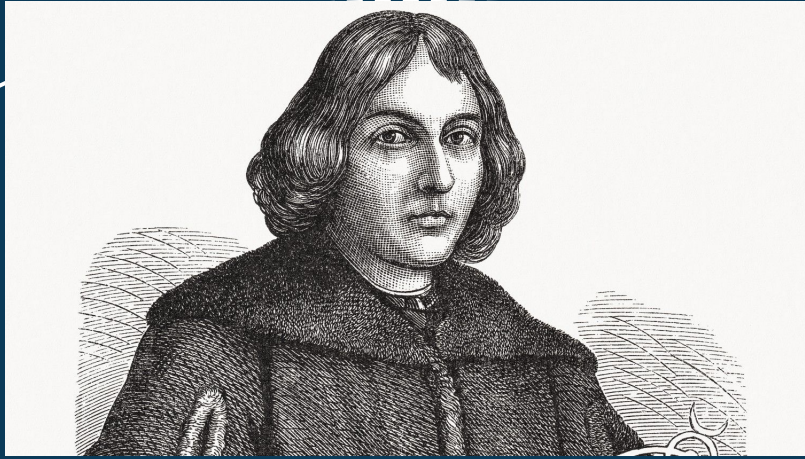




Revolution Physics: Copernicus

Maks, Rhythm, Marin



Nicolaus Copernicus

- Young Polish Astronomer (1473-1573)
- Came to the realization that the earth was not the center of the universe, but rather the earth goes around the sun
- His theory of planetary motion was published after his death and took more time to become widely accepted





The three key aspects that changed in the Copernican Revolution

- Astronomy- changed to using universal physical laws instead of simple circular motions
- Physics- we moved away from Aristotelian physics which was based on quality (common sense) and replaced it with physics based on quantity or quantitative attributes of matter
- Natural philosophy- the idea that the earth was the center from religious teaching was replaced with facts from what we know from experience



Major Implications of the Copernican Revolution

- Introduced new scientific methods that are needed to explain the planetary motion of Earth in homogeneous space
- Political struggle for authority because the teaching of this new science went against the teaching of the church, that the Earth was the center of the universe, which was held as common knowledge for the time.



Structure of Copernicus's Theory

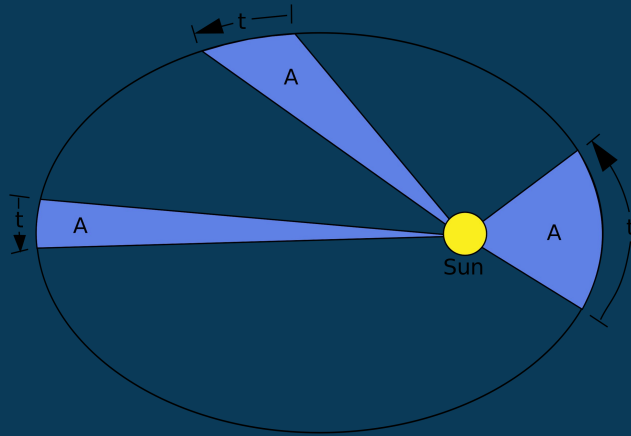
- Two out of three motions of Earth depicted in the theory are accepted today. The first of which is diurnal (day and night cycle) rotation of the Earth, and that we orbit around a stationary sun.
- These ideas were not accepted, because the current physics of the time could not explain it. For example, if the Earth spins, how are we not thrown off by the force.
- The idea that we orbit the sun also accounts for the retrograde motion that we observe with other planetary bodies, but they could not explain it with the physics of the time.

Starting to accept Copernican Theory

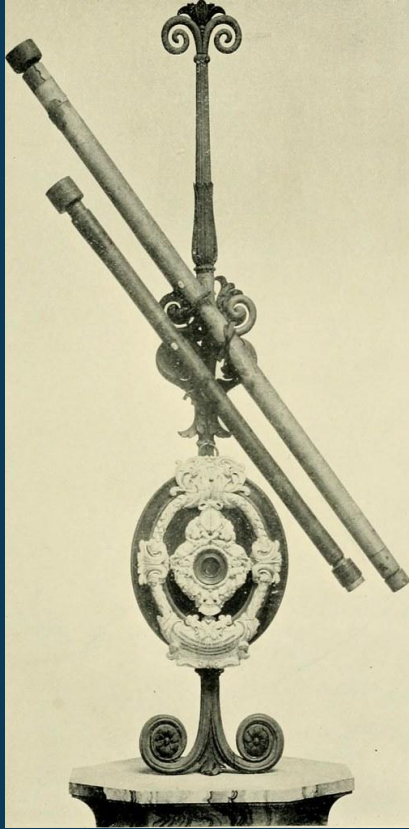
- The turning point when people started to accept the Copernican theory is came when Johannes Kepler (1571 - 1630) and Galileo Galilei (1564 - 1642) provided proof that supported the Copernican theory
- During this time, the idea that the Earth was the center of the universe was still widely accepted and was taught by the Catholic Church. Going against the teaching of the church, even with sound evidence could still lead to persecution during the time.

Johannes Kepler

- Studied Mars and produced two laws that define the modern theory of planetary motion
- The first of which is elliptical orbits with the center being the sun
- The second is that the area swept out by the radius vector from the sun to the planet at any given amount of time will always be the same, regardless of where the planet is in its orbit.



Galileo Galilei



- At the same time as Kepler, Galileo (in Italy) discovered a spy glass that makes things further away look closer. This leads to him making glass that can be used in the first telescope he starts to create. The telescope provided proof to the Copernican theory that we orbit the sun. Major evidence was when he discovered that Jupiter has moons disproving the uniqueness of the earth-moon theory as previously thought. He could also depict the orbit of Venus because of the spots on the sun from it
- He was threatened by the church to not publish teaching that went against their own.
- He was later persecuted and put to death by the Church



Isaac Newton and the End of the Copernican Revolution

- Nearing the end of the Copernican Revolution, the Copernican theory was thought to be the base of how the planets moved. This allowed Isaac Newton to continue study the problems of the dynamics of the heavens, which led to his discovery of gravity.
- Gravity accounted for many of the phenomena that was not explainable in the copernican theory, such as the fall of bodies near the earth, the orbits of the earth and other planets, the moon and the moons of Jupiter and even comets and tidal motions.
- The return of Halley's Great Comet in 1680 confirmed Newton's theory of Universal Gravitation.

The Origins of the Copernican Revolution

by J. R. Ravetz



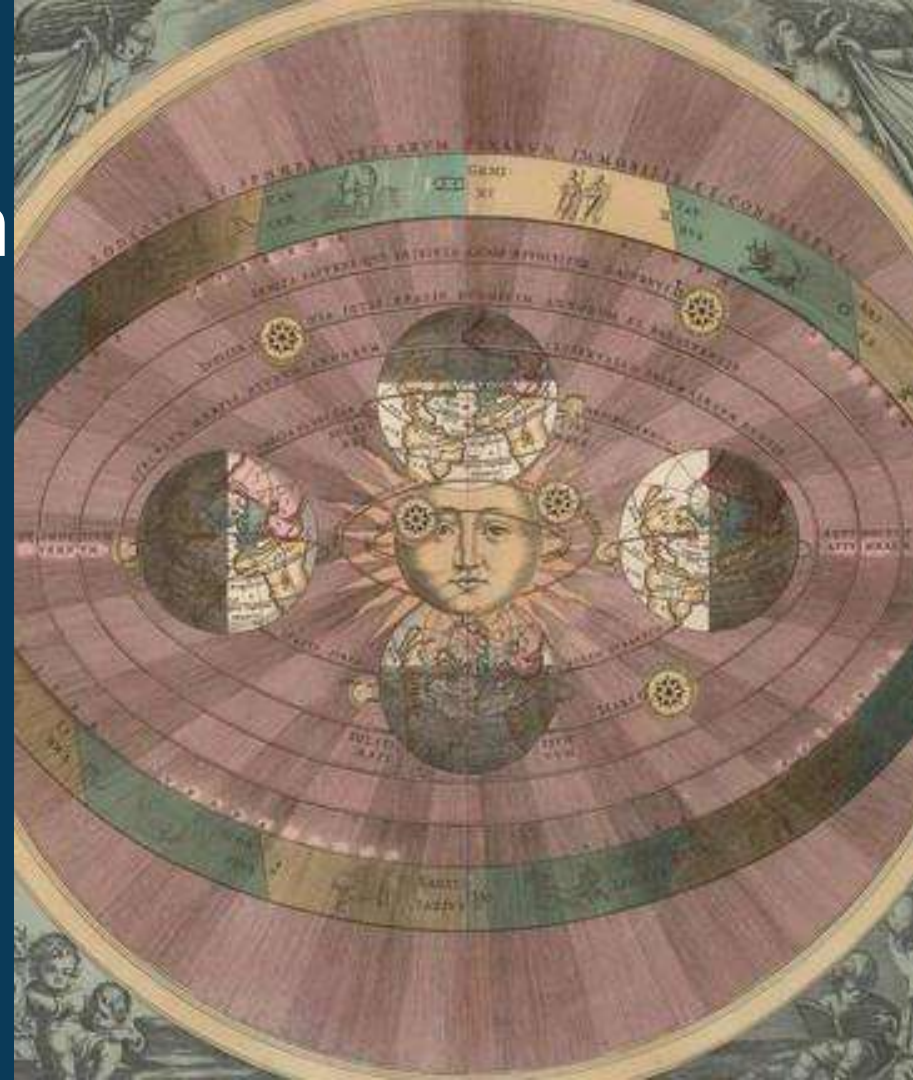
- **Copernicus's shift** in 1543 (The start of the Copernican Revolution)
- Motivated by the desire to satisfy **Plato's principle of uniform of circular motion**
- Manuscript “*De revolutionibus orbium coelestium*”



The Origins of the Copernican Revolution

by J. R. Ravetz

- **Heliocentric Model** (Sun is in the middle of the universe)
- Argued with **Geocentric Model** (Aristotle and Ptolemy's Almagest)
- **Galileo, Tycho Brahe, Johannes Kepler** supported his theory



How did Copernicus come up with heliocentric theory?

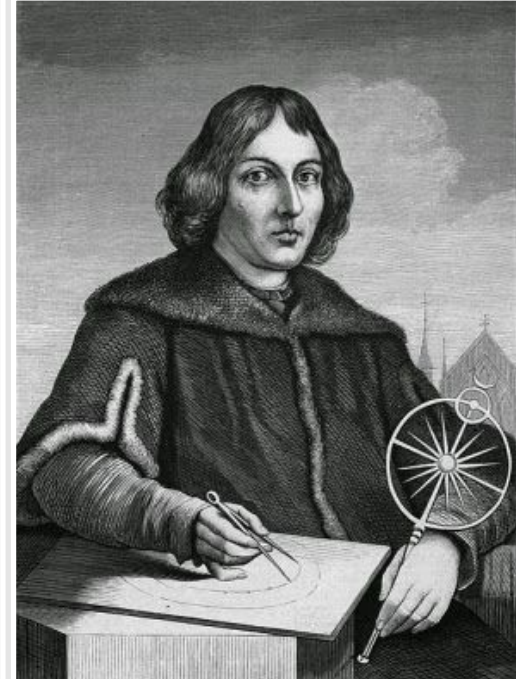
- Domenico Maria Novara (Teacher in Bologna)
- Copernicus thought that there were **translation mistakes** in Ptolemy's manuscript about geocentrism
- He was a **skeptic**, and everyone back in the day **believed in geocentric model**
- Shared a copy of his manuscript to **Nikolaus von Schonberg** who praised him for his talent



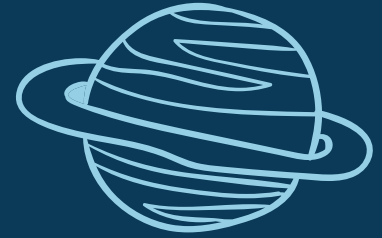
Who published his
work after his death?

Rheticus

- Follower of Copernicus
- Tried to convince him to publish the manuscript earlier
- Took on a responsibility to publish his work
- https://www.youtube.com/watch?v=vzo8vnxSARg&ab_channel=CrashCourse



The Rationality of the Copernican Revolution by Martin Curd

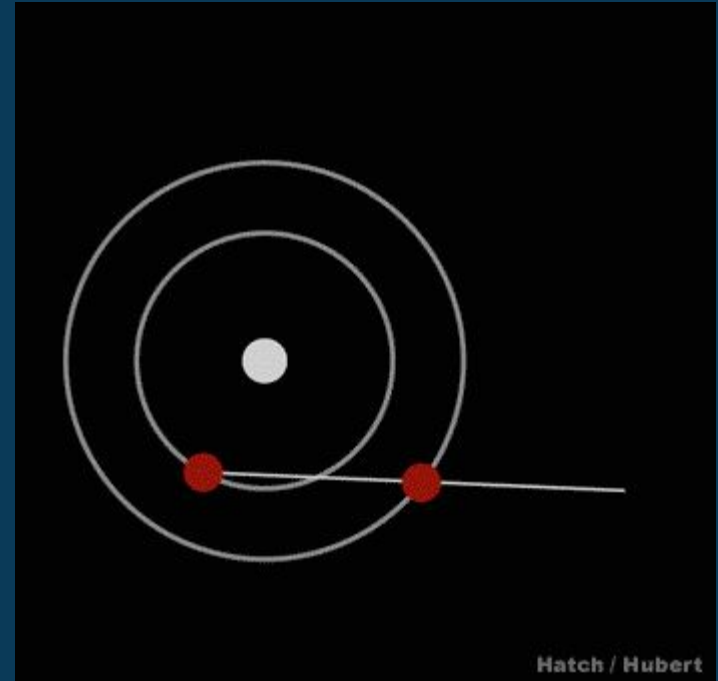


- Copernican theory - ability to explain and be tested by facts of positional astronomy
- Predictive power
- $1/T_p = 1/T_e \pm 1/S_p$ (existence of inferior and superior planets, derived from observation, empirical)
 - T_p = heliocentric period of the planet P
 - T_e = heliocentric period of the Earth (1 year, 365.25 days)
 - S_p = interval of time between successive episodes of the retrograde motion of P as viewed from the Earth (aka one “cycle of anomaly”)

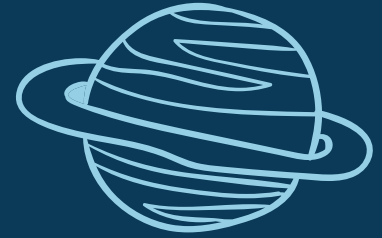


The Rationality of the Copernican Revolution by Martin Curd (continued)

- Explanation of S_p -
 - Perspective effect
 - Earth passes a slower moving outer planet
 - Makes planet appear to be moving backwards relative to stars behind it



The Rationality of the Copernican Revolution by Martin Curd (continued)



- Distances of each planet, order of planets
- Ptolemaic theory - geocentric, Earth stationary, sun and planets orbit Earth
- Tychonic theory - also geocentric and Earth stationary, but sun/moon revolve around Earth, planets revolve around sun
- Determining Ptolemaic and Tychonic theories as incorrect
 - Galileo's observations → Venus orbit around Sun
 - Newton's gravitational theory → proves Earth is not stationary





Why was the Copernican Revolution fundamental?

Use of Empirical Data

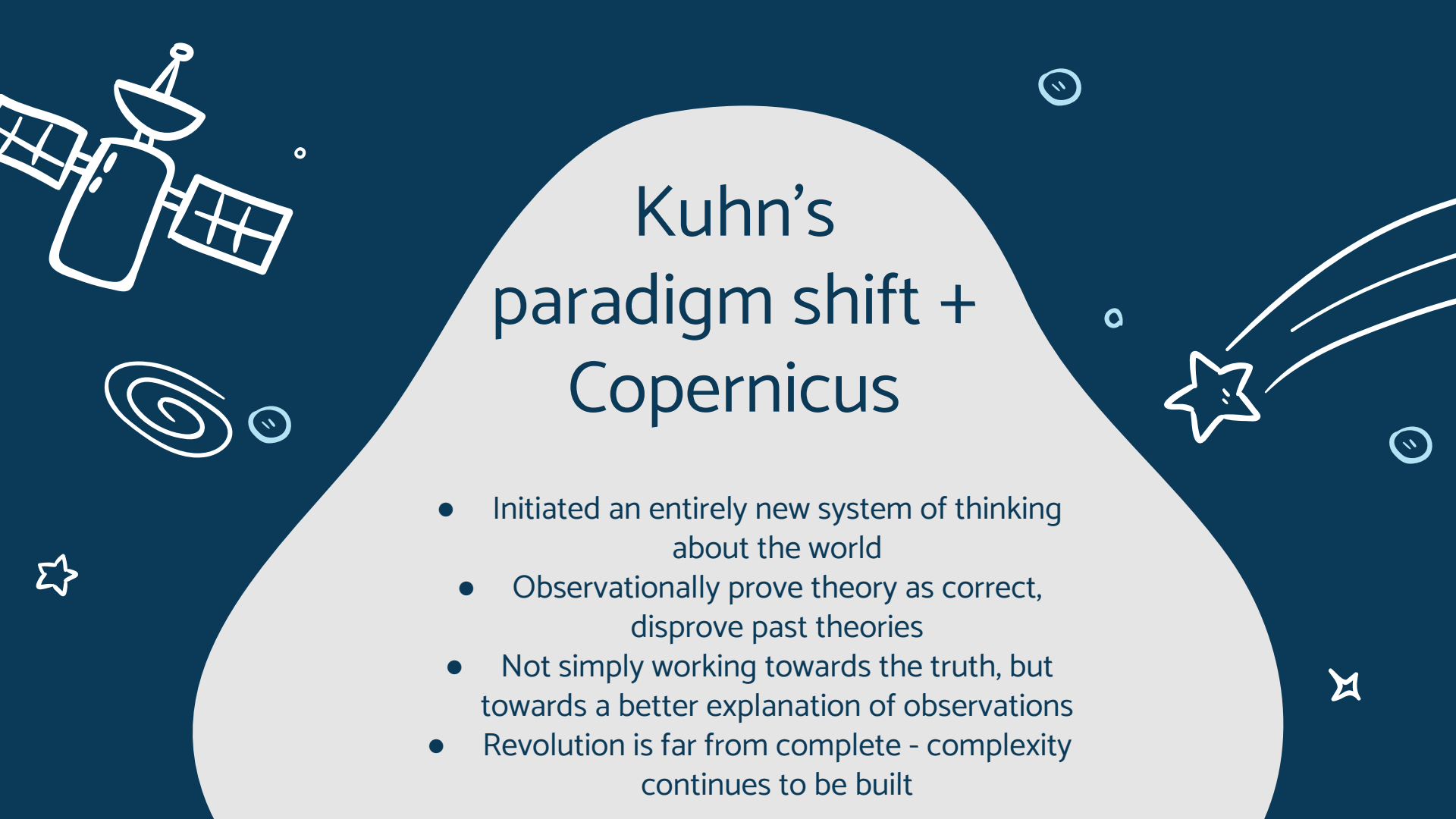
Theory developed through observation, mathematical explanation unlike predecessors

Paradigm Shift

Initiated change from geocentric model to heliocentric model

Basis for New Discoveries

Galileo, Newton, etc. built on Copernican ideas to create their own theories



Kuhn's paradigm shift + Copernicus

- Initiated an entirely new system of thinking about the world
- Observationally prove theory as correct, disprove past theories
- Not simply working towards the truth, but towards a better explanation of observations
- Revolution is far from complete - complexity continues to be built

Key Takeaways

Copernicus

Iconic scientist who appreciated the use of observation in theory-making

Heliocentric model

Sun is now seen as center of the solar system

Paradigm shift

Changed way of seeing astronomy and of seeing the world around us

Social influence

The efforts of Galileo and Newton helped to solidify theory

References

1. The Rationality of the Copernican Revolution, Martin Curd
2. The Copernican Revolution, J. R. Ravetz
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5. Scientific Revolutions, New Scientist