Light, Optics and Telescopes

The Electromagnetic Spectrum

Visible Light

Wavelength (nanometers)

400 500 600 700

Table of Contents  Visual Stimulus
Photons of different energies radiate at different wavelengths or frequencies

\[ \text{wavelength} \times \text{frequency} = \text{velocity of light} \ (c) \]

\[ \lambda \nu = c \]

The Inverse Square Law of Radiation
Physical Properties of Light

Refraction
Refraction is wavelength dependent.

Reflection

PLANE MIRROR
Formation of an image

- **Law of Reflection**
  \[ \theta_i = \theta_r \]

- **Image Formation by Plane Mirrors**
  \[ d_o = d_i \]

- **Spherical Mirrors**
  \[ f = \frac{r}{2} \]

Incident rays which travel parallel to the principal axis will refract through the lens and converge to a point.
Telescopes -- Refractors

Yerkes Observatory – Lake Geneva, Williams Bay Wisconsin
Properties of the telescope

Collecting Area -- diameter squared \((D^2)\)

Resolution or Resolving Power - wavelength/diameter \((\lambda/D)\)

Limitations -- Atmospheric -- weather
"seeing" -- turbulence
Reflecting Telescopes

Prime

Newtonian

Cassegrain

Coude
20th Century Large Reflectors

Mt Wilson 100-inch – 100 yrs old

Palomar
200-inch

Cerro Tololo 4 -meter
Modern Observatories

Cerro Tololo Interamerican Obs.
MMT on Mt. Hopkins, AZ
Very Large Telescopes

Mauna Kea

ESO – VLT
Minnesota’s $5M (private) investment in a very large telescope (> $100M)

Large Binocular Telescope (LBT) Mt. Graham Arizona

Design

Other partners -- University of Arizona, Germany, Italy, Ohio State University, University of Virginia, Notre Dame
Astronomical Instruments

Cameras/Imagers -- pictures,
Photometers – brightness and colors

Spectrographs -- the spectrum, energy vs. wavelength.

Doppler Effect – any wave motion

Away – longer $\lambda$, lower $\nu$

Redshift

Toward – shorter $\lambda$, higher $\nu$

Blueshift
Radio Telescopes

A diagram of a radio telescope showing the primary parabolic reflector surface (dish), subreflector, feed horn, incoming radio waves, distant celestial radio source, magnetic tape, video display, computer and recording devices, receiver and amplifier, and cables (for carrying the signal to the control room for processing).
Telescopes in Space -- other wavelengths – UV, X ray, gamma ray and far-IR