The
Video
Encyclopedia
of
Physics
Demonstrations™

Explanatory Material By: Dr. Richard E. Berg
University of Maryland

Scripts By: Brett Carroll
University of Washington

Equipment List By: John A. Davis
University of Washington

Editor: Rosemary Wellner

Graphic Design: Wade Lageose/Art Hotel

Typography: Malcolm Kirton

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CHAPTER 61

DIFFRACTION

Demo 23-01 Microwave Diffraction

The microwave setup discussed in Disc 21 Demonstration 14 is used to illustrate diffraction from a single slit. Microwaves from emitter E pass through the slit to the receiver R. The apparatus, shown in *Figure 1,* uses a bar graph to indicate the intensity of the microwaves. Slits of two different widths are used, and their diffraction patterns compared in the video. An interesting effect, shown clearly in the video, is that the radiation pattern for a narrow slit is actually more spread out than that of a wider slit.

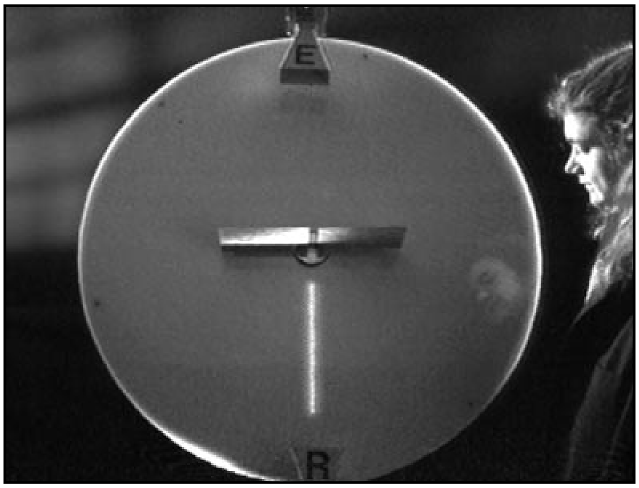

Figure 1

This setup consists of a microwave emitter, a microwave receiver, and a bar-graph display whose length is proportional to the intensity of the microwaves picked up by the receiver.

We'll use it to show how a beam of microwaves is diffracted as it passes through a narrow slit.

These two metal sheets are attached to the center of the board, with a narrow gap between them.

If the microwave receiver is swung through the area in front of the gap, the pattern of microwaves is quite wide.

If the slit is widened, will the pattern of emerging microwaves become wider or narrower?

The pattern narrows as the slit is widened.

Equipment

1. Brett Carroll microwave board.
2. Two metal sheets attached to the magnetic retaining bar to form an adjustable slit for the microwaves.
3. AC power.

Demo 23-02 Single Slit Diffraction

Single slit diffraction, shown in *Figure 1,* is illustrated using a laser beam and a variable slit.[†] As in the case of Demonstration 1, when the slit becomes smaller the radiation pattern spreads out, as is clearly seen in the video.

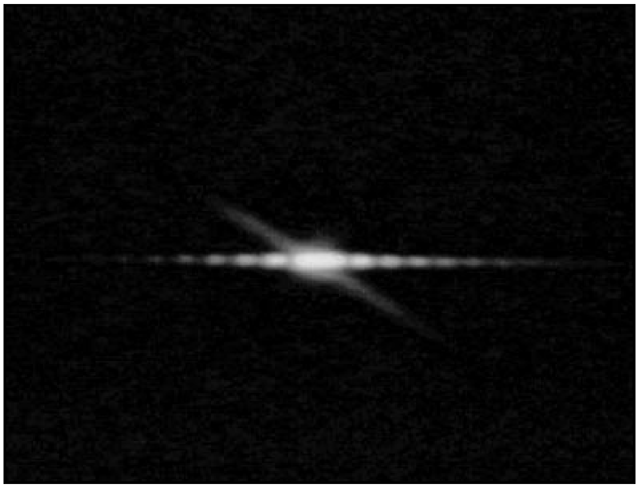

Figure 1

[†] Frieir and Anderson, *A Demonstration Handbook for Physics,* Demonstration Ol-7, Adjustable Slit.

We'll shine the beam from this laser through a slit whose width can be varied by turning a screw.

Here is the laser spot on the screen when the slit is open wider than the beam. We'll close the slit down partway. The laser spot now appears to spread out slightly.

As we continue to narrow the slit, a pattern of bright and dark spots appears on the screen.

When the slit is almost closed, the pattern spreads out so far it nearly disappears.

As the slit is opened again the spot narrows, and the pattern of bright and dark spots reappears.

Equipment

1. Laser.
2. Adjustable single slit.
3. Screen.
4. AC power.

Demo 23-03 Single Slit Diffraction (Cornell Slides)

Single slit diffraction is illustrated using a laser beam and three single slits, of widths 0.704 mm, 0.352 mm, and 0.176 mm.† A graphics segment, shown in part in *Figure 1,* describes the geometry and a scale is provided for the diffraction pattern so that measurements can be made. Using the size of the pattern and the slit-to-screen distance, the wavelength of the laser light can be determined. Alternatively, using the wavelength of the light and the distance from the slit to the screen, the size of the slit can be calculated and compared with the actual values given above.

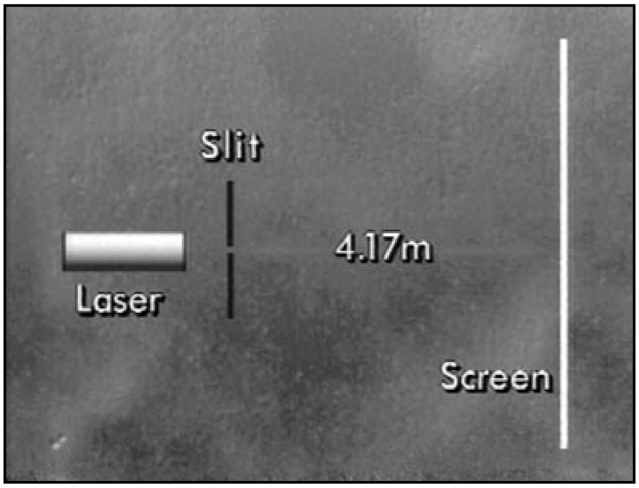

Figure 1

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† Sutton, *Demonstration Experiments in Physics,* Demonstration L-83, Projection of Single and Double Slit Patterns.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Ol-6, Single Slit Diffraction Pattern.

Single Slit Diffraction (Cornell Slides) / Script

This slide has a set of narrow single slits which we can use to diffract a laser beam. We'll shine the beam through three different slits and observe the pattern on the screen.

Here is the arrangement of laser, slit, and screen.

Here is the laser spot with no slit in place.

Here is the laser after passing through a 0.704 millimeter slit.

Here is the laser spot after passing through a slit 0.352 millimeters wide.

Here is the laser spot after passing through a slit 0.176 millimeters wide.

Equipment

1. Cornell slide of slits.
2. Laser.
3. Screen.
4. AC power.

Demo 23-04 Thin Wire Diffraction

Light from a laser is diffracted by a wire of diameter 0.22 mm.[†] For comparison the laser beam is first shown without the wire and then with the wire in place. The distance from the wire to the screen is given, as shown in the geometry graphics of *Figure 1,* so that calculation of the size of the wire or the wavelength of the laser light can be made, assuming knowledge of the other.

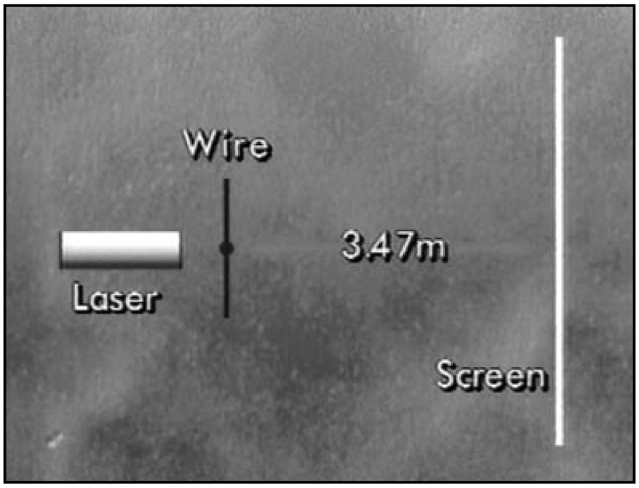

Figure 1

[†] Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Ol-21, Diffraction.

Light passing a thin wire is diffracted. We'll use a thin wire and a laser to show the pattern of bright and dark spots caused by the diffraction.

Here is the setup of laser, wire, and screen.

This is the laser spot on the screen with no wire in the beam. This is the diffraction pattern obtained on the screen when the wire is inserted.

Equipment

1. Mask with a hole in its center and a thin wire running across its center.
2. Laser.
3. Screen.
4. AC power.

Demo 23-05 Poisson's Bright Spot

When light diffracts around a sphere or a disc, the expectation is that the diffraction pattern should be near the edge of the shadow region and the center of the shadow should be dark. A surprising feature of diffraction by a sphere is that the center of the shadow is actually bright; this phenomenon is called the Poisson bright spot, as shown in *Figure 1*.[†] In this video the sphere is viewed from a large distance in front of the light source. As the camera zooms in, the Poisson bright spot becomes apparent and then very striking.

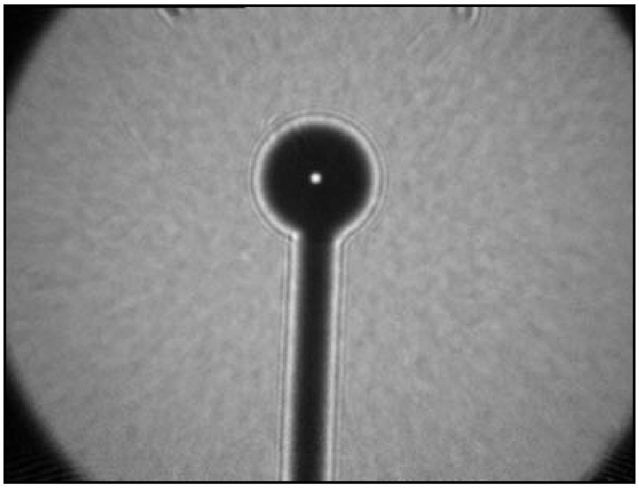

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration L-78, Diffraction about Circular Object.

Poisson's Bright Spot / Script

Although light has properties similar to those of waves, the wavelength of light is so small we seldom notice the wavelike nature of light. This pinpoint light source will allow us to demonstrate that wavelike nature.

If we put the light source behind a small sphere and look at the light coming past the sphere, we see a pattern around the edges caused by interference between different waves of light.

Notice the bright spot in the center of the sphere where we would normally expect no light at all.

Equipment

1. Bright point source of light.
2. Small sphere mounted on a support system.
3. Both numbers 1 and 2 mounted on an optical bench.
4. Two optical bench clamps.
5. Optical bench turn table.
6. AC power.

Demo 23-06 Shadow of Needle

A needle eye and needle tip are viewed from a distance in front of a white light source.† As the camera zooms in for a closer view, the diffraction of the light around the needle becomes apparent, as seen in *Figure 1*.

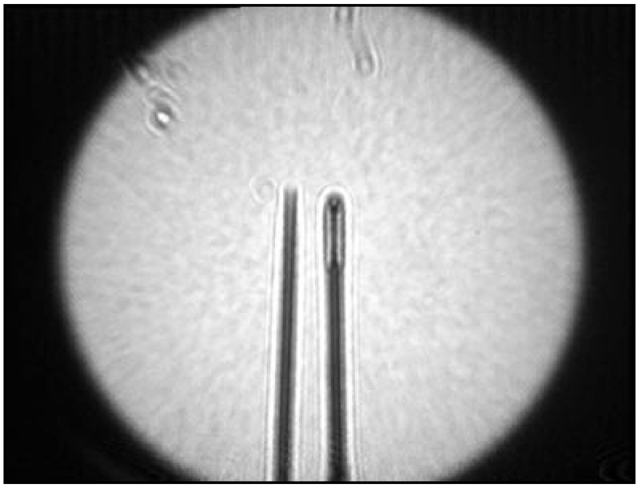

Figure 1

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† Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Ol-21, Diffraction.

Shadow of Needle / Script

Although light has properties similar to those of waves, the wavelength of light is so small that we seldom notice the wavelike nature of light. This pinpoint light source will allow us to demonstrate that wavelike nature.

If we put the light source behind a pair of needles and look at the light coming past the needles, we see a pattern around the edges caused by interference between different waves of light.

Equipment

1. Same setup as Demonstration 23-05.
2. Substitute a point and an eye of a needle in place of the small sphere in the previous Demonstration.

Demo 23-07 Pin Hole Diffraction

A diffraction pattern is created by shining laser light through a pinhole. The pattern is then viewed on a distant screen. In a two-dimensional analysis similar to the one-dimensional analysis of the diffraction by a single slit, the pattern is shown to be a series of alternating concentric dark and light rings, as seen in the video and in *Figure 1.*

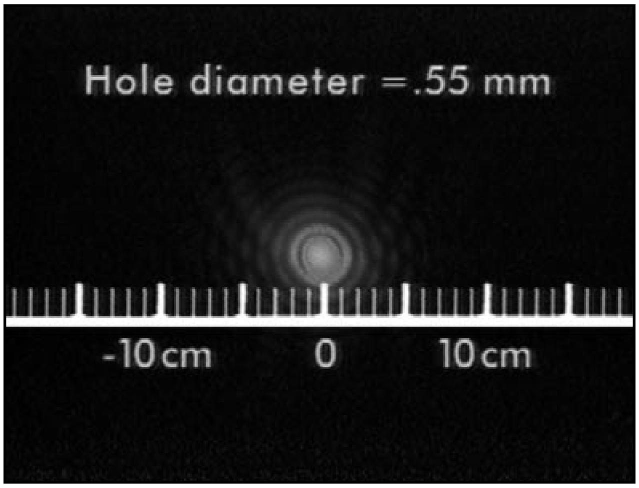

Figure 1

Pin Hole Diffraction / Script

When laser light passes through the pinhole in aluminum foil onto a screen, the light on the screen is not a simple spot. Instead, we see a pattern of bright and dark circles around a central bright point.

Equipment

1. Laser.
2. Mask with a small circular hole at its center.
3. Clamp and stand for the mask.
4. Screen.
5. AC power.

Demo 23-08 Knife Edge Diffraction

A knife edge is slowly moved into the laser beam as the laser light is viewed on a distant screen, as seen in *Figure 1*.[†] As the knife edge is inserted into the beam, the diffraction pattern of the knife edge is observed on the screen.

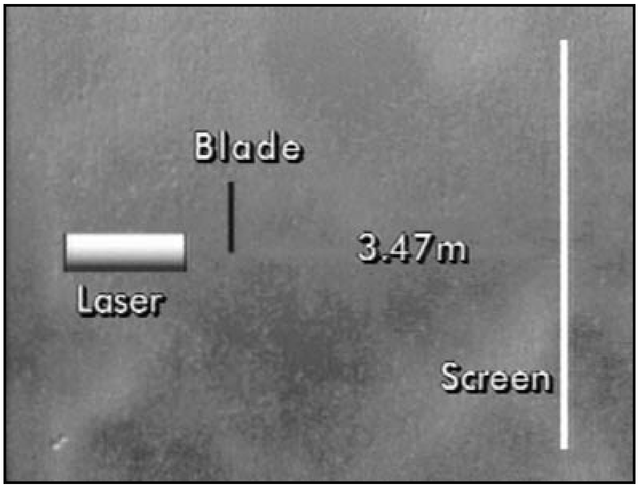

Figure 1

[†] Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Ol-21, Diffraction.

Light passing a sharp edge is diffracted around the edge. We'll use this razor blade and a laser to show the pattern that results.

Here is the setup of laser, blade, and screen.

This is the pattern obtained on the screen.

Equipment

1. Laser.
2. Razor blade.
3. Parallel jaw clamp.
4. Right angle clamp.
5. Ring stand.
6. Screen.
7. AC power.

Demo 23-09 Resolving Power

Five sets of double slits with different slit separation are viewed with the video camera from a distance. Only the double slit with the greatest separation is resolved. As the video camera zooms in on the slits, the pairs with closer spacing become resolved, as shown in *Figure 1*.

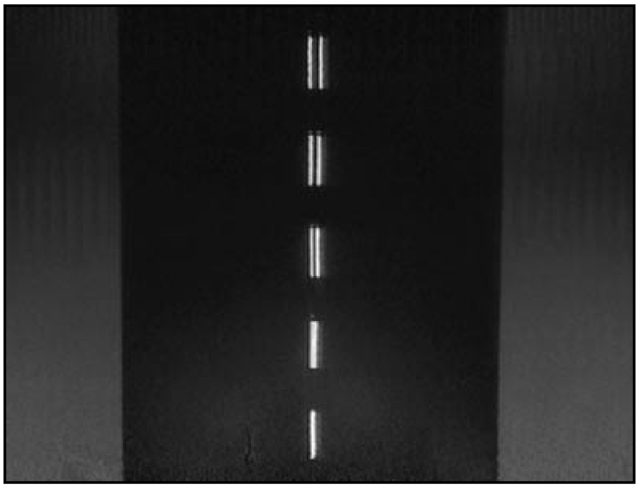

Figure 1

This black screen has five pairs of slits through which light passes from behind. Each successive pair of slits is separated by half the distance of the pair above it. The upper pair of slits can easily be seen as separate, but pairs of slits lower down become progressively more difficult to resolve as separate slits.

As the camera moves in, these closer pairs of slits are progressively resolved as separate slits.

Equipment

1. Flat black screen with five pairs of slits with varying distances of separation as described in the above script.
2. Light source that evenly illuminates all the slits.
3. AC power.

CHAPTER 62

INTERFERENCE

Demo 23-10 Microwave Double Slit Interference

The microwave unit of Disc 21 Demonstration 14 and Demonstration 1 on this disc is used to create double slit interference patterns using the arrangement shown in *Figure 1.* Two slit separations are shown, and the patterns for each pair are shown using graphics in the video and compared.

Figure 1

Microwave Double Slit Interference / Script *Demo 23-10*

This device consists of a microwave emitter, a microwave receiver, and a bar-graph display whose length is proportional to the intensity of the microwaves picked up by the receiver.

We'll use it to show how a microwave beam is affected as it passes through two closely spaced slits in a metal plate.

When we attach this pair of slits to the center of the board and swing the receiver around, the pattern is more complicated than might be expected from a simple pair of slits.

If we replace this pair of slits with another, more closely spaced pair, how will the pattern be affected?

Here is the pattern from the new pair of slits.

Here is the pattern from the original wider pair of slits.

Equipment

1. Brett Carroll microwave board.
2. Magnetic retaining bar.
3. Several metal sheets with a pair of slits at varying distances of separation.
3. Several metal sheets with a pair of slits at varying distances of separation.
4. Protractor overlay.
5. AC power.

Demo 23-11 Double Slit Interference

Double slit interference is illustrated using laser light and three sets of double slits with spacing of 0.62 mm, 0.26 mm, and 0.09 mm respectively, using the geometrical arrangement shown in *Figure 1*.[†] The interference pattern is spread apart more when the slits are closer together, as shown in the video. Note that this observation is complicated by the fact that the double slit interference pattern is superposed on the single slit diffraction pattern characteristic of the width of either of the two slits. The geometry is presented in a graphics segment (shown in *Figure 1*) to allow measurements. Using two of the three variables, slit separation, distance from slits to screen, and wavelength of the laser light, the third can be calculated.

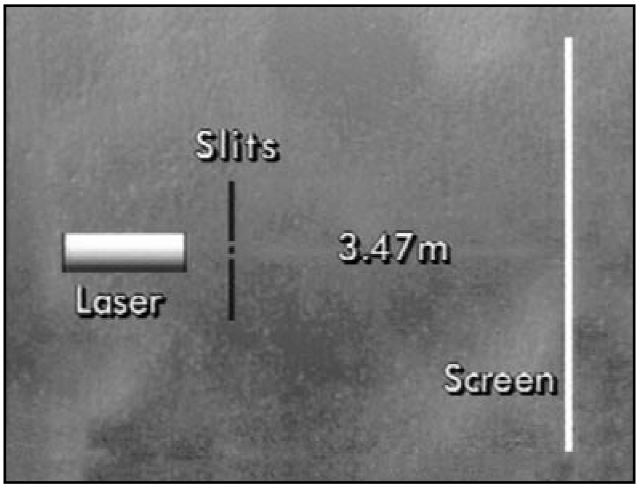

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration L-83, Projection of Single- and Double-slit Patterns.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Ol-9, Interference Pattern of Two Slits.

When light passes through two thin slits that are closely spaced and onto a screen, it produces an interference pattern of bright and dark spots.

These slides have three such pairs of slits, each with a different separation.

We'll pass a laser beam through each pair to show the resulting interference patterns.

Here is the setup of laser, slits, and screen, as seen from above.

This is the pattern on the screen from a pair of slits separated by 0.62 millimeters.

This is the pattern from a pair of slits separated by 0.26 millimeters.

Note that the pattern has spread.

Here is the pattern from a pair of slits separated by 0.09 millimeters. The pattern has spread even more.

Equipment

1. Cornell slide of slits.
2. Laser.
3. Screen.
4. AC power.

Demo 23-12 Multiple Slit Interference

Using laser light, the interference pattern is observed for multiple slits of spacing 80 slits/cm, 160 slits/cm, and 320 slits/cm, using the geometrical arrangement shown in *Figure 1.* The video illustrates that the pattern, consisting of a series of equally spaced bright dots, spreads out more as the number of slits per centimeter increases. The geometry of the system is shown in a graphics segment so that calculations can be made. If the value of two of the three variables, slit separation, slit to screen distance, and laser wavelength, are taken from the video, the third can be calculated and compared with the actual value.

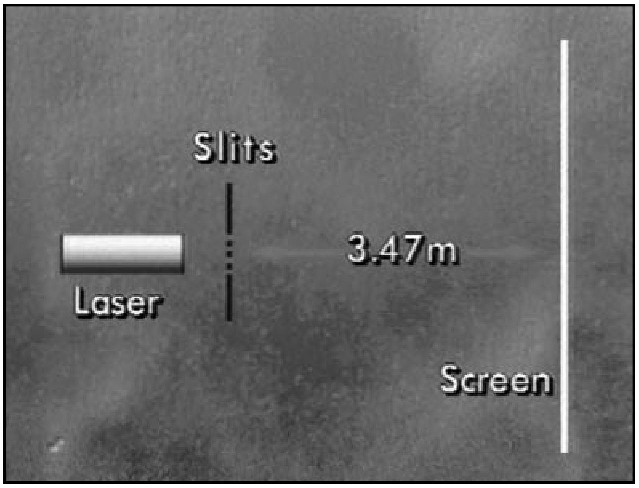

Figure 1

We'll use these sets of multiple slits on a slide to show the interference of light passing through the slits.

This laser will be our light source.

Here is the setup of laser, slits, and screen.

This is the pattern obtained with a slit spacing of 80 slits per centimeter.

Equipment

1. Cornell slide of slits.
2. Laser.
3. Screen.
4. AC power.

Demo 23-13 Interference Gratings

Gratings of 3000, 4000, and 6000 lines per centimeter are used to create the spectrum of white light.[†] As the number of lines per centimeter increases, both the deviation and the dispersion of the light increases, as can be clearly seen in the video. For the first two cases two orders of diffracted light can be seen, as shown in *Figure 1*. The "interference grating" is often called a "diffraction grating," even though the physical process by which the spectra are formed can be more accurately described as interference.

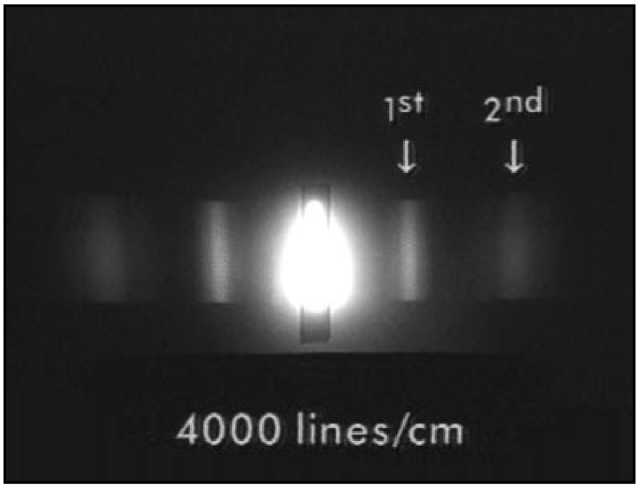

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration L-85, Diffraction Grating.

We'll shine white light through these three diffraction gratings, each with a different spacing of ridges on its surface, and onto a screen.

This is the pattern from a grating with 3000 lines per centimeter. Notice the first and second order spectra.

Here is the pattern from a grating with 4000 lines per centimeter. The spectra have moved farther out to the sides.

Here is the pattern from a grating with 6000 lines per centimeter. Now the spectra have spread out so far that only the first order spectra is visible. The colors are now much more intense than before.

Equipment

1. Slide projector.
2. Mask with a one-millimeter slit at its center in the projector's slide carrier.
3. Several diffraction gratings with differing number of lines per unit of length.
4. Translucent screen.
5. AC power.

Demo 23-14 Glass Plates in Sodium Light

Two large glass plates are placed one on the other and illuminated by sodium light.[†] (Sodium light is effectively monochromatic yellow). The interference of the light reflected off the two adjacent surfaces causes a series of bright and dark rings, which are shown in *Figure 1.* Pushing on the top plate changes the spacing between the plates and thus modifies the interference pattern, as shown in the video.

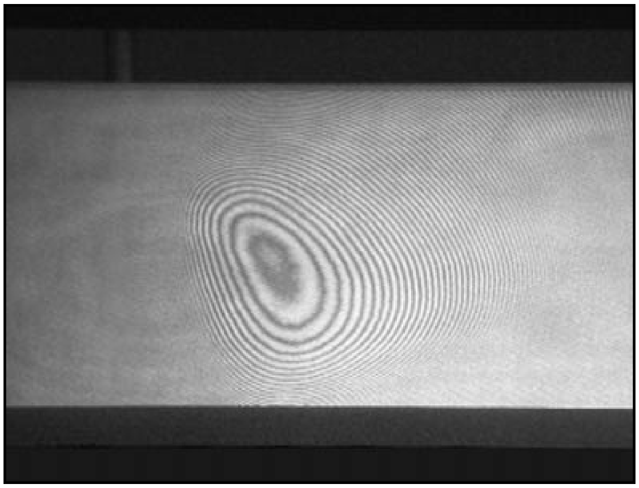

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration L-70, Interference in Thin Air Films.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Ol-18, Air Wedge.

Glass Plates in Sodium Light / Script

When two transparent plates are pressed together and viewed in a bright light, interference patterns can often be seen.

We'll use this monochromatic sodium light and two large glass plates to demonstrate one type of pattern.

With just one glass plate in place, the reflection of the sodium light is uniform.

When we add the second plate, an interference pattern appears.

The pattern shifts as the flexible pieces of glass relax into position.

Squeezing down on the plates causes a shift in the pattern.

Equipment

1. High intensity sodium lamp.
2. Piece of frosted glass suspended above a pair of ordinary plate glass stacked upon each other and held at a viewing angle.
3. Cardboard light shield.
4. AC power.

Demo 23-15 Newton's Rings

White light illuminates a flat glass plate that is held in contact with a convex glass surface. The interference of light between the two adjacent surfaces creates a series of light and dark rings, shown in *Figure 1,* known as Newton's rings.[†] Pushing on the plates to change the geometry results in a change in the interference pattern.

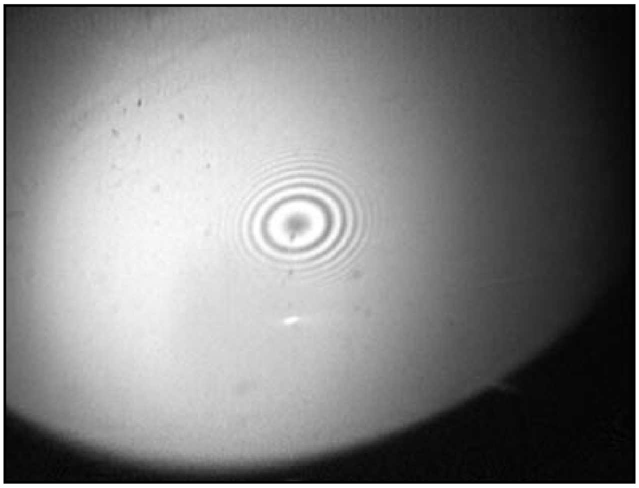

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration L-71, Newton's Rings.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Ol-17, Newton's Rings.

Newton's Rings / Script

Here are two glass plates, with one resting on top of the other in a circular frame. The lower surface of the upper plate is slightly convex, as shown in this drawing.

When we reflect light off the glass plates and onto a screen, a circular interference pattern appears.

When we press down on the upper plate, we decrease the minute separation between the plates, and the pattern shifts as a result.

Equipment

1. Newton's rings apparatus.
2. Lens.
3. Mirror.
4. Support system for the above.
5. Screen.
6. Carbon arc lamp with the lens.
7. DC power.

Demo 23-16 Interference Filters

An interference filter is a glass plate coated with a thin uniform layer of dielectric material. Light of a single wavelength is prevented from reflecting by interference between the front and rear surfaces of the dielectric, resulting in primarily one color of light passing through the filter, with the complementary color (white minus the color removed) being reflected. Three interference filters are shown in the video, using the arrangement shown in *Figure 1,* with a thread screen used to view the reflected and the transmitted light. The colors are, in order:

Filter	Transmitted Light	Reflected Light
1	B	Y = W − B
2	G	M = W − G
3	R	C = W − R

where R = red, G = green, B = blue, W = white, Y = yellow, M = magenta, and C = cyan.

Figure 1

Interference Filters / Script

We'll use these glass plates with a thin coating of transparent magnesium fluoride to demonstrate interference of light reflecting from very thin films.

The thickness of the coating determines which colors are reflected, and which are transmitted.

This first plate has a relatively thin coating of magnesium fluoride; it reflects yellow light and transmits blue light.

This plate has a slightly thicker coating; it reflects violet light and transmits green light.

This plate has a still thicker coating. It reflects green light and transmits red light.

Equipment

1. Three interference filters with differing coating densities.
2. Thread screen.
3. White light source.
4. AC power.

Demo 23-17 Pohl's Mica Sheet

A thin mica sheet is illuminated by a mercury lamp. Interference between the light reflecting off the front and the back surfaces of the mica sheet creates a series of colored fringes, as shown in the video.[†] The geometry, presented in the video using graphics, is shown in *Figure 1.* A nice close-up video of the colors created by the interference is presented.

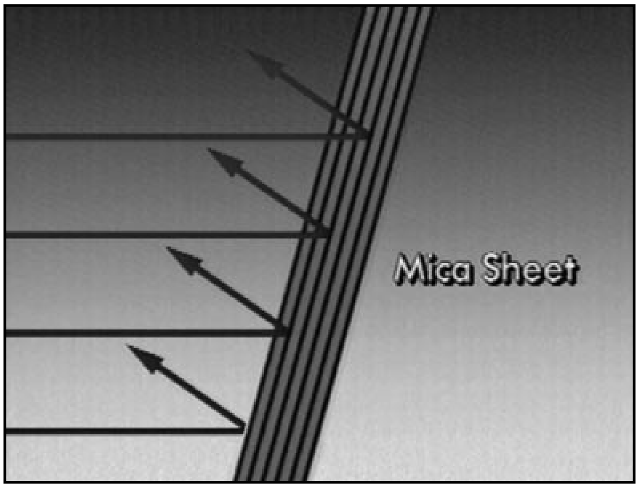

Figure 1

[†] Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Ol-15, Interference in Thin Sheets.

Pohl's Mica Sheet / Script

Here is the light from a mercury lamp shining straight onto a screen. If we reflect the light off a sheet of mica and onto the screen, an interference pattern appears.

The light is reflected from many thin layers in the mica, creating a circular interference pattern of violet and green rings.

Equipment

1. Mercury lamp and its transformer.
2. Thin sheet of mica.
3. Flat black background sheet and the support system.
4. Screen.
5. AC power.

Demo 23-18 Soap Film Interference

Interference between light reflecting off the two sides of a soap film is responsible for the colors seen in soap bubbles. This demonstration illustrates the interference of white light by a soap film, as indicated in *Figure 1* in black and white.† As time passes, the soap film becomes so thin on top that the interference disappears, leaving only a dark region, as shown nicely in the video.

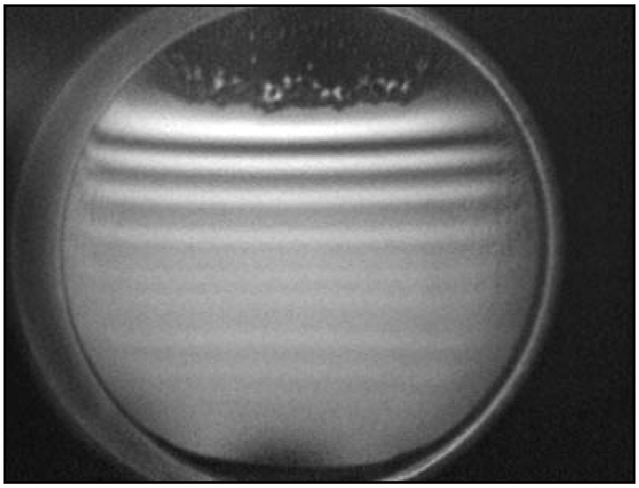

Figure 1

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† Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Ol-16, Soap Film Interference.

Soap bubbles display dazzling colors when seen under bright light.

If we dip this cylinder into a soap solution, a thin flat film is placed on the mouth of the cylinder. We'll shine the light off the soap film and onto the screen to show how the colors we see depend on the thickness of the film.

Immediately after the film is produced, the colors are pale and difficult to see.

As the fluid drains to the bottom, the film thins at the top, and the colors become more distinct.

Now the film is so thin at the top that the colors have disappeared, leaving a dark space where almost no light reflects.

Finally, the film breaks.

Equipment

1. Reservoir of soap solution.
2. Rotating cylinder whose end is mostly closed.
3. Lens.
4. Support system for the above.
5. White light source.
6. Projection screen.
7. AC power.

Demo 23-19 Microwave Interferometer

An interferometer is constructed for use with 3-cm microwaves using the apparatus of Disc 21 Demonstration 14.[†] A mesh screen at 45° with respect to the incoming beam, shown in *Figure 1,* functions as a half-silvered mirror. If the path lengths of the two arms of the interferometer are equal or differ by exactly one wavelength, the two waves will be in phase when they recombine and are picked up by the receiver at the left of the Figure. If the two path lengths differ by an odd number of half wavelengths, the two waves will be out of phase and interfere destructively. Thus as the reflector at the right is moved to the right the receiver will indicate a series of maxima and minima, as shown clearly in the video. Distance calibration is included by graphics overlay for the movable mirror position, so measurement may be made to determine the wavelength of the microwaves.

Figure 1

[†] Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Ol-20, Michelson Interferometer with Radar.

This device consists of a microwave emitter, a microwave receiver, and a bargraph display whose length is proportional to the intensity of the microwaves picked up by the receiver.

The microwave beam first strikes a mesh screen which reflects about half the beam and transmits the other half.

Each of these beams strikes a metal sheet and reflects back. Part of each beam reaches the receiver, where they combine.

The two beams interfere either constructively or destructively, depending on the phase difference between them,

which depends on the path lengths followed by each of the beams.

If we move one of the mirrors to change the path length of one of the beams, the intensity at the receiver shows a regularly spaced pattern of highs and lows.

Equipment

1. Brett Carroll microwave board.
2. Interferometer analog made from hail screen and two metal sheets mounted on drawer guides and held in the center of the board.
3. Electrical power.

Demo 23-20 Michelson Interferometer with White Light

This demonstration shows white light fringes from a Michelson interferometer using the system shown in *Figure 1*.[†] When the two optical path lengths are exactly the same the two signals are out of phase, due to the difference in the phase changes at the boundary on one side of the beam splitter. As one of the mirrors is moved, the two waves go in and out of phase at a different rate for each wavelength or color, creating a beautiful sequence of negative colors. Circular fringes are produced when the two reflecting mirrors are exactly perpendicular to their respective optic axes; tilting one mirror produces line fringes. Both types of white light fringes are illustrated in the video. Finally, a hot match head is inserted into one of the paths, creating a series of fringes due to changes of the index of refraction of the air by heating.

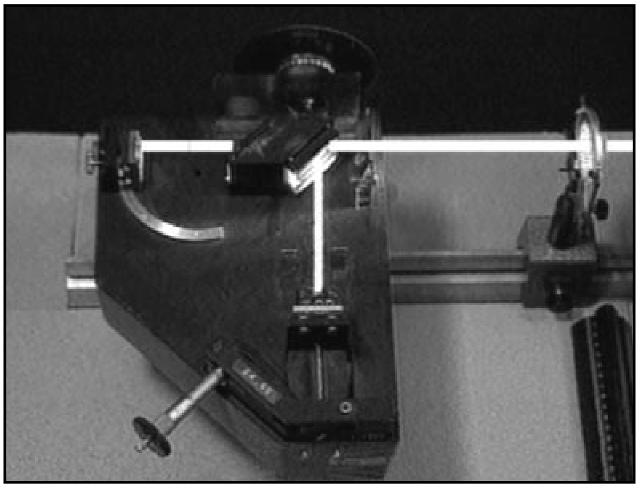

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration L-72, Michelson Interferometer. Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Ol-19, Michelson Interferometer.

We will now use this setup to view white light from a Michelson interferometer.

White light from this bright quartz-halogen point source is collimated by this condensor lens and directed through a heat filter into the Michelson interferometer.

The interference fringe pattern can be observed, with the use of a lens at the exit of the interferometer, on the screen.

When the two paths of the interferometer are of very nearly equal length, light from the two paths will interfere destructively at one or more wavelengths.

This creates fringes of non-spectral colors, that is, fringes of white light from which one or more wavelengths have been removed. The length of this path can be varied by adjusting the position of this moving mirror using this micrometer.

This mirror, called the fixed mirror, can be rotated using the two screws on the back of the mirror. When the two mirrors are aligned perpendicular to their optic axes, circular fringes can be obtained.

We now start with the moving mirror in too close to obtain fringes and slowly move it outward so that we can see the sequences of colors produced.

Now the mirror is too far to obtain fringes.

The moving mirror has now been returned to the equal path length position and the fixed mirror has been tilted so that we can see line fringes.

Once again the mirrors have been aligned perpendicular to their respective optic axes and a hot match tip is inserted into one path of the interferometer.

Equipment

1. Michelson interferometer.
2. Quartz-halogen point source of bright white light.
3. Condenser lens.
4. Heat filter.
5. Screen.
6. Supply of matches.
7. Electrical power.

Demo 23-21 Holograms

A hologram is a three-dimensional image created by interference of light from a film that has been exposed by laser light. Two holograms are shown in this video, a reflecting white light hologram and a cylindrical laser light hologram. The three-dimensional character of the holograms is clearly shown.

Holograms are three-dimensional photographs usually made with laser light. Unlike an ordinary photograph, which looks much the same from any angle, a hologram looks different from different angles. Being able to look around images in a hologram gives a strong illusion of depth.

Equipment

1. White light reflection hologram.
2. Point source of white light.
3. 360° transmission hologram.
4. Laser.
5. Beam expander.
6. AC power.
7. Appropriate clamps and support systems.

CHAPTER 63

SPECTRA AND COLOR

Demo 23-22 Infrared in Spectrum

The existence of infrared radiation in the spectrum of white light is shown in this video.[†] A thermopile, mounted behind a slit in the screen shown in *Figure 1,* picks up infrared radiation. As the slit passes from the ultraviolet, through the visible spectrum, and into the infrared, a galvanometer attached to the thermopile indicates the energy in the radiation on the screen. This demonstration clearly shows that the greatest fraction of the radiation in the spectrum is in the infrared region.

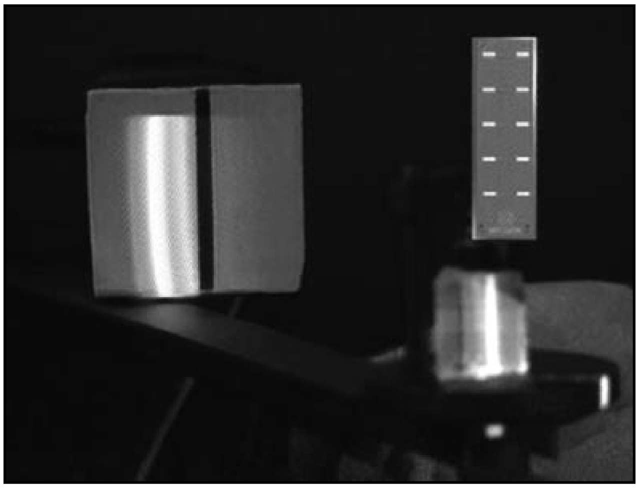

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstrations L-98, Radiation Intensity Curve, and L-112, Infrared Shown by Thermopile or Radiometer.

We'll investigate the infrared light which exists below the low frequency end of the visual spectrum by passing the light of this carbon arc lamp through a prism.

Light passing through this slit strikes a thermopile, which detects the energy in the light and drives a galvanometer. The higher the galvanometer reading, the more energy there is in the portion of the light striking the thermopile.

What part of this spectrum do you think contains the greatest amount of energy?

The greatest amount of energy in the spectrum is in the invisible infrared light.

Equipment

1. Optical bench.
2. Carbon arc without its lens.
3. Beam mask.
4. Lens.
5. X-flint prism (or better quality).
6. Thermopile.
7. Projection galvanometer, and its rotating arm.
8. Two lens clamps.
9. Three optical bench clamps.
10. Support stand for the prism and the rotating arm.
11. DC power.

Demo 23-23 Colors in Spectral Light

A rose looks red if it is illuminated by red light or white light, which contains red. If it is illuminated by any other color, it will appear black, or perhaps slightly red if there is some red in the light by which it is illuminated. This demonstration shows a red rose illuminated by white light, red light, green light, and blue light.[†]

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration L-87, Color.

Colors in Spectral Light / Script

The petals of this rose are red because they scatter the red light portion of the white light shining on it.

But what color will they be if the light shining on them is not white?

We'll shine different colors of light onto the rose to show the effect on its appearance.

Here is the rose in red light.

Here is the rose in green light.

Here is the rose in blue light.

Equipment

1. Rose (real, if possible).
2. White light source.
3. Red optical filter.
4. Green optical filter.
5. Blue optical filter.
6. AC power.

Demo 23-24 Rainbow Disc

A narrow beam of light strikes a plastic disc as shown in *Figure 1.* At the first surface the light ray mostly refracts into the disc, with some dispersion. At the back surface it partially reflects internally and partially refracts out of the disc. The internally reflected light then refracts out of the disc with additional dispersion. This illustrates the passing of light through water droplets, which leads to creation of a rainbow. Notice that the raindrop is viewed looking away from the sun, and, as shown in the video, the angle at which the rainbow appears is defined by the total angle at which the light is reflected and refracted in the drop.

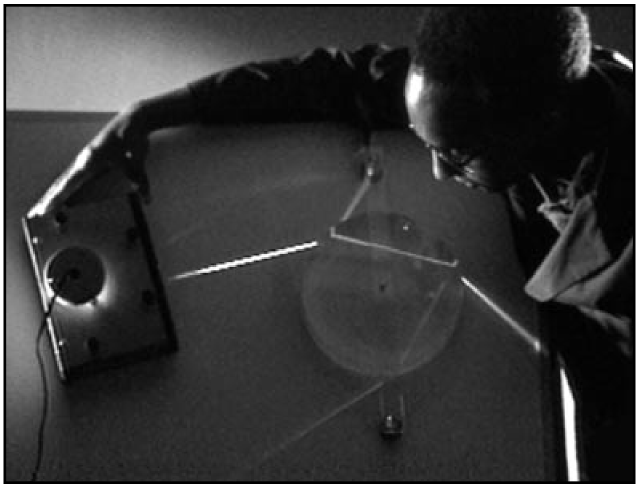

Figure 1

We'll use this disc, called a rainbow disc, to show one way in which the colors composing white light can be separated.

When a beam of light enters the disc it is refracted, then totally internally reflected, and then refracted again as it leaves the disc. The beam of white light spreads into a spectrum.

Equipment

1. Optics board setup.
2. Large circular lens and its support bracket.
3. Single beam from white light source.
4. Sheet of white paper.
5. AC power.

Demo 23-25 Newton's Color Disc

A disc, known as Newton's color disc, contains a variety of pie-shaped colored segments, as shown in black and white in *Figure 1*.[†] When the disc is illuminated by strong white light and rapidly spun, the colors add together, creating white light, as shown clearly in the video.

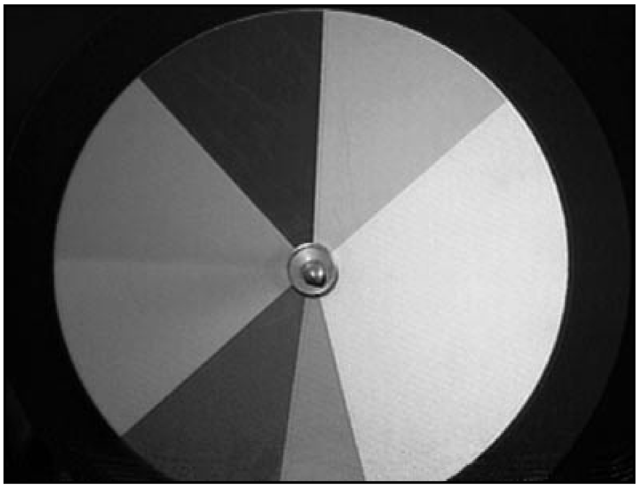

Figure 1

[†] Sutton, *Demonstration Experiments in Physics,* Demonstration L-93, Color Discs.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Oj-2, Synthesis of Colors.

Newton's Color Disc / Script

This disc with different colored sectors can be used to show that white light consists of many separate colors.

When the disc is spun rapidly, the colors merge into white.

Equipment

1. Commercially available Newton's color disc.
2. Hand rotator.

Demo 23-26 Additive Color Mixing

Circles of light of the three primary colors, red, green, and blue, are observed individually and in various combinations, as indicated in black and white in *Figure 1*.† When viewing the video, colors are indicated by letters: red (R), green (G), blue (B), yellow (Y = R + G), cyan (C = B + G), magenta (M = R + B), and white (W = R + G + B = R + C = G + M = B + Y). Mixing red and blue create magenta, mixing red and green create yellow, and mixing blue and green create cyan. Mixing the three primary colors produces white light. Complementary colors are also illustrated in this demonstration. Cyan (blue and green) mixes with red to produce white; magenta (red and blue) mixes with green to produce white light; yellow (red and green) mixes with blue to produce white light.

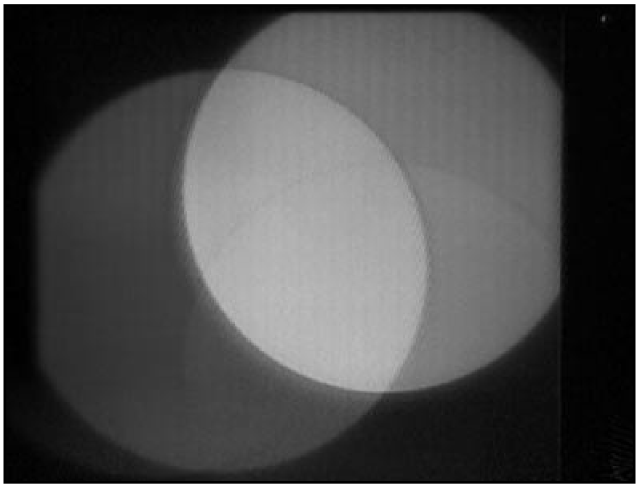

Figure 1

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† Sutton, *Demonstration Experiments in Physics,* Demonstration L-88, Combination of Colors by Addition.
Freier and Anderson, *A Demonstration Handbook for Physics,* Demonstration Oj-3, Color Box.

Additive Color Mixing / Script

This color mixing box will be used to show how light of different colors can be mixed to produce other colors.

Three light sources inside the box each have a filter to produce different colored beams, and a power control to change the intensity.

We'll insert three filters which produce red, green, and blue light and examine the colors produced where the beams overlap.

Notice the different colors produced where any two beams overlap, and a white light in the center where all three beams meet.

Equipment

1. Color mixing box with three intensity controlled lamps and three basic filters, and a translucent screen.
2. AC power.