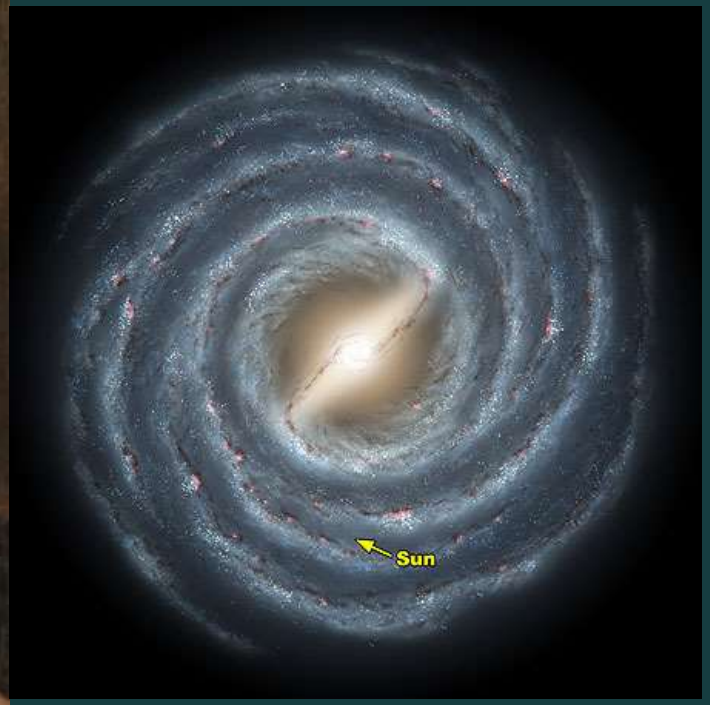
Kepler and *Our Motion Through Space*



Culpeper Astronomy Club
Meeting
April 22, 2019

Overview

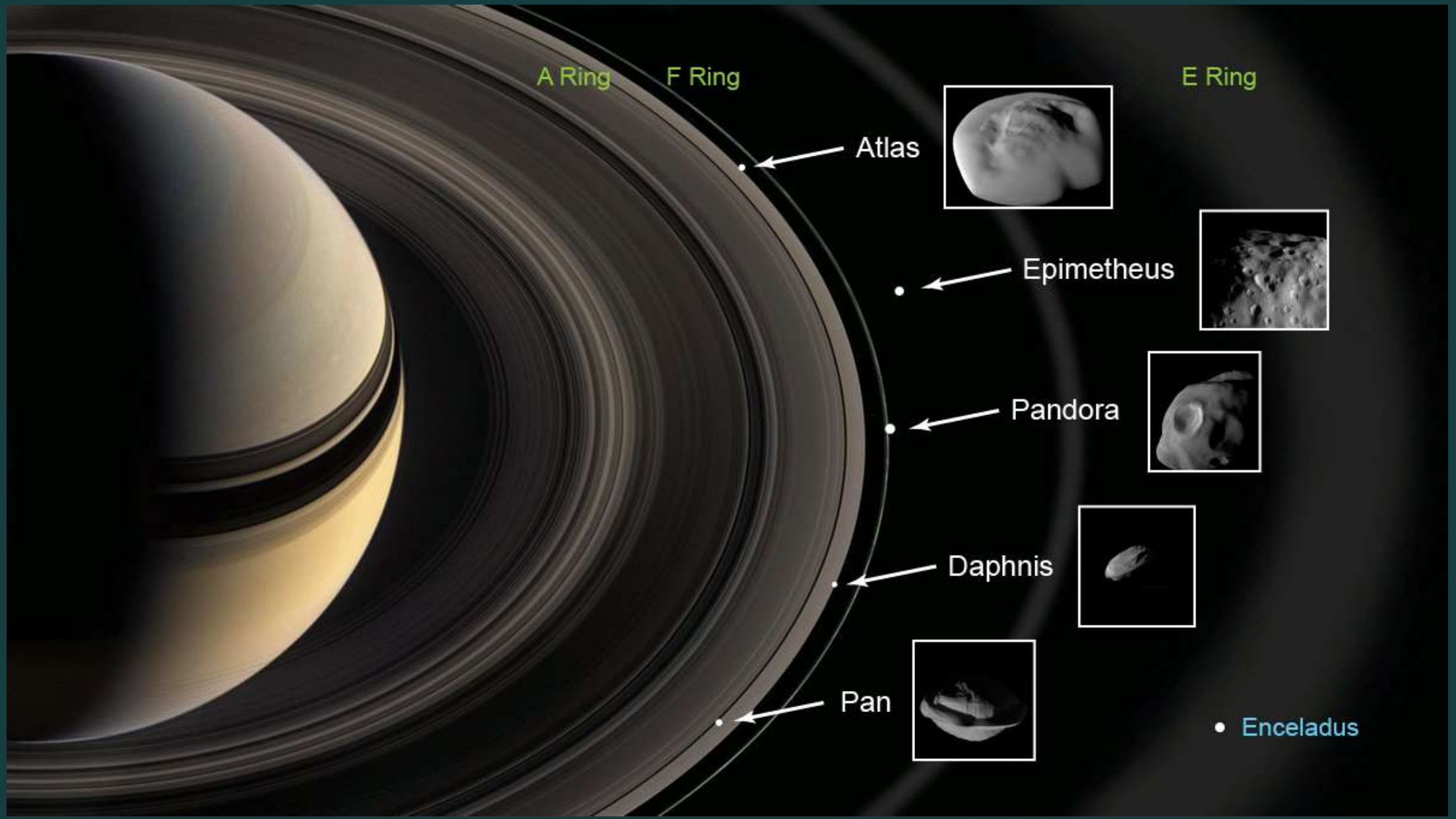
- Introductions
- Tonight's Topics: Kepler and Motion
- Constellations: Cancer, Leo, Virgo
- Observing Session (Weather permitting)

Observing Sessions

- 27 March, 1 April, 10 April (Culpeper):
  - SV110ED, 110mm refractor
  - Lots of double stars (about 50) and open star clusters
  - M3 (Glob) and Orion Nebula
- 15 April (Culpeper):
  - 1959 Unitron, 60mm refractor
  - Lunar observing from 23x to 150x

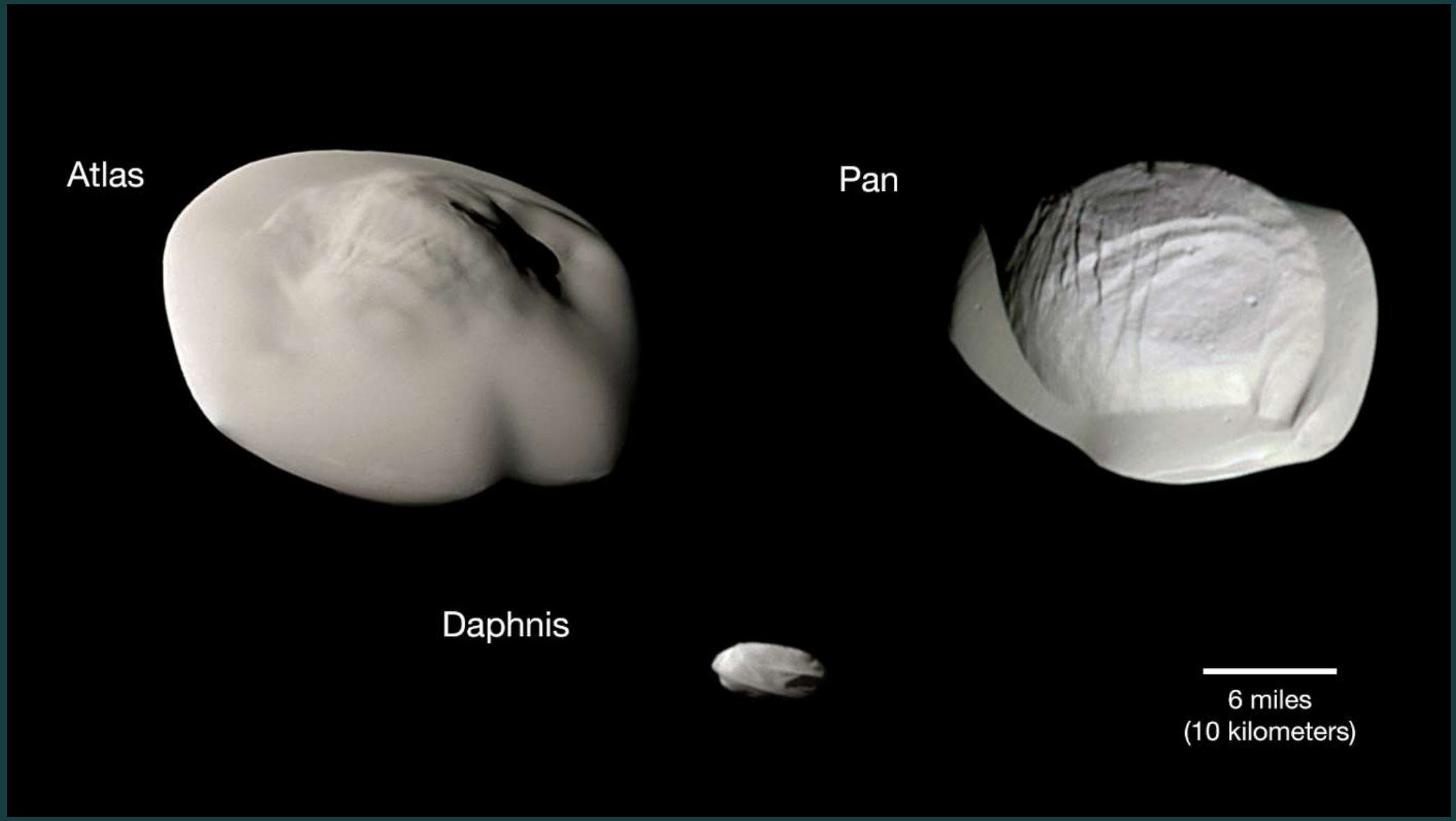
Saturn and Cassini Mission

- Data gathered by six of Cassini's instruments before its mission ended in 2017 is a clear confirmation that dust and ice from the rings accretes onto the moons embedded within and near the rings
- New findings have emerged about five tiny moons nestled in and near Saturn's rings
  - The closest-ever flybys by NASA's Cassini spacecraft reveal that the surfaces of these unusual moons are covered with material from the planet's rings
  - And from icy particles blasting out of Saturn's larger moon Enceladus
  - Paints a picture of the competing processes shaping these mini-moons
- Scientists also found the moon surfaces to be highly porous, further confirming that they were formed in multiple stages as ring material settled onto denser cores that might be remnants of a larger object that broke apart
- The porosity also helps explain their shape
  - Rather than being spherical, they are blobby and ravioli-like, with material stuck around their equators.


A Ring
F Ring
E Ring
Atlas
Epimetheus
Pandora
Daphnis
Pan
Enceladus

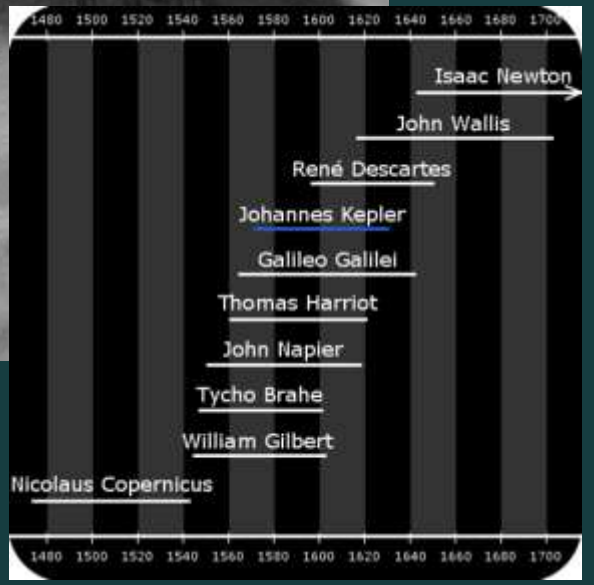
Saturn and Cassini Mission

- Moons are scooping up particles of ice and dust from the rings to form the little skirts around their equators; a denser body would be more ball-shaped because gravity would pull the material in
- Of the satellites studied, the surfaces of those closest to Saturn — Daphnis and Pan — are the most altered by ring materials
  - Surfaces of the moons Atlas, Prometheus and Pandora, farther out from Saturn, have ring material as well — but they're also coated with the bright icy particles and water vapor from the plume spraying out of Enceladus
  - Ring moons closest to Saturn appear the reddest, similar to the color of the main rings; likely a mix of organics and iron
  - The moons just outside the main rings appear more blue, similar to the light from Enceladus' icy plumes


Atlas
Pan
Daphnis
6 miles
(10 kilometers)

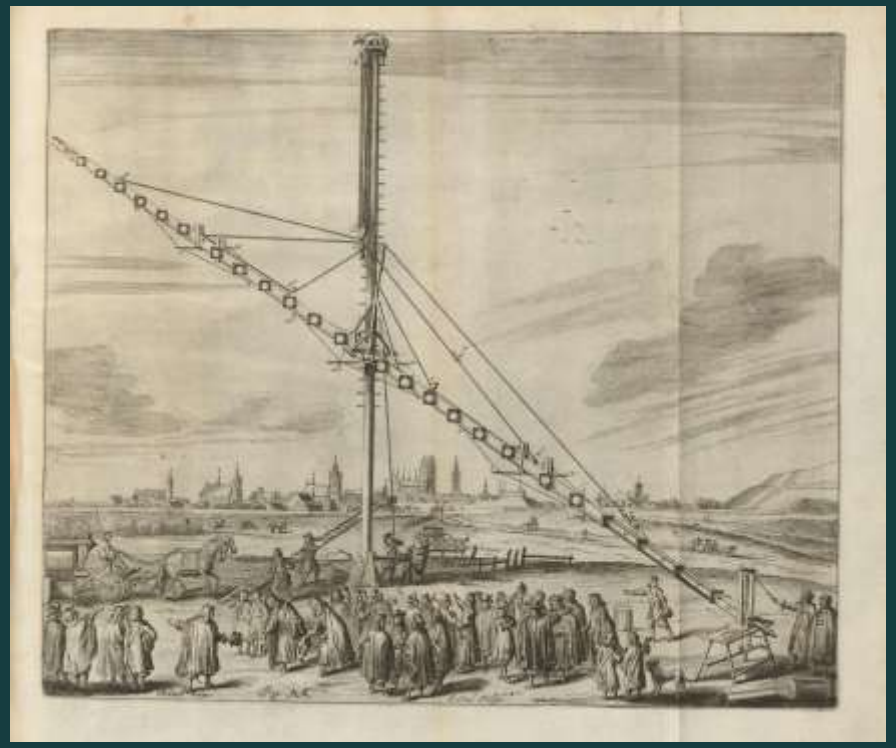
Johannes Kepler - Life

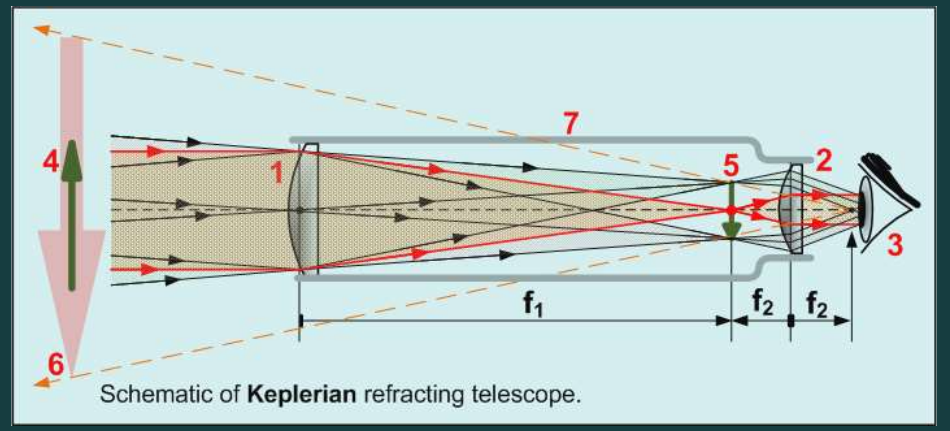
- Johannes Kepler (1571 – 1630) was a German mathematician and astronomer who was a key figure of the Scientific Revolution
- Was a sickly child of underprivileged parents; studied in the University of Tubingen under a scholarship to become a Lutheran minister
- While there, Kepler studied the research of Nicolaus Copernicus
- The latter taught that the planets revolved around the sun instead of the Earth, despite the fact that he had no observational proof to offer as evidence
- In 1596, Johannes Kepler wrote the first public justification of the Copernican system



Johannes Kepler - Contributions

- His most famous accomplishments are his three laws of planetary motion which laid the foundation of celestial mechanics
- Apart from his contributions to astronomy, Kepler laid the foundation of modern optics
  - Formulated the inverse-square law governing the intensity of light
  - Invented an improved refracting telescope
  - Correctly explained the working of a human eye
- As founder of celestial mechanics and optics, Johannes Kepler is considered one of the most influential scientists in history

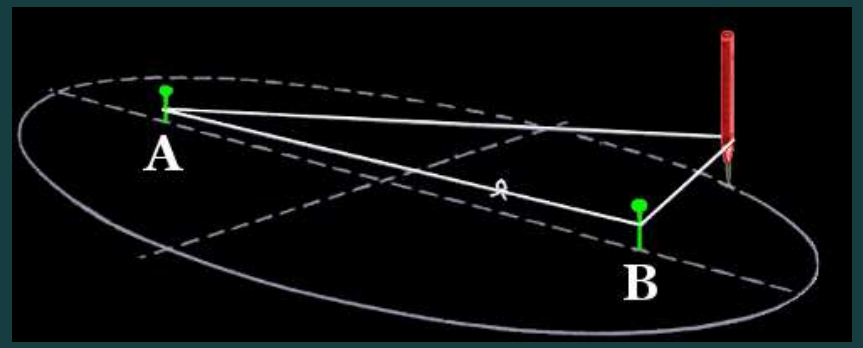


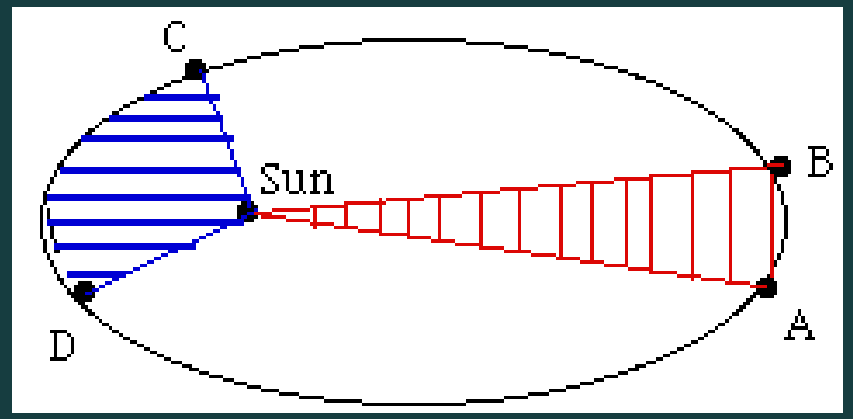


Schematic of **Keplerian** refracting telescope.

Johannes Kepler – Planetary Motion

- Developed three laws of planetary motion that revised Copernican theory
  1. Planets orbit the sun in ellipses, with the sun at one focus
  2. A line between the Sun and a planet sweeps out equal areas as long as the time intervals are equal
  3. The square of a planet's orbital period is proportional to the cube of its semi-major axis, or average distance from the Sun; the farther a planet is from the sun, the slower it moves along its orbital path





$$(T1)^2 = (A1)^3$$

“When, after a long day of running around, you finally find the time to relax in your favorite armchair, nothing seems easier than just sitting still.

But have you ever considered how fast you are really moving when it seems you are not moving at all?”

Daily Motion

- Because we "ride" with the spinning Earth, it appears to us that the Sun and the stars are the ones doing the moving as day and night alternate
- In actually, it is our planet that turns on its axis once a day -- and all of us who live on the Earth's surface are moving with it
- To make one complete rotation in 24 hours, a point near the equator of the Earth must move at close to 1000 miles per hour (1600 km/hr)
- Because gravity holds us tight to the surface of our planet, we move with the Earth and don't notice its rotation in everyday life

Yearly Motion

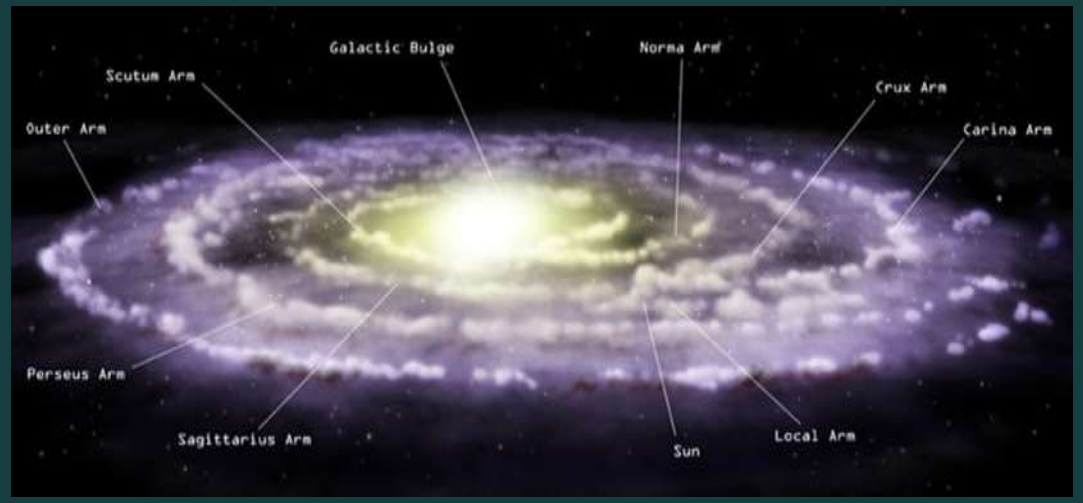
- In addition to spinning on its axis, the Earth also revolves around the Sun
- We are approximately 93 million miles (150 million km) from the Sun, and at that distance, it takes us one year (365 days) to go around once
- The full path of the Earth's orbit is close to 600 million miles (970 million km); to go around this immense circle in one year takes a speed of 66,000 miles per hour (107,000 km/hr)
- At this speed, you could get from San Francisco to Washington DC in 3 minutes

The Sun's Motion

- Our Sun is just one star among several hundred billion others that together make up the Milky Way Galaxy
- This is our immense "island of stars" and within it, each star is itself moving; any planet orbiting a star will share its motion through the Galaxy
- Relative to the local standard of rest, our Sun and the Earth are moving at about 43,000 miles per hour (70,000 km/hr) roughly in the direction of Vega in the constellation Lyra

Orbiting the Galaxy

- It takes our Sun approximately 225 million years to make the trip around our Galaxy. This is sometimes called our "galactic year"
- Since the Sun and the Earth first formed, about 20 galactic years have passed; we have been around the Galaxy 20 times
- It's a huge circle, and the speed with which the Sun has to move is an astounding 483,000 miles per hour (792,000 km/hr)



Moving Through the Universe

- And how fast is the Milky Way Galaxy moving?
- The speed turns out to be an astounding 1.3 million miles per hour (2.1 million km/hr)!
- We are moving roughly in the direction on the sky that is defined by the constellations of Leo and Virgo

So our "armchair Astronaut" is now moving through 6 different directions and a combined speed of approximately 574,585 MPH

69,361 MPH Spin and Orbit
43,200 MPH Towards Vega
15,624 MPH Perpendicular to Galactic Plane
446,400 MPH Orbiting the Galactic Center {or Galactic Spin Rate}

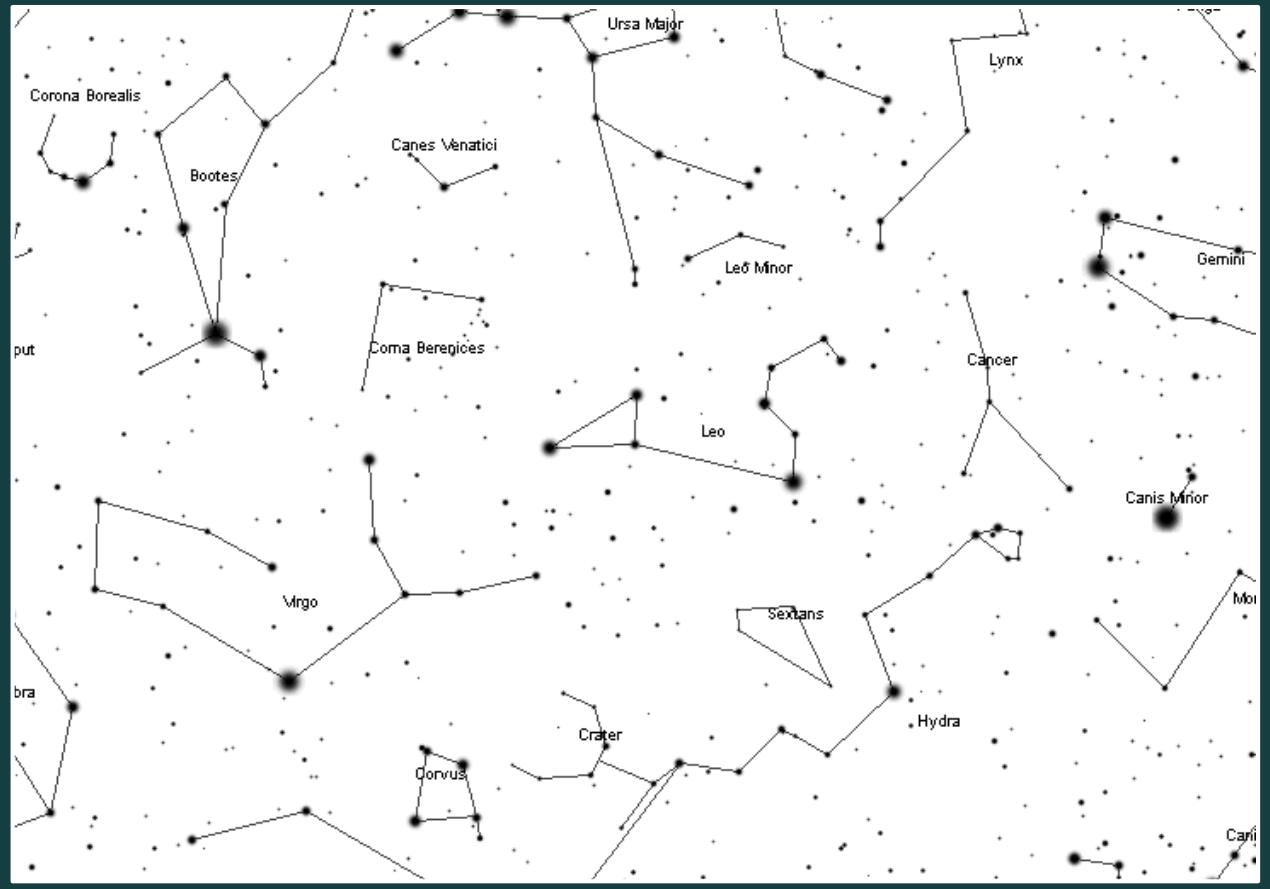
574,585 MPH Speed of Earth within Our Galaxy

Now if you want to leave the galaxy ADD another 1,339,200 MPH to the calculations

Note: C = 670,615,200 MPH

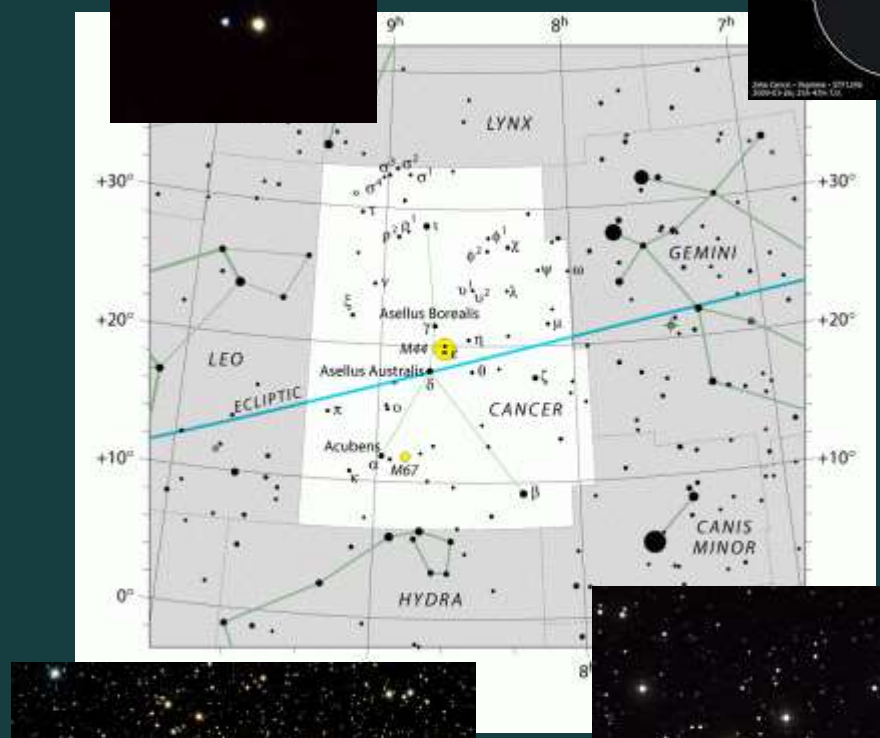
Constellations

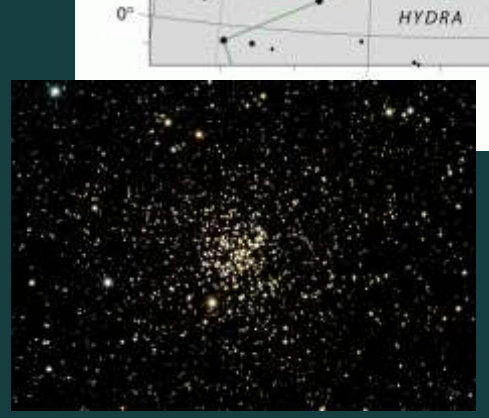
- Cancer – The Crab
- Leo - The Lion
- Virgo – The Maiden



Cancer – The Crab

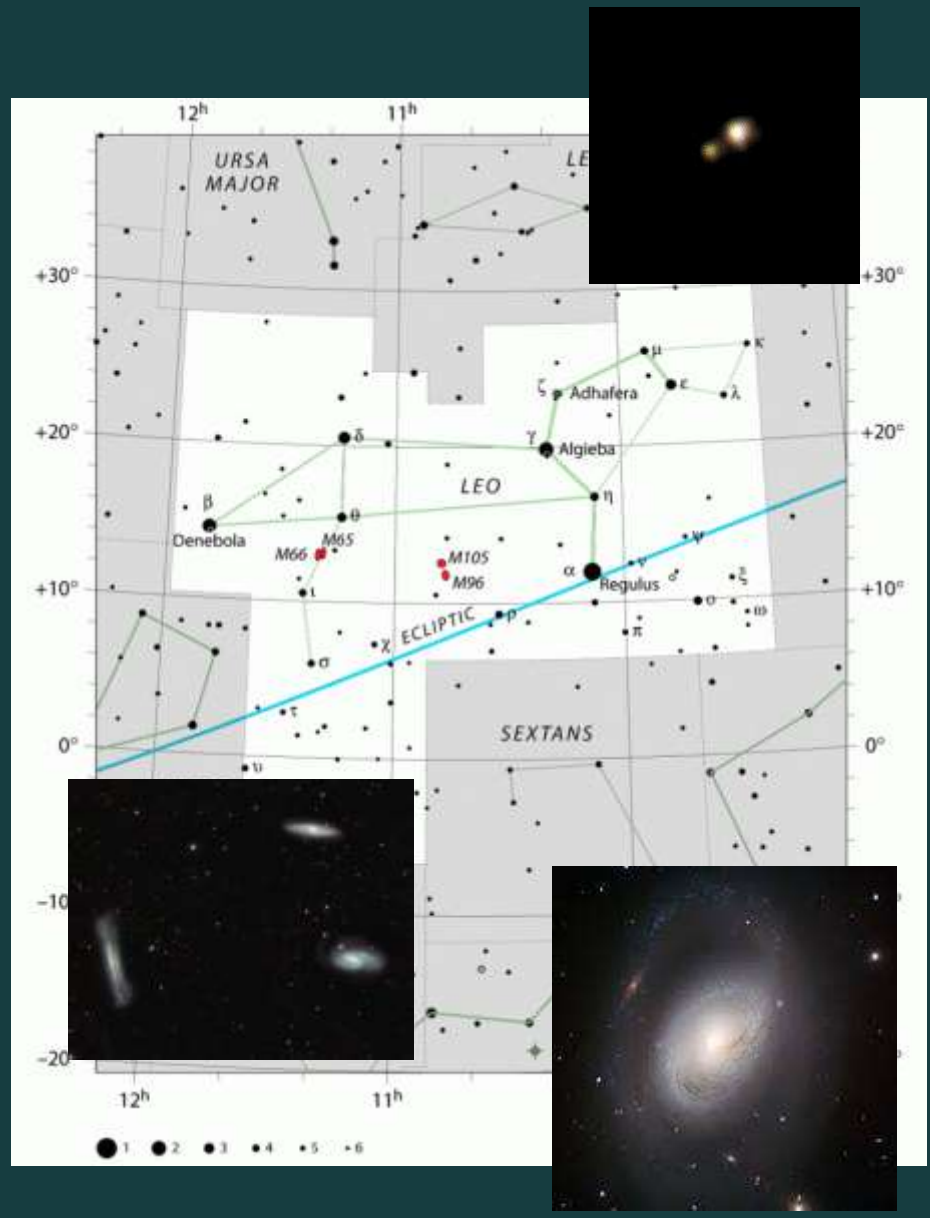
- Represents giant crab that attacked Hercules
  - Sent by Goddess Hera
- Dimmest of the constellations of the Zodiac; only two above 4th mag
- Double Stars
  - Iota Cancri: 30” Sep
  - Zeta Cancri: 5” Sep (1” and .3”)
- Contains two Messier objects
  - M44: Beehive Cluster of about 1000 gravitational bound stars
  - M67: another open star cluster; one of the oldest known at 3.2B years age





Leo – The Lion

- Highly recognizable constellation; one of the few constellations that resemble its name
- The Lion which was killed by Hercules on one of the 12 labors he had to perform for killing his family
- Double Stars:
  - Algieba: 4.6” Sep
- M65: a spiral galaxy at a distance of about 35M light years
- M66: another spiral galaxy 36M light years distant and spread across 95 thousand light-years; has had four recorded supernovae
- M96: spiral galaxy about 35M Light years; diameter 100K light years (about same size as the Milky Way)



Virgo – The Maiden

- Virgo is the largest constellation in the Zodiac; second largest constellation overall
- "Follow the arc to Arcturus, then speed on to Spica."
- Double Stars:
  - Porrima – 3.4" and widening
- Virgo contains eleven Messier objects:
  - Virgo Galaxy Cluster (52M Light Years): M49, M58, M59, M60, M61, M84, M86, M87, M89, M90
  - M104 (Sombrero Galaxy)