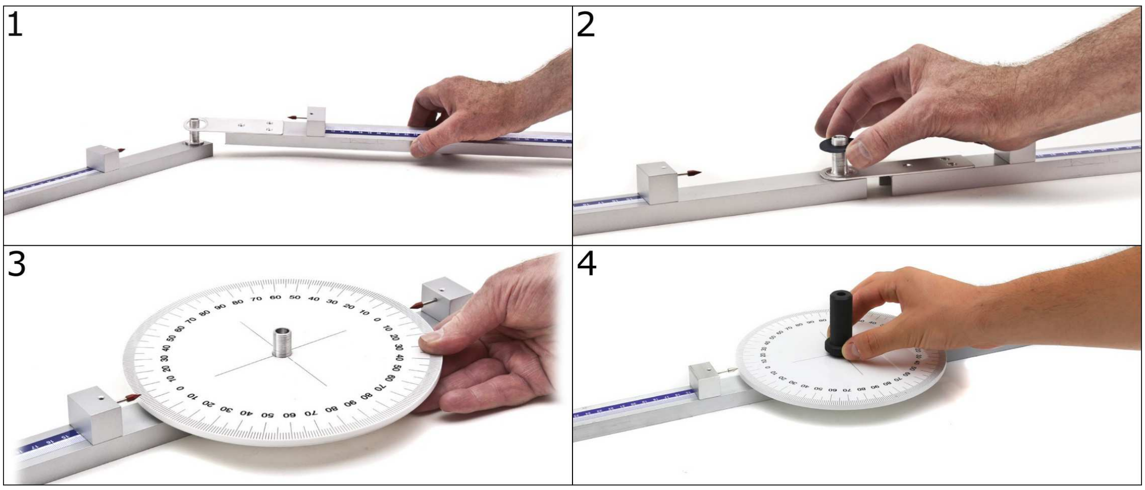

Fig. 4: Set-up of rail.

Position the transmitter and the receiver both 25-30 cm away from the centre of rotation of the rail. Plug in the power supply. Turn the volume knob on the loudspeaker fully to the right.

Note the signal during this initial set-up. Then start to rotate the receiver slowly as shown in Fig. 5. Try to determine the angle of the receiver position where the signal reaches a minimum intensity compared to the original set-up.

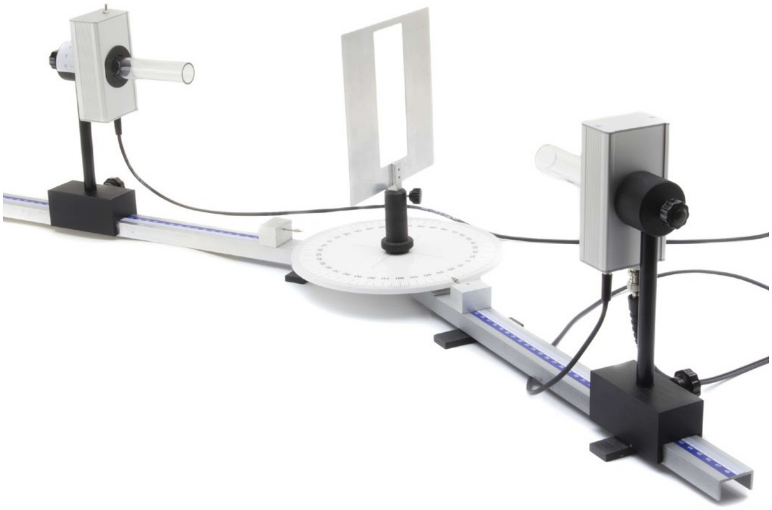

Fig. 5: Diffraction through a slit.

Diffraction of microwaves due to two slits (Young's experiment)

First, set the transmitter and receiver in the positions indicated in Fig. 2, and replace the single slit grating with the two slits grating (Fig. 6). The radiation diffracted by each of them will interfere with each other. The purpose of this experiment is to understand this interaction.

Fig. 6: Set-up using the two slits grating.

Take note of the signal with this set-up.

By rotating the receiver, it is possible to study the result of this overlap for different angles (Fig. 7).

Fig 7: Set-up with rotated receiver.

Note

During the experiment, do not stand in the direct vicinity of the beam path. The human body reflects microwaves so that the measurement result may be invalidated. The same applies to all types of metallic objects. If several experiments are performed simultaneously in a laboratory, ensure sufficient distance between the experiment stations in order to avoid interference signals caused by reflected radiation and/or scattered radiation from the other set-ups. Stay in the direct vicinity of the set-up only for adjusting the angle.

Theory and evaluation

Diffraction through a single slit

During the diffraction through a (single) slit in the first experiment, for example, the microwaves are diffracted into an angle (or angular range) so that, when the slit is removed from the beam path, the intensity under the same angle is lower than before.

When a wave reaches an obstacle, in which a slit slightly wider than the wavelength is made, the phenomenon of diffraction occurs. Beyond the slit, the energy does not spread uniformly, but presents maximum points alternating with minimum points. This strange distribution is explained by the Huygens-Fresnel principle according to which all the points of the slit, belonging to the same wave front, behave like coherent wave sources, so in a generic point of space, beyond the slit, the intensity will be the result of the overlapping of these elemental waves. Beyond the screen there will be an alternation of maximum intensity points with minimum intensity points.

In the central position the intensity is maximum, but moving the receiver slowly, a sequence of minimums and maximums is detected. It can be shown that the angular distance between the central maximum and the first minimum satisfies the following relationship:

$$sin(\alpha) = \pm\frac{\lambda}{d} \tag{1}$$

where α is the displacement angle of the receiver, λ is the wavelength, and d is the width of the slit.

Being λ = 2.85 cm and d = 5 cm, the first minimum must be at the angle of rotation of the receiver of about 34°. You can verify this by gently adjusting the amplitude of the signal to cancel possible reflected signals (Fig. 5).

Diffraction of microwaves due to two slits (Young's experiment)

When using the two slits grating metal sheet, the radiation diffracted by each of them will interfere with each other.

This is Young's experiment. The effect obtained in this case is a superposition of two phenomena: the interference between the elemental waves produced by the two slits and the diffraction obtained from each of the two slits (Fig. 8).

In this situation the received signal is maximum, as the two elementary waves travel the same distance.

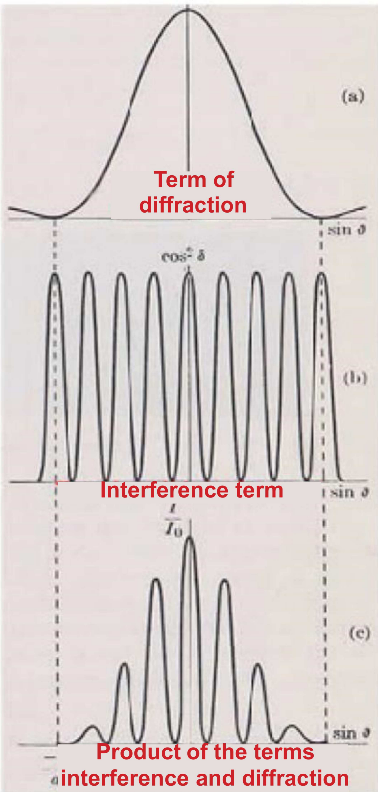

Fig. 8: Two phenomena occuring due to two slits.

After rotating the receiver from the initial position, it is possible to study the result of this overlap for different angles. If a is the distance between the two slits, the first order maxima of the interference figure are given by the following relation:

$$sin(\alpha) = \pm\frac{\lambda}{a}\,. \tag{2}$$