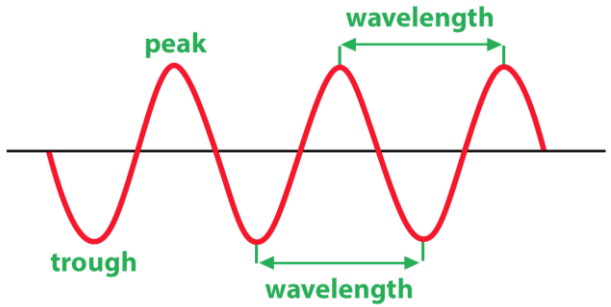
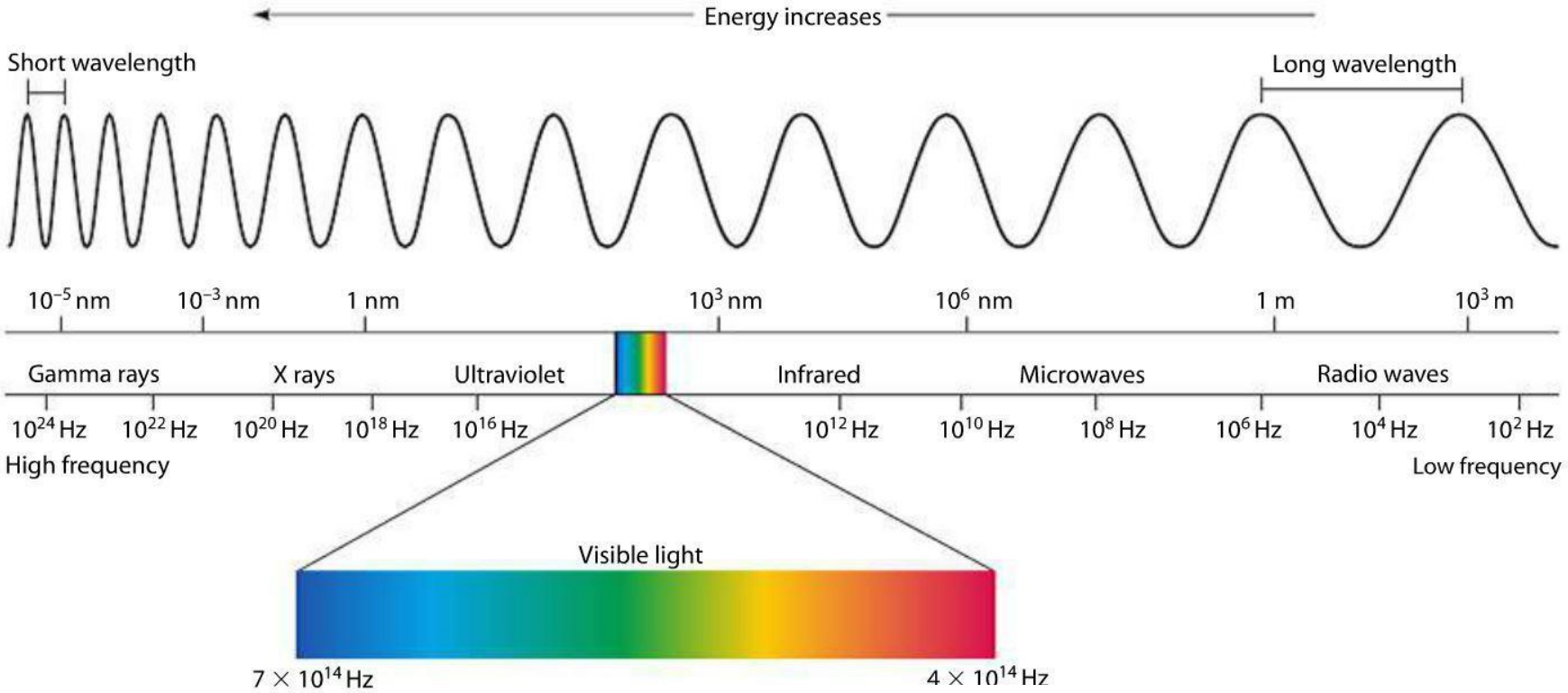
Observational Astronomy

Indian Space Science Olympiad

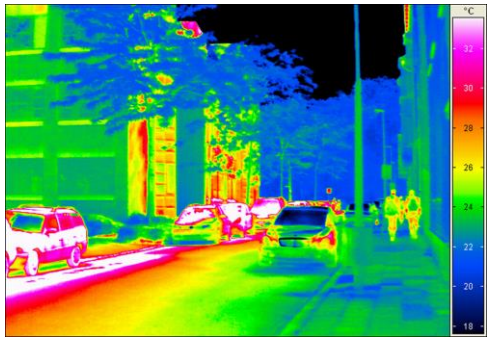
Telescopes

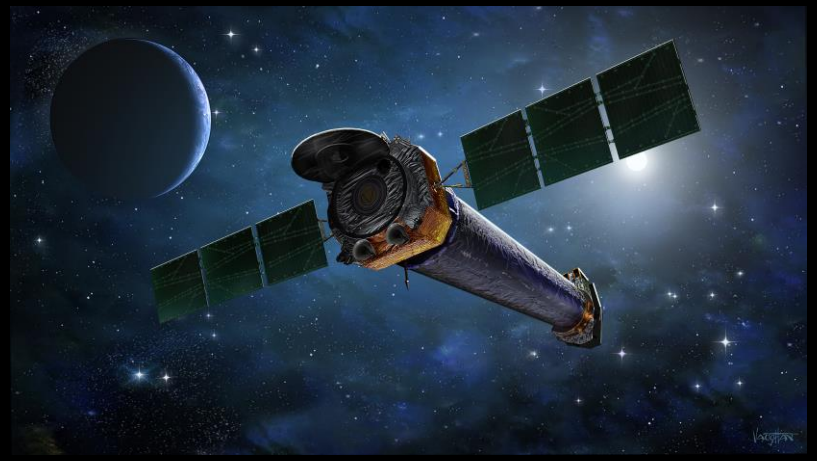

wavelength
peak
trough
wavelength

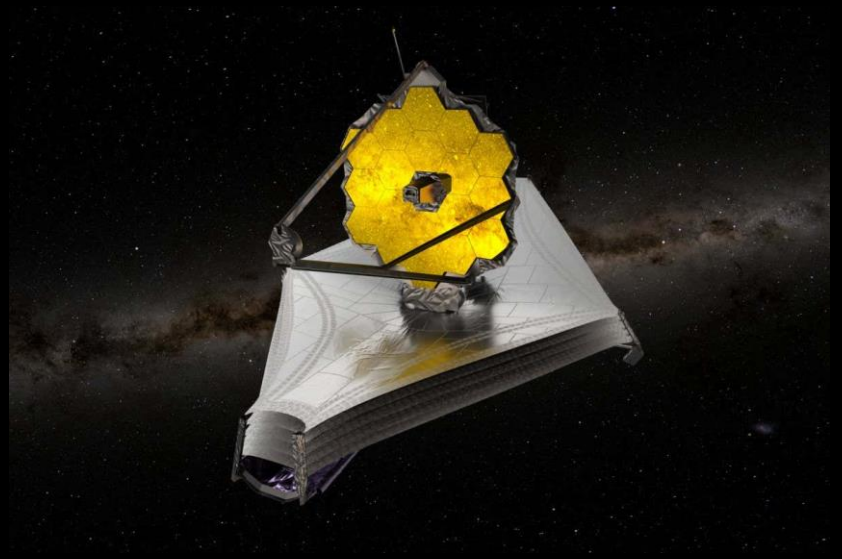

Energy increases
Short wavelength
Long wavelength
10⁻⁵ nm
10⁻³ nm
1 nm
10³ nm
10⁶ nm
1 m
10³ m
Gamma rays
X rays
Ultraviolet
Infrared
Microwaves
Radio waves
10²⁴ Hz
10²² Hz
10²⁰ Hz
10¹⁸ Hz
10¹⁶ Hz
10¹² Hz
10¹⁰ Hz
10⁸ Hz
10⁶ Hz
10⁴ Hz
10² Hz
High frequency
Low frequency
Visible light
7 × 10¹⁴ Hz
4 × 10¹⁴ Hz


12:08

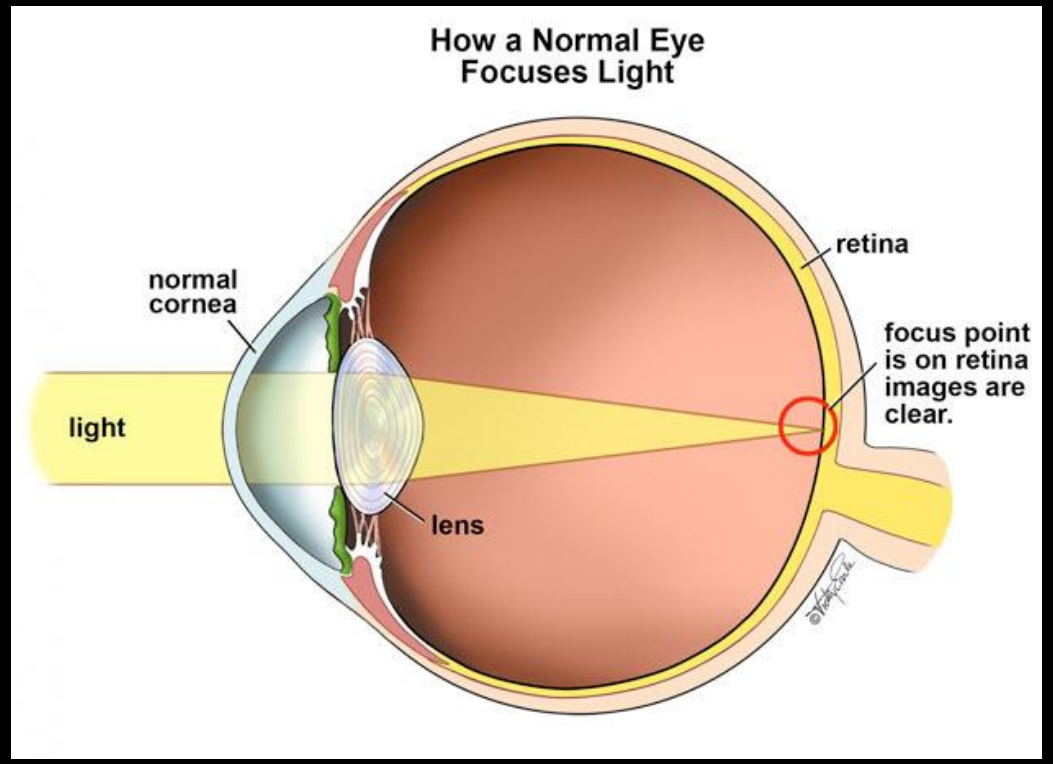

FM
MHz
VOLUME
TUNING

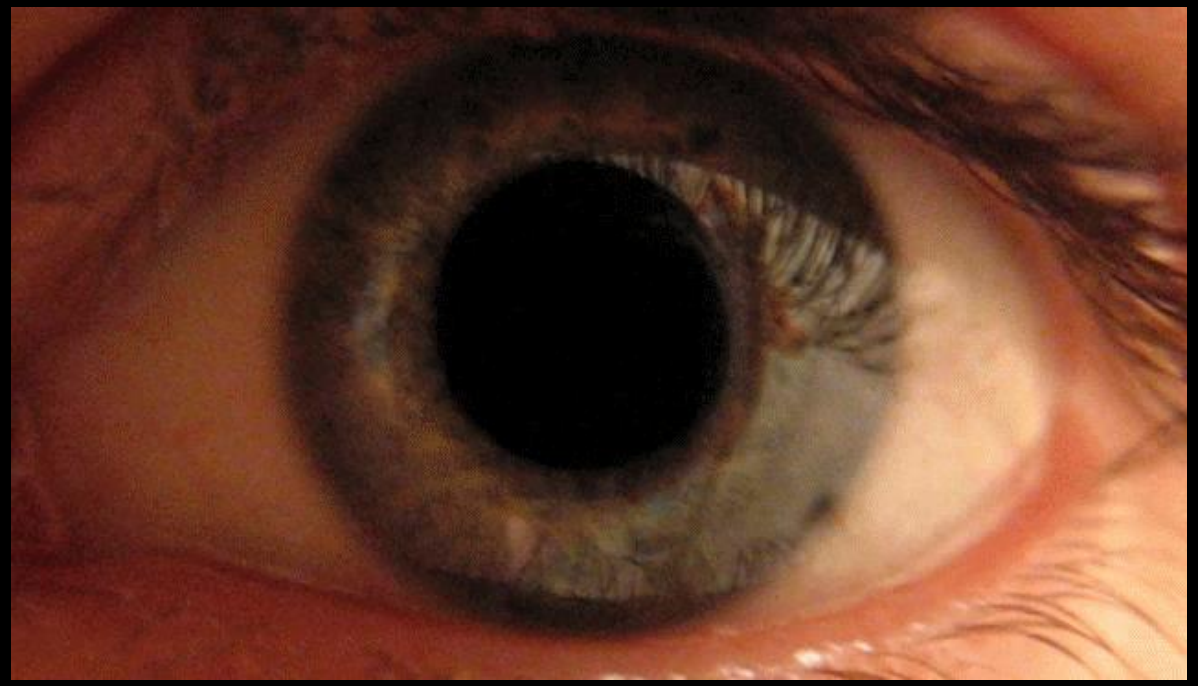


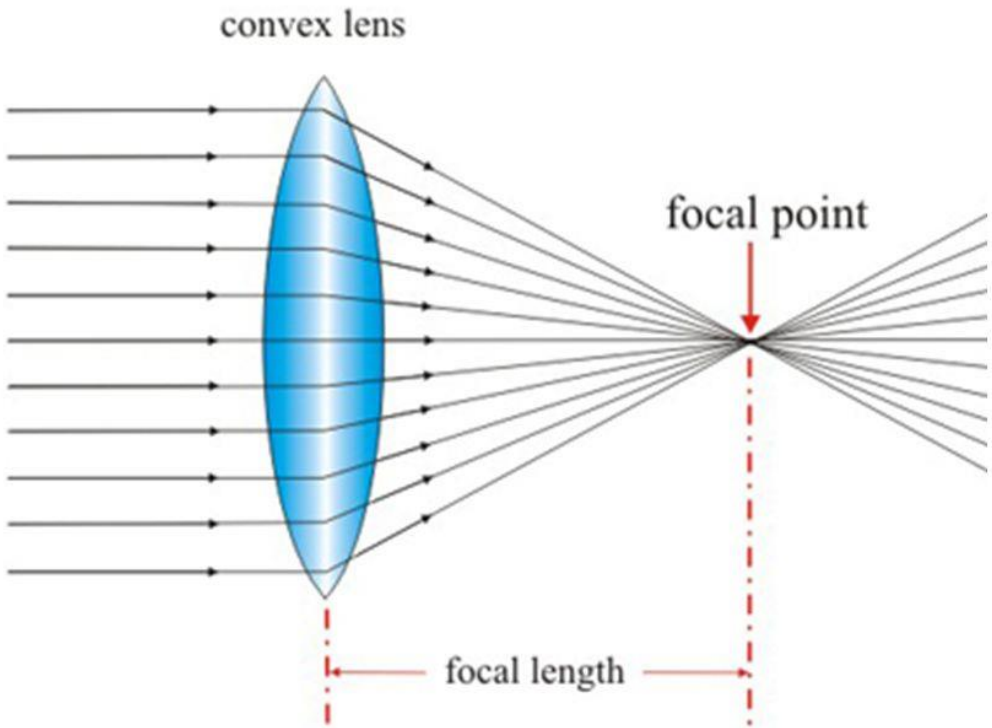


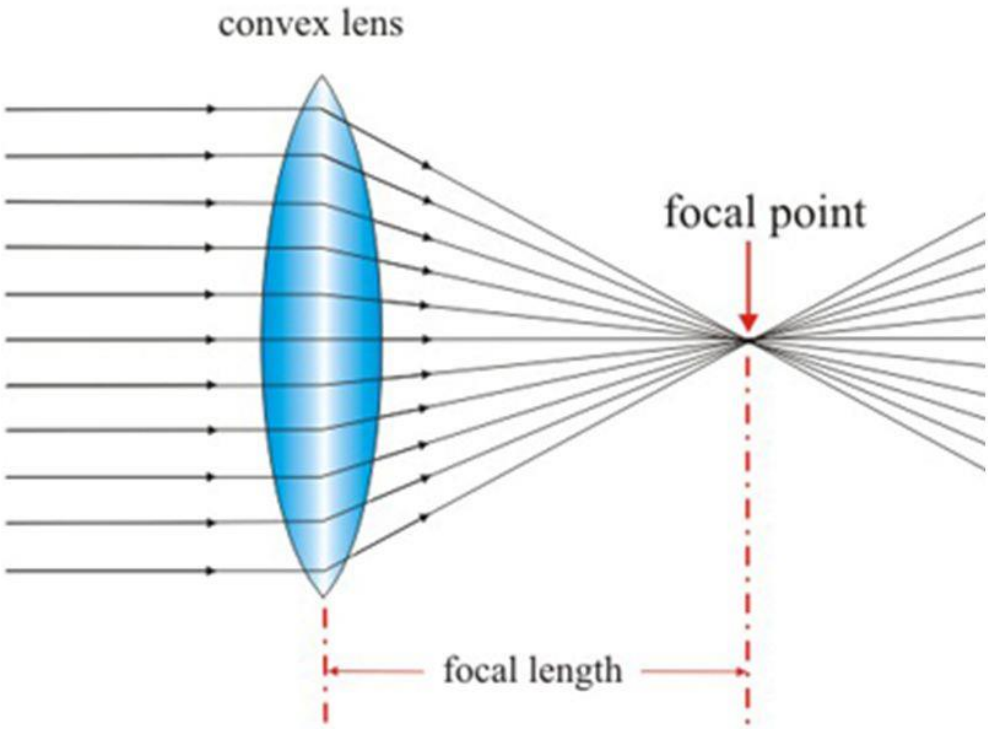


Why Telescopes ?

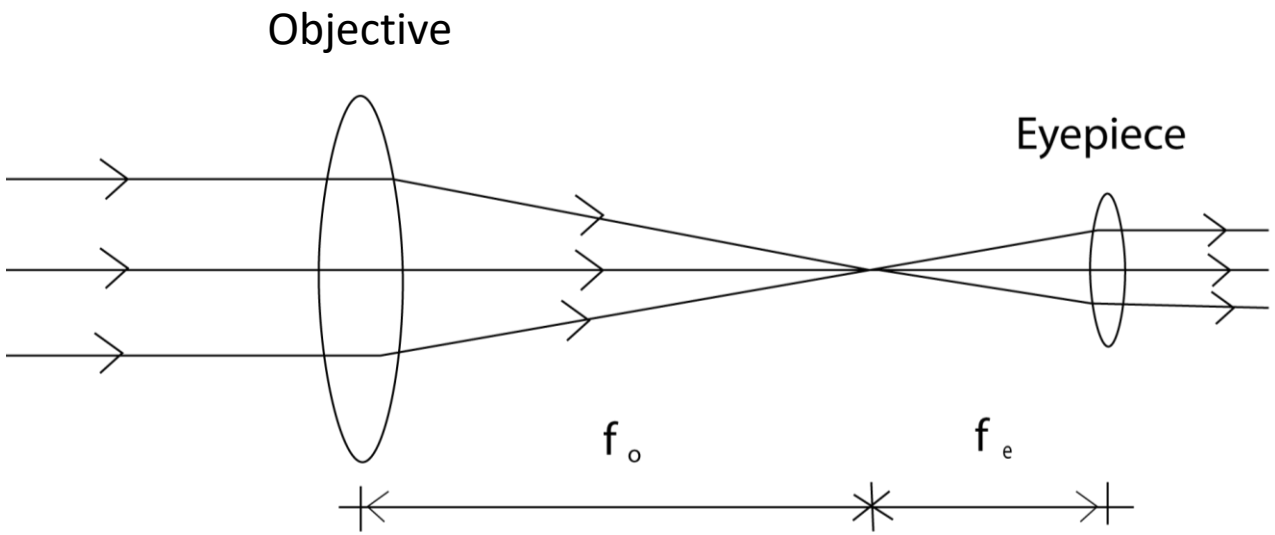




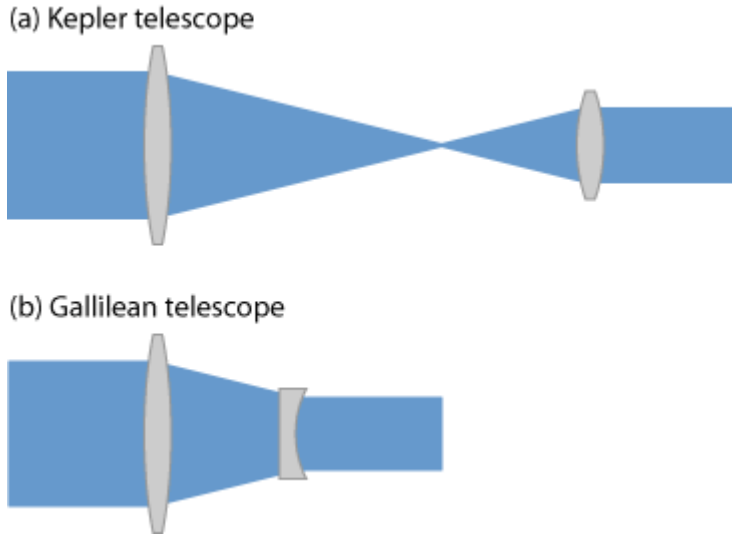

convex lens
focal point
focal length

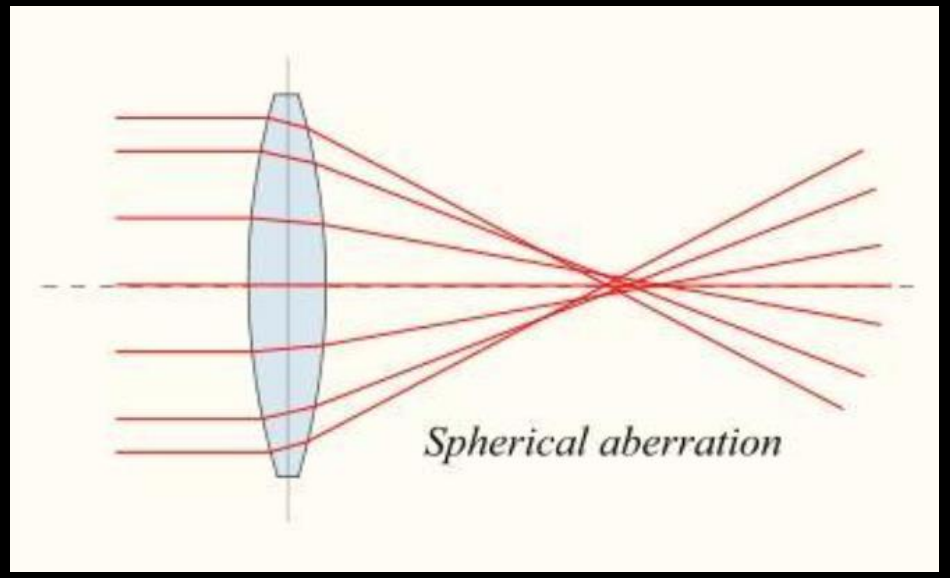

convex lens
focal point
focal length

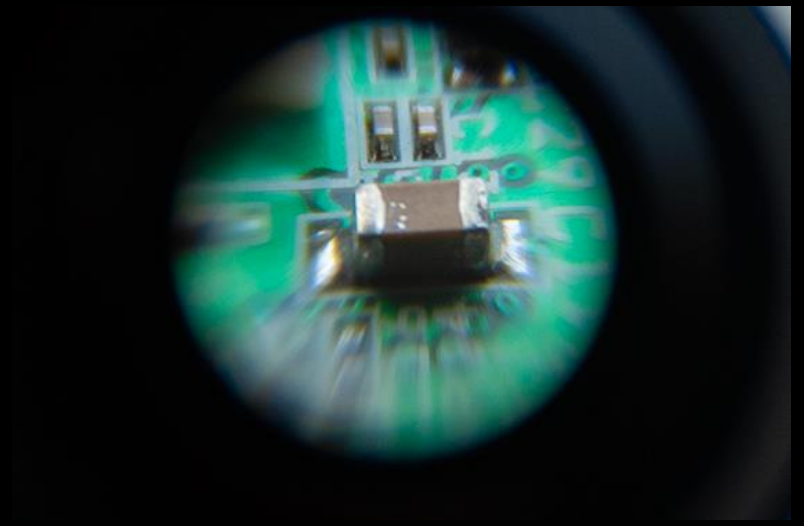
REFRACTING TELESCOPES

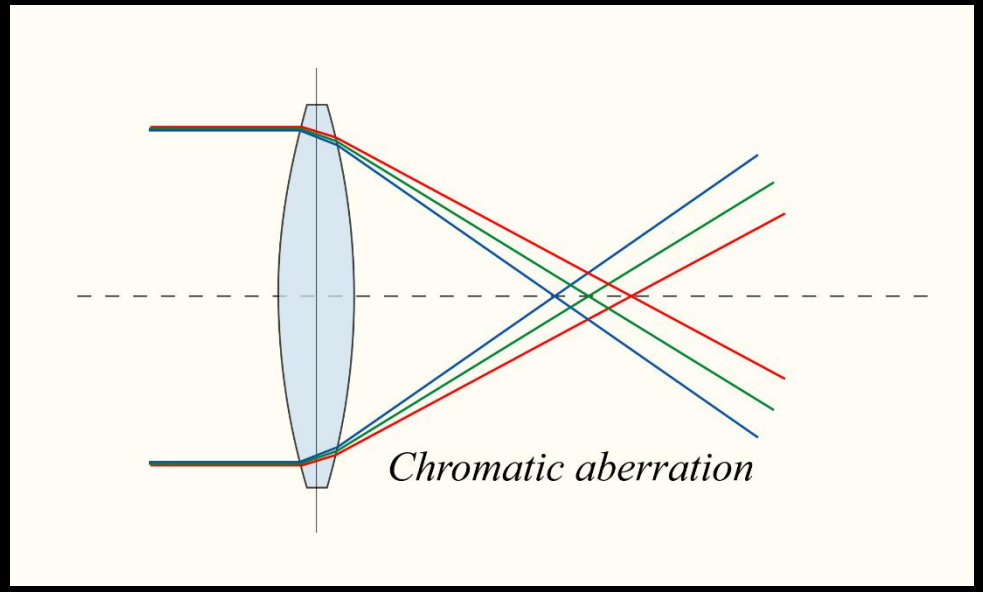


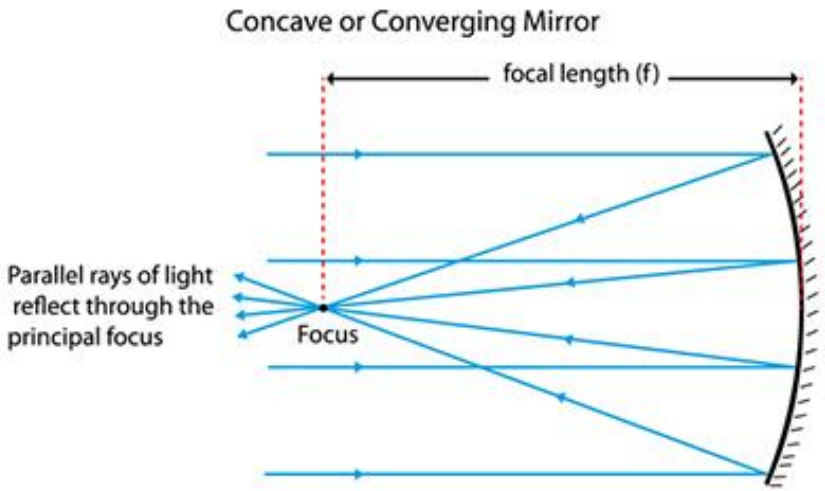
$$m = \frac{f_{\text{obj}}}{f_{\text{eye}}}.$$



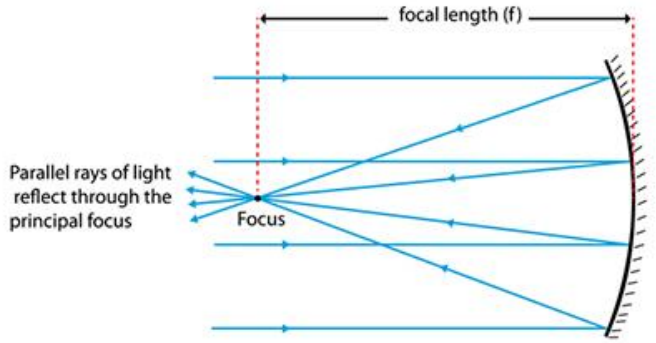

Spherical aberration

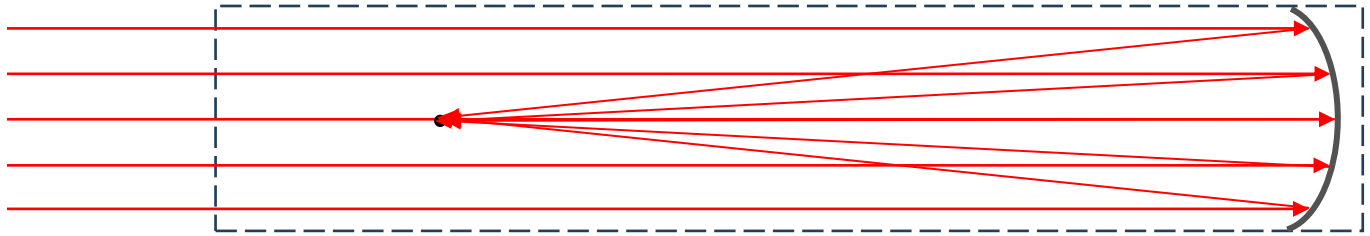



Chromatic aberration

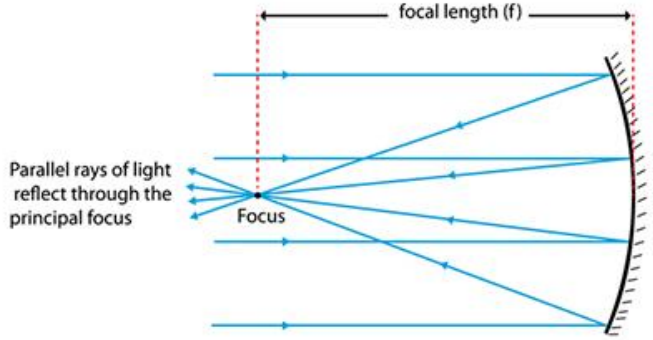

Concave or Converging Mirror
focal length (f)
Parallel rays of light
reflect through the
principal focus
Focus

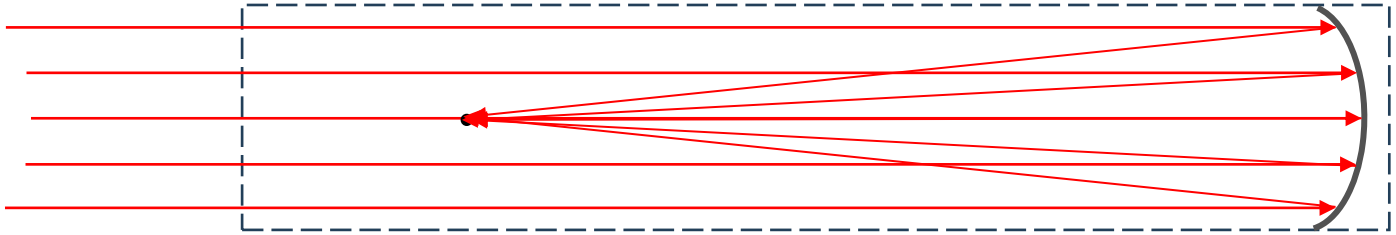
REFLECTING TELESCOPES

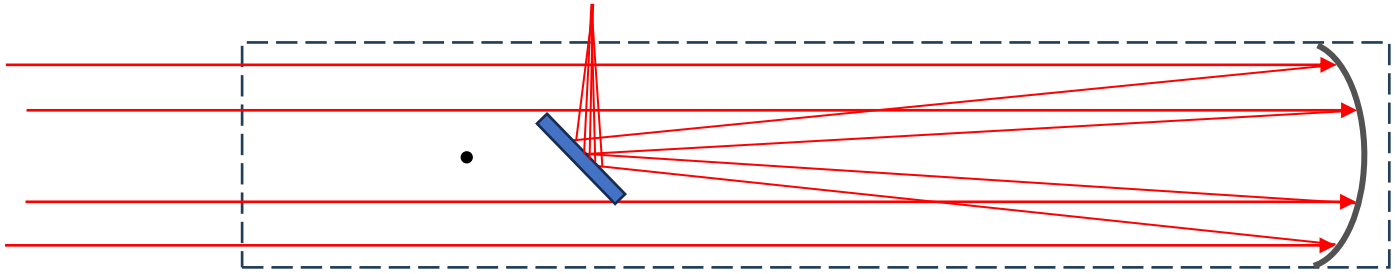




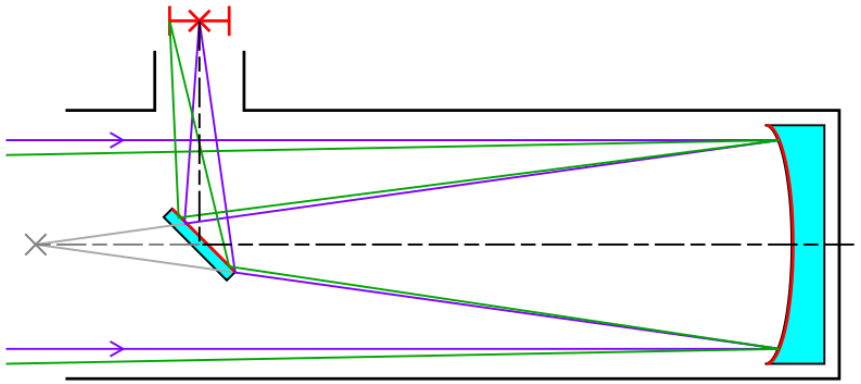
REFLECTING TELESCOPES



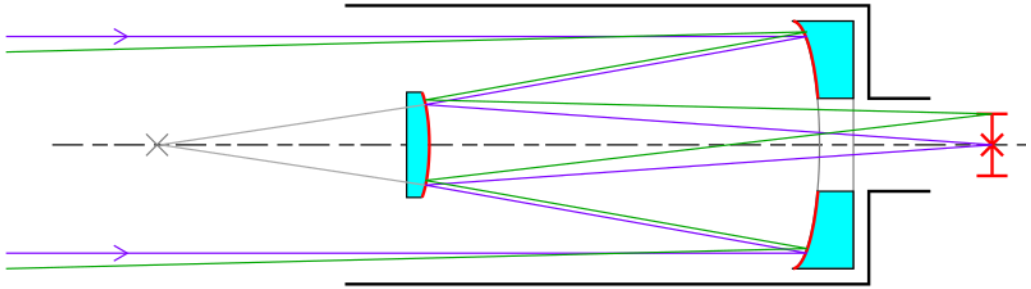




REFLECTING TELESCOPES

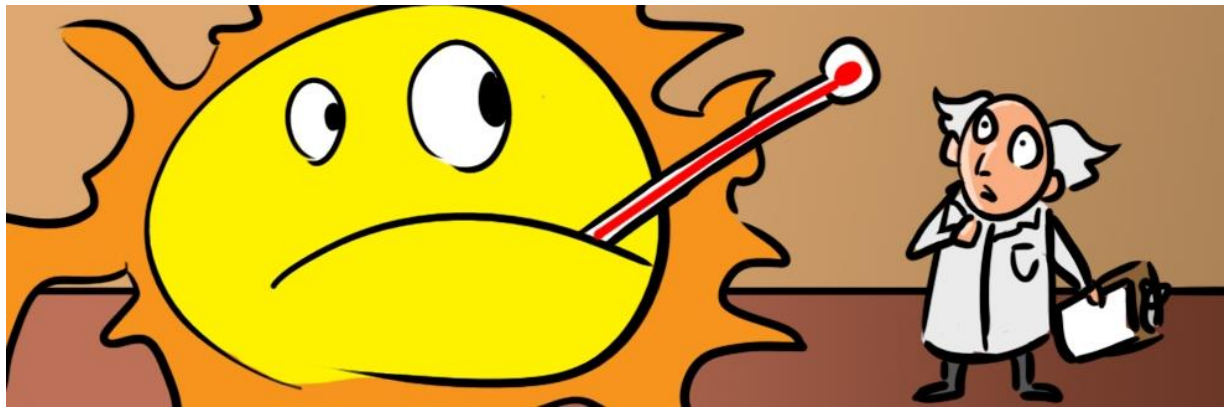


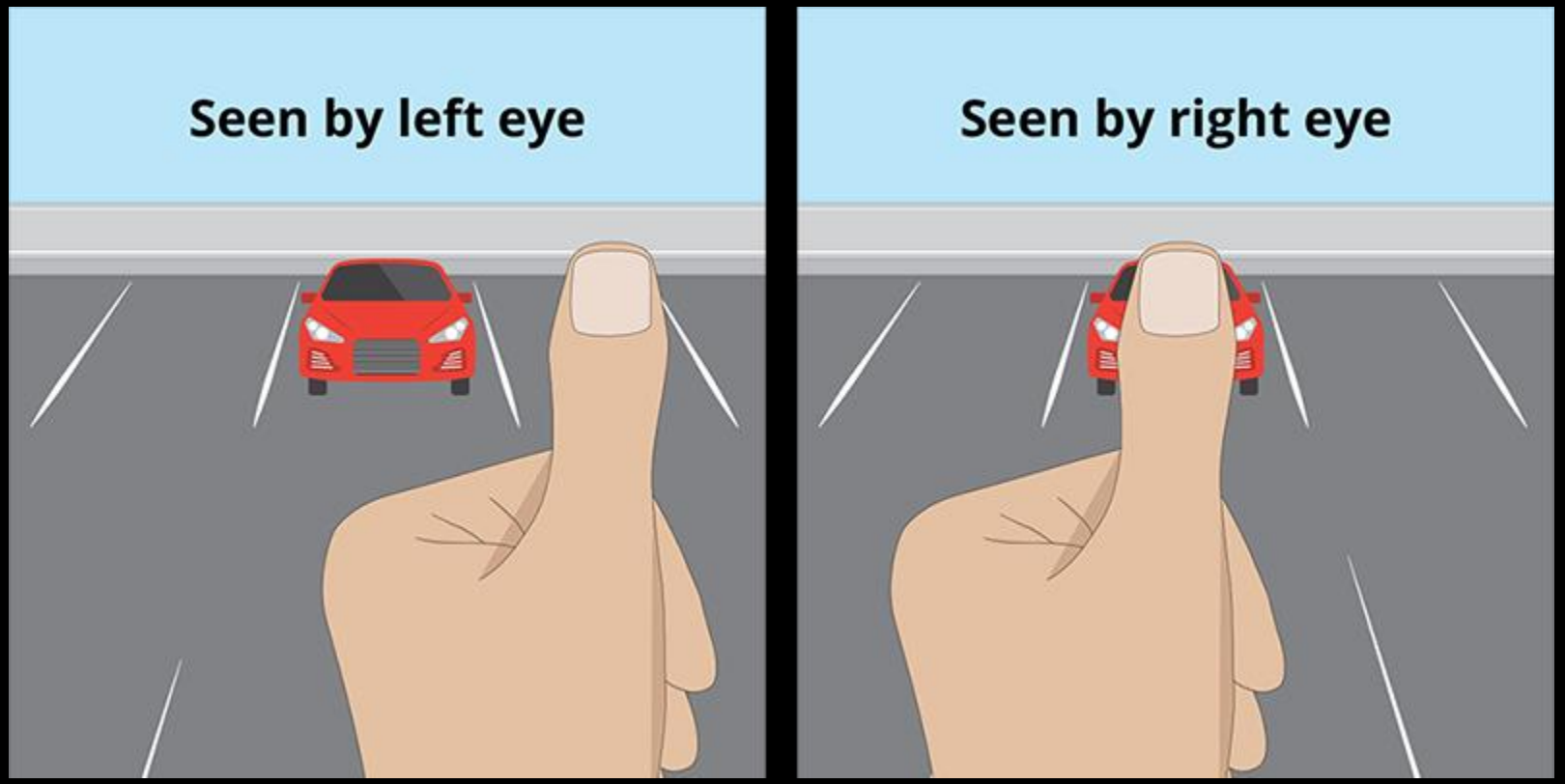
Newtonian

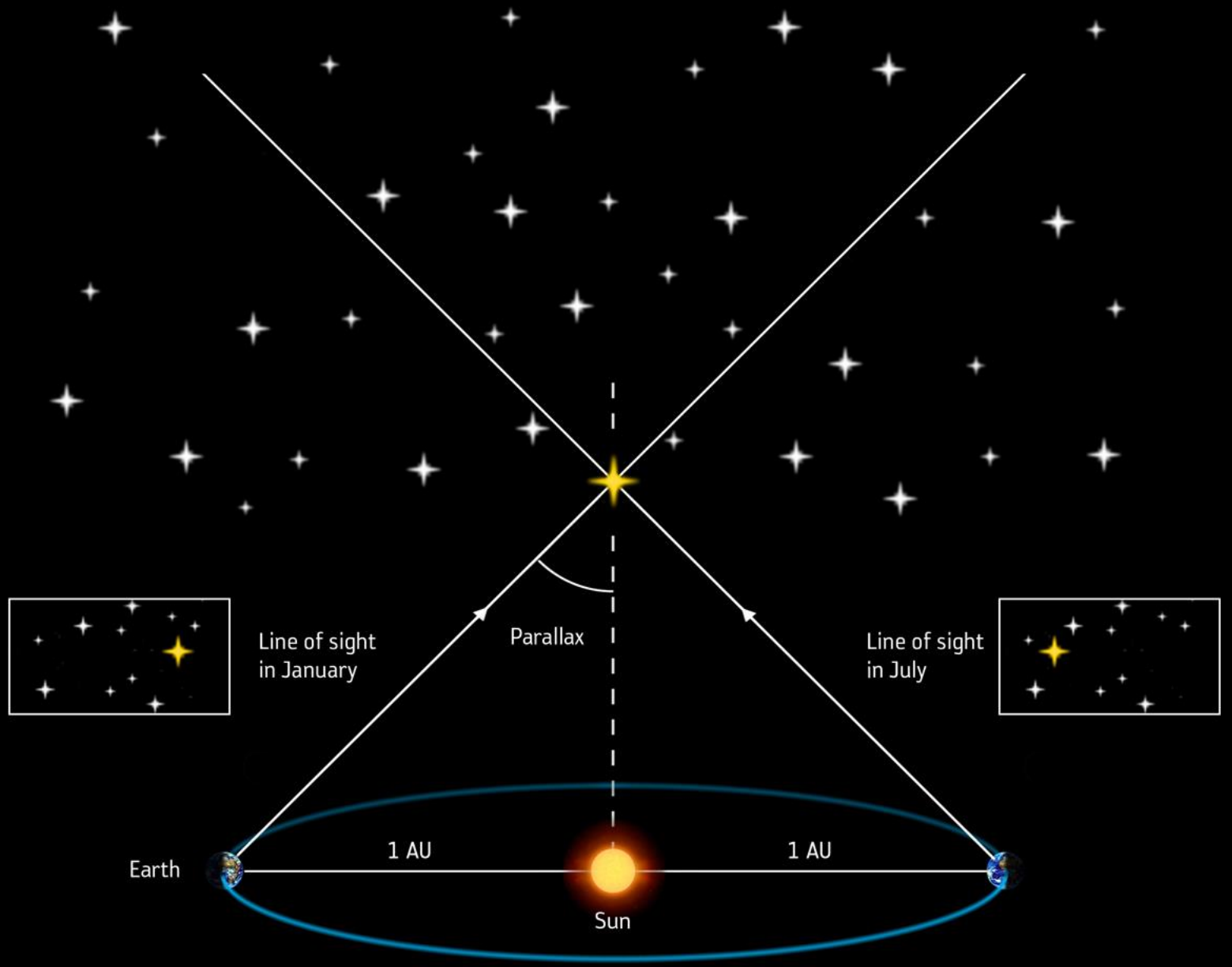


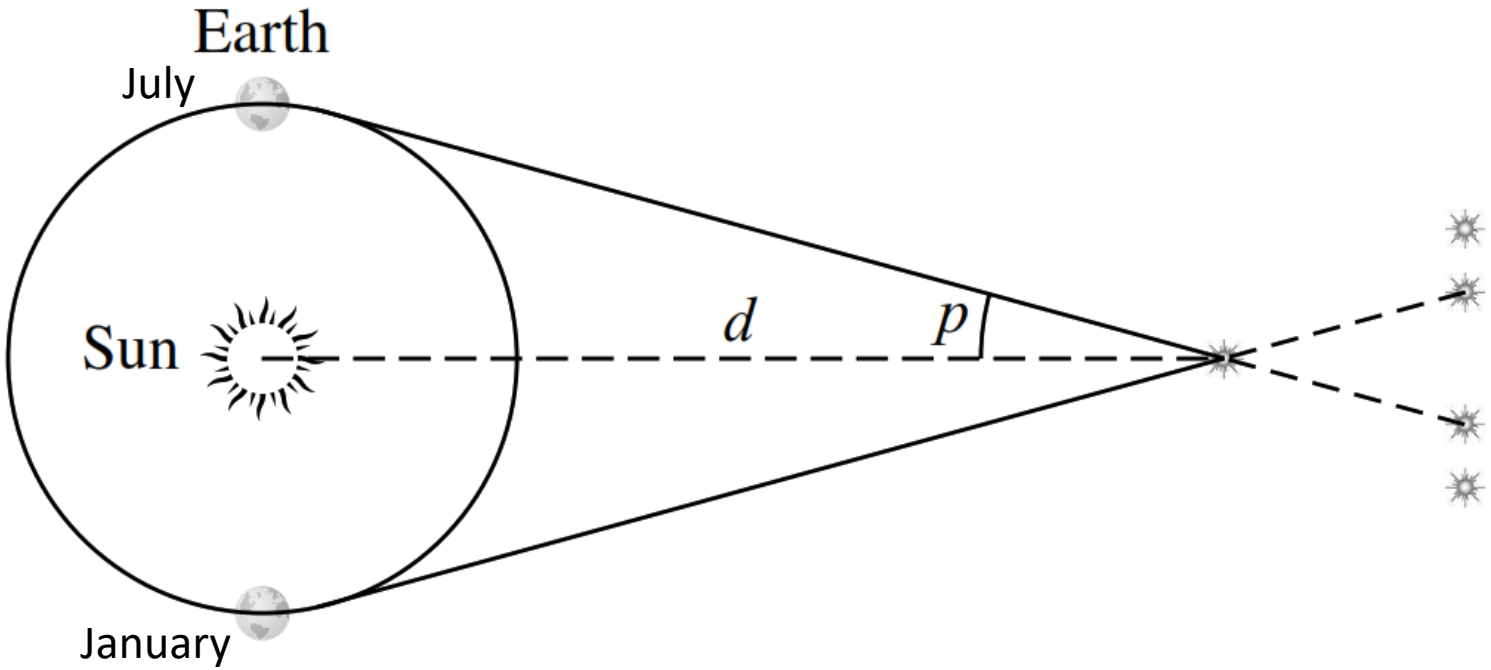
Cassegrain

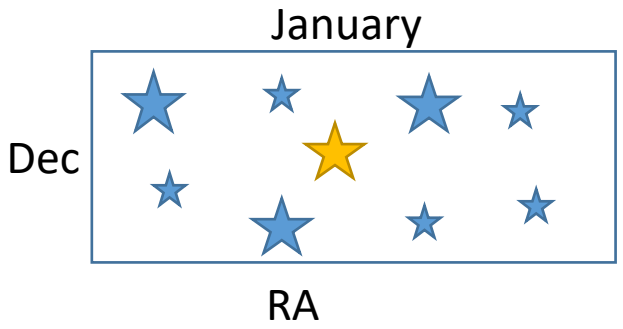

47
48
49
50
51
52
25
24

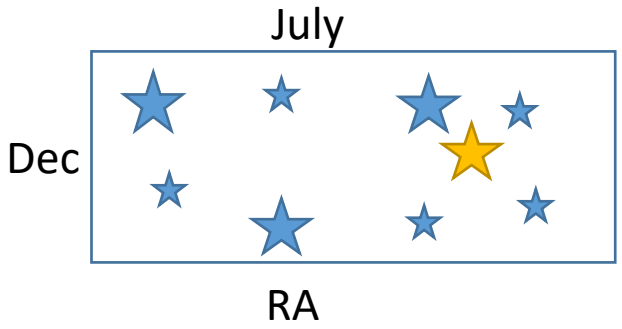


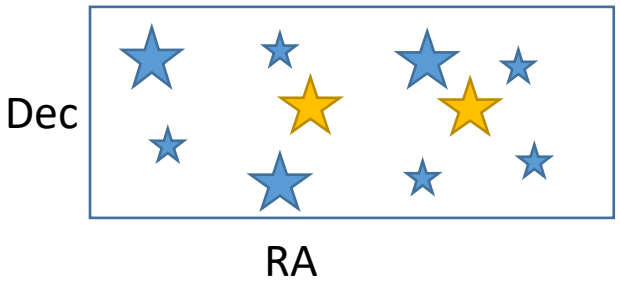

Seen by left eye
Seen by right eye


Line of sight
in January
Parallax
Line of sight
in July
Earth
1 AU
1 AU
Sun









Up to about 1,000 light-years with current space telescopes

Flux and Luminosity

Luminosity

- **Luminosity (L)** is the total amount of energy emitted by an astronomical object per second in all directions. It is an intrinsic property of the object, meaning it does not depend on the observer's location.
- Measured in **watts (W).**
- $\mathbf{L_{sun}}$=3.846×10^{26}W

Flux

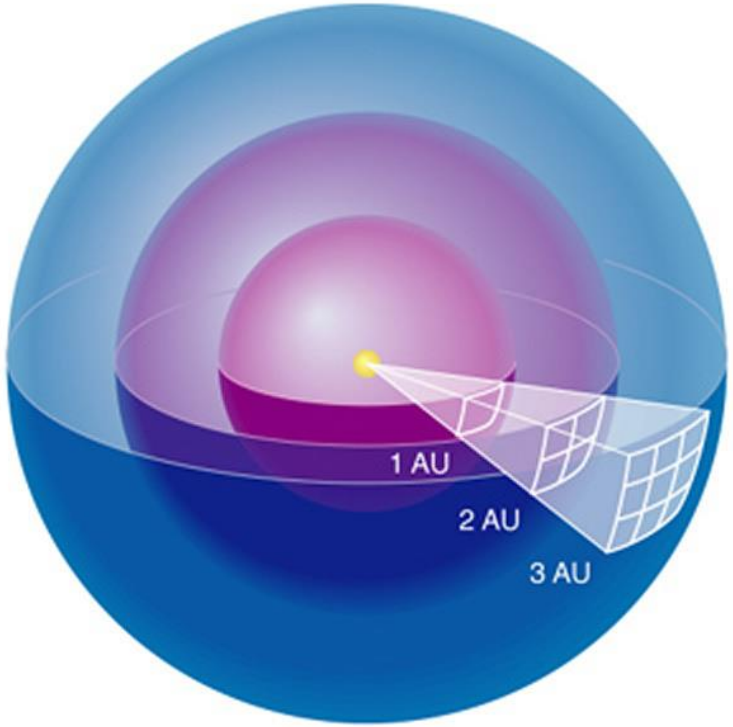
- **Flux (F)** is the amount of energy from an astronomical object passing through a unit area per second. It is an *apparent property*, meaning it depends on the distance between the object and the observer.
- Measured in **watts per square meter (W/m^2)**
- F_{sun}= 1361W/m2

Inverse Square Law of Light

- Brightness is measured in units of Flux
- Total amount of light energy in all wavelengths that passes through unit area per unit time
- Flux received depends on intrinsic luminosity and the distance

$$F = \frac{L}{4\pi r^2},$$

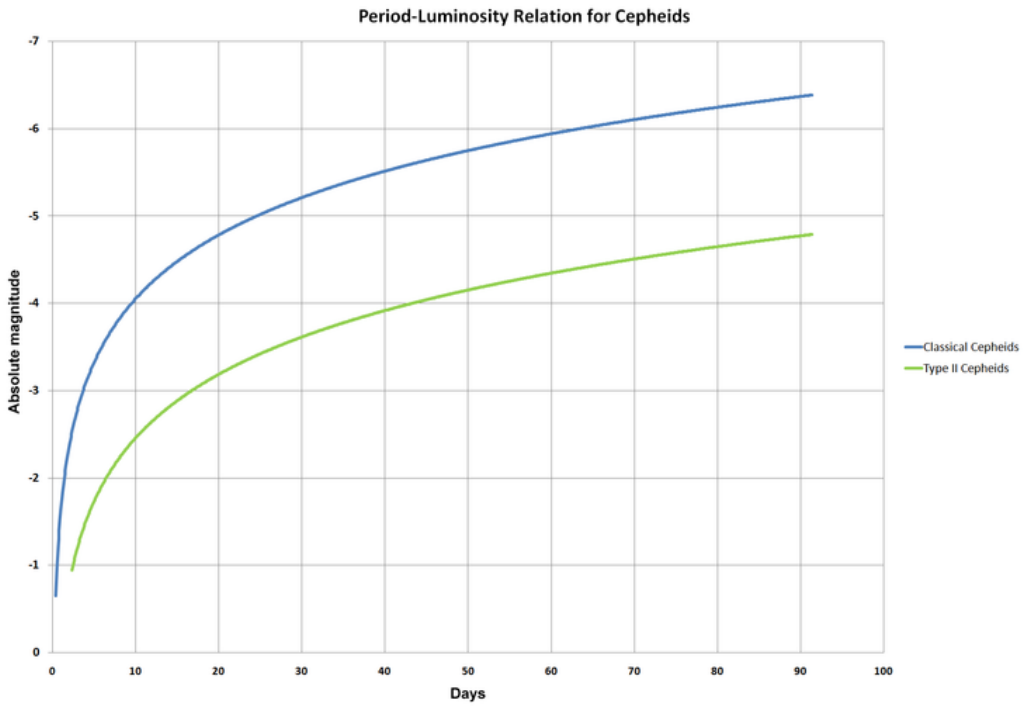
inverse square law for light

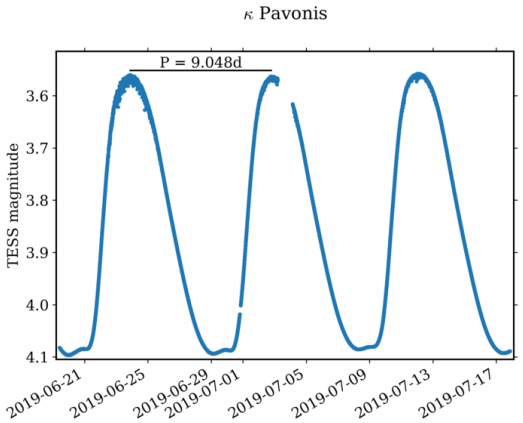


Standard Candles - Cepheid Variables

These stars pulsate with a regular period, and their luminosity is directly related to this period. By observing their pulsations, we can infer their distance.

Henrietta Swan Leavitt

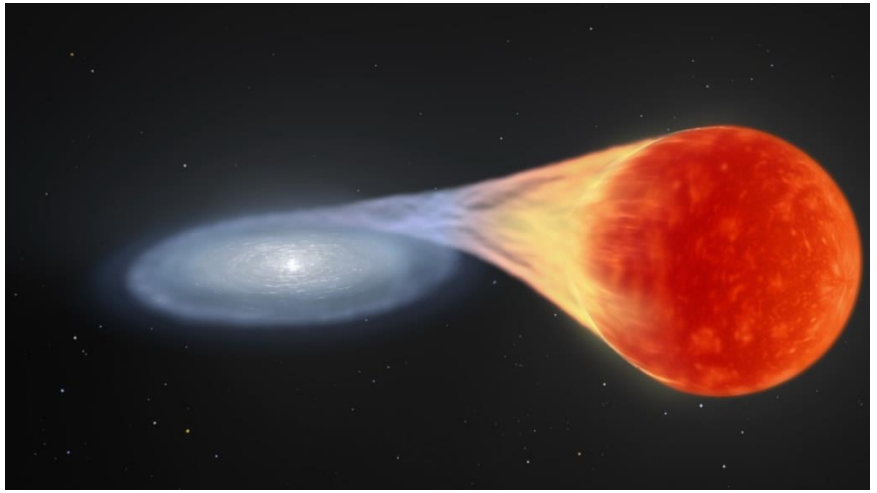


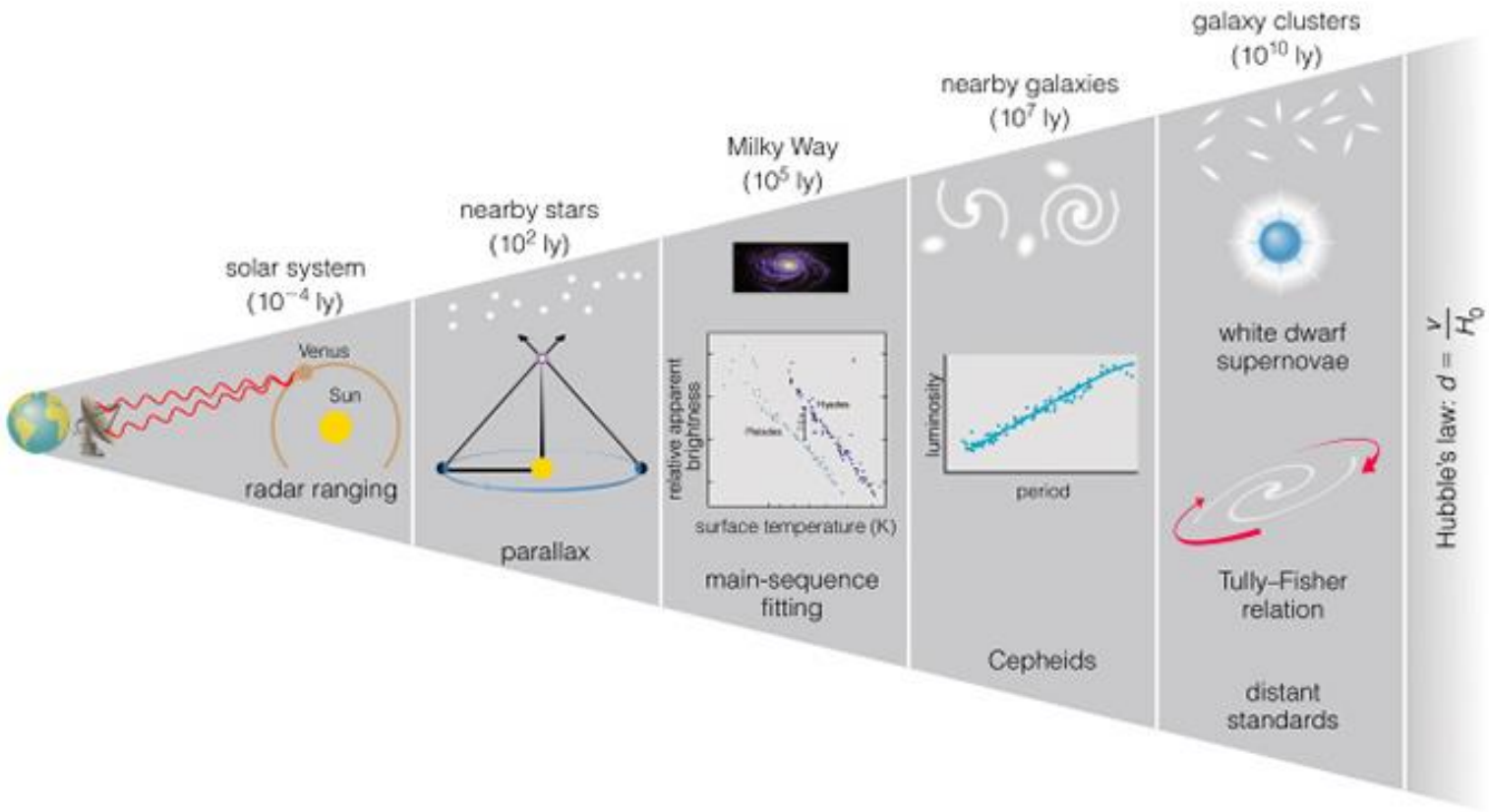


Standard Candles – Type 1a Supernova

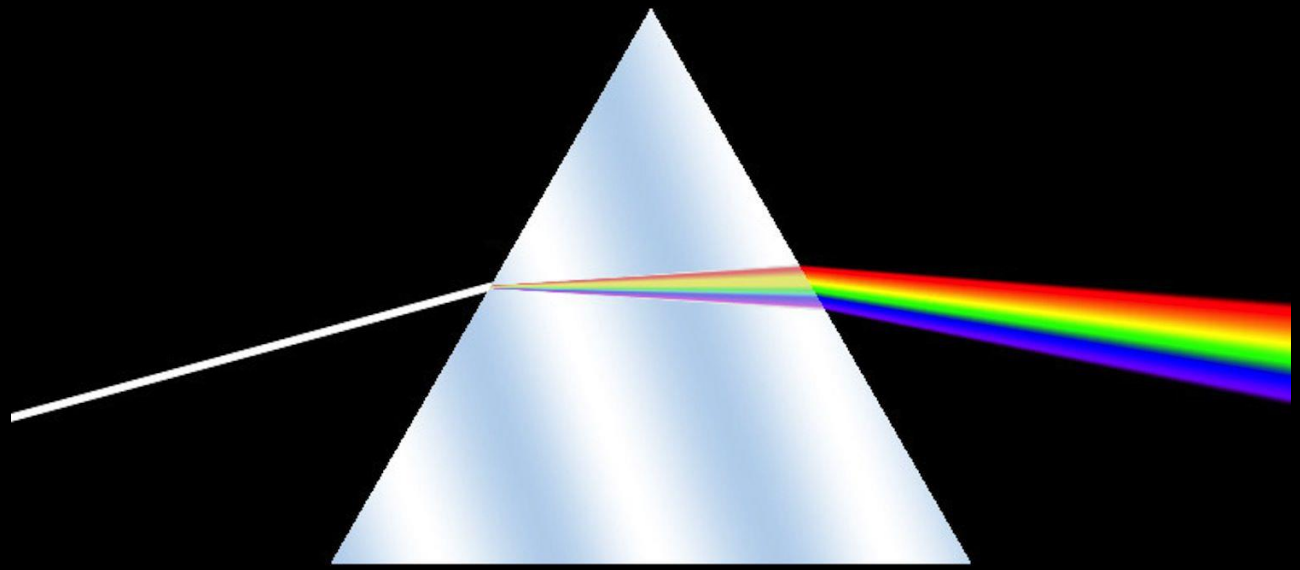
Type Ia Supernovae are a class of supernovae that occur in binary star systems where one of the stars is a **white dwarf**.

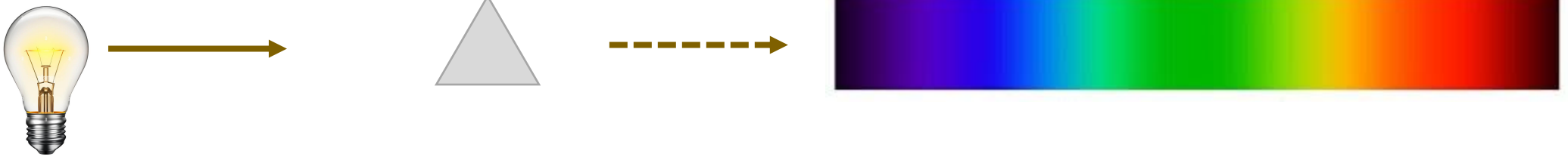
Explosions of white dwarf stars that have a predictable maximum brightness, making them excellent for measuring distances to galaxies.

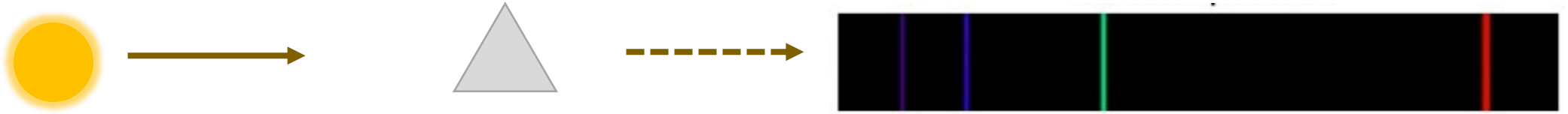


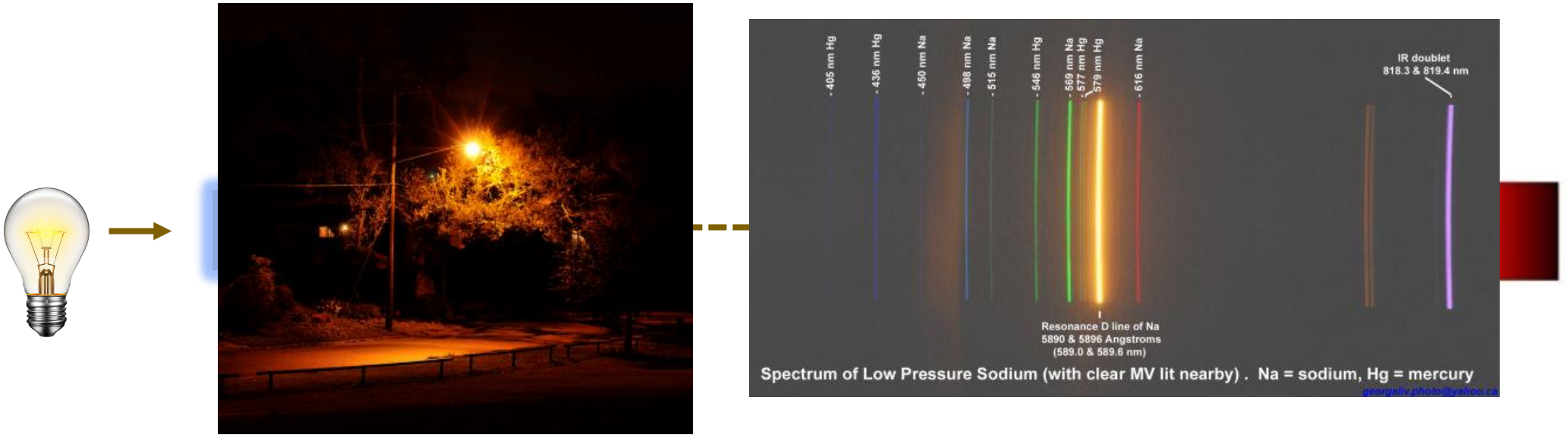

solar system
(10^{-4} ly)
Venus
Sun
radar ranging
nearby stars
(10^{2} ly)
parallax
Milky Way
(10^{5} ly)
relative apparent brightness
Hyades
Pleiades
surface temperature (K)
main-sequence fitting
nearby galaxies
(10^{7} ly)
luminosity
period
Cepheids
galaxy clusters
(10^{10} ly)
white dwarf supernovae
Tully–Fisher relation
distant standards
Hubble's law: $d = \frac{v}{H_0}$

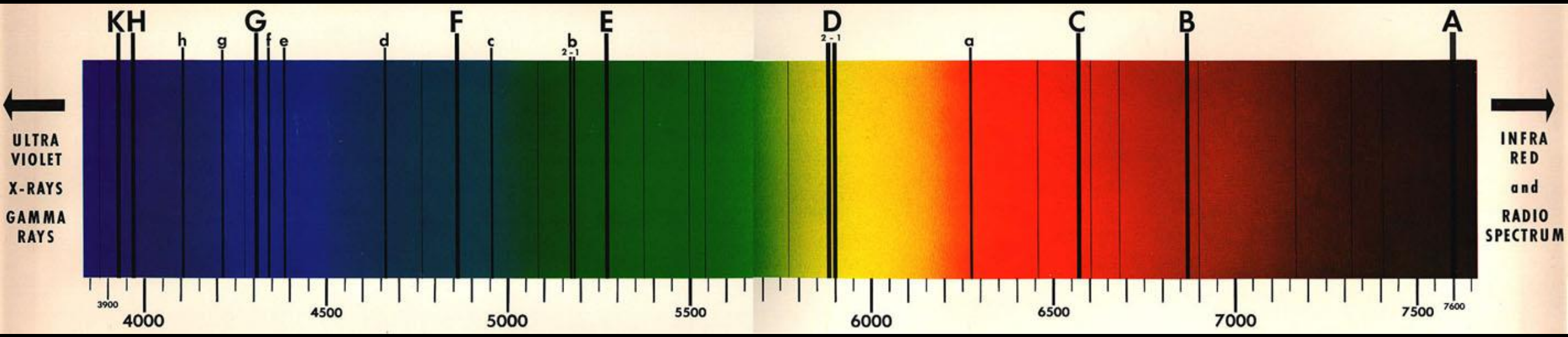
Spectroscopy

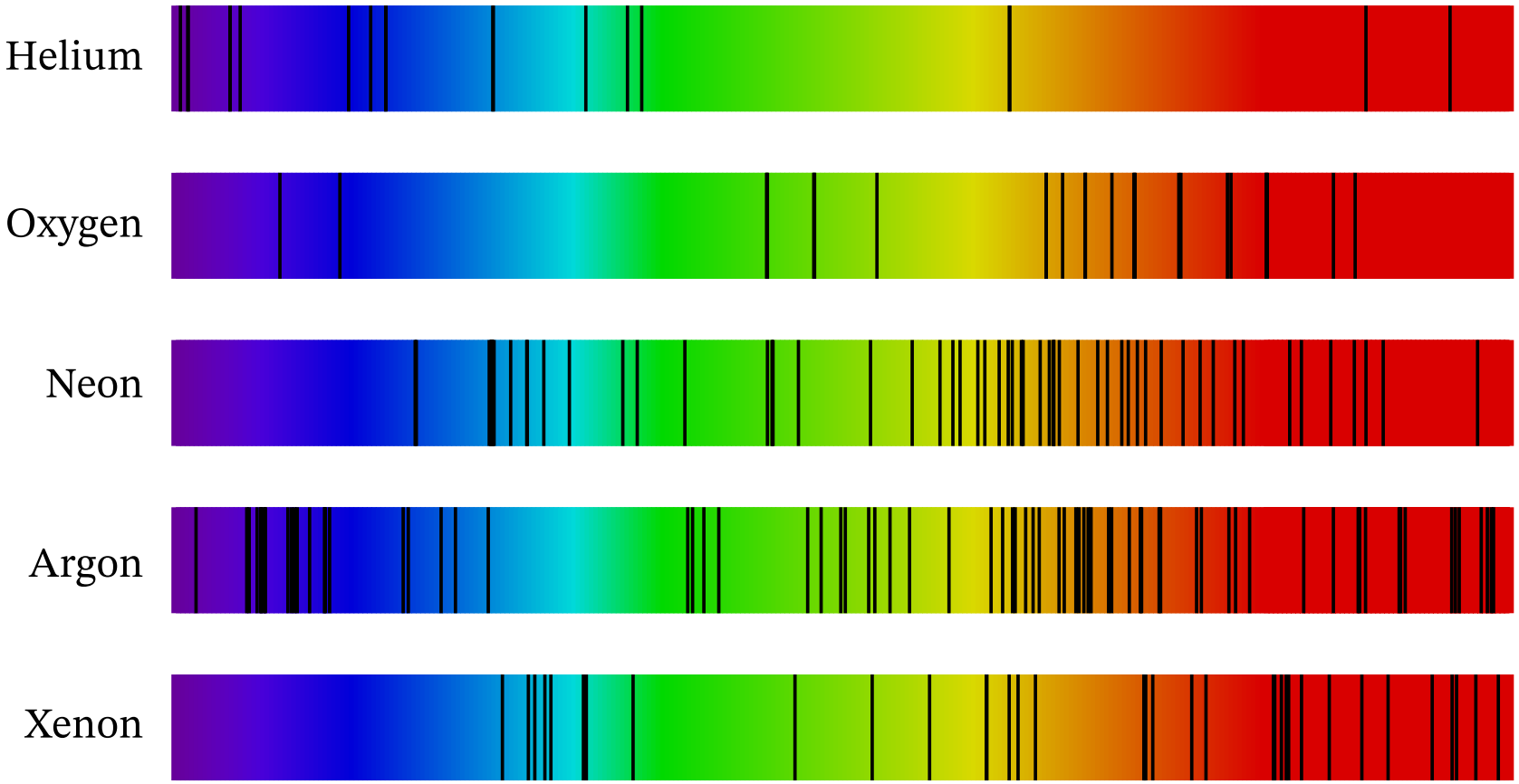


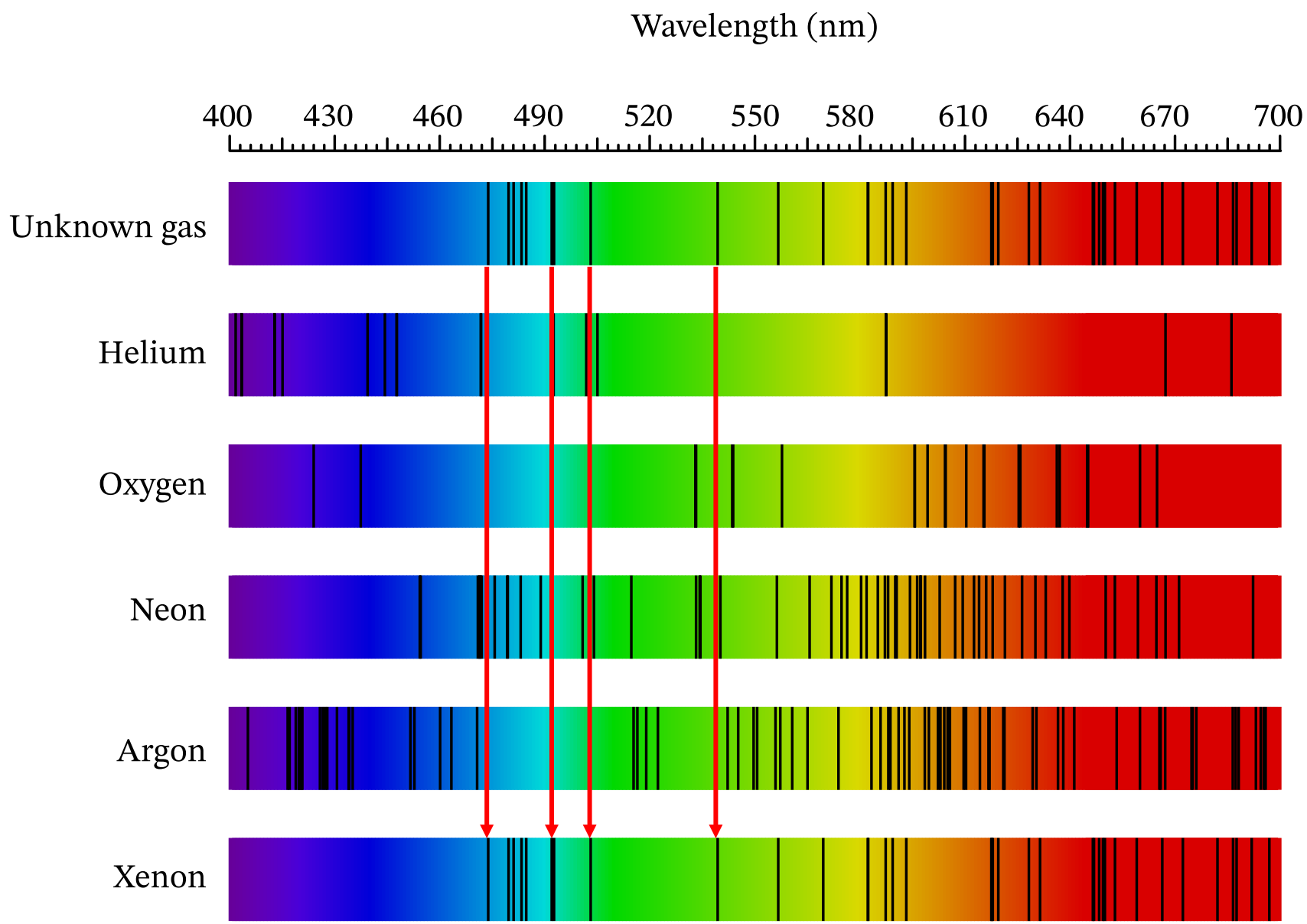




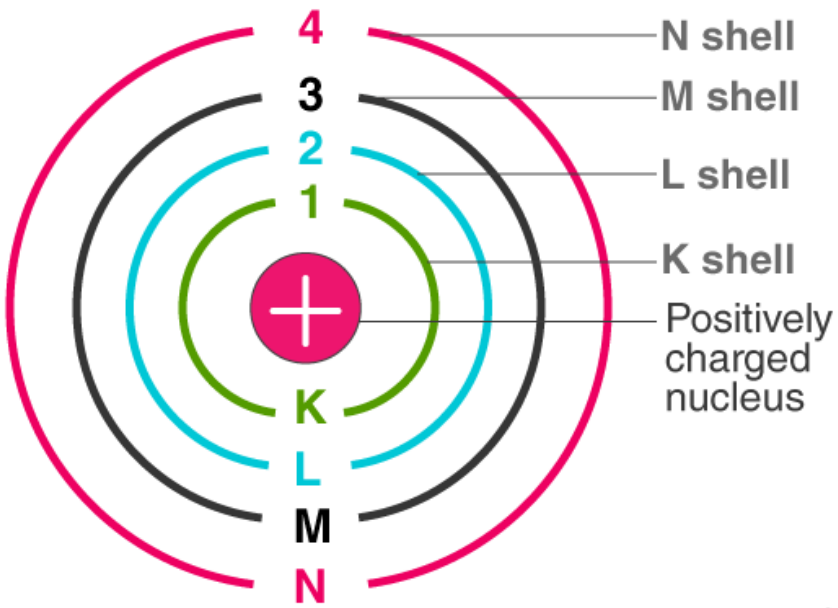

- 405 nm Hg
- 436 nm Hg
- 450 nm Na
- 498 nm Na
- 515 nm Na
- 546 nm Hg
- 569 nm Na
- 577 nm Hg
- 579 nm Hg
- 616 nm Na
IR doublet
818.3 & 819.4 nm
Resonance D line of Na
5890 & 5896 Angstroms
(589.0 & 589.6 nm)
Spectrum of Low Pressure Sodium (with clear MV lit nearby) . Na = sodium, Hg = mercury
georgeliv.photo@yahoo.ca

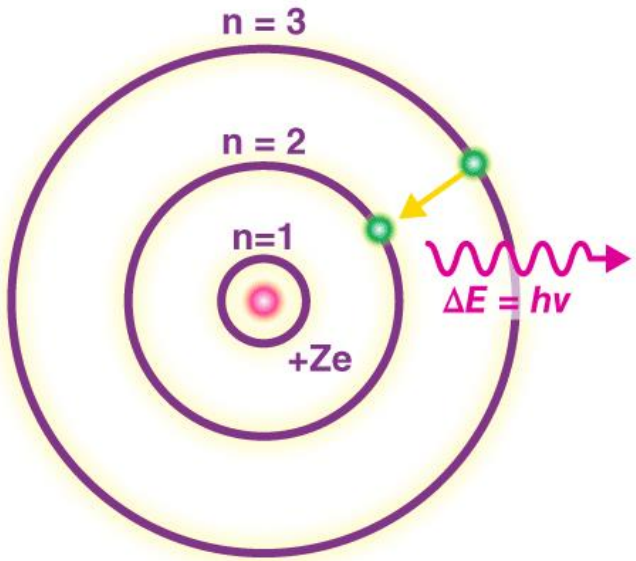

K
H
G
F
E
D
C
B
A
h
g
f
e
d
c
b
2 - 1
2 - 1
a
ULTRA
VIOLET
X-RAYS
GAMMA
RAYS
INFRA
RED
and
RADIO
SPECTRUM
3900
4000
4500
5000
5500
6000
6500
7000
7500
7600

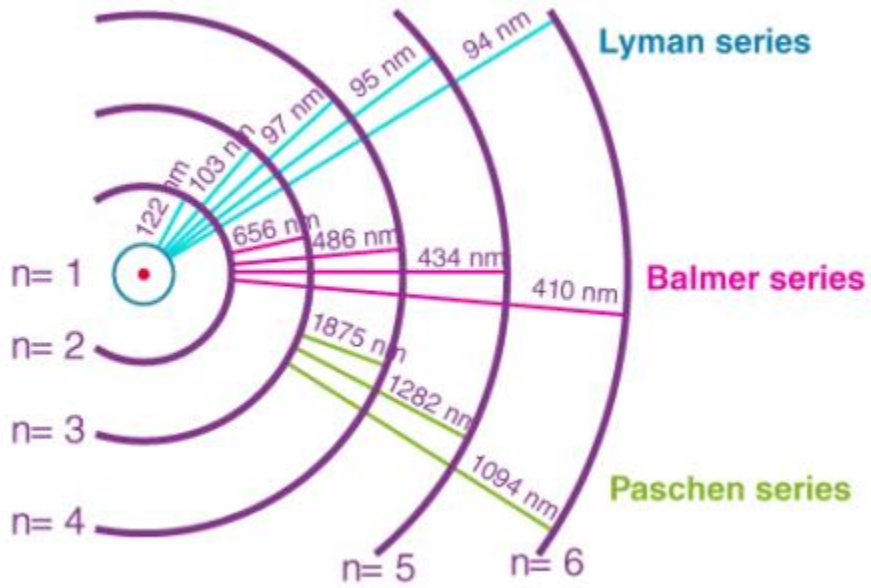

Helium
Oxygen
Neon
Argon
Xenon


Wavelength (nm)
400
430
460
490
520
550
580
610
640
670
700
Unknown gas
Helium
Oxygen
Neon
Argon
Xenon

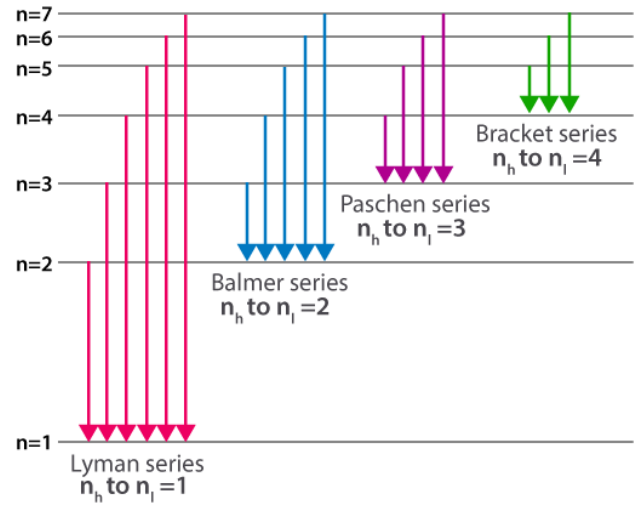
BOHR'S MODEL OF AN ATOM

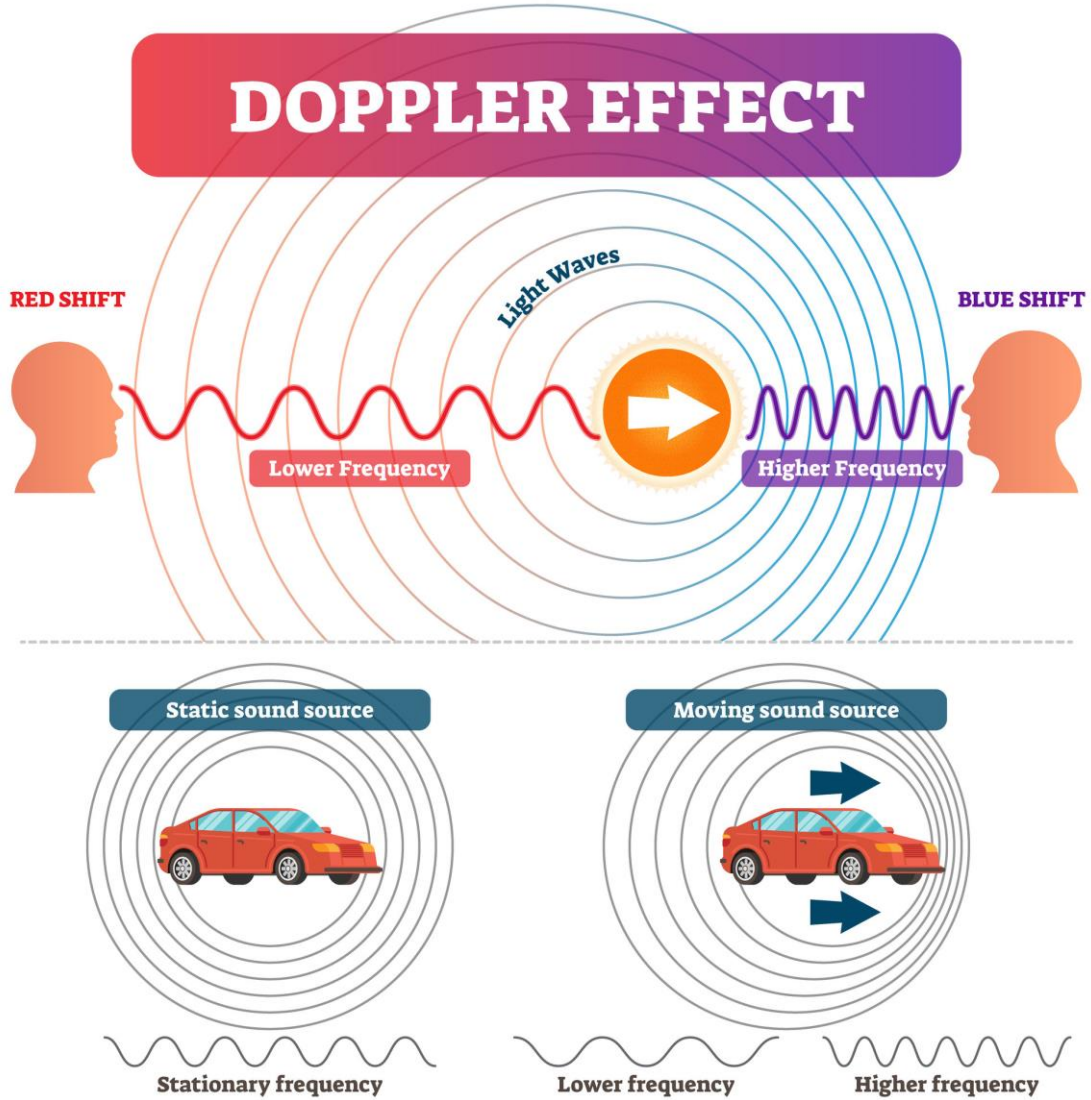


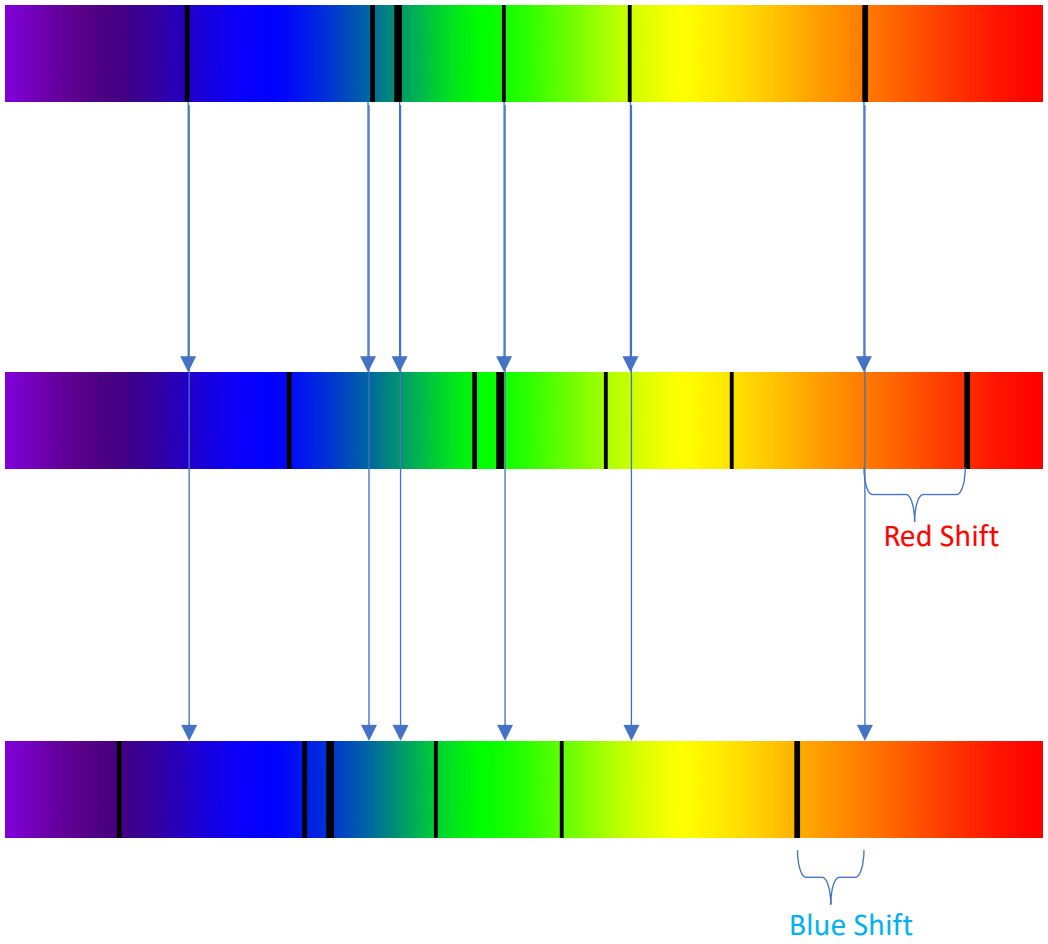




ELECTRON TRANSITIONS FOR THE HYDROGEN ATOM



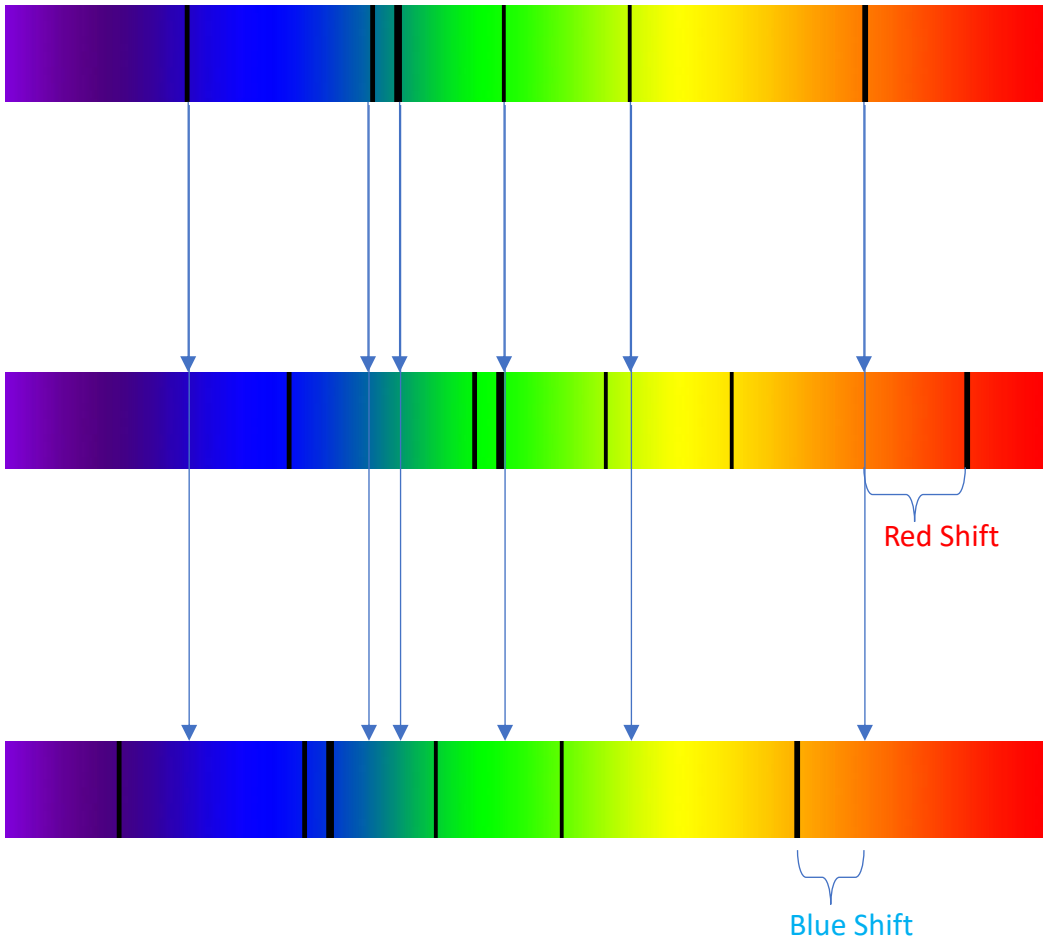

DOPPLER EFFECT
RED SHIFT
Light Waves
BLUE SHIFT
Lower Frequency
Higher Frequency
Static sound source
Moving sound source
Stationary frequency
Lower frequency
Higher frequency



object at rest

o b j e c t m o v i n g a w a y

object moving towards

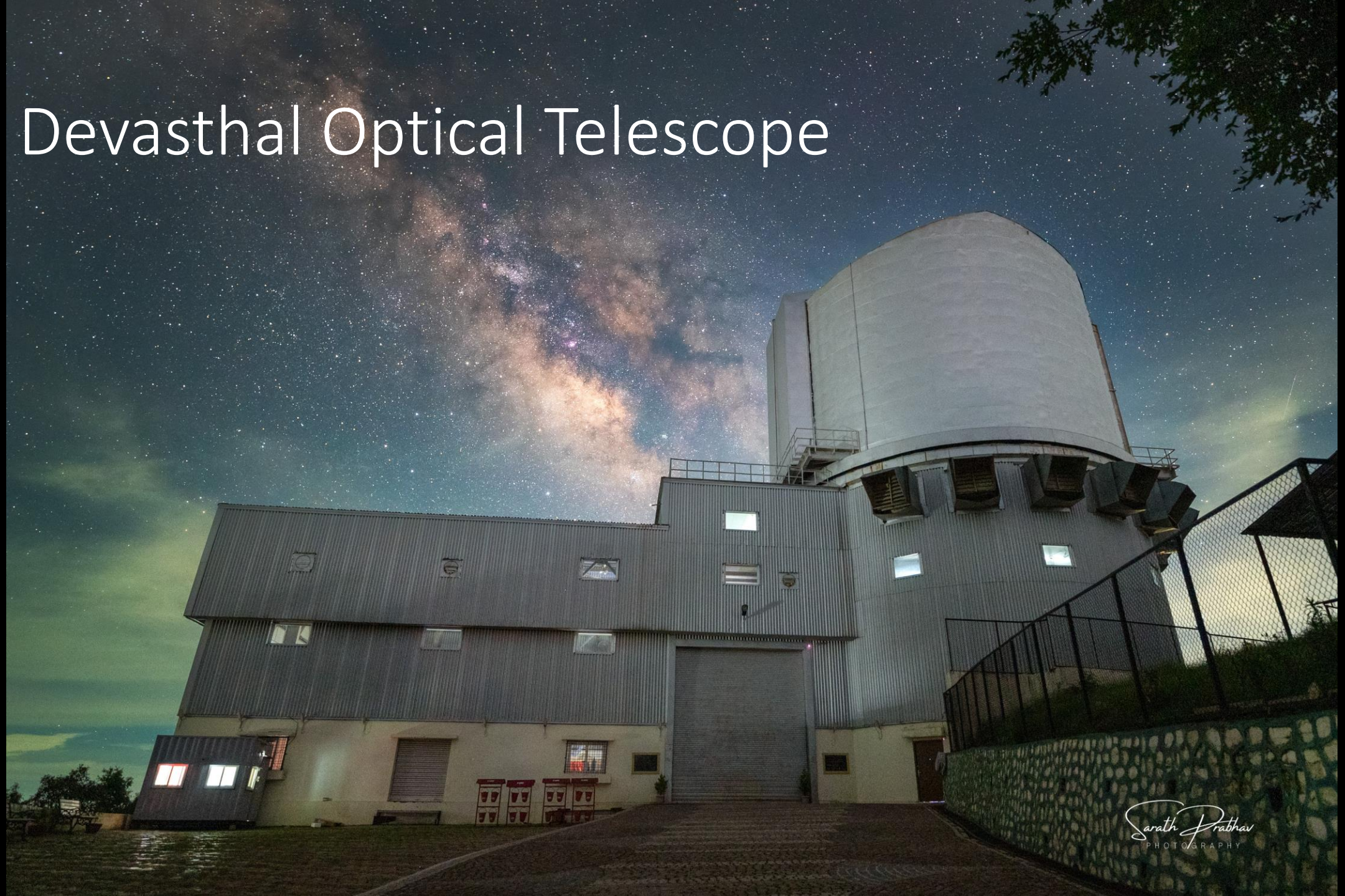


object at rest

o b j e c t m o v i n g a w a y

object moving towards

Devasthal Optical Telescope



3.6m Devasthal Optical Telescope

- Built by Aryabhatta Research Institute of Observational Sciences (ARIES)
- Located at the Devasthal Observatory site near Nainital, Kumaon, India.

Altitude	2540m
Mirror	3.6m
Wavelength	350 nm–5,000 nm
Telescope style	optical telescope Ritchey–Chrétien telescope

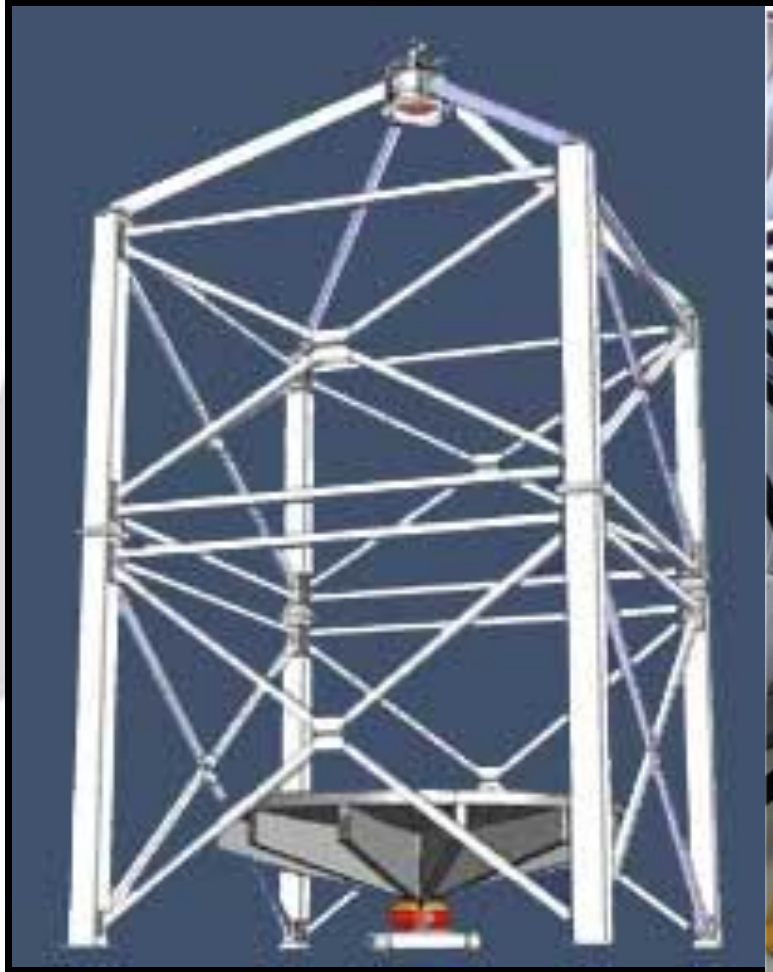
Devasthal Optical Telescope

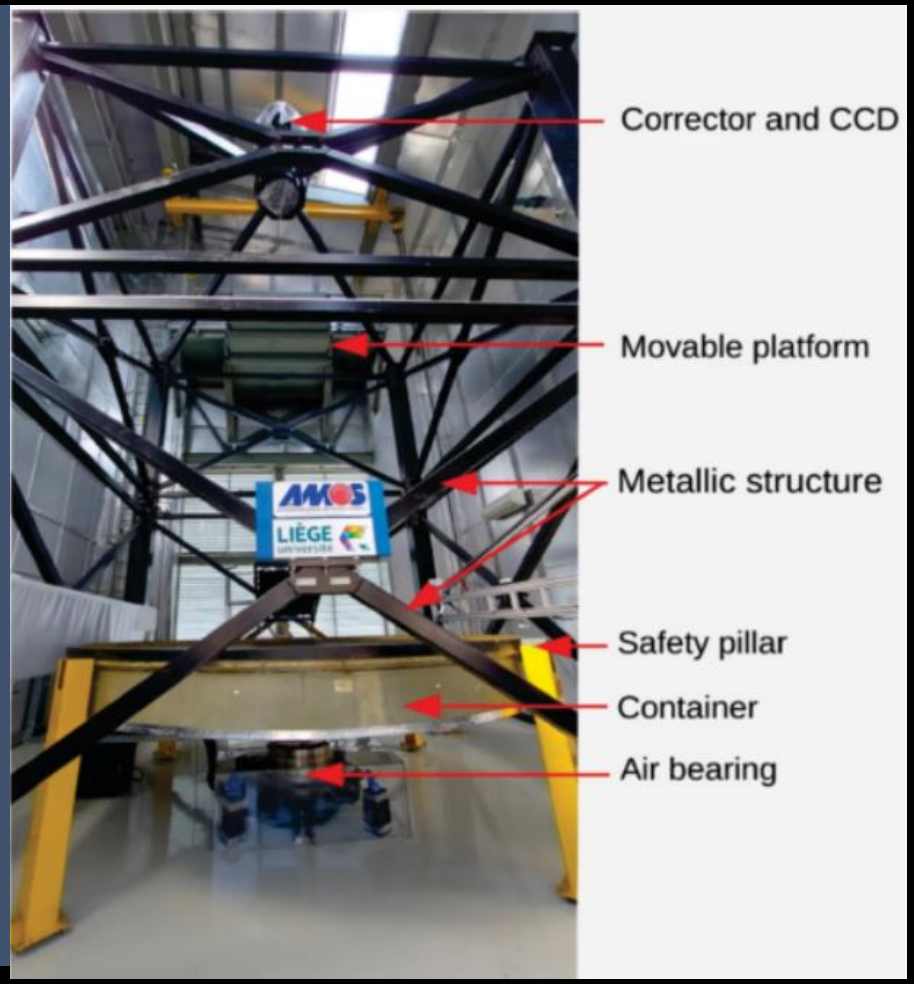
- India's largest fully steerable optical telescope (3.6 m).
- Equipped with state-of-the-art instruments for optical and near-infrared observations.
- Used for stellar, galactic, and extra-galactic studies.

ILMT

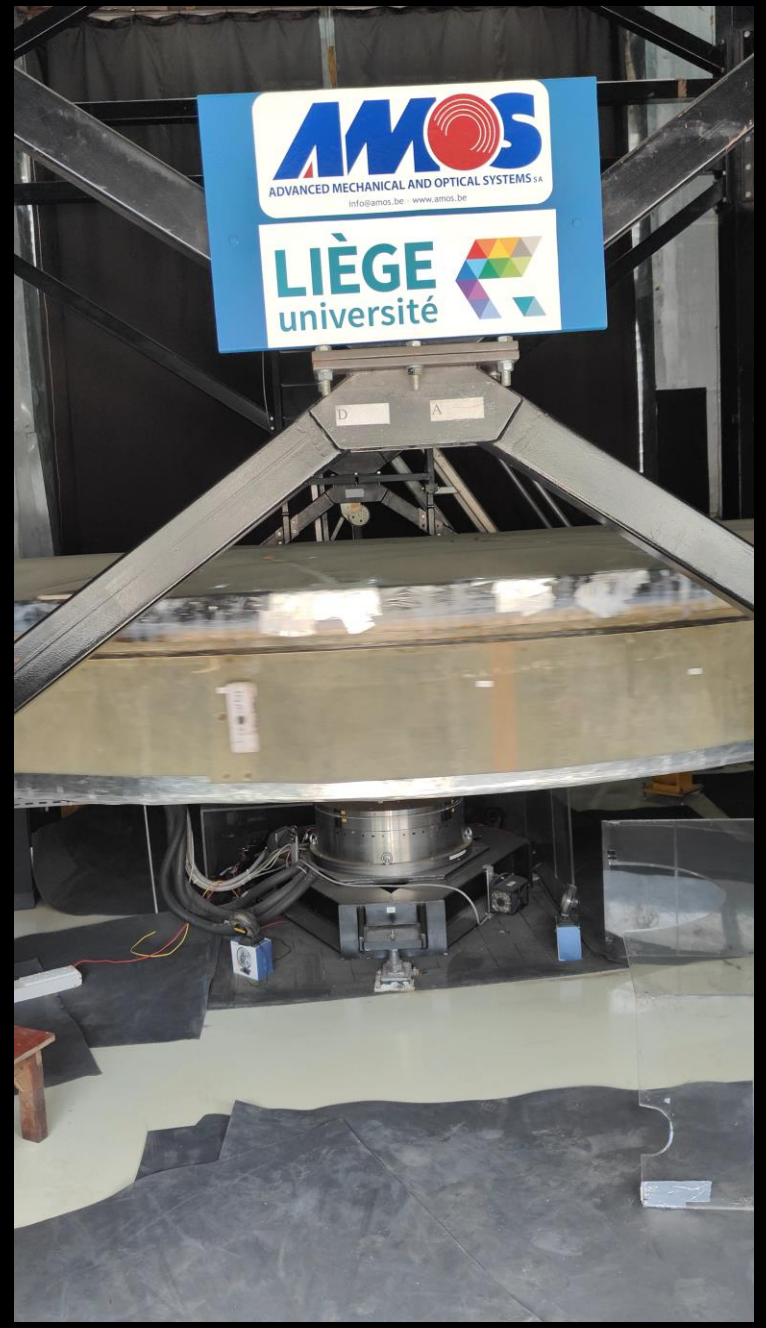
Location : Devasthal, Utharaghand
Lat Lon : 29◦21′41.4 69 ′′ N , 79◦41′07′′ E
Alt : 2378 m
First Light : 29 April 2022
Commisioned : 21 March 2023
Filters : SDSS g ′ , r ′ and i ′
Primary Mirror : 4m
Rotation Period : ~8 sec
Focal Length : 8m
Focal Length : 9.43 (Corrector)
Mercury Thickness : 3.5mm
Weight of Hg : 650
Mirror Weight : ~1000 kg
CCD : 4096 X 4096 pixels
Pixel Size : 15microns
FoV : 22.3 arcmin
TDI Scan time : 102 s
Image Size : 36864 x 4096 – 1.25 sq degree
Total Sky coverage over night : 36


Electronic detector
Thin reflecting surface of mercury
Rotating mirror platform




Corrector and CCD
Movable platform
Metallic structure
Safety pillar
Container
Air bearing
AMOS
LIÈGE

Primary Mirror

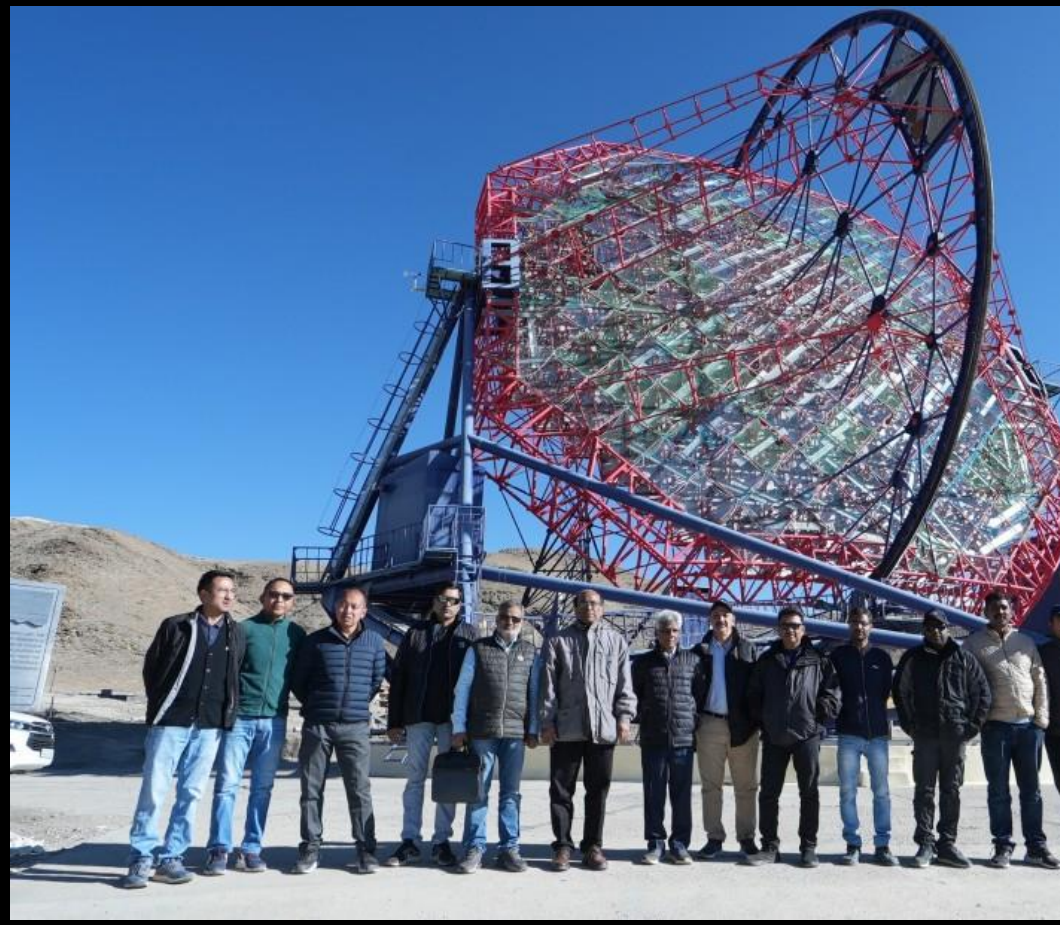


Giant Metre wave Radio Telescope (GMRT)

- Established: 2002
- Operated by: National Centre for Radio Astrophysics (NCRA-TIFR)
- Used for studying cosmic phenomena like pulsars, galaxies, the cosmic web, and hydrogen in the early universe.
- Array of 30 Parabolic Antennas
- Diameter: 45 meters each.
- Total collecting area: ~30,000 square meters.
- Frequency Range: Operates between 50 MHz and 1.5 GHz.

Major Atmospheric Cherenkov Experiment (MACE) telescope

- MACE is designed to detect very high-energy gamma rays indirectly.
- Gamma rays interact with the Earth's atmosphere, producing a cascade of particles that emit Cherenkov radiation
- MACE captures this light to study the sources of these high-energy gamma rays.
- Location: Hanle, Ladakh, India - chosen for its high altitude (4,270 meters)
- Light Collector: A large, 356-square-meter honeycomb structure made up of 356 mirror panels.
- Imaging Camera: A high-resolution camera weighing about 1,200 kilograms.



Vainu Bappu Observatory

- owned and operated by the Indian Institute of Astrophysics.
- It is located at Kavalur in the Javadi Hills, near Vaniyambadi in Tirupathur district in the Indian state of Tamil Nadu.

Altitude	700 meters (2,297 feet)
Established	1986
Vainu Bappu Telescope	2.3 meter reflector
Carl Zeiss telescope	1 meter reflector

Giant Metrewave Radio Telescope

- The Giant Metrewave Radio Telescope (GMRT), located near Narayangaon, Pune in India, is an array of thirty fully steerable parabolic radio telescopes of 45 metre diameter, observing at metre wavelengths.
- It is operated by the National Centre for Radio Astrophysics (NCRA), a part of the Tata Institute of Fundamental Research, Mumbai.

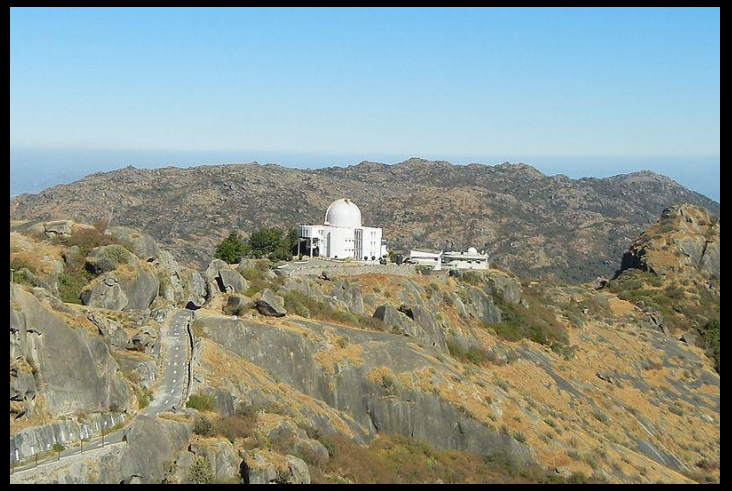
Wavelength	50, 1,500 MHz (6.00, 0.20 m)
First light	1995
Number of telescopes	30
Diameter	45 m (147 ft 8 in)

Kodaikanal Solar Observatory

- The Kodaikanal Solar Observatory is a solar observatory owned and operated by the Indian Institute of Astrophysics.
- Established Year 1895 (British - East India Company)
- Solar data collected by the lab is the oldest continuous series of its kind in India. Precise observations of the equatorial electrojet are made here due to the unique geography of Kodaikanal.
- Director : Annapurni Subramanian 2019–Present

Mount Abu InfraRed Observatory

- The Mount Abu InfraRed Observatory (MIRO) is located near the town Mount Abu in the state of Rajasthan, India. The observatory is at an altitude of 1680 metres and is adjacent to Guru Shikhar, highest peak of the Aravalli Range. The 1.2 m infrared telescopeat It is the first major facility in India specifically designed for ground-based, infrared observations of celestial objects.
- Organization
- Physical Research Laboratory
- Established 1990



Indian Astronomical Observatory

- The Indian Astronomical Observatory (IAO) is a high-altitude astronomy station located in Hanle, India and operated by the Indian Institute of Astrophysics. Situated in the Western Himalayas at an elevation of 4,500 meters (14,764 ft), the IAO is one of the world's highest located sites for optical, infrared and gamma-ray telescopes. It is currently the highest optical telescope in the world. It is India's first dark-sky preserve.
- **Himalayan Chandra Telescope (HCT)**
  - The Himalayan Chandra Telescope is a 2.01 meters (6.5 feet) diameter optical-infrared telescope named after India-born Nobel laureate Subrahmanyam Chandrasekhar. It contains a modified Ritchey-Chretien system. The telescope is remotely operated via an INSAT-3B satellite link which allows operation even in sub-zero temperatures in winter.
- **GROWTH-India Telescope**
  - The GROWTH-India telescope is a 0.7 meter wide-field optical telescope that had first light in 2018. It is the country's first fully robotic research telescope. The telescope is operated jointly by IIT Bombay and the Indian Institute of Astrophysics.

- **IIA-Washington University Cassegrain telescope**
  - Since 2011, the Indian Institute of Astrophysics (IIA) collaborates with the McDonnell Center for the Space Sciences of Washington University in St. Louis to operate two 0.5 meters Cassegrain telescopes.
- **High Altitude Gamma Ray Telescope**
  - The High Altitude Gamma Ray Telescope (HAGAR) is an atmospheric Cerenkov experiment with 7 telescopes setup in 2008. Each telescope has 7 mirrors with a total area of 4.4 square meters. Himalayan Gamma Ray Observatory (HiGRO) was set up at Hanle in collaboration with Tata Institute of Fundamental Research, Mumbai and Bhabha Atomic Research Centre, Mumbai.