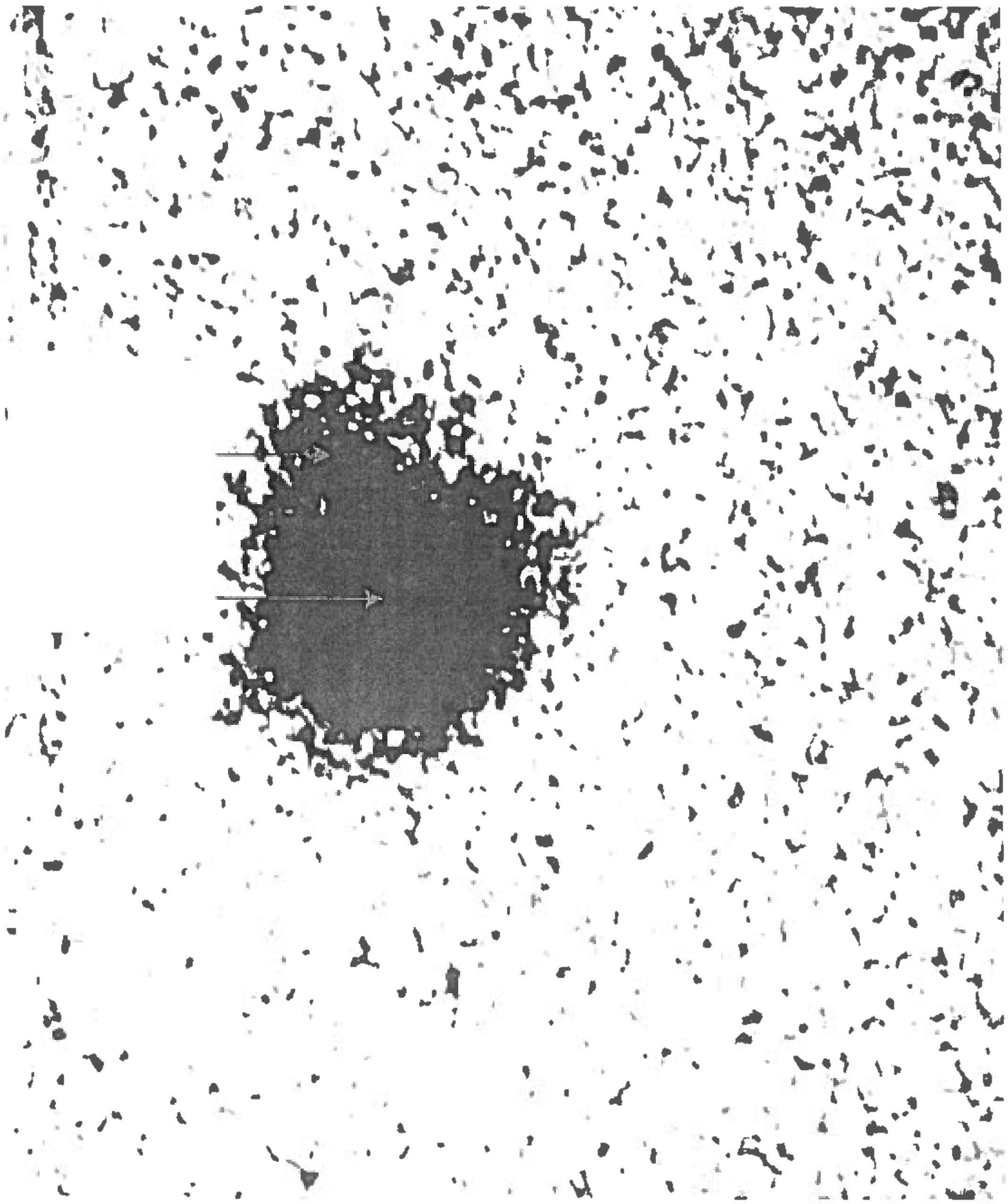
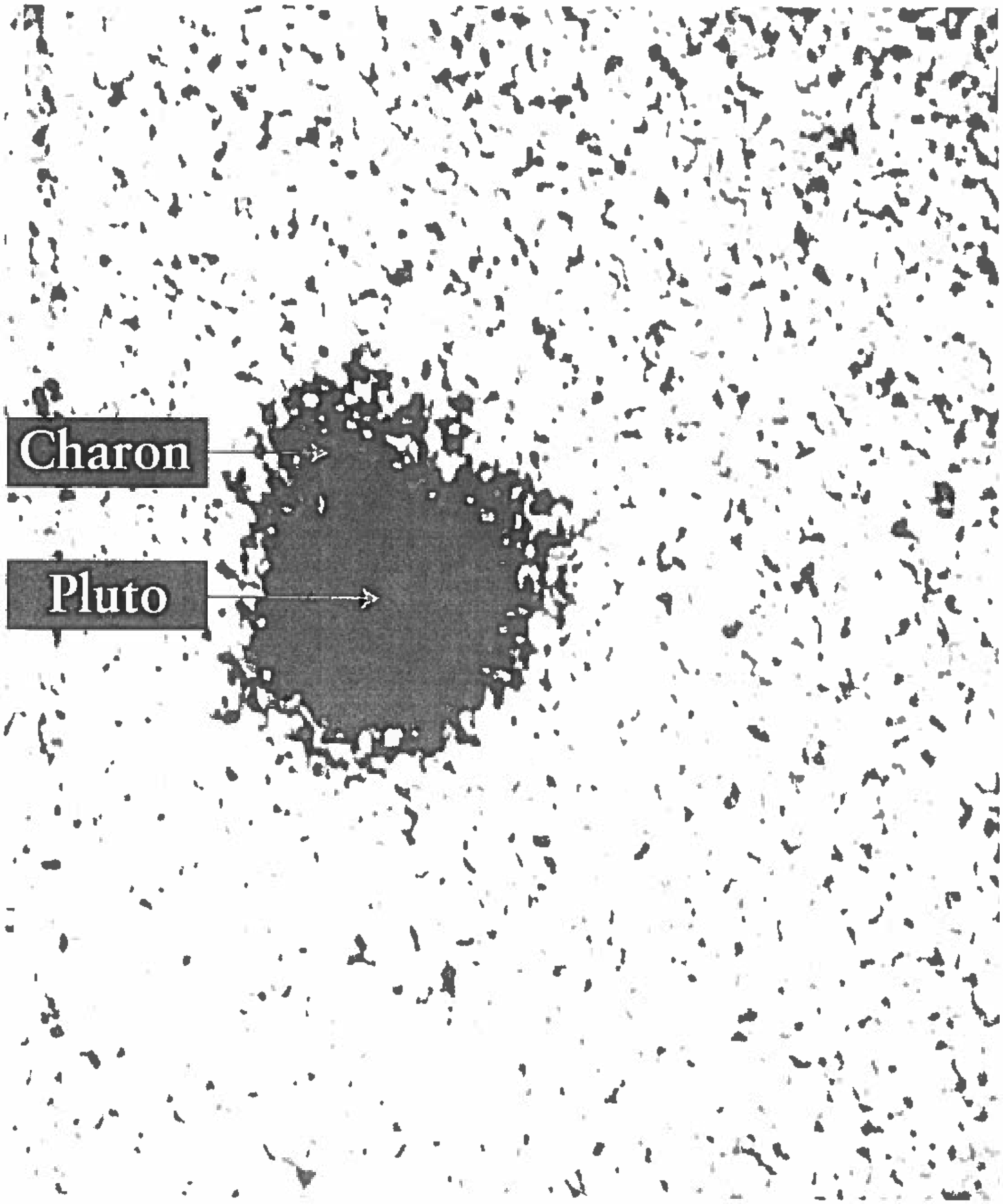
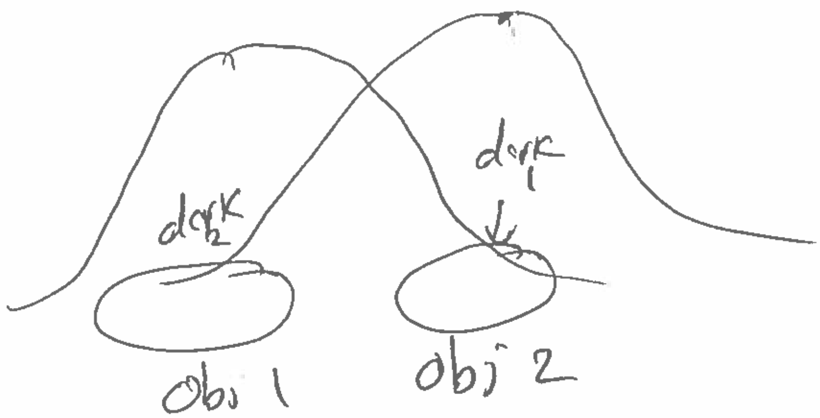
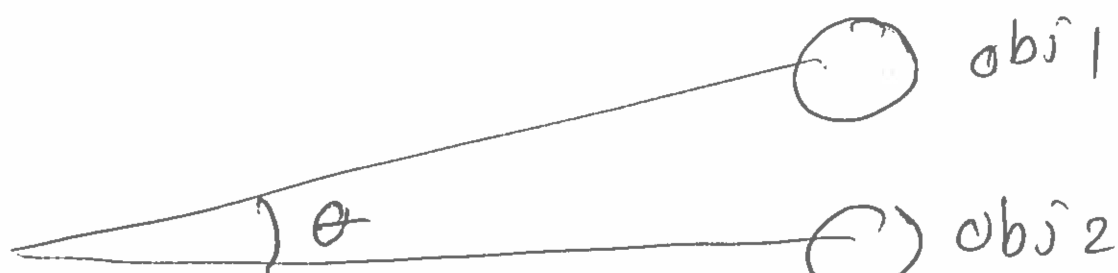



Charon
Pluto

Resolving Power – The ability to distinguish between multiple objects.

Two objects are considered just resolved when the first dark fringe sits on the central max of a second object and vice-versa

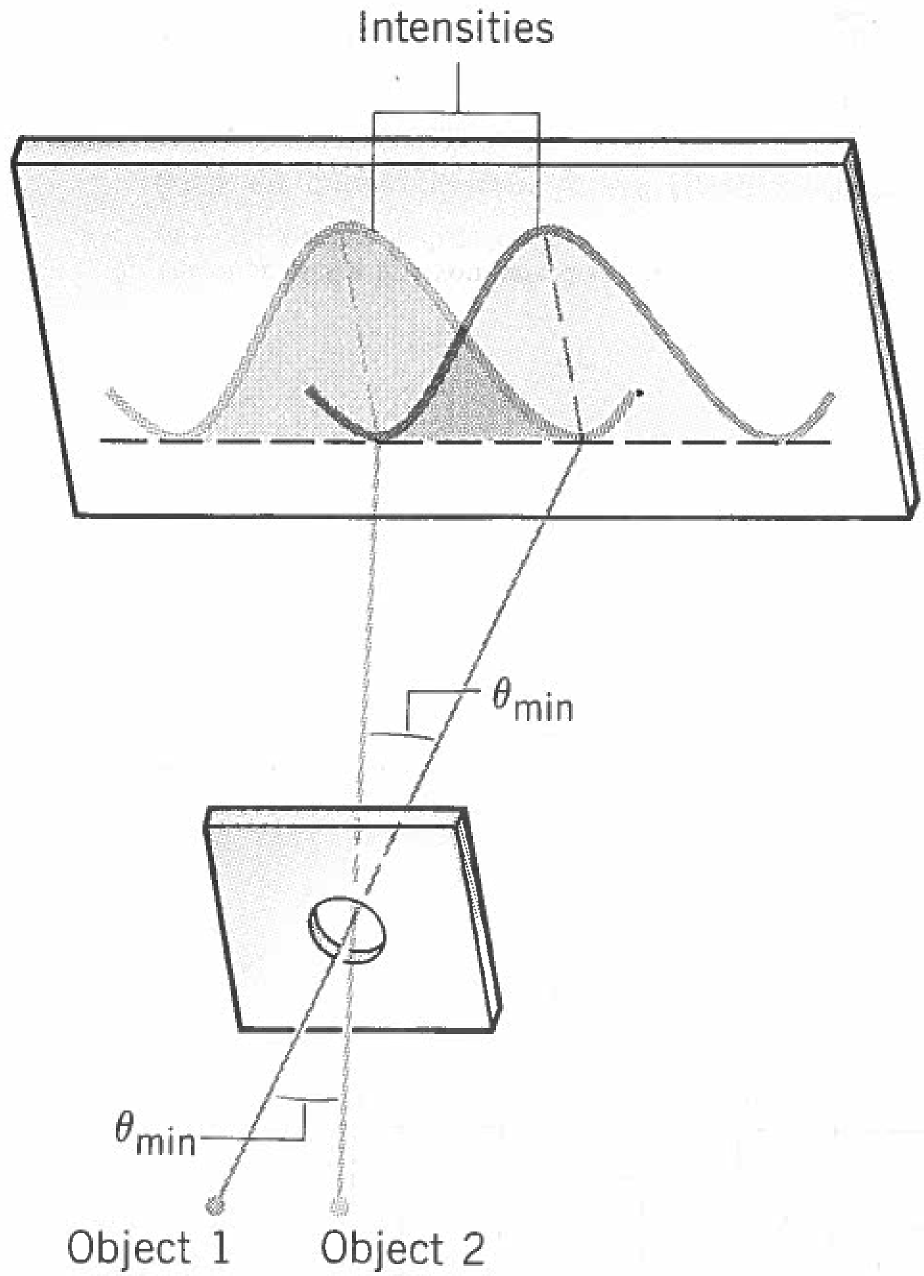




$$\theta_{min} = 1.22 \frac{\lambda}{D}$$

λ – wavelength of light used

D – Diameter (or Aperture) of object trying to resolve.

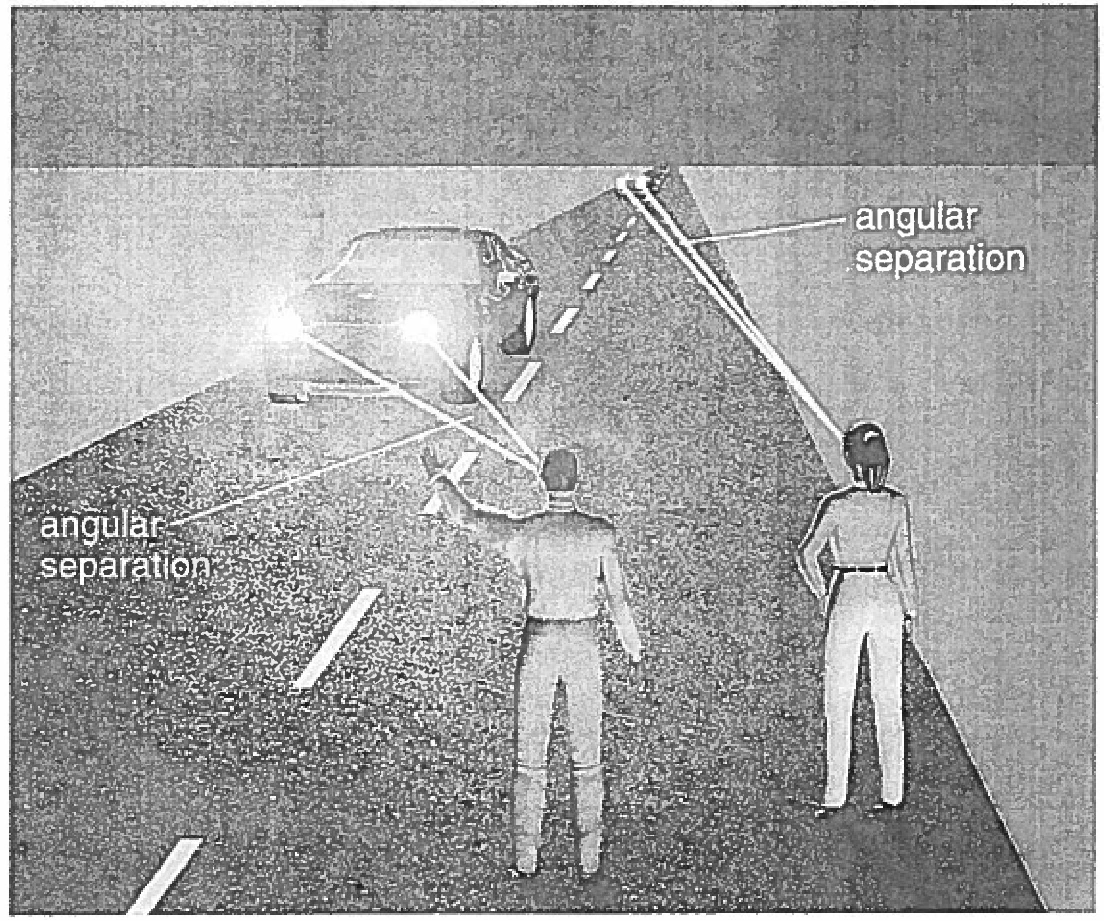


(a)

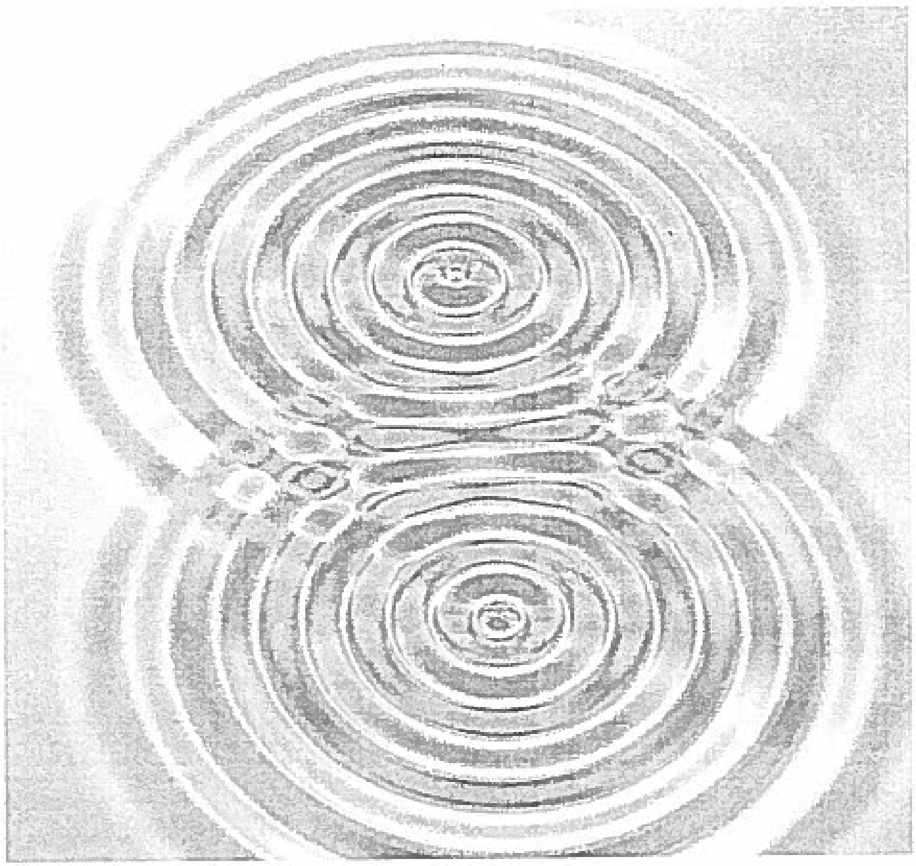
FIGURE 27.27 a

Angular Resolution

- The *minimum* angular separation that the telescope can distinguish

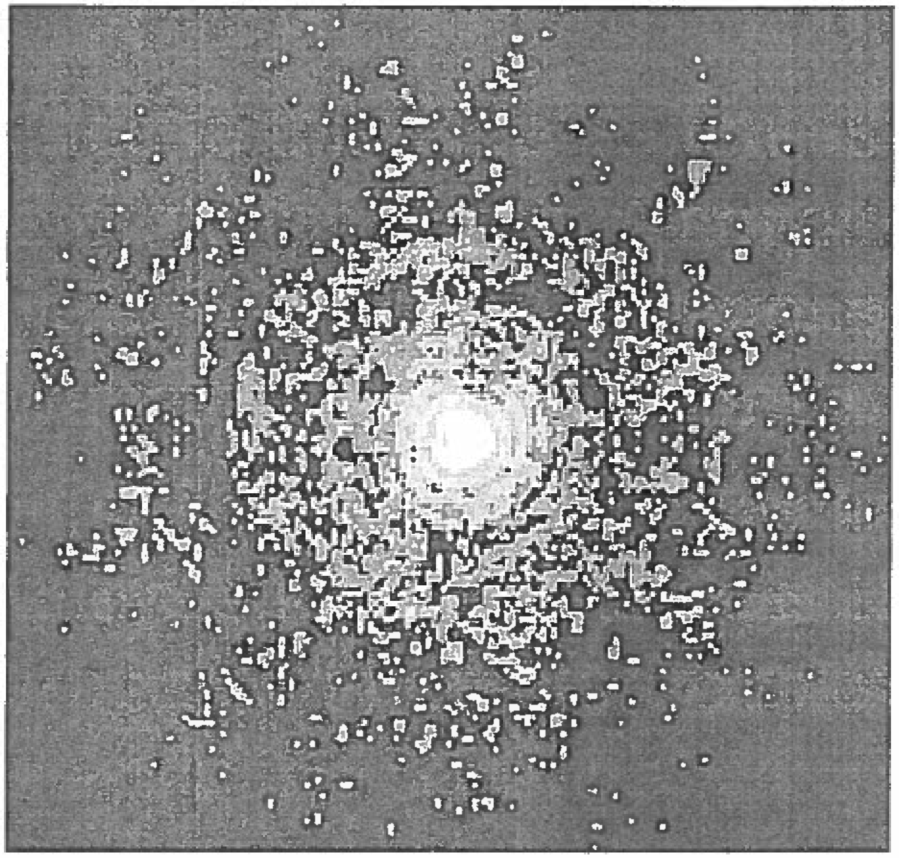


Angular Resolution



- Ultimate limit to resolution comes from interference of light waves within a telescope.
- Larger telescopes are capable of greater resolution because there's less interference.

Angular Resolution



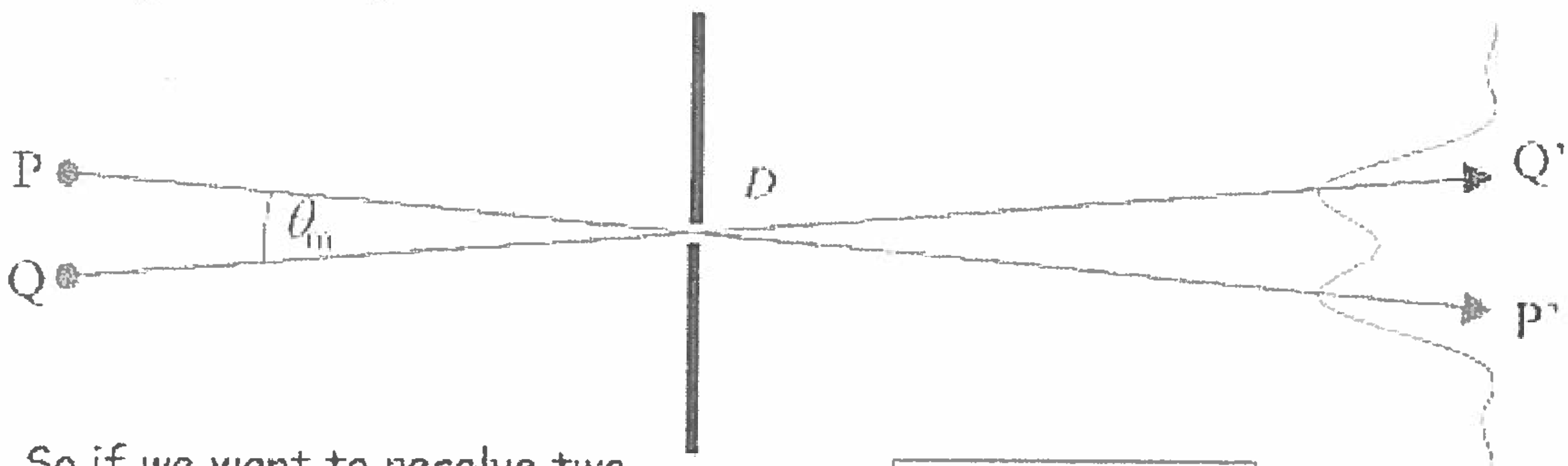
- Close-up of a star from the Hubble Space Telescope

- The rings in this image of a star come from interference of light wave.
- This limit on angular resolution is known as the **diffraction limit.**

http://physics.stackexchange.com/questions/255421/why-is-the-wavelength-of-light-proportional-to-the-minimum-angle-of-resolution

Resolution and the Rayleigh Criterion

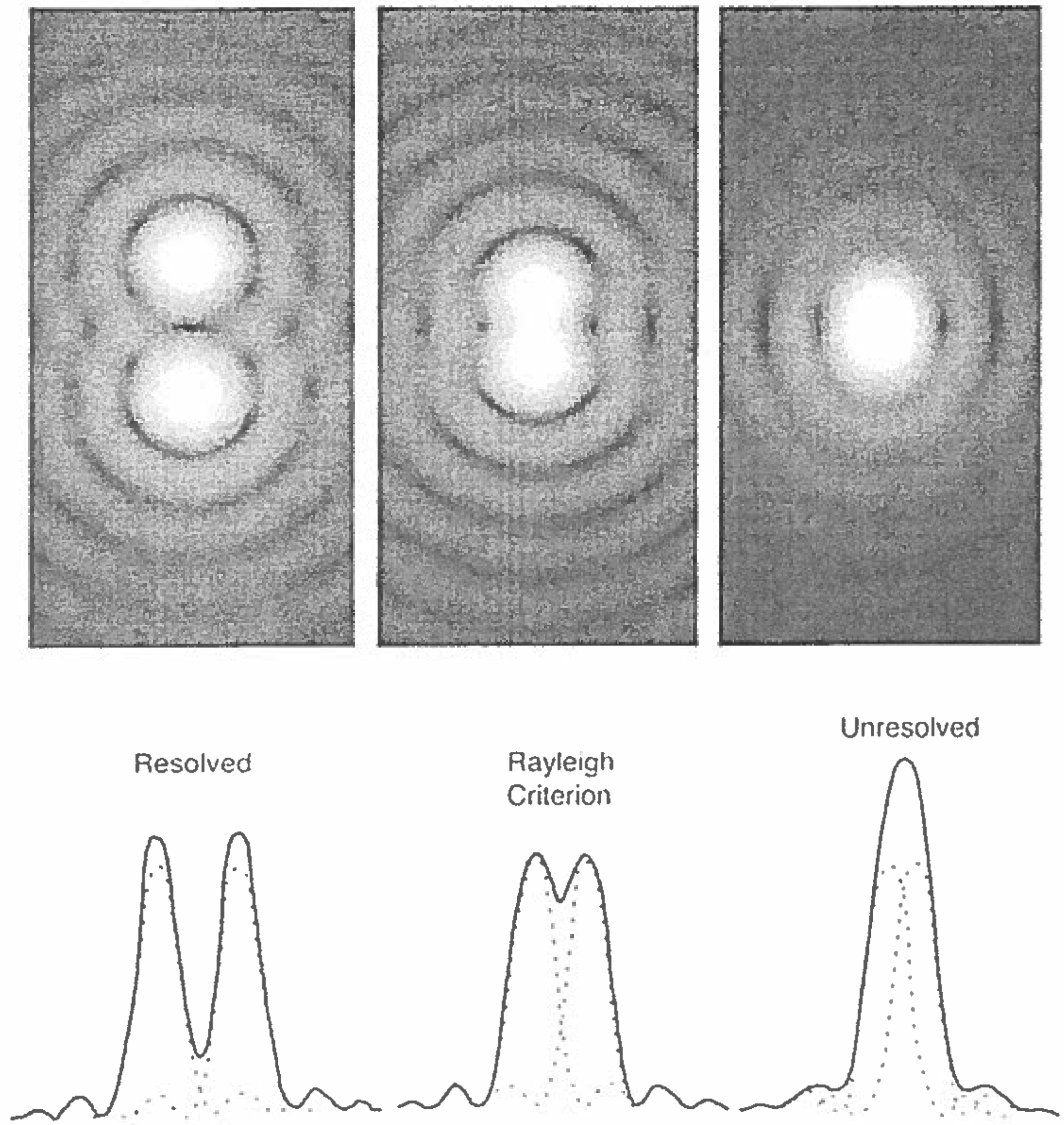
For a circular aperture of diameter D, the minimum angle of resolution, θ_m, given by the **Rayleigh criterion** is:



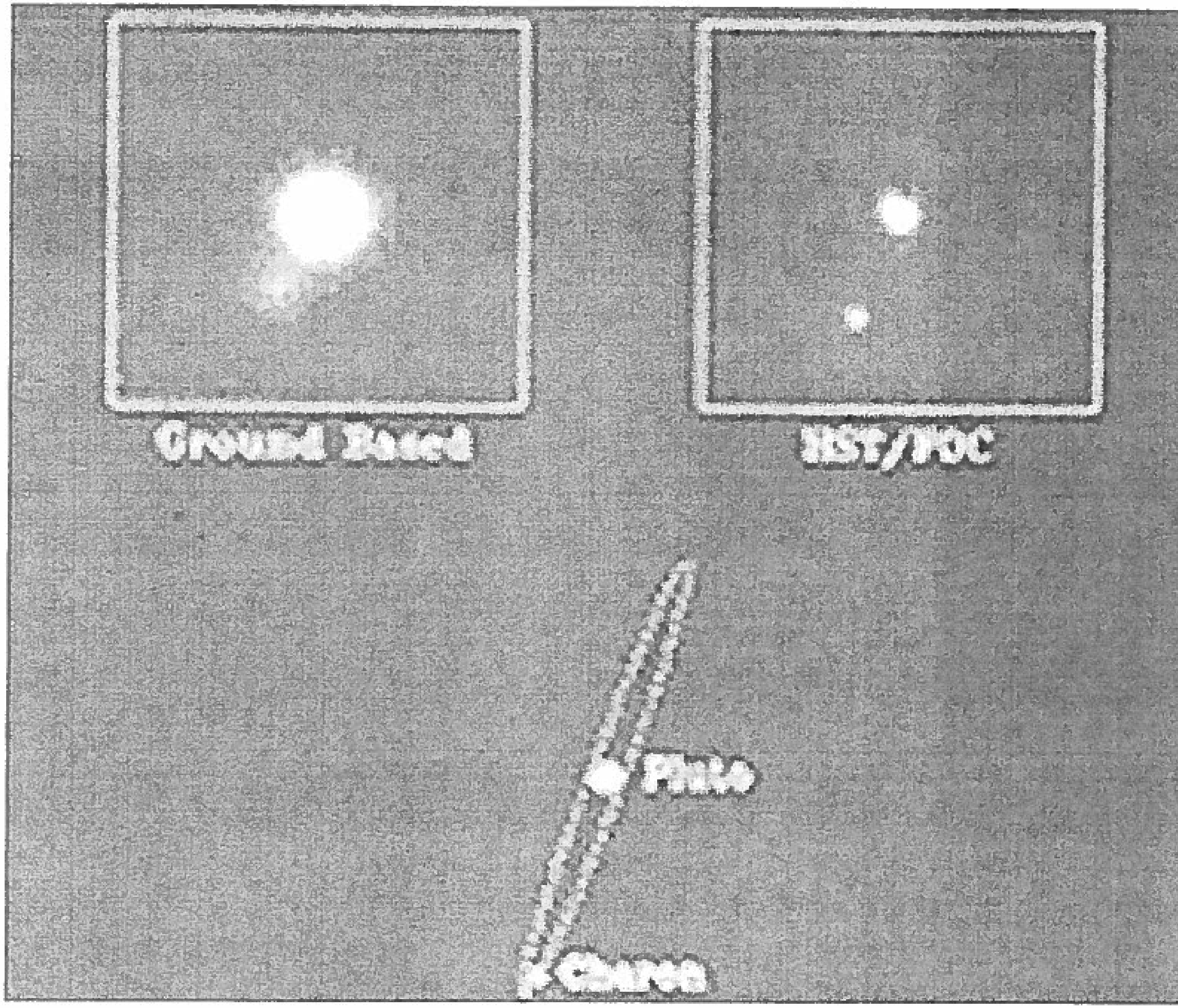
So if we want to resolve two objects which are very close together (get θ_m small), D needs to be big!

$$\theta_m = 1.22\frac{\lambda}{D}$$

[Note θ is given in radians from this formula] https://en.wikipedia.org/wiki/Angular_resolution



http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/raylei.html http://solarviews.com/cap/pluto/pluto.htm



eg/ a 10 m Diameter Telescope

$\lambda = 550\ nm \qquad \theta_{min} = ?$

$$\theta_{min} = 1.22\frac{\lambda}{D} = \frac{1.22(550\times10^{-9}\,m)}{10\ m}$$

$$\theta_{min} = 6.7\times10^{-8}\ rad$$

eg/ $\theta_{min\ eye}$?

$$\theta_{min\ eye} = \frac{1.22(550\times10^{-9}\,m)}{2\times10^{-3}\,m}$$

$$\theta_{min\ eye} = 3.36\times10^{-4}\ rad$$

why can't we see Apollo leftovers?

$$\theta_{Moon\ Lander} \approx \frac{y}{L} = \frac{10m}{3.84\times10^{8}\,m}$$

$$\theta_{Moon\ Lander} \approx 2.6\times10^{-8}\ rad$$

eg/ If two stars are just resolved and they are 10^{16} m away how far apart are they?

$$\theta \approx \frac{y}{L} \qquad y \approx L\theta$$

$$y = (10^{16}\ \text{m})(6.7 \times 10^{-8}\ \text{m})$$

$$y \approx 6.7 \times 10^{8}\ \text{m}$$ ~ Diameter sun

Q·27-33

Two stars 3.7×10^{11} m apart equally distant from Earth.

$\lambda = 550$ nm $\quad D_{tel} = 1.02$ m

Just detects two stars what is Distance from Earth?

$$\theta_{min} = 1.22 \frac{\lambda}{D} \qquad \sin\theta \sim \tan\theta \sim \theta$$

$$\tan\theta \sim \frac{s}{L} \sim 1.22 \frac{\lambda}{D}$$

$$L = \frac{sD}{1.22\lambda} = \frac{(3.7 \times 10^{11}\,m)(1.02\,m)}{1.22\,(550 \times 10^{-9}\,m)}$$

$$L = 5.62 \times 10^{17}\,m$$

27-34

$D_{baseball} = 0.0738\,m$

Distance we can resolve this length

$D_{pupil} = 2.00\,mm \quad \lambda = 550\,nm$

$$\theta_{min} = \frac{1.22\lambda}{D_{pupil}} = \frac{D_{baseball}}{L}$$

$$L = \frac{D_{baseball}\,D_{pupil}}{1.22\lambda} = \frac{(0.0738\,m)(2\times10^{-3}\,m)}{1.22(550\times10^{-9}\,m)}$$

$$L = 2.20\times10^{2}\,m = 220\,m$$

$L_{Home\ Pitch} = 18.4\,M$

AS $L \downarrow$ $\theta \uparrow$

SO 220 M is farthest to resolve so closer than 220 M you should be able to resolve.

27-37

$L = 1.6\ km$

$y = 10\ cm$

$\lambda = 498\ nm$

$\theta \approx \frac{10\ cm}{1.6\ km} = \frac{10^{-2} m}{1.6 \times 10^{3} m} = 6.25 \times 10^{-6}\ rad$

$\theta_{min} = \frac{1.22\lambda}{D} \qquad D = \frac{1.22\lambda}{\theta_{min}}$

$D = \frac{1.22(498 \times 10^{-9} m)}{6.25 \times 10^{-6}\ rad} = 9.72 \times 10^{-3} m$

$D = 9.72\ mm$

Typically $D_{pupil} \sim 2\ mm$

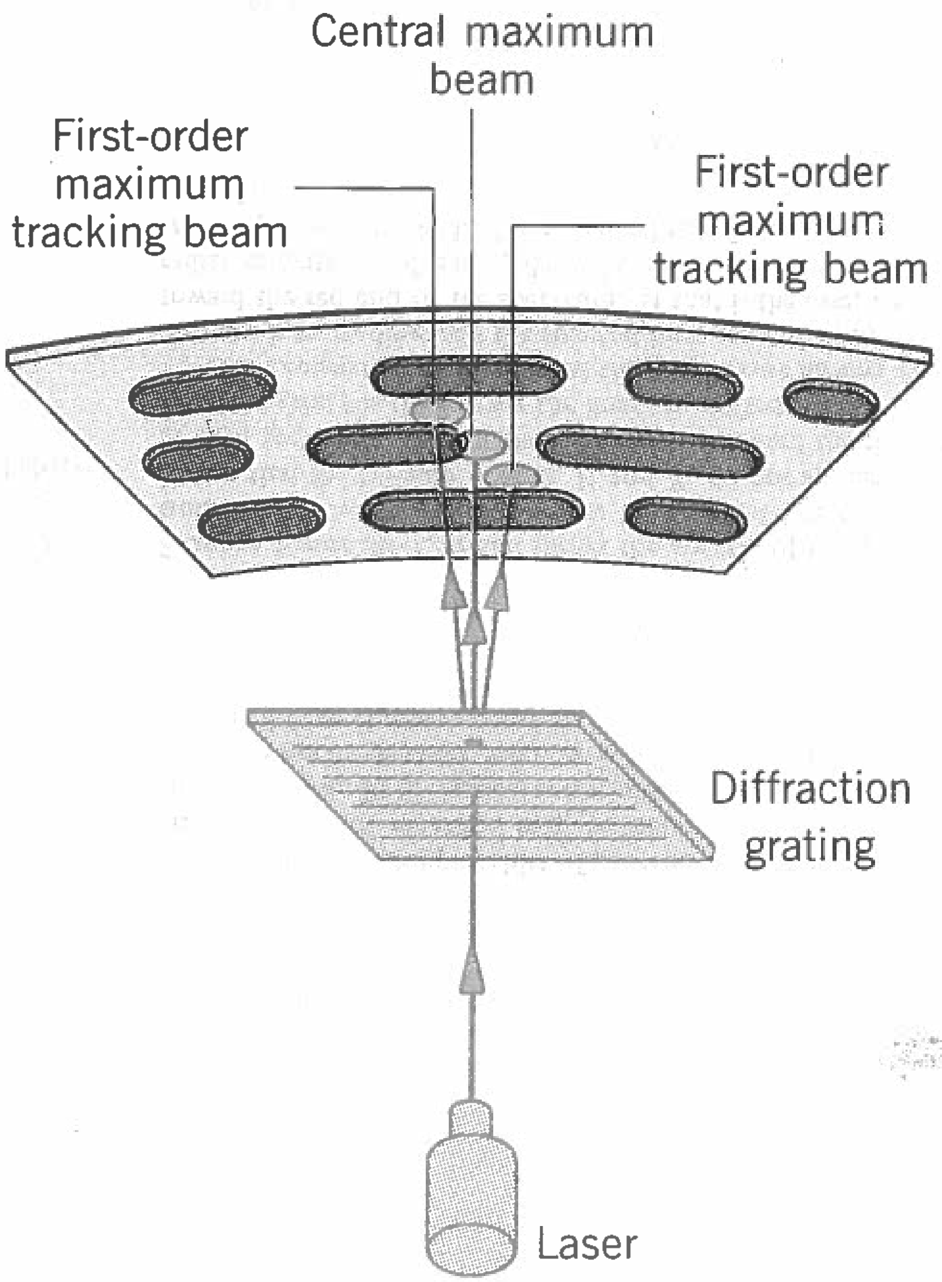
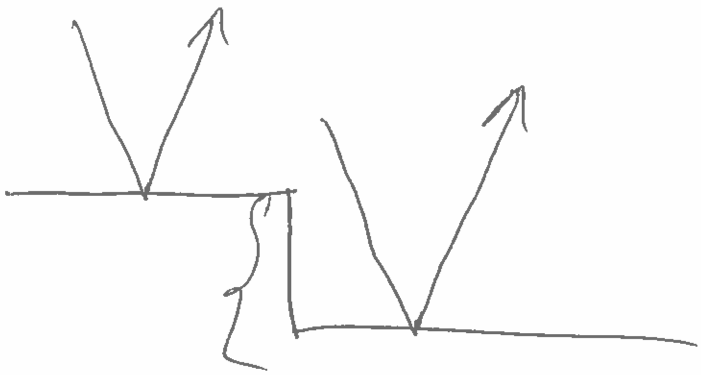

Central maximum beam
First-order maximum tracking beam
First-order maximum tracking beam
Diffraction grating
Laser

FIGURE 27.34

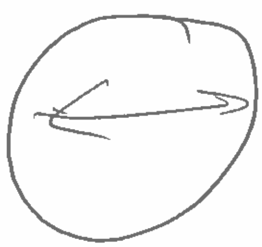


0
1 — Binary code

CD ~ 800 MB

DVD ~ 4.7 GB — Single layer
9.4 GB — Double layer

Blue Ray — 30 GB



5.5"

what if you have more than 2 slits

Diffraction Grating.

for a diffraction Grating

$d \sin\theta = m\lambda$ - brights

d is spacing between slits

$\frac{1}{d}$ - Grating constant = $\frac{\text{\# of slits}}{\text{length}}$

5000 lines/cm

ference occurs, according to the following reasoning. The extra distance traveled by light from slit 51 compared to that from slit 1 is $50(\lambda + \lambda/100) = 50.5\lambda$. The additional half wavelength means that crests and troughs from these two slits combine to create destructive interference. The same result applies to light from slits 52 and 2, 53 and 3, and so on—in other words, to all the light from the grating. If a grating contains 10 000 slits/cm instead of 100 slits/cm, then destructive interference occurs when the extra distance traveled by light from adjacent slits is $\lambda + \lambda/10\,000$, instead of $\lambda + \lambda/100$. Thus, for a greater number of slits per centimeter, a smaller displacement from the maximum is required to produce the adjacent point of destructive interference on the screen, with the result that the principal fringes are even narrower. Note in Figure 27.31 that between the principal fringes there are secondary maxima with much smaller intensities.

The next example illustrates the ability of a grating to separate the components [illegible] ors.

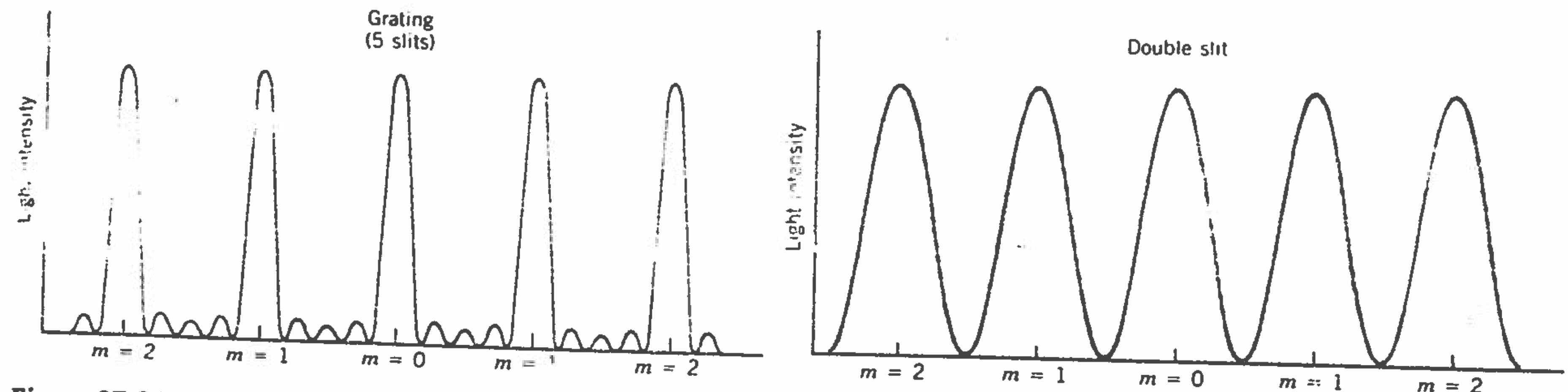


Figure 27.31 The bright fringes produced by a diffraction grating are much narrower than those produced by a double slit. Note the three small secondary bright fringes between the principal bright fringes of the grating. For a large number of slits, these secondary fringes become very small.

27-47

$\lambda = 780\,nm$ Grating Produces Tracking Beams 1.2 mm $L = 3.0\,mm$

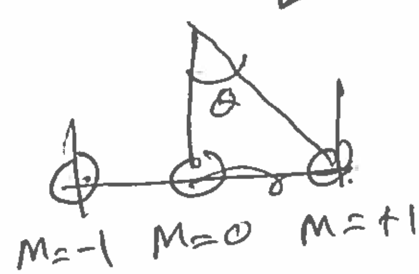
What is slit spacing?

$d \sin\theta = m\lambda$ for brights

Tracking are $m = \pm 1$ $m = 0$ is The information beam

$d = \frac{\lambda}{\sin\theta}$ $\tan\theta = \frac{y'}{L}$

$\tan\theta = \frac{1.2\,mm/2}{3.0\,mm}$



$\theta = 11.3°$

$d = \frac{\lambda}{\sin\theta} = \frac{780 \times 10^{-9}\,m}{\sin(11.3°)}$

$d = 4.0 \times 10^{-6}\,m$