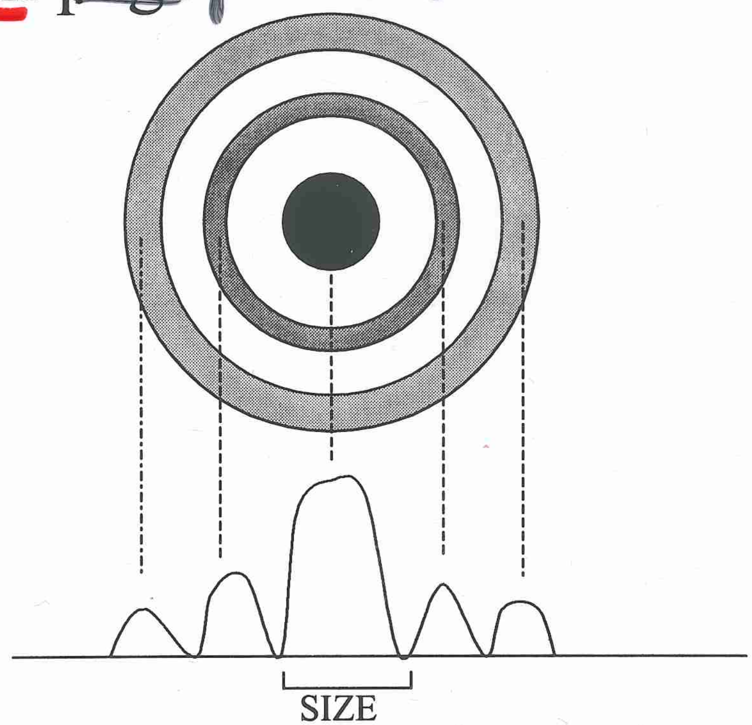
ASTRONOMICAL TELESCOPES

- Collect light for analysis by auxiliary instruments
  - LIGHT GATHERING POWER
- Image the sky
  - RESOLVING POWER

- LIGHT GATHERING POWER
  - Scales as the AREA of the principal light collector
- TELESCOPES are referred to by the DIAMETER of this collector

$$\text{AREA} \propto \text{DIAMETER}^2$$

- RESOLVING POWER of a perfect telescope in perfect conditions(I. E. no atmosphere) is set by DIFFRACTION
  - pointlike stars not imaged as points but as a diffraction ~~page~~ patch



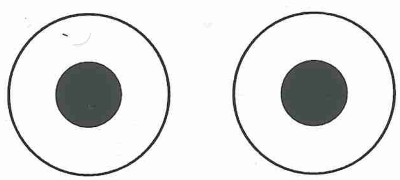
SIZE scales as $\frac{\lambda}{D}$

- $$\text{ANGULAR SIZE} \propto \frac{\text{WAVELENGTH}}{\text{DIAMETER}}$$

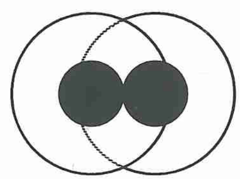
  $$\approx \frac{\text{12 sec of arc}}{\text{DIAMETER in cm}}$$

  VISIBLE LIGHT

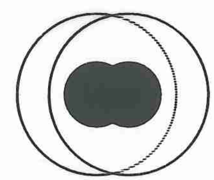
- Small angular size corresponds to high resolving power.



Well resolved



Just resolved



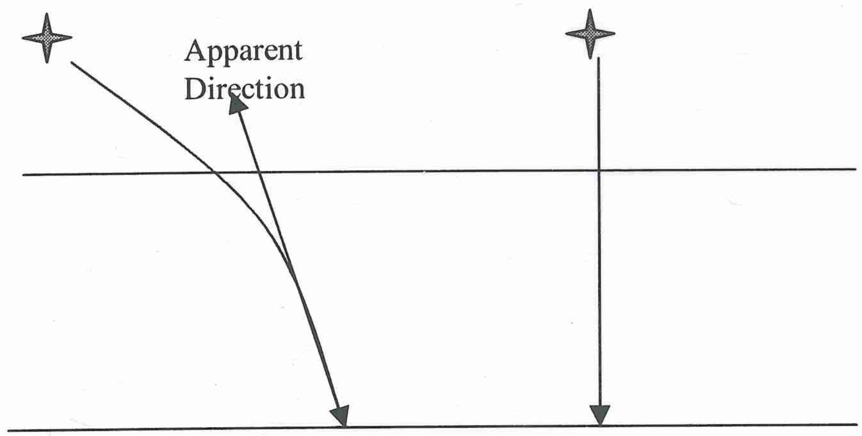
Not resolved

- EARTH’S ATMOSPHERE degrades image quality and lowers the resolving power: image size is 0.5 sec of arc or worse for all telescopes.
- THEREFORE, LARGE TELESCOPES (D ≥ 25cm) are built for their light gathering power not primarily for their higher resolving power

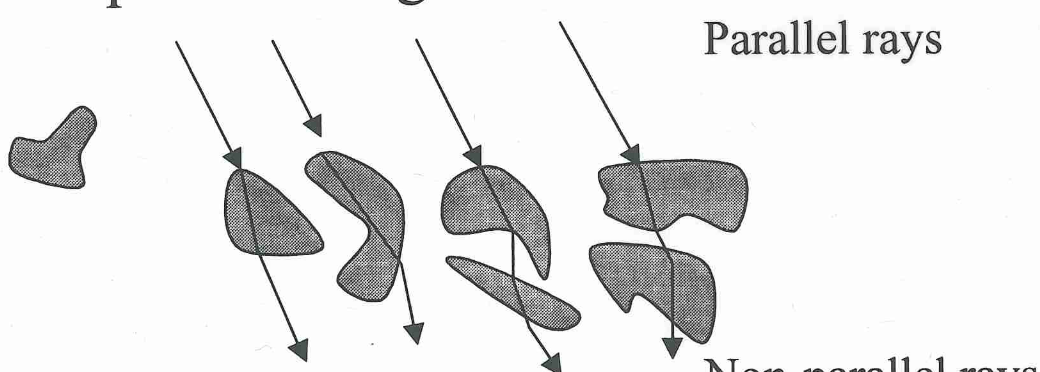
HOW TO BEAT THE ATMOSPHERE

- Choose site after testing for “seeing”
- Correct in real time for “seeing” (rubber mirrors, guide stars)
- Go into space!

Atmospheric refraction



Atmosphere seeing



OPTICAL TELESCOPES come in two varieties:

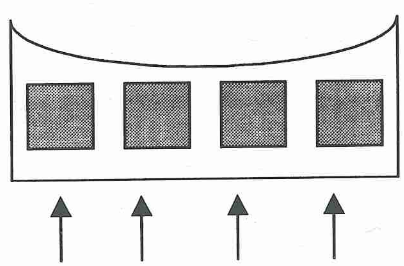
1. REFRACTOR [LENS]
2. REFLECTOR [MIRROR]

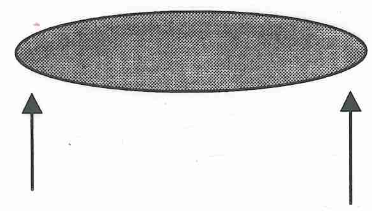
and a hybrid

3. SCHMIDT

WHY ARE LARGE TELESCOPES REFLECTORS AND NOT REFRACTORS?

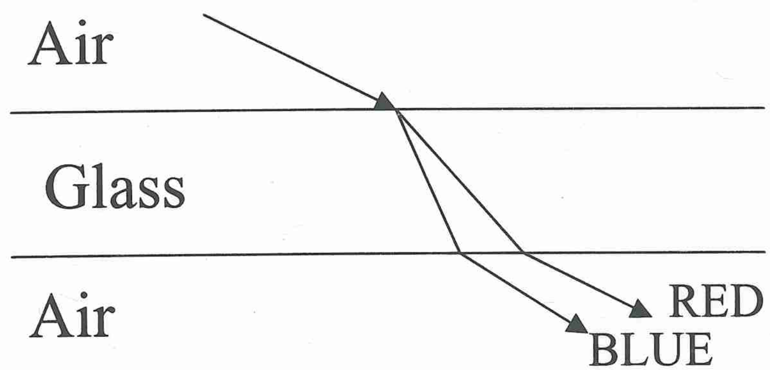
- Chromatic aberration
- Glass quality
  - limited choices for lenses
    - lens: must be transparent
    - mirror: need not be transparent or reflective
- Easier to support a mirror





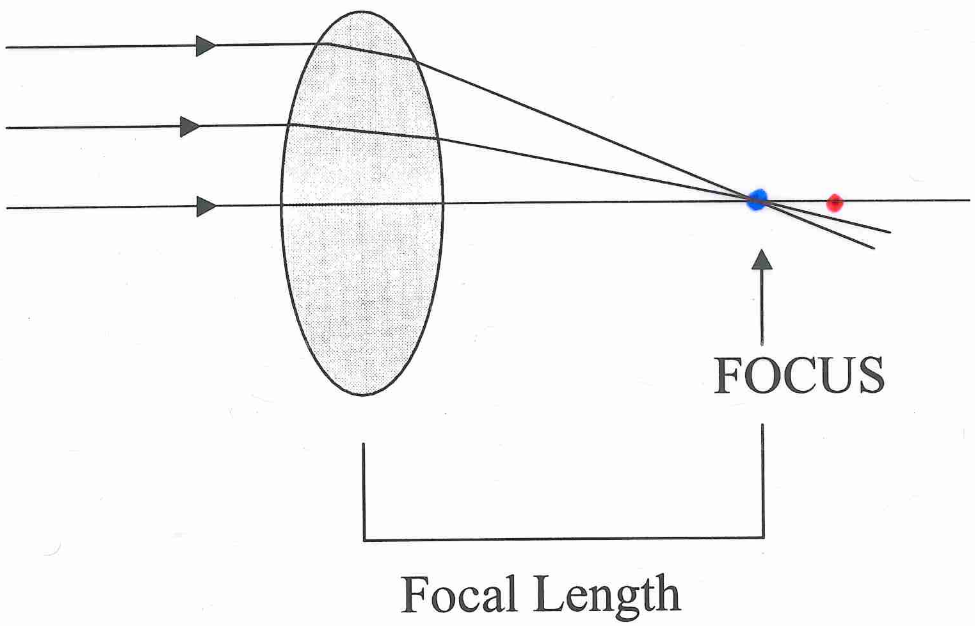
REFRACTING TELESCOPES

- Law of refraction



  - Light bent toward the 'normal' on entering denser material and away on leaving
  - Bending angle depends on color(≡ wavelength)

Focussing by a lens

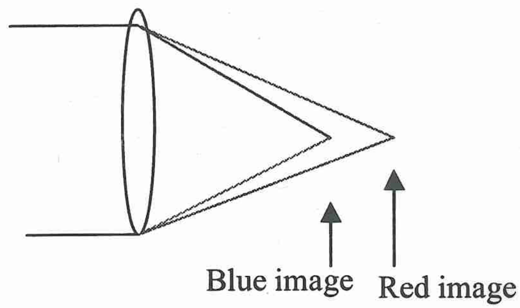


Convex lens:

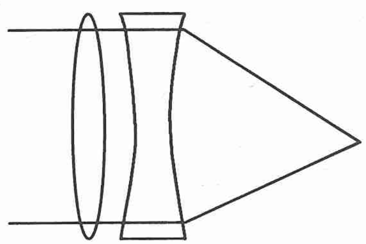
surface curved so that outer light rays are more severely bent than inner rays.

CHROMATIC ABERRATION

– Glass bends blue light more than red light



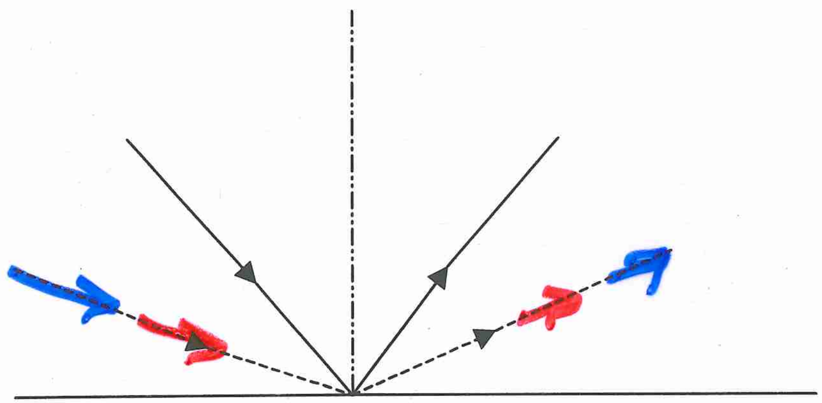
– Achromatic doublets of different glasses correct partially for this aberration



Red and blue foci at same point
but other colors not quite focus.

REFLECTORS

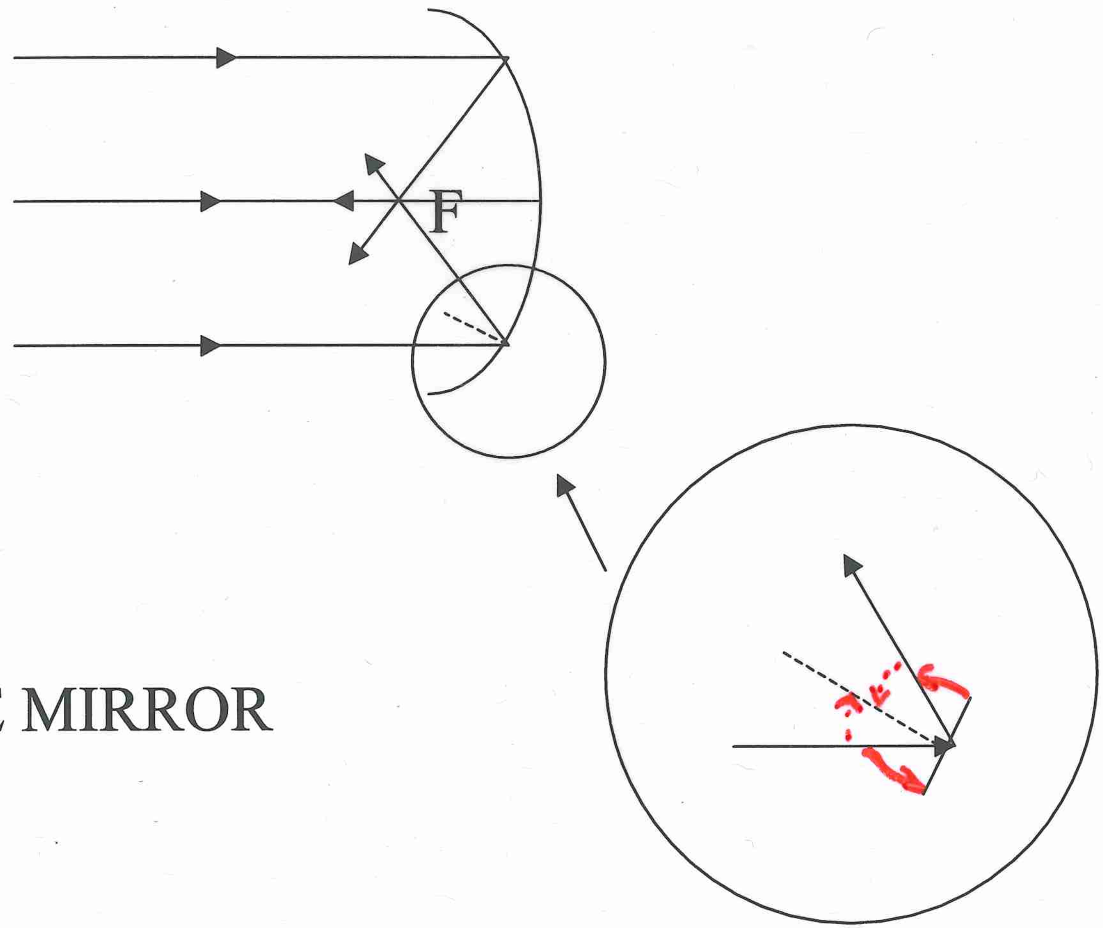
- Laws of reflection



Angle in = angle out

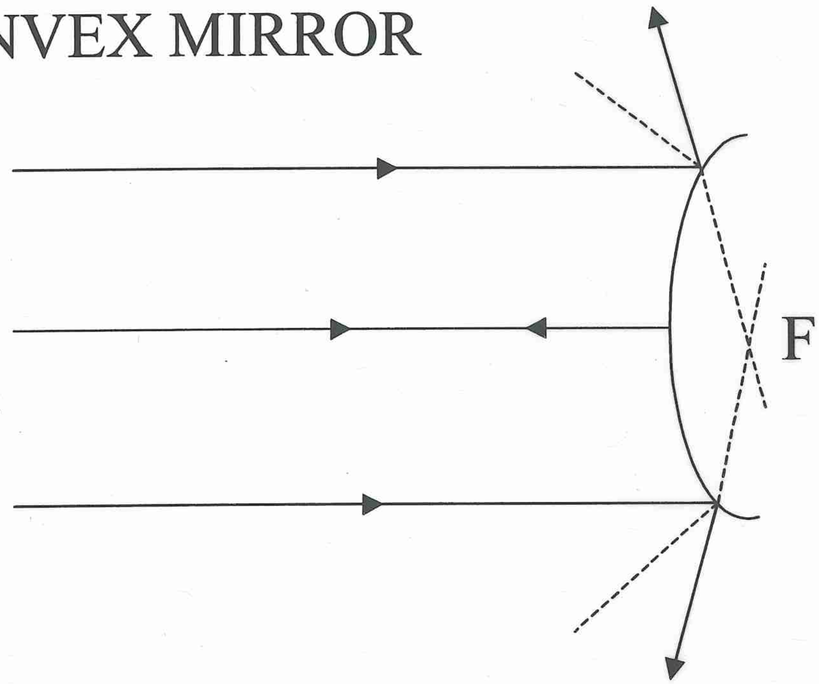
Same for all colors(wavelengths)

- Focusing by a mirror

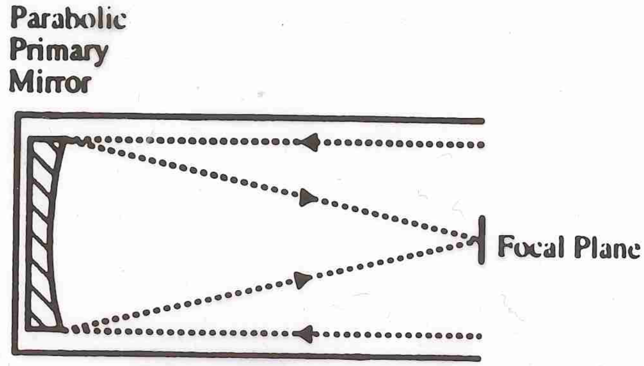


CONCAVE MIRROR

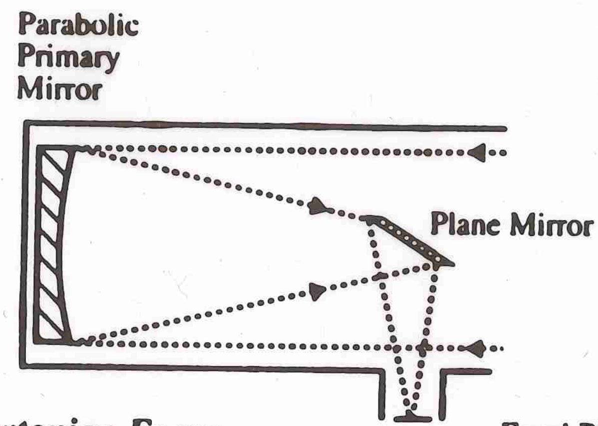
CONVEX MIRROR



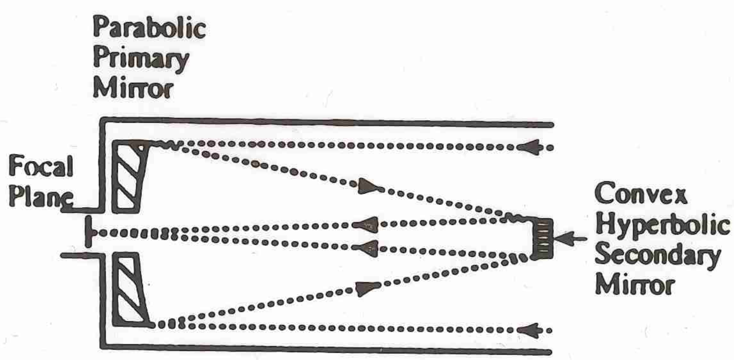
“ defousses “ light from virtual focus F



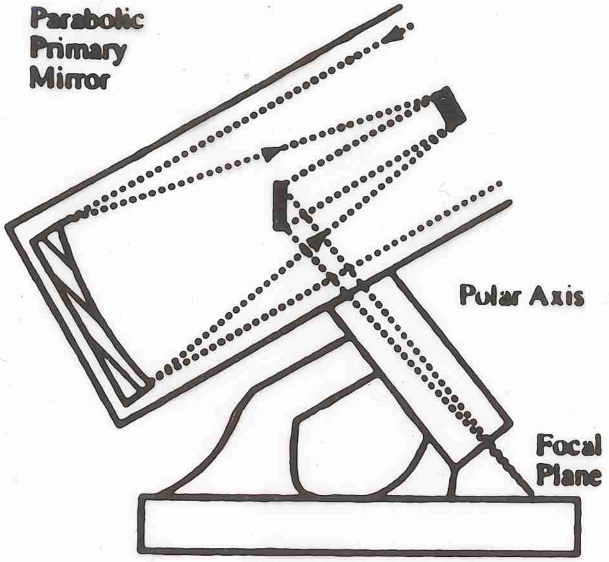
Prime Focus



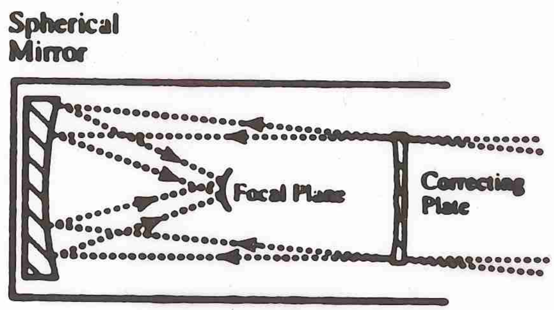
Newtonian Focus



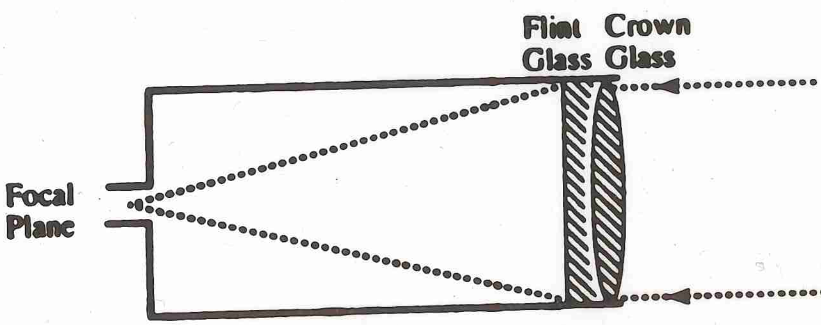
Cassegrain Focus



Coudé Focus



Schmidt Telescope



Refracting Telescope

WHY SPACE?

① ACCESS TO E/M SPECTRUM BLOCKED BY OUR ATMOSPHERE:

γ, X, UV ,IR

② RESOLVING POWER NOT SET BY ATMOSPHERIC BLURRING.

NEED EARTH- AND SPACE-BASED TELESCOPES

COSTS!

RADIO TELESCOPES

- Short wavelengths(mm-cms)

  → DISHES
- Long wavelengths(meters)

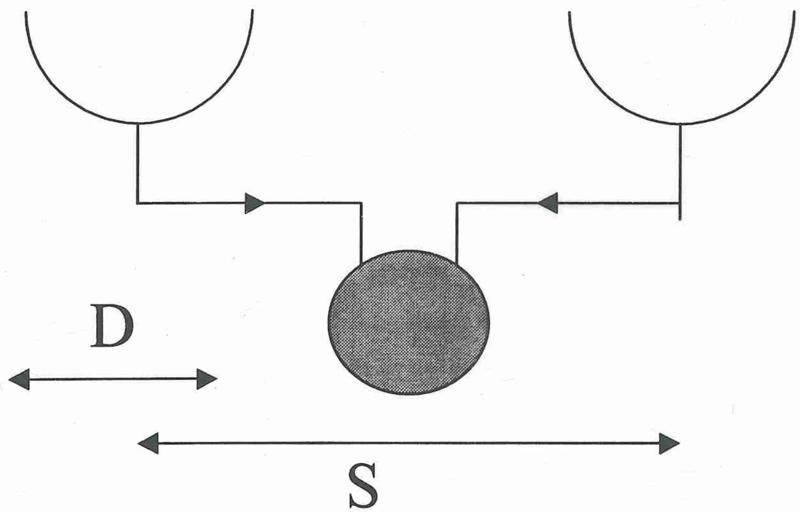
  → AERIALS/WIRES
- These reflect fact that surface accuracy of collector must be constant fraction of operating wavelength to get good resolving power. Radio waves have long wavelengths.

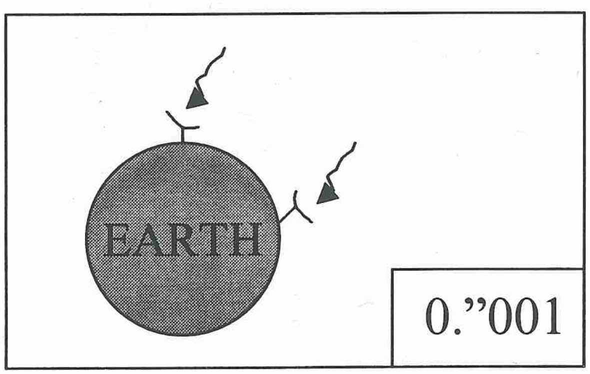
Resolving power problem:

- Diffraction $\Rightarrow$ Angular size $\propto \dfrac{\text{WAVELENGTH}}{\text{DIAMETER}}$

TELESCOPE	λ	D	ANG. SIZE
McDonald	5×10^{-5} cm	270 cm	0".04
Bonn	10 cm	100m	200"

How do radio astronomers obtain high resolving power?





Angular resolution $\propto \frac{\lambda}{S}$ NOT $\frac{\lambda}{D}$