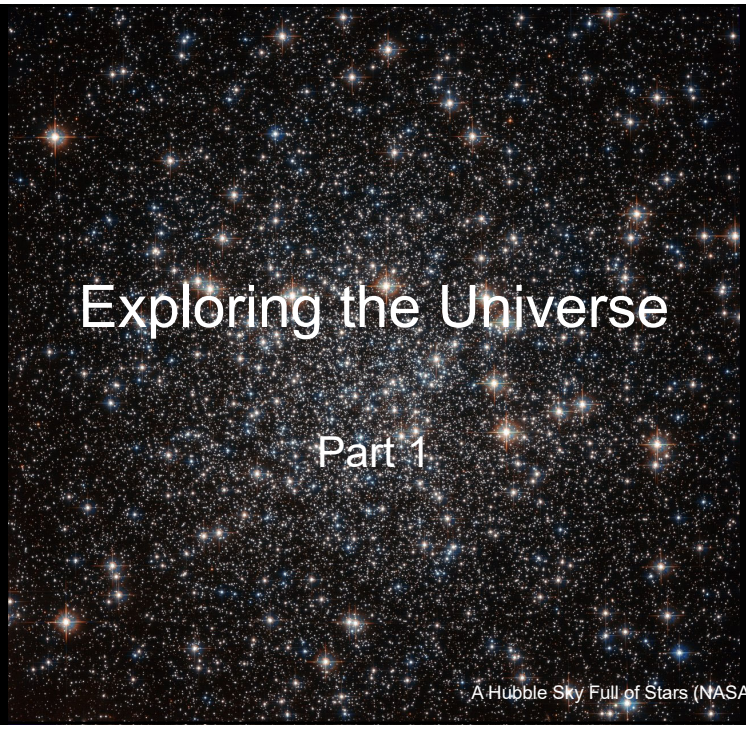
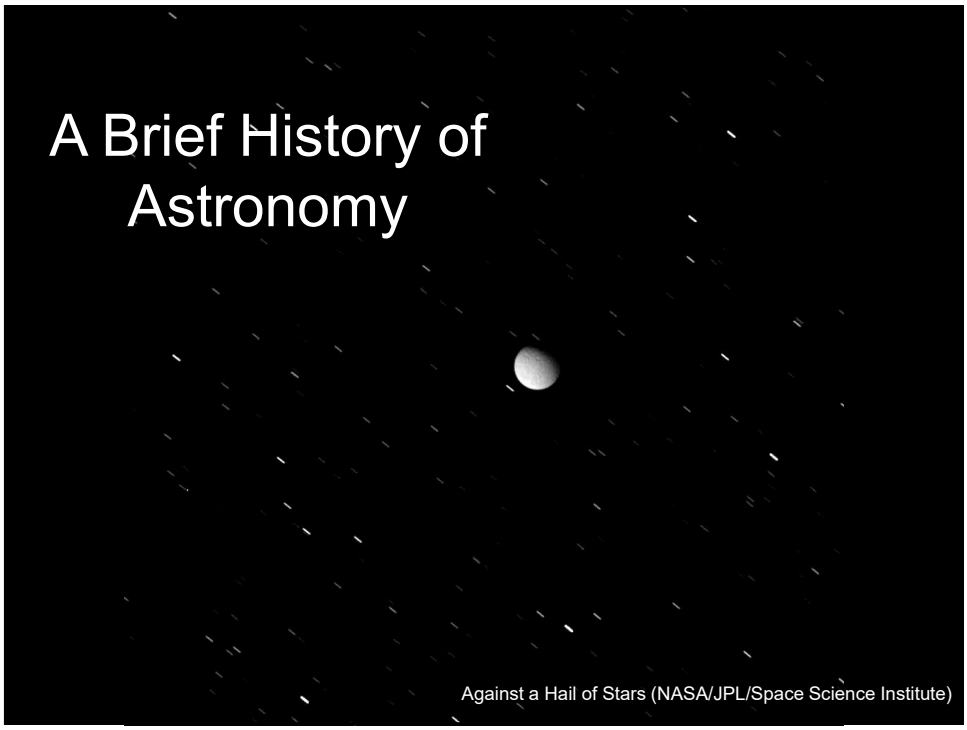
Exploring the Universe

Part 1



A Hubble Sky Full of Stars (NASA Goddard)

A Brief History of Astronomy

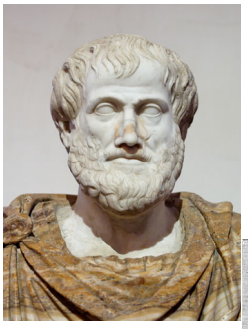


Against a Hail of Stars (NASA/JPL/Space Science Institute)

https://youtu.be/rh0fxJkvL44

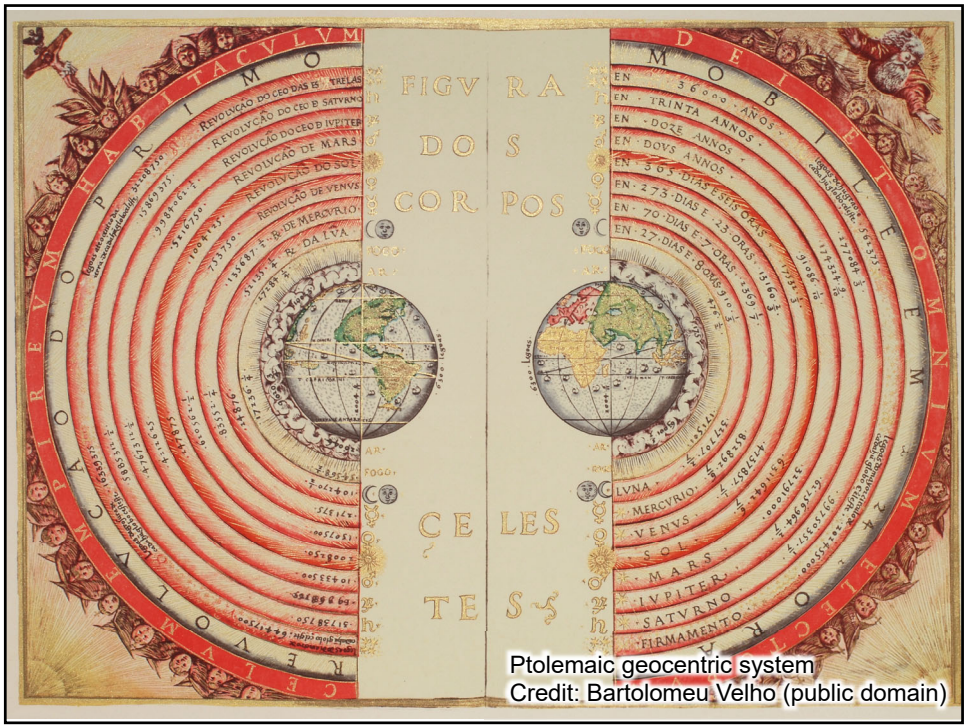
Geocentric Universe

- Supported by ancient Greek philosophers such as Aristotle
- Ptolemaeus (Ptolomy) standardized the geocentric model in the early 2nd century CE



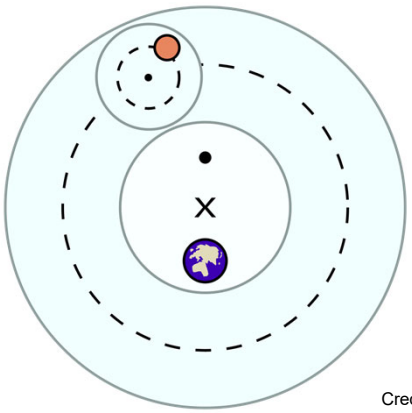
Aristotle – after Lysppidos (photographed by Jastrow (public domain)

Ptolomy – Unknown (public domain)



Ptolemaic geocentric system
Credit: Bartolomeu Velho (public domain)

- In the Ptolemaic system, each planet is moved by a system of two spheres: one called its deferent; the other, its epicycle
- This model explained **retrograde** motion



Credit: Fastfission (public domain)

In the Ptolemaic system, each planet is moved by a system of two spheres: one called its deferent; the other, its epicycle.

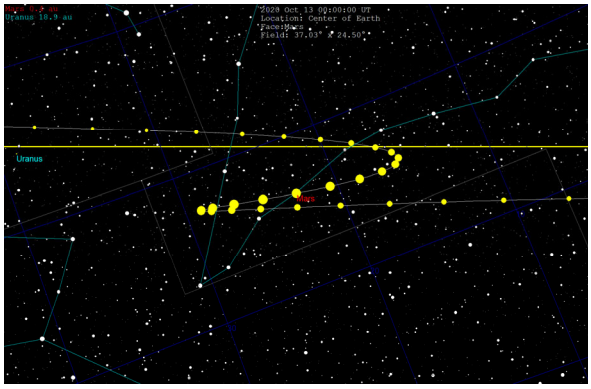
The deferent is a circle whose center point, called the eccentric and marked in the diagram with an X, is removed from the Earth. The original purpose of the eccentric was to account for the difference in length of the seasons (northern autumn was about five days shorter than spring during this time period) by placing the Earth away from the center of rotation of the rest of the universe.

Another sphere, the epicycle, is embedded inside the deferent sphere and is represented by the smaller dotted line to the right.

A given planet then moves around the epicycle at the same time the epicycle moves along the path marked by the deferent. These combined movements cause the given planet to move closer to and further away from the Earth at different points in its orbit, and explained the observation that planets slowed down, stopped, and moved backward in retrograde motion, and then again reversed to resume normal, or prograde, motion.

Retrograde Motion

- Planets appear to travel backwards during part of their journey across the sky

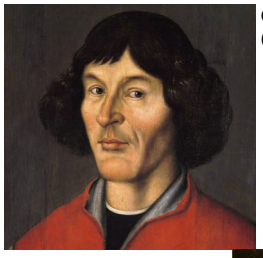


Mars motion 2020
Credit: Tomruen (CC BY-SA 4.0)

https://youtu.be/-FYvy3_egHw

Heliocentric Universe

- Copernicus (1543) proposed a heliocentric model based on geometry and observations
- Kepler (1609-1619) introduced elliptical orbits



Copernicus – unknown (public domain)

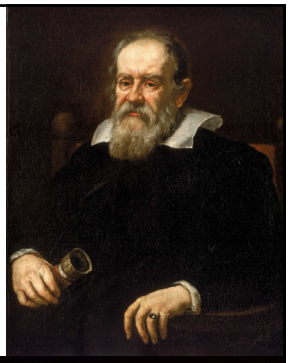
Kepler – Unknown (public domain)

The Greek astronomer and mathematician Aristarchus of Samos (c. 310 – c. 230 BC) developed a heliocentric model placing all of the then-known planets in their correct order around the Sun.

In 1543, the geocentric system met its first serious challenge with the publication of Copernicus' "De revolutionibus orbium coelestium "(On the Revolutions of the Heavenly Spheres), which posited that the Earth and the other planets instead revolved around the Sun. The geocentric system was still held for many years afterwards, as at the time the Copernican system did not offer better predictions than the geocentric system, and it posed problems for both natural philosophy and scripture. The Copernican system was no more accurate than Ptolemy's system, because it still used circular orbits. This was not altered until Johannes Kepler postulated that they were elliptical (Kepler's first law of planetary motion).

- Galileo (1609) presented supporting observations made using a telescope
- Herschel (1782 – 1802) made observations that showed that the Sun was not the center of the universe

Galileo – Justus Susterman (public domain)



Herschel – Lemuel Francis Abbott
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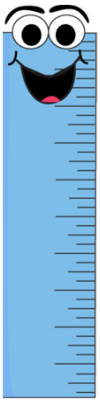
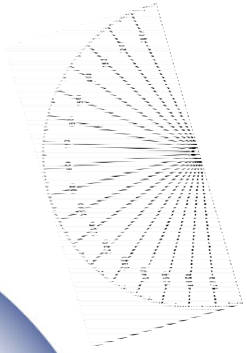
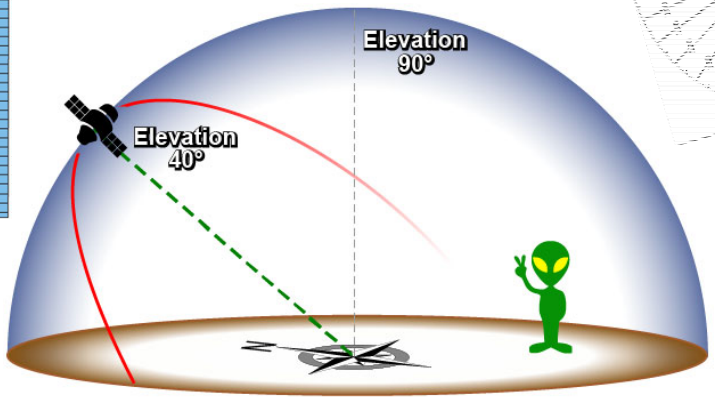


Measurements

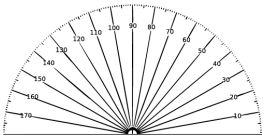




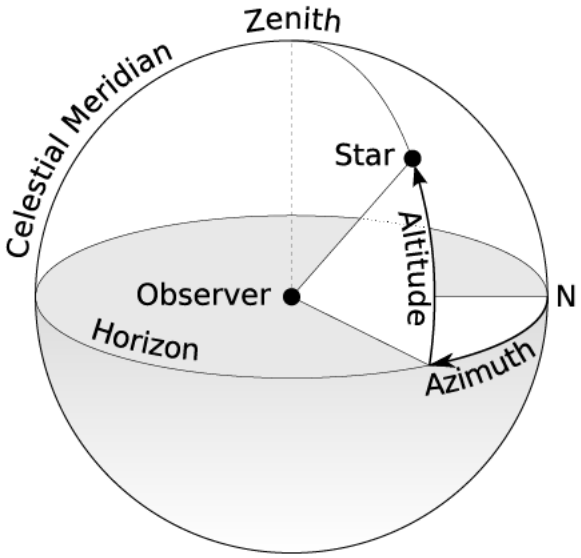
Cartoon Ruler ©MyCuteGraphics.com (Used with Permission)
Measuring Elevation From The Horizon – AeroGeek (public domain)
Protractor – yamachem (public domain)

Altitude and Azimuth

- The horizontal coordinate system is a method for describing the exact position of objects in the sky.
  - Altitude
    - Angle above horizon
  - Azimuth
    - Angle clockwise from North

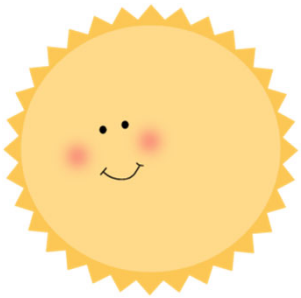


Protractor – yamachem (public domain)
Compass – rg1024 (public domain)



Credit: TWCarlson (CC BY-SA 3.0)

Astronomical Unit



- AU, au, or a.u.
- The distance between the Sun and the Earth
  - 1.5×10^8 km

Light Year

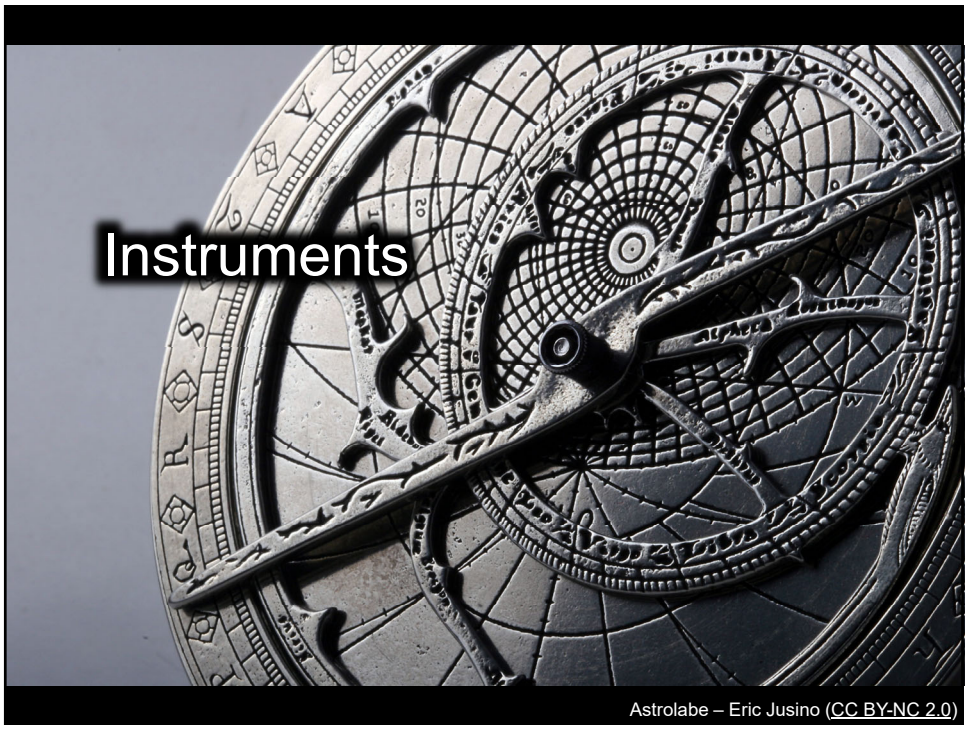
- ly
- The distance light travels in one year
  - 9.5×10^{12} km
- Used to measure the distance to stars and other objects outside of our solar system
  - The distance to the nearest star outside of our solar system, Alpha Centauri, is 4.37 ly

Parsec

- pc
- Used to measure distances to stars
  - Defined as the distance at which a star will show an annual parallax of one arcsecond
  - 3.26 ly

"It's the ship that made the Kessel Run in less than twelve parsecs! I've outrun Imperial starships, not the local bulk-cruisers, mind you. I'm talking about the big Corellian ships now. She's fast enough for you, old man."

- Han Solo



Astrolabe – Eric Jusino (CC BY-NC 2.0)

Astrolabe

Historically used by astronomers, it is able to measure the altitude above the horizon of a celestial body, day or night; it can be used to identify stars or planets, to determine local latitude given local time (and vice versa), to survey, or to triangulate.

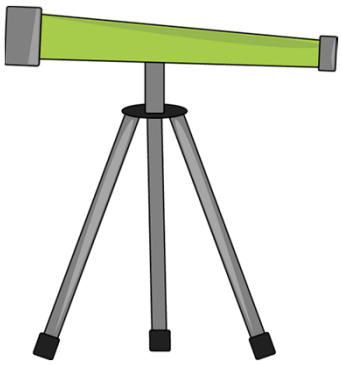
Mamluk era astrolabe – Mustafa-trit20 (CC BY-SA 4.0)

Disassembled 18th Century Astrolabe – Evan (CC BY 2.0)

A replica of Samuel Champlain's astrolabe which is accompanying a voyage of his 1609 exploration from Quebec down through Lake Champlain for the 400th anniversary.

Astrolabe – kicksonrt66 (CC BY-NC 2.0)

Telescope



A telescope is an optical instrument using lenses, curved mirrors, or a combination of both to observe distant objects, or various devices used to observe distant objects by their emission, absorption, or reflection of electromagnetic radiation.

https://youtu.be/mYhy7eaazIk

Telescope – Newsum Antiques (CC BY 2.0)

Telescope – Ryan Wick (CC BY 2.0)

Telescope at Chabot (Oakland, CA) – Danny Howard (CC BY-NC 2.0)

https://chabotspace.org/

Very Large Array near Socorro, NM – Hajor (CC BY-SA 2.0)

https://youtu.be/dIwmBDBey_Y