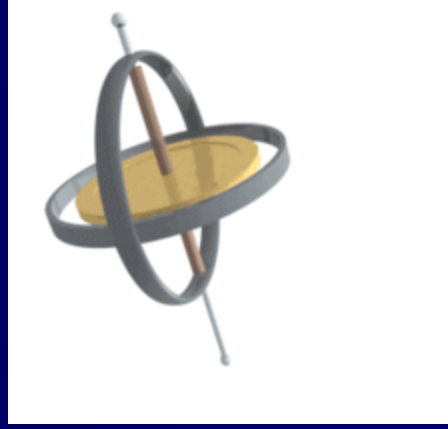
Ptolemy & Copernicus

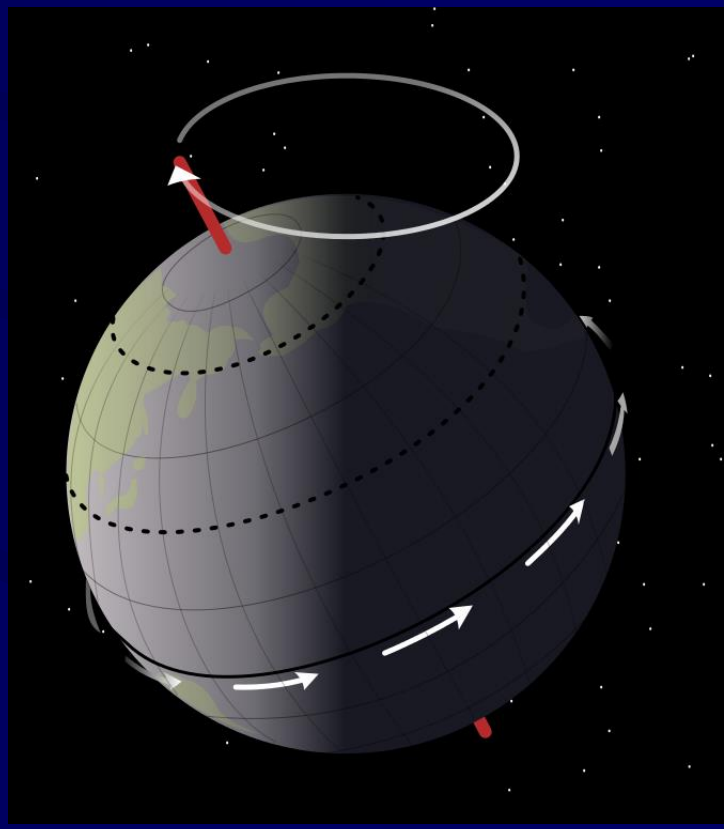
Hipparchus's (190-120 BCE) achievements

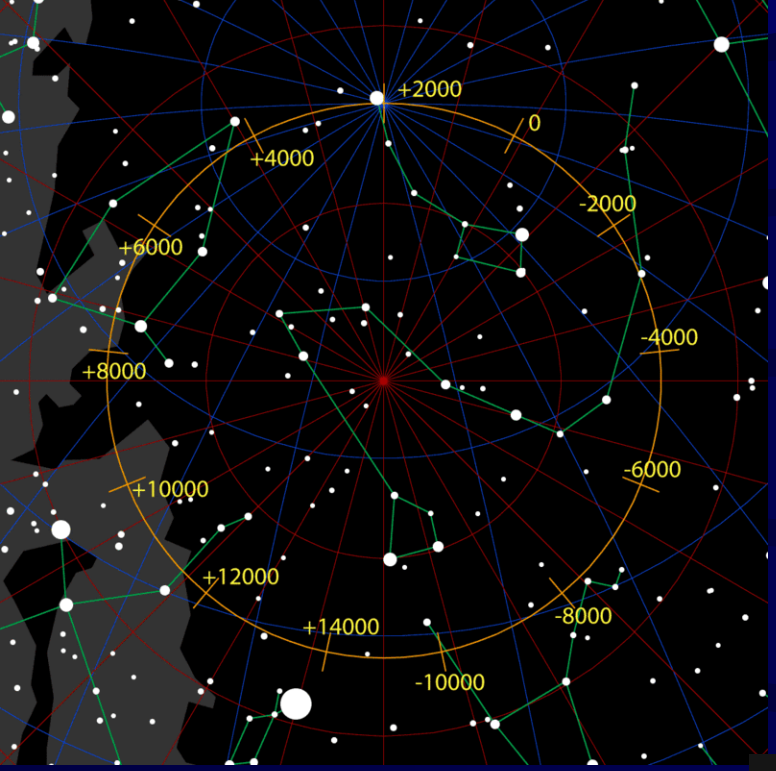
- Compiling an accurate Star Catalog in use for a milenium
- Discovery of Precession
  (Shift of the equinoxes)
- Invention of the
  Eccentric Circle

Precession of the Equinoxes



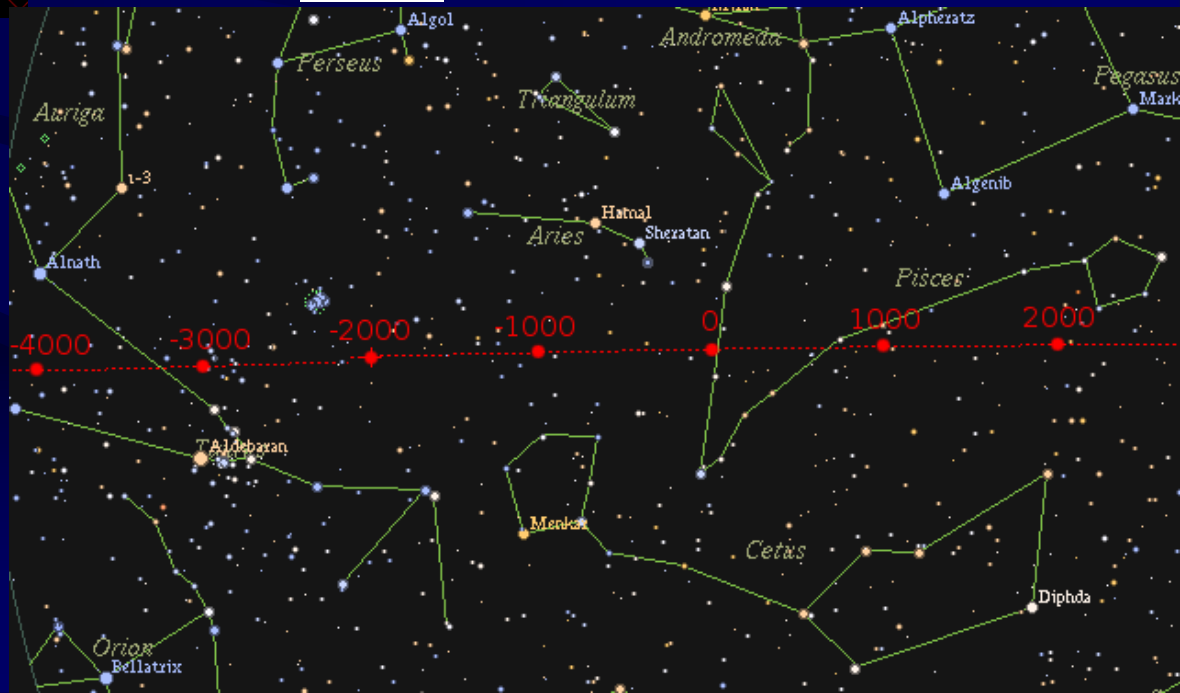
- Earth rotates around its axis
- The axis itself rotates very, very slowly (26,000 years) around the pole of the ecliptic
- This effect can only be discovered by meticulous recordkeeping, comparison with historic data → cumulative effect





When celestial coordinates were "invented" 2,000 years ago, the equinox was in Aries, hence the ram sign ♈

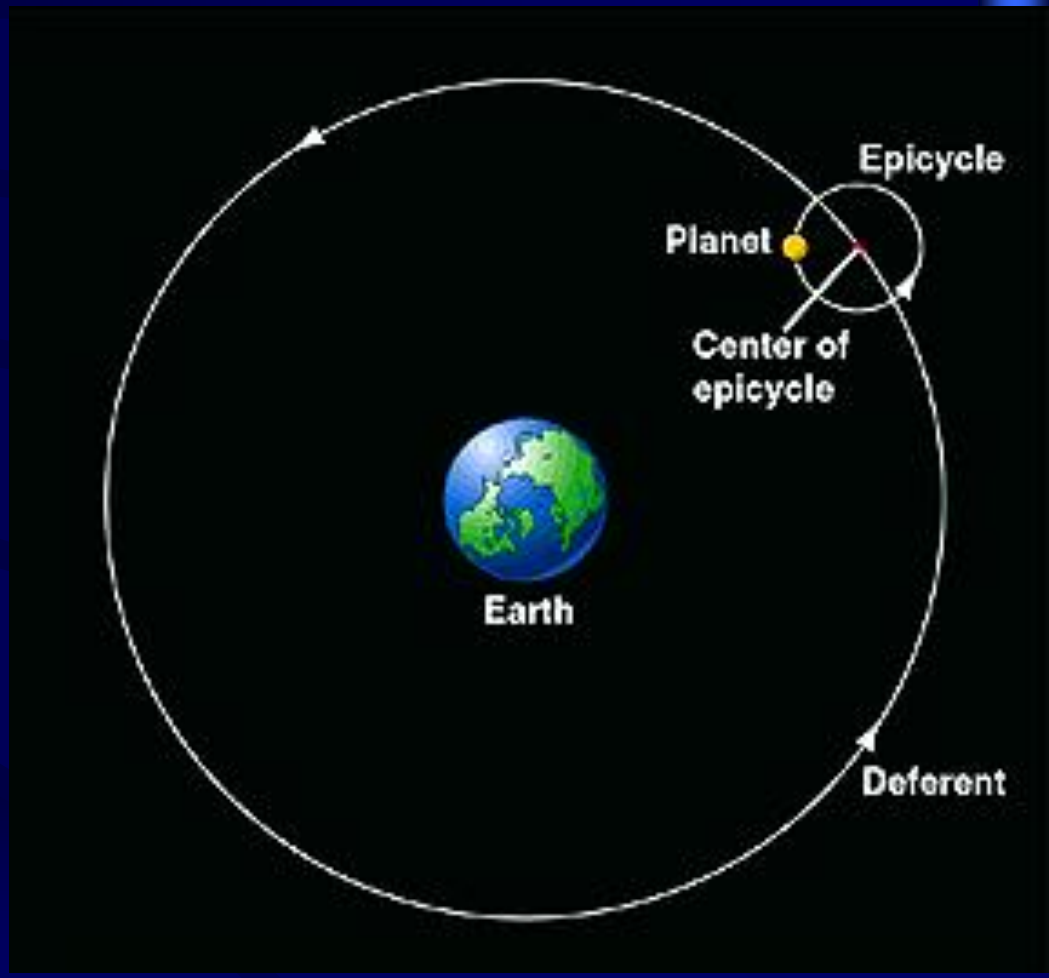
Path of CNP and Equinox due to Precession



Ptolemy (~140 AD)

- Puts forth a complete geocentric model
- dominates scientific thought during the Middle Ages
- Longest lasting (wrong) theory ever: 1000yrs

Major Work: **Almagest**



What was known? Which appearances had to be saved?

1. Daily motion of all celestial objects
2. Sun and moon move on inclined circles
3. Sun and moon are slower than the stars
4. Retrograde motion of the planets
5. Planets are brightest at opposition
6. Planets are always close to ecliptic
7. Venus and Mercury are always close to the sun

What was the accuracy of the data?

1. Planetary positions: about 1º
2. Duration of the year to a few minutes
3. Duration of the lunar month to a few seconds
4. Absolute sizes of sun and moon (Aristarchus)
5. Babylonian wisdom of eclipse prediction
6. Star positions: smaller than 1º (Hipparchus)
7. Precession of the equinoxes: 1º in 72 years

Ptolemy's Assumptions

1. All celestial objects move in (combinations of) uniform circular motion

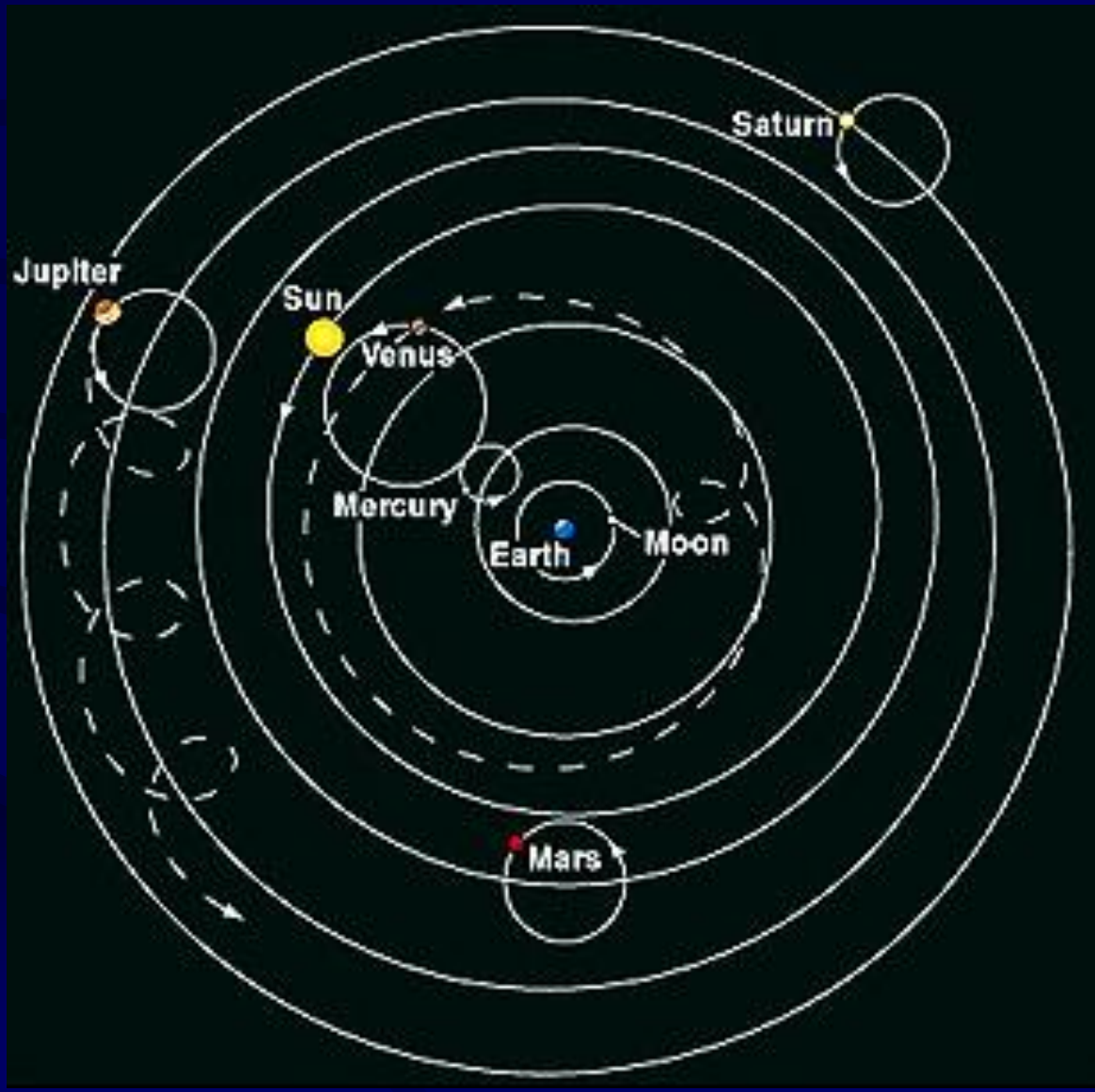
2. The Earth is stationary at the center of the universe

Epicycles

- **Ptolemy's** explanation of **retrograde motion**
- Ptolemy Simulator

(Sun can be simulated as an inferior planet with no epicycle)

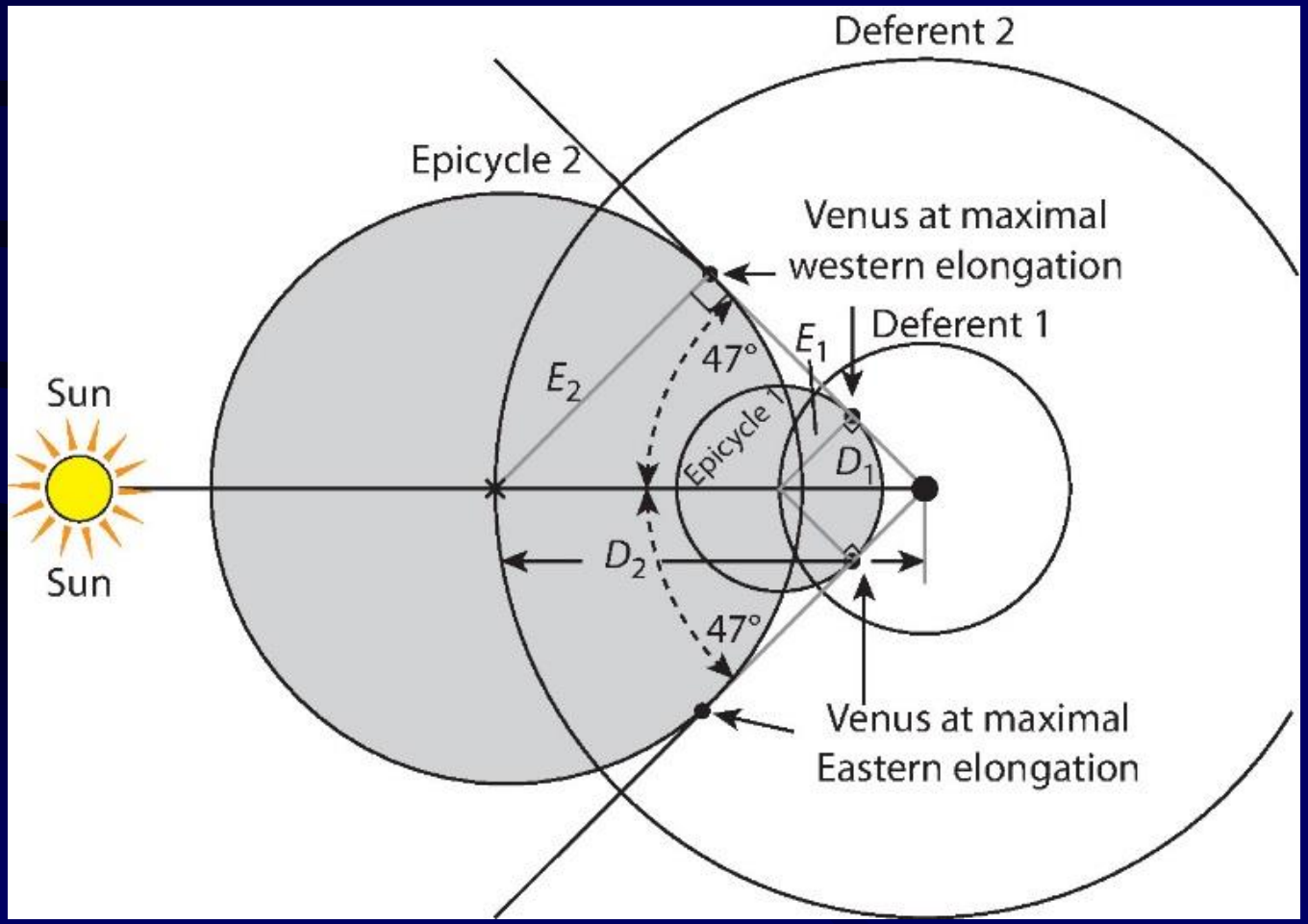
- Several epicycles necessary to explain all observations
  ➔complicated theory
- Saves the appearances!



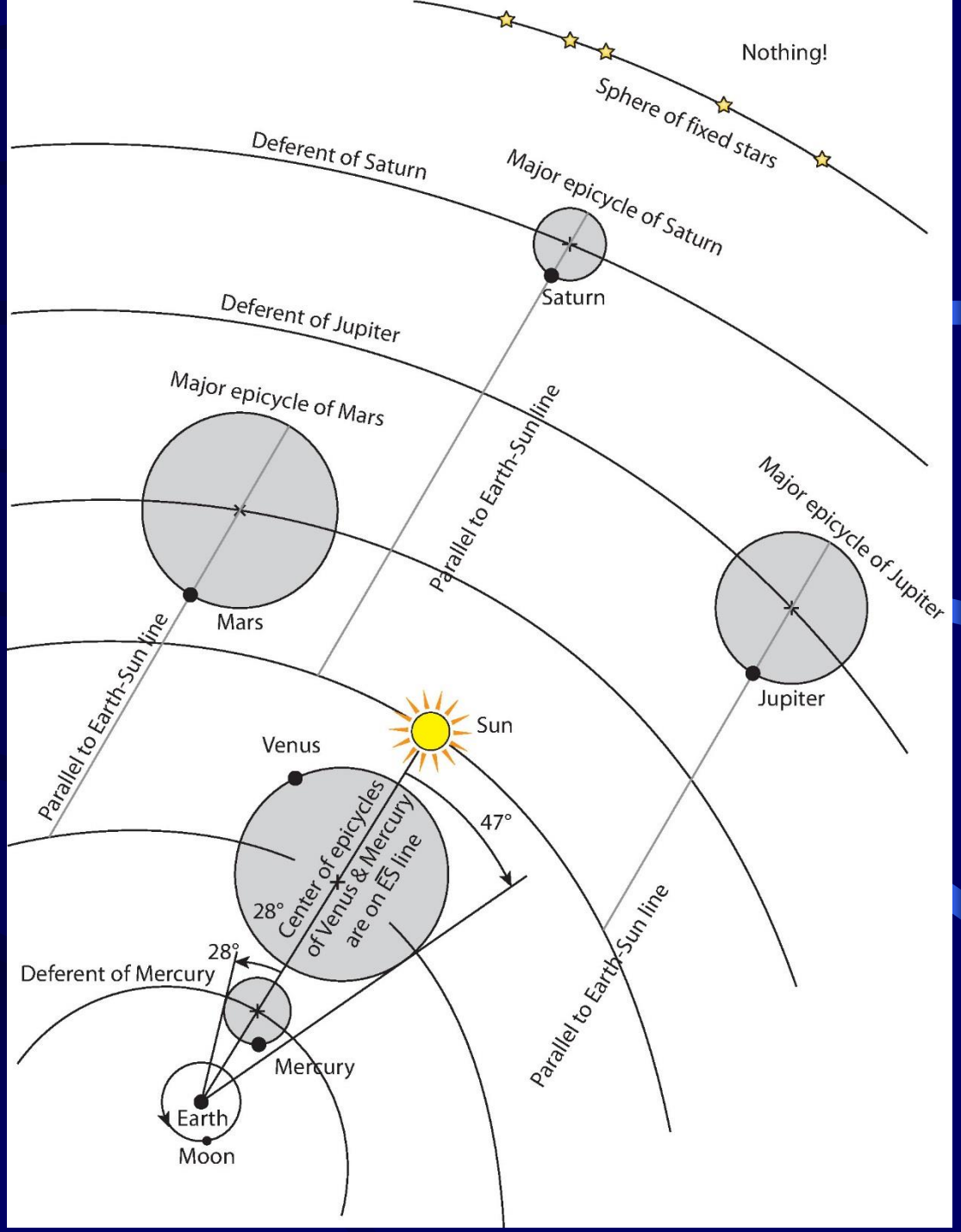
Ptolemy as a mathematical Astronomer

- Ptolemy employs a set of geometrical tools (epicycles, equants, eccentric circles) to describe the cosmos (planetary motion) mathematically
- He is concerned more with saving the appearances, less with explaining what is physically going on
- Is this wrong? No, because you can describe ANYTHING with epicycles!
- But it doesn't lead anywhere: it is sterile and not useful – at least if you want to understand the cosmos

Epicycle Sizes can be chosen, are not determined by data in Geocentrism



Ptolemy's System of Epicycles



The Medieval Setting

- Dominant Church
- 1000 years of relative stagnation
- Experimental research greatly reduced
- To answer a question:

  “Study the Bible or Aristotle!”

The Renaissance Setting

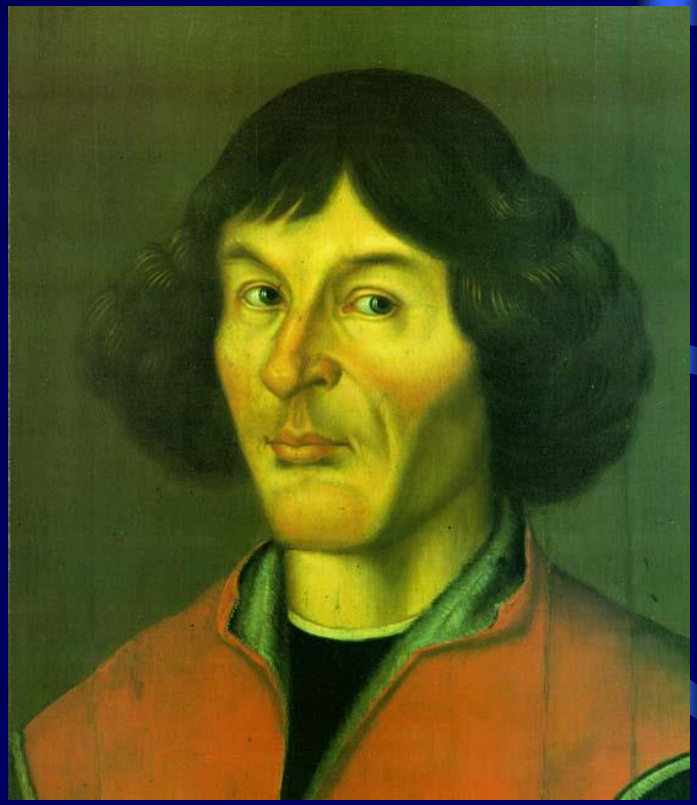
- Invention of the print (1450) by Gutenberg

➔Books widely available!

(Think: Manuscripts vs Amazon.com)

- End of Middle Age Church Domination
- Back to the roots (renaissance=rebirth)
- Study of Arabic astronomers
- Intellectual movement

Nicolas Copernicus (1473–1543)



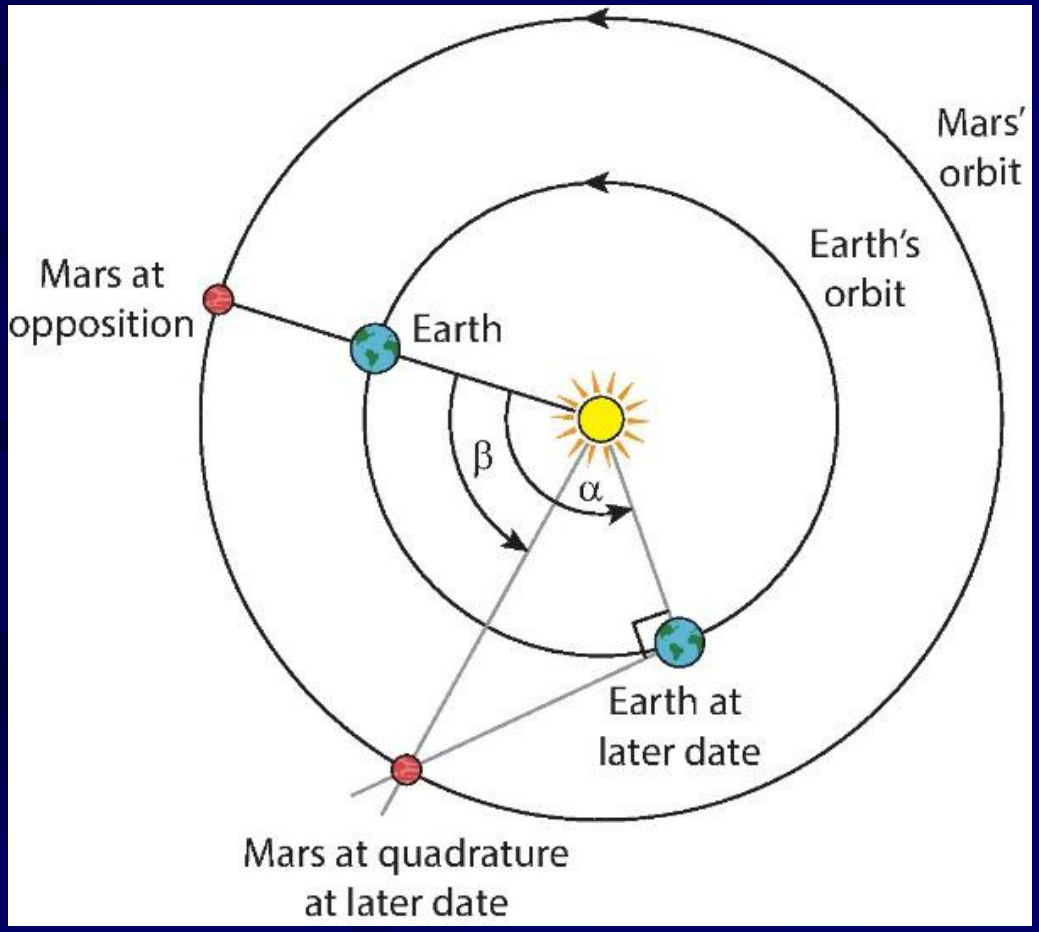
- Rediscovers the heliocentric model of Aristarchus → BOOKS!
- Planets on circles
- Not more accurate than Ptolemy
- *Copernicus simulation*

Major Work : ***De Revolutionibus Orbium Celestium***

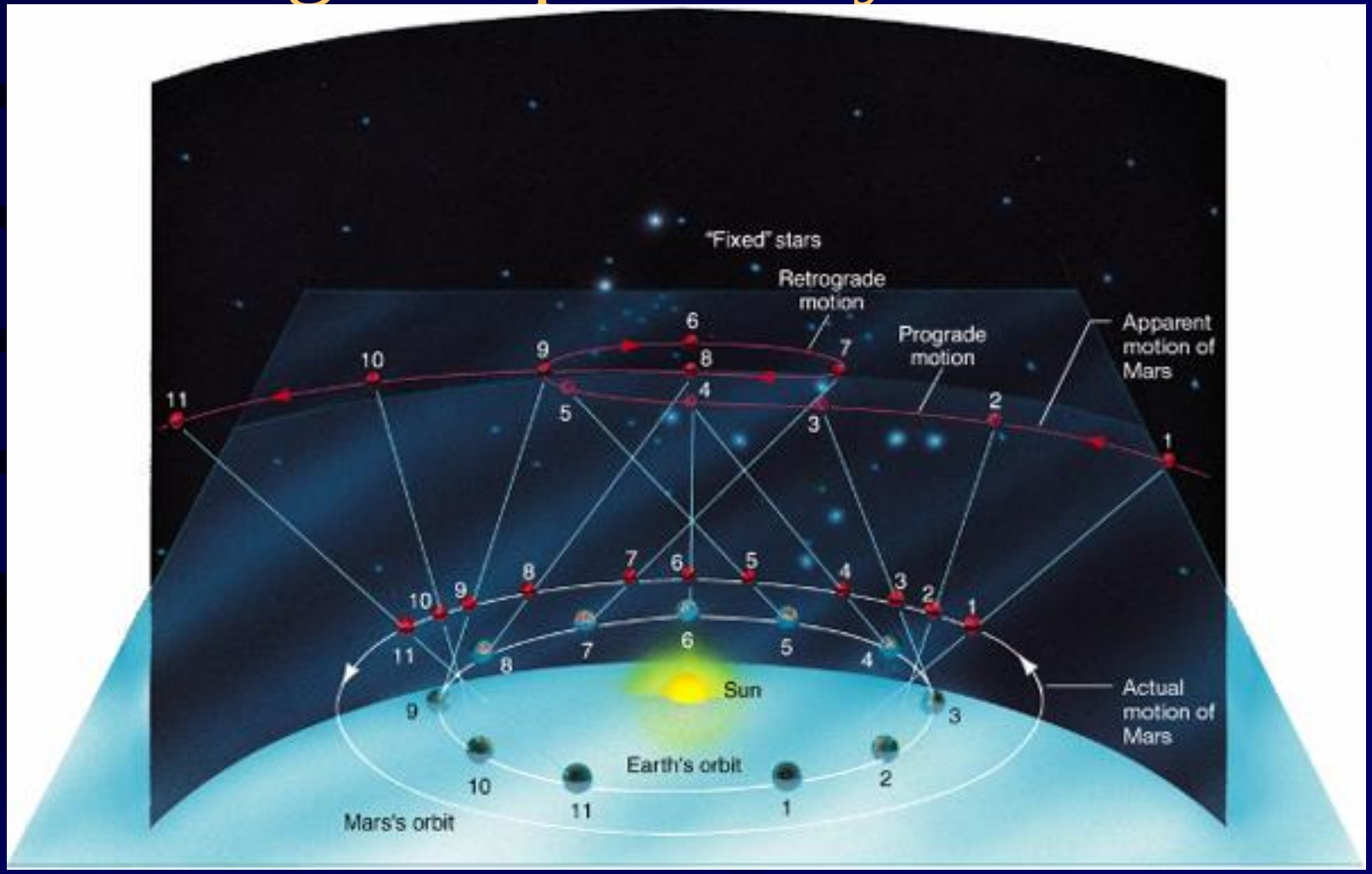
(published posthumously)

Copernicus had to (and could!) determine the sizes of the planets' orbits from data

Due to the non-observation of the stellar parallax, in Copernicus's model the stars had to be exceedingly far away – a good counter-argument for his opponents!



Copernicus' heliocentric explanation of retrograde planetary motion



Simulation, see also: SkyGazer