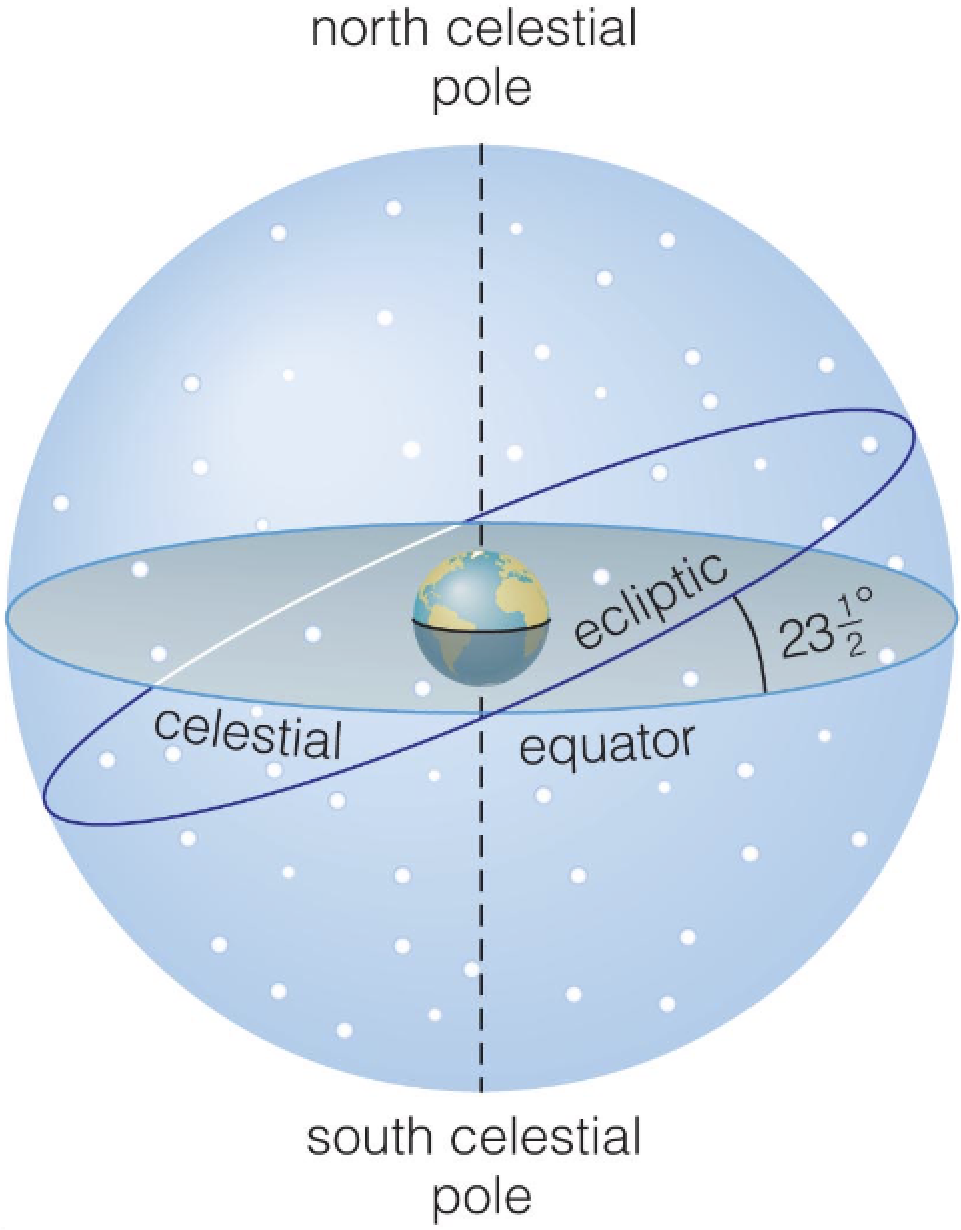
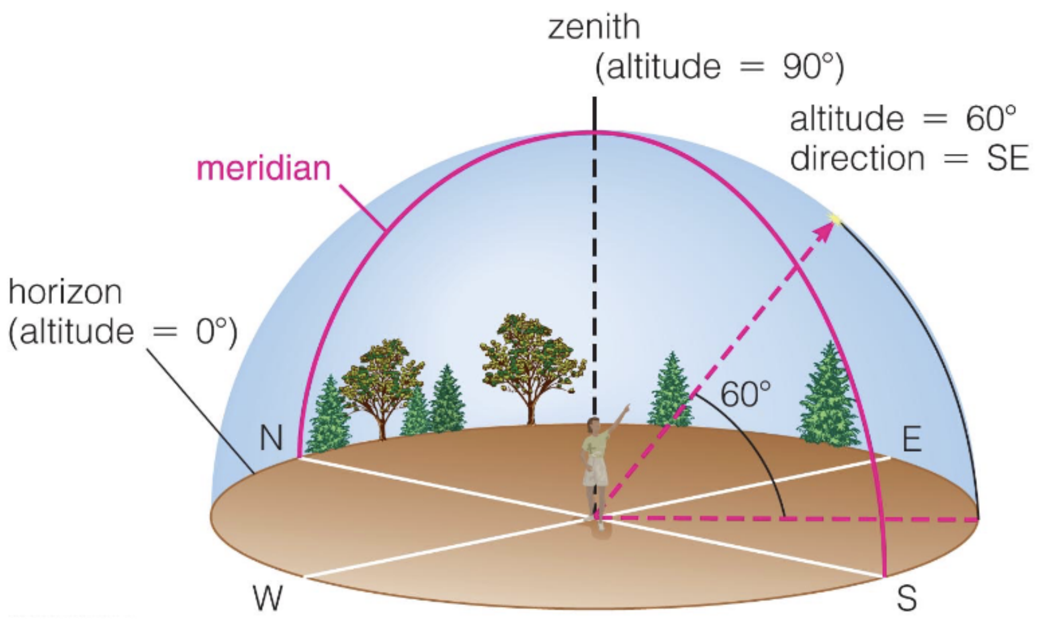
Astronomy - Exam 1 - Study Guide

Celestial Sphere



Ecliptic - The path the sun takes through the sky over the course of a year.

Local Sky



- **Zenith** - The point directly above you.
- **Horizon** - All points 90 degrees away from the zenith.
- **Meridian** - The line that goes from the north point on the horizon, through the zenith, to the south point on the horizon.
- **Azimuth** - The angle along the horizon.

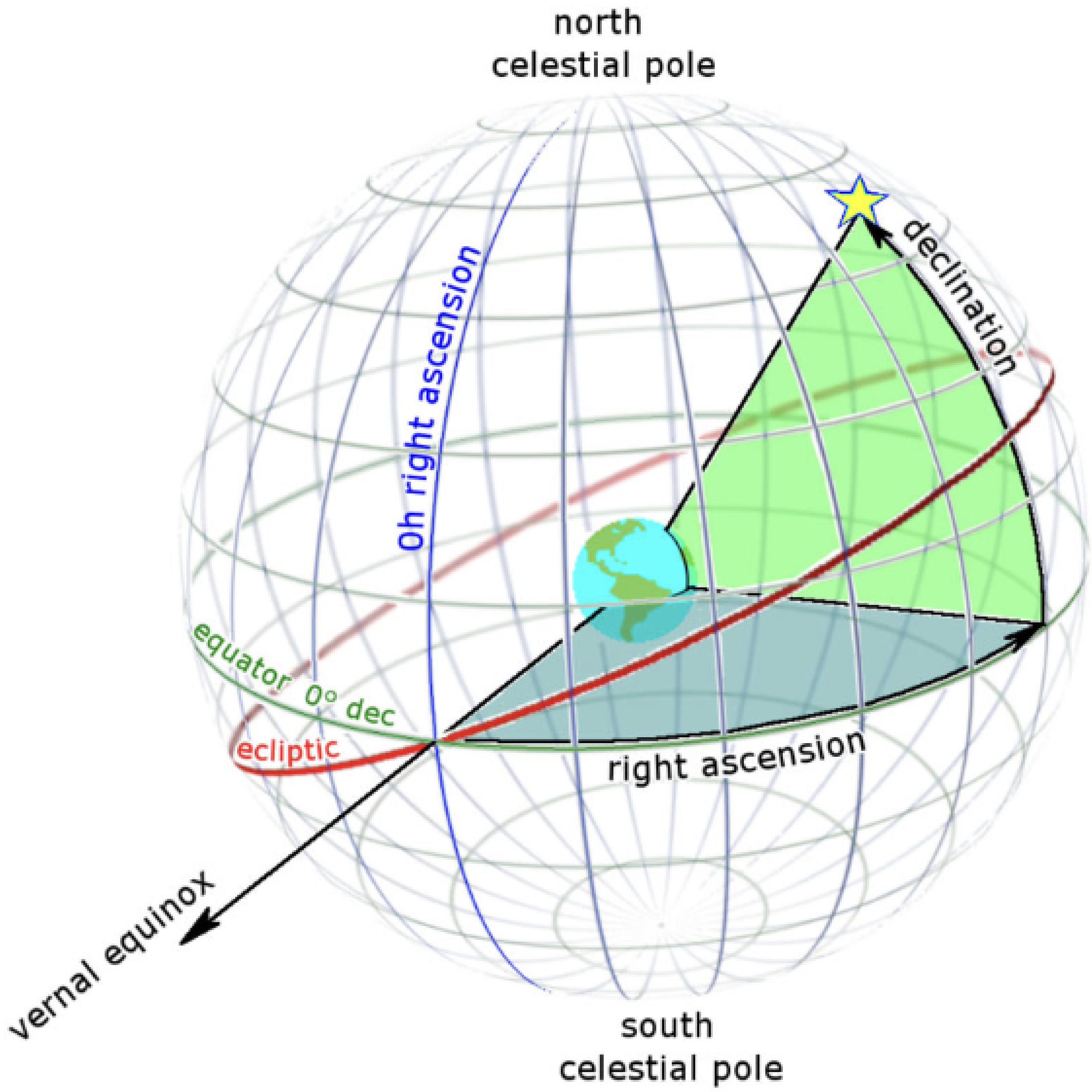
Altitude and **Direction** are used to describe the position of an object in the local sky.

Coordinates

Earth

- **Latitude** - North or south from the equator
- **Longitude** - East or west from the prime meridian

Star



- **Declination** - North or south
- **Right Ascension** - East or west

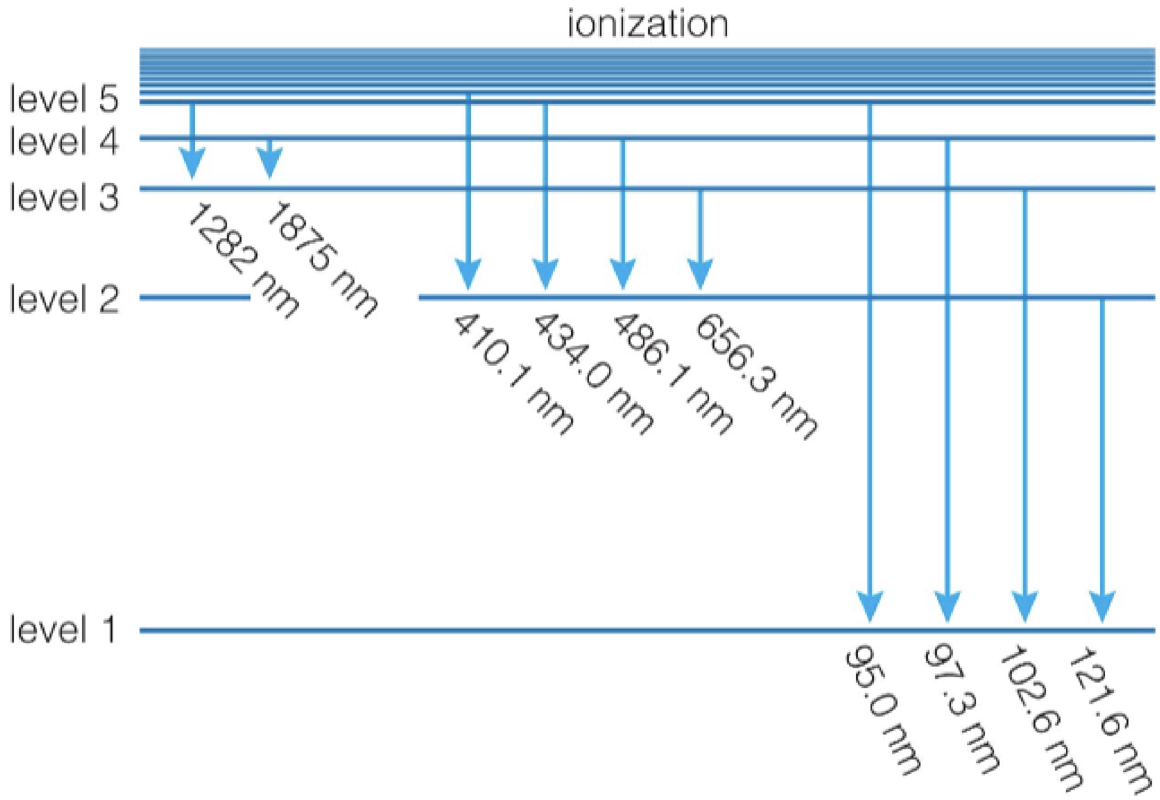
History of Astronomy

The Greeks

Geocentric Model : The Earth is at the center of the universe and the planets move in circles around it

Noticed a period of **retrograde motion** in the sky

- **Retrograde Motion** : The apparent motion of a planet in a direction opposite to that of other bodies within its system as observed from a particular vantage point
- Planets usually move from West to East relative to the stars. However, they sometimes appear to move from East to West for a short period of time.
- Plato and Aristotle believed that the Earth was at the center of the universe



Ptolemy (100-170 AD)

- Created a model (Ptolemaic Model) that explained retrograde motion using **epicycles**
- **Epicycles** : Small circles that planets move in as they orbit the Earth

Aristarchus (310-230 BC)

- First to propose a **heliocentric model** (Sun at the center of the universe)
- He noticed that the stars are much farther away than the Sun

The Middle Ages

- The Church was the main authority

Copernicus (1473-1543)

- Proposed a heliocentric model
- He was the first to use the term "revolution" to describe the Earth's motion around the Sun

a Energy level transitions in hydrogen correspond to photons with specific wavelengths. Only a few of the many possible transitions are labeled.

c This spectrum shows absorption lines produced by upward transitions between level 2 and higher levels in hydrogen.

The Renaissance

Tycho Brahe (1546-1601)

- Made the most accurate measurements of the positions of the stars and planets
- Showed that geocentric and heliocentric models were both incorrect through his observations
- Would lead to Kepler's Laws

Kepler (1571-1630)

- Used Brahe's data to come up with his laws (see above)

The Scientific Revolution

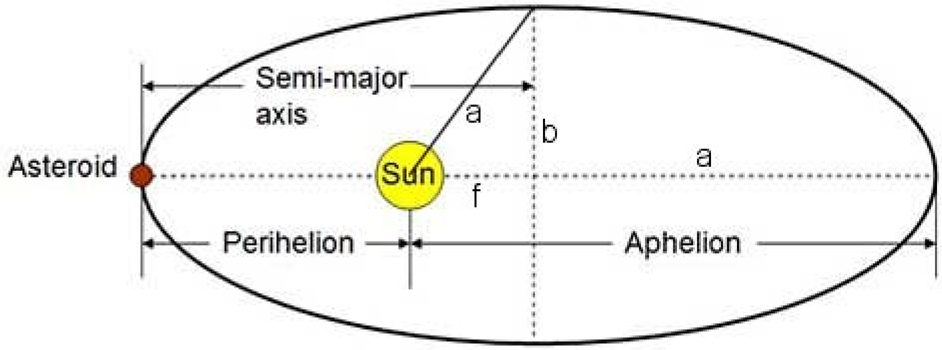
Galileo (1564-1642)

- Used a telescope to observe the sky
- Discovered the moons of Jupiter, the phases of Venus, and sunspots
- The only way for the phases of Venus to occur as he observed was if it was orbiting the Sun
- After it was essentially proven that the Earth was not at the center of the universe

Kepler's Laws

Kepler's First Law

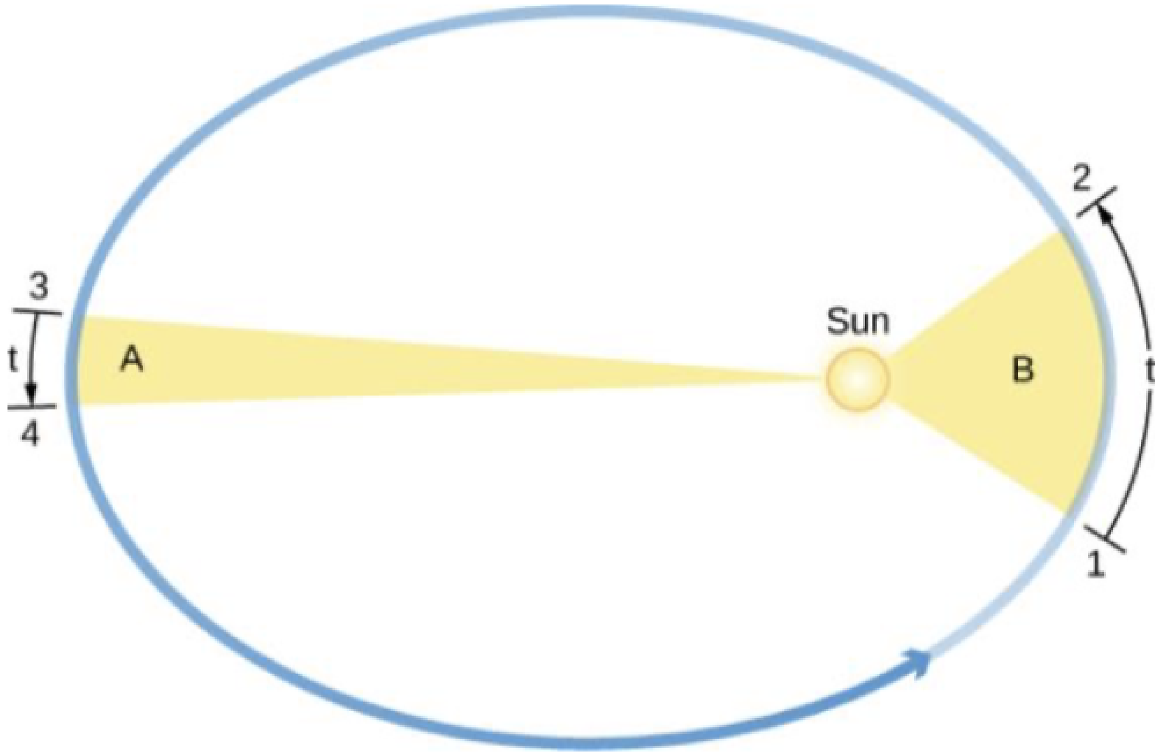
The orbit of a planet is an ellipse with the Sun at one of the two foci



One tack is the sun.

Kepler's Second Law

A line segment joining a planet and the Sun sweeps out equal areas during equal intervals of time

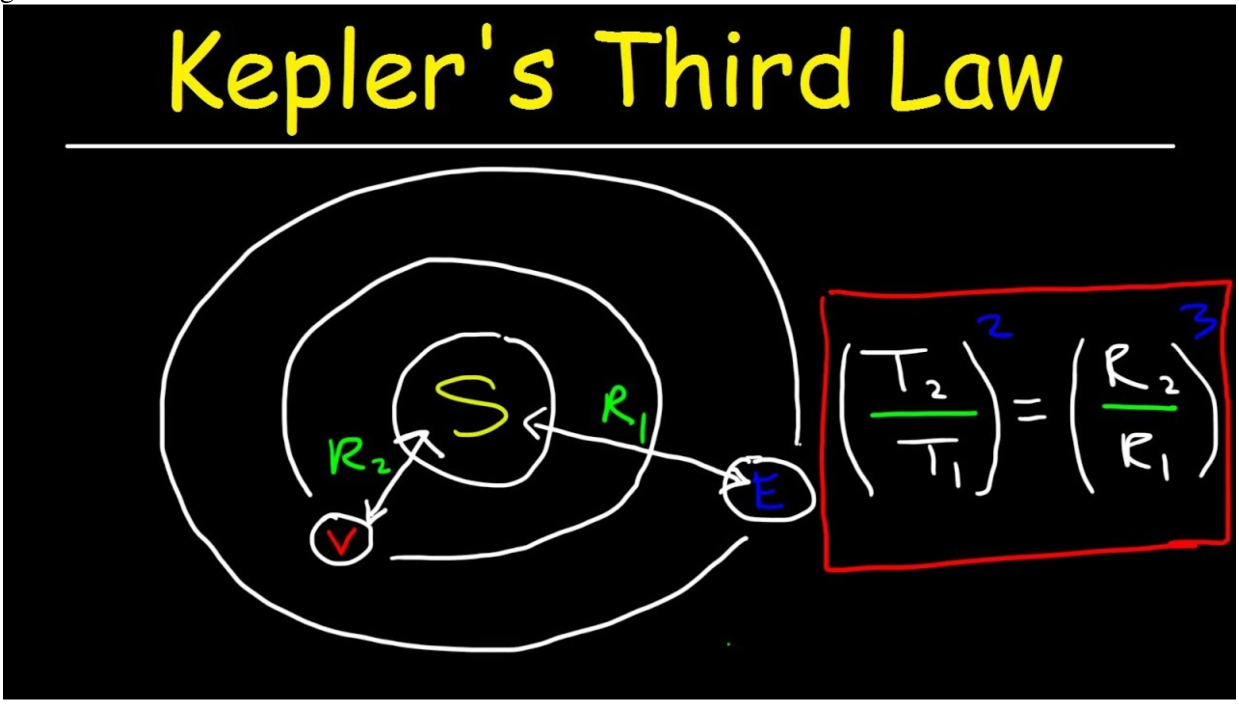


$$A = B$$

Kepler's Third Law

$$P^2 \propto r^3$$

The square of the orbital period of a planet is directly proportional to the cube of the semi-major axis of its orbit



$$\frac{GM}{4\pi^2} = \frac{d^3}{T^2}$$

So we know that ratio is a constant

Newton's Version

$$P^2 = \frac{4\pi^2}{G(M_1 + M_2)}a^3$$

- P is the orbital period
- G is the gravitational constant
- M_1 and M_2 are the masses of the two objects
- a is the semi-major axis of the orbit

Gravity

$$F = \frac{GM_1 M_2}{R^2}$$

Orbital Velocity

$$v = \sqrt{\frac{GM}{R}}$$

- v is the orbital velocity
- G is the gravitational constant ($6.674 \times 10^{-11} \mathrm{m}^3 \mathrm{kg}^{-1} \mathrm{s}^{-2}$)
- M is the mass of the object being orbited
- R is the distance between the two objects

Escape Velocity

$$v_{\mathrm{escape}} = \sqrt{\frac{2GM}{R}}$$

Conservation of Angular Momentum

$$L = mvr$$

- L is the angular momentum
- m is the mass of the object
- v is the velocity of the object

Conservation of Energy

$$E = \frac{1}{2}mv^2 - \frac{GMm}{r}$$

Important Numbers

- **Gravitational Constant (G)** : $6.674 \times 10^{-11} \mathrm{m}^3 \mathrm{kg}^{-1} \mathrm{s}^{-2}$
- **Mass of the Earth** : $5.972 \times 10^{24} \mathrm{kg}$
- **Mass of the Sun** : $1.989 \times 10^{30} \mathrm{kg}$
- **Distance from the Earth to the Sun** : $1.496 \times 10^{11} \mathrm{m}$ = 1 AU
- **Radius of the Earth** : $6.371 \times 10^{6} \mathrm{m}$

Light

Wavelength (λ)

The distance between two peaks in a wave.

Frequency (f)

The number of peaks that pass a point in a given time. Corresponds to the color of light and the energy of the light.

Speed of Light (c)

$$c = \lambda f$$
$$c = 3.00 \times 10^{8} \mathrm{m/s}$$

Energy of Light

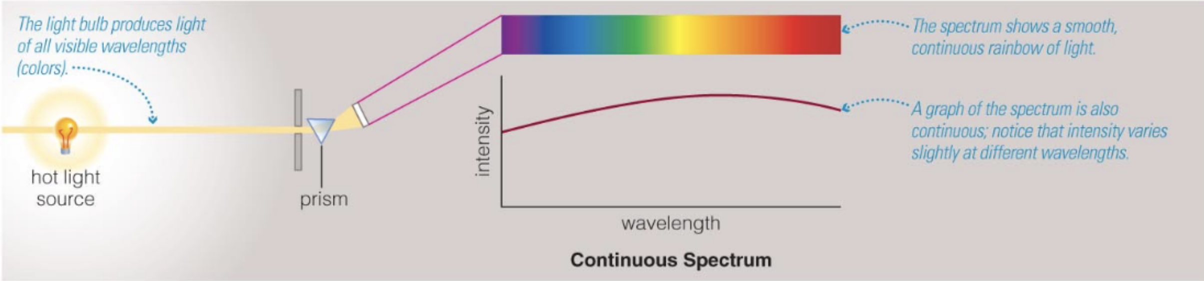
$$E = hf$$

- E is the energy of the light
- h is Planck's constant (6.626×10^{-34} J s)

Spectra

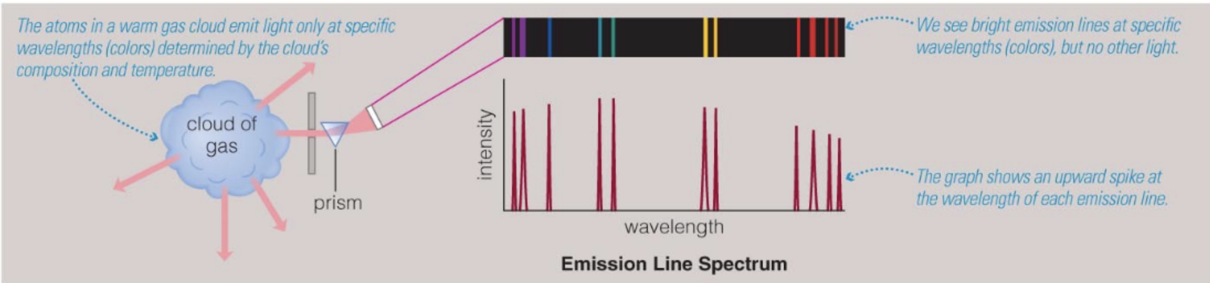
The colors of light emitted by an object.

Continuous Spectra



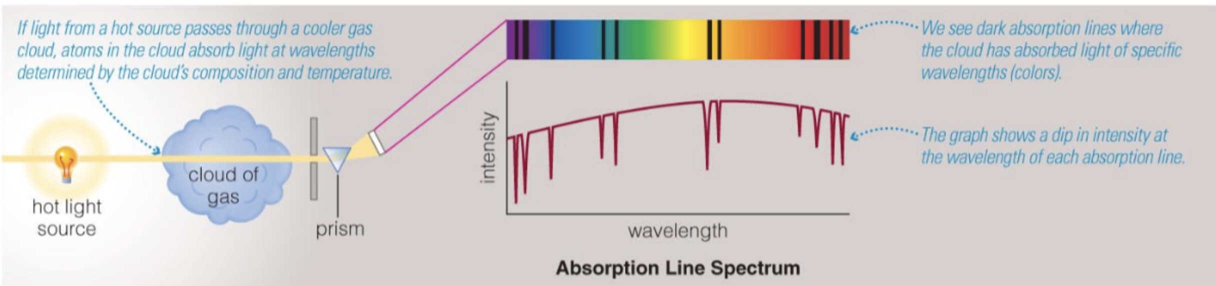
Spans all visible wavelengths without interruption

Emission Line Spectra



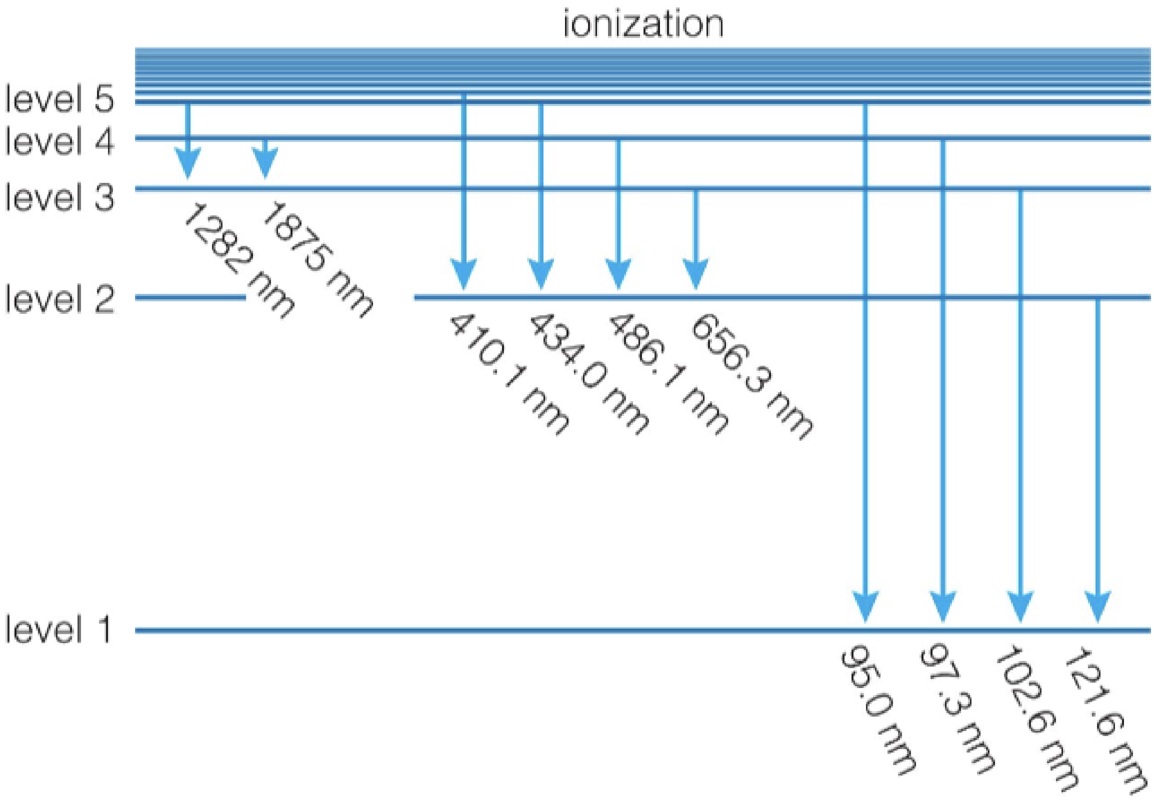
Only emits light at specific wavelengths. Like a thin gas cloud.

Absorption Line Spectra



When something like a gas cloud absorbs light at specific wavelengths.

Chemical Fingerprints



Each element has a unique set of energy levels and therefore a unique set of spectral lines.

By looking at the absorption or emission lines of a star, we can determine what elements are present in the star.

a Energy level transitions in hydrogen correspond to photons with specific wavelengths. Only a few of the many possible transitions are labeled.

c This spectrum shows absorption lines produced by upward transitions between level 2 and higher levels in hydrogen.

Wein's Law

$$\lambda_{\max} = \frac{b}{T}$$

- $\lambda_{\max}$ is the peak wavelength
- b is Wien's displacement constant $(2.90 \times 10^{-3}\,\mathrm{m\ K})$

Blackbody Radiation

1. Hotter objects emit more light at all frequencies per unit area.
2. Hotter objects emit photons with a higher average energy.

Doppler Effect

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

- $\Delta\lambda$ is the change in wavelength
- λ is the original wavelength
- v is the velocity of the object
- c is the speed of light

Telescopes

Light Collecting Area

The area of the primary mirror that collects light. Increases with the square of the diameter (alot more than our eyes)

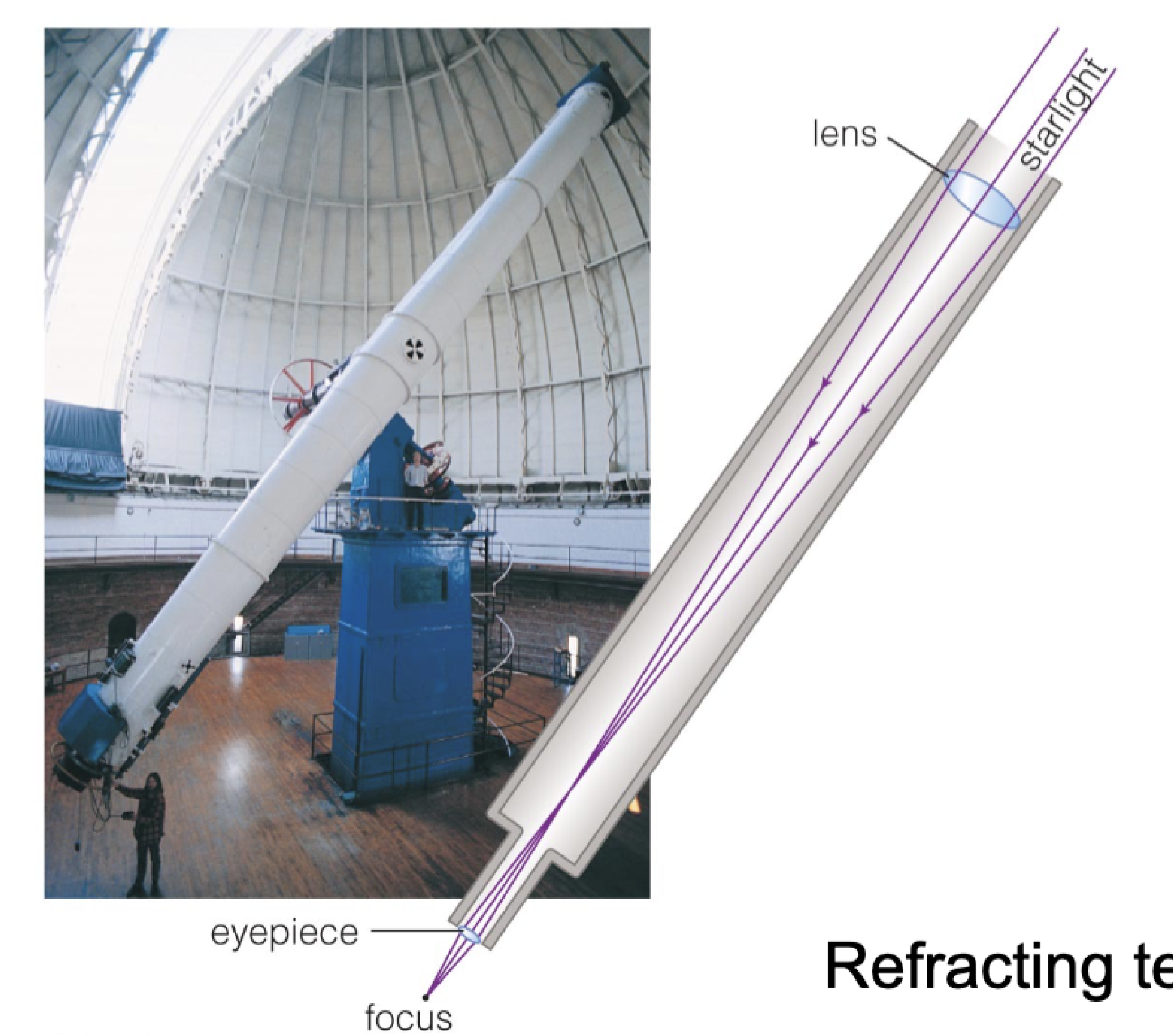
Angular Resolution

The smallest angle over which we can tell that two objects are distinct.

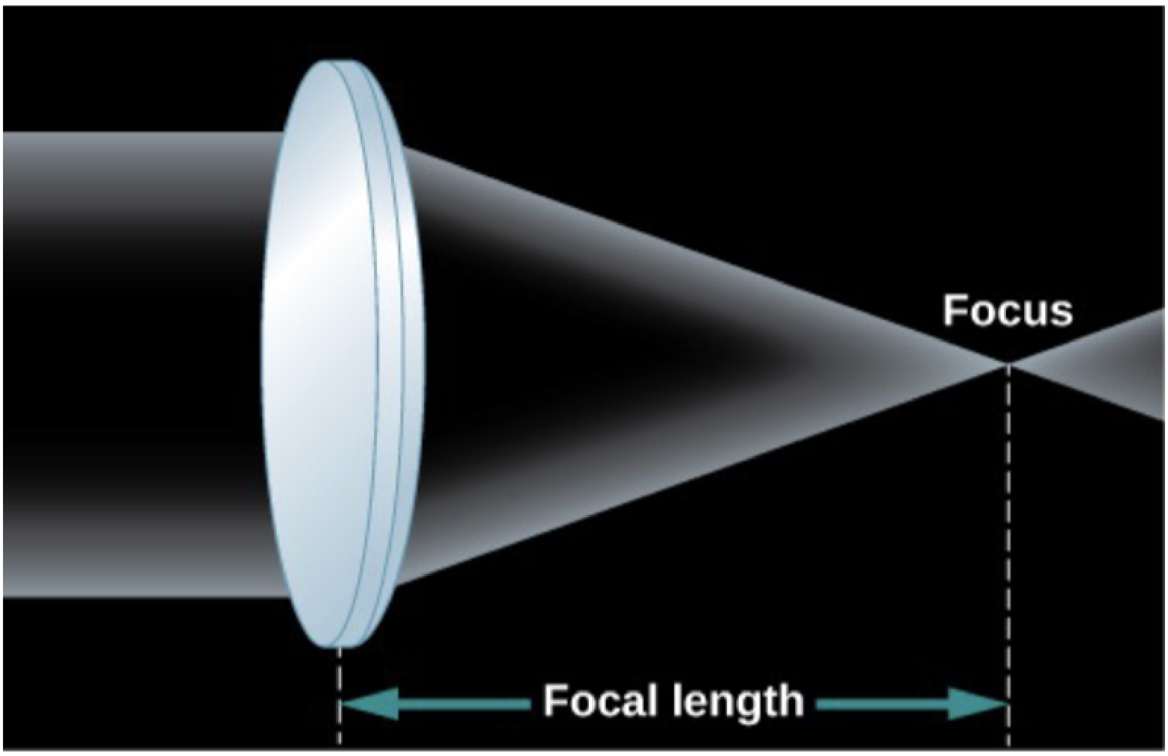
$$\theta_{\min} = \frac{1.22\lambda}{D}$$

Types of Telescopes

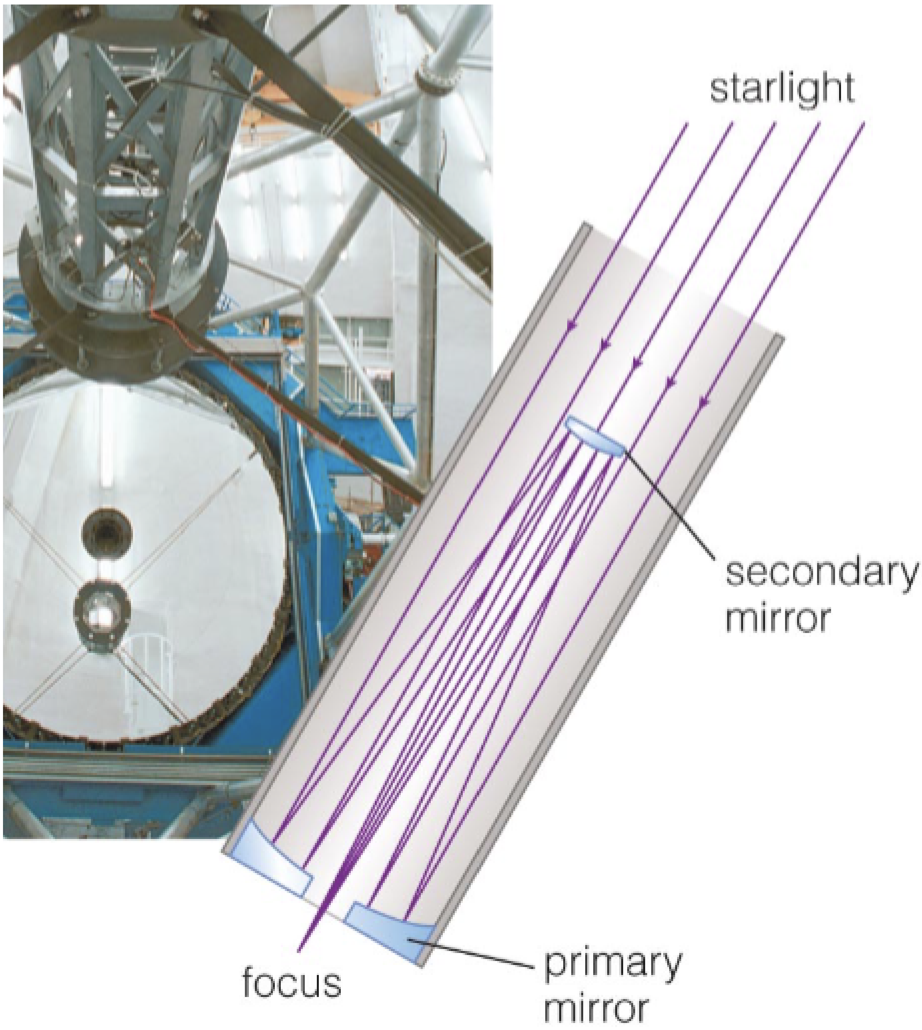
Refracting Telescopes



Uses lenses to focus light.

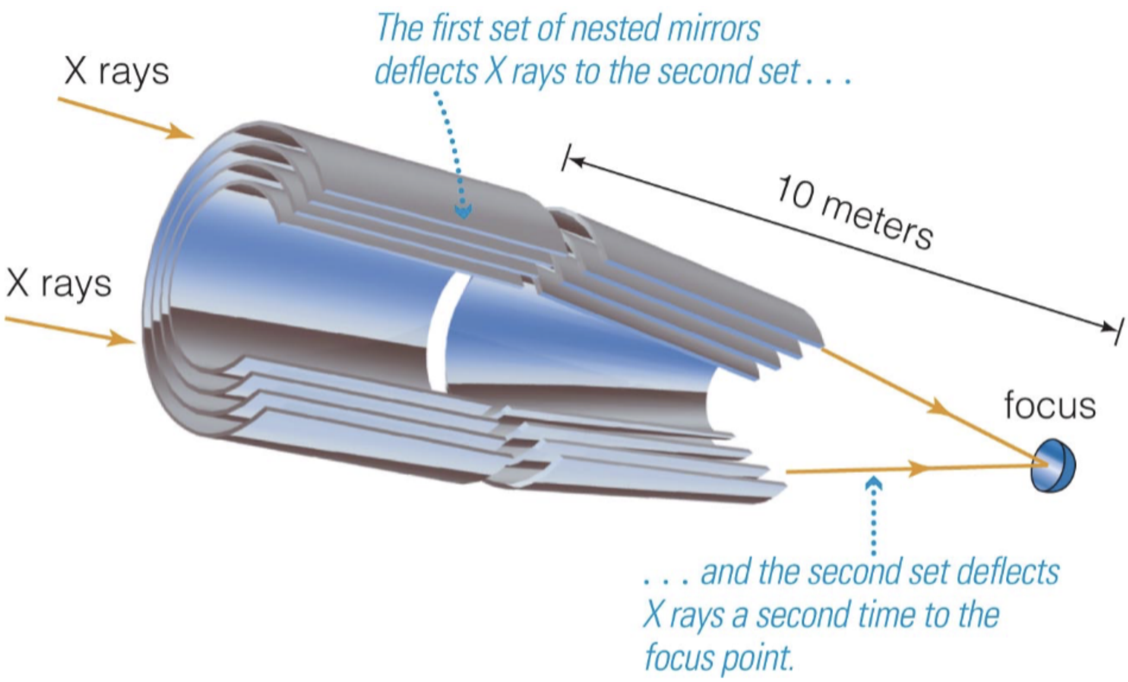


Reflecting Telescopes



Uses mirrors to focus light.

X-Ray Telescopes



Uses mirrors to focus x-rays.

Why we send telescopes into space

- Light pollution
- Atmosphere absorbs certain wavelengths
- Turbulence causes stars to twinkle. The temperature of the air changes the refractive index of the air.

The Solar System

Properties

- Large bodies in the solar system have orderly motions.
- Planetary orbits are nearly circular and lie nearly in the same plane.
- Most planets rotate in the same direction in which they orbit.
- Asteroids and comets are leftovers from the formation of the solar system.
- Exceptions: Rotation of Ur anus / Venus, Earth's large moon, etc.
- The solar system contains two types of planets:

Terrestrial Planets

- Dense
- Rocky
- Small
- Slow rotation

Jovian Planets

- Low density
- Gaseous
- Large
- Fast rotation

Formation

Nebular Theory

1. **Collapse** - The cloud of gas and dust collapses under its own gravity.
2. **Flattening** - The cloud flattens into a disk.
3. **Condensation** - The center of the disk becomes the sun and the rest of the disk forms the planets.