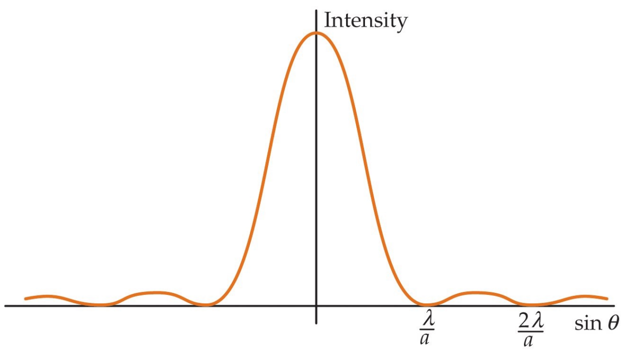
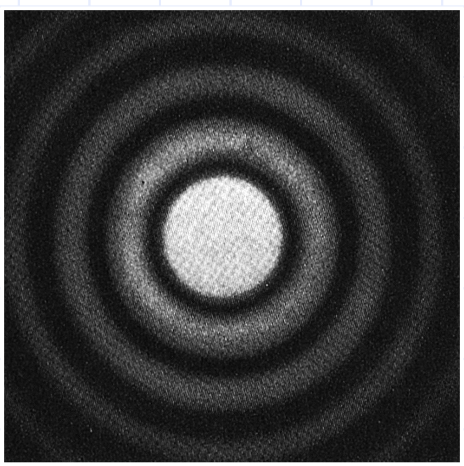
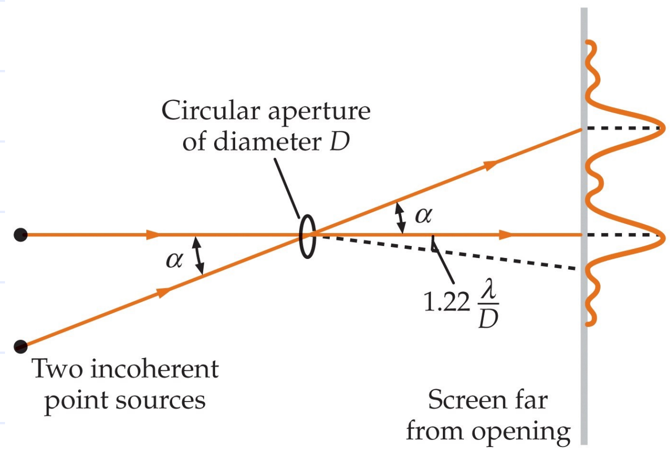
Resolution Limits for Single-Slits and Circular Apertures

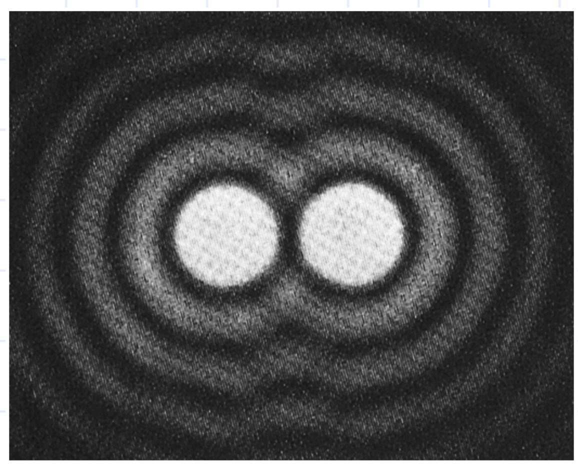
- Single source

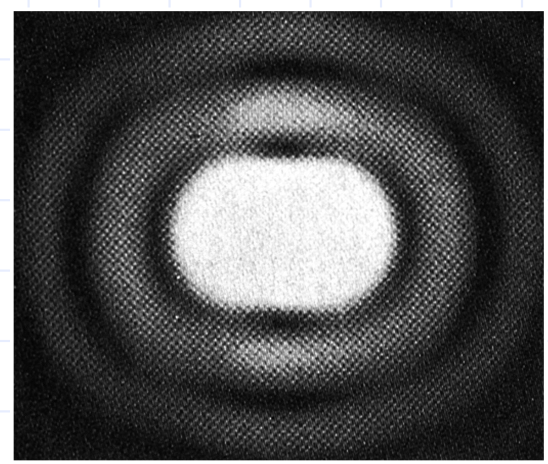




- Two sources







Example Problem

- A binary star system in the constellation Orion has an angular separation of 1.00×10^{-5} rad. If $\lambda = 500$ nm, what is the smallest diameter a telescope can have to just resolve it?

- We define the <u>Chromatic Resolving Power</u> R needed to distinguish the two wavelengths

$$\boxed{R = \frac{\lambda}{\Delta\lambda}} \qquad \text{where}$$

$$\lambda = (\lambda_1 + \lambda_2)/2 \qquad \Delta\lambda = \lambda_2 - \lambda_1$$

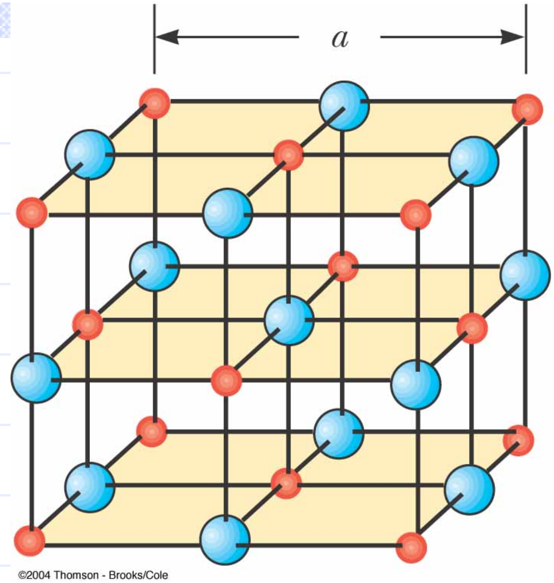
- For example, in a field of study called spectroscopy, we want to know the wavelength of various transitions in atoms or molecules. Therefore, we need to measure λ accurately.
- It turns out (without proof), that $\boxed{R = Nm}$ where N is the number of slits illuminated by the source
- Therefore, the larger m or N, the better the resolution

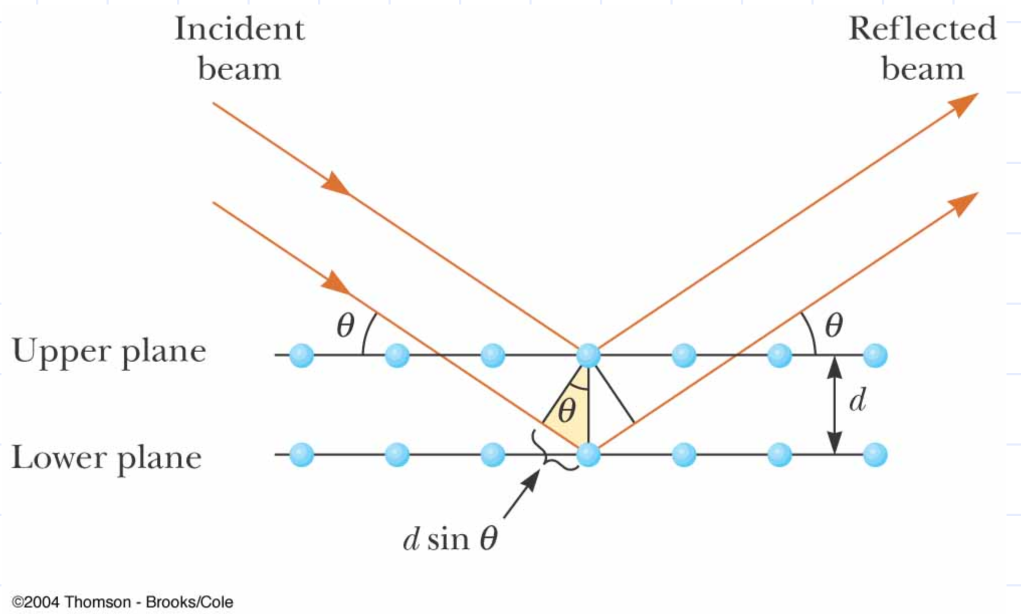
Example Problem

- Three discrete spectral lines occur at angles of 10.09, 13.71, and 14.77 in the first-order spectrum of a grating spectrometer. (a) If the grating has 3660 slits/cm, what are the wavelengths of the light? (b) At what angles are these lines found in the second-order spectrum? (c) How many slits must be illuminated in first- and second-order to resolve lines at 695.5 nm and 695.0 nm?

X-ray Diffraction of Crystals

- Consider the surface of some crystalline material
- It consists of a regular spacing of atoms with a separation of a in uniform planar rows with interplanar spacing of d
- a and d are ~10^{-10} m
- Radiation is directed at the surface at an angle of θ (with respect to the horizontal)





Example Problem

- The first order diffraction maximum is observed at 12.6° for a crystal in which the interplanar spacing is 0.240 nm. How many other orders can be observed?