Lecture 4: Telescopes

- Web site
- Stuff from last time
- Naked eye and magnitudes
- Development of telescopes
- Types of telescopes

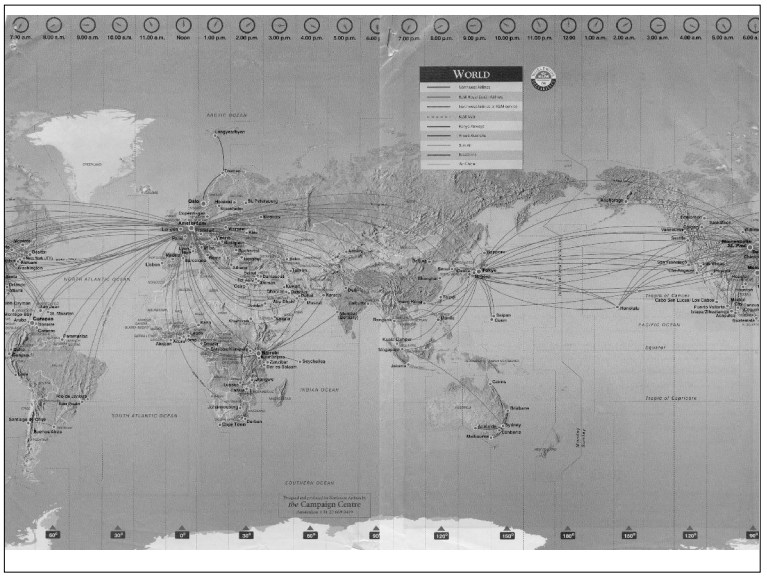
http://www.pa.msu.edu/courses/2003spring/ast312/

This is the class web page. Be sure to check it often. Class notes will be posted there roughly one week after class. Assignments and announcements will also be posted.

Once we begin observing, check the web page for announcements regarding location and to see if we have canceled due to weather.

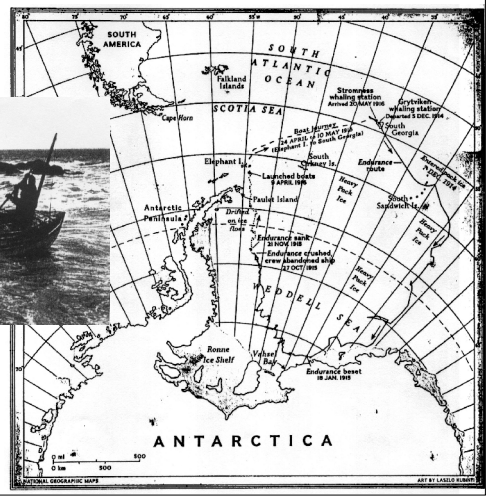
Previous Topics

- How can you tell if a star is circumpolar from your location?
- Why do we have time zones?
- How can you use the stars to get your latitude and longitude?



Shackleton Expedition, 1914-1916

Crew members traveled over 800 miles in one of the life boats navigating by dead reckoning and the Sun's position to reach help.



The Magnitude Scale

- Introduced by Ptolemy, 2nd century A.D.
  - Catalog included ~1000 stars
  - Brightest stars given a 1, slightly fainter were given a 2, etc.
  - Some problems
    - Broad range of things fall into "magnitude 1"
    - Brightness ratio between two magnitudes not quite uniform
- Refined in 1850 by N. R. Pogson
- Magnitude difference of 5 is a brightness ratio of 100/1
  - So a mag 1 star is 100 times as bright as a magnitude 6 star

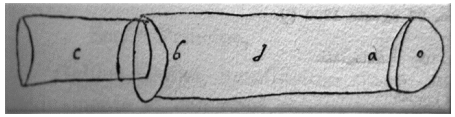
Brightness α Amount of Radiation received from object

$m2 - m1 = 2.5 \log (B1 / B2)$

History Highlights

- Pre-Galileo
- Galileo (first astronomical use)
  - The moon
  - Galilean satellites
- Newton (reflector)
- Modern designs

Earliest known sketch of telescope (1609)



Telescope first unveiled in Netherlands in 1608 and described as a device for "seeing faraway things as though nearby."

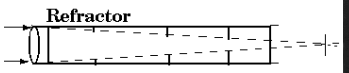
Most practical applications were maritime use; spotting ships or land from far off.

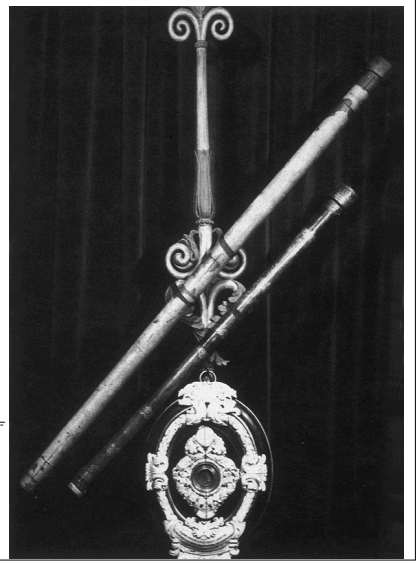
Thomas Harriot actually observed the moon with a telescope *prior to* Galileo (April 1609), but his work was not published until much later.
(Remember this general rule: Publish or Perish!)

Galileo's telescopes:

2" aperture
~ 20 x magnification

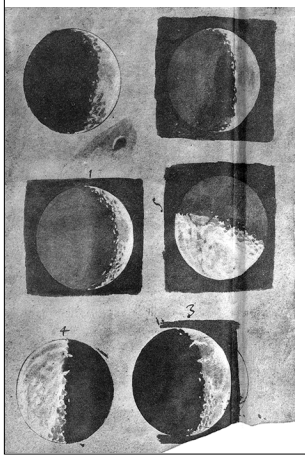
Although of extraordinary quality for his time, you can build one for less than $30 in parts.



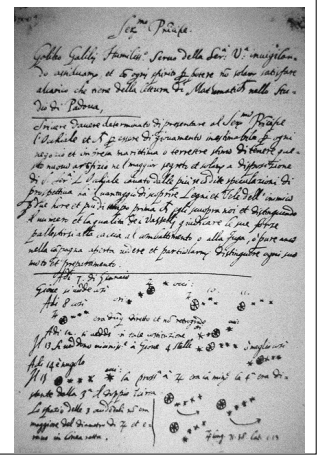


1609-1610

Galileo's moon drawings (Thomas Harriot actually beat him to it)



Jupiter's moons



FOV- Angular size of the viewing field. Usually given in degrees, arcminutes (1/60 th of a degree) or arcseconds (1/60 th of an arcminute)

Magnification - ratio of the focal length of telescope and focal length of eyepiece (f_telescope / f_eyepiece)

Light Gathering Power - proportional to the square of the size of the mirror (area of the light bucket) Limiting magnitude for a telescope is

$$m = 2.7 + 5 \log D$$

Where D is telescope aperture in millimeters.

Resolving Power - Smallest angular separation that the telescope can resolve

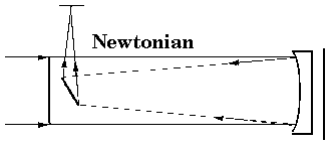
4.56 / diameter of primary in inches

Or

116 / diameter of primary in millimeters

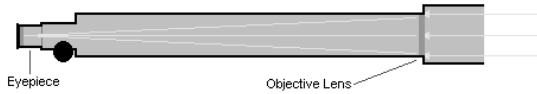
Newton's reflector (1671)

The "mirror" was actually highly polished metal. With this technique, you could make telescopes with a larger field of view, but the metal tended to oxidize and needed to be removed and polished regularly.



Types of telescopes

- Refracting
- Reflecting
- Catadioptic
  - Schmitt Cassegrain
  - Maksutov



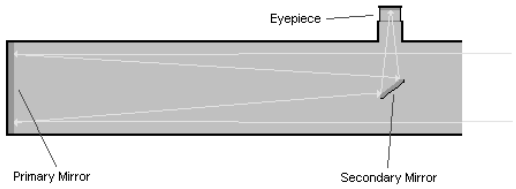
Refractor

Advantages

- Good image definition and contrast
- Optics hold alignment well

Disadvantages

- Expensive for large aperture
- Large aperture are bulky
- Glass lenses can only be made so large



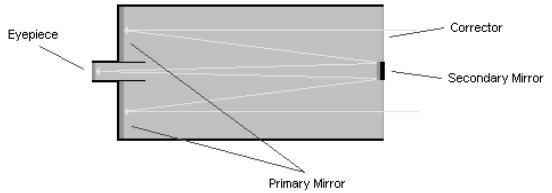
Reflector

Advantages

- Inexpensive for their size
- Eyepiece in comfortable spot
- Easy to make large aperture

Disadvantages

- Sensitive to optical alignment
- Aluminized mirror surfaces deteriorate
- Secondary blocks some of the light



Catadioptric

Advantages

- Very compact for aperture
- Due to size, easy to view any part of sky from comfortable position

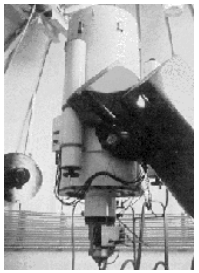
Disadvantages

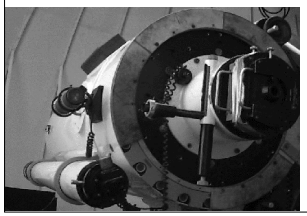
- Large secondary blocks a lot of light; so lower contrast images
- Secondary can also cause "blind spot" in center of field

MSU's Telescope

24 inch Cassegrain
6 inch refractor finder scope

Magnification up to 295X
FOV 17' or 28' (secondary mirror can be changed)

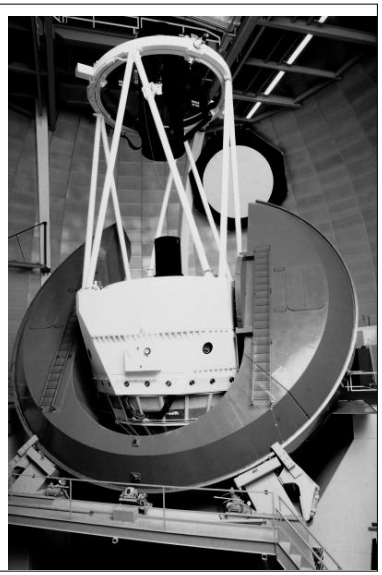


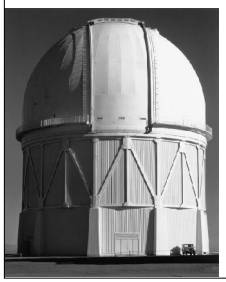


Kitt Peak

- Outside Tucson, AZ
- 26+ telescopes
- 4-m Mayall is largest

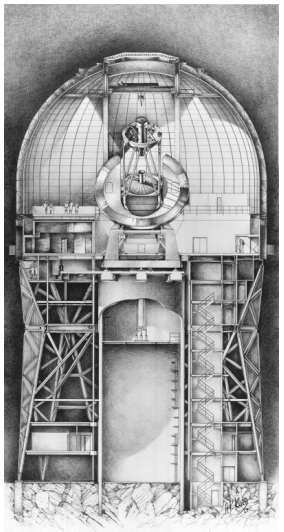
4-m Mayall (KPNO)





The 4-m mirror at KPNO (above)

There is a "twin", the 4-m Blanco at CTIO in Chile (left)



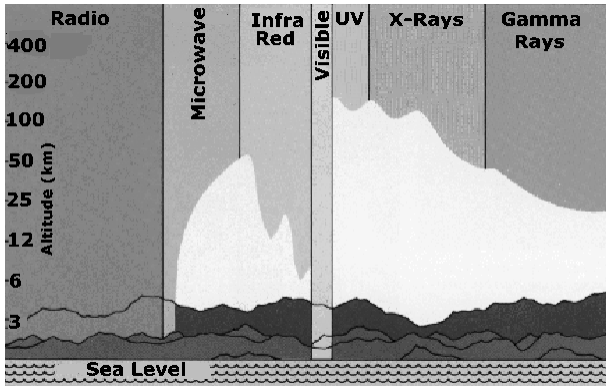
Problems with Ground Based

- Weather
- Weather
- Weather
- Seeing
- Location
  - Is your object actually viewable from your location?
- Light / radio pollution
- Daylight
  - Not so much of a problem with radio

Seeing: the quality of observing conditions induced by turbulence in Earth's atmosphere, which blurs the images of astronomical objects. -Astronomy magazine

Absorption

Our atmosphere blocks radiation, preventing broadband observations. It also allowed life to exist.



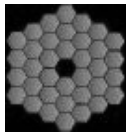
I guess it's a fair trade...

Keck Mauna Kea, Hawaii

10 m .... now we are talking....

36 independent segments are used to make up the 10 m mirror.

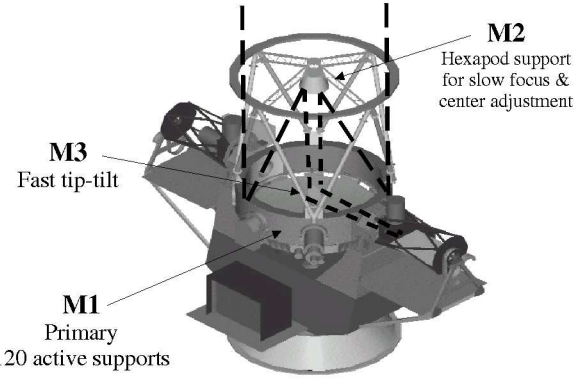
Much easier to build than a single large mirror, but difficulty is in keeping them aligned...



SOAR Cerro Pachón, Chile

4.2 m, designed for IR, with full adaptive optics

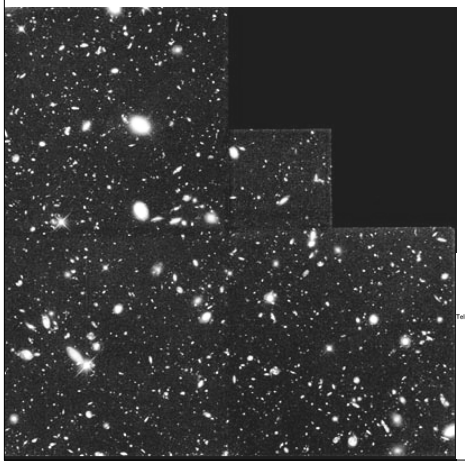
3-mirror optical path



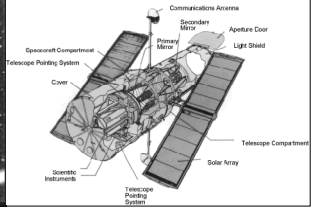
Why Chile?
The view of course...

4m Blanco Telescope at Cerro Tololo

Hubble Space Telescope

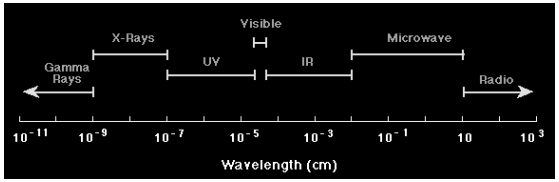


- 2.4 m telescope
- Image is deepest ever taken (1 week of observations)
  - 20 stars
  - 5000 galaxies

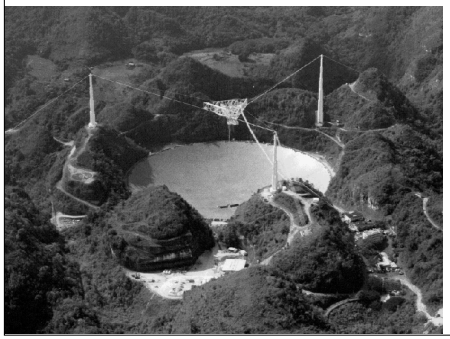


Non-Optical

- Most emission does not fall within the optical wavelengths.
- We can build instruments to probe other parts of the spectrum



Arecibo Radio Telescope, Puerto Rico
(As seen in Contact)



- 305 m (1000 ft) dish
- Largest single dish telescope in the world
- Used to study many radio phenomena
  - Pulsars
  - Interstellar molecular gas
  - SETI
  - Can also broadcast

VLA Radio Telescope,

Socorro New Mexico

(Images courtesy of NRAO/AUI)

- 27 radio telescopes
  - Each 25 m (82 ft) diameter
- Used together, acts like a single dish of 36 km diameter