Telescopes

History and Basics

By Steve Clark
Galway Public Library Astronomy Club

History

Hans Lippershey (1570 – 1719),

1608: invented telescope

History

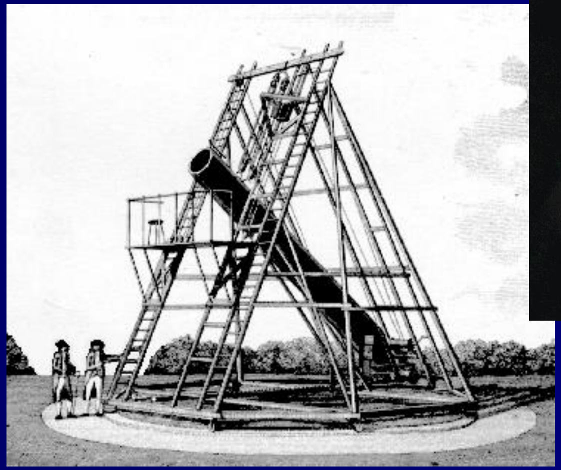
Galileo Galilei, 1609 - 1632: 1st astronomical use of a telescope (Jupiter).

History

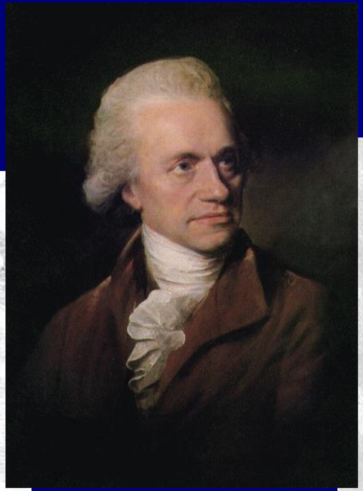
Isaac Newton, 1671: Newtonian Telescope
Born to combat chromatic aberration.

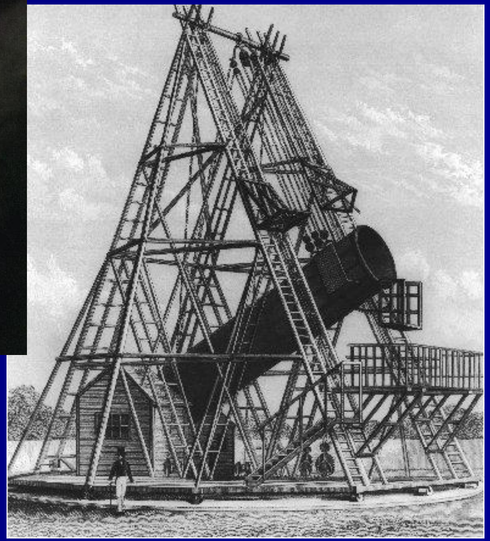
History

William Herschel, 1780s: Large Reflectors



20 foot

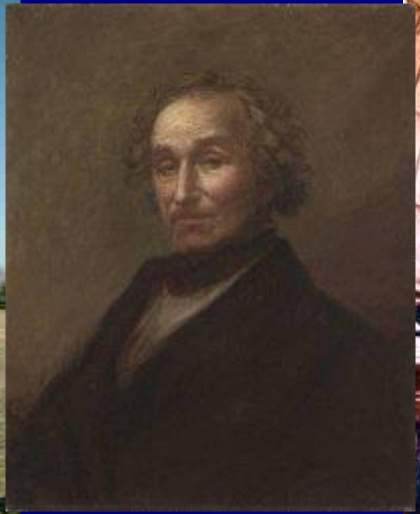




40 foot

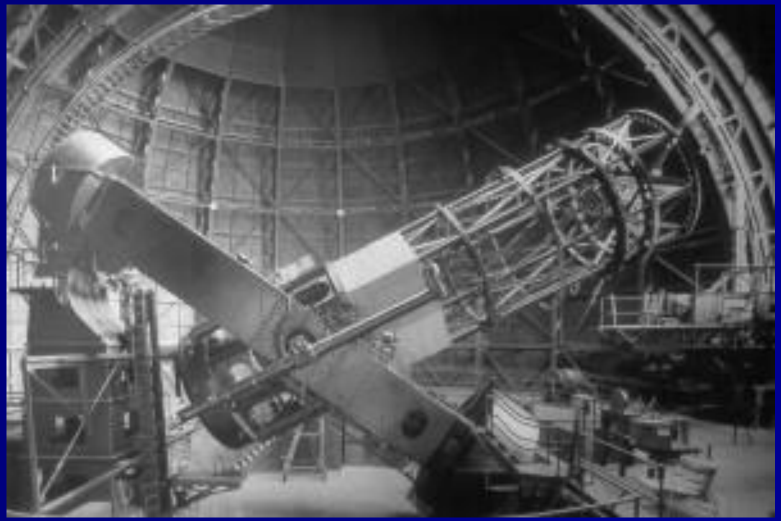
History

- Alvan Clark & Sons, 1880s: Large refractors – 40” Yerkes.



History

- 60” and 100” Telescopes at Mt. Wilson – Beginning of the Big Reflectors, 1st use of steel construction.

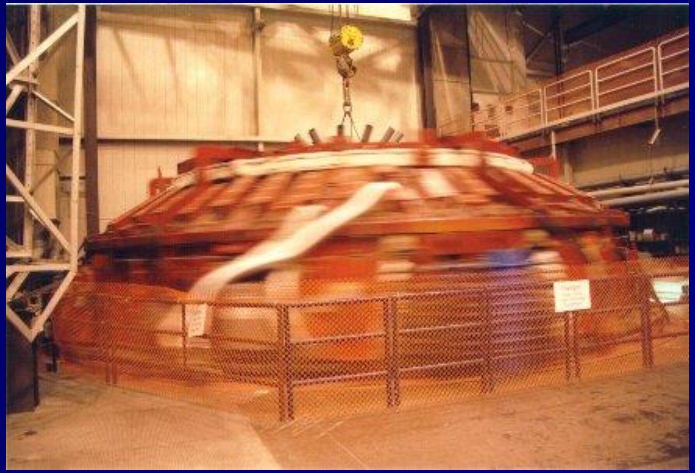


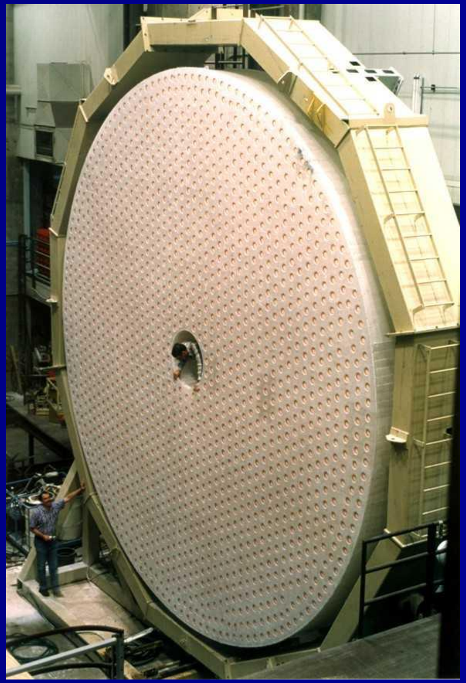
History

200” Hale at Mt. Palomar – Modern truss design, BIG construction era.

History

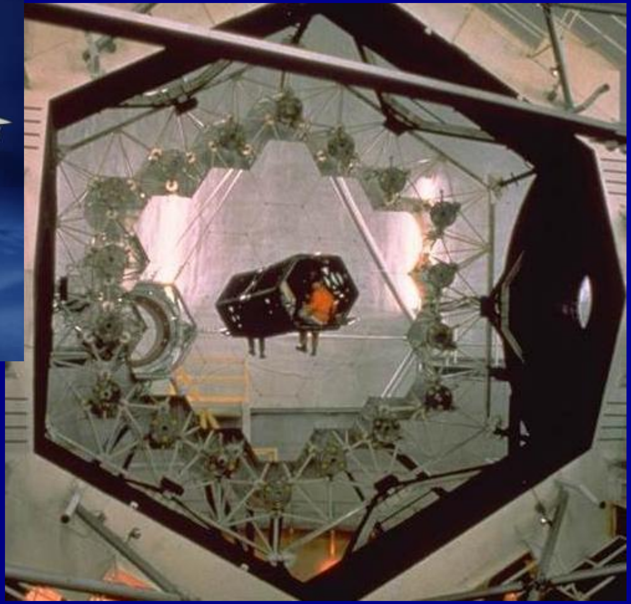
Spin Casting up to 8.4m mirrors.





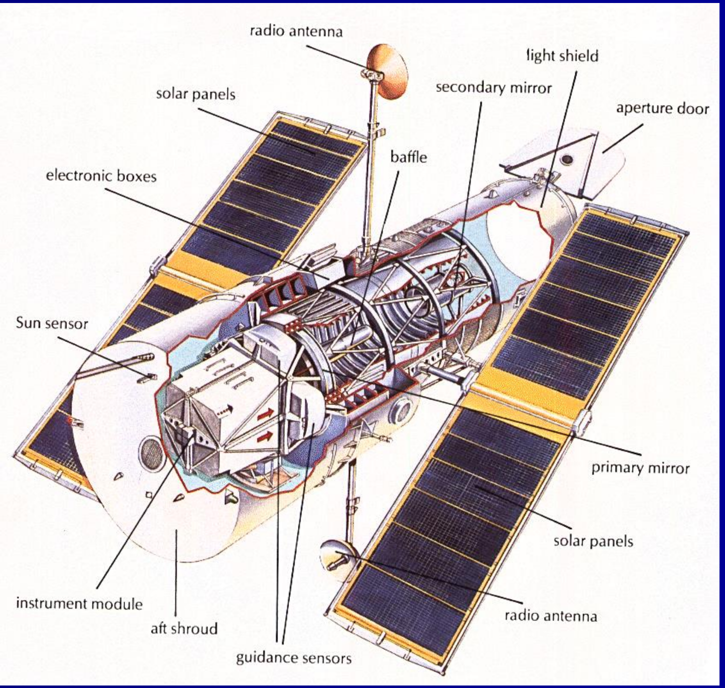
History

Twin 10m Kecks at Mauna Kea – Multiple mirror Technology.



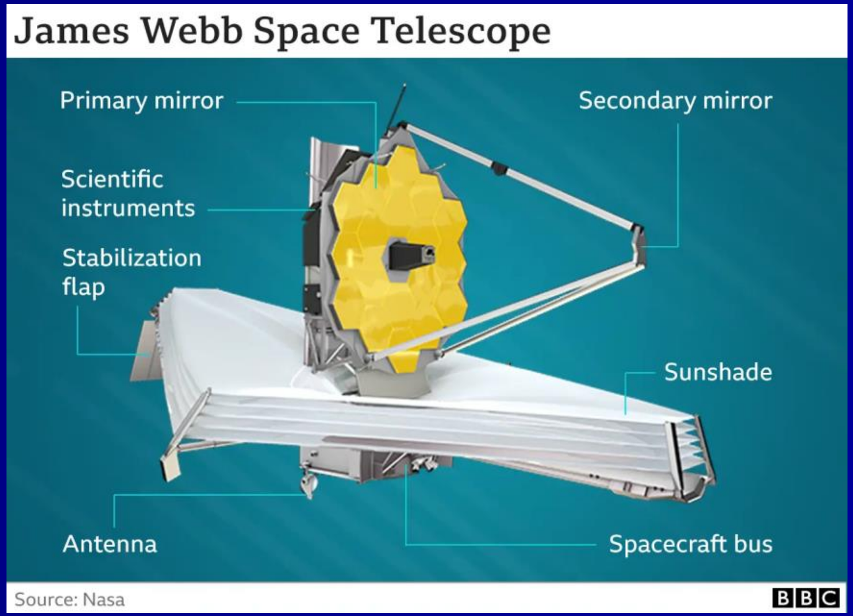
History

- Hubble Space Telescope.



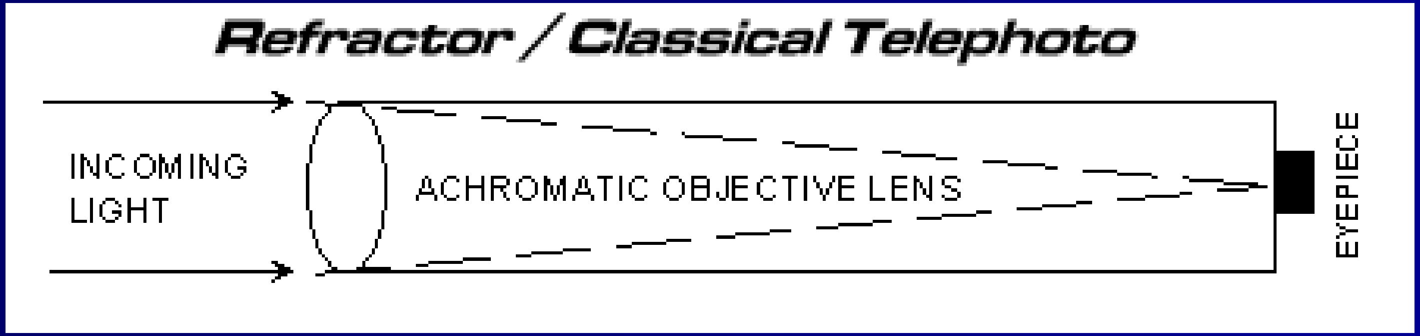
History

James Webb Space Telescope



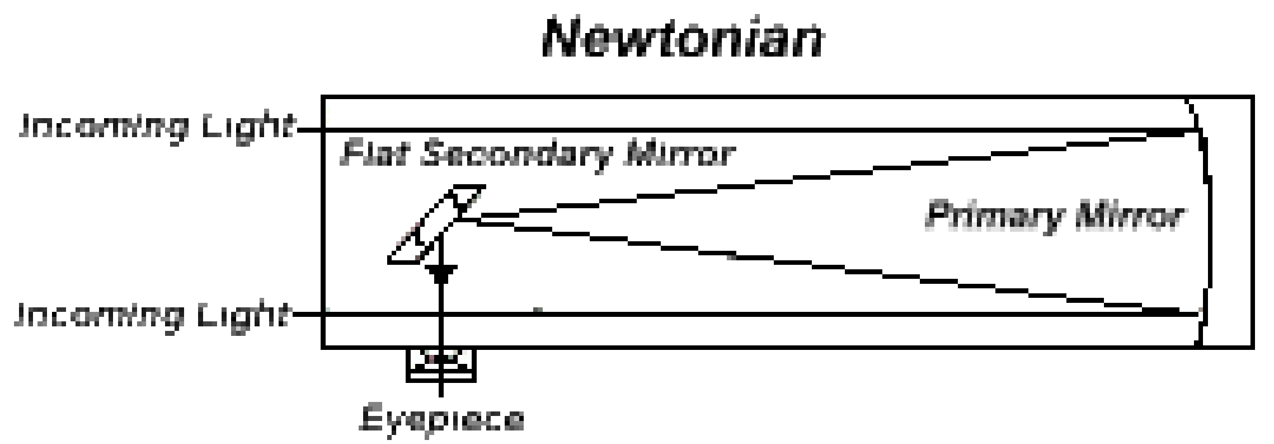
Telescope Types

Refractor



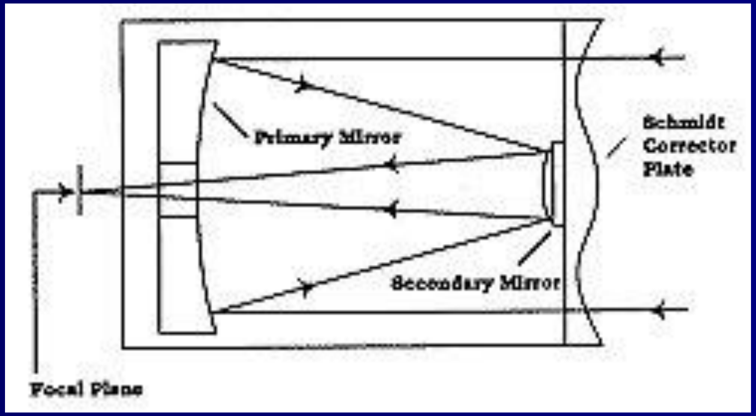
Telescope Types

Newtonian Reflector

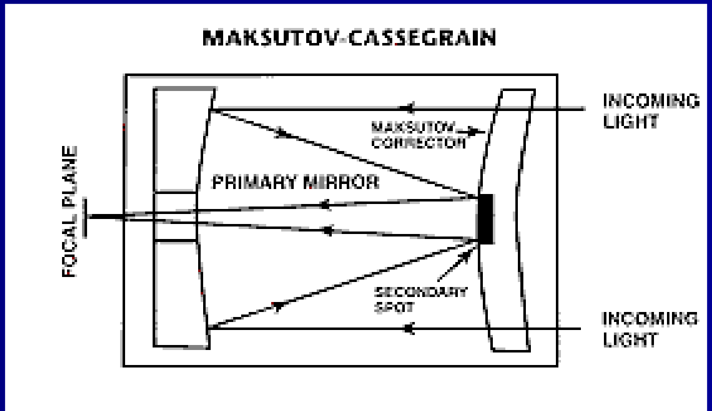


Telescope Types

Catadioptrics (CATs)

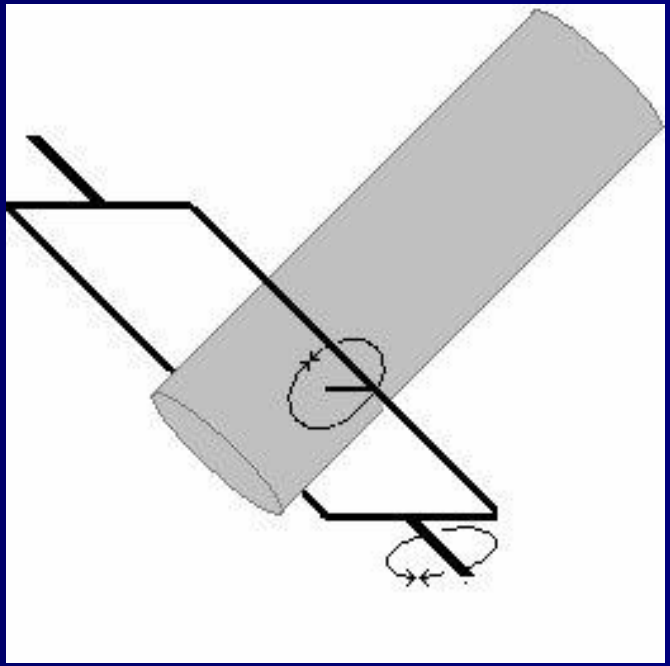


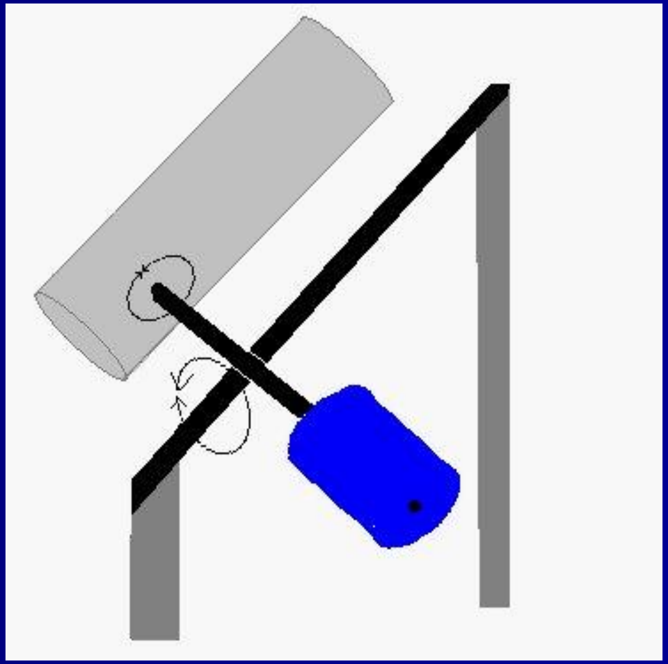
Schmidt-Cassegrain (SCT)



Maksutov-Cassegrain (Mak)

Telescope Mounts

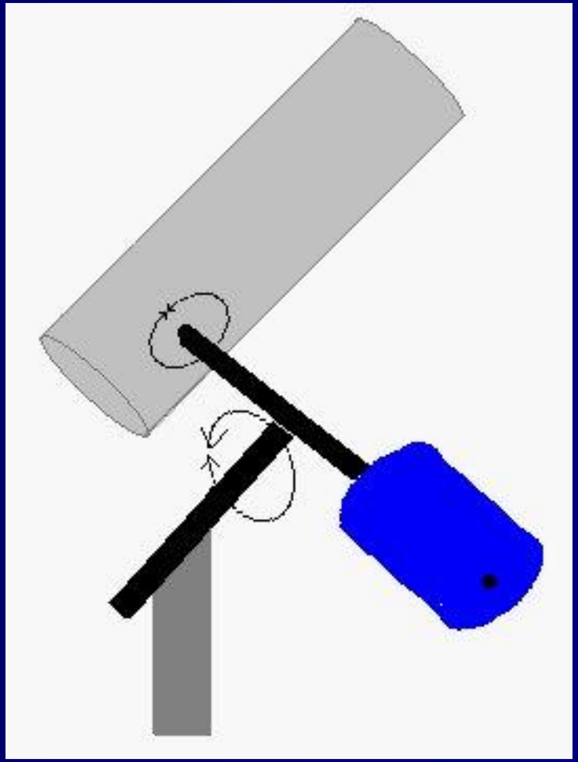


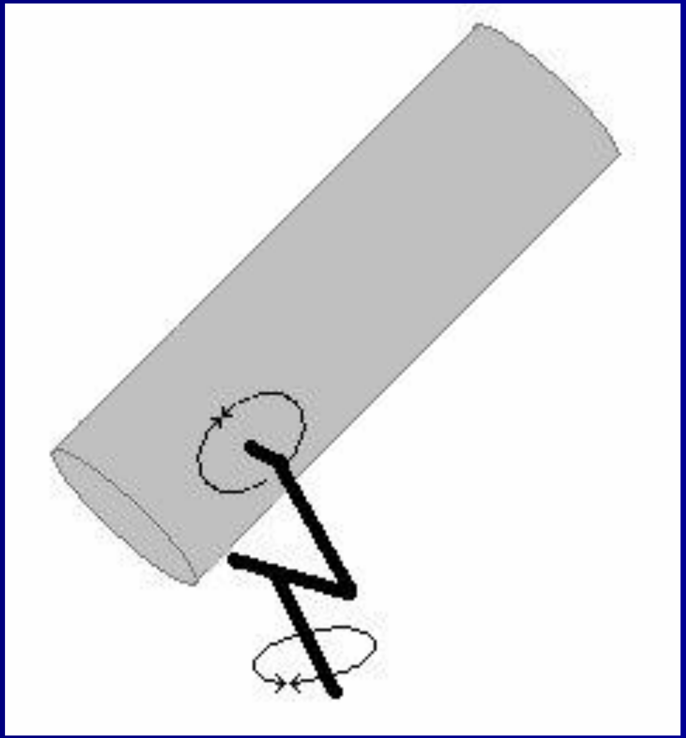


English Cradle

Cross Axis

Telescope Mounts

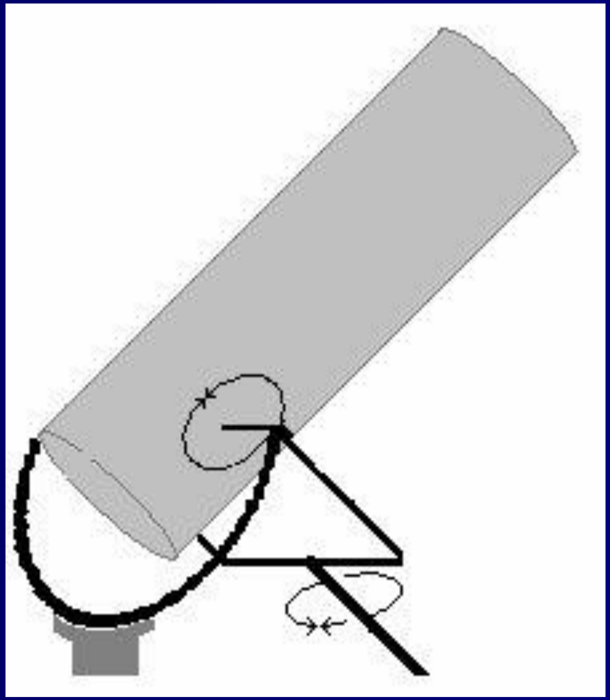




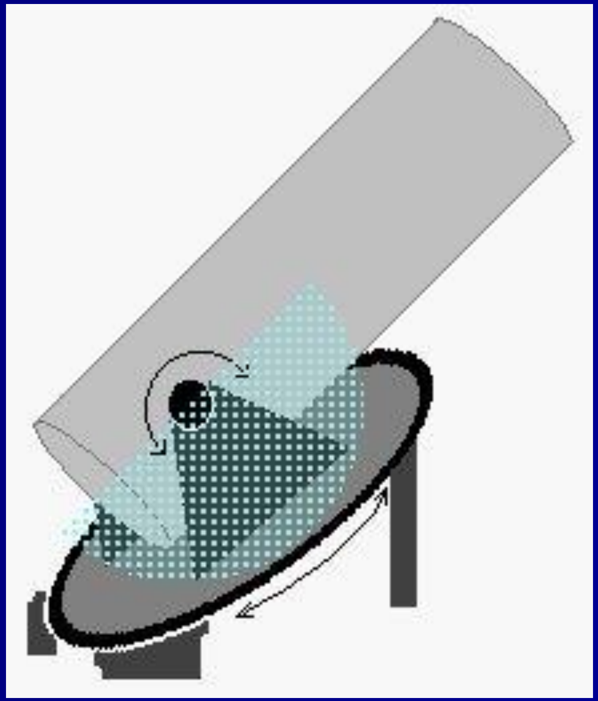
German Equatorial

Fork Mount

Telescope Mounts

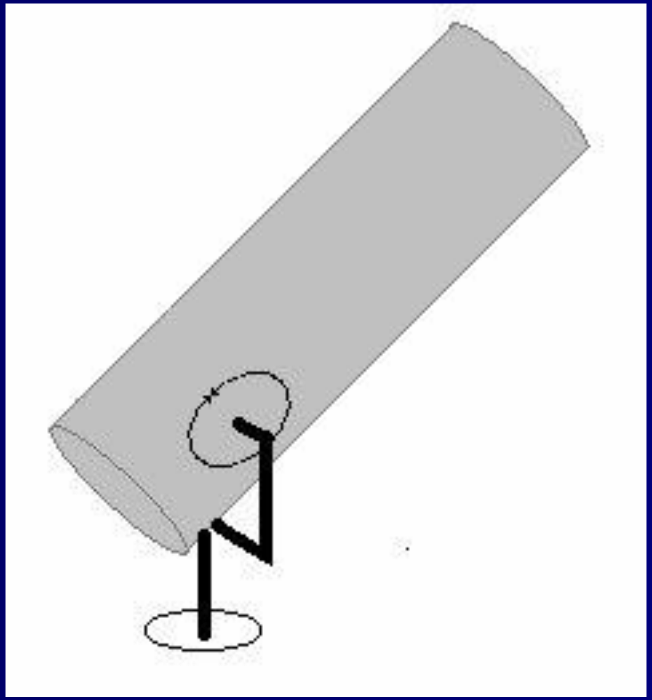


Horseshoe Mount



Polar Disk

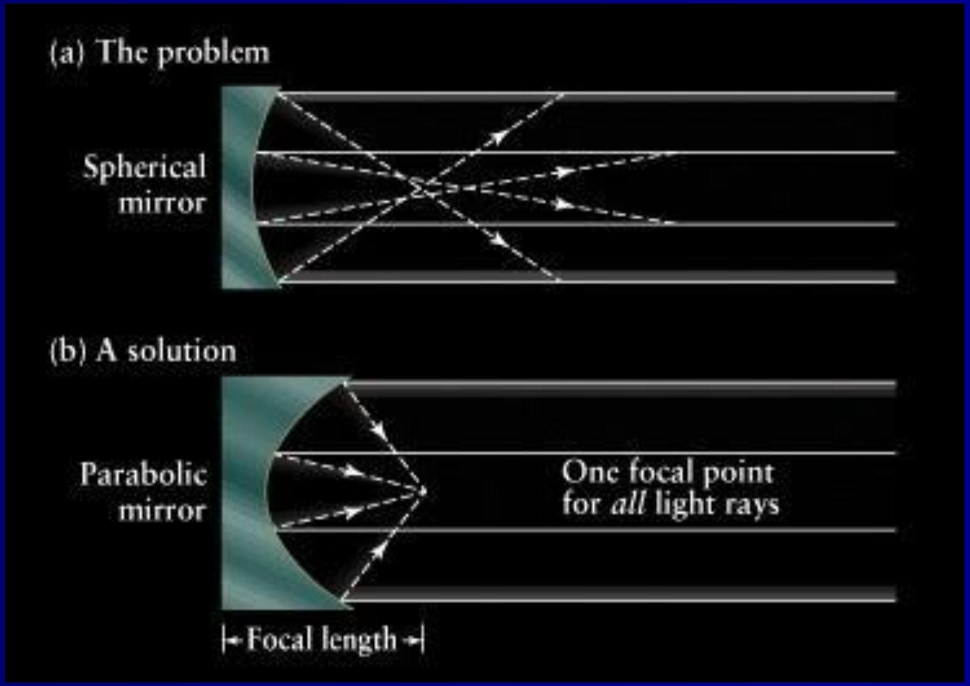
Telescope Mounts



Alt-Azimuth Mount

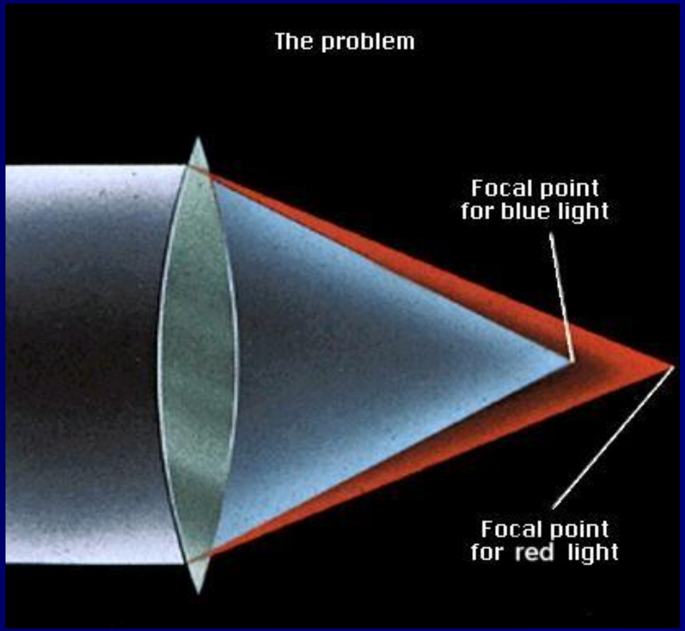
Dobsonian Mount

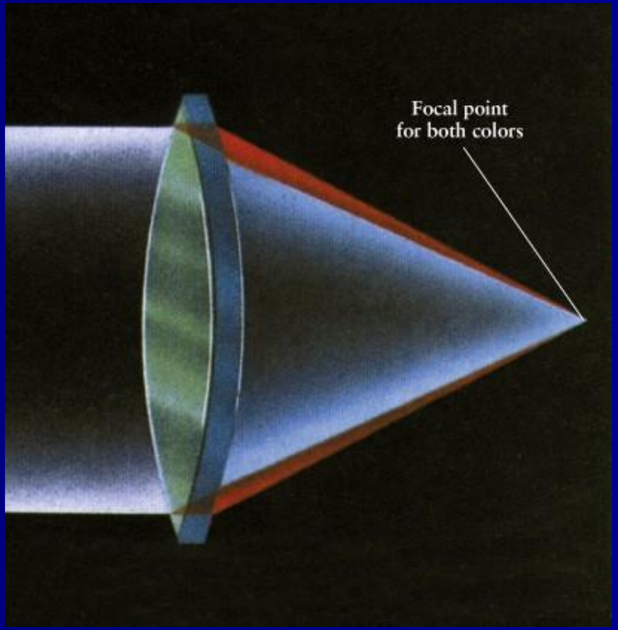
Optical Aberrations



Spherical Aberration

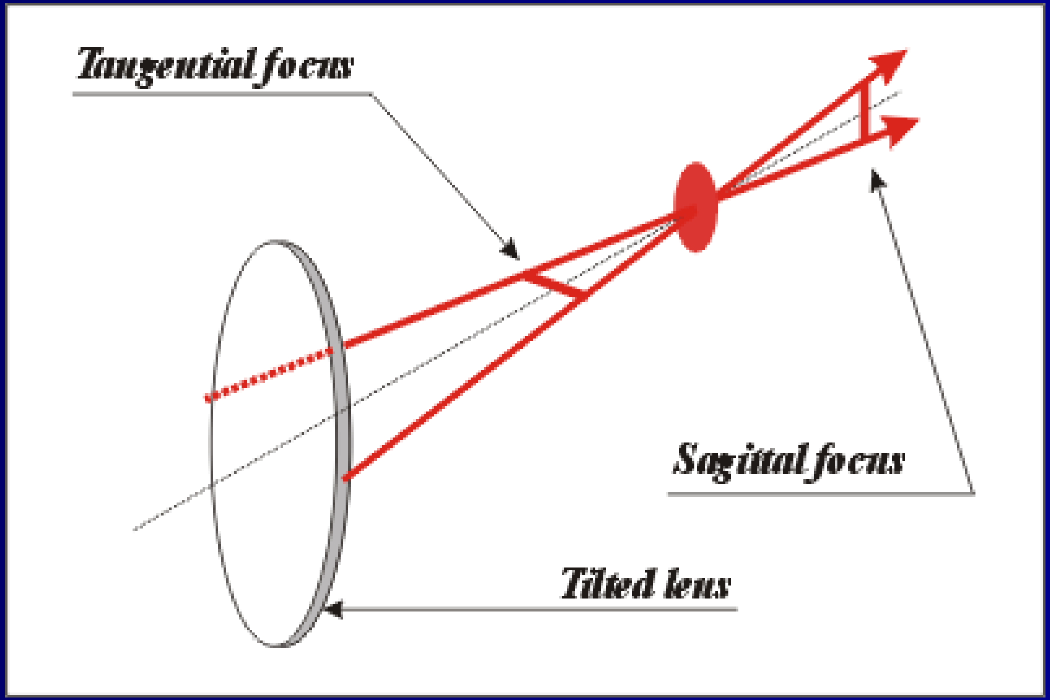
Optical Aberrations





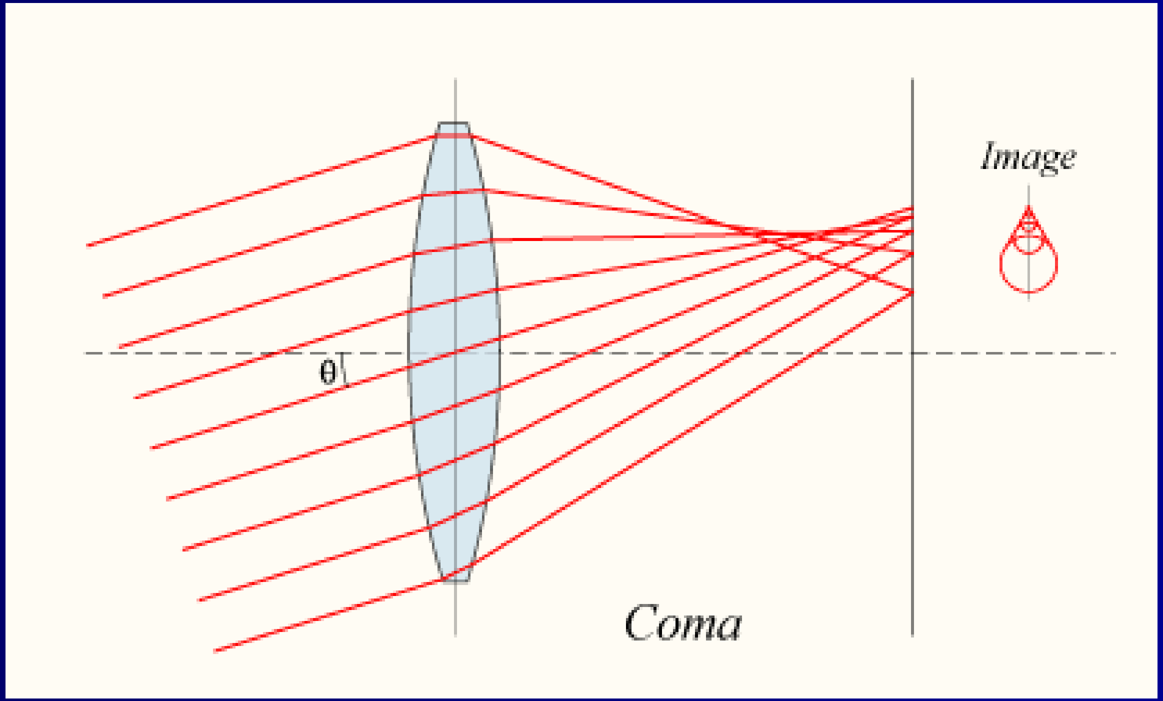
Chromatic Aberration

Optical Aberrations



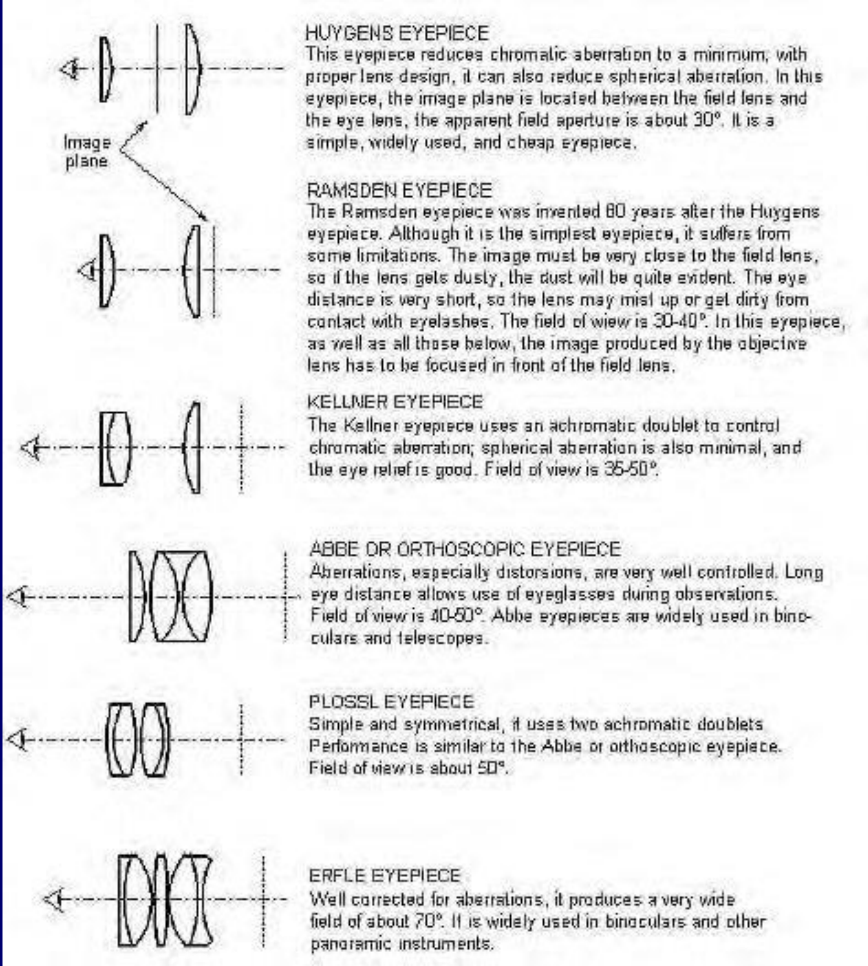
Astigmatism

Optical Aberrations



Coma

Eyepieces (oculars)



HUYGENS EYEPIECE
This eyepiece reduces chromatic aberration to a minimum; with proper lens design, it can also reduce spherical aberration. In this eyepiece, the image plane is located between the field lens and the eye lens, the apparent field aperture is about 30°. It is a simple, widely used, and cheap eyepiece.

Image plane

RAMSDEN EYEPIECE
The Ramsden eyepiece was invented 80 years after the Huygens eyepiece. Although it is the simplest eyepiece, it suffers from some limitations. The image must be very close to the field lens, so if the lens gets dusty, the dust will be quite evident. The eye distance is very short, so the lens may mist up or get dirty from contact with eyelashes. The field of view is 30-40°. In this eyepiece, as well as all those below, the image produced by the objective lens has to be focused in front of the field lens.

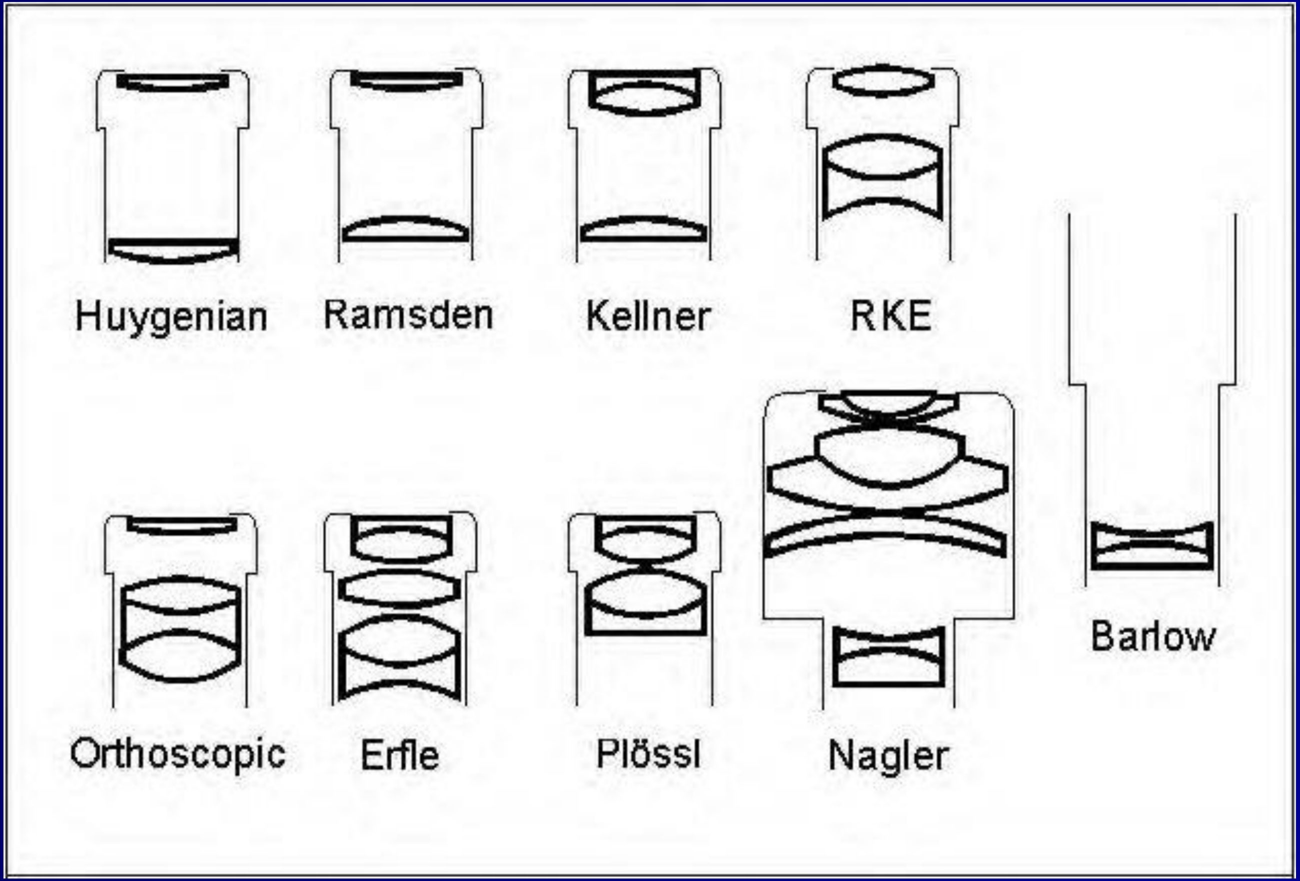
KELLNER EYEPIECE
The Kellner eyepiece uses an achromatic doublet to control chromatic aberration; spherical aberration is also minimal, and the eye relief is good. Field of view is 35-50°.

ABBE OR ORTHOSCOPIC EYEPIECE
Aberrations, especially distorsions, are very well controlled. Long eye distance allows use of eyeglasses during observations. Field of view is 40-50°. Abbe eyepieces are widely used in binoculars and telescopes.

PLOSSL EYEPIECE
Simple and symmetrical, it uses two achromatic doublets. Performance is similar to the Abbe or orthoscopic eyepiece. Field of view is about 50°.

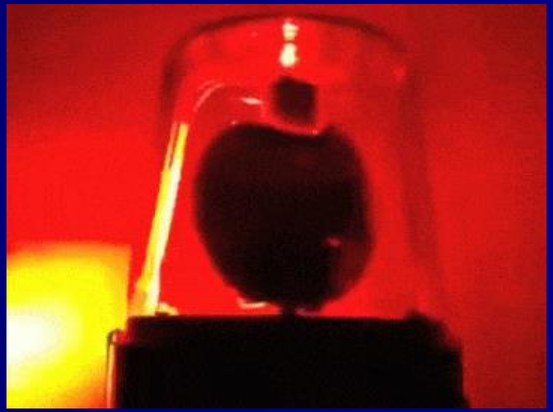
ERFLE EYEPIECE
Well corrected for aberrations, it produces a very wide field of about 70°. It is widely used in binoculars and other panoramic instruments.

Eyepieces (oculars)



Warning!

Math Alert



Telescope Resolution

Dawes Limit or "D" apparent size of smallest object clearly resolved

$$D = \frac{4.56}{\text{aperature of telelscope in inches}}$$

$$D = \frac{4.56}{6} = 0.76\ \text{arcsec}$$

Magnification

$$M = \frac{\text{telescope focal length}}{\text{eyepiece focal length}}$$

UNITS MUST BE THE SAME!! **1in = 25.4mm**

$$M = \frac{2000mm}{20mm} = 100X$$

Limiting Magnitude

Faintest magnitude that can theoretically be seen.

$$M_l = 4.4 + 4.5 \log A$$

Where: A = the aperture in mm

Telescope Types

Refractors

Pros	Cons
•Closed tube construction	•Not portable above 4”
•Unobstructed aperture	•Needs heavier mount
•High contrast images	•Chromatic aberration
•Holds collimation well	•Difficult to manufacture
•Low maintenance	•High initial costs
•No Coma	•Eyepiece positioning

Telescope Types

Reflectors

Pros

- Totally Achromatic
- Ease of portability
- Ease of manufacture
- Wide field of view
- Lower initial costs
- More aperture per $

Cons

- Central Obstruction
- Optical coatings deteriorate
- Easily misaligned
- More complex optical mounting
- Field restricted by coma
- Tube air currents

Achromat vs. Apochromats

FYI Only

Achromat

- Two widely spaced colors brought together
- Generally crown & flint doublet sometimes coated
- About 5% chromatic aberration
- Reasonable sharp and bright images on better scopes
- More expensive than reflector

- Good 4" Meade is $900 - $1200

Apochromat

- Three widely spaced colors brought together
- Doublet with exotic materials such as calcium fluorite
- Color error reduced by 10%
- Slightly sharper & brighter (claimed by some)
- Double or more the cost of comparable achromat
- Meade 4" Apo is $2000 - $2500
- Takahashi 4" $6,000 - $8000

Telescopes

Thank You

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