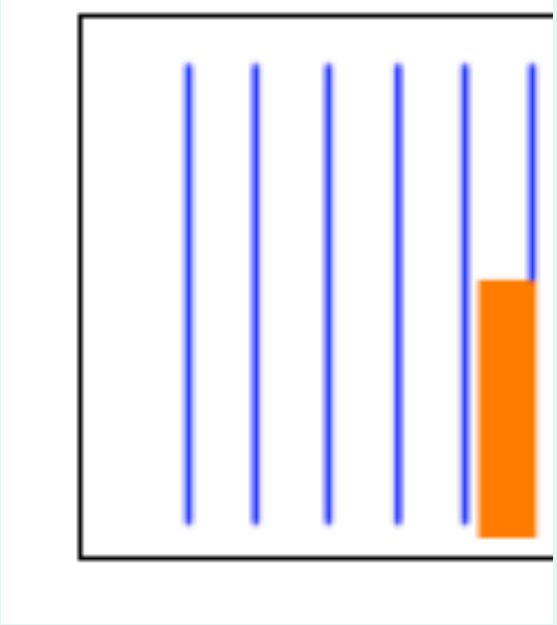
# Exploring Light:
# The Optics of Diffraction

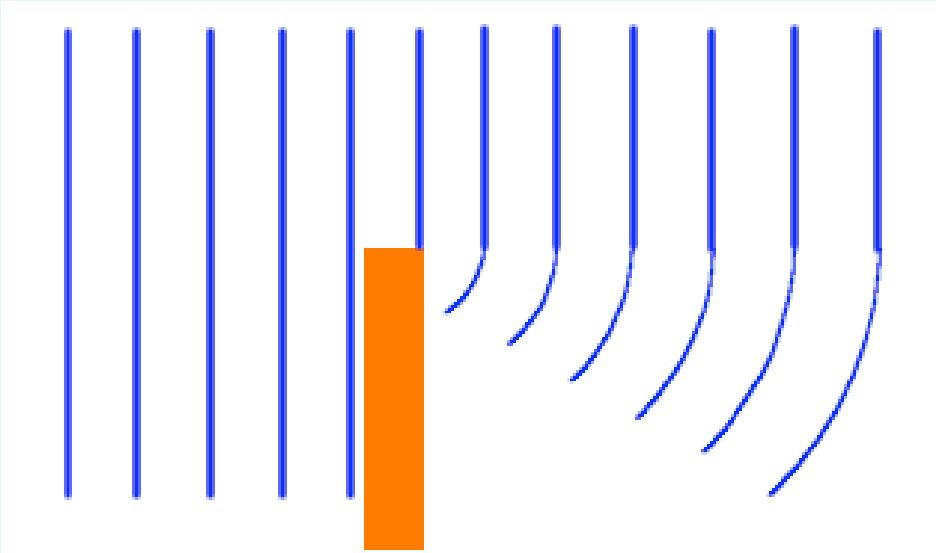
McDonald Observatory

The University of Texas at Austin

# Diffraction Activity Annex

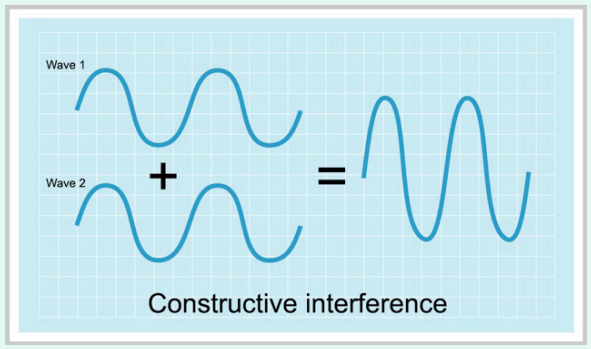


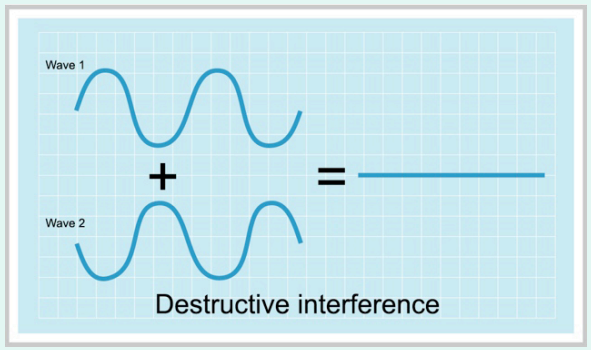
Predict what happens to the waves as they pass the barrier.

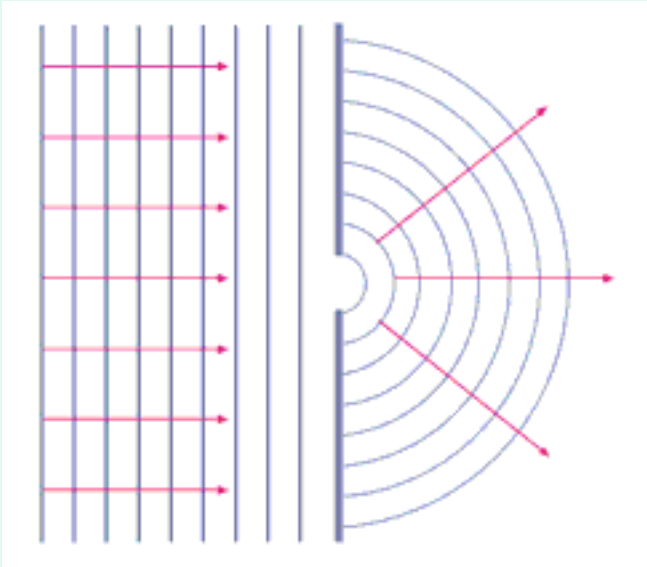


The waves bend around the barrier.

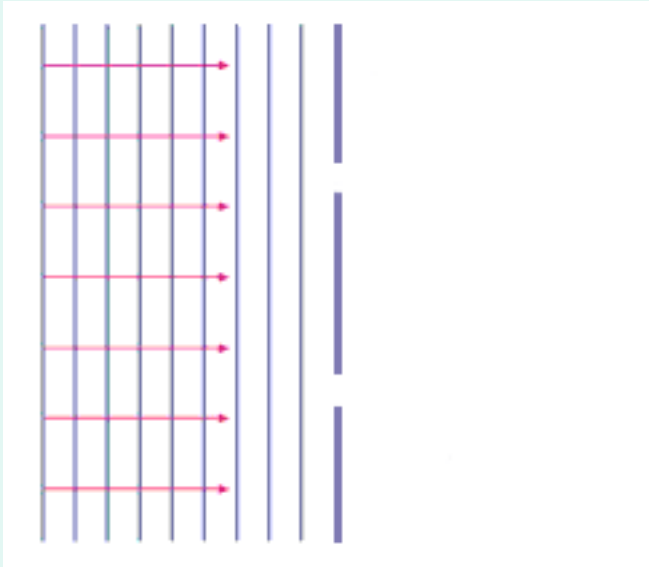
# Interference



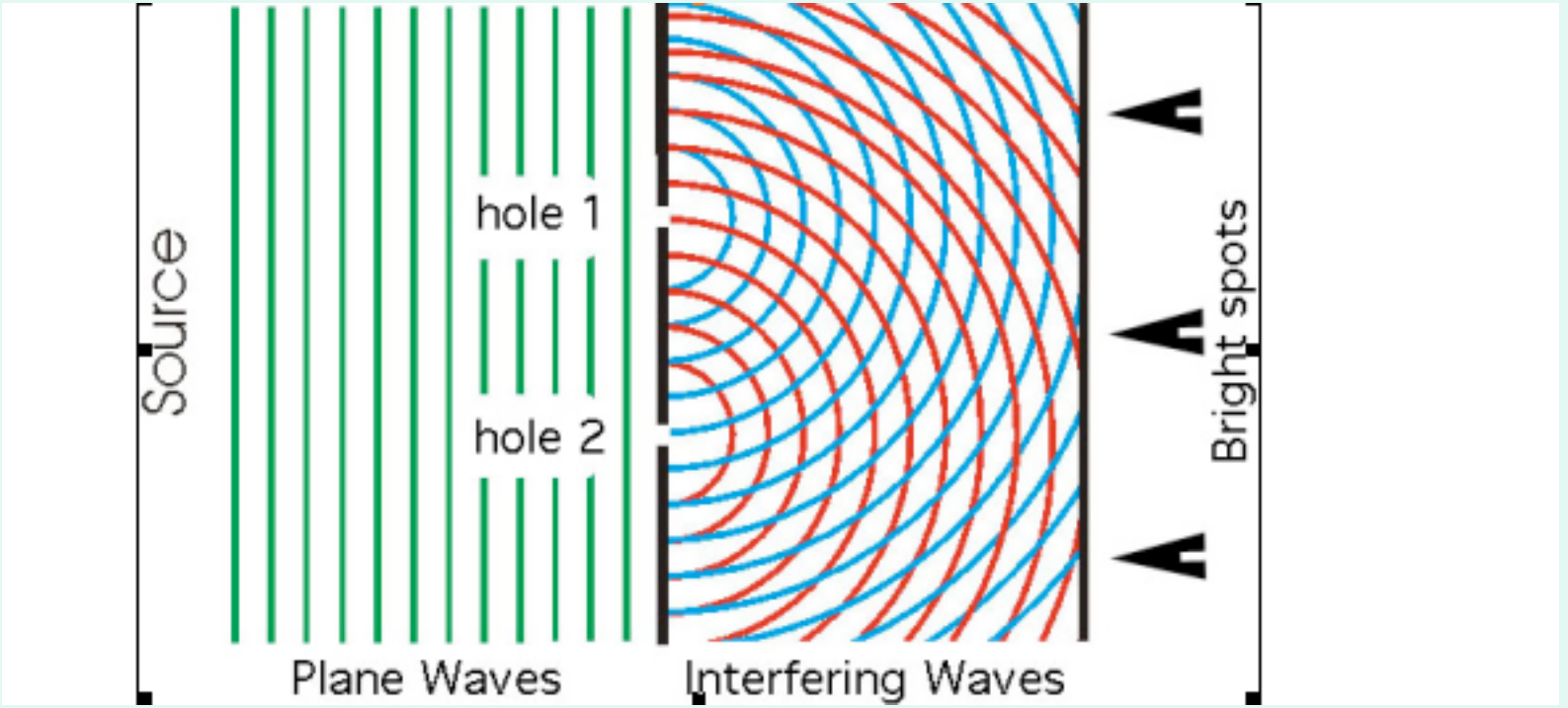



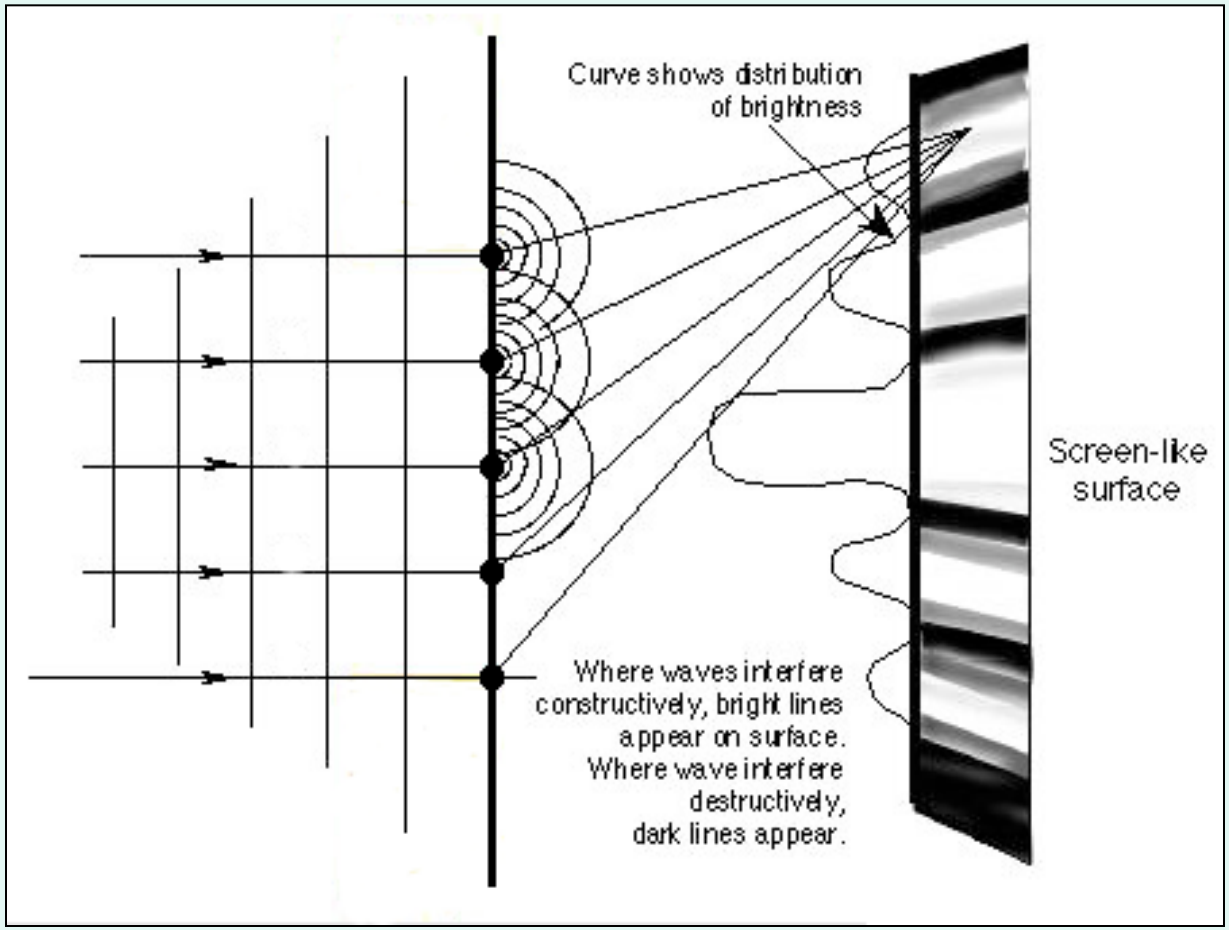


One hole

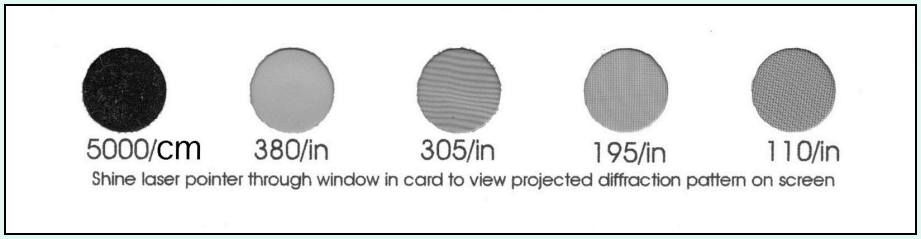


Predict pattern for two holes


Source
hole 1
hole 2
Bright spots
Plane Waves
Interfering Waves

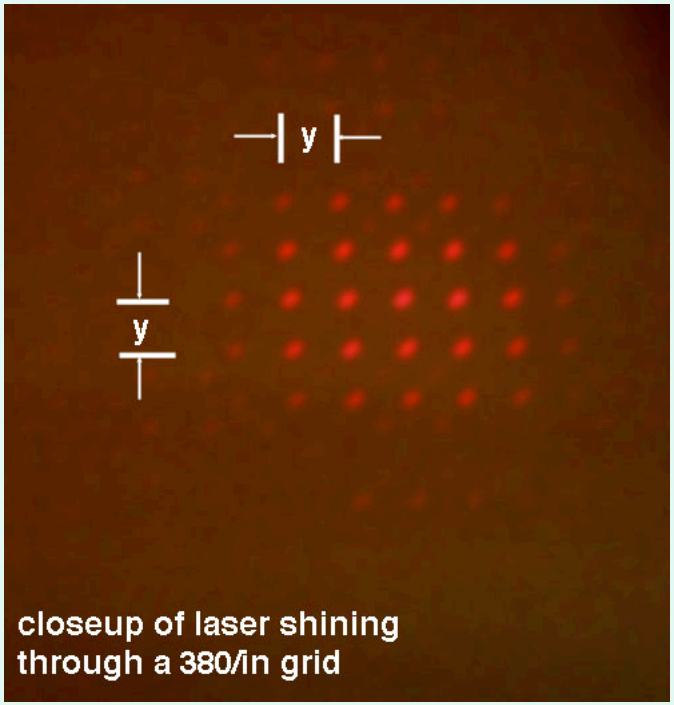

Curve shows distribution of brightness
Screen-like surface
Where waves interfere constructively, bright lines appear on surface.
Where wave interfere destructively, dark lines appear.

# Diffraction materials card

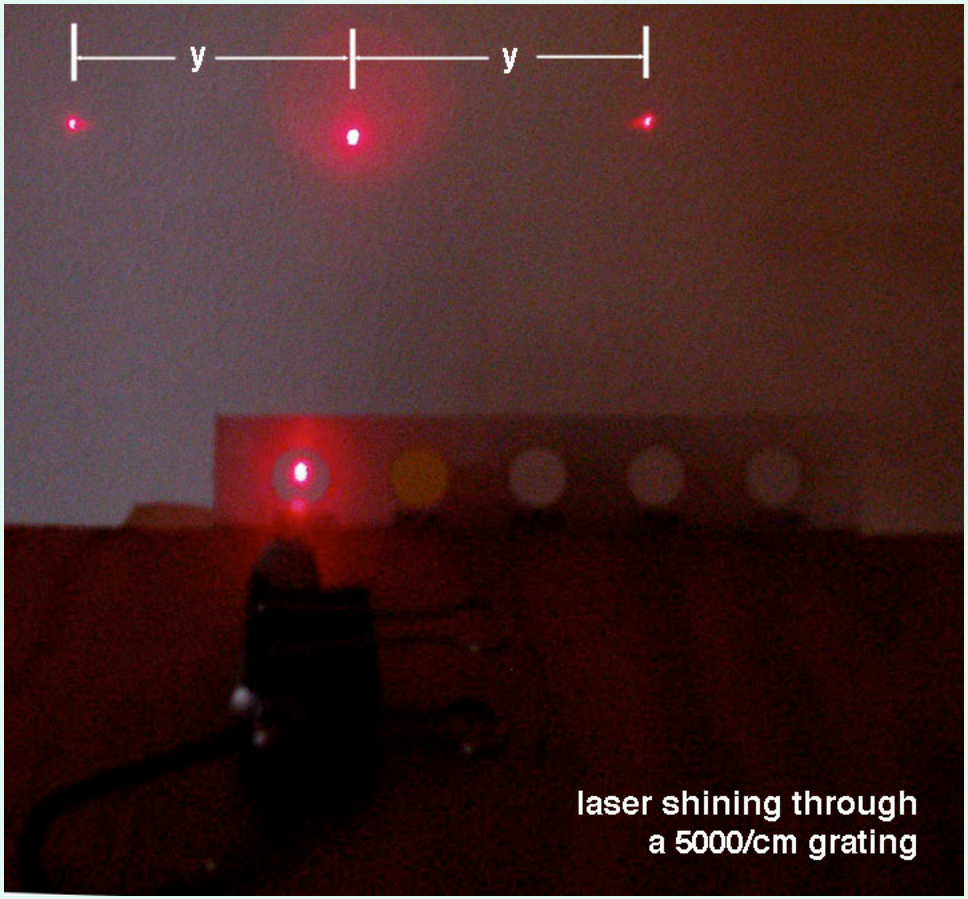



# Seeing Diffraction

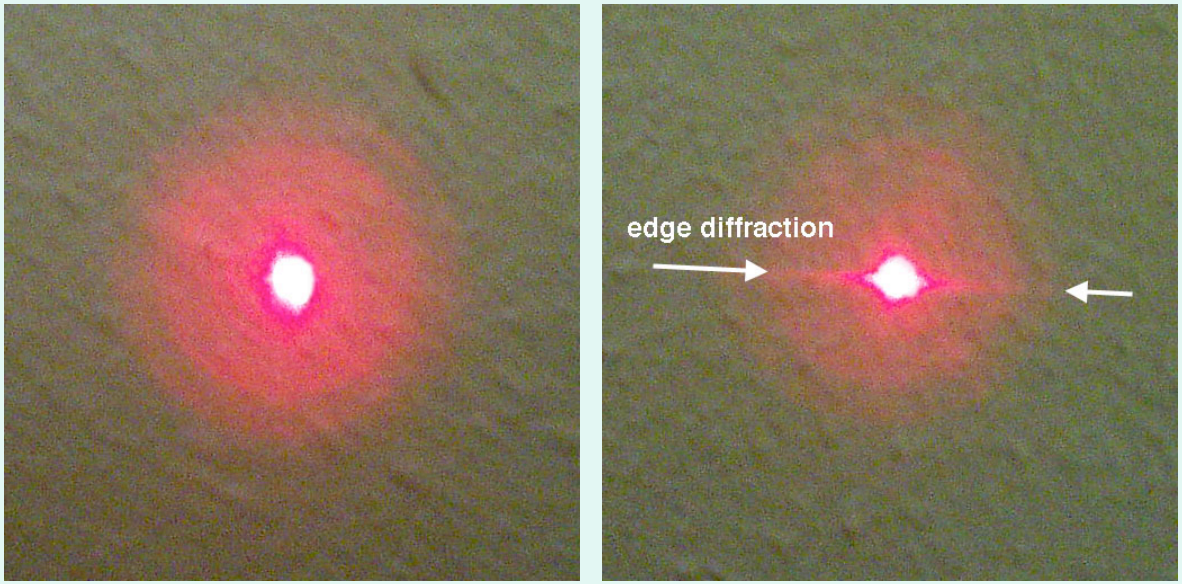

This shows the setup of the laser pointer shining at the Diffraction Materials Card that is taped to the edge of a table. The diffracted laser spot is projected on the far wall.

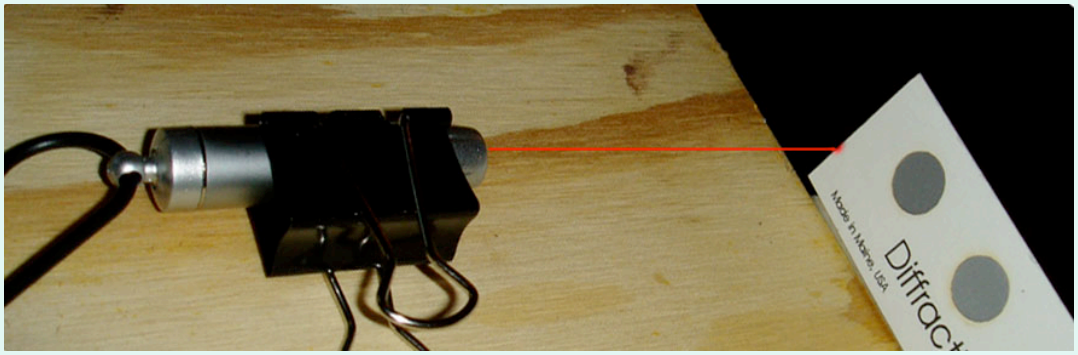



This shows a close-up of the projected laser beam with the setup laid out in the previous Annex slide. The diffracted spots are clearly visible. Projected on a piece of white paper, the spots can be marked for measurement.

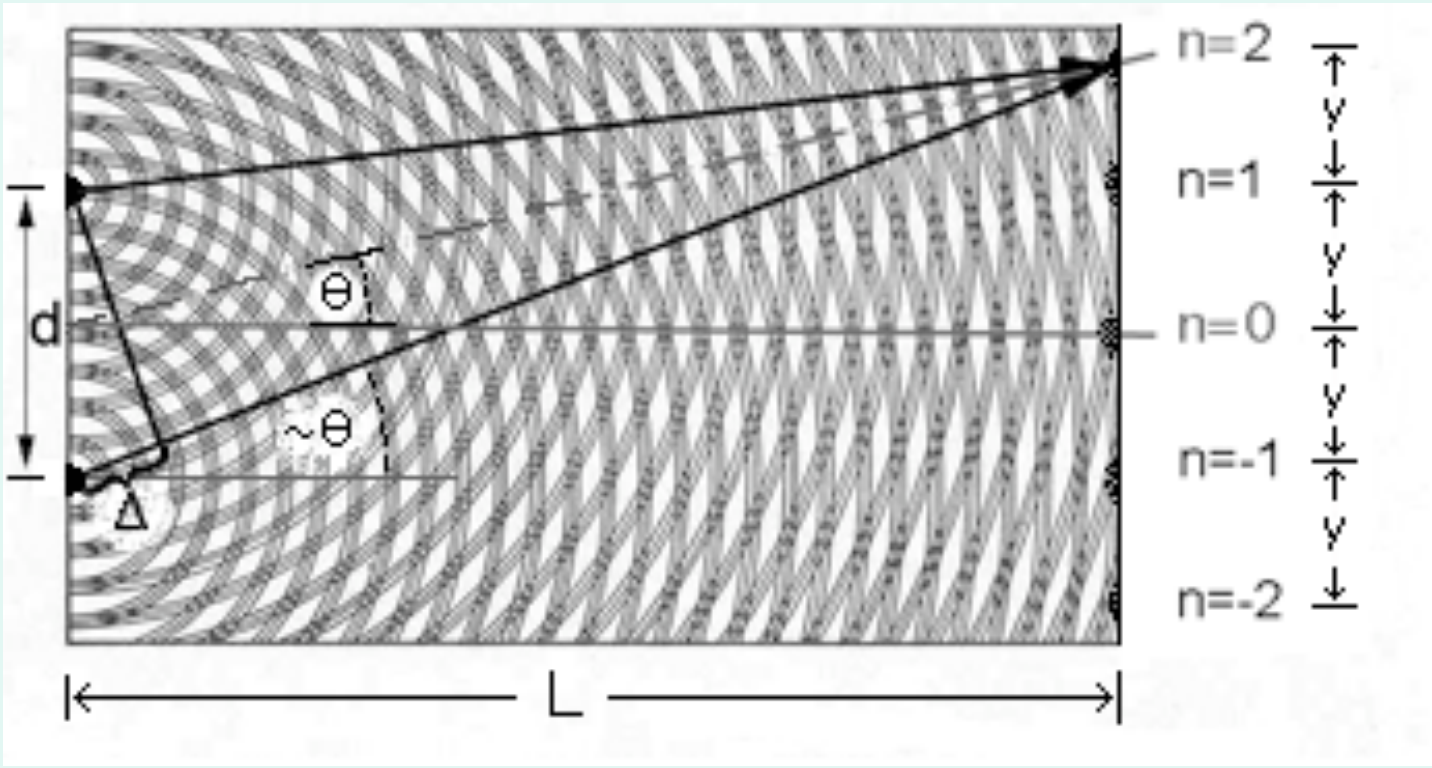


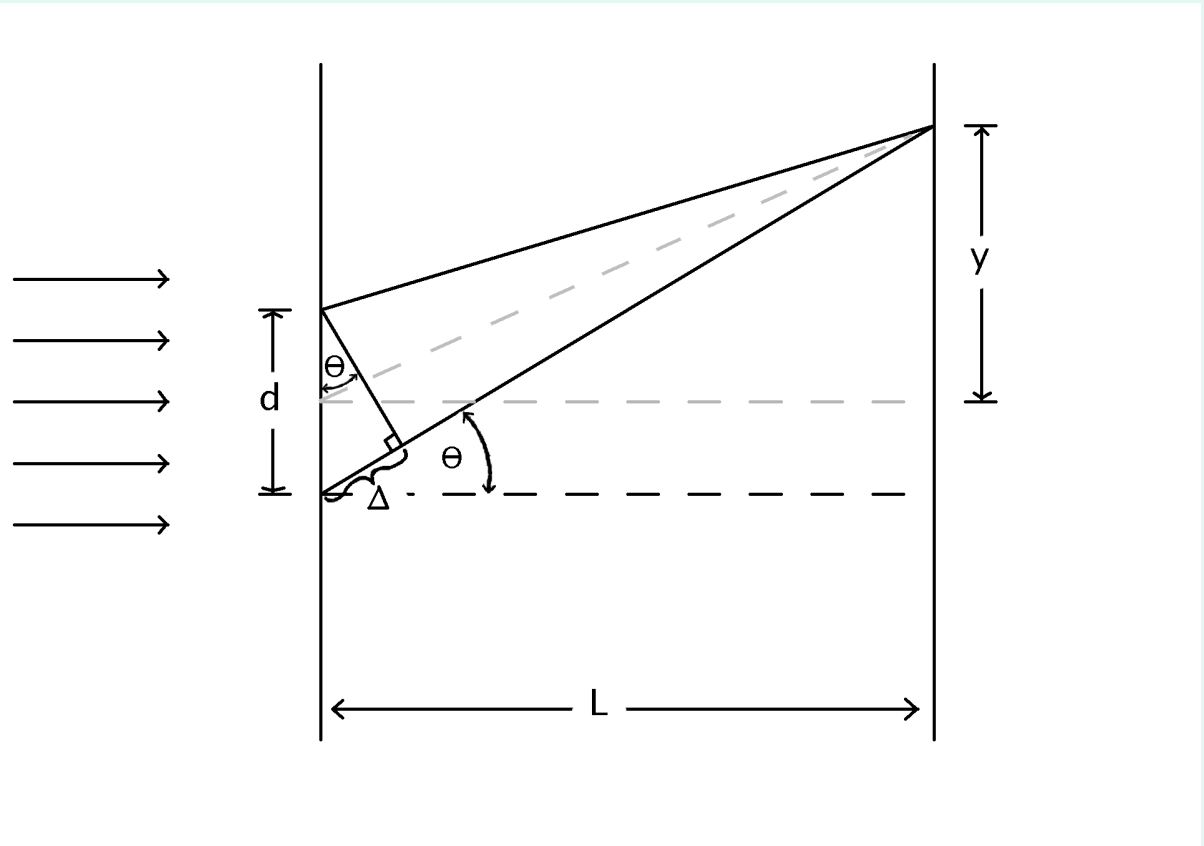

Same setup as in the previous slides, but with the 5000/cm grating. The spots now extend only in one direction, and are much more spread out.

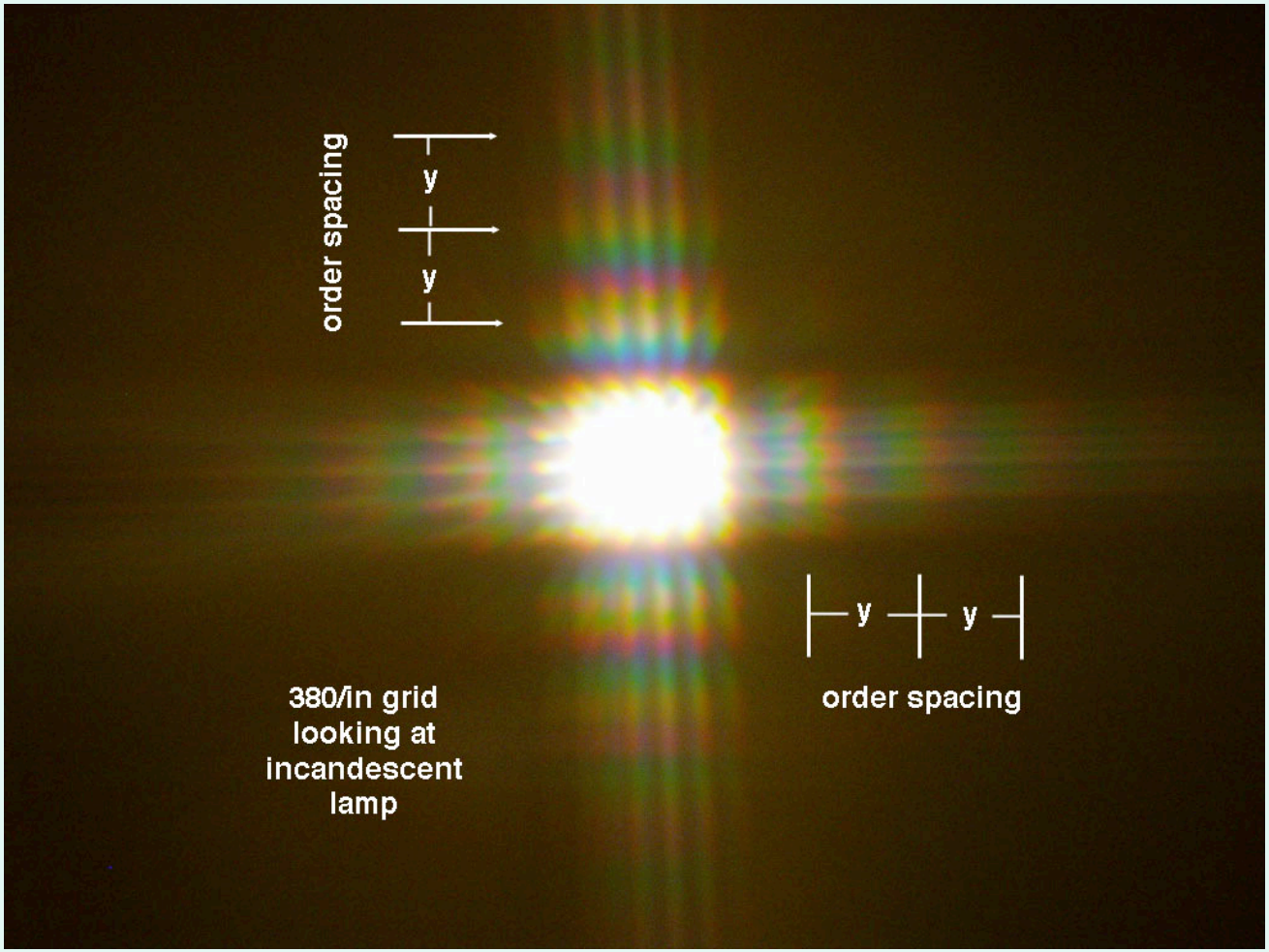


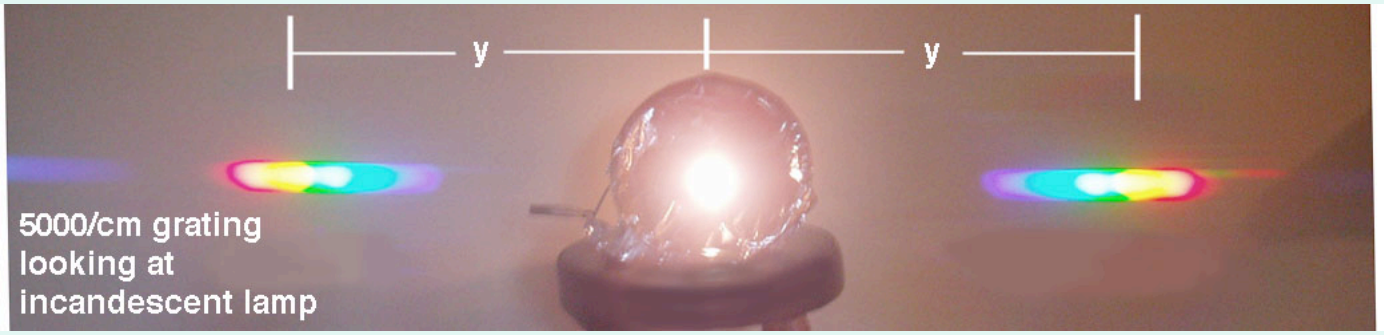
Diffraction from the edge of the card: At left above is the laser spot on the wall unobstructed, and at right is the spot on the wall when the laser beam is cut into by the card as shown below. This image shows the faint “spikes” that come from diffraction bending of light around the edge of the card.


n=2
n=1
n=0
n=-1
n=-2
d
θ
~θ
Δ
L


y
d
θ
θ
Δ
L




Appearance of incandescent lamp through 380/in grid. The spots (“orders”) are clearly separated.
Measure the order spacing by looking at one color

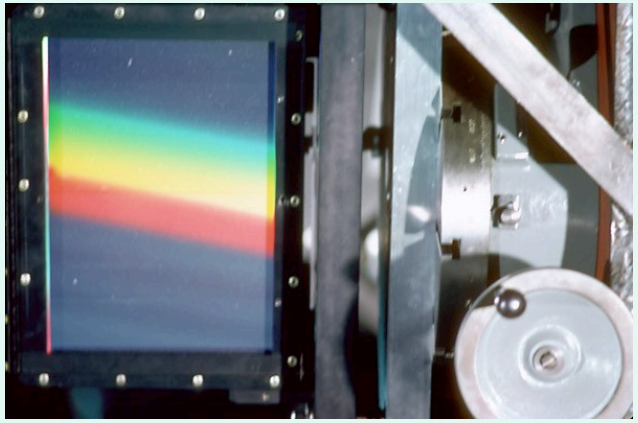


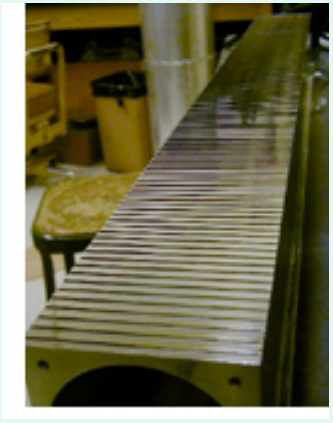

Appearance of incandescent lamp through the 5000/cm grating. The spots (“orders”) are widely separated. Measure the order spacing by looking at one color.


Diffraction is easily seen in reflected light off the surface of a CD, and produces the familiar iridescent appearance of these disks.


Appearance of incandescent lamp through a CD (compact disk). The spots (“orders”) are widely separated, as for the 5000/cm grating. The ease with which these spots can be seen depends a lot on the CD. Do not use one with opaque labels. Disks with printed surfaces often allow enough light through to be viewed in this way.

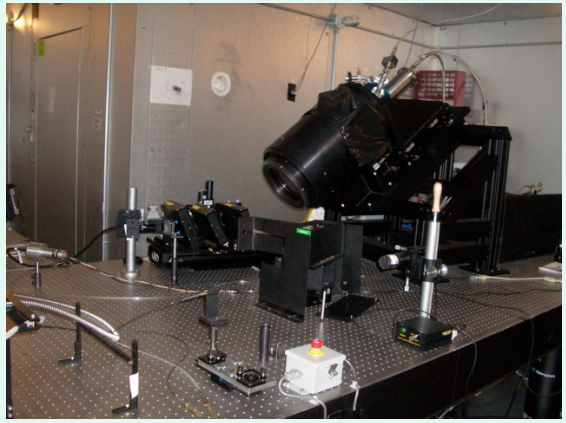
# Different types of gratings





Grating at coudé focus of 2.7-m telescope and 1-m long echelon grating for EXES instrument (to fly on SOFIA)

# Some spectrometers at McDonald Observatory

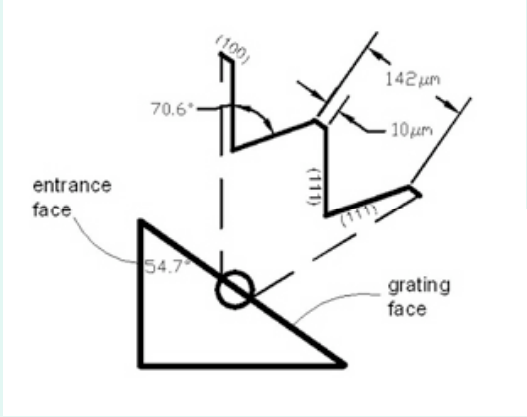


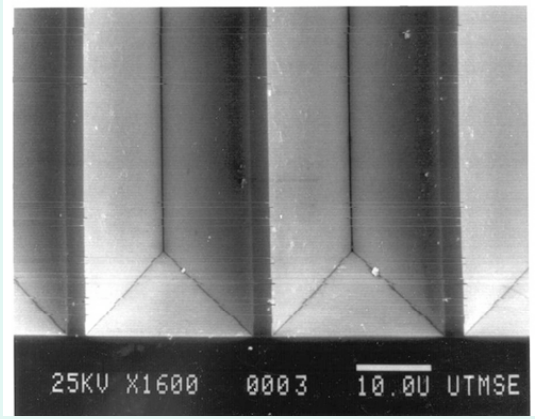
Medium resolution spectrograph on the Hobby-Eberly Telescope and CoolSpec at Cassegrain focus on the 2.7-m telescope. Both use diffraction gratings.

# Astronomical Spectroscopy is used to find:

- Temperature of stars
- Chemical  composition
- Radial velocity (Doppler effect)
- Magnetic fields
- Rotation rate

# Micromachined Silicon Diffractive Optics

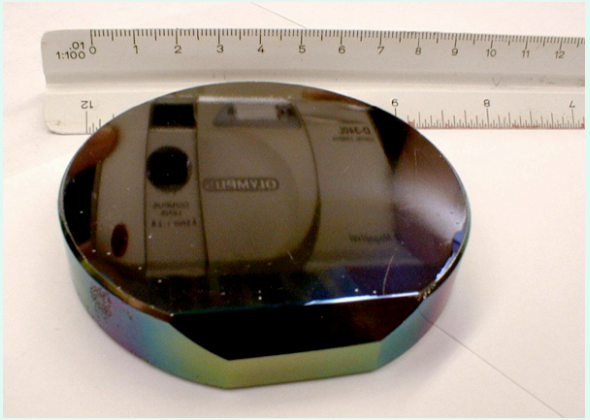


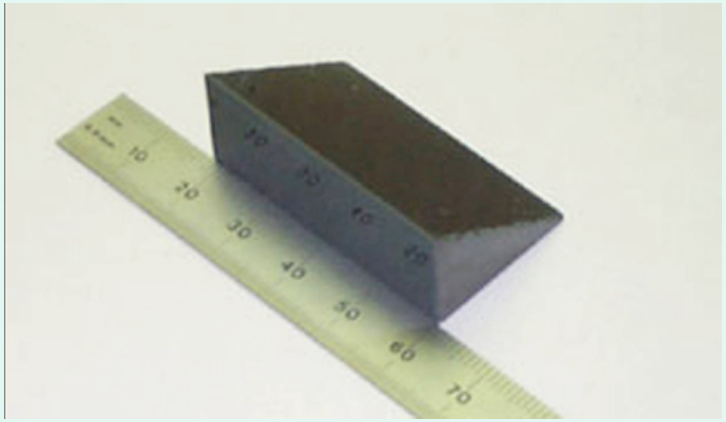




*In an immersion grating, the light enters from the left and is incident on the grating surface from the inside, where the wavelength is shortened by a factor equal to the refractive index (3.44 for Si). This allows a grating of a given size to have 3.44 times the resolving power of a conventional front-surface device.*

*The other image is a scanning electron micrograph of grooves micromachined into a silicon wafer in Dr. Jaffe's lab.*

# The resultant grism





*Silicon grating etched into the surface of a thick disk.*

*Completed silicon immersion grating. The light enters by the polished face on the left, strikes the grooved surface (along the hypotenuse of the prism) from the inside, and then re-emerges from the flat front surface.*