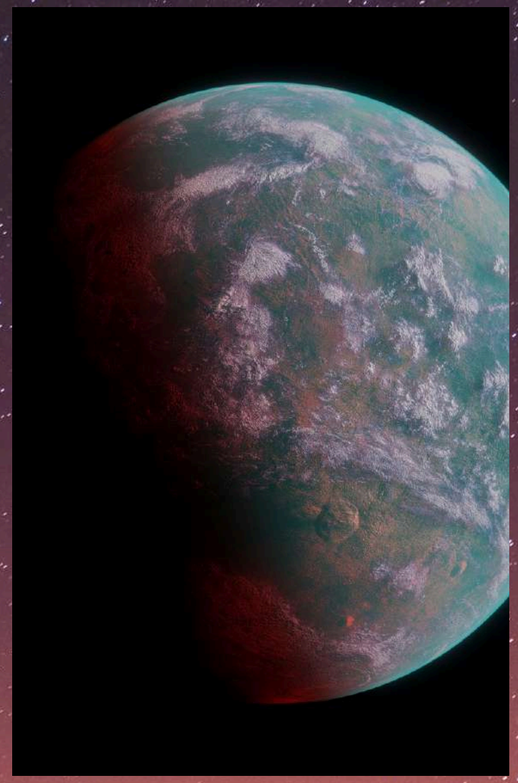
Summer Project'25

Astral Trails

SESSION 1

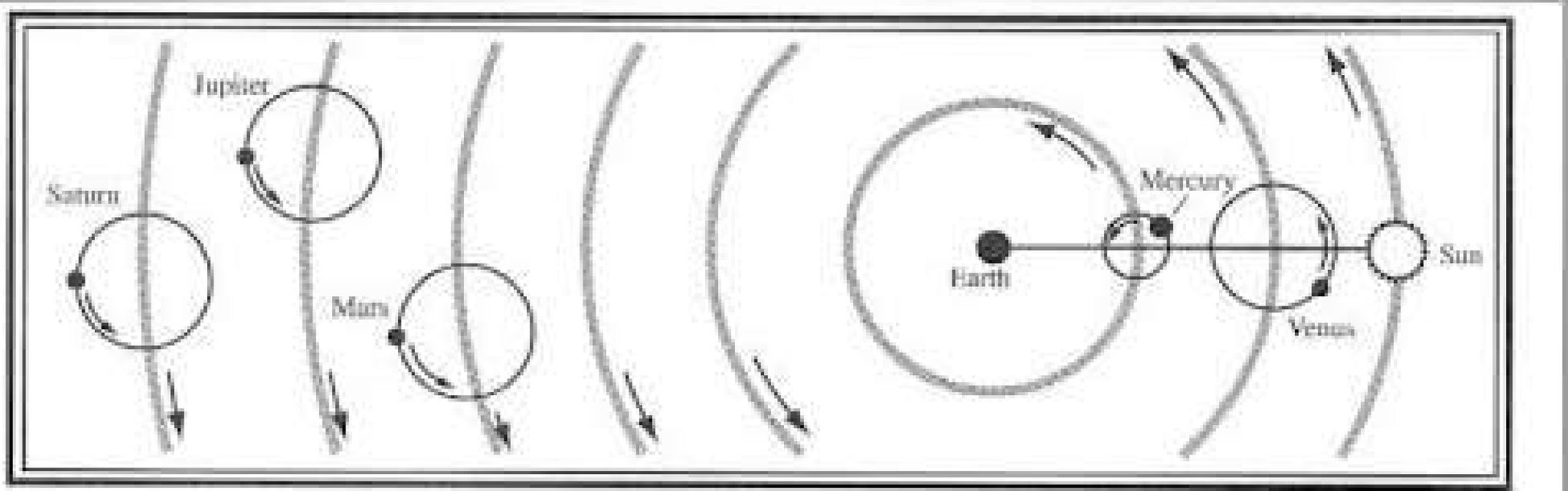


HISTORY OF ASTRONOMY

The History of Astronomy

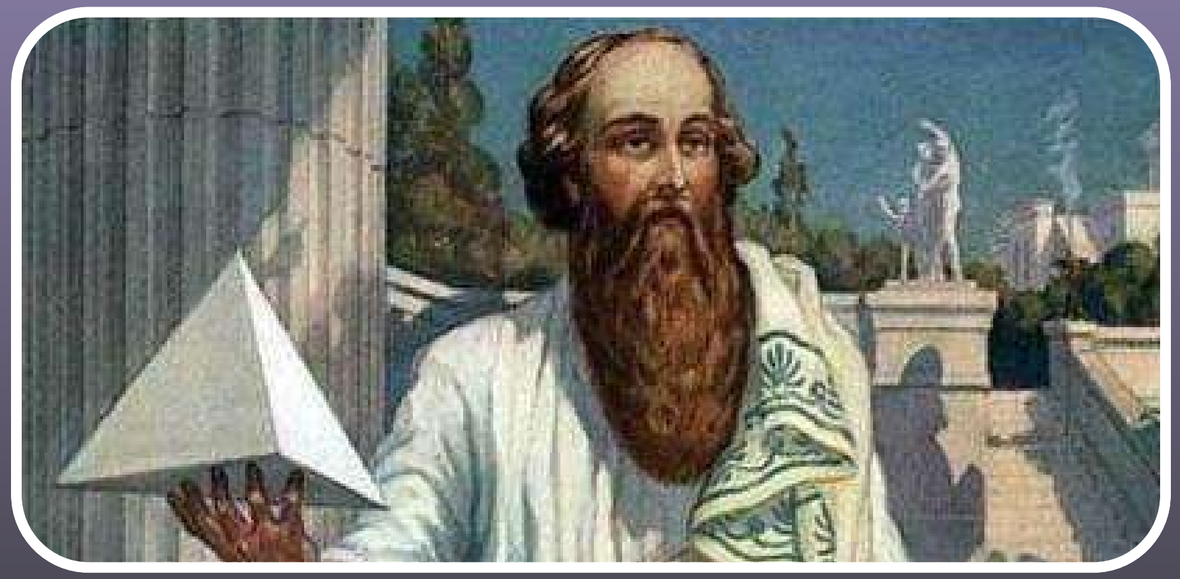
The Ancient Greeks

- The Astronomy of the ancient Greeks was linked to mathematics, and Greek astronomers sought to create geometrical models that could imitate the appearance of celestial motions.

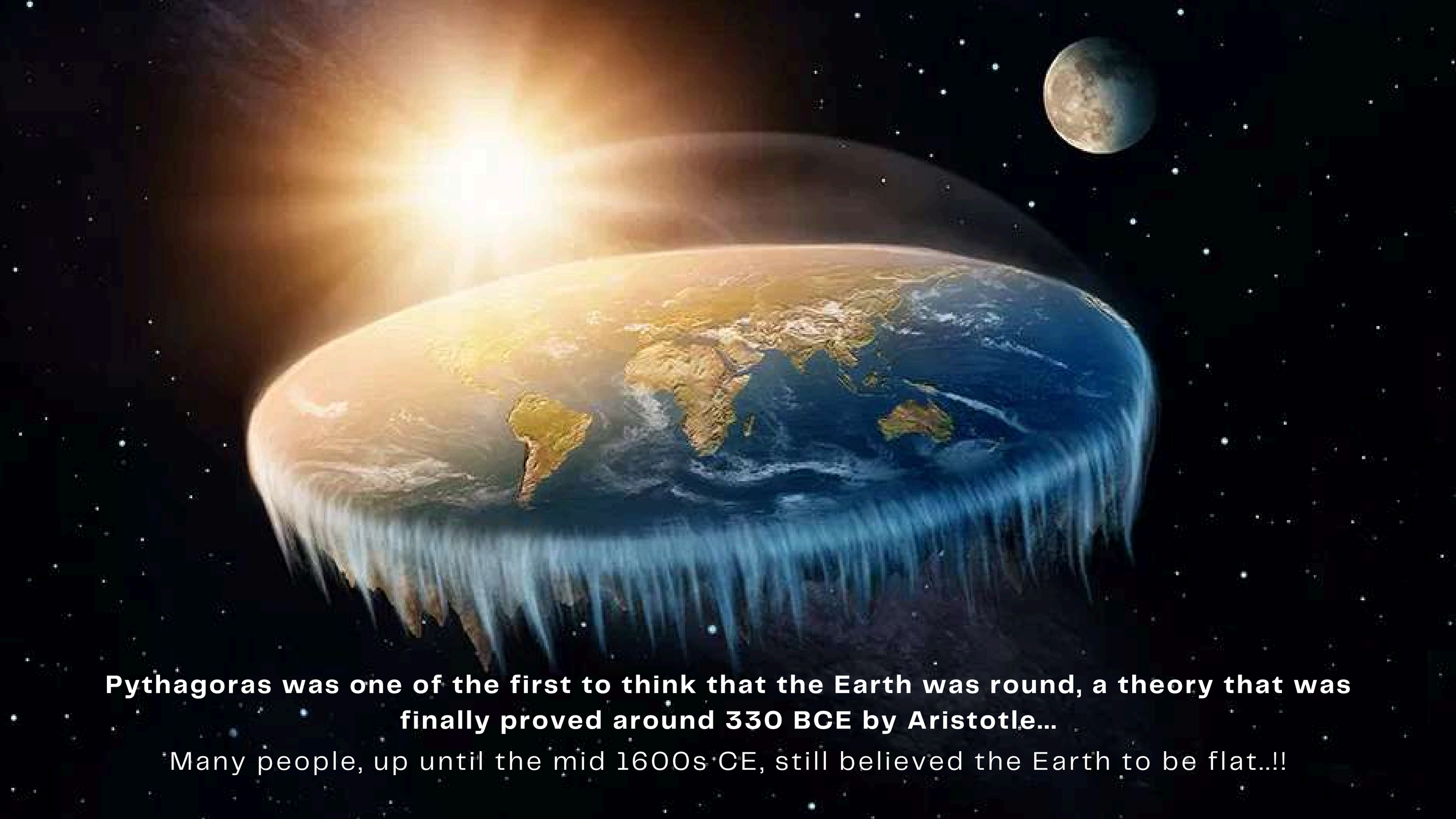


Pythagoras (570 - 495 BCE)

- He believed that everything was related to mathematics and that through mathematics everything could be predicted and measured in rhythmic patterns or cycles.
- Pythagoras placed astronomy as one of the four mathematical arts, the others being arithmetic, geometry and music.
- While best know for the Pythagorean Theorem, Pythagoras did have some input into astronomy.
- By the time of Pythagoras, the five planets to the naked eye - Mercury, Venus, Mars, Jupiter and Saturn - had long been identified.



- The word 'planet' is a Greek term meaning 'wanderer', as these bodies move across the sky at different speeds from the stars, which appear fixed in the same positions relative to each other.



Pythagoras was one of the first to think that the Earth was round, a theory that was finally proved around 330 BCE by Aristotle...

Many people, up until the mid 1600s CE, still believed the Earth to be flat..!!

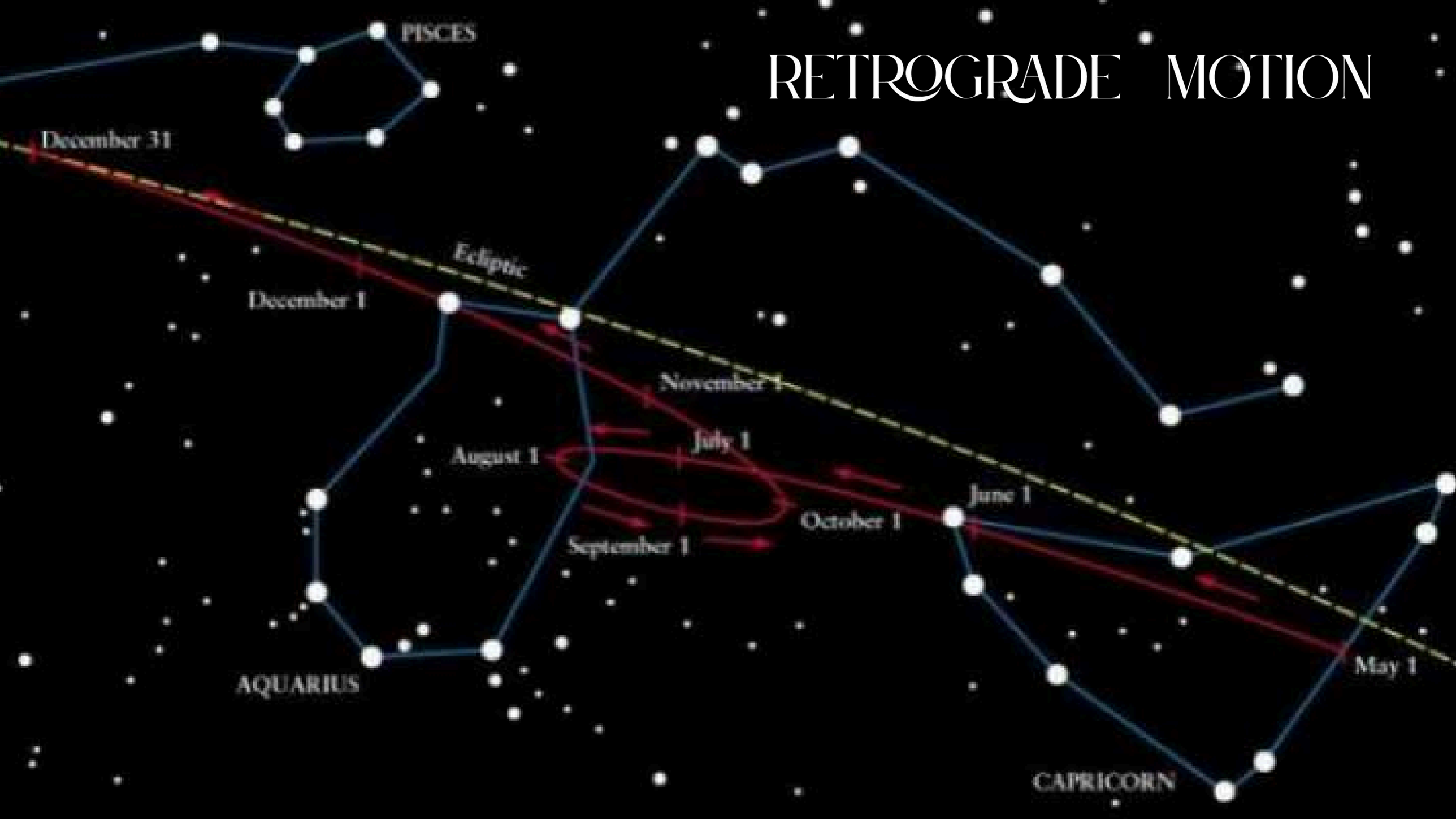
Aristotle's Theories:

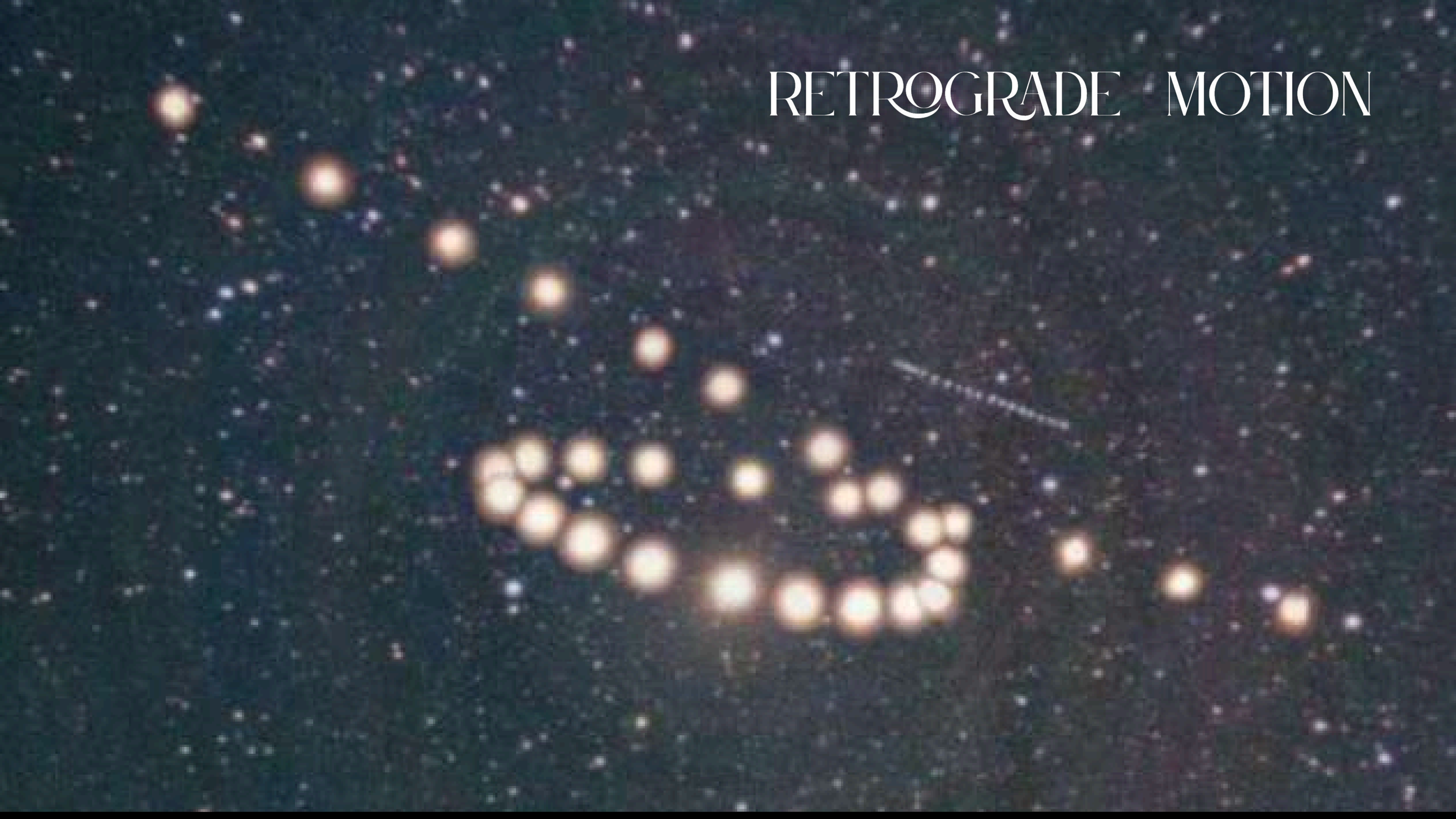
- The Earth was in the center, and the Sun, the Moon, the stars, and the planets orbited on separate spheres that encased each other and spun at different rates
- Motion caused by a supernatural being
- Earth was a sphere (could see shadow on moon during eclipse) and non-moving (because we could not feel it and falling objects would not drop straight down)

Geocentric Universe:

Earth centered, model of the Universe

RETROGRADE MOTION

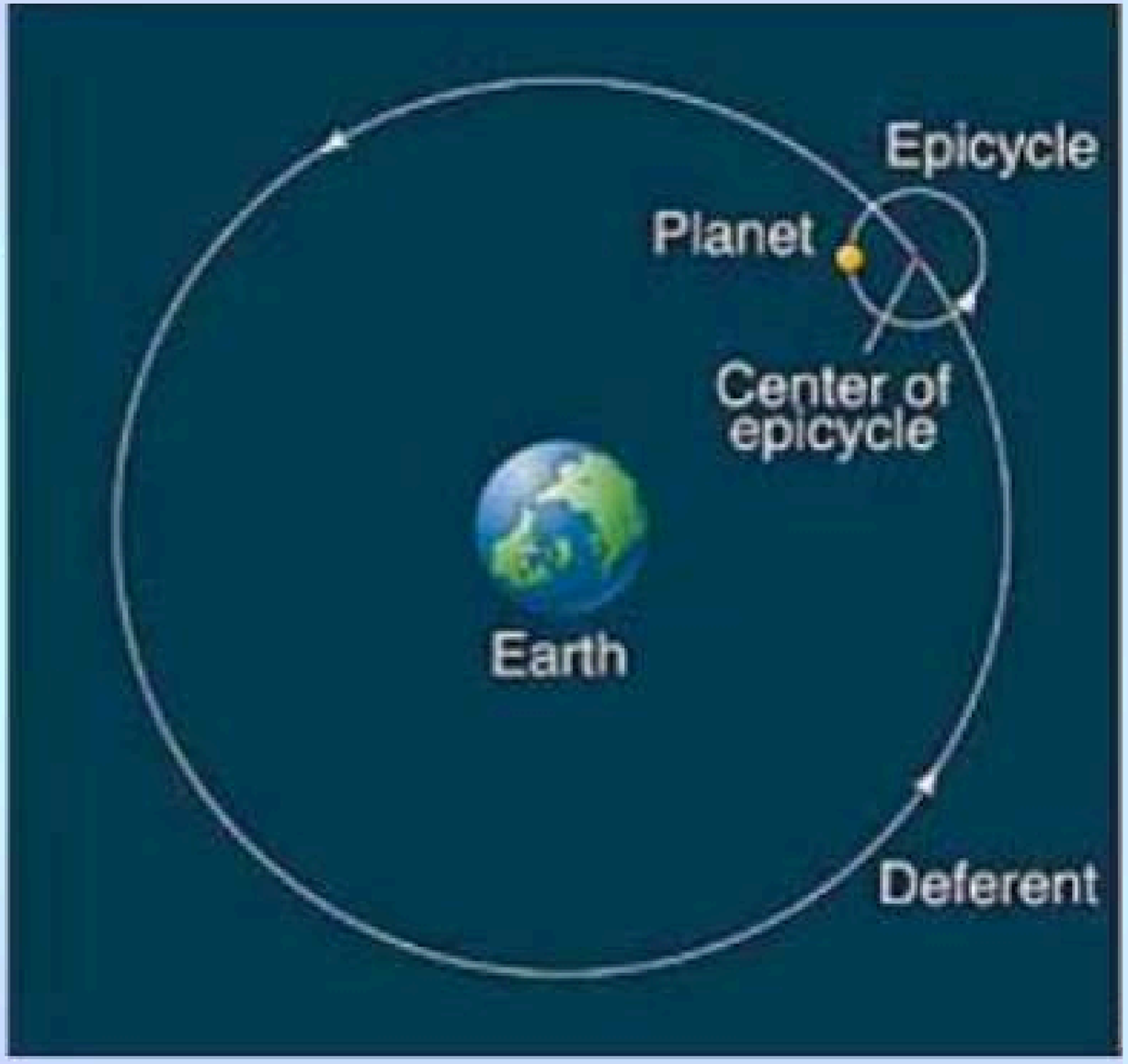



RETROGRADE MOTION

- Aristotle's ideas:
  - Heavy objects fall faster than light objects
  - Objects have inertia – all objects prefer to be at rest
  - The heavens are perfect and immutable
  - All heavenly objects travel about the Earth at a constant speed in a perfect circle

So how did Aristotle explain retrograde motion?

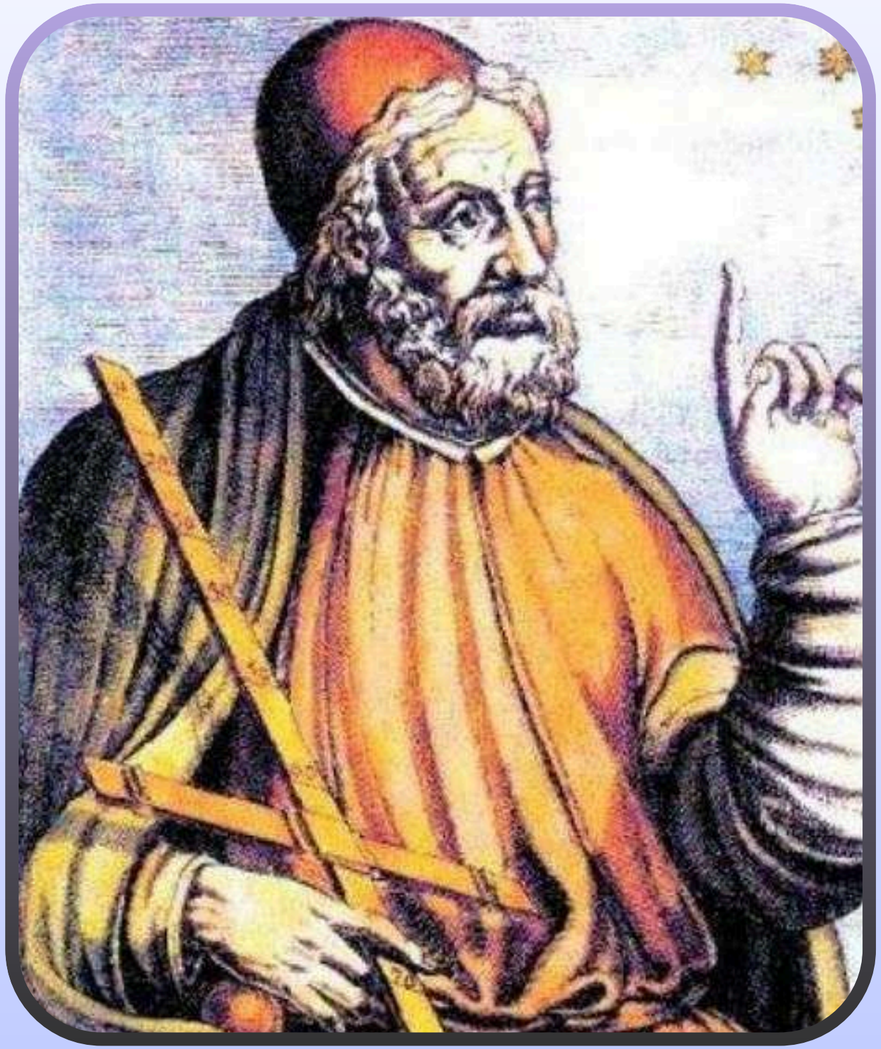
- Earth at the center (since it is not moving).
- Sun and Moon orbit the Earth (west to east).
- Planets move at a constant speed around small circles called epicycles.
- Epicycles orbit around Earth (west-to-east) at a constant speed in a circle called a deferent.



Combination of orbital and epicyclic motion creates retrograde motion.

Ptolemy (90-168 CE)

- A citizen of Egypt, Ptolemy was a mathematician, astronomer, and geographer.
- He outlined his geometrical reasoning for a Geocentric View of the Universe.

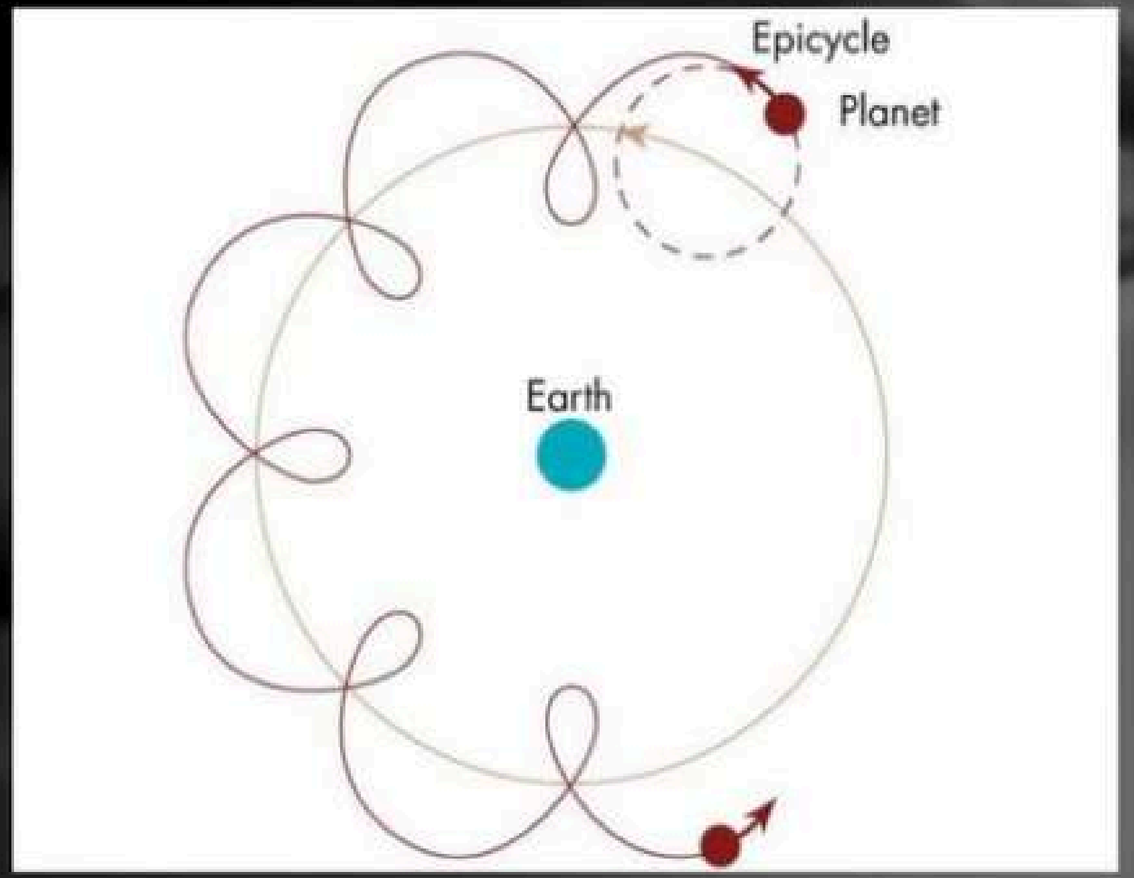


- Put the Earth slightly off center at a point called the eccentric
- State that epicycles only move at a constant speed about the deferent when viewed from a special place called the equant

Model is more complicated, and, though it does better, it still doesn't predict the exact positions of the planets.

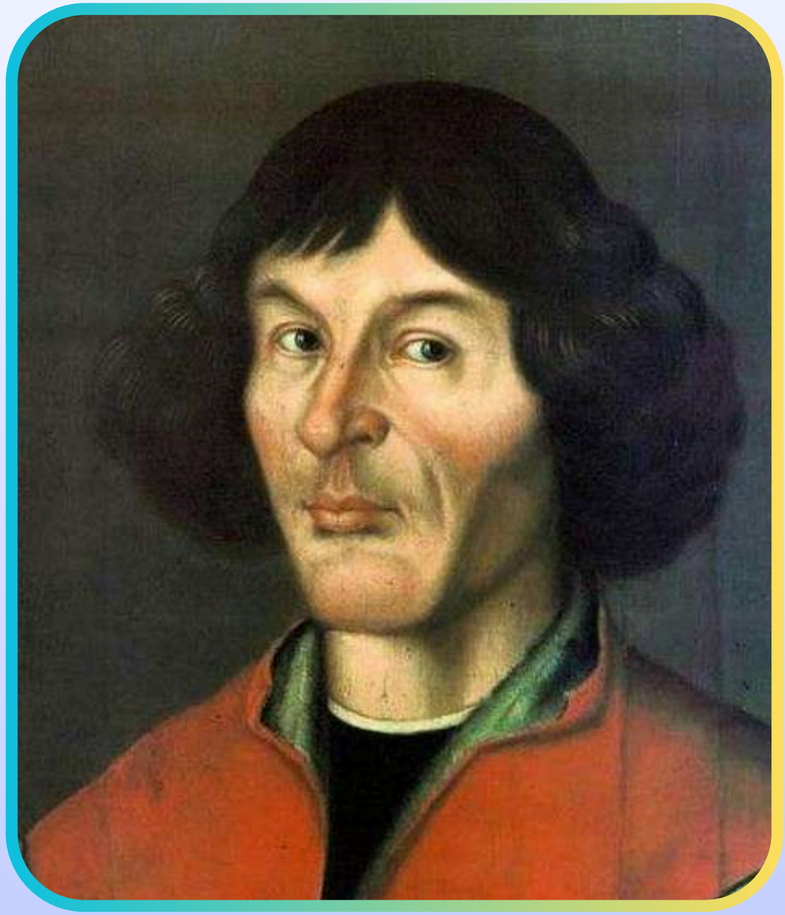
Ptolemy's Theories:

- Geo-centric
- Each planet was fixed to a small sphere that was fixed to a larger sphere
- No changes made for a 1,000 years until the inaccuracies in predictions became to big to blame on primitive equipment



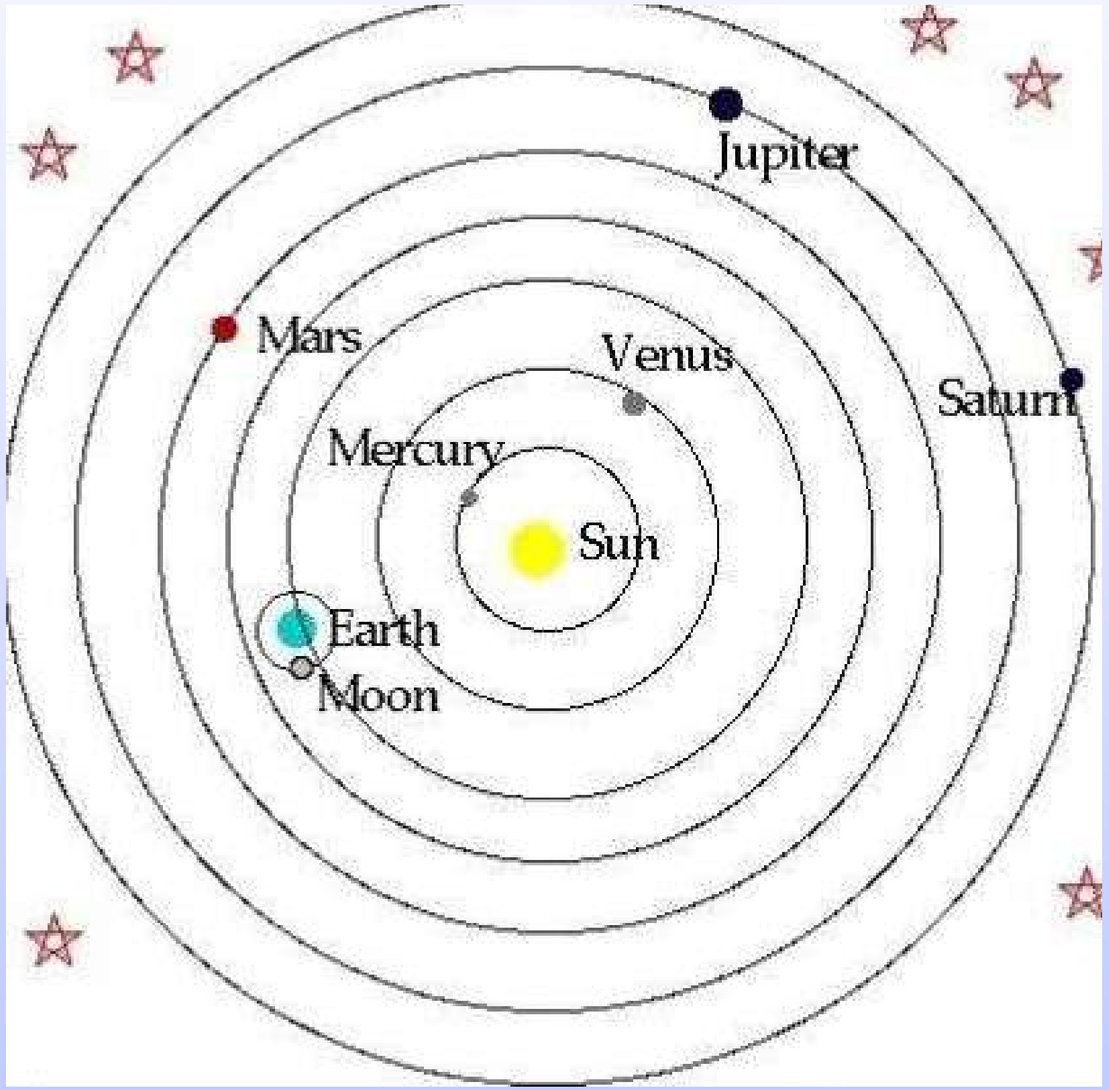
Copernicus (1473 -1543 CE)

- Introduced a sun centered design of the Universe called the Heliocentric View.
- Therefore, Ptolemy's astronomy was seriously questioned and eventually overthrown.



The Heliocentric View

- Copernicus' theory of a system in which the Earth, like all planets, revolved around the sun.
- His book, "On the Revolutions of the Celestial Orbs" was completed in 1530, but it wasn't published until the year he died, 1543.
- It has been suggested that Copernicus knew the publication would incur the wrath of the Catholic church and he didn't want to deal with problems so he didn't publish his theory until he was on his death bed.



Tycho Brahe (1546 - 1601 CE)

While attending university to study law and philosophy, he became interested in astronomy and spent most evenings observing the stars.
Tycho Brahe's major contributions were...

1. The detection and correction of several serious errors in the standard astronomical tables.
2. The discovery of a supernova in the constellation of Cassiopeia.
3. The most complete and accurate observations available without the use of a telescope.

Tycho Brahe's fame led to the funding of an astronomical observatory on the island of Van
He did not accept Copernicus's model of the **Universe.**

Kepler (1571 - 1630 CE)

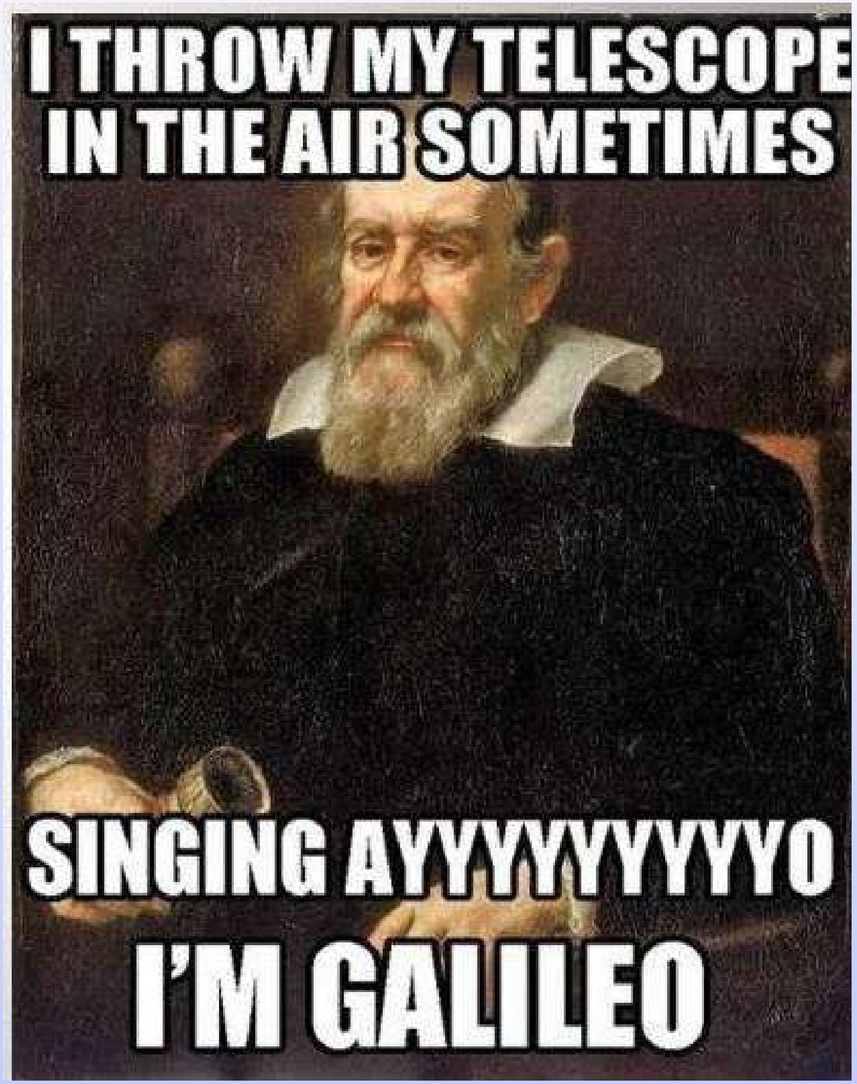
Tycho's assistant, Kepler had full access to Tycho's data. He determined that the orbits were not circular but elliptical.

Kepler's Three Laws of Planetary Motion:

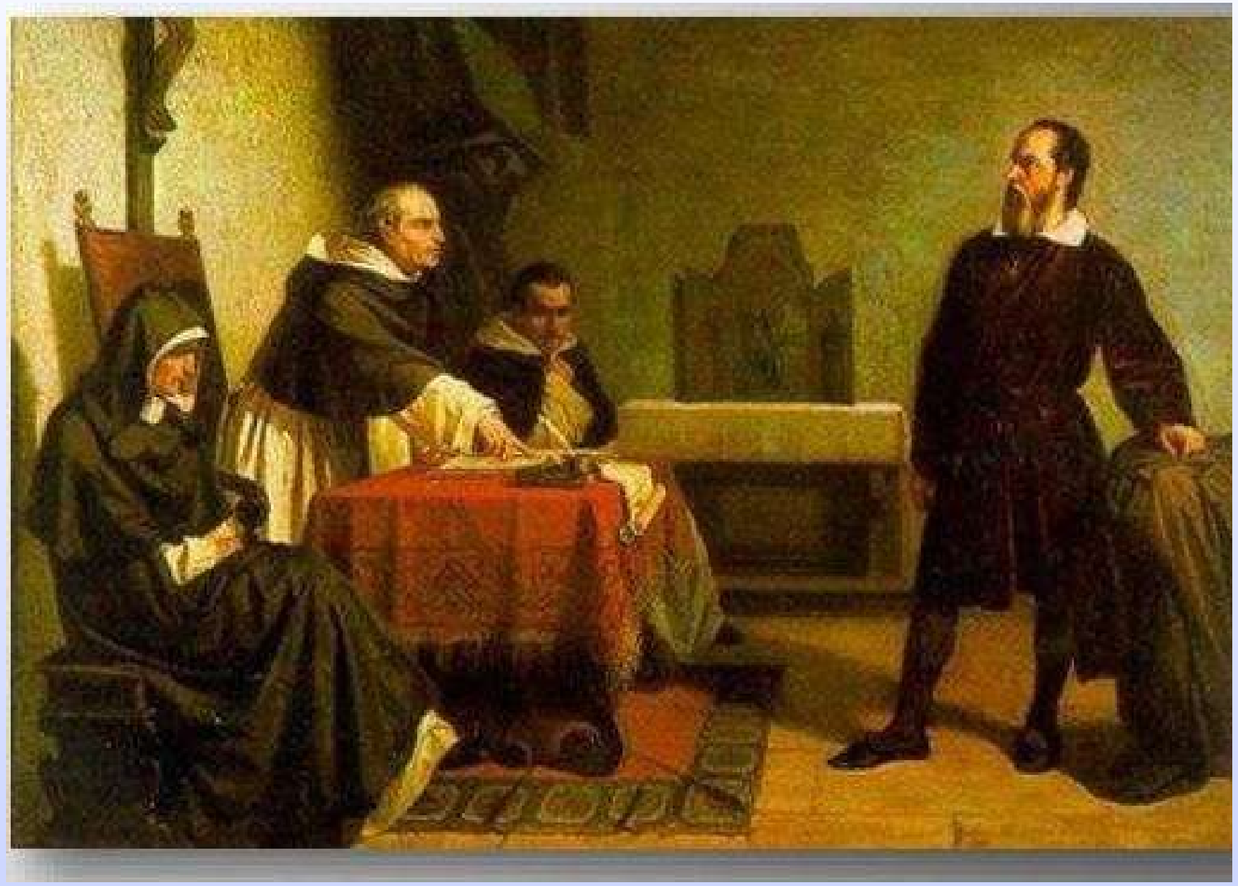
1. The orbits of the planets are elliptical.
2. The earth's orbital speed varies at different times of the year. The earth moves fastest in its orbit when closest to the sun and slowest when farthest away.
3. Shows the relationship between the size of a planet's orbit radius and its orbital period.

Galileo (1564 - 1642 CE)

- A key figure in the development of modern astronomy.
- He provided the crucial observations that proved the Copernican hypothesis.



- Galileo used his telescope to show errors in Aristotle's opinion of the universe and the worldview that it supported.
- Galileo's challenge of the Church's authority through his refutation of the Aristotelian concept of the Universe eventually got him in deep trouble!
- Late in his life he was forced, under the threat of torture, to publicly recant his Copernican views and spent his last years under house arrest.

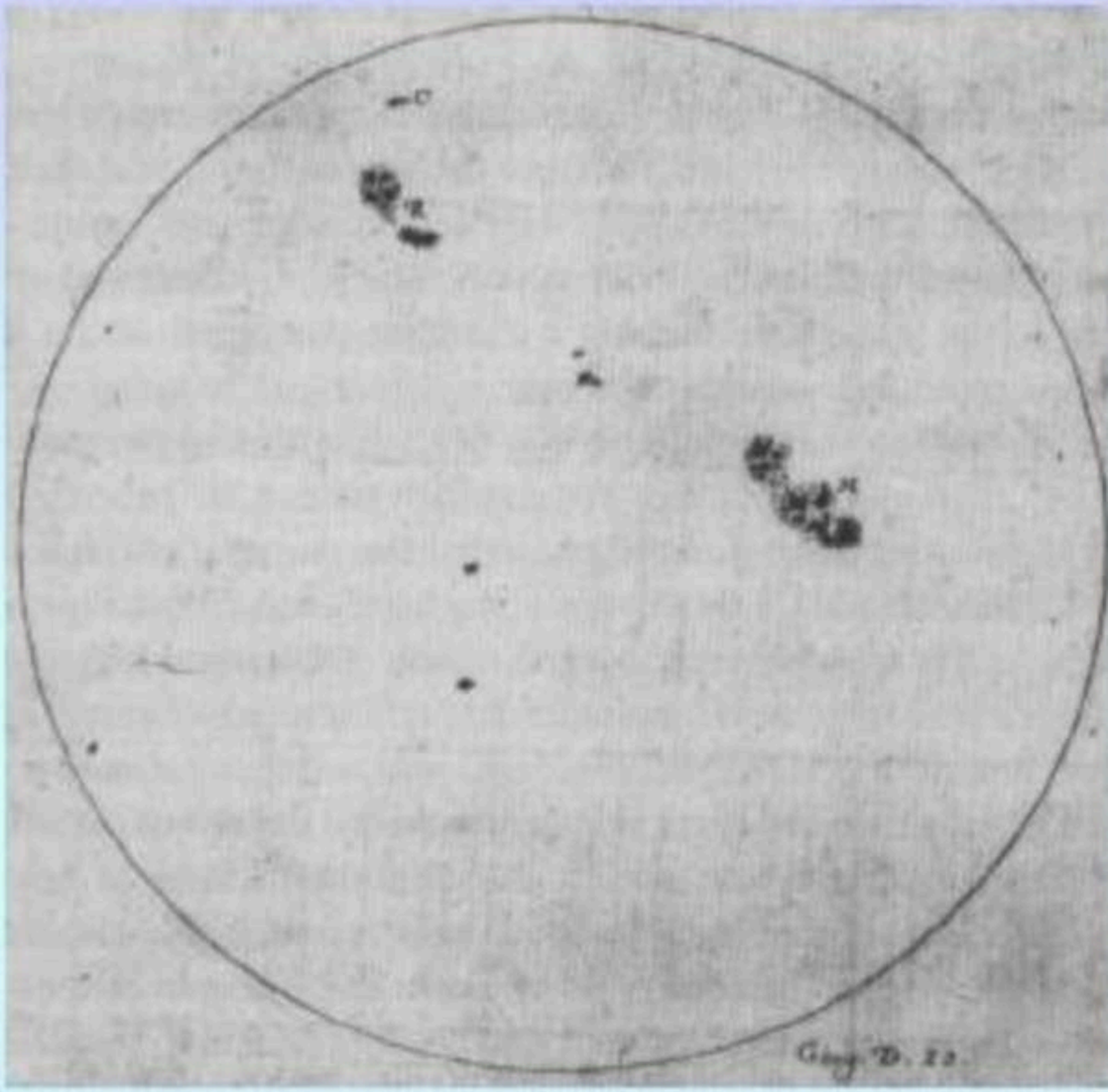


Galileo tried something new – doing experiments!

- Dropping balls to measure gravity
- Rolling balls to examine inertia
- Observing the sky through a telescope!

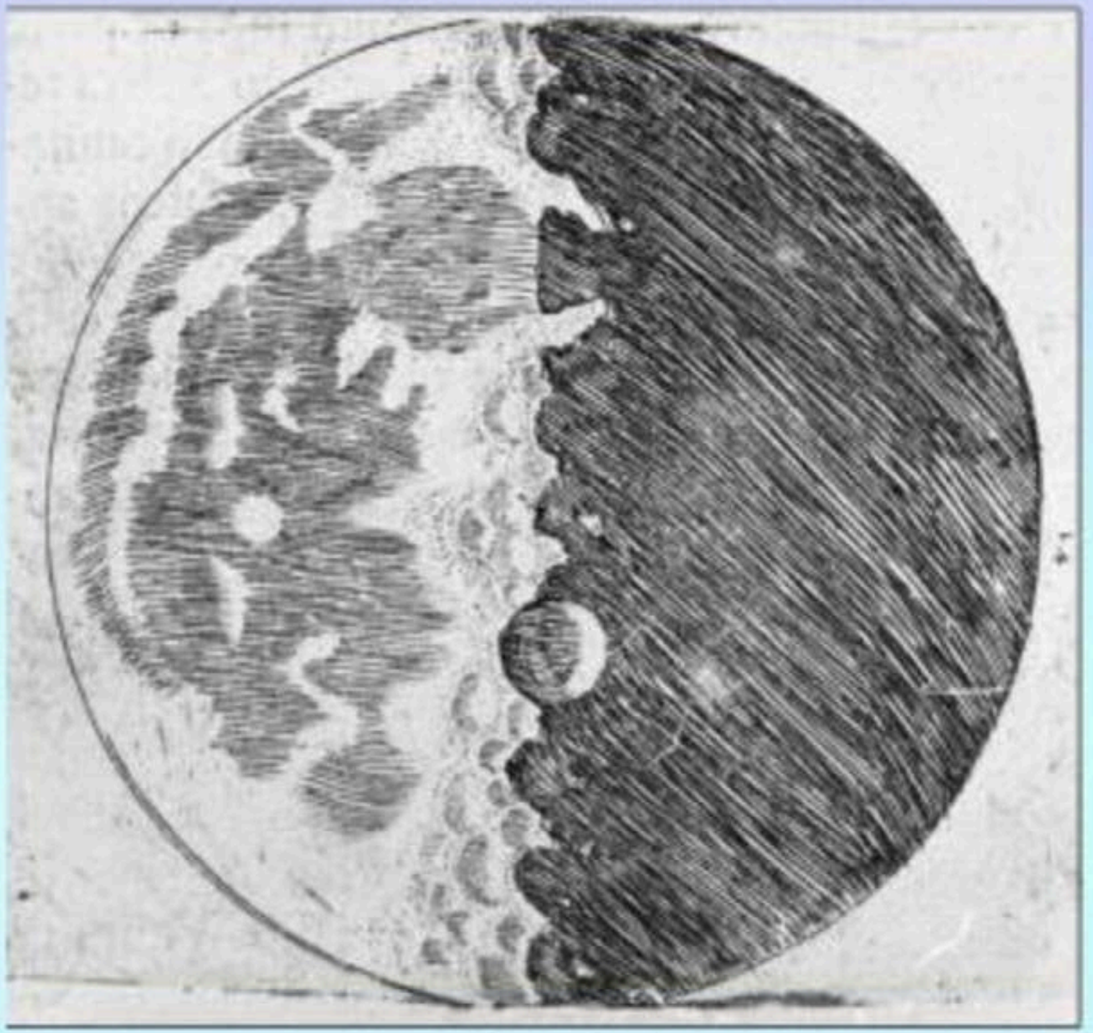
What Galileo Saw

- An imperfect Sun (sunspots)



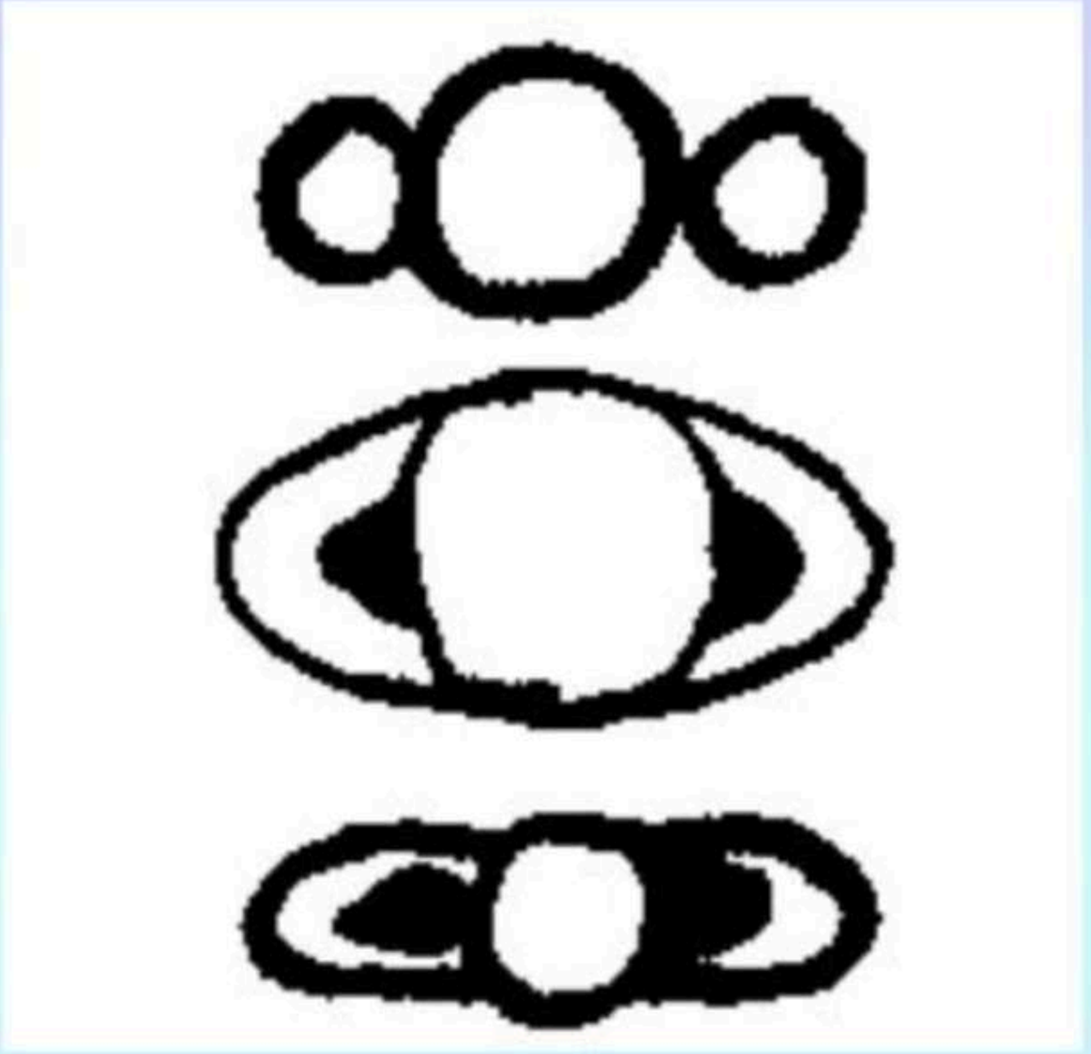
What Galileo Saw

- An imperfect Sun (sunspots)
- A Moon with mountains and craters



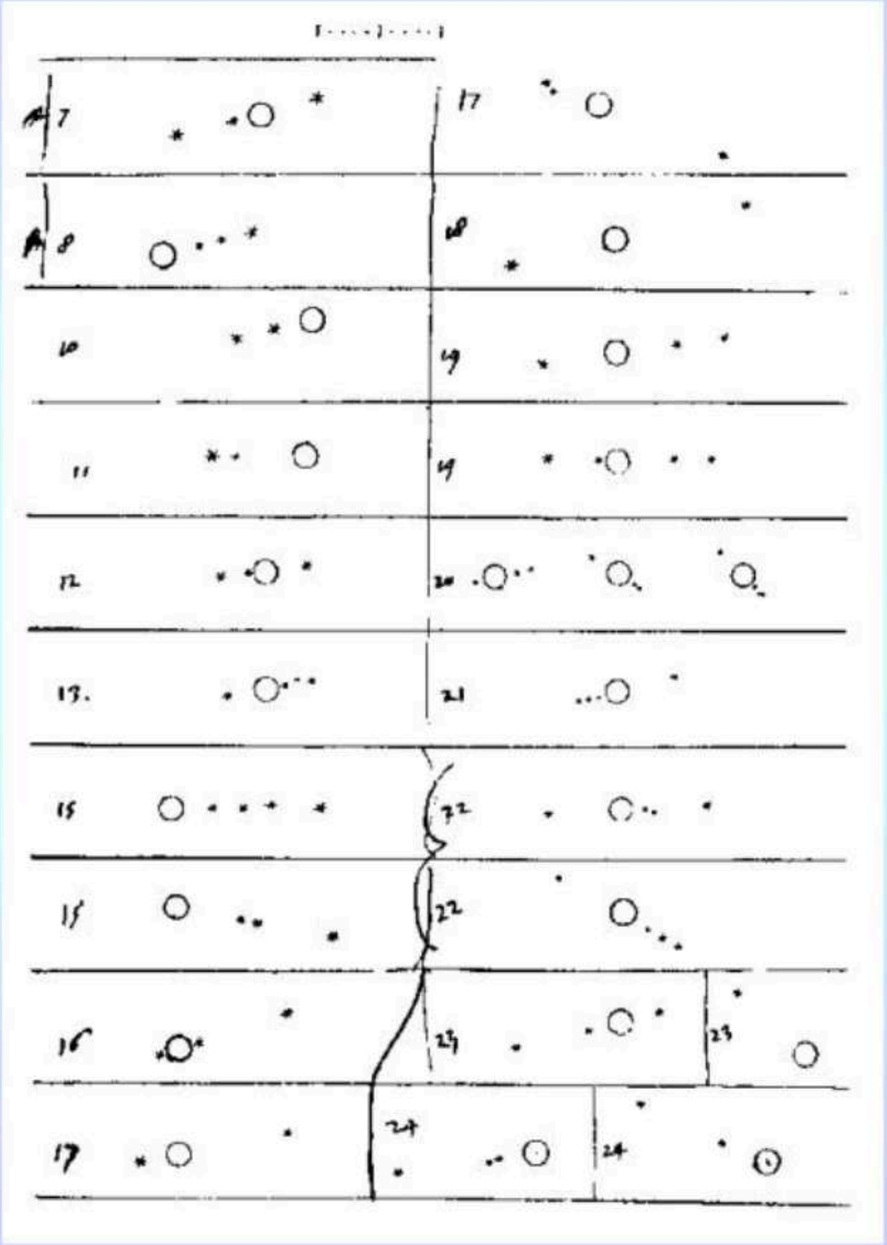
What Galileo Saw

- An imperfect Sun (sunspots)
- A Moon with mountains and craters
- The “ears” of Saturn



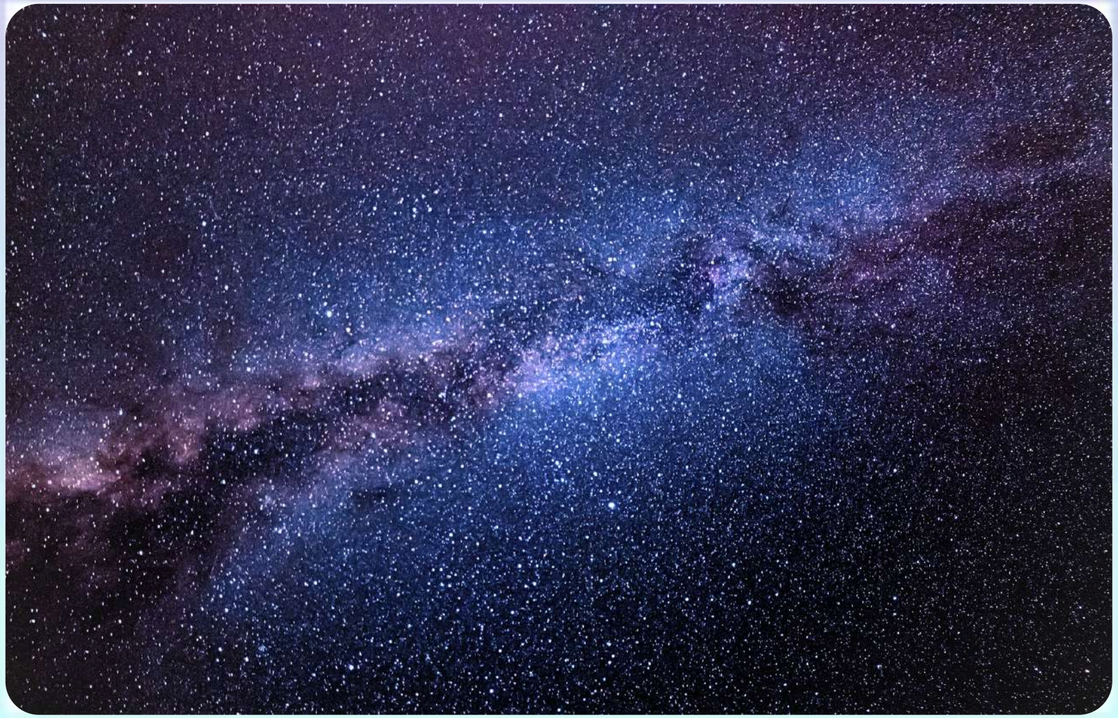
What Galileo Saw

- An imperfect Sun (sunspots)
- A Moon with mountains and craters
- The “ears” of Saturn
- Four moons orbiting Jupiter



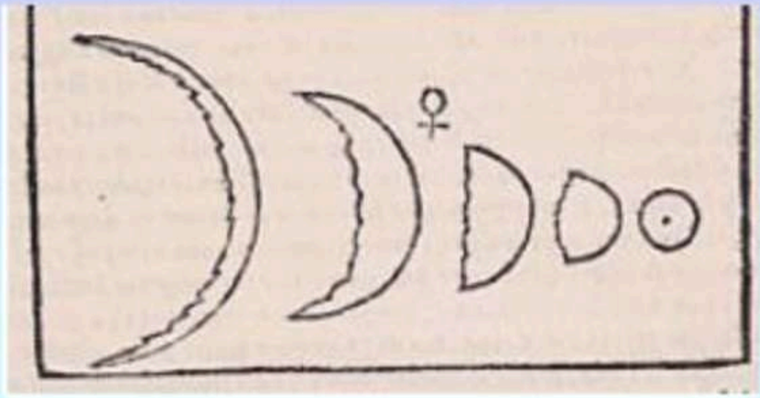
What Galileo Saw

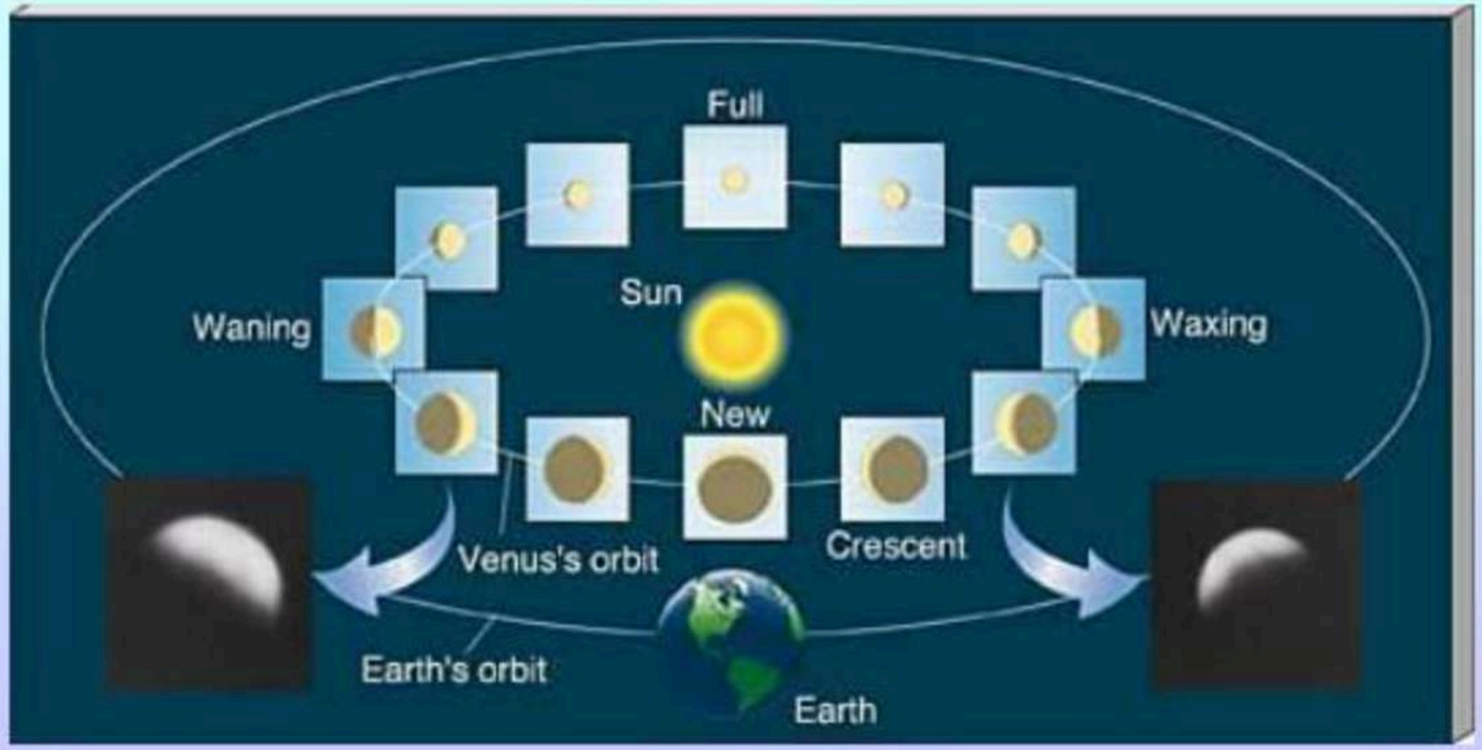
- An imperfect Sun (sunspots)
- A Moon with mountains and craters
- The “ears” of Saturn
- Four moons orbiting Jupiter
- The Milky Way’s stars



What Galileo Saw

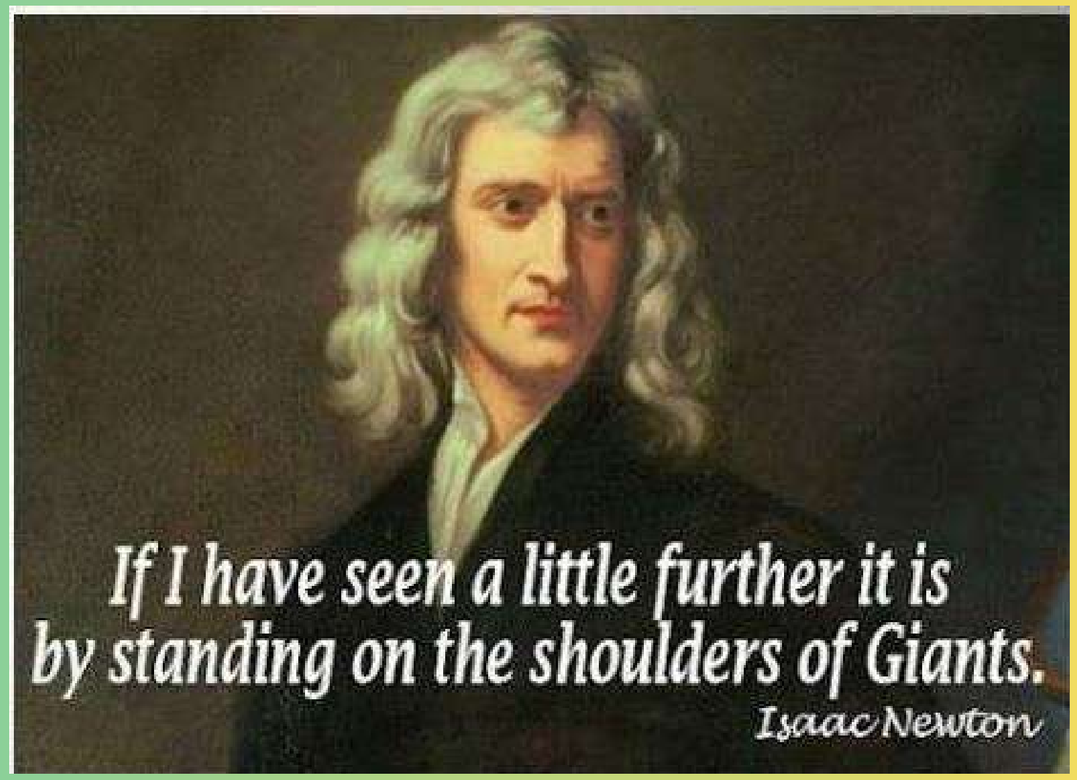
- An imperfect Sun (sunspots)
- A Moon with mountains and craters
- The “ears” of Saturn
- Four moons orbiting Jupiter
- The Milky Way’s stars
- The Phases of Venus





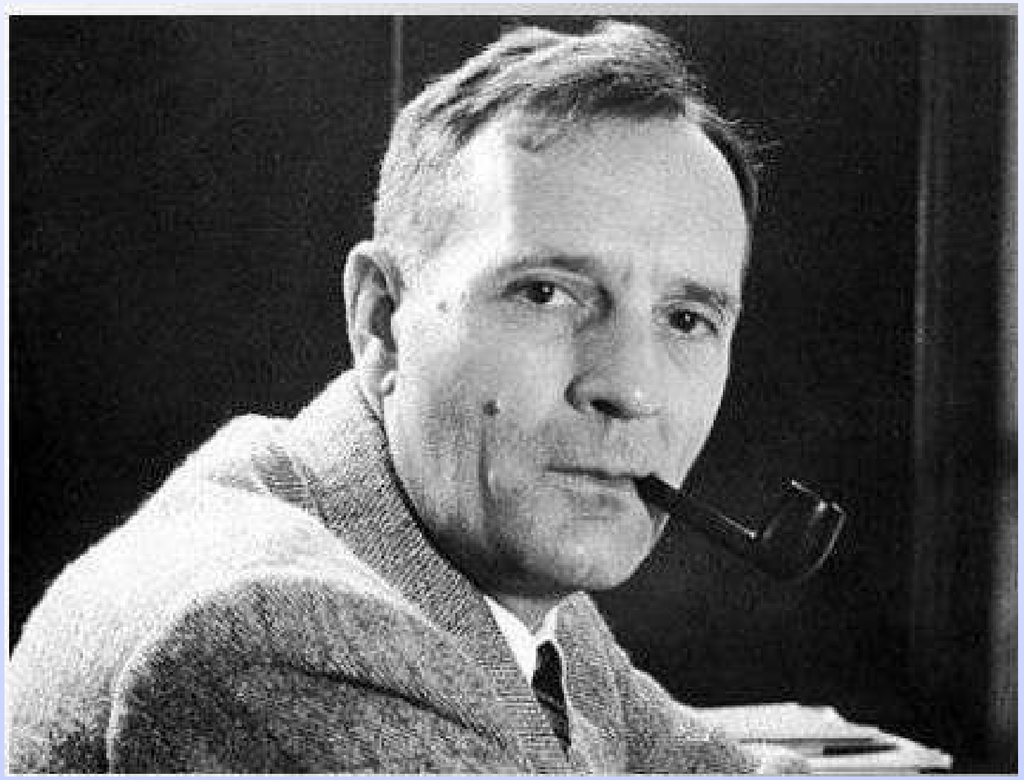
Sir Isaac Newton (1642 - 1727 CE)

- Built on Galieo's ideas to demonstrate that the laws of motion in the heavens and on Earth were the same.
- Newton completed the synthesis of astronomy and physics.
- He gave reasons for and corrected Kepler's Laws and came up with three new Laws of Motion based on his idea of the existence of a force called 'Gravity'.



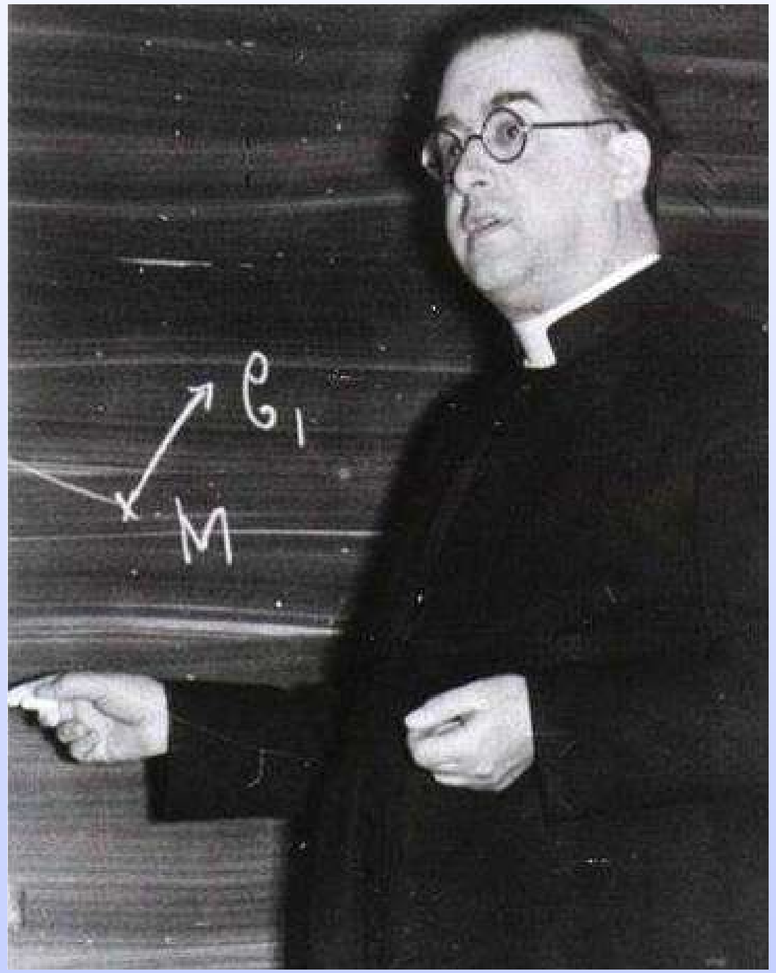
Edwin Hubble (1889 - 1953 CE)

- Was able to measure the distance to observed celestial objects.
- He discovered that the Milky Way was only one of many galaxies.
- Provided evidence to suggest that most distance galaxies were moving away from us.



Georges Lemaitre (1894 - 1966 CE)

- A Belgian priest, astronomer and professor of physics.
- Suggested that the Universe must be expanding.
- His theory, supported by Hubble's work, suggested that the Universe must have begun as a small, extremely dense point of matter.
- Lemaitre's theory is famously called the "Big Bang Theory".



In Summary

...

- Pythagoras was one of the first scientists to think that the earth was round.
- Aristotle concludes that the earth does not move and the celestial objects rotate around the earth in circular orbits.
- Ptolemy designs the Geocentric design of the cosmos to agree with Aristotle's ideas and to provide an explanation of the motion of planets.
- Copernicus suggests a sun-centered Heliocentric system with the earth being one of the planets that revolve around the sun.
- Kepler produces his three laws of planetary motion based on Tycho's observations.
- Newton contributes his three laws of motion and the concept of gravity which provides the reasons for objects following Kepler's laws.
- Hubble provides evidence that the universe is larger than just the Milky Way and also provides evidence that all other galaxies are moving away from our own galaxy.
- Lemaitre suggests the Big Bang Theory.


Here begins...
The journey to infinity!

LINKS

- https://youtu.be/iugaXcHxY90?si=Lg7yvcqan4z-iwG7
- https://youtu.be/_25I-F1FxZQ?si=sBsG_47nuK2zHShC
- https://youtu.be/BcjmoEspoRI?si=_ZPjY8lvVDep-6ZH
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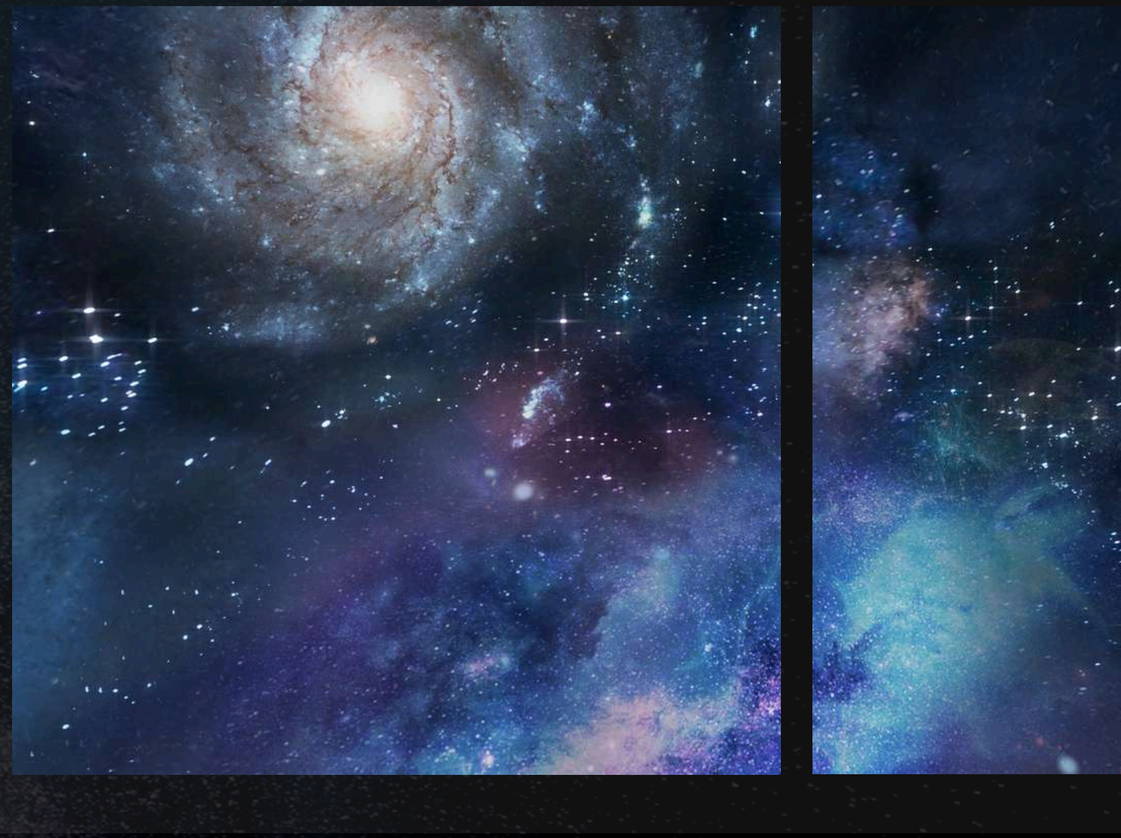
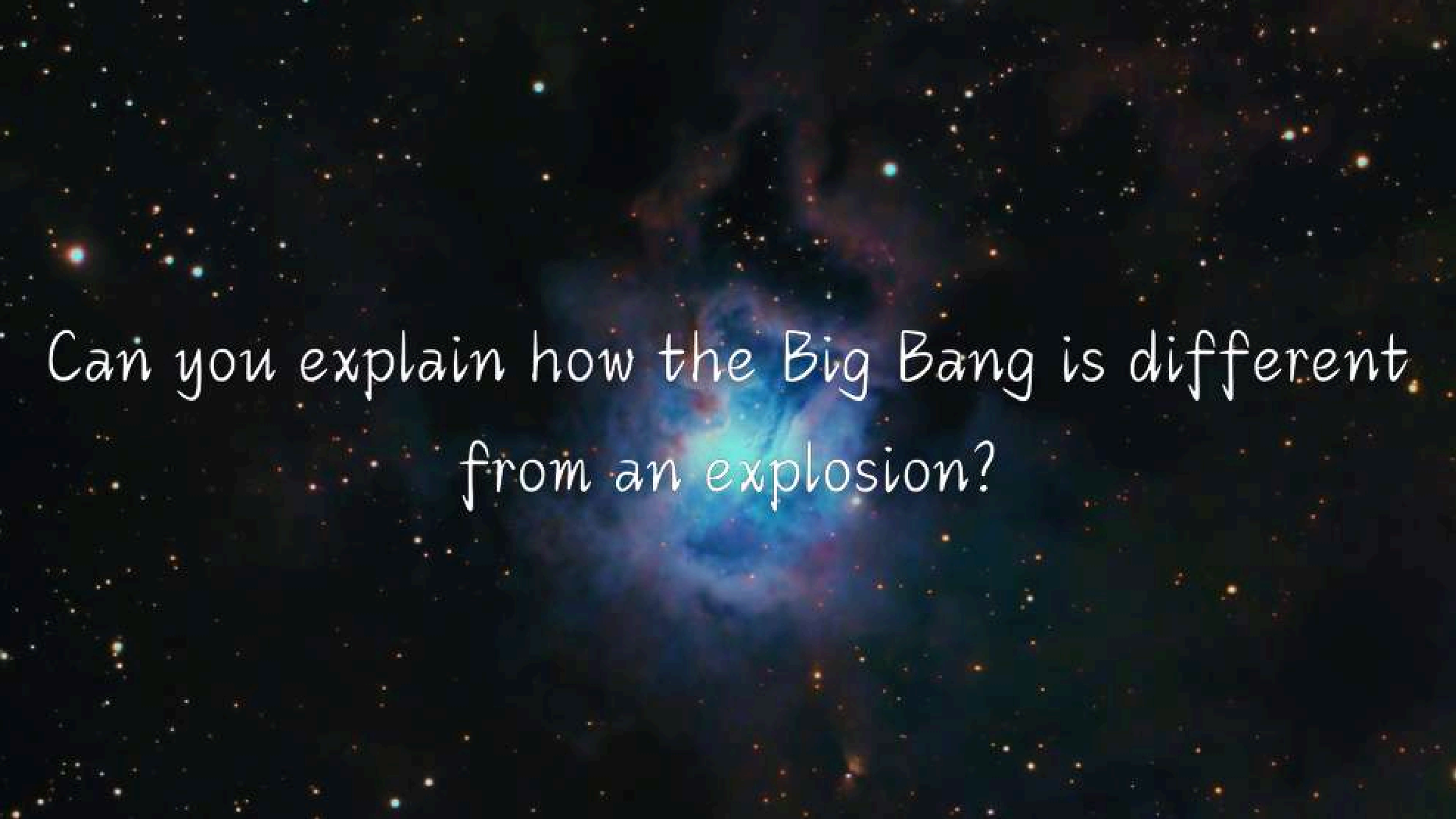



So, it all started with a
BANG...


Can you explain how the Big Bang is different from an explosion?

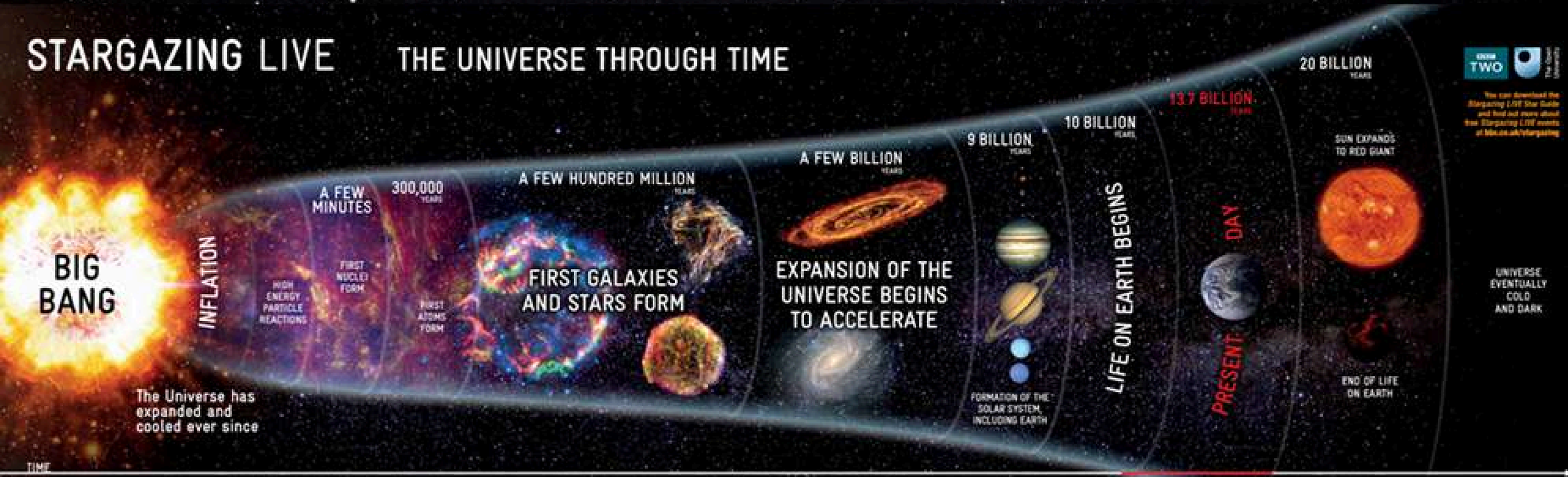
In an explosion, fragments are flung out from a central point into a pre-existing space.

But the Big Bang was an expansion of space itself, i.e. all the distances in the universe are stretching out at the same rate.

Any two galaxies separated by distance X are receding from each other at the same speed, while a galaxy at distance 2X recedes at twice that speed.

STARGAZING LIVE

THE UNIVERSE THROUGH TIME



BBC TWO

You can download the Stargazing LIVE Star Guide and find out more about free Stargazing LIVE events at bbc.co.uk/stargazing

UNOBSERVABLE UNIVERSE (PAST)

THE BEGINNING

The Universe begins 13.7 billion years ago with an event known as the Big Bang.

Both time and space are created in this event.

FRACTION OF A SECOND

Cosmic expansion occurs at a speed of a billionth of a billionth of a billionth of a second – the visible Universe is the size of a grapefruit.

1 SECOND

The Large Hadron Collider at CERN is recreating the conditions that prevailed a fraction of a second after the Big Bang.

100 - 1000 SECONDS

Nuclei of hydrogen, helium, lithium and other light elements form.

300,000 YEARS

We can detect radiation from the early formation of the Universe back as far as this point. Before this, the Universe is opaque. It's as if a veil has been pulled over it.

POTENTIALLY OBSERVABLE UNIVERSE (PAST)

A FEW HUNDRED MILLION YEARS

Matter clumps together under its own gravity forming the first protogalaxies and within them, the first stars.

Stars are nuclear furnaces in which heavier elements such as carbon, oxygen, silicon and iron are formed. Massive stars exploding as supernovae create even heavier elements. Such explosions send material into space ready to be incorporated into future generations of stars and planets.

A FEW BILLION YEARS

Initially, the expansion of the Universe decelerated – but a few billion years after the Big Bang, the expansion began to accelerate. The acceleration is caused by a mysterious force known as 'dark energy' – the nature of which is completely unknown.

9 BILLION YEARS

The Sun, along with its eight planets, and all the asteroids, comets and Kuiper Belt objects, such as Pluto, form from the debris left behind by earlier generations of stars.

10 BILLION YEARS

The first life appears on Earth in the form of simple cells, inhabiting comets and asteroids might have contributed organic molecules to Earth. Life spreads across the globe.

TODAY

13.7 BILLION YEARS

This is where we are today. Using our own ingenuity, humanity is probing the depths of the Universe and trying to unravel its mysteries, even our tiny, home planet, Earth. The visible Universe contains billions of galaxies, each containing billions of stars. Within our own Galaxy, hundreds of exoplanets have been discovered orbiting other stars.

FUTURE

20 BILLION YEARS

In a few billion years the Sun's outer layers will expand as it runs into a Red Giant star. Life on Earth will become impossible.

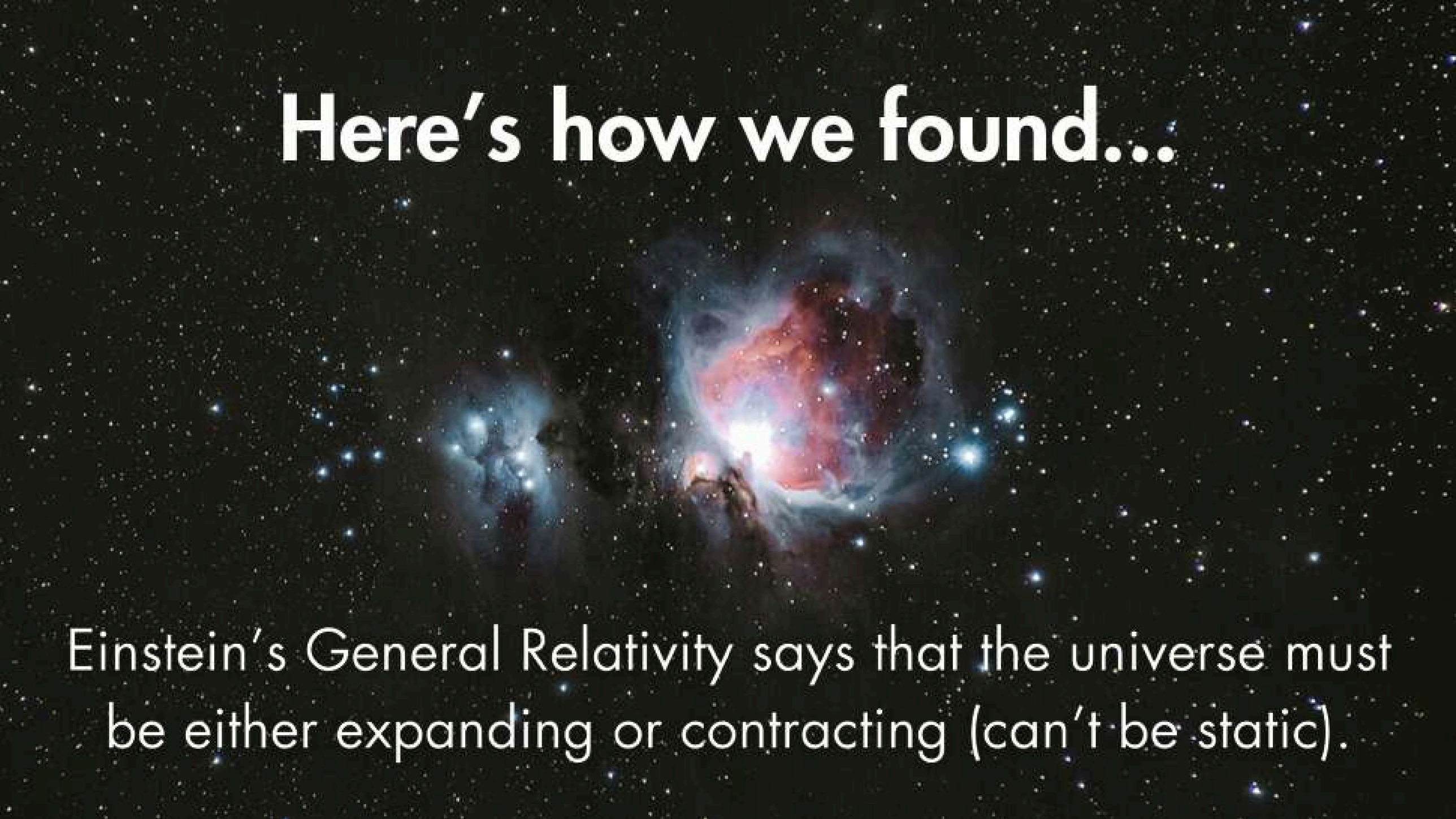
Expansion of the Universe will continue to accelerate.

10[100] YEARS

Electrons no longer form matter as trapped in black holes or dead stars. Protons decay and black holes evaporate, leaving the universe to its ultimate fate as cold, dead, empty space, containing only radiation, which itself has still eventually expired.


And how do
we know?

Here's how we found...



Einstein's General Relativity says that the universe must be either expanding or contracting (can't be static).

Here's how we found...

Hubble Space Telescope discovered that galaxies are moving away: farther ones at a faster rate.

Here's how we found...

Cosmological redshift and discovery of CMBR led to further mathematical evidences.

How to kill the universe?

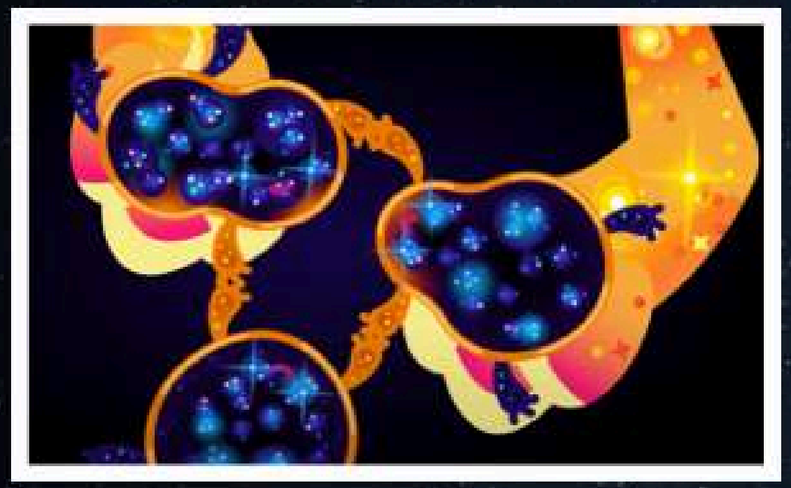
How to kill the universe?

VS

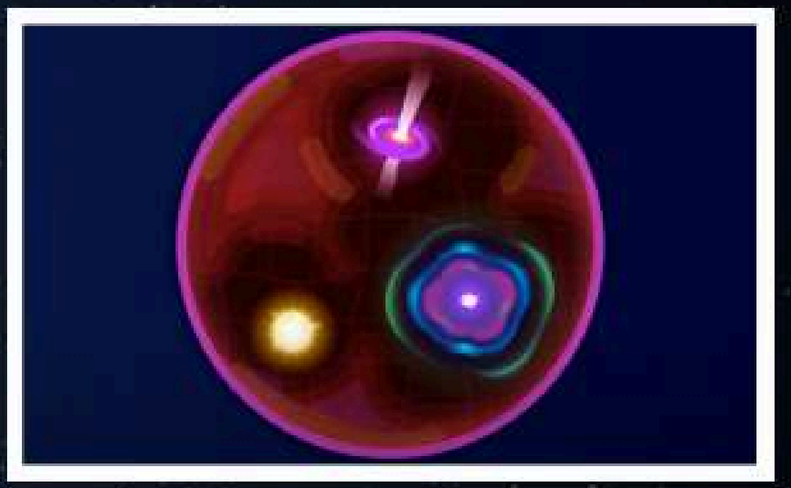
DARK ENERGY

GRAVITATION

HEAT DEATH



BIG CRUNCH



BIG RIP

HEAT DEATH

- Local group of galaxies will merge and other galaxies will drift apart
- Over quadrillions of years, white dwarfs and neutron stars will cool down and become truly dark
- Black holes will radiate away over a googol years.

Density of Dark Energy remains same

BIG RIP

- Dark Energy overcomes gravity creating empty spaces at smaller & smaller distances
- Empty space starts to push between individual stars dissolving the galaxy.
- Stars, neutron stars, planets, asteroids, everything solid is ripped into pieces

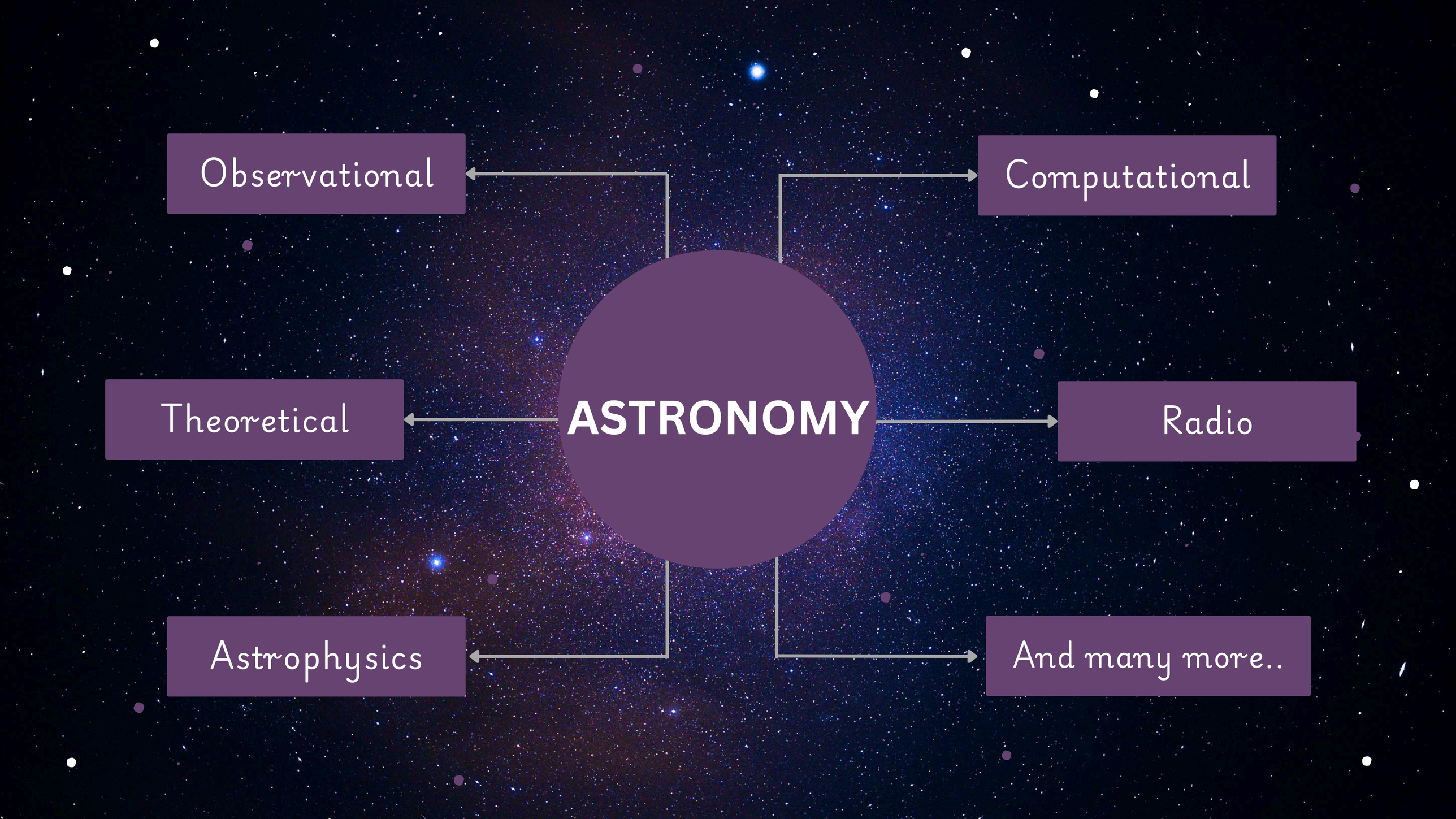
Dark Energy increases

BIG CRUNCH & BIG BOUNCE

- All things in existence will move towards each other, making the universe collapse into itself
- Galaxies and galaxy clusters approach each other until they evntually collide
- EITHER the universe will collapse into a singularity

  OR the universe could bounce back, restarting the cosmic expansion

Gravitation dominates

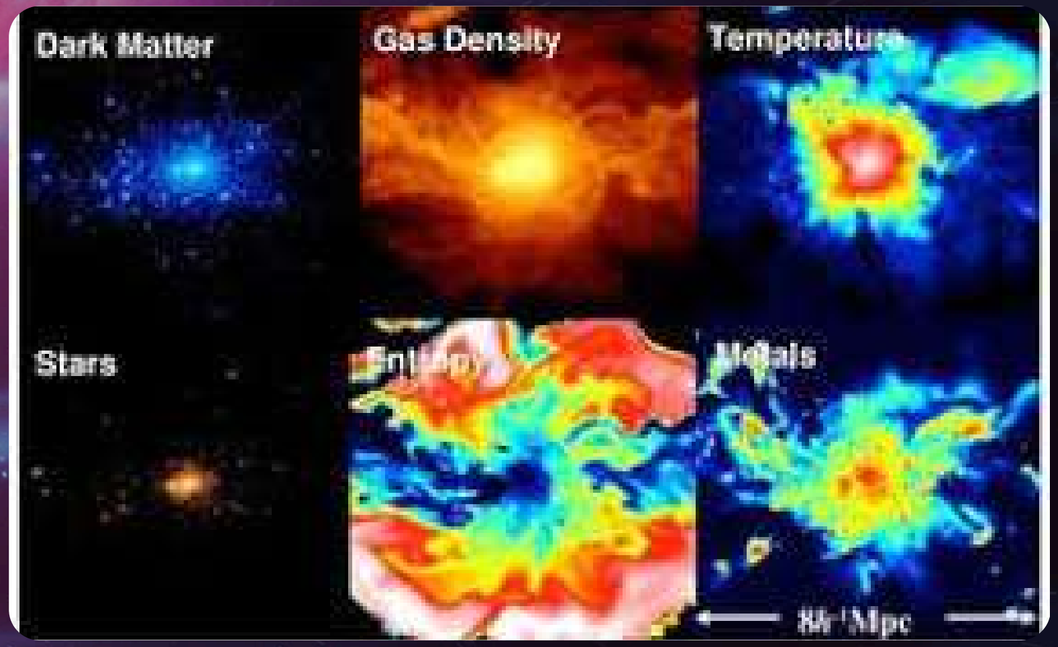

Observational
Computational
Theoretical
ASTRONOMY
Radio
Astrophysics
And many more..

Theoretical Astronomy

Theoretical astronomy is a branch of astronomy that uses physics and chemistry to create models that explain astronomical phenomena. Theoretical astronomers use analytical models and computational simulations to describe astronomical objects and phenomena.

Computational Astronomy

- Huge amounts of data to process
- Time Series Analysis
- Simulations for easy understanding
- Models for analysis
- Image enhancement and pre processing



Radio Astronomy

Radio astronomy is the study of celestial objects and phenomena by using radio waves. It involves collecting and analyzing data from radio telescopes to gain insights into the universe. Radio astronomers convert the numbers collected by a telescope into pictures. Each number represents information from a specific point in space.

Observational Astronomy

Observational astronomy is focused on acquiring data from observations of astronomical objects. This data is then analyzed using basic principles of physics.

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Observational astronomy is focused on acquiring data from observations of astronomical objects. This data is then analyzed using basic principles of physics.

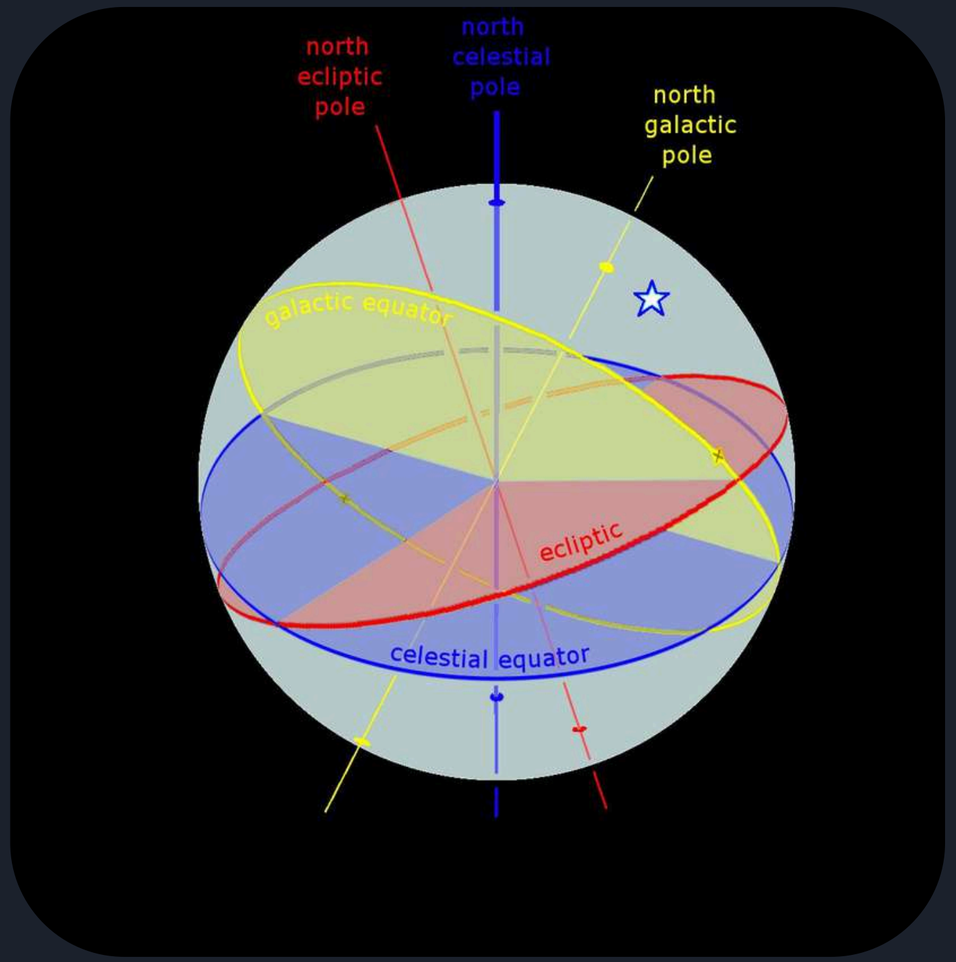
Let’s dive into some basic concepts of Observational Astronomy now

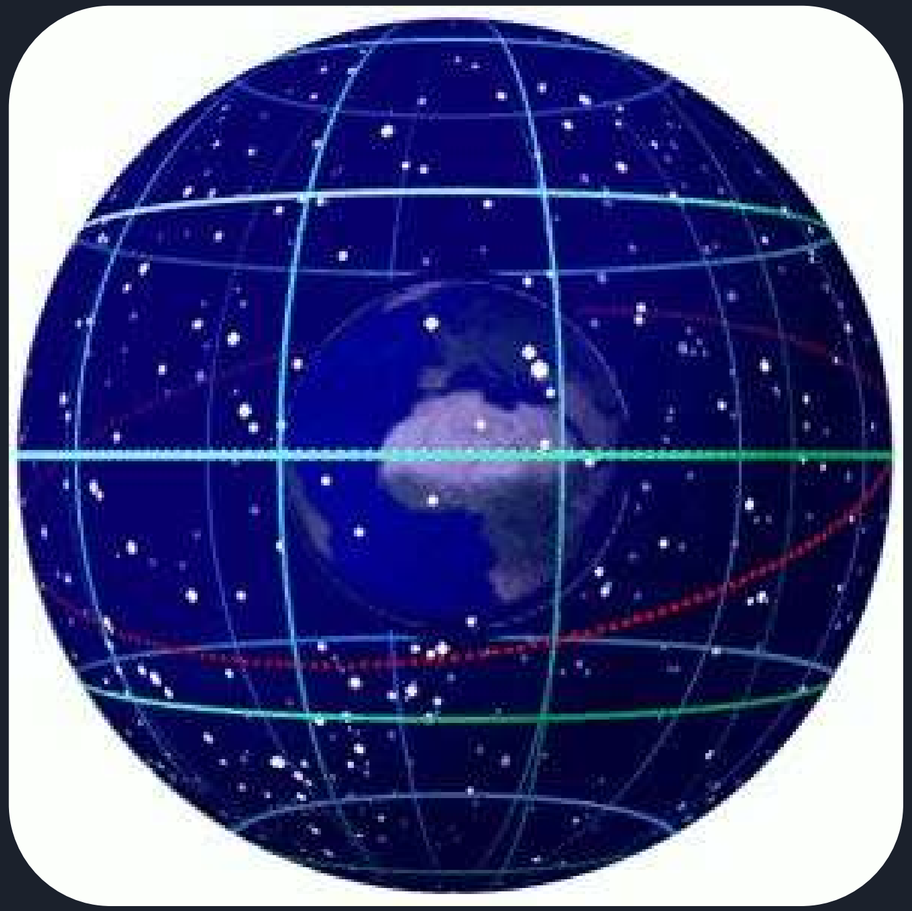
Navigating the Cosmos: A Guide to the Different Coordinate Systems in Astronomy

Contents

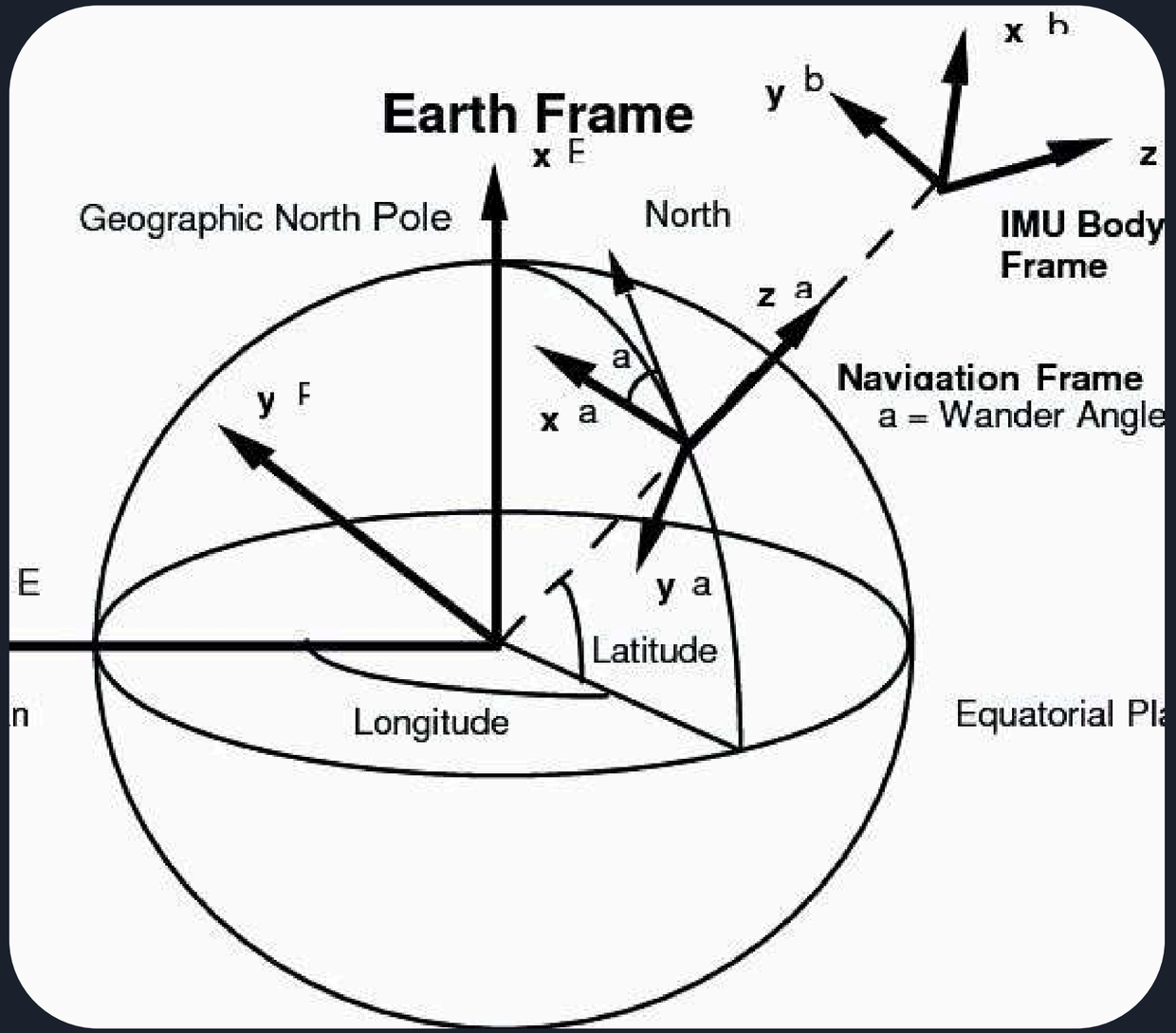
Geometrical Coordinate System

Astronomical Coordinate System

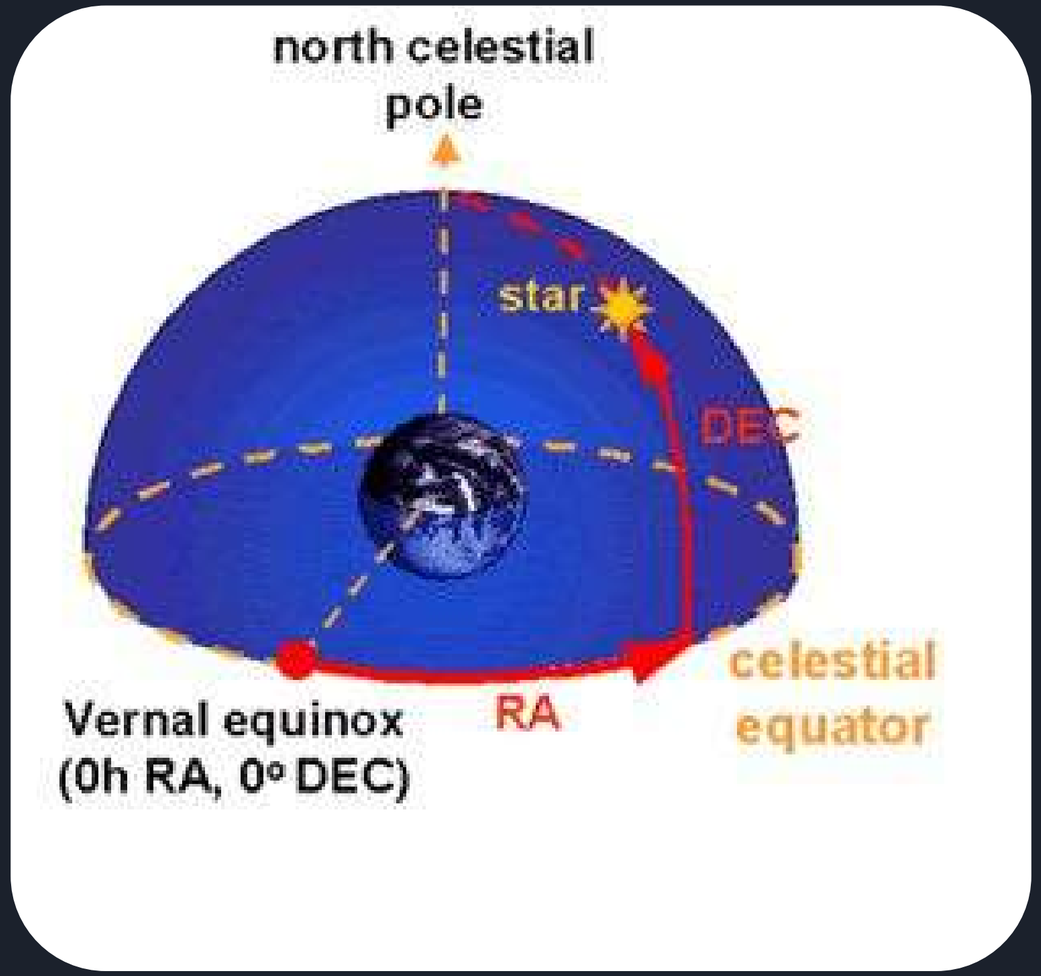




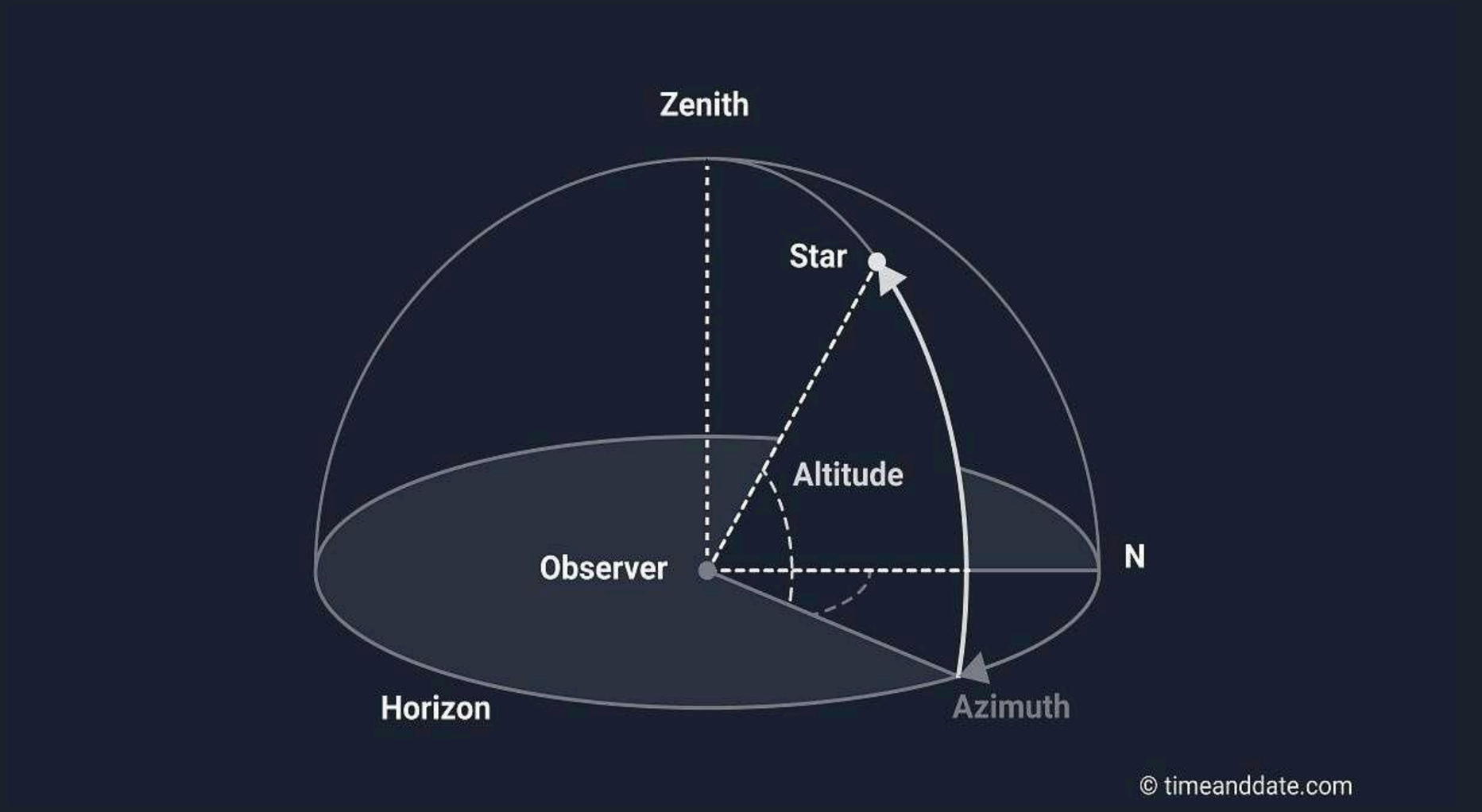
Reference Frames



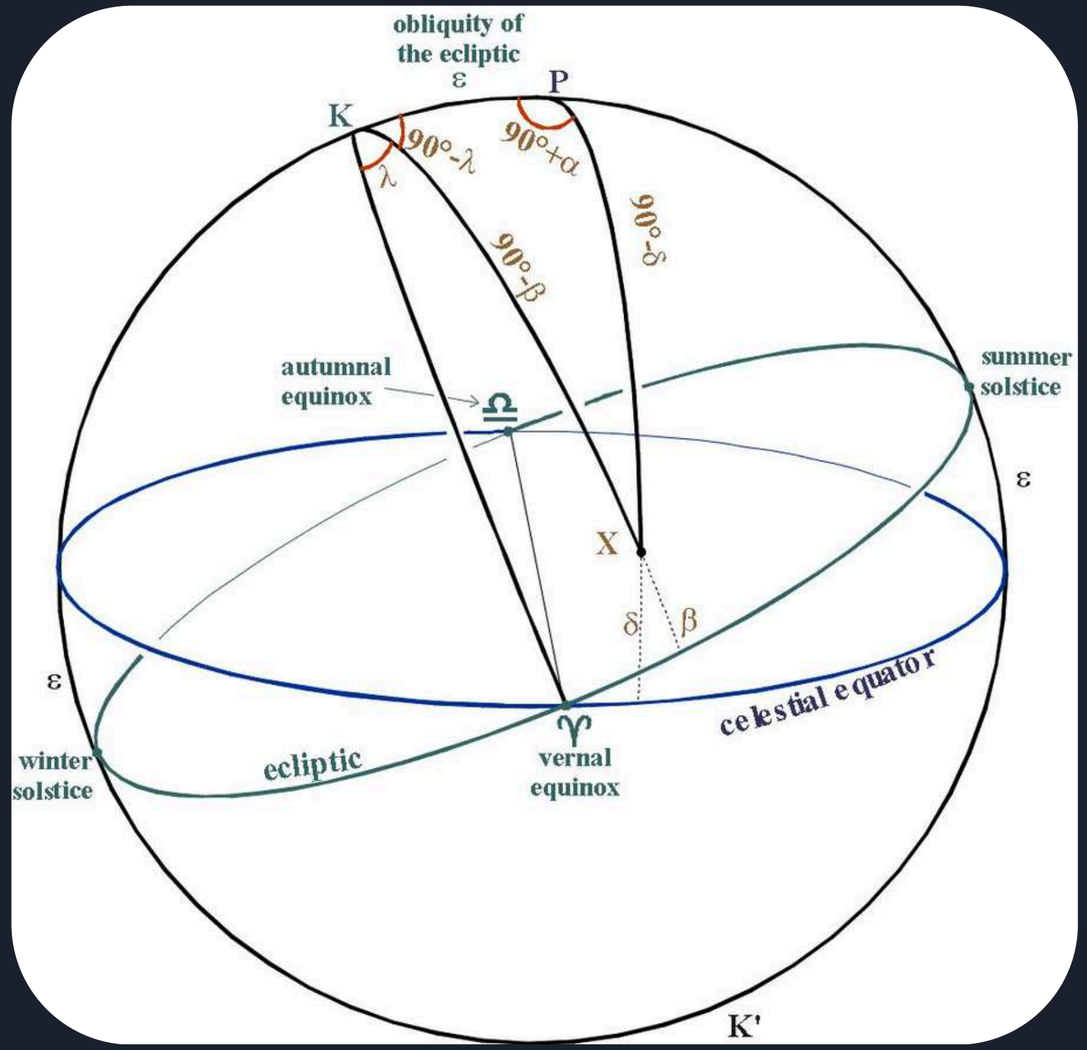
Equatorial Coordinate System

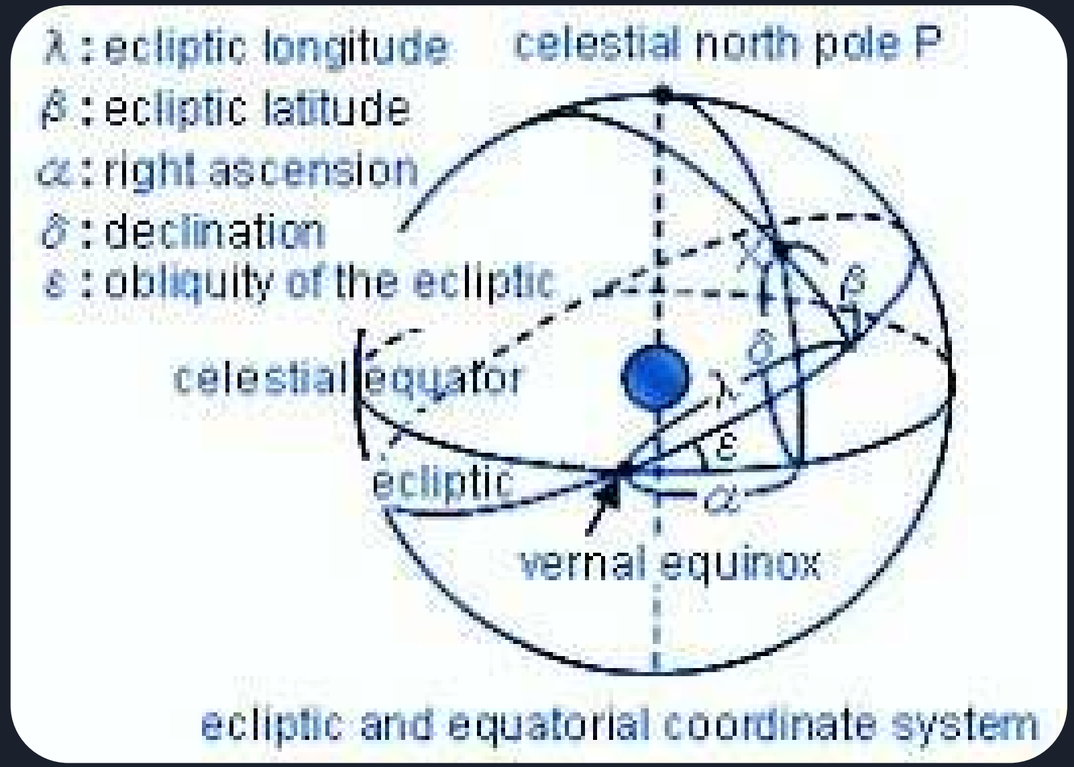


Alt-Az Coordinate System

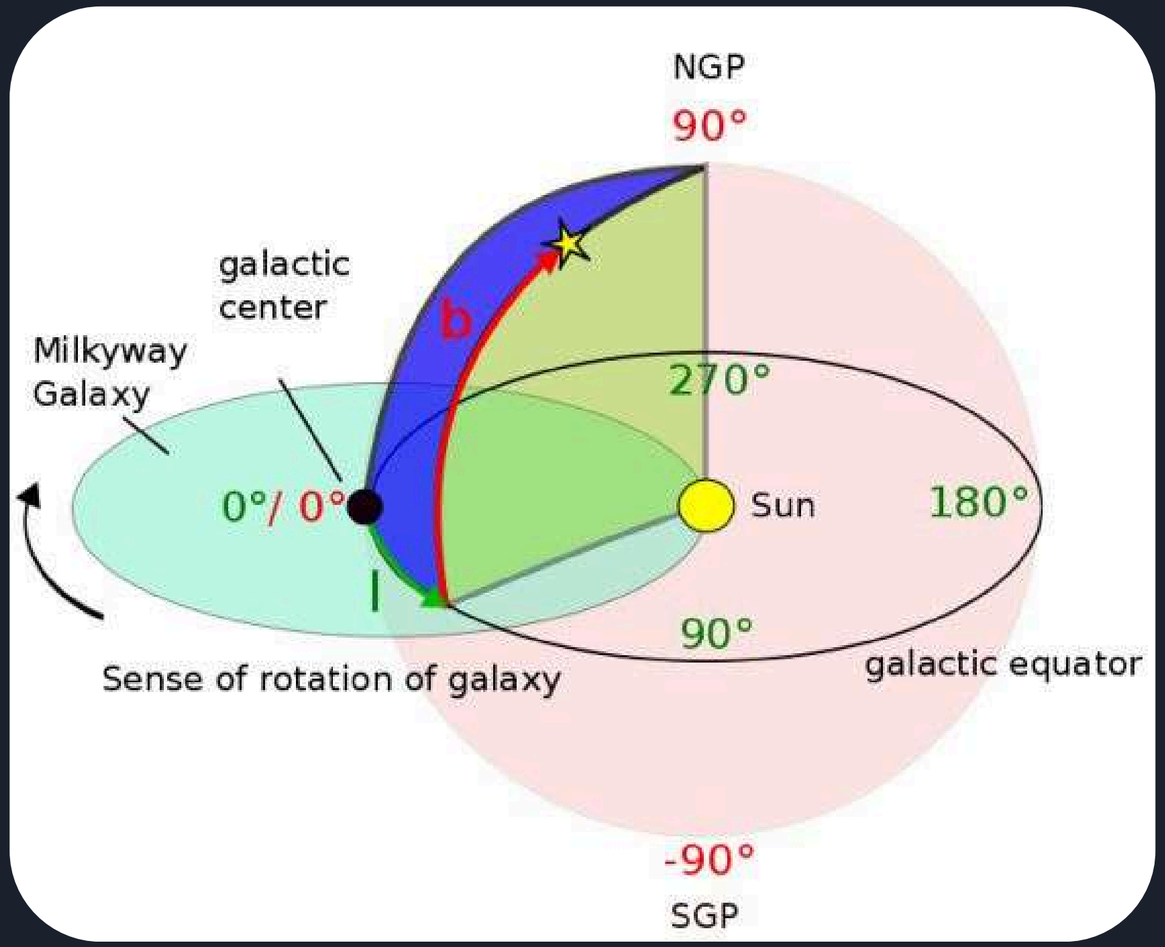


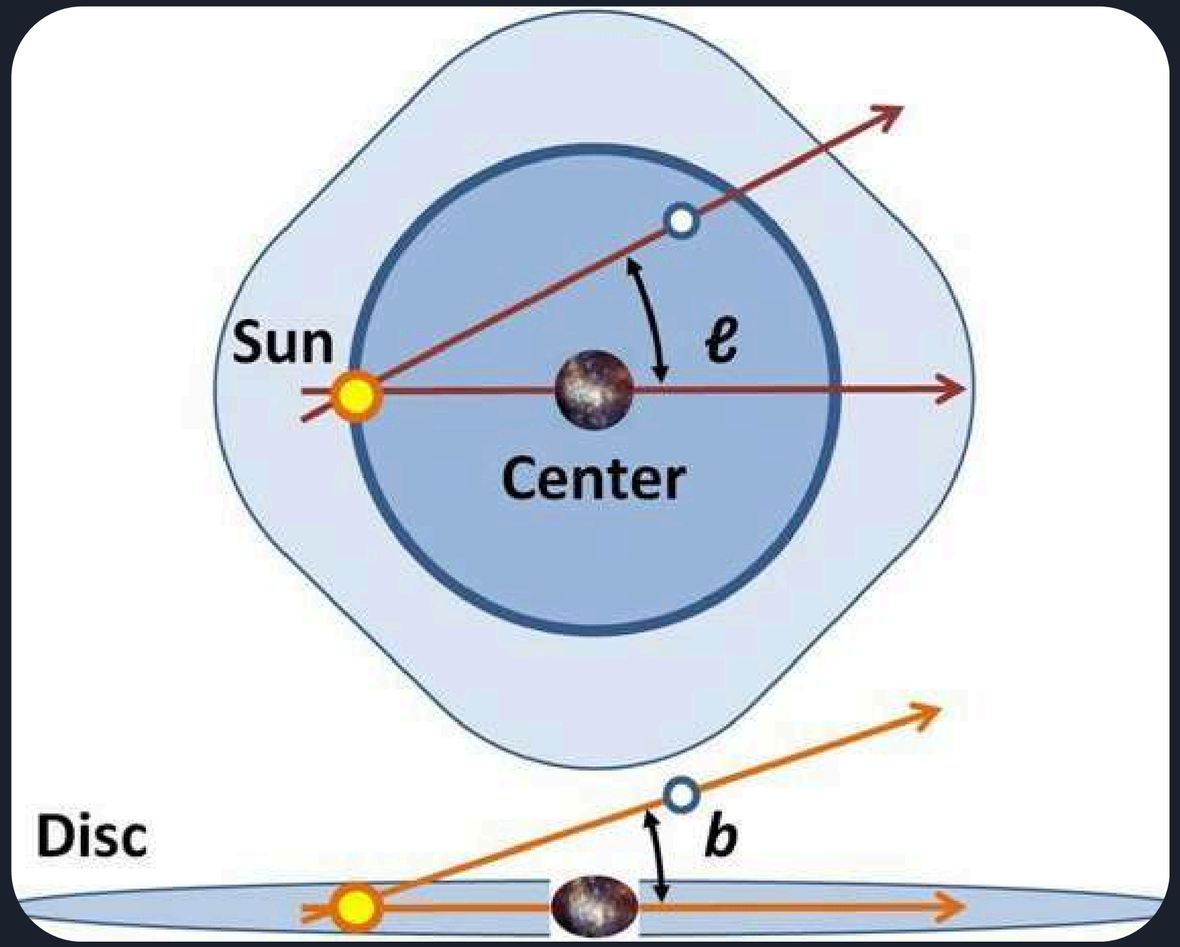
Ecliptic Coordinate System



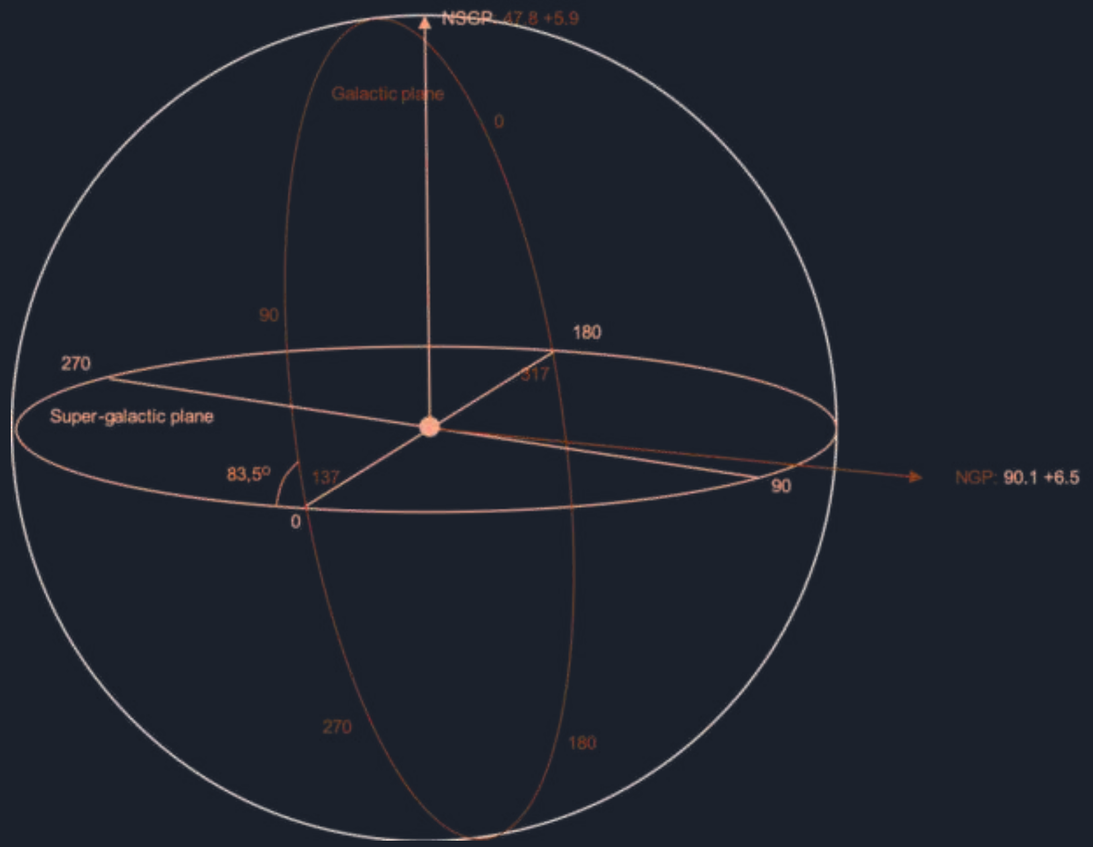


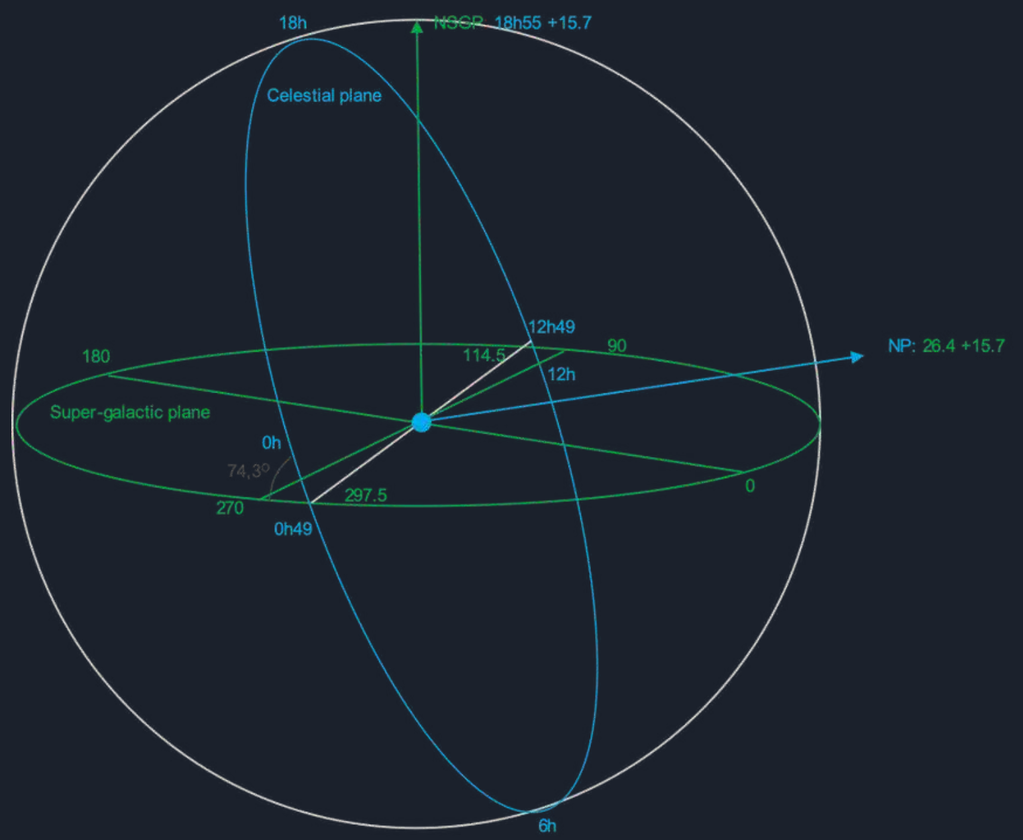
Galactic Coordinate System

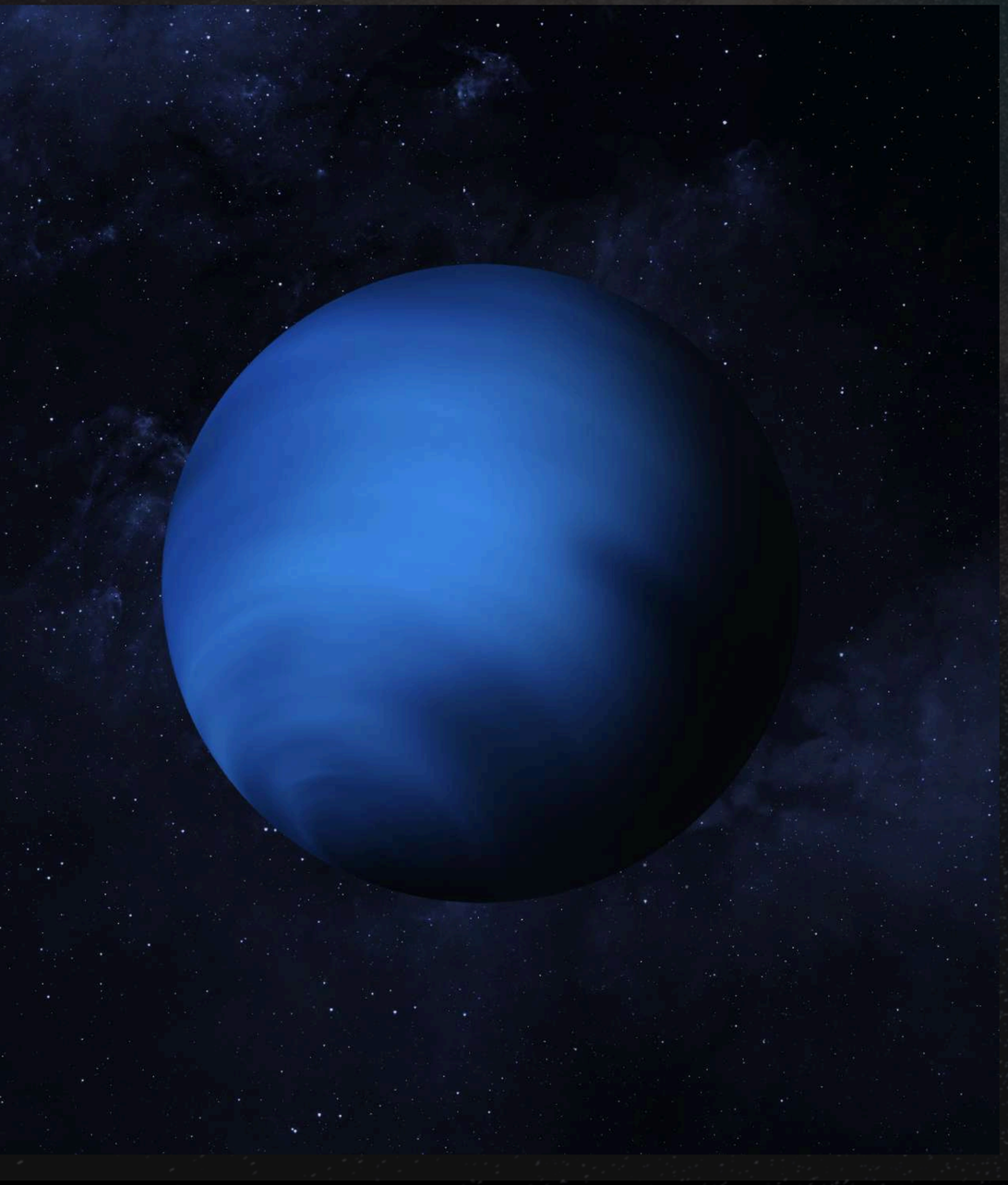




Supergalactic Coordinate System







THANK YOU!