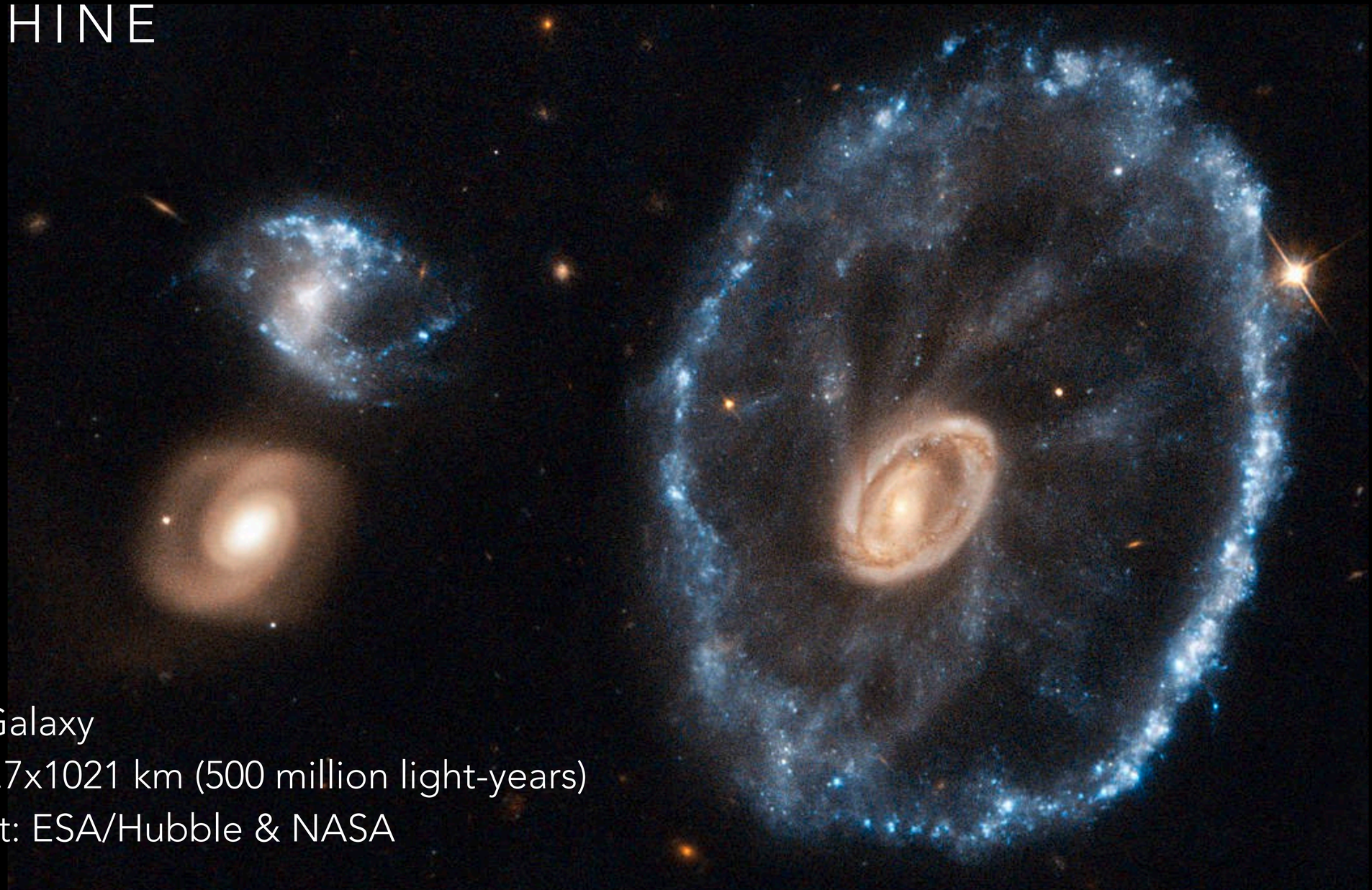
THE NIGHT LAB

PARTS OF A TELESCOPE

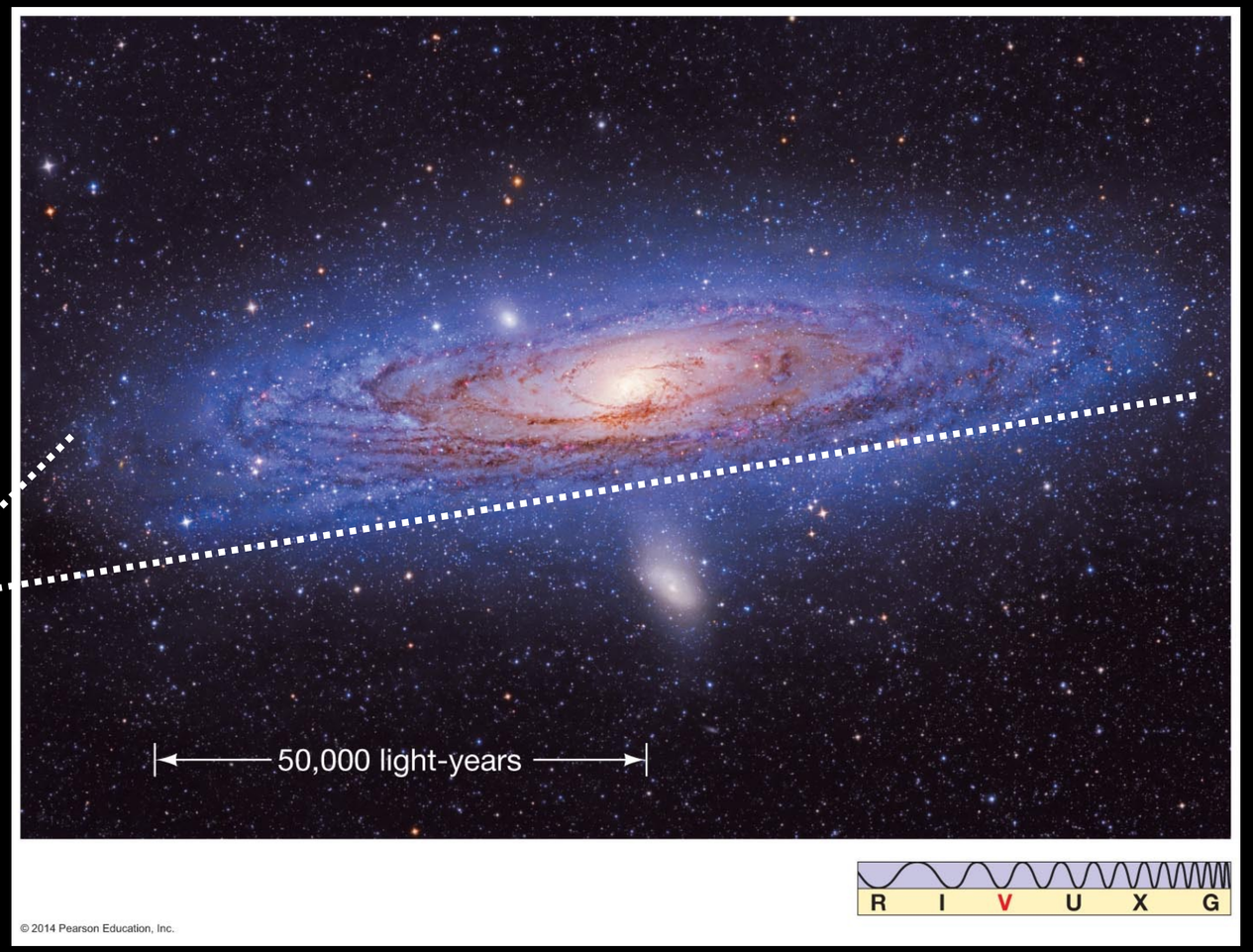
A TELESCOPE IS A SPACESHIP AND A TIME MACHINE



Cartwheel Galaxy
Distance: 4.7x1021 km (500 million light-years)
Image credit: ESA/Hubble & NASA

DISTANCE TO ANDROMEDA GALAXY = 24,010,000,000,000,000,000 KM

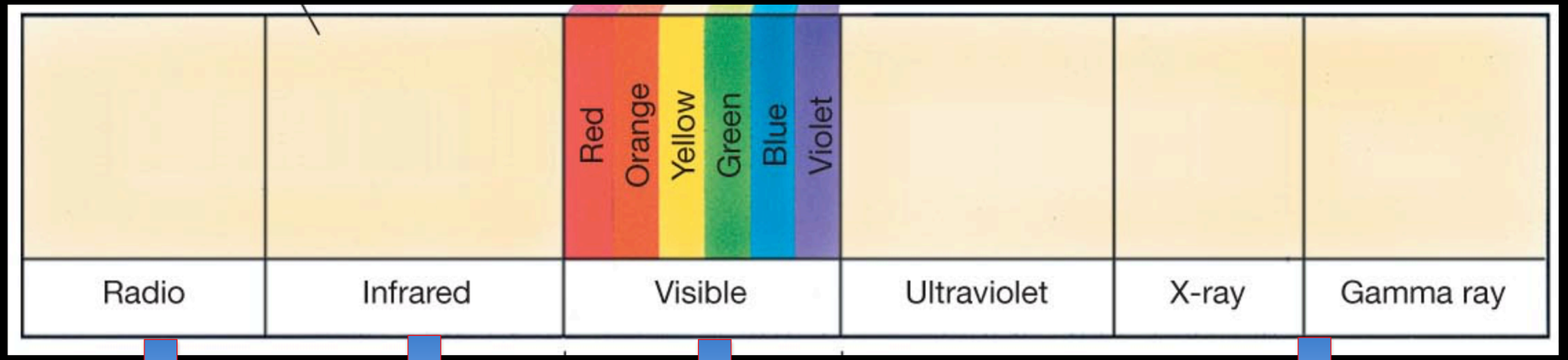
TIME FOR LIGHT TO TRAVEL THIS DISTANCE = 2.5 MILLION YEARS



Compare:

Sun	8.3 light-minutes
Moon	1.3 light-seconds
Alpha Centauri	4.3 light-years

DIFFERENT WAVELENGTHS REQUIRE DIFFERENT TELESCOPES AT DIFFERENT LOCATIONS



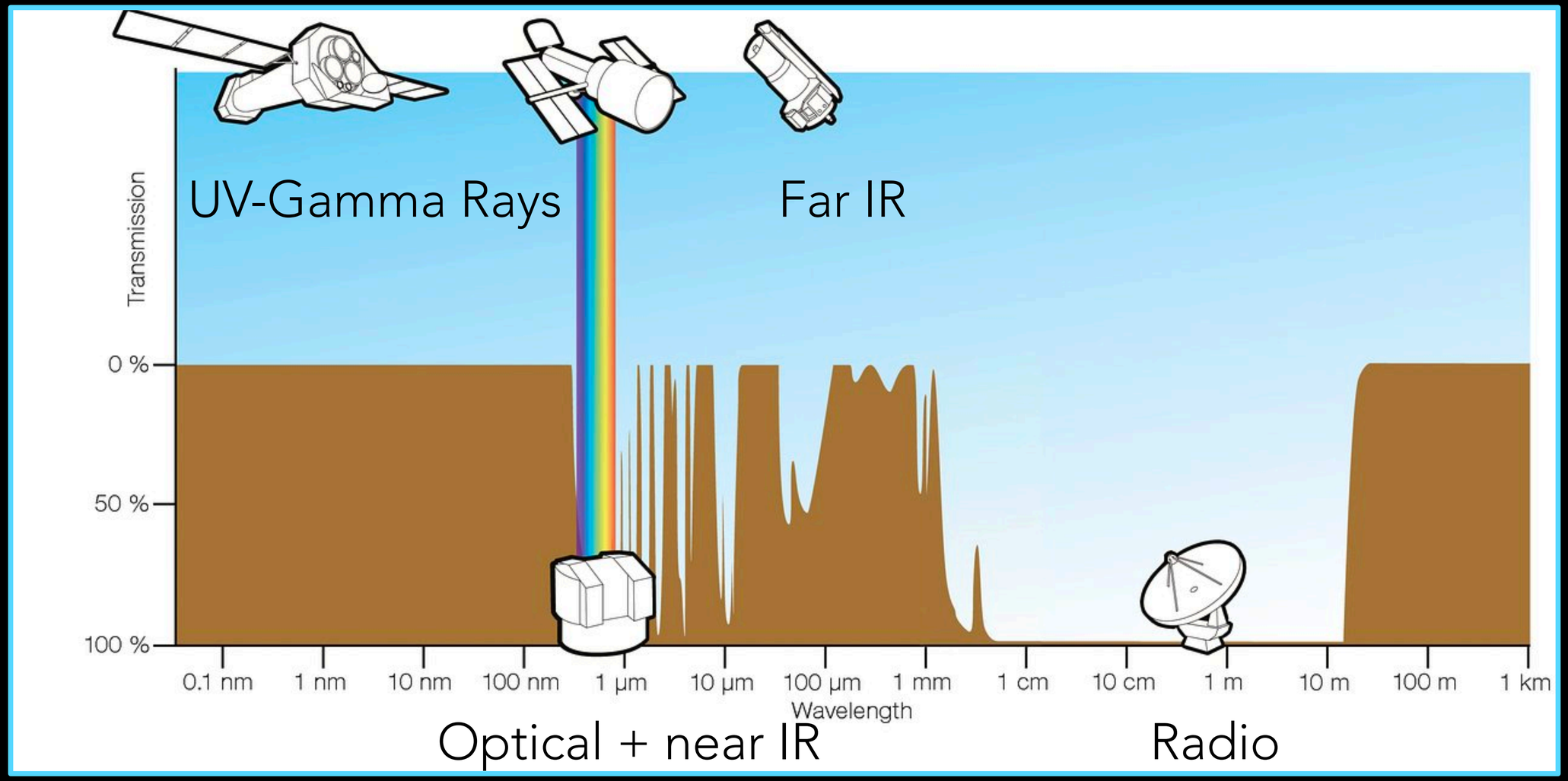
Radio telescopes: Ground based

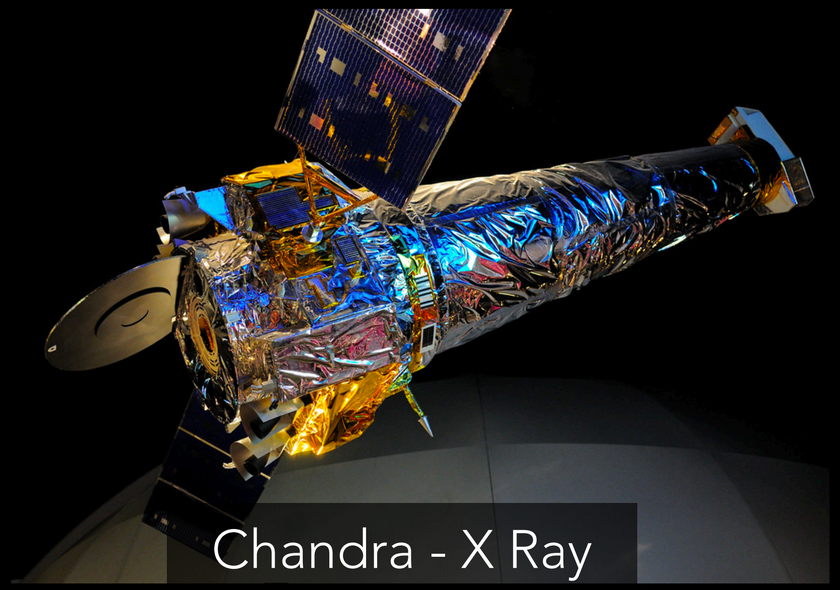
Infrared telescopes: Ground and space based

Optical telescopes: Ground and space based

X-ray and gamma ray: Always space based

REASON? EARTH'S ATMOSPHERE!

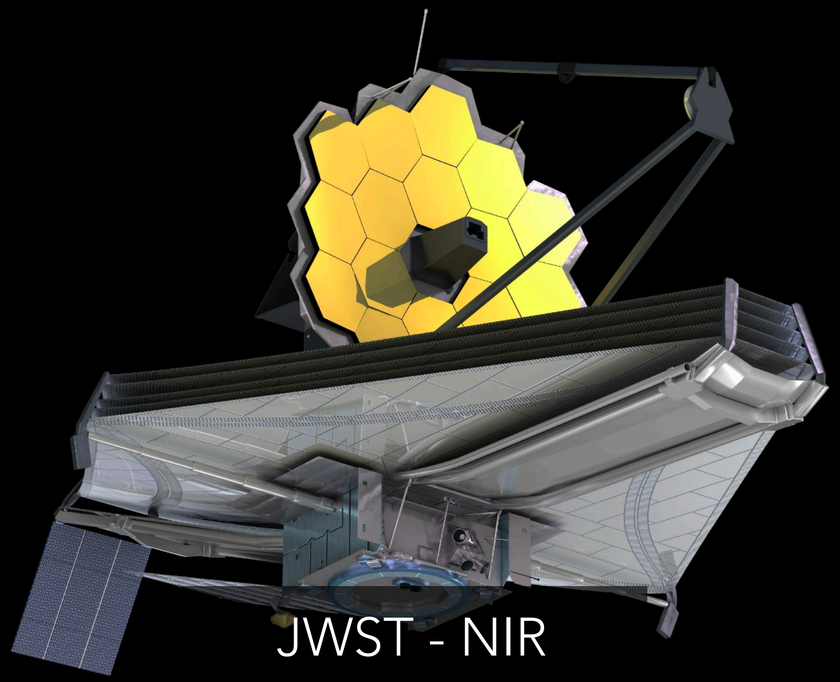




Chandra - X Ray

Hubble - Optical

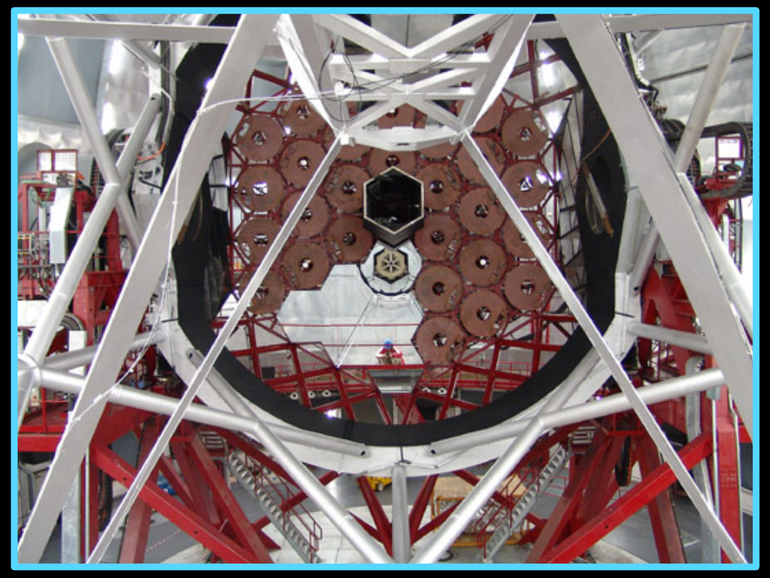
Gemini - NIR



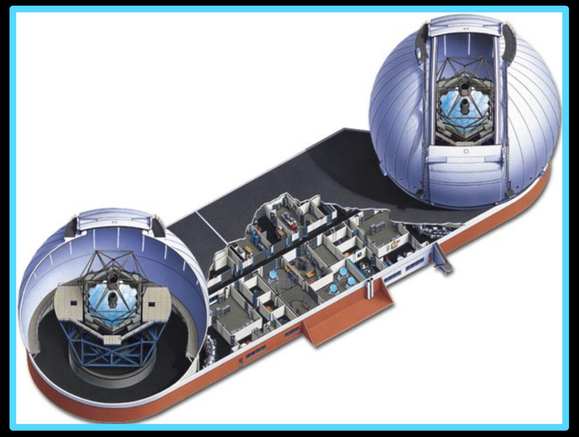
JWST - NIR

Spitzer - FIR

ALMA - mm



10.4-m Canarias Gran, Spain

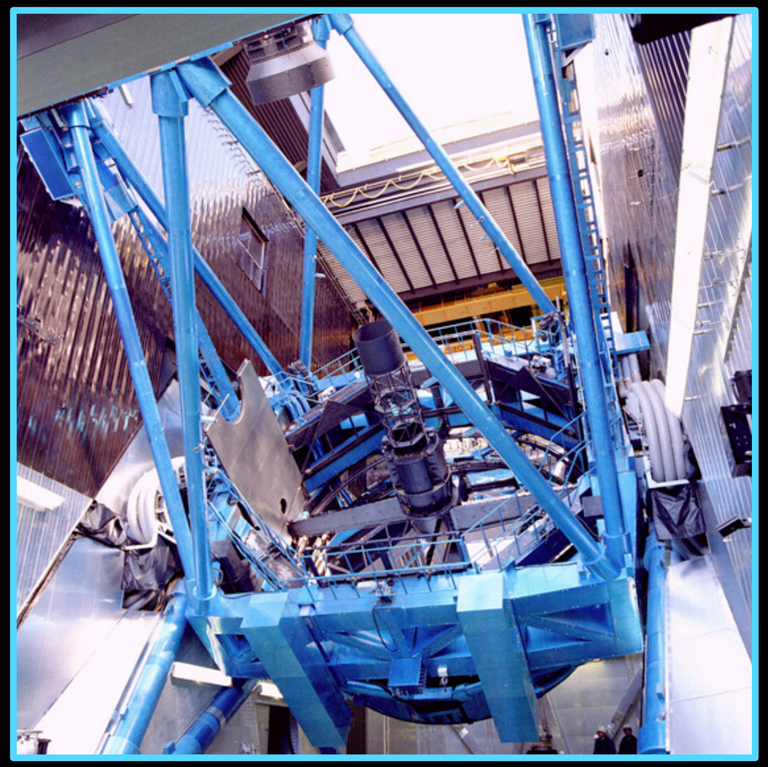


10-m Keck, Hawaii

6.5-m Magellan1 , 2, Chili

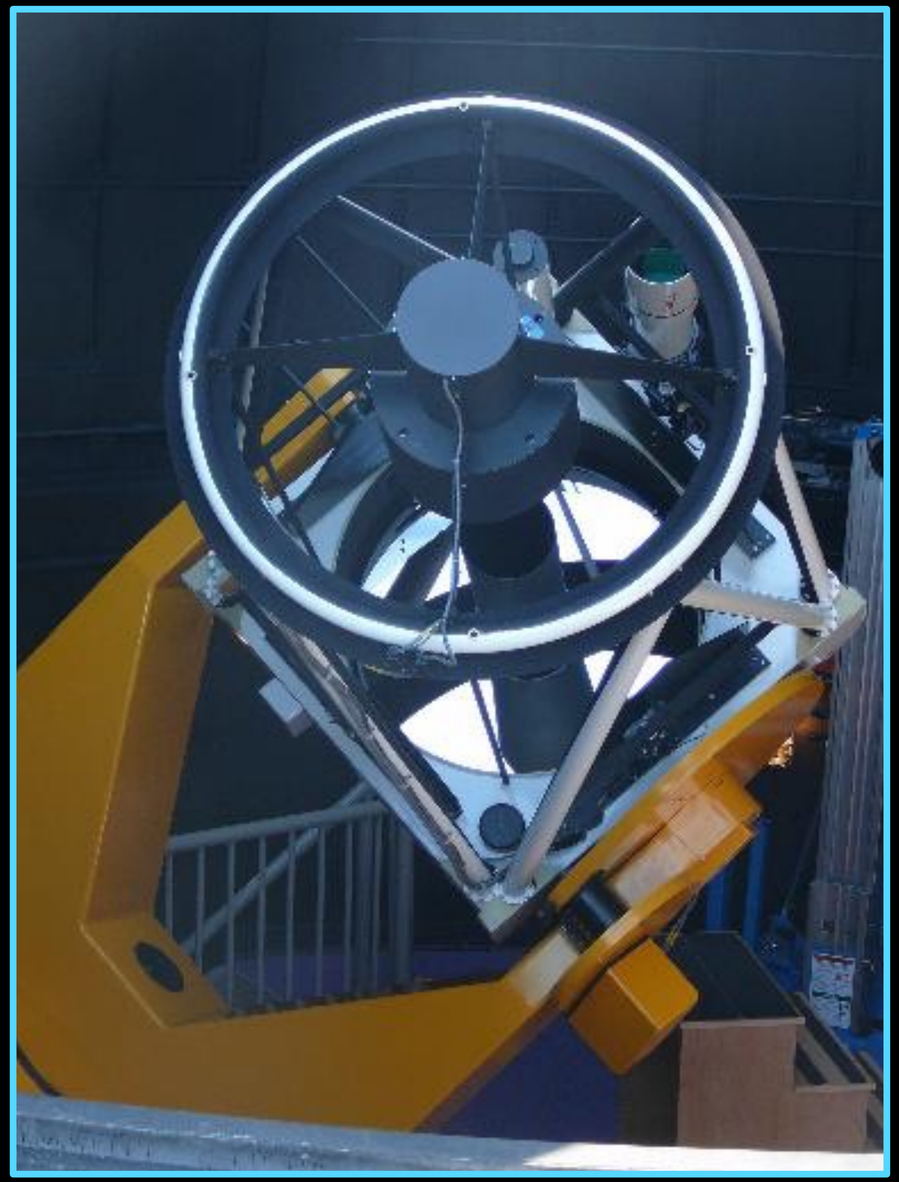
3.58-m CFHT, Hawaii

6-m BTA-6, Russia



8.2-m Subaru, Hawaii

DFM CCT-32 AT THE UNIVERSITY OF VICTORIA



OPTICAL TELESCOPES

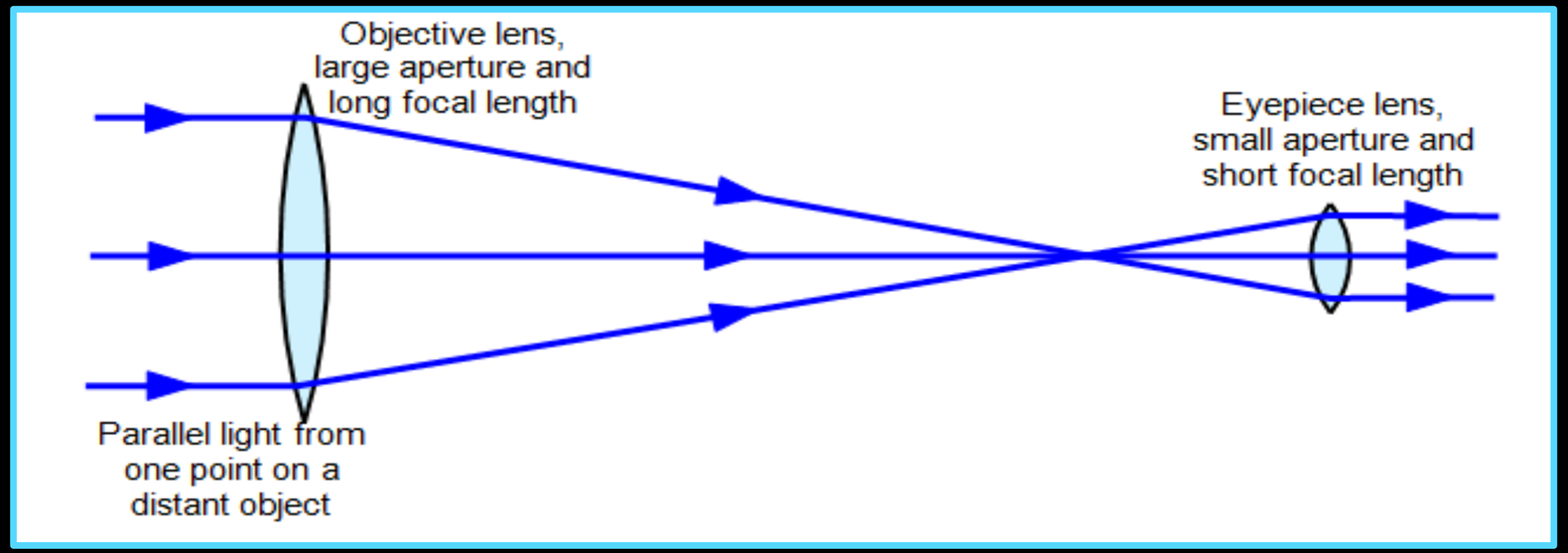
- Is an optical instrument (uses lenses, mirrors, etc.)
- Collects light (‘a light bucket’) from very distant (= very faint) astronomical objects
- Magnifies and enhances the view of these faraway objects
- Separates (= resolves) very closely spaced objects
- Uses instruments (camera, spectrograph, etc) to scientifically analyze the collected light.

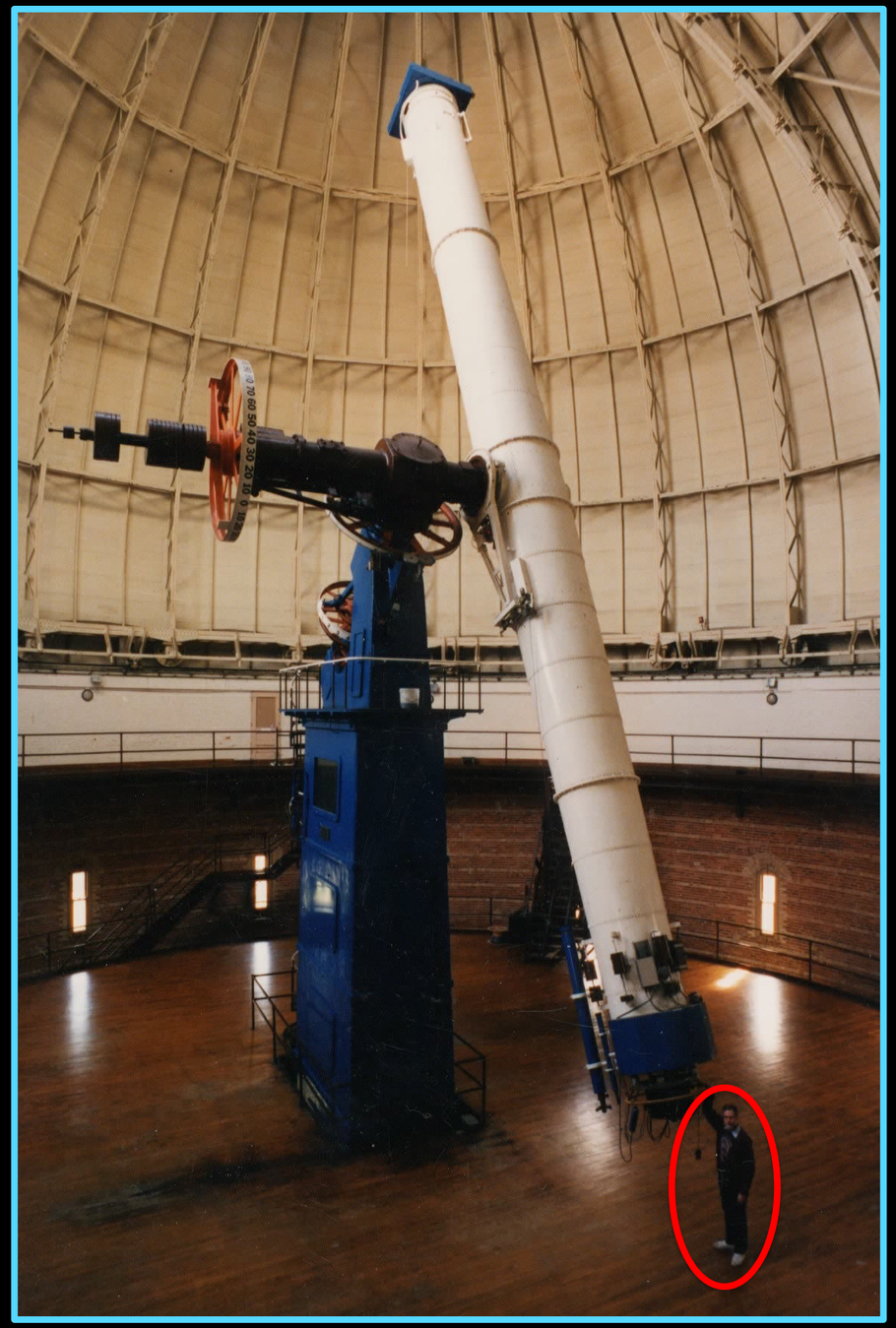
TWO TYPES OF OPTICAL TELESCOPES

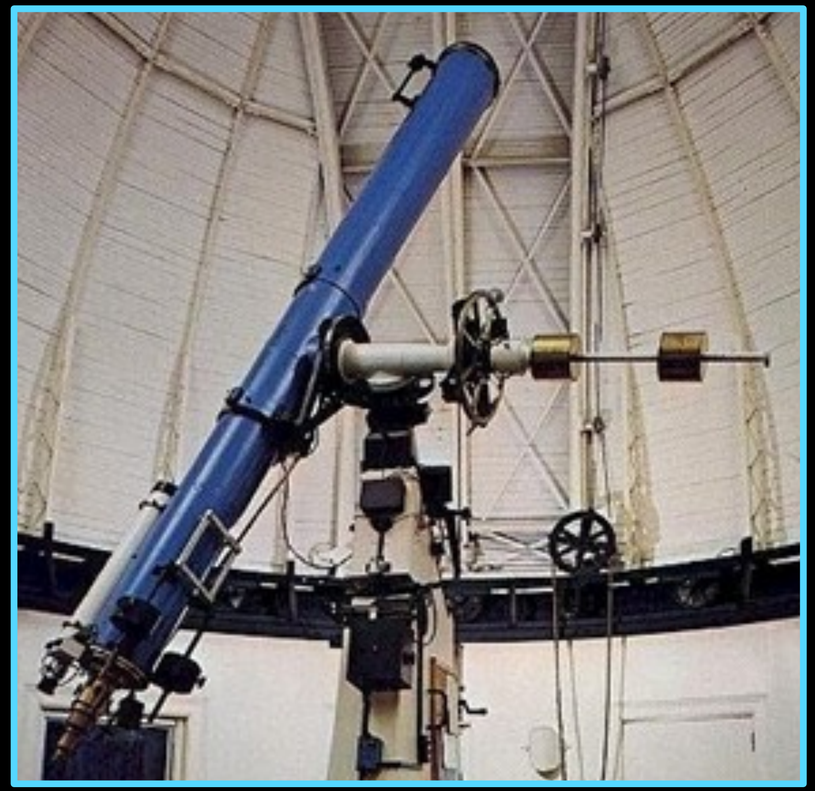
- **Refractor**
  - Primarily uses lenses as the optical elements to collect and magnify light
  - Used for small amateur telescopes and telephoto lenses (photography)
- **Reflector**
  - Primarily uses mirrors as the optical elements.
  - Used in all modern large scientific telescopes

REFRACTOR TELESCOPES

- Is essentially a tube with a lens at each end.
- Light enters through a main objective lens at one end, refracts (bends) to a point of focus at the other end where an image is formed by the eyepiece.
- The eyepiece can be moved back and forth to adjust the sharpness of the focus.







REFRACTOR TELESCOPES CONT.

Advantages

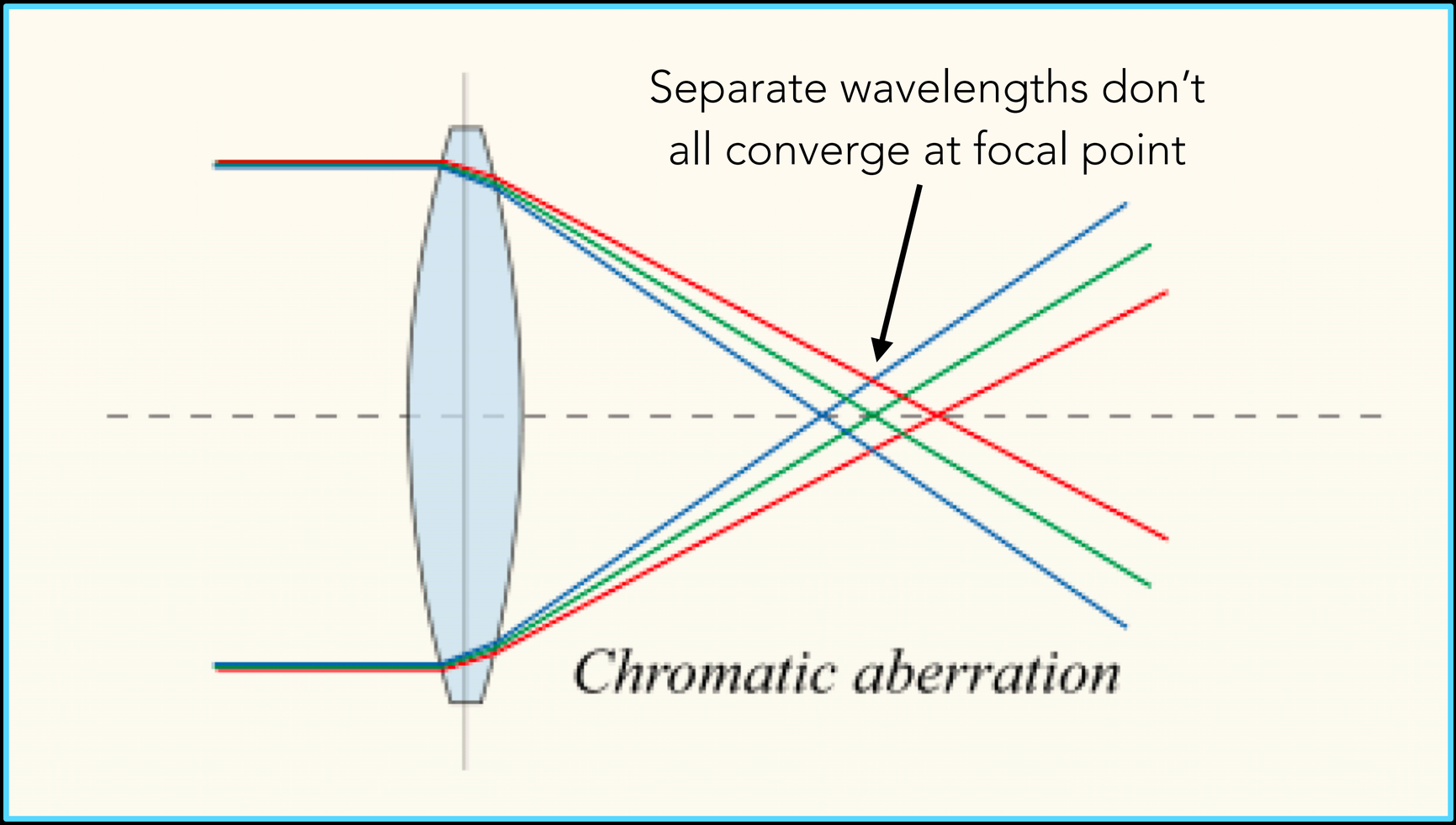
- The optical system is **more resistant to misalignment** than the reflector telescopes.
- The glass surface inside the tube, sealed from the atmosphere, **rarely needs cleaning**.
- Due to sealed tube, air currents and effects from changing temperatures are reduced, meaning that the **images are steadier and sharper** than those from an open reflector telescope of the same size.
- Good for objects inside our solar system.

REFRACTOR TELESCOPES CONT.

Disadvantages

- Refractors suffer from an effect called **chromatic aberration** (``color deviation or distortion'') that produces a rainbow of colors around the image.
- How well light passes through a lens decreases as the thickness of the lens increases
- Making a large glass lens with no internal imperfections is extremely difficult and expensive.
- The lens can only be supported on its edge. A heavy glass lens will sag under its own weight.

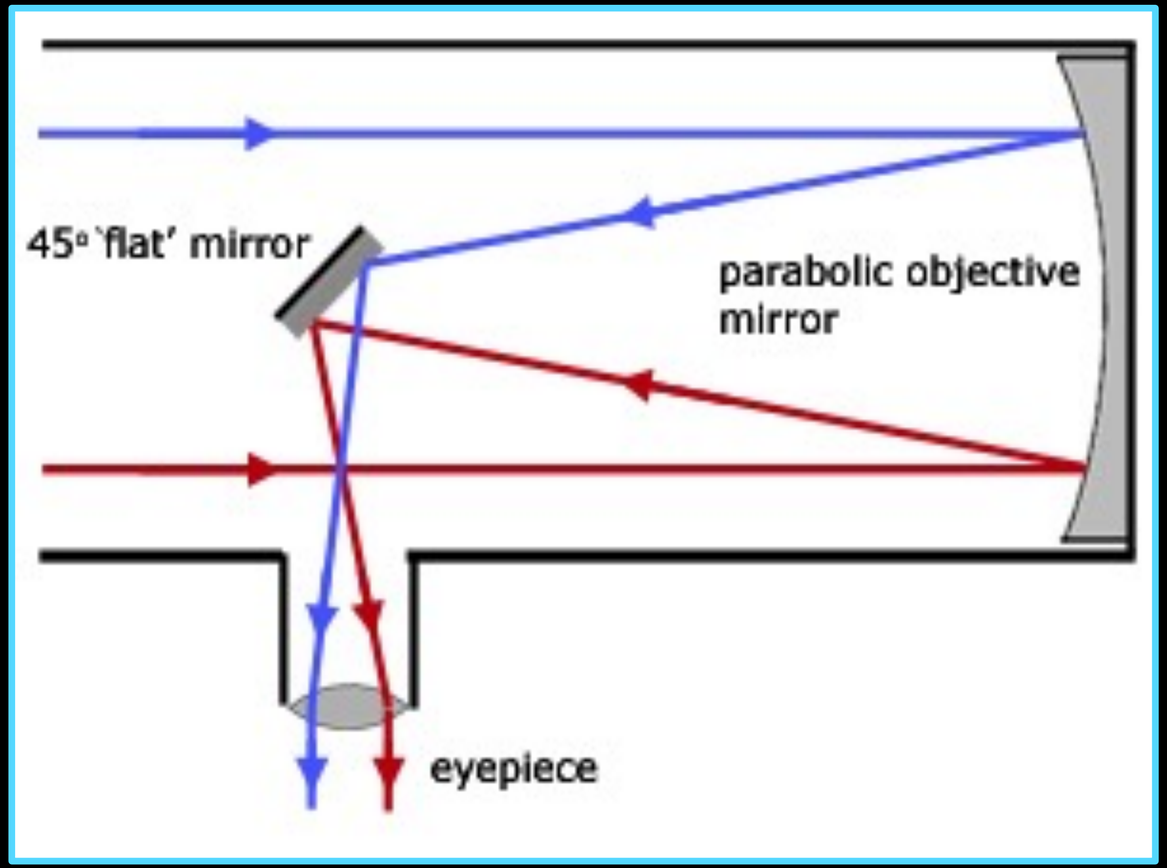
CHROMATIC ABERRATION



REFLECTOR TELESCOPES

Newtonian Reflector

Incident light collected by the parabolic mirror is reflected to a plane (flat) mirror, which then directs it into an eyepiece located at the side of the telescope.



REFLECTOR TELESCOPES CONT.

Advantages

- No chromatic aberration because all wavelengths are equally reflected.
- Objective mirror is fully supported along the back side and are lighter than lenses. This allows for large telescopes to be constructed.
- Only one good surface on mirror is needed.
- Lower cost to make reflector than refractor of the same size.

REFLECTOR TELESCOPES CONT.

Disadvantages

- a shadow is produced by the secondary mirror
- depending on the size of the secondary mirror, less light gets to the eye than originally enters the telescope tube.
- Mirrors are exposed, meaning they must be cleaned regularly.

PARTS OF A NEWTONIAN TELESCOPE

Tube: Holds the whole optic system.

Mount (Base): Supports and allows movement of the telescope tube.

Primary mirror (concave mirror): Gathers the light and reflects it back toward the secondary mirror.

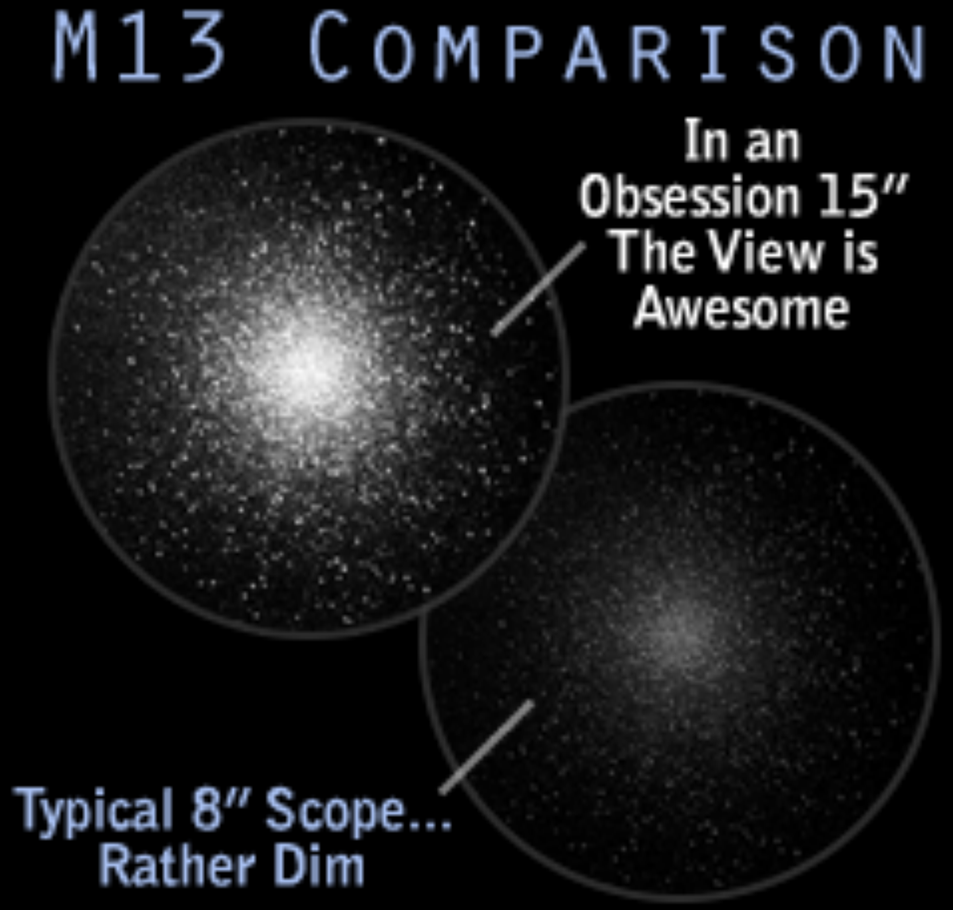
Secondary mirror: A flat mirror reflects the light to the side of the telescope toward the eyepiece.

Eyepiece: Creates the final focus correction.

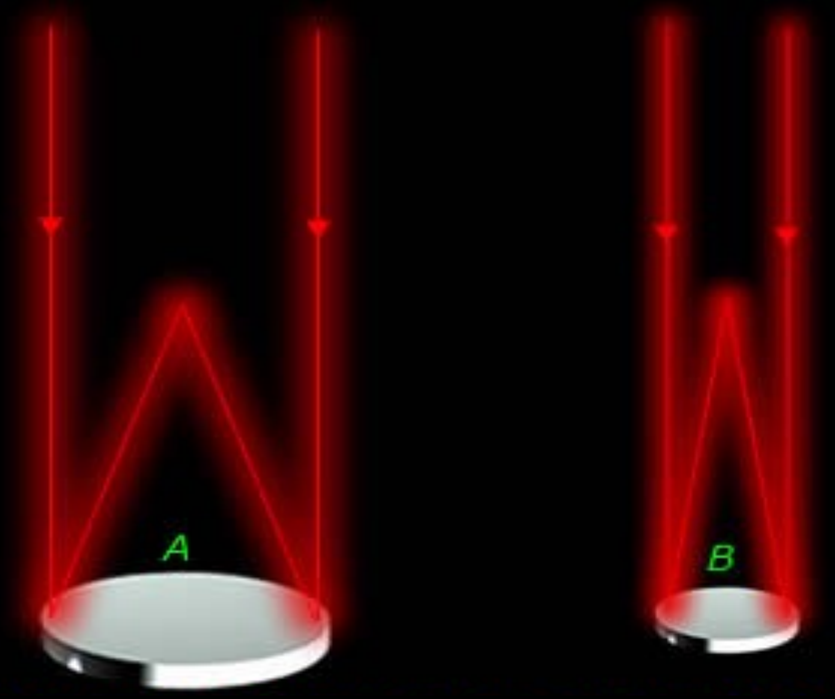
Finder (a refractor): Locates the object in a much larger FOV.

Focuser: Adjusts the focus.

LIGHT COLLECTING POWER OF AN OPTICAL TELESCOPE



A larger mirror collects more photons making an object appear brighter

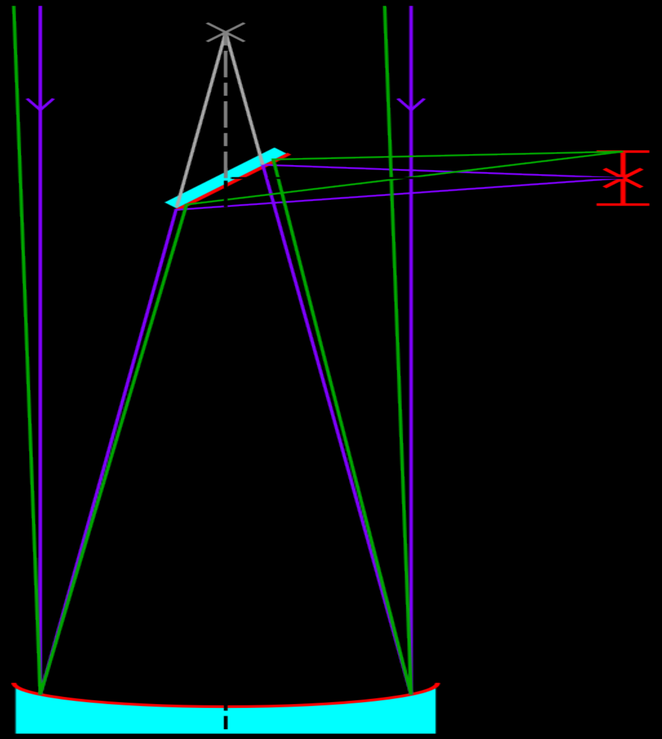


The light gathering power of a telescope is directly proportional to the area of the primary mirror.

EXAMPLE

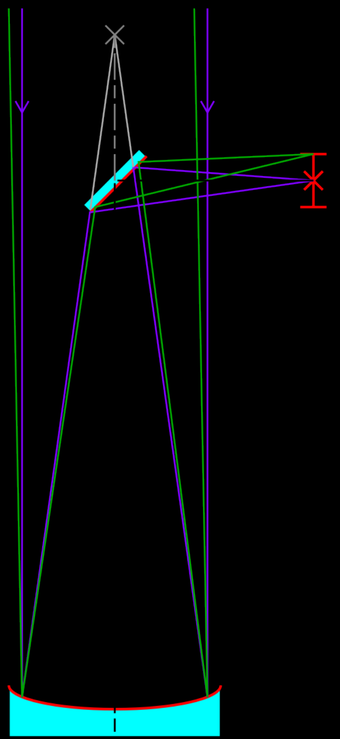
How much more light will the large telescope gather compared to the small telescope?

Telescope #1



Large mirror of radius = 20 cm

Telescope #2



Small mirror of radius = 5 cm

COMPLETING THE NIGHT LAB

Stellarium

Jupiter through 8-in telescope

Ring Nebula through 32-in telescope