

Interference

Light plus light can produce dark

Introduction

Pass laser light through two slits to produce an interference pattern on a distant screen. This interference pattern of bright and dark regions shows that light behaves like a wave. Shine the light through one slit and the laser beam spreads into a line of light. Open a second slit and dark regions appear in this line of light showing that light plus light equals dark.

Materials

Laser (Any visible laser such as the new solid state, battery operated laser pointers which sell for under \$ 20 and produce about 1 milliwatt of light or less.)

clay (a few tablespoons)

piece of white cardboard

empty 35 mm slide holders or a microscope slide

2 human hairs

some tape

method 1

2 microscope slides

black enamel spray paint

2 sharp knives

method 2

a 35 mm slide holder

aluminum foil

tape

razor blades

Assembly

Method 1

Use enamel spray paint to paint one side of the microscope slide black. Allow it to dry.

(Optional, blacken the slide with soot from a candle.)

Make a narrow slit in the paint 2 cm from one end of the slide using the knife blade. To make a straight slit, you can use a second microscope slide as a straightedge. We use knife blades rather than razor blades because they make wider slits. Wider slits allow more light to get through and so make a brighter pattern. Wider slits make narrow patterns of laser light, however, the patterns will be wide enough.

Make 2 closely spaced narrow slits in the paint about 2 cm from the other edge. Make the 2 slits by drawing the knife along the straightedge, moving the straightedge and then cutting the second slit. You might have to experiment to obtain the best distance between the slits. The slits must be close enough together that the laser beam illuminates them both at the same time, yet far enough apart to give a visible pattern of dark bands. The two slits should be 0.5 mm apart or less.

Method 2

Tape a piece of aluminum foil over the hole in one slide holder.

Put the slide down onto a piece of cardboard.

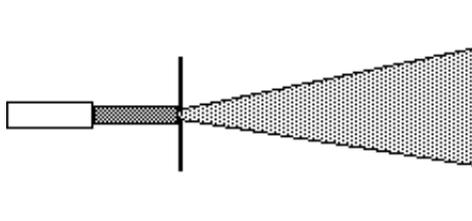
Use the razor to cut a slit into the aluminum.

To cut 2 slits use 2 razors held side by side.

Tape down one hair across the empty 35 mm slide holder, or on a clear microscope slide. Tape down a second hair close to the first one. You have then made the opposite of two slits, two anti-slits.

To do and notice

Shine the laser through the single slit and onto the white cardboard. Mount the laser and the microscope slide 2 cm or so apart using clay. Mount the white cardboard 2 meters from the laser (for example tape it to a wall.)



A laser shines a beam through a slit onto a screen. The beam spreads via diffraction.

Notice the pattern on the wall. The laser beam spreads out when it goes through a single slit. It spreads along a line perpendicular to the slit. You may see that it spreads into a line of light and dark blobs. The central blob will be the widest and the brightest. Examine the central blob.

Shine the laser through the 2 slits. Notice that the central blob of the line of light is broken by many dark regions.

Use the knife to cover one of the slits. Then uncover the slit.

Notice that the dark regions appear when the slit is open and they disappear when it is closed.

Thus light plus light can make dark.

Replace the microscope slide with the hairs. Notice that the hairs produce a pattern of blobs of light similar to that produced by the slits.

What's going on.

The laser produces a very pure color of light, i.e. light of one wavelength. When the laser beam illuminates the 2 slits, the light going through the slits is in phase, i.e. the crests and troughs of the lightwaves arrive at the slits together. (We say that the laser light is coherent.) The light from the slits illuminates the cardboard screen. Where the light arrives at the screen having travelled the same distance to the screen from each slit, the waves arrive in-phase and there is a bright blob.

However, to the side of this point, the path of light from one slit to one point on the screen is longer than the path from the other slit. When the path difference is equal to one-half a wavelength the crest of the lightwave from one slit arrives at the wall just as the trough from the other slit arrives. These two waves cancel and produce darkness.

Further to the side, the path lengths differ by one full wavelength. Once again the crests line up and a bright blob appears.

To study the interference of light further see the snack Chain Interference Analogy.

etc

In 1801 Thomas Young observed the diffraction of light through a slit. This observation indicated that light was a wave. After all, light plus light equalled dark. It was easy to conceive of two waves adding out of phase to create darkness whereas it was hard to visualize two particles coming together to cancel each other.

Interference is a poor name for this phenomenon, When two light beams come together, they simply add to each other. The two beams do not interfere with each other in the english sense of the word. Two light beams pass through each other without affecting each other at all. Light interacts with charges, light itself does not possess electric charge. So light does not interact with light it simply adds together.

etc

To cut good slits in aluminum foil fold over the aluminum foil several times, e.g. double it over twice, cut the slits, use the pieces of aluminum foil from the center of the stack.

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