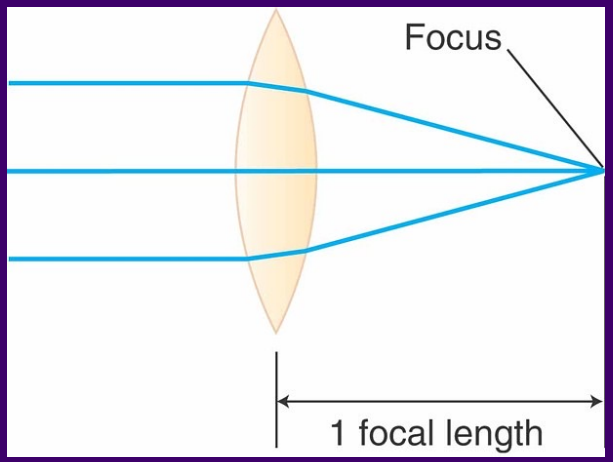
Telescopes

Today:

- Different telescope designs
- Why bigger is better
- Research telescopes, past and present
- Light detectors
- Telescopes for invisible “light” and other signals
- Amateur telescopes

Purpose of a telescope: Gather light over a large area and focus it onto a small area

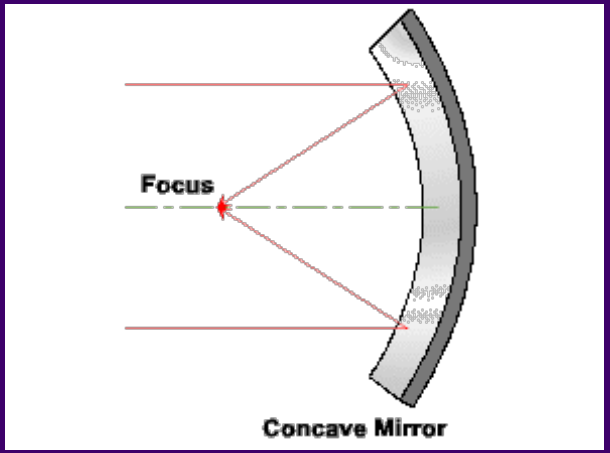
Method 1: Refraction (using a convex lens)



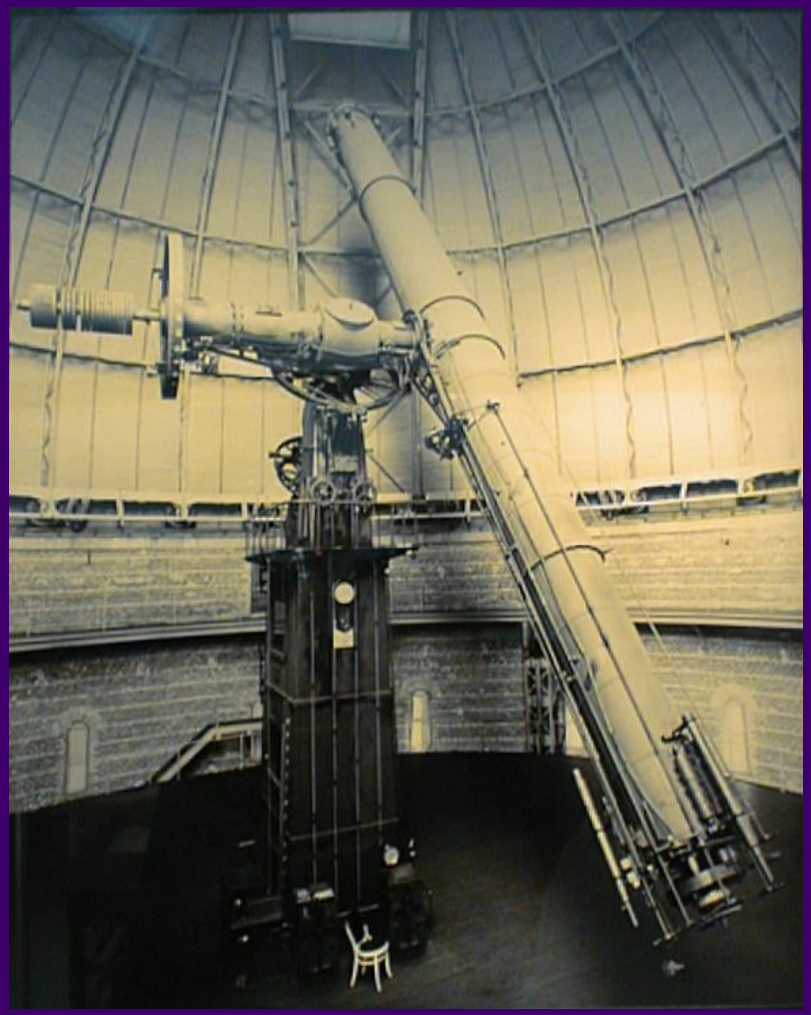
Disadvantages: Hard to make a large lens with two perfect surfaces; hard to support a large lens by edges; different colors are focused at slightly different distances

Purpose of a telescope: Gather light over a large area and focus it onto a small area

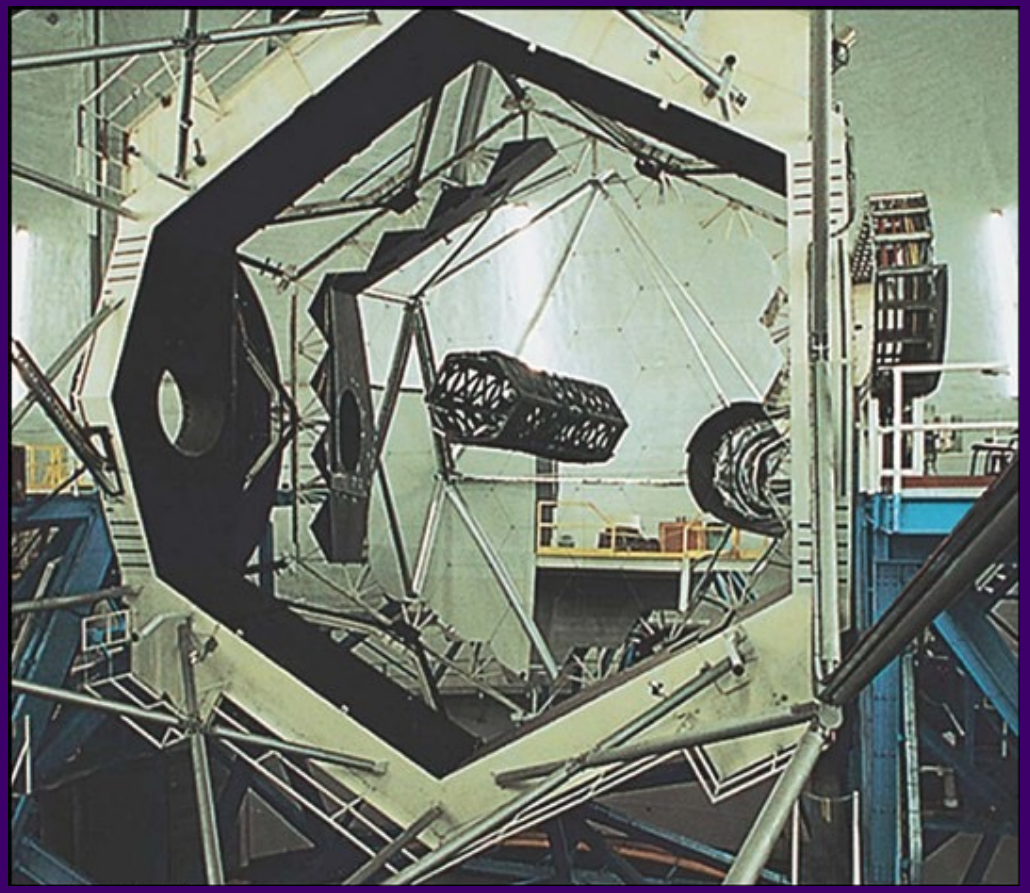
Method 2: Reflection
(using a concave mirror)



Disadvantage: Focal point is within the incoming light path.



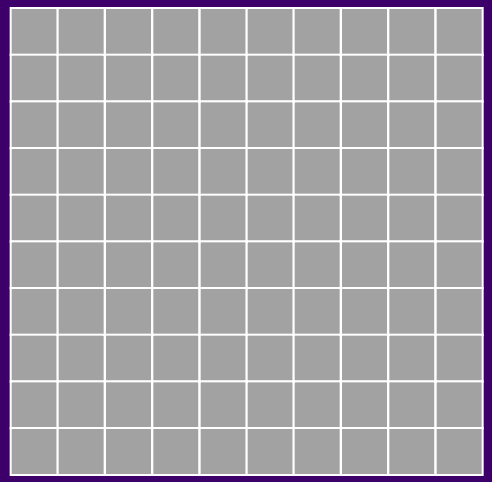
1-meter refractor, Yerkes Observatory, Wisconsin



10-meter reflector (Keck telescope), Mauna Kea, Hawaii

Light-gathering ability

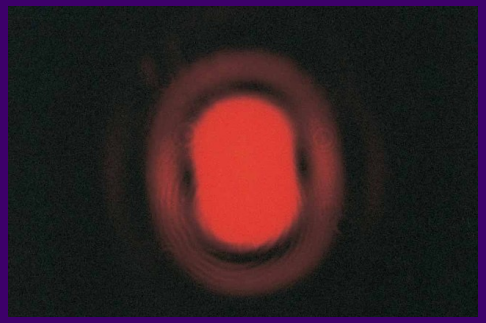
1 meter across



10 meters across

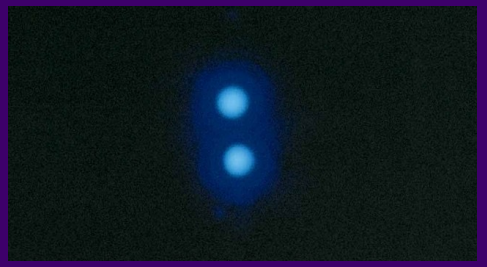
A 10-meter telescope gathers 100 times as much light as a 1-meter telescope.

Resolving Power
(Ability to see detail)



Wave behavior of light causes diffraction: bending at the edges of the telescope.

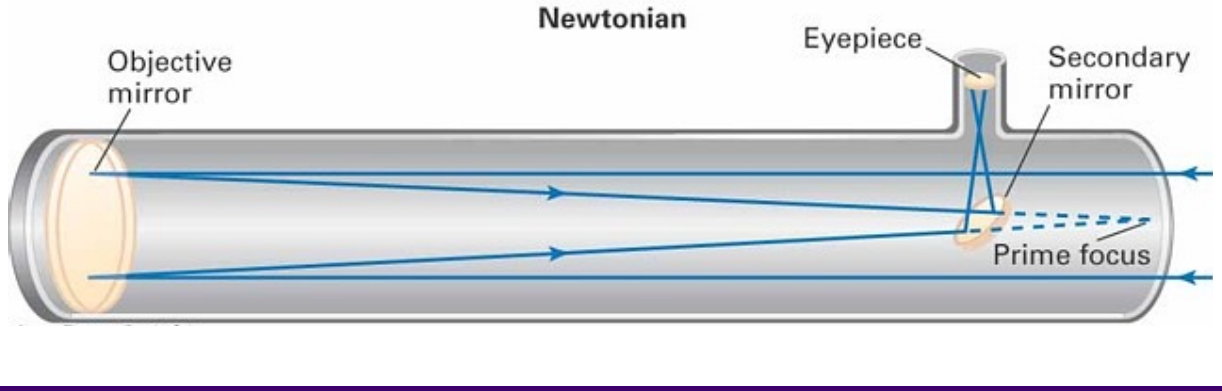
The wider the telescope's lens or mirror, the less diffraction and the more detail can be resolved.

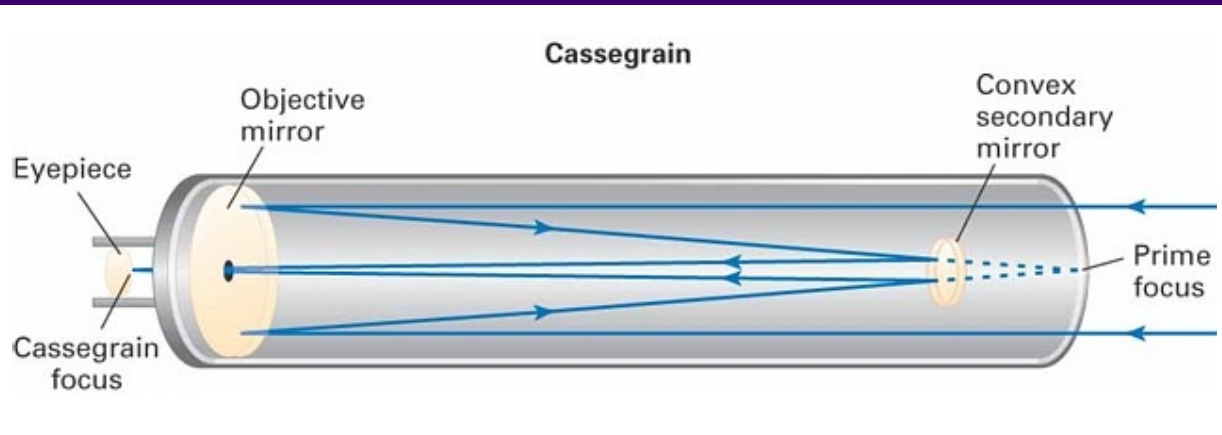


Light with a shorter wavelength also diffracts less.

But: Air turbulence usually causes even more blurring.

Reflector Designs





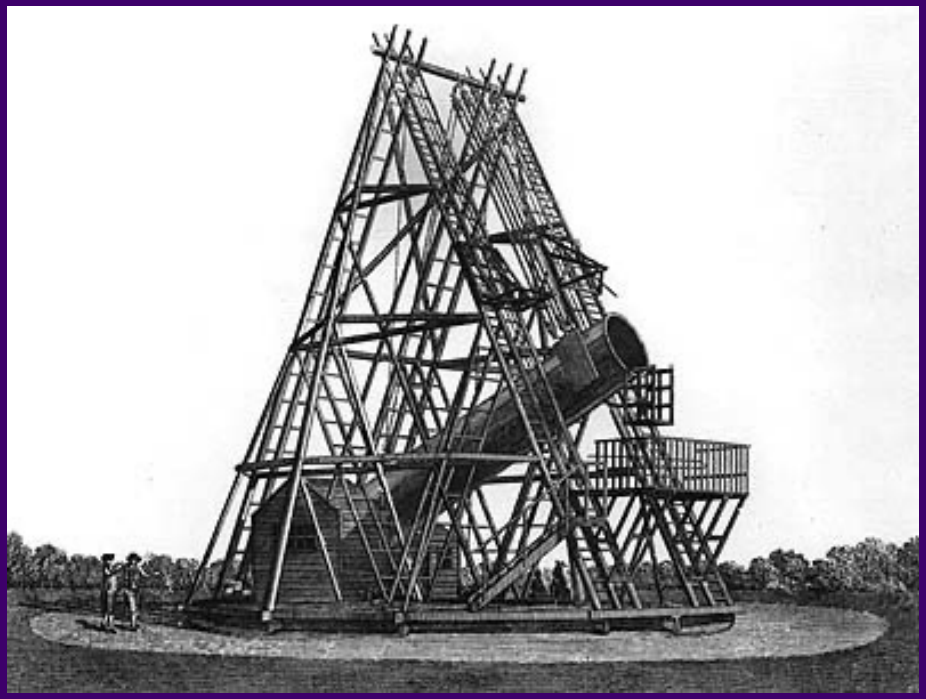
Diffraction spikes from secondary mirror supports

Early Telescopes

Galileo's refractor

Newton's reflector

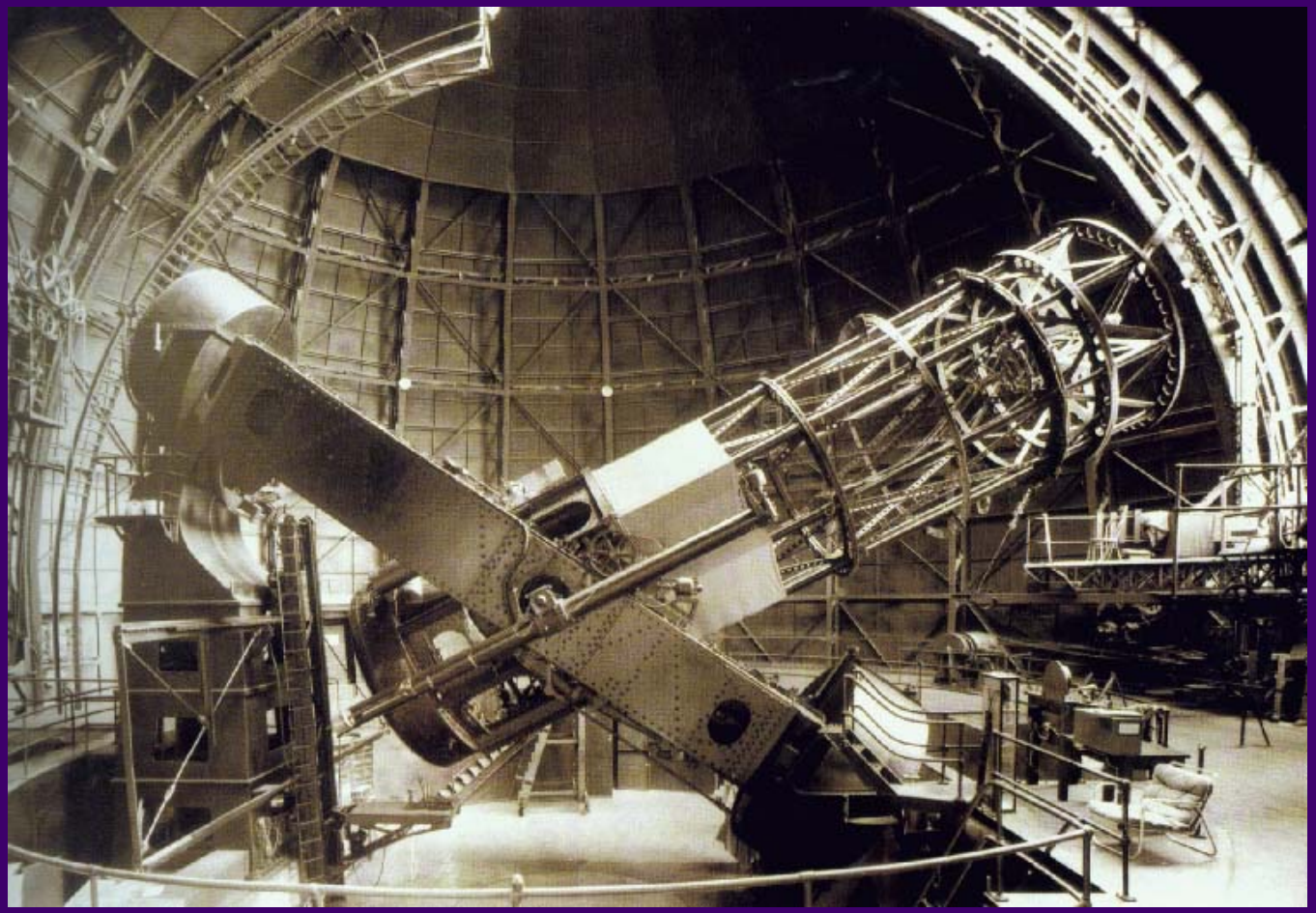
The first big reflectors



William Herschel's
largest telescope
(late 1700's)

Lord Rosse's telescope
(1840's)

Large Photographic Telescopes



2.5 meter Hooker telescope, Mt. Wilson, California

Large Photographic Telescopes

Prime focus

5 meter Hale telescope, Mt. Palomar, California

Book Recommendation:

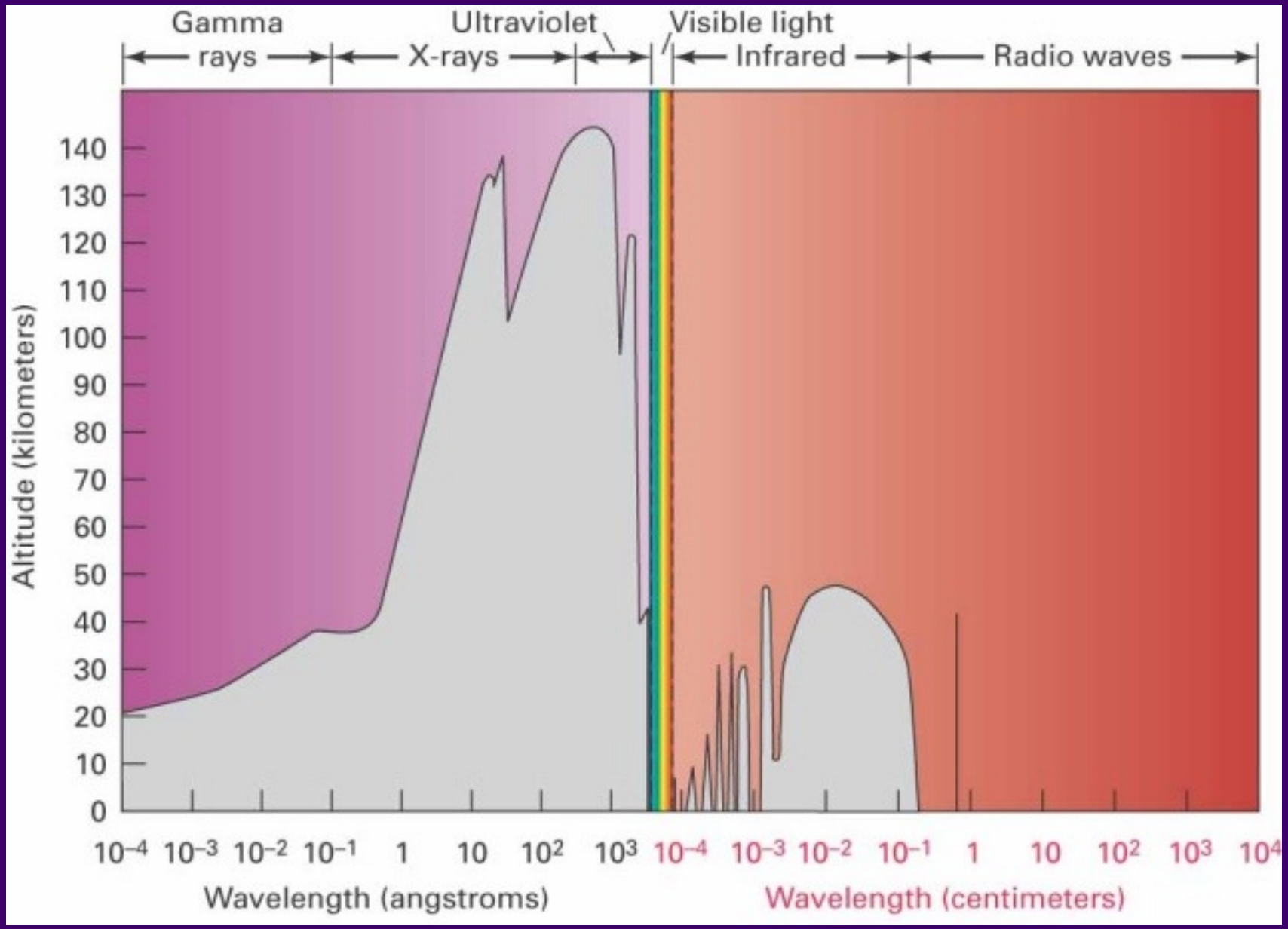
First Light, by Richard Preston. Describes the “Big Eye” and the other telescopes at Palomar Observatory, as well as the research done there and some of the more interesting researchers.

Light Detectors

- Human eye
- Photographic emulsions (late 1800's)
- Electronic cameras (1970's)

- Spectrographs (prisms or diffraction gratings) combined with one of the above

Other Wavelengths

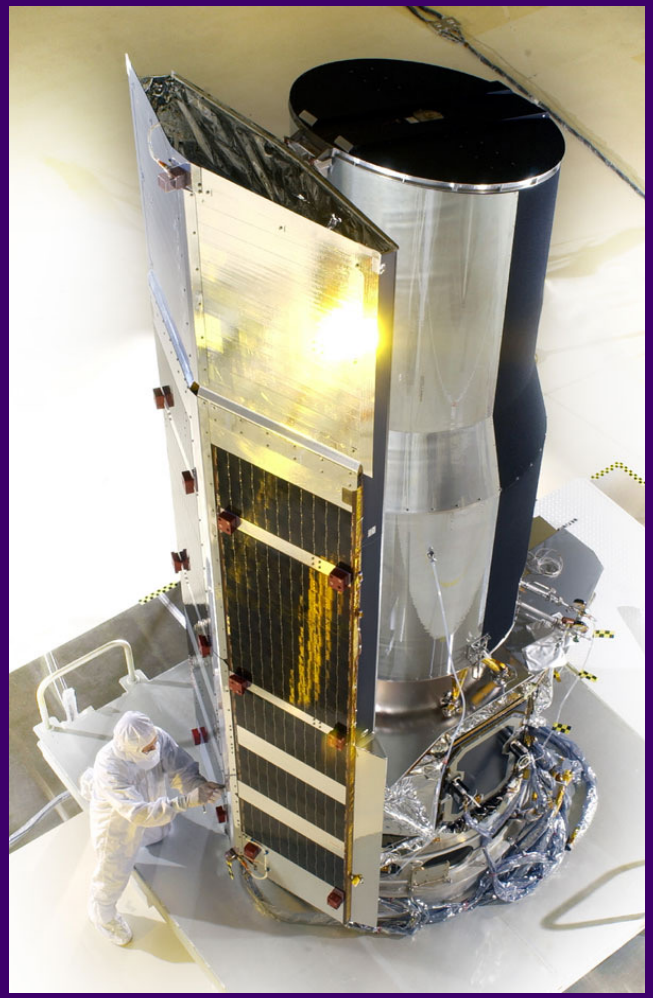


Radio Telescopes

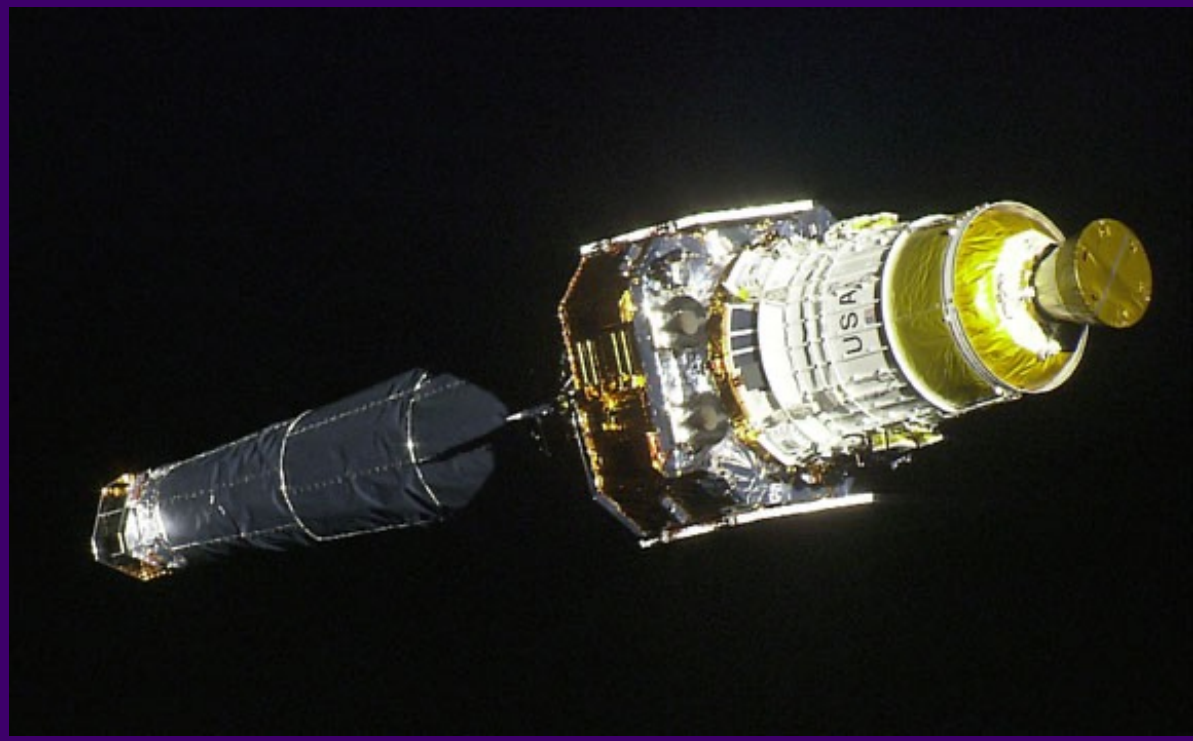
HiRes Fly's Eye Cosmic Ray Detector
(Utah west desert)

Hubble Space Telescope

Other space telescopes



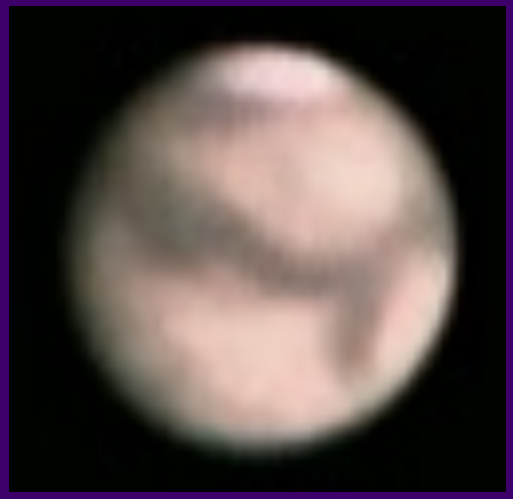
Infrared



X-ray

Advantages of space telescopes

- Observe wavelengths that don't penetrate earth's atmosphere
- Sharper images without atmospheric refraction ("twinkling")



Mars from earth's surface

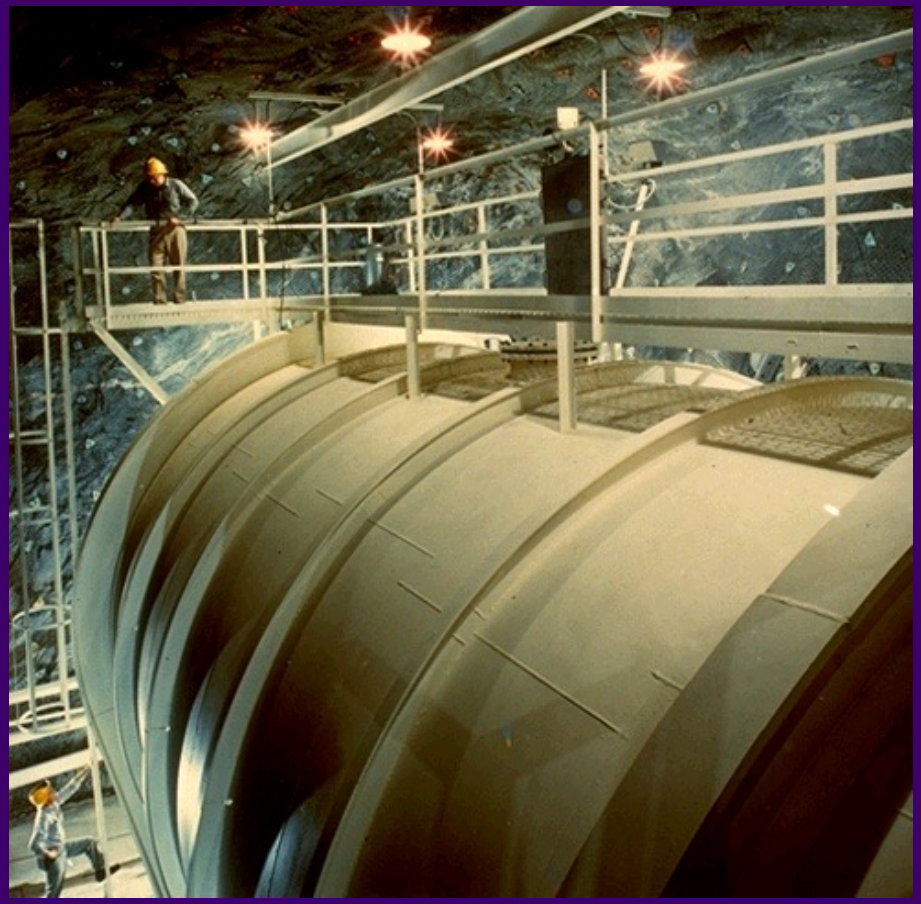
Mars from Hubble

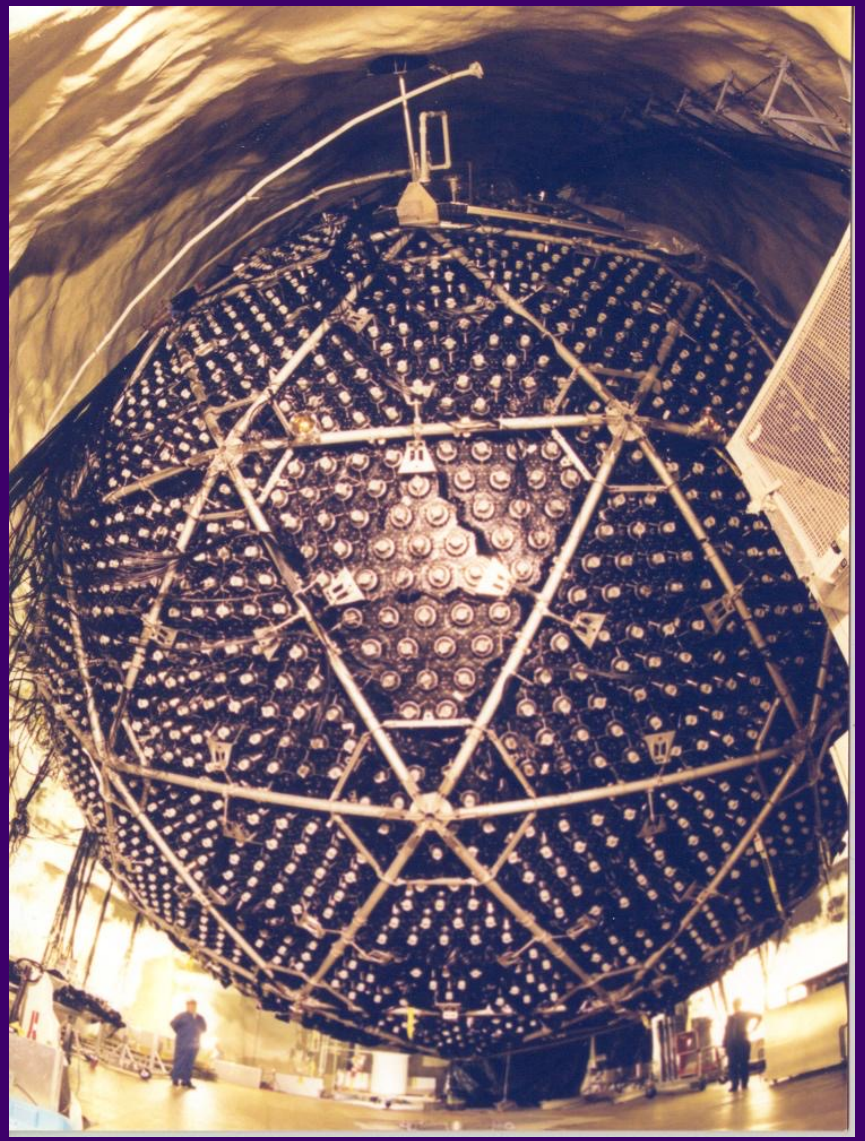
- NASA has lots of money

Other signals (besides “light”)

- Cosmic rays (charged subatomic particles that collide with earth’s atmosphere)
- Neutrinos (highly penetrating particles, given off by sun and other stars)
- Gravitational waves (not yet detected directly)

Neutrino Detectors

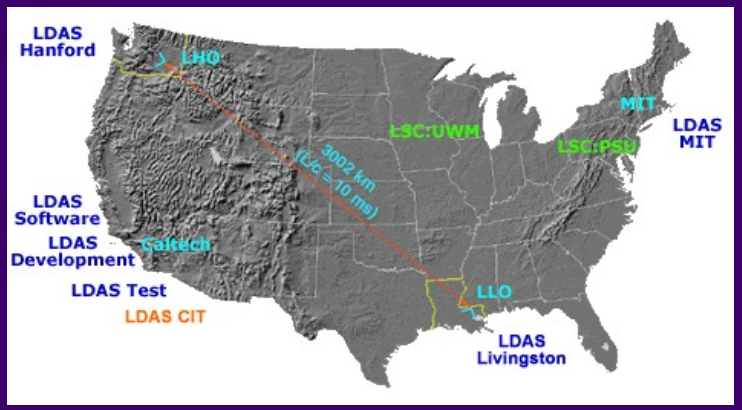




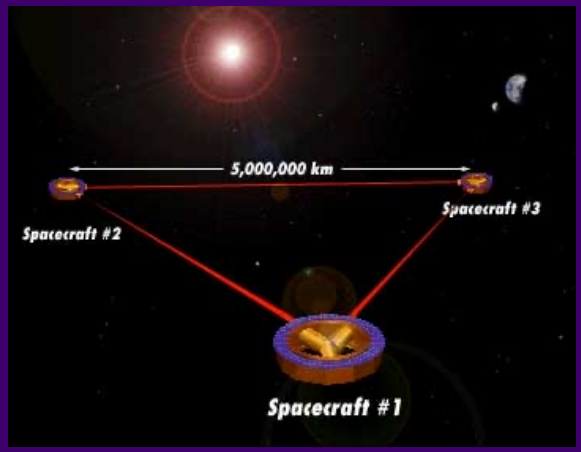
Gravitational Wave Detectors (LIGO)

Hanford, WA

Livingston, LA



Proposed "LISA" detector in solar orbit



Telescopes for amateur use

- Binoculars
- Small refractors
- Dobsonian reflectors
- Motor-driven telescopes

Binoculars

Great for viewing the moon, Jupiter's moons, Milky Way, and several of the brighter star clusters, nebulae, and galaxies.

7 x 50 (my favorite)

Mostly for daytime use

Too big to hold steady

Small Refractors

OK for viewing moon and planets, IF the mount is steady. Usually a major disappointment. Beware of cheap department store brands! High-magnification eyepieces are useless.

Dobsonian Reflectors

These are Newtonian reflectors with a simple mounting system designed by John Dobson. Versatile, economical, and very easy to use! Sizes range from 4.5 inches to 25 inches and more.

Motor-Driven Telescopes

For the serious amateur astronomer/astrophotographer.
Rather expensive compared to Dobsonians.