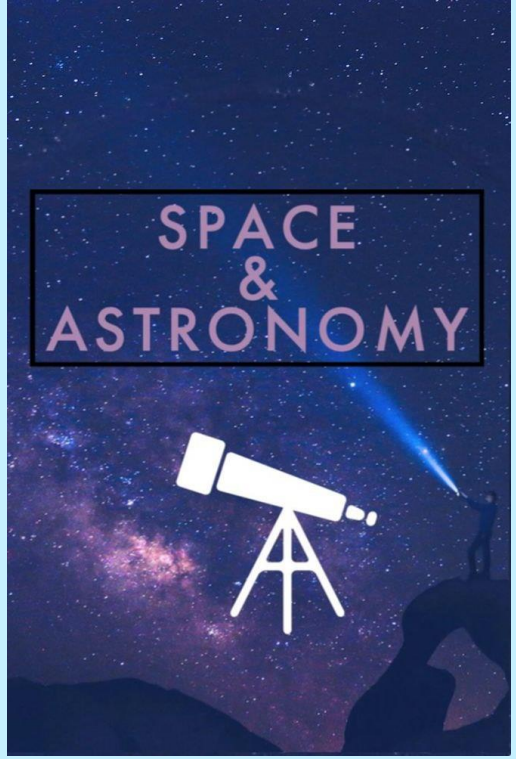

Space, Astronomy and Astrophotography

Dr. Marco Pezzutto

Voices Of the World

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Space and Astronomy

Types of Telescopes

Many Types of Telescopes

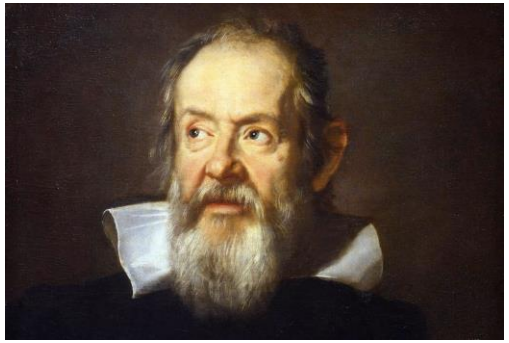
Throughout history many different strategies were invented to build telescopes

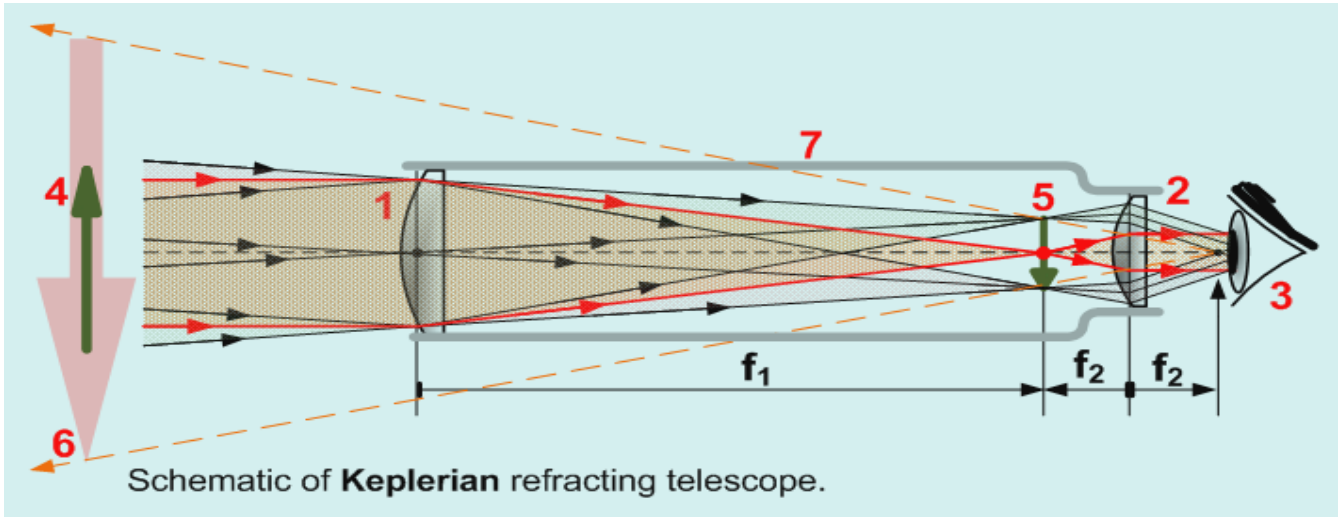
- The first one (early 17th Century) is the **Refractor:** a **single lens** as primary optics, plus a second lens as eyepiece
- Just few decades afterwards, the second type of telescope was invented: the **Reflector**, where the primary optics is a curved **mirror**
- Later on, **Cassegrain & Catadioptric** telescopes were invented, to achieve more *power* in a more *compact* device
- In the 30s, **Radio Telescopes** appeared. They don't really look like telescopes, in fact they are *huge parabolic antennas*
- Since the 60s, so many new devices were invented for observing Space in more and more regions of the electromagnetic spectrum: X-ray, Infrared, microwave telescopes…

Video: [Astrophotography P1: Telescope OTAs - YouTube]

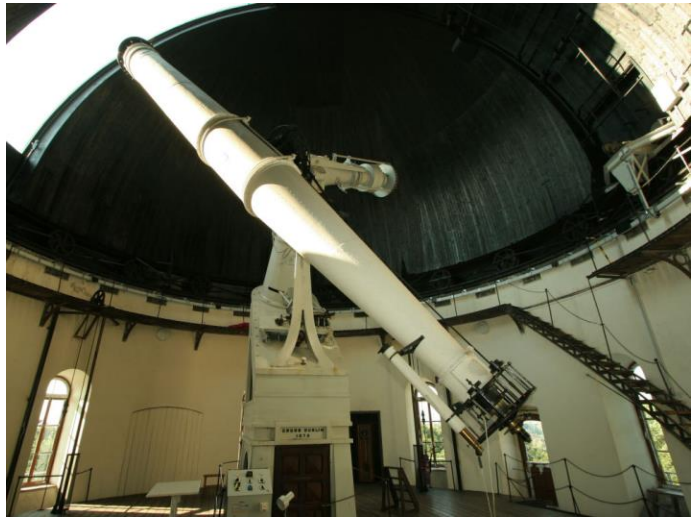
Refractors, Galilean and Keplerian

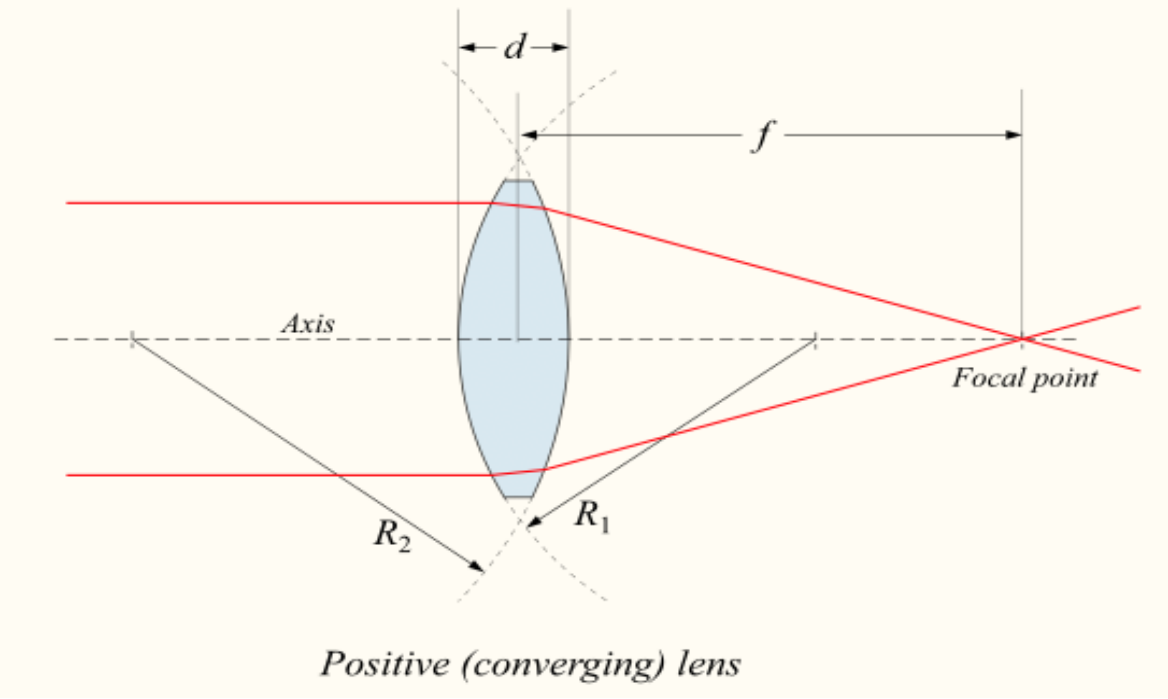
- The Gelilean Refractor is the first type of telescope, actually invented in the early 17th Century in *Netherlands,* and later perfected by Galileo Galilei in Italy
- The main optics is provided by a **Single Glass Curved Lens**, usually *spherical*
- Nowadays, the optics is usually improved and includes two or three *aspherical and apochromatic* elements, for improved resolving power, colour accuracy and focusing precision
- An eyepiece is needed for visual observation



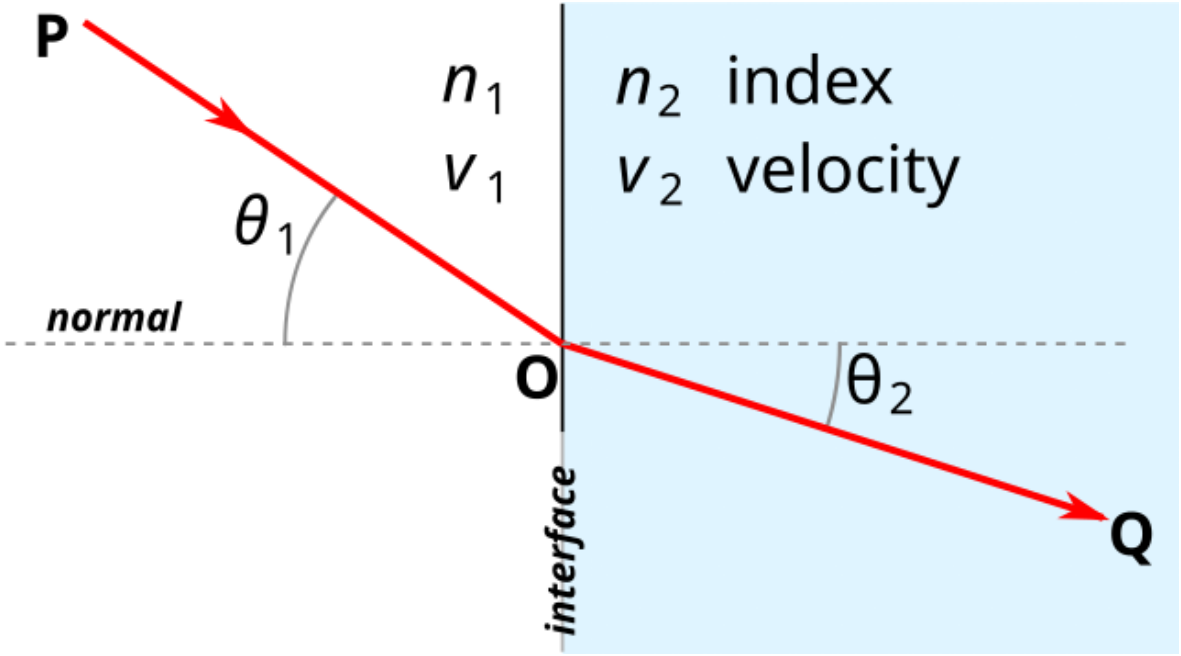


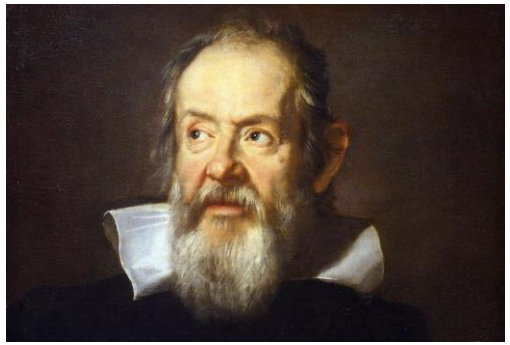
Schematic of **Keplerian** refracting telescope.





Positive (converging) lens





Snell Law of Refraction

REFRACTION

*The change of **direction** of a ray of light when passing **from one medium to another***

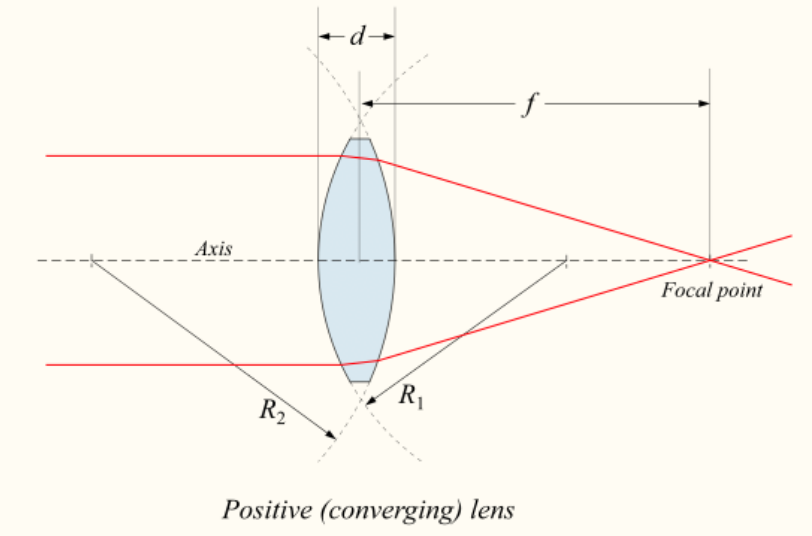
$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{n_1}{n_2}$$

Lens Focus Control

- Any photo lens, no matter how complicated, works essentially like a **single converging lens**.
- Lenses have a key parameter:

Focal Length

The distance behind the lens at which the lens focuses rays of light coming parallel to the optical axis from a very distant objects.

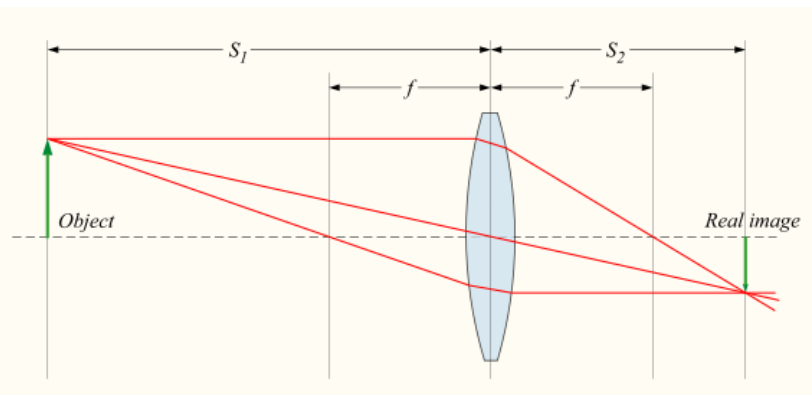


Positive (converging) lens

- Simple lenses work accordingly to the following law:

Lens constructor's rule

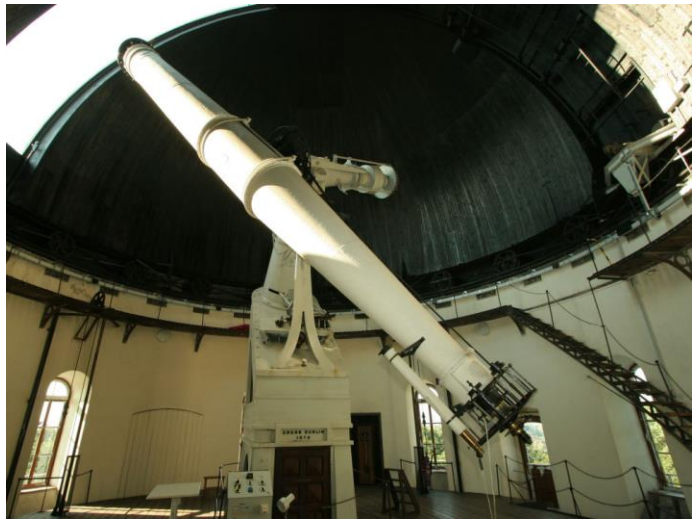
$$\frac{1}{f} = \frac{1}{S_1} + \frac{1}{S_2}$$

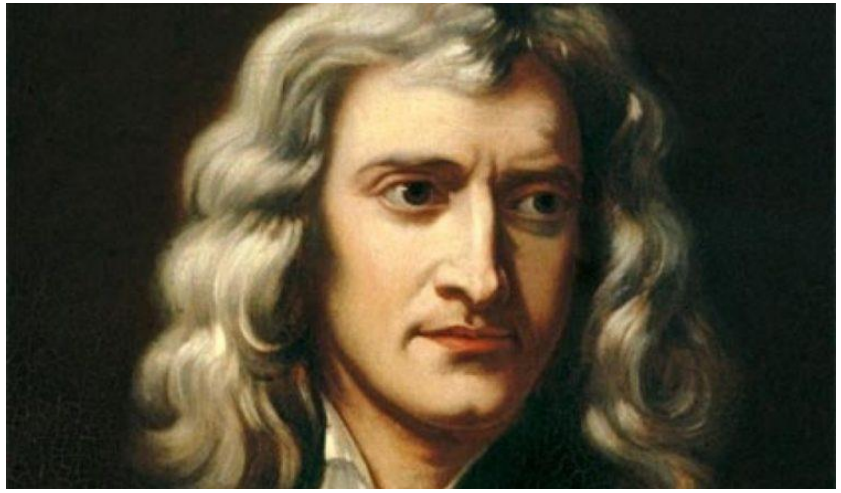


- Therefore, the *lens/sensor distance* must be set according to the *subject/camera distance*, to have the sharpest possible image on the focal plane. This corresponds in practice to **focusing the lens.**

Refractor's PROs and CONs

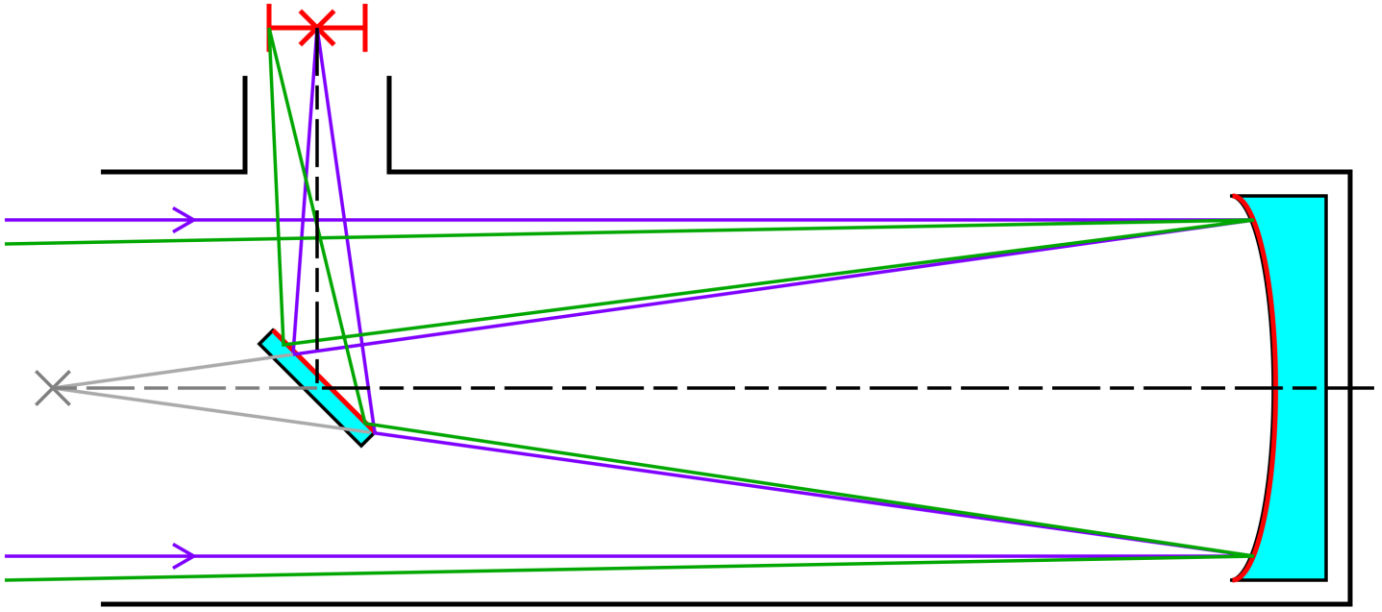
- Refractor telescopes are among the most popular and successful telescopes in history and for good reasons! Few of them are:
  1. **Simple** built, and also to use
  2. **Relatively cheap** compared to the other types of telescopes
  3. **Lighter** to carry
  4. **Easy** to use for photography (they work just like any other lens!)
  5. **Best Contrast** for photography!
- Of course they also have some limitations and disadvantages:
  1. **LONG!** (At least as much as their focal length)
  2. **Not very Large Relative Aperture** (not much light coming in, compared to other telescopes of similar dimension/cost)
  3. **Spherical aberrations Colour Fringes** in the simplest models (although they are almost completely corrected in the best models)
- In conclusion, refractors are typically **great for**:
  1. Having **small** and **portable** telescope
  2. Solar **system** observations (objects that are not too far
  3. Getting started with **astrophotography** with little effort

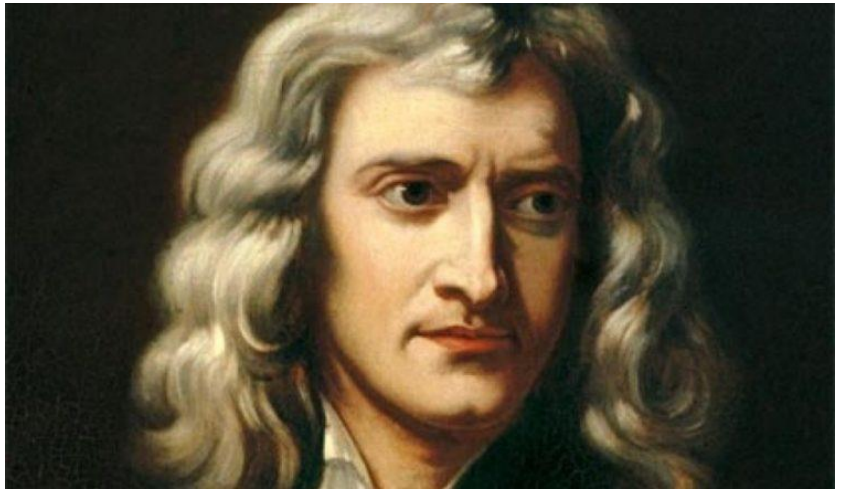




Newtonian Reflector

- Uses a **Parabolic Mirror** as main focusing device
- Invented by Sir Isaac Newton in early 1600s
- Requires an additional eyepiece for visual astronomy



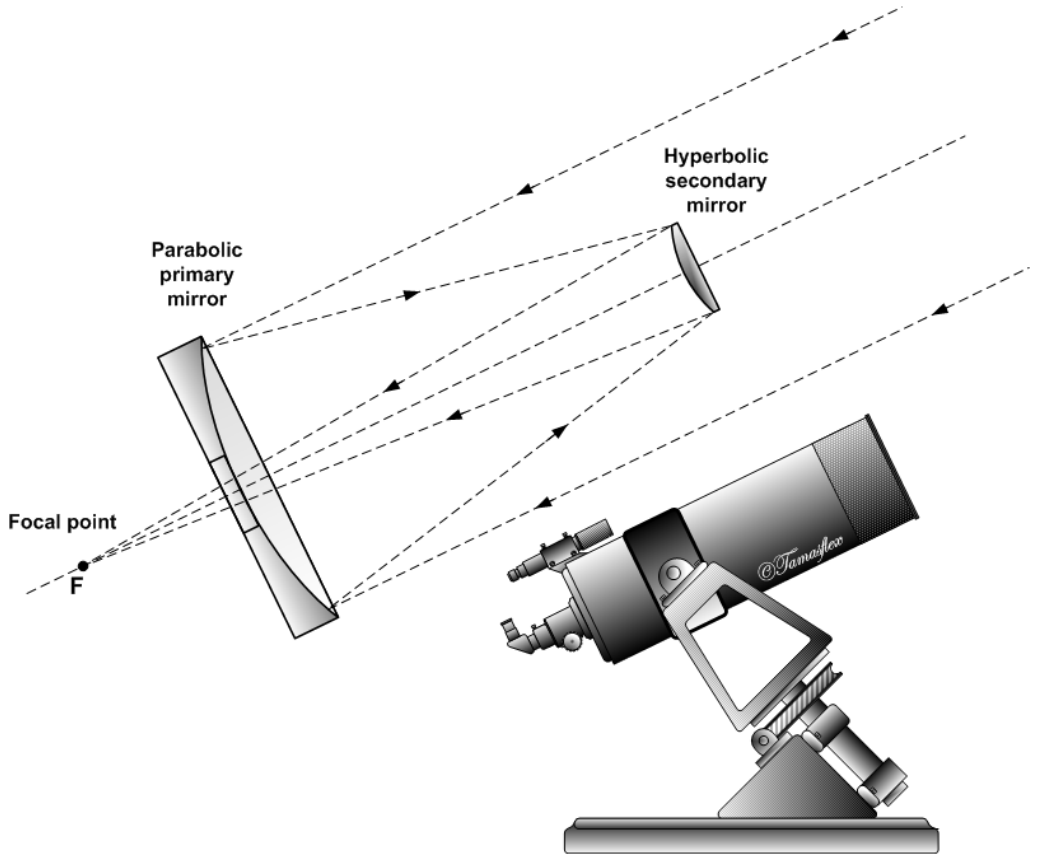


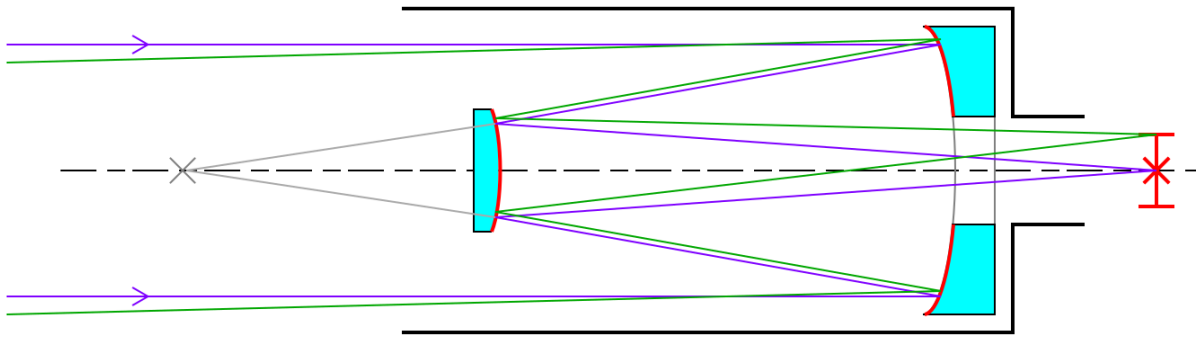
Reflector's PROs and CONs

- Besides refractors, Newtonians Reflectors are the most popular telescopes used by astronomers throughout history, for many good reasons:
  1. **High quality** for the price
  2. **Simple** to manufacture and build (just two mirrors + eyepiece)
  3. **High Luminosity** for a given size and focal length
  4. **More compact** than a refractor of comparable focal length and price
  5. **Free from chromatic aberrations** (if mirror is perfectly parabolic)
- Reflectors also have some limitations though:
  1. **Large** (usually)
  2. **Not too great power** (short focal length), max around 1000-1500 mm
  3. **Prone to coma** (optical aberration at the edges of the image)
  4. **Not as easy as refractor for photography**: Astrophotography P1: Telescope OTAs – YouTube (min 19:00)
- In Conclusion, Reflectors are great for:
  1. **Observations of solar system** and **near deep space** objects
  2. **Photography!** (*if technical problems are sorted out*)
  3. **… anything**, within its reach

Cassegrain & Catadioptric

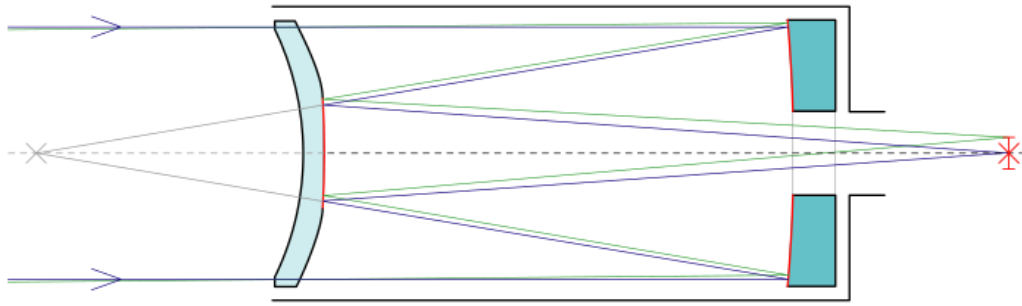
- **Cassegrain** telescopes are composed by **two mirrors**:
  1. A *primary concave* mirror (parabolic)
  2. A *secondary convex* mirror (hyperbolic)
- They were first conceived by *Laurent Cassegrain* in 1672
- The parabolic primary mirror works exactly as the primary mirror of a Newtonian
- The secondary mirror is hyperbolic and therefore it adds an **enlarging effect**
- This is the optical design used in many of the greatest telescopes we have, including GCT ☺ in La Palma, and the ESA telescope in Tenerife… and so many others in the world, even *radio* telescopes

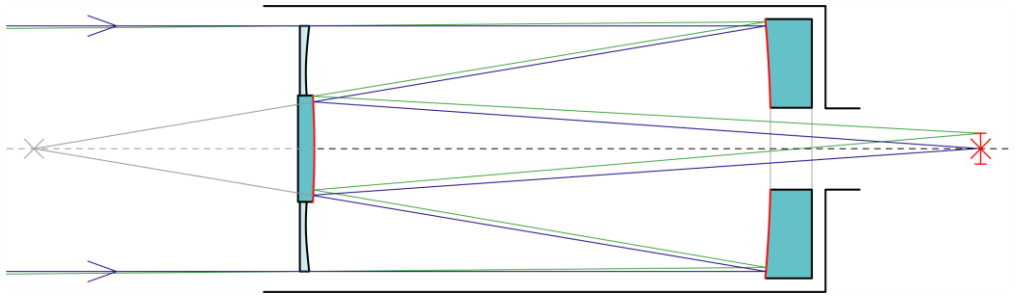




Cassegrain & Catadioptric

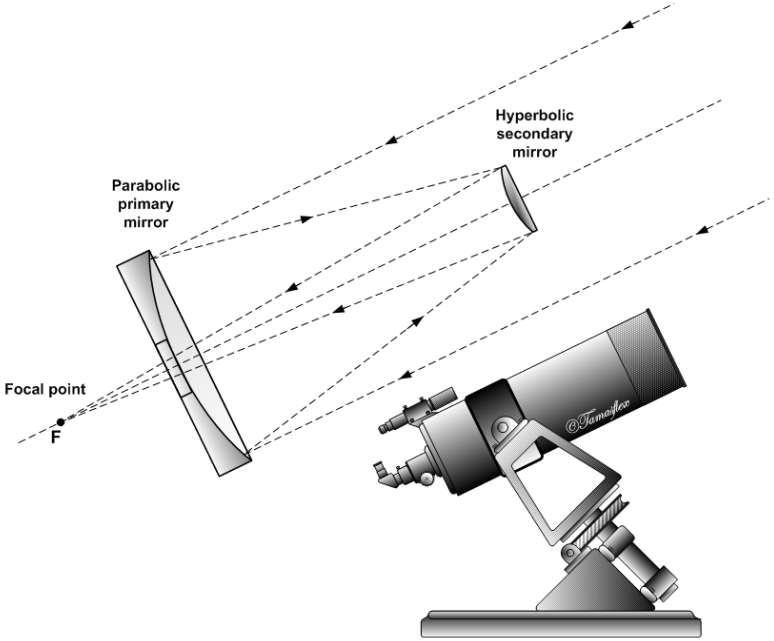
- Cassegrain telescopes are great, but **difficult** to manufacture with the required precision, because of the difficulty of building the mirrors with the exact curvature
- Pure Cassegrain designs are only present in observational stations, and are custom-made
- For easiness of manufacturing, **Catadioptric Variations** of the Cassegrain design were invented. They combine **SPHERICAL MIRRORS** and **LENSES.**
- In catadioptric designs, lenses are used to **correct the spherical aberrations** induced by the spherical mirrors.
- The two most popular catadioptric designs are:
    1. *Maksutov-Cassegrain*
    2. *Schmidt Cassegrain*





Cassegrain & Catadioptric PROs and CONs

- **PROs**:
  1. Very compact
  2. They can be very powerful (long focal length)
  3. Also easy for photography (primary focus behind the primary mirror)
- **CONs**:
  1. Not as large relative aperture as a reflector
  2. Usually “too long” focal length for near objects (solar system, galaxies, nebulas…)
  3. More expensive
- **Great for:**
  1. Deep space objects observations
  2. Portability
  3. … pretty much anything!



Earth Observatory Telescopes

Astrophotography P1: Telescope OTAs – YouTube (30:30)

Some of the greatest telescopes in the world use similar designs to those we have just seen

- ESA Very Large Telescopes in Chile: 4 telescopes with 8-meter primary mirrors
- Canary Islands: Grand Telescope Canarias in La Palma: 10.4 primary mirror
- Radio telescopes
- … Hubble in space…

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