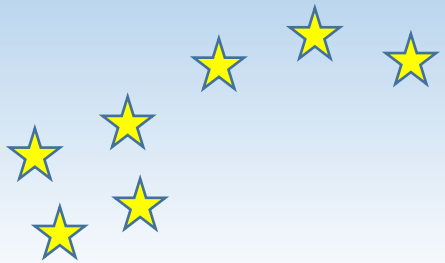


Telescopes

Physical Sciences

Broward College

Prepared for AST 1002

Horizons in Astronomy

Objectives

- What are the forms of light?
- Telescopes and optical systems

Pathways of Light

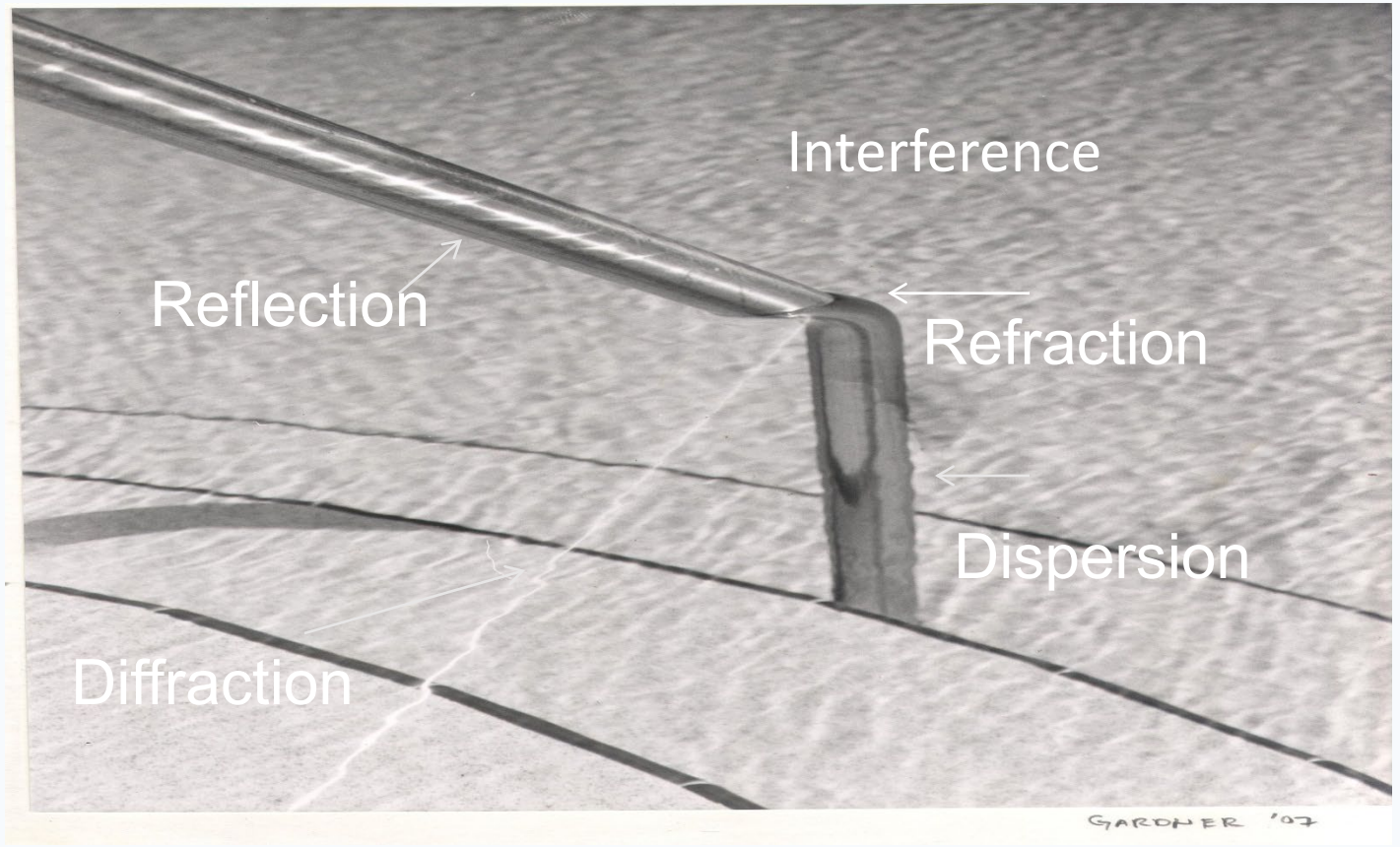
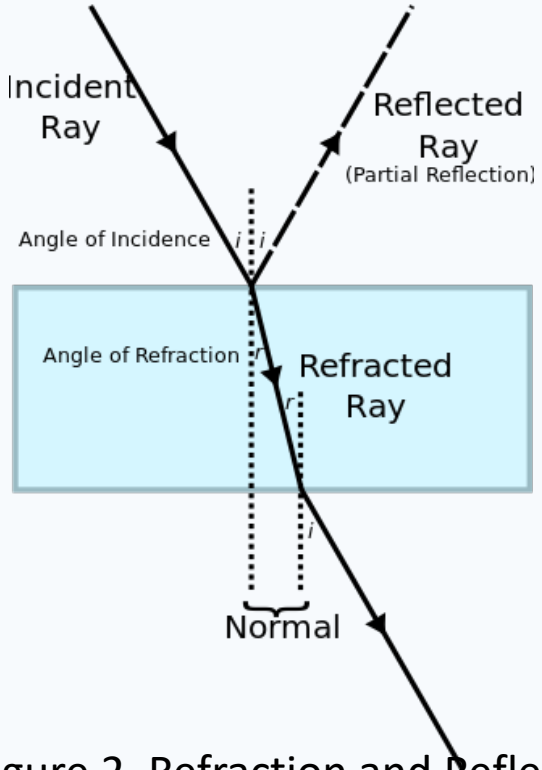


Figure 1. Photography Project, Gardener, 2007

Refraction/Reflection and Lenses/Mirrors

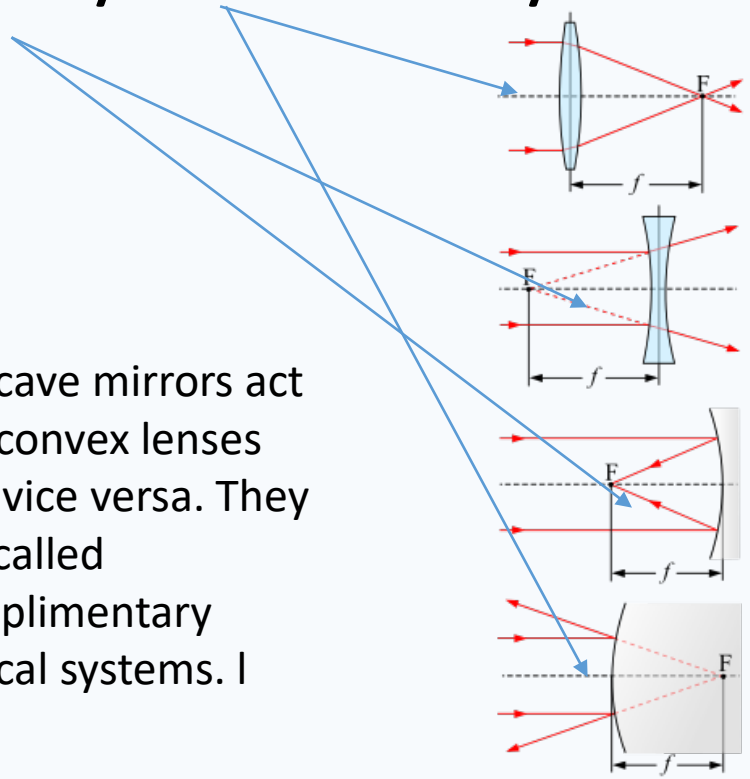
Light Rays reflecting off and refracting through a medium.



Light rays reflect off the surface of material at the same angle with the light bends towards the normal within the medium. We construct mirrors and lenses to harvest light.

Figure 2. Refraction and Reflection in a medium (Wiki)

Concave/Convex Mirrors/Lenses



Lenses

Mirrors

Concave mirrors act like convex lenses and vice versa. They are called complimentary optical systems. l

Figure 3. Lenses and Mirrors (Wiki)

Wave Nature of Light – Diffraction and Interference

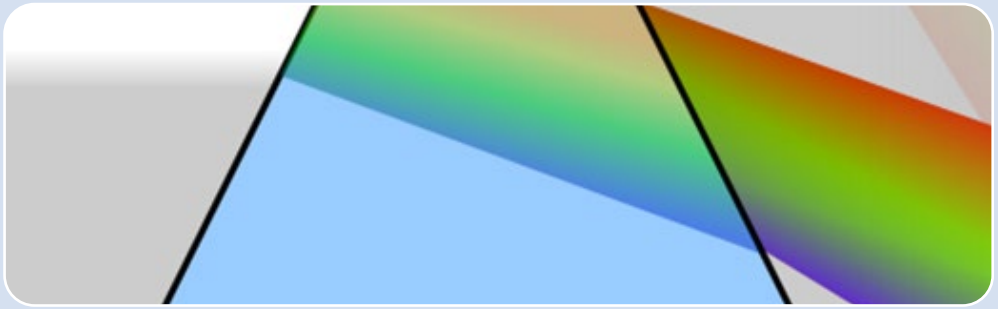
Diffraction

Christian Huygens first explored the diffraction nature of light. Light reflecting around an opaque object. Diffraction spikes on the star are produced from light bending around stress points in the mirror in the Hubble Telescope. Figure 4. (Wiki)

Interference

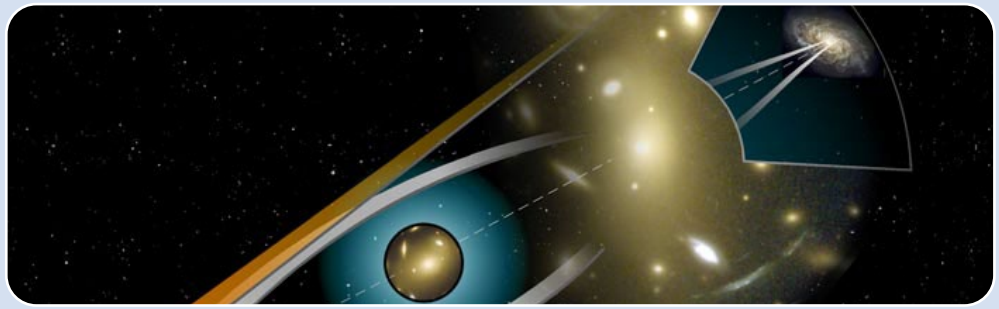
Waves interacting with each other create areas of superposition (addition) and interference (subtraction). Creates interference patterns as we see here. Figure 5. (Wiki)

Particle Nature of Light – Dispersion and Lensing



Dispersion

The prism works because of the different energies of the light. The greater the energy of the color bends less towards the normal thus creating a spectrum. Isaac Newton studied this phenomenon when he returned to Cambridge. Figure 6. (Wiki)



Lens

Photons are diverted around gravitational objects like pebbles rolling around rocks in a rock slide. A double image is created from the interaction of light from massive objects. Figure 7. (Wiki)

Interferometer and Spectrometer Complex Optical Systems

Interferometer

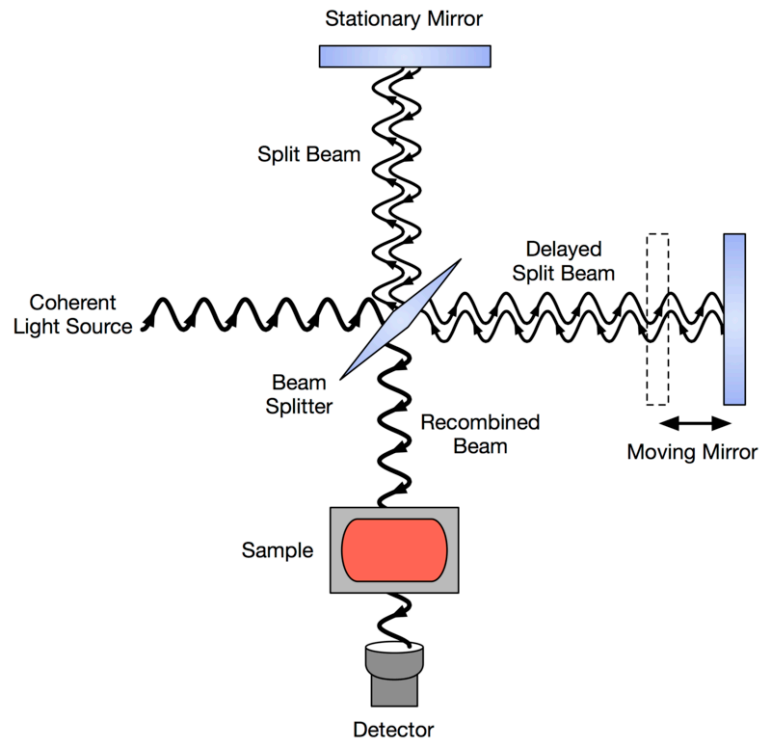
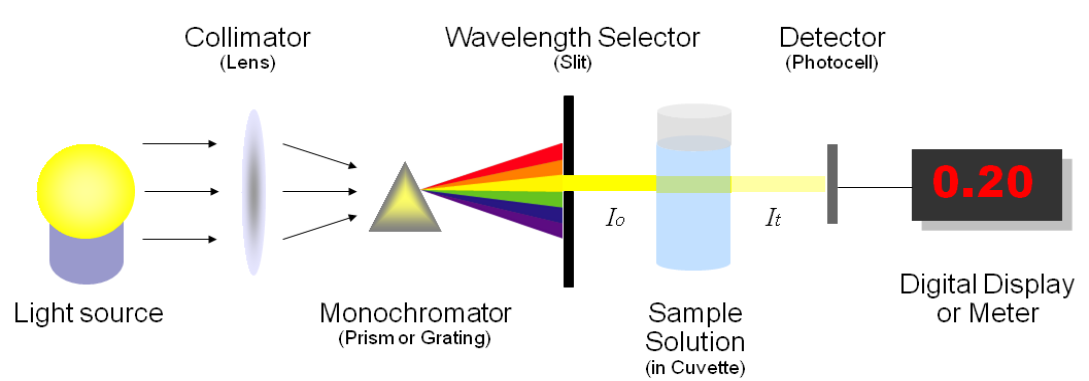


Figure 25. Interferometer (Wiki)

Spectrometer



We create complex optical systems with mirrors, lenses, diffraction gratings, and prisms. These are used as instruments on telescopes

Figure 26. Spectrometer (Larson, 2105)

George Ellery Hale

- 1868 – 1938
- Studied at MIT, Harvard, and Berlin
- Appointed director at Kenwood Observatory, Beloit, and was professor at University of Chicago
- Father of the Modern Telescope; built at Mts. Wilson and Palomar and Yerkes
- Suffered psychological problems much of life

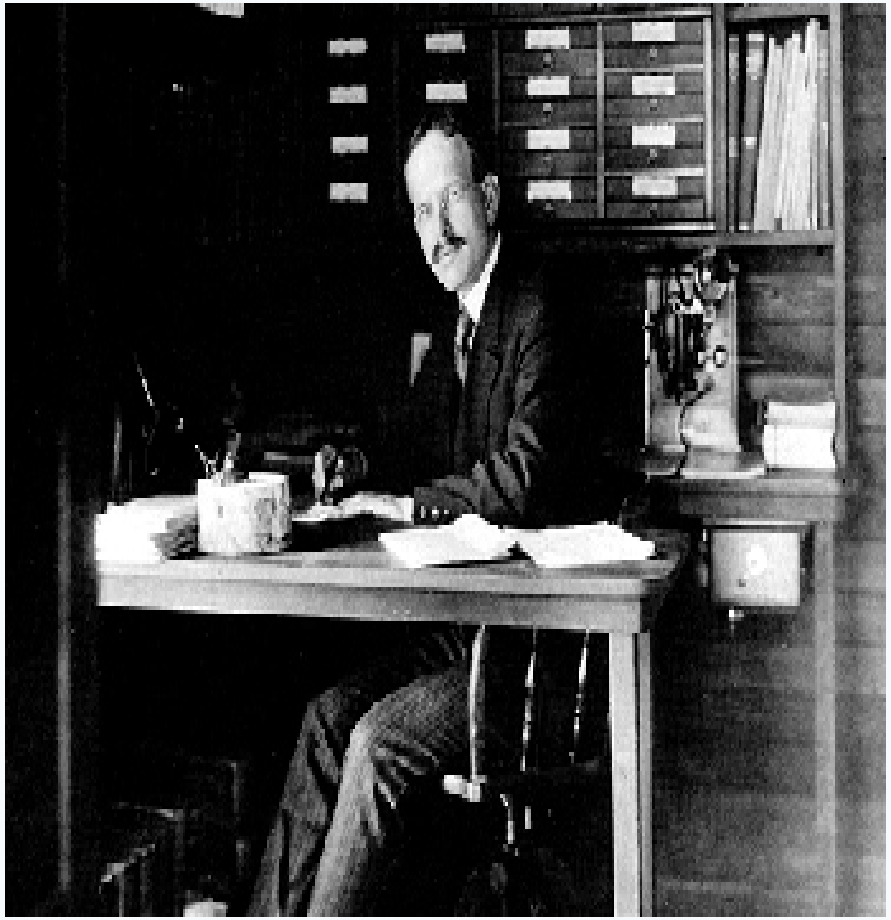


Figure 27. George Ellery Hale (Wiki)

Refracting Telescopes

- Developed by the Dutch and Galileo
- Has two lenses; main: Objective, secondary: Eyepiece
- Largest: Yerkes Observatory @ 40 inches

Figure 28 Chamberlain Observatory, University of Denver, Rolando Branly, 2011

Reflecting Telescope

- Developed by Isaac Newton
- Has a primary mirror, possibly a secondary mirror, and lens for an eyepiece
- Largest: Keck @ 10 meters

Figure 29. Lowell Observatory, Arizona, Sean Casey, 2011

Telescopic Properties and Challenges

Properties

- Light Gathering Power
- LGP= $(D_1 \backslash D_2)^2$
- F-ratio
  - f-ratio=f\D
- Resolution
  - TR=$(2.52X10^6)(\lambda/D)$
- Magnification
  - MP=$f_o \backslash f_e$

What is the difference in LGP between a 10 meter and a 0.09 meter telescope?

$$LGP = \left(\frac{D_1}{D_2}\right)^2 = \left(\frac{10m}{0.9m}\right)^2 = 123X$$

Challenges

- Bad seeing limits LGP and resolution
- Atmospheric Absorption limits resolution and wavelengths
- Space Astronomy limits which objects you can observe
- Light Pollution

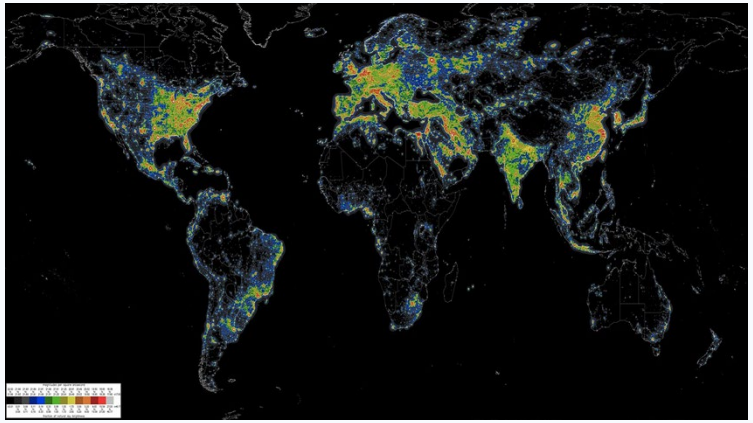


Figure 34. A Nighttime picture of World (Wiki)

Kitt Peak National Observatory

SARA Observatory

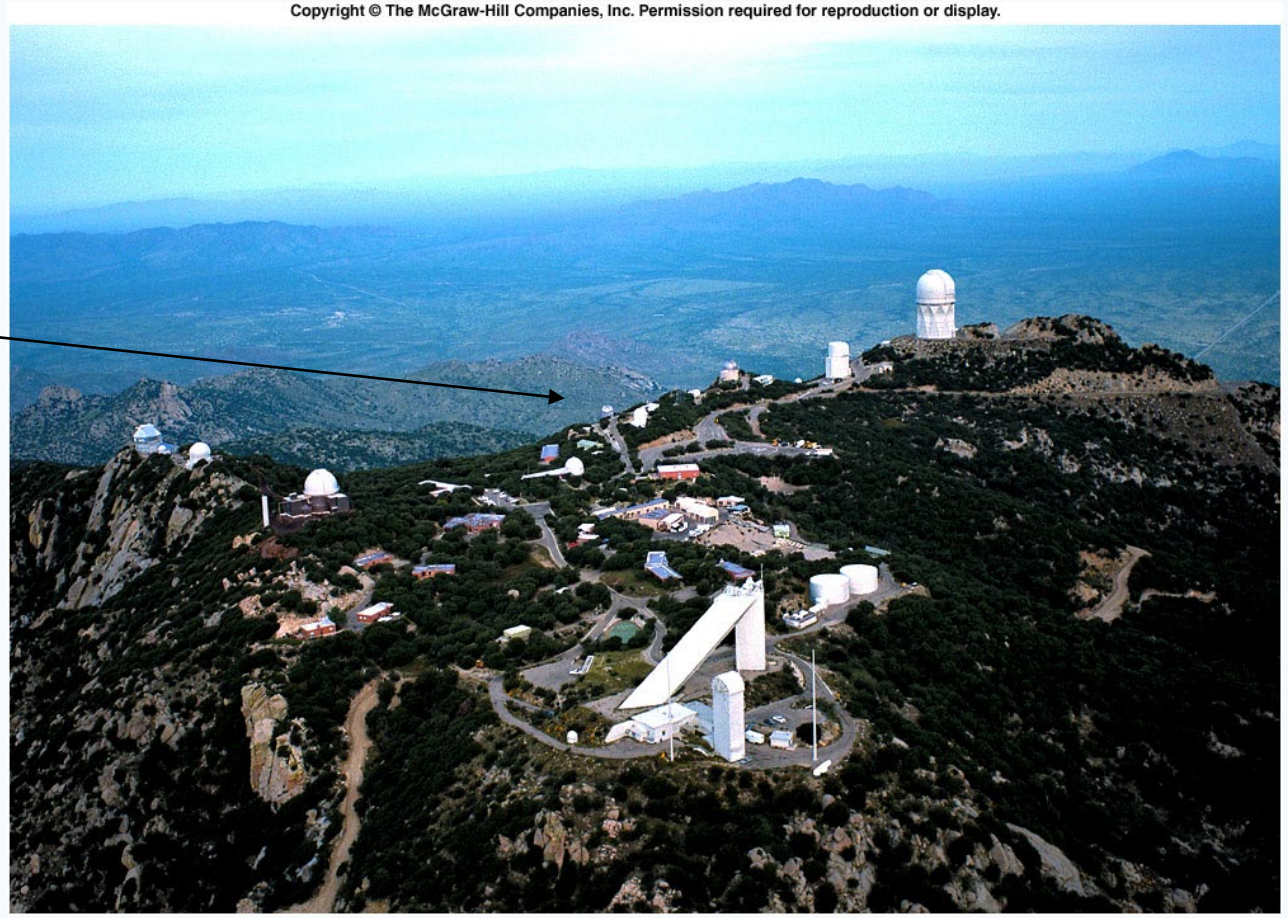


Figure 30. Kitt Peak National Observatory (Fix, 2004)

Types of Telescopes

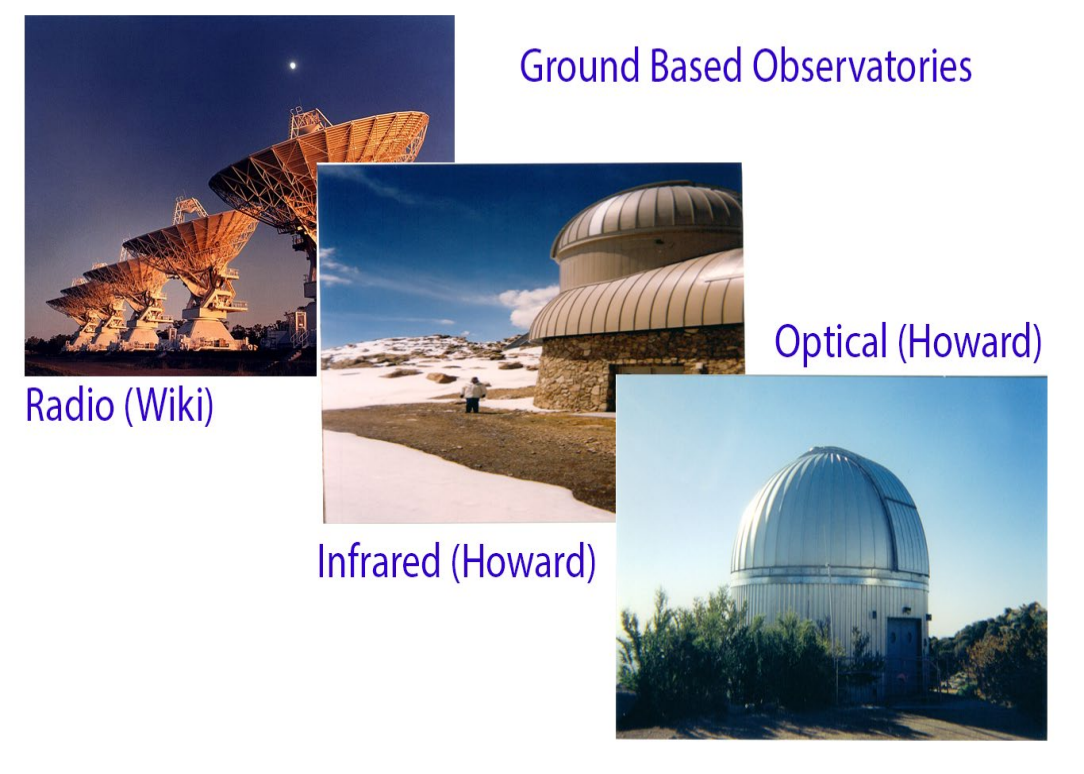


Figure 31. Ground Based Observatories (As Listed)

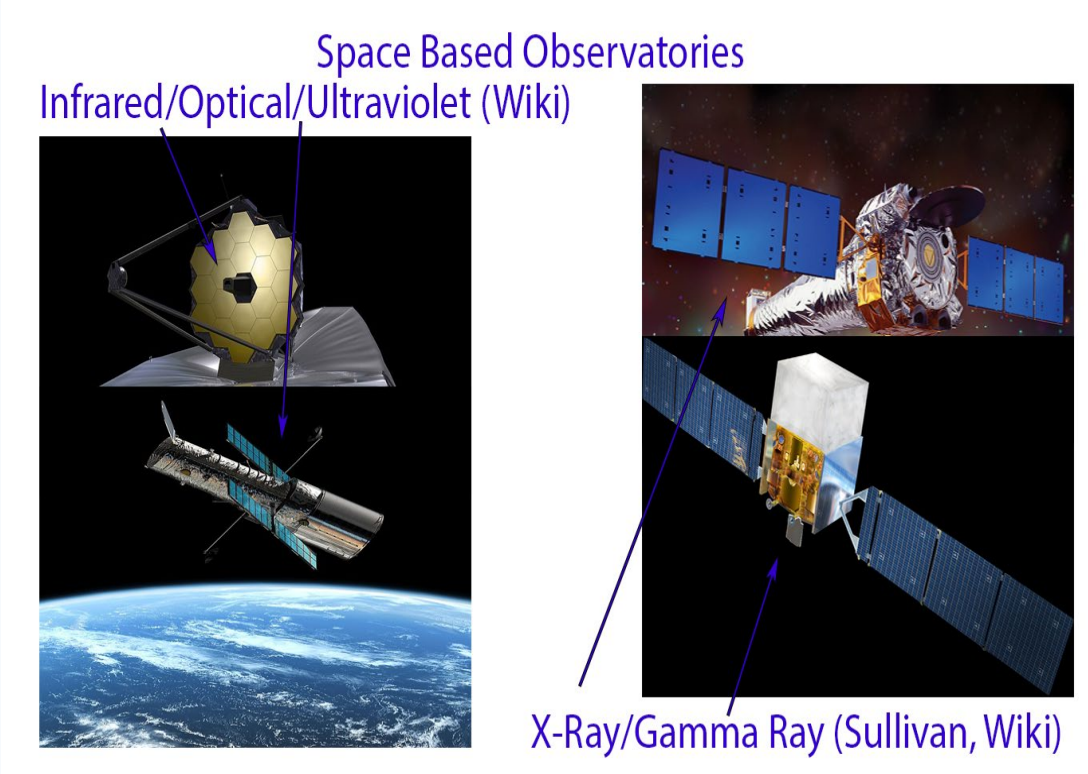
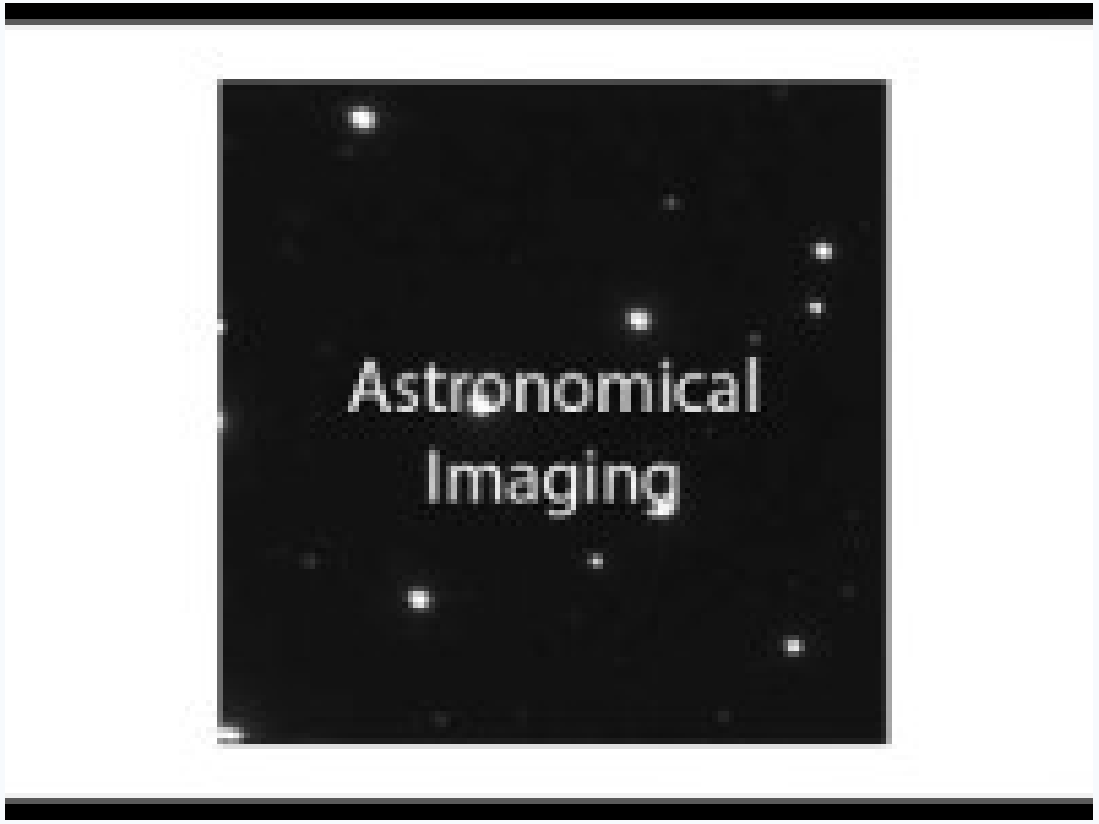


Figure 32. Space Based Observatories (As Listed)

CCD/CMOS Cameras and Astronomical Images



- We use mainly Charged Coupled Devices (CCD)/ Complementary Metal-Oxide-Semiconductor (CMOS) cameras to obtain Astronomical Images
- To create a scientific image we need three calibration images: bias, dark, and flat.
- Click on the image to see a playlist describing these cameras and the processes to processing these image.

Book/Course Image References

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- Sullivan, Robert (2017), Chandarsehkar Telescope, Retrieved from: https://www.flickr.com/photos/my_public_domain_photos/35337940272

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- Interferometer: "FTIR Interferometer" by Sanchonx (talk) - I, Sanchonx (talk), created this work entirely by myself.. Licensed under Public Domain via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:FTIR_Interferometer.png#/media/File:FTIR_Interferometer.png
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- Optical/UV Space Telescope: By Hubble ESA - The Hubble Space Telescope in orbit, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=97339390

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- Radio Telescope: By CSIRO, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=46733713
- Refraction and Reflection in a medium: "Rays of light through a different medium (labelled)" by Boweruk - Own work. Licensed under CC BY 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:Rays_of_light_through_a_different_medium_(labelled).svg#/media/File:Rays_of_light_through_a_different_medium_(labelled).svg