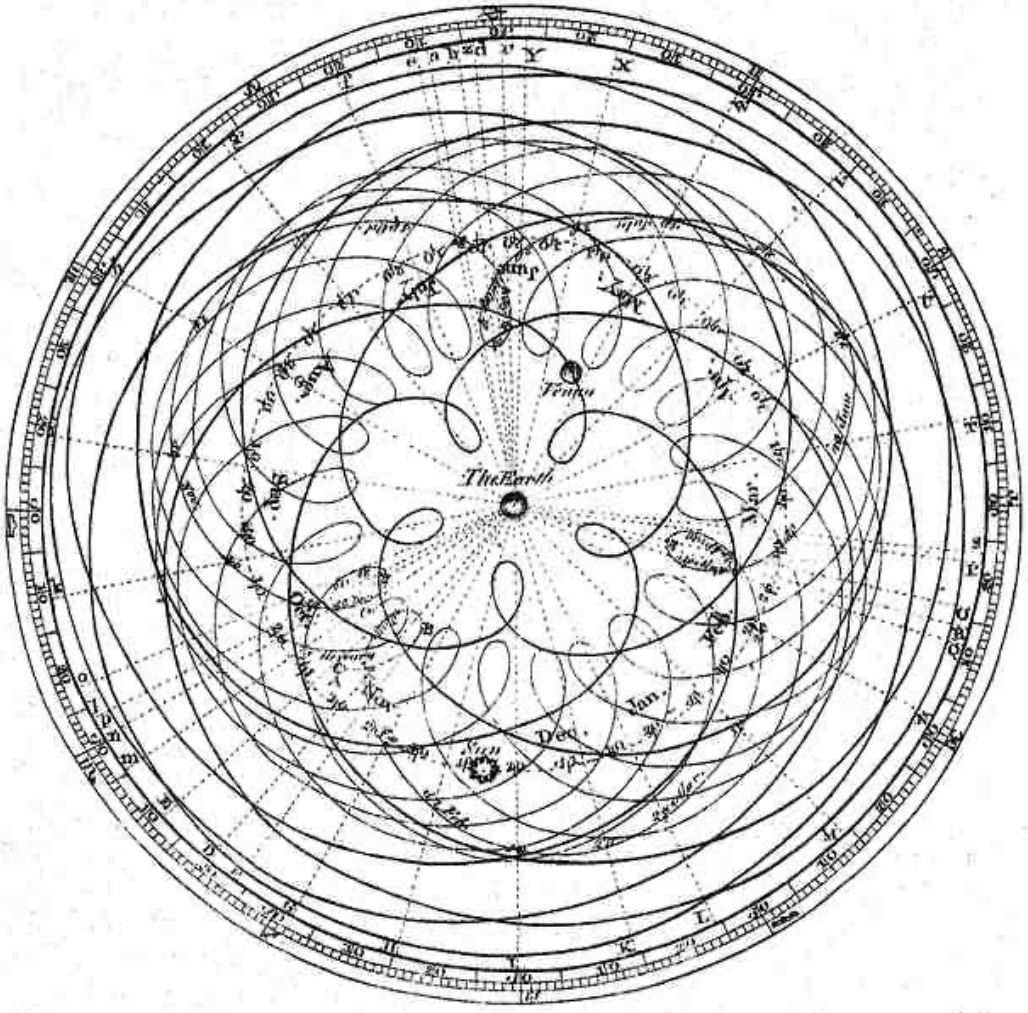
13. Two World Views

1. Ptolemaic System
2. Copernican System
3. Pro-Copernicus
4. Contra-Copernicus

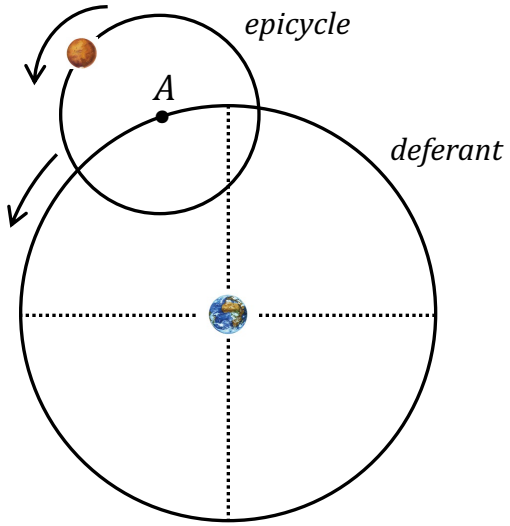
1. The Ptolemaic System

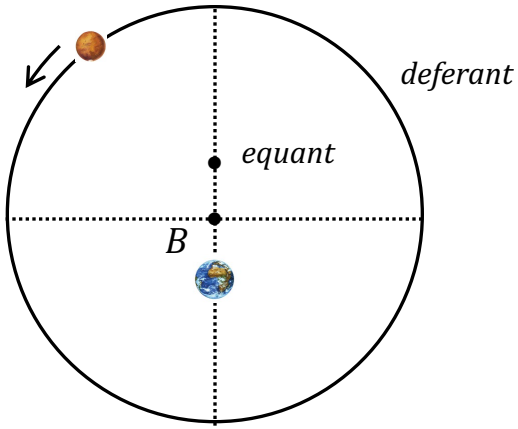
- *The Almagest* (127-141 A.D.). "The Great Compilation".
  - Account meant to save the phenomena (no explicit ontological claims).
  - <u>*Major constraint*</u>: Aristotelian assumption of perfect motion: uniform (constant speed) along circle.

Claudius Ptolemy
(~85-~165AD)



Two primary models



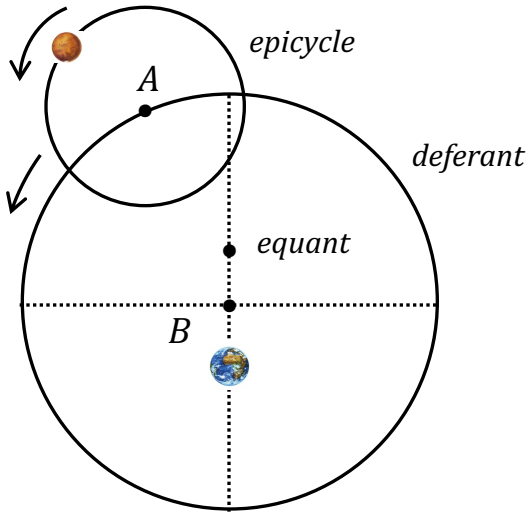


Epicyclic model

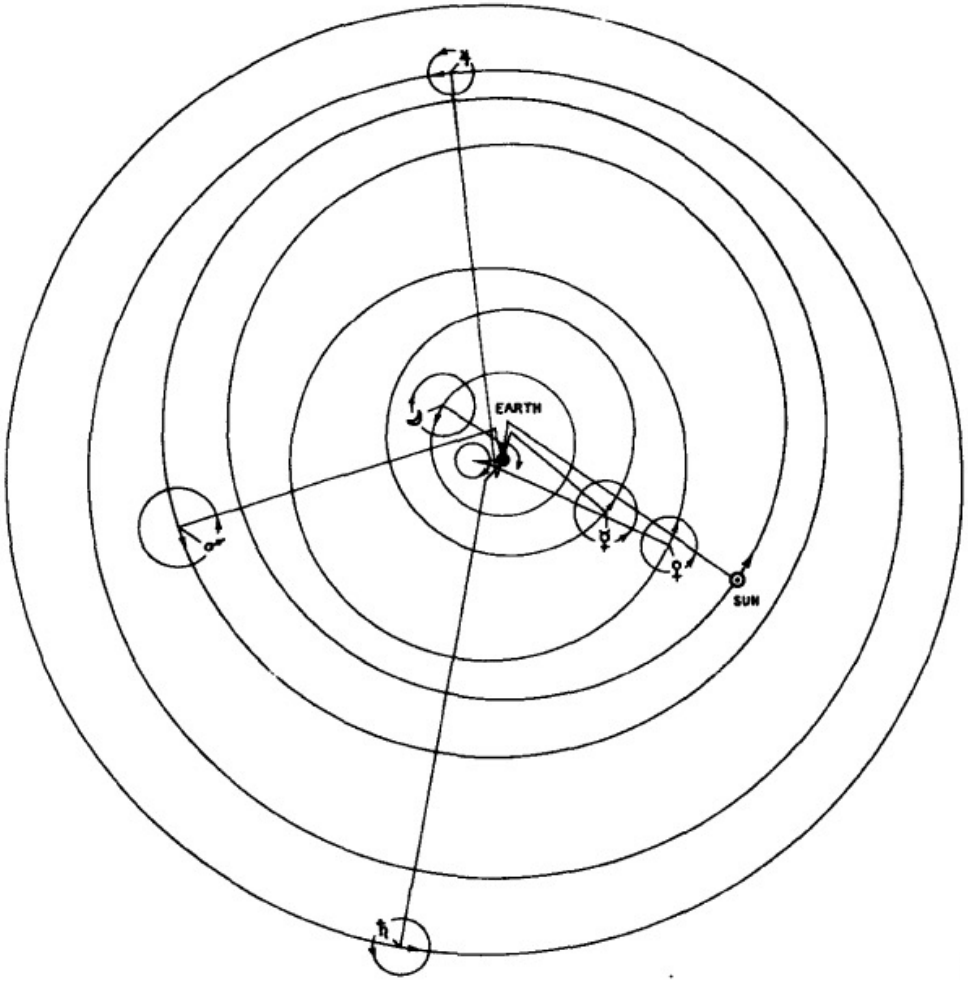
- Planet moves at constant speed with respect to *A* along *epicycle* centered at *A*.
- Center *A* of epicycle moves at constant speed with respect to Earth along *deferant* centered on Earth.
- *Explains observed retrograde motion.*

Equant model

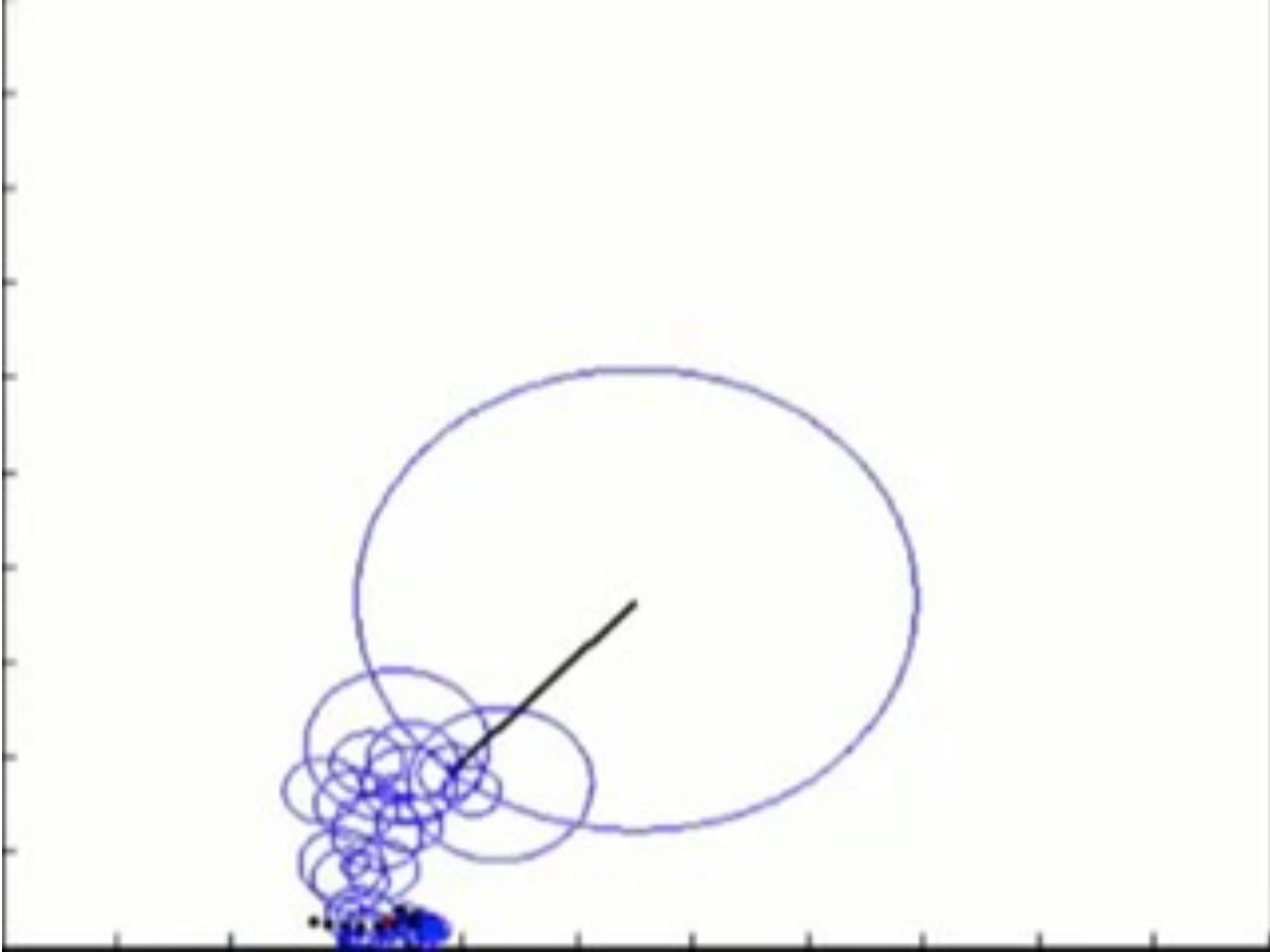
- Planet moves along deferant (centered at *B*) at constant speed with respect to *equant*.
- *Explains observed changes in speed with respect to Earth.*



Combined model

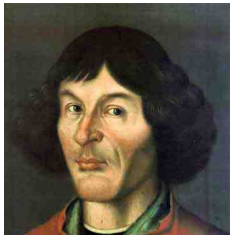


- Combinations of two models account for all observed planetary motions.
- Geostatic description of cosmos (stationary earth).
- Not quite geocentric!

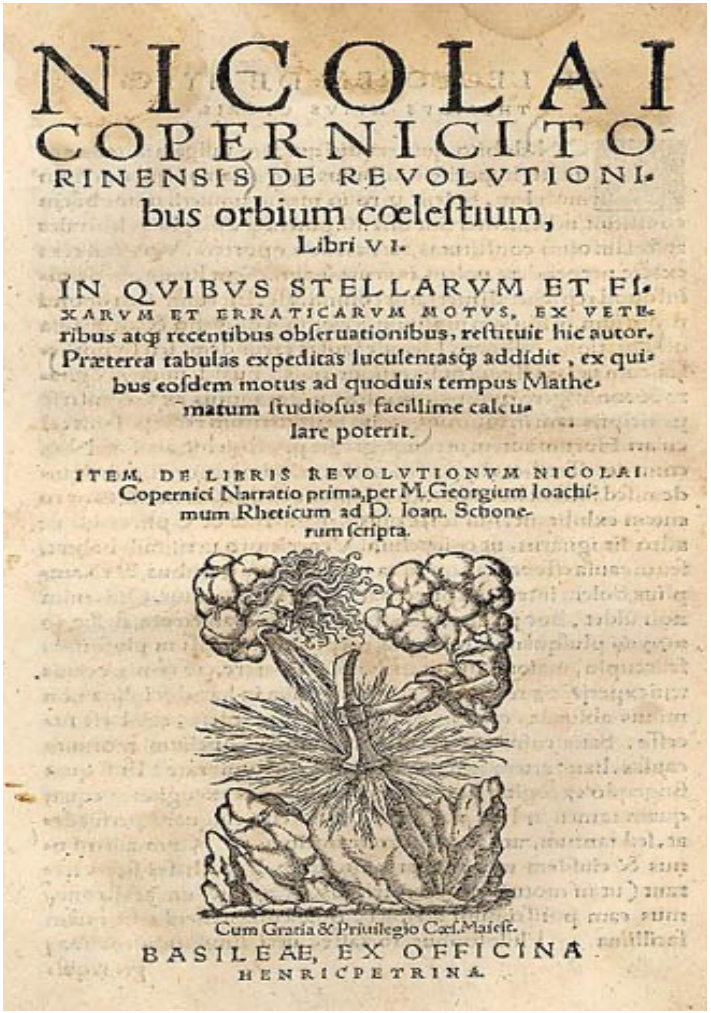


2. The Copernican System

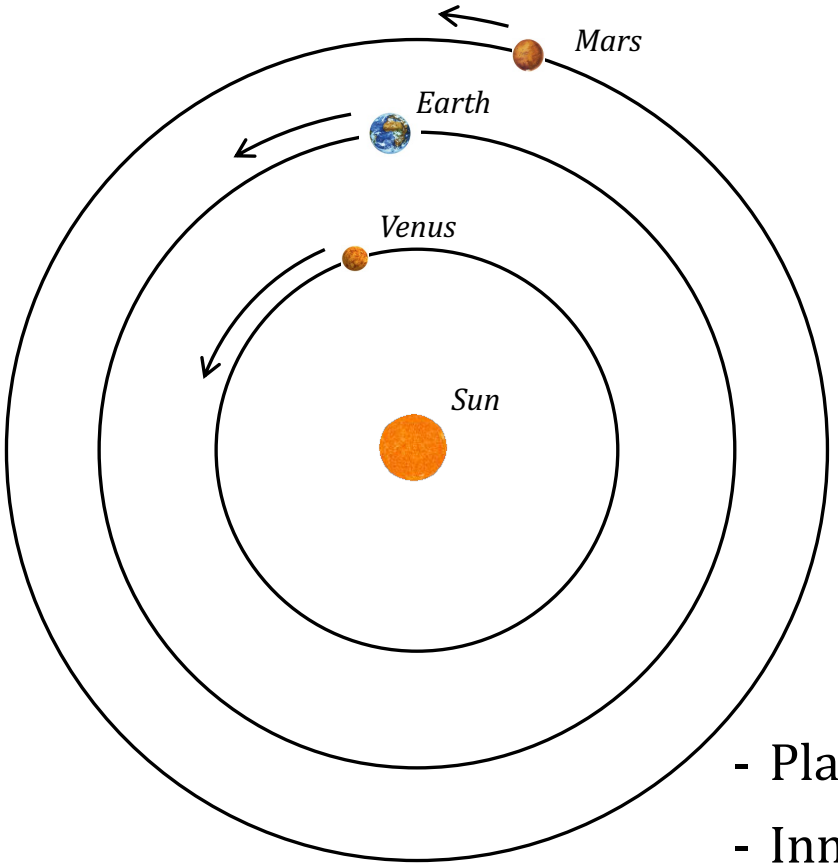
De revolutionibus orbium coelestium (1543)



Nicholas Copernicus (1473-1543)



Simplified model



- Planets move along *circles* at *constant speeds*.
- Inner planets move faster than outer planets.
- *Explains observed retrograde motion*.

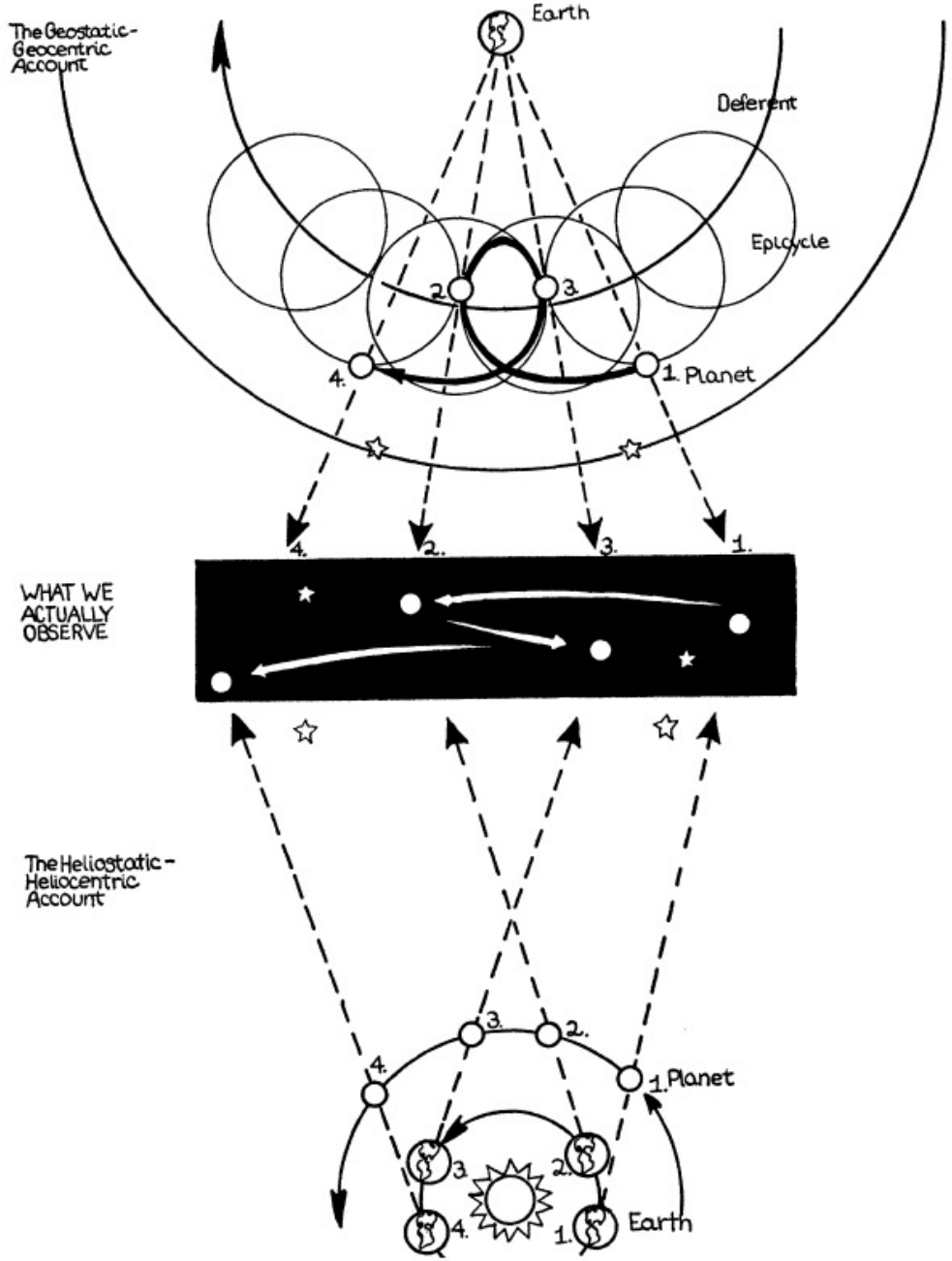


FIGURE 5. Retrogradations of the superior planets.

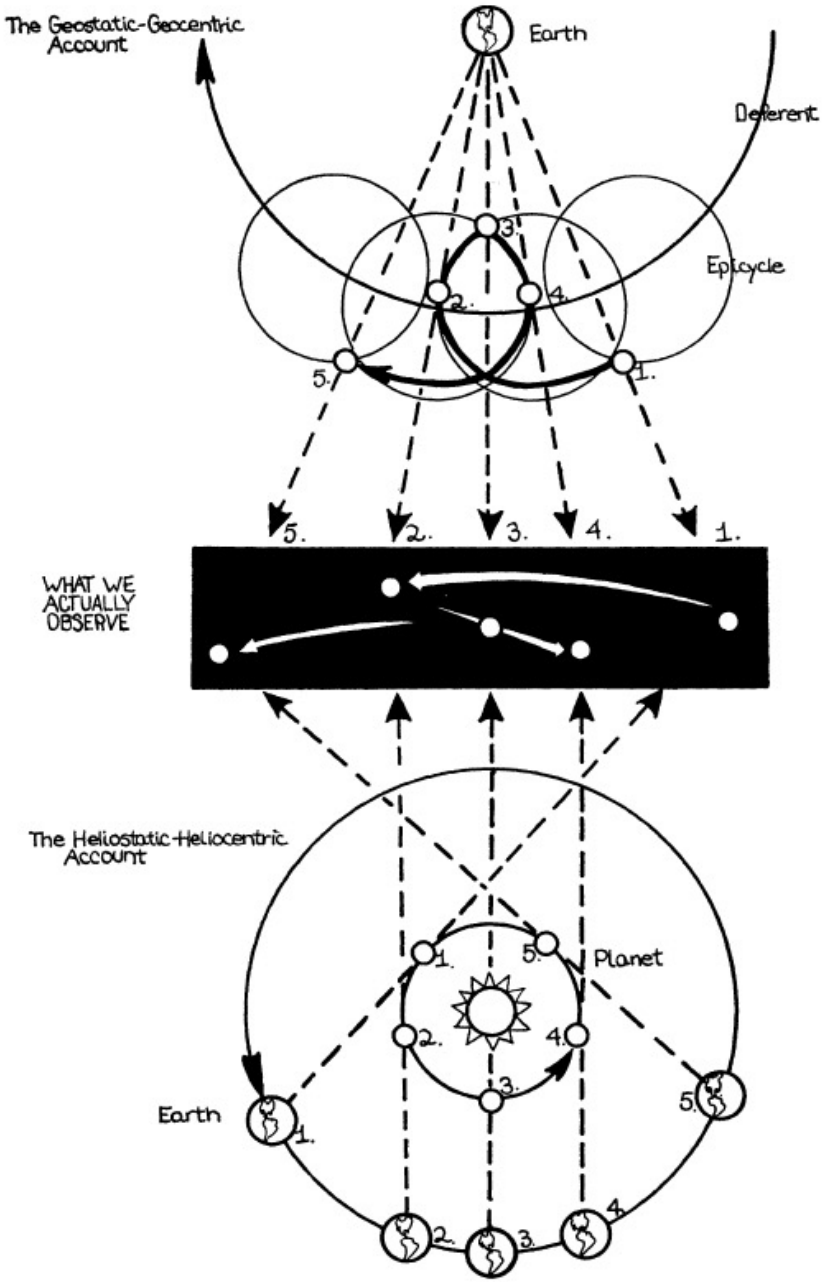
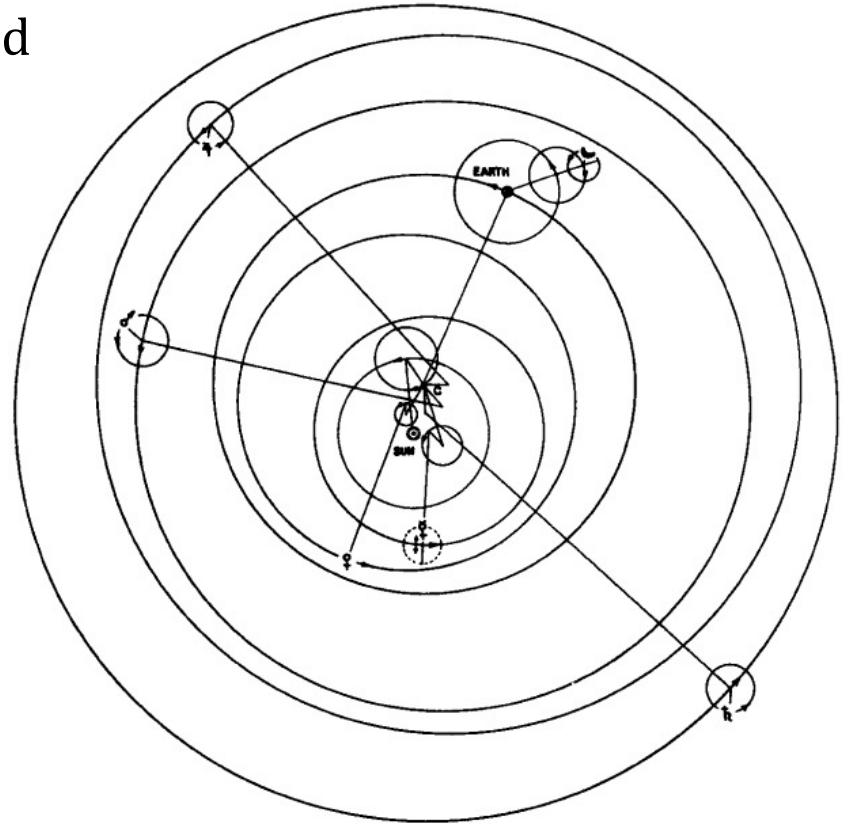


FIGURE 6. Retrogradations of the inferior planets.

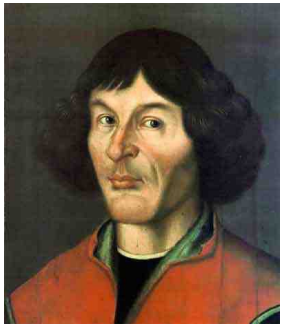
Figures from Hanson, N. R. (1964) "Contra-Equivalence: A Defense of the Originality of Copernicus", *ISIS 55*, pp. 308-325.

- *But*: To save all the phenomena, epicycles and equants are required.
- Heliostatic (stationary sun) description of cosmos.

Why heliostatic?



"In the middle of all sits Sun enthroned. In this most beautiful temple could we place this luminary in any better position from which he can illuminate the whole at once? He is rightly called the Lamp, the Mind, the Ruler of the Universe; Hermes Trismegistus names him the Visible God, Sophocles' Electra calls him the All-Seeing. So the Sun sits as upon a royal throne ruling his children the planets which circle around him."



3. Arguments In Favor of Copernicus

(1) Simple explanation of retrograde motion.

(2) Simple explanation of why Venus and Mercury are never seen at midnight.

- *In what sense are the Copernican explanations more simple?*
- *Why should simplicity be a criterion governing theory choice?*

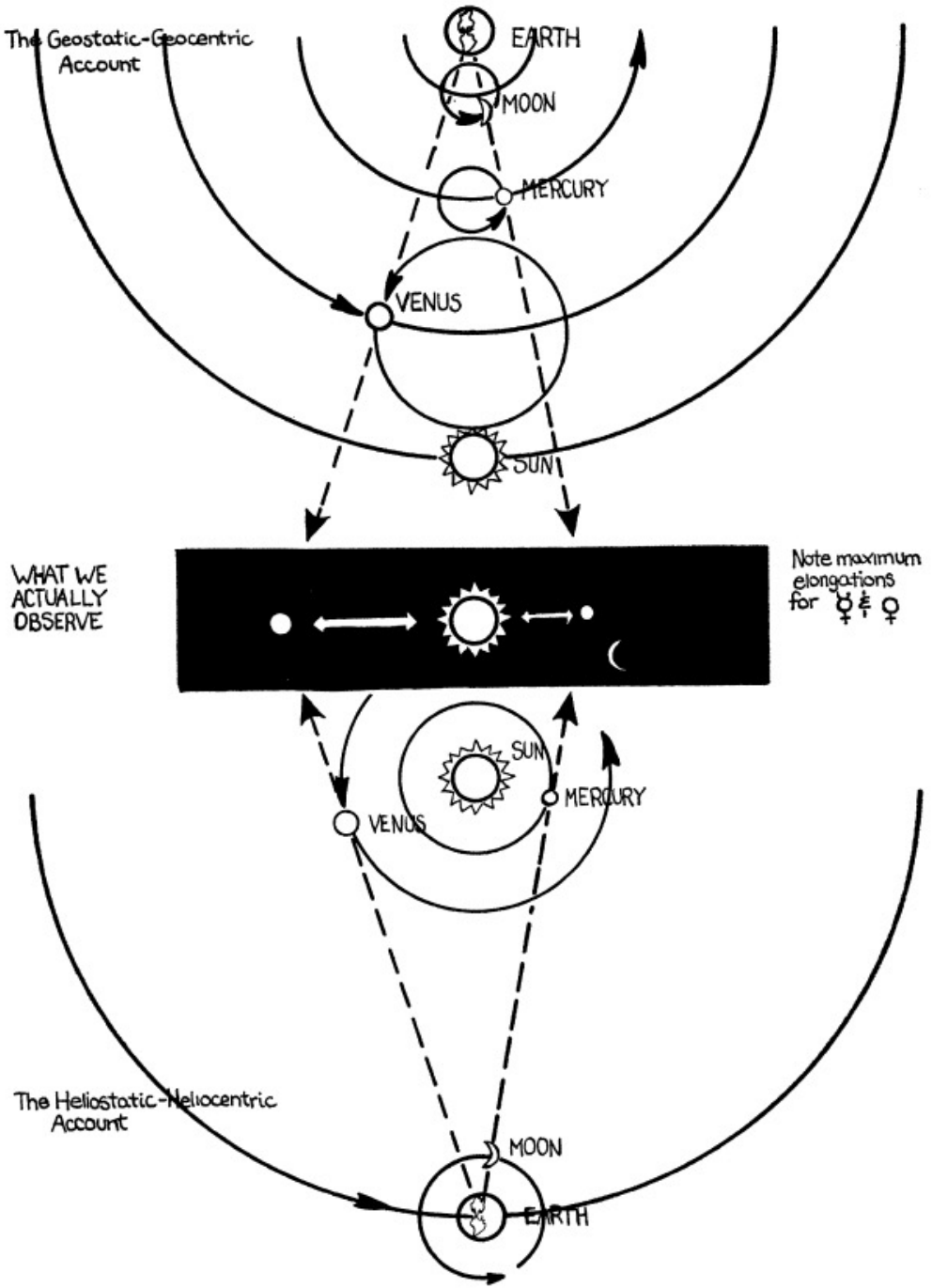
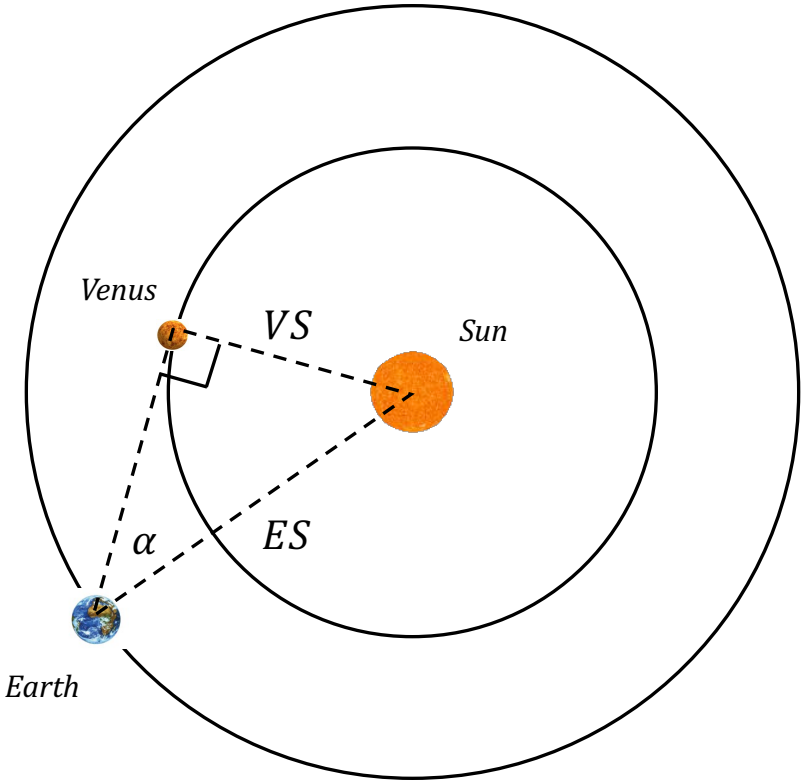


FIGURE 4. The sun-dependent motion of Mercury and Venus.

Figure from Hanson, N. R. (1964).

(3) Can calculate the distance between a planet and the sun, *relative* to the distance between the Earth and the sun.



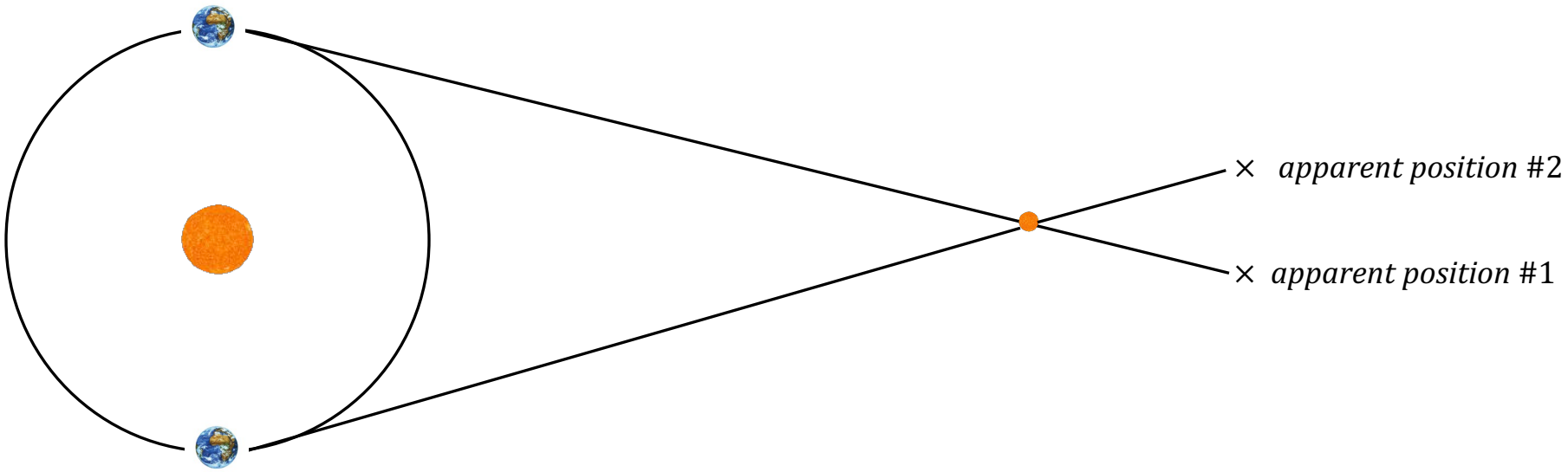
- $\alpha =$ angle of greatest separation of Venus from Sun (determined *via* observation).
- $VS = ES\sin\alpha$
- If β is the angle of greatest separation of Mars from Sun, then $MS = ES\sin\beta$.
- If we know ES, we can know the absolute distances VS, MS, *etc*, of the planets from the sun.

- <u>*But*</u>: Why should this be of interest?
  - *Cabalists can calculate the number of heavenly hosts:* 301,655,172.

4. Arguments Against Copernicus

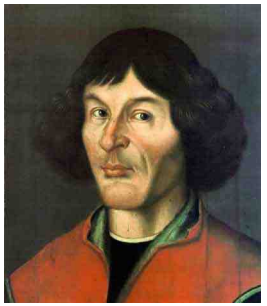
(1) No observed stellar parallax.

- *stellar parallax* = shift in apparent position of a star observed from Earth due to shift in the position of the Earth.



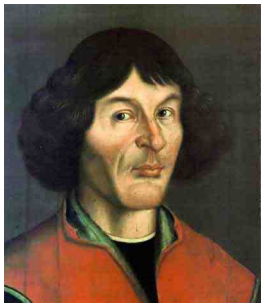
- No problem if Earth is not in motion.
- Alternatively:

"...so great is the Universe that though the distance of the Earth from the Sun is not insignificant compared with the size of any other planetary path... it is insignificant compared with the distance of the Sphere of Fixed Stars."



(2) "Terrestrial" argument:

- If the Earth is in motion, why do objects thrown upward return to the same spot? Why don't birds, clouds, *etc*., get left behind?



"Surely not only the Earth, with the water on it, moves thus, but also a quantity of air and all things so associated with the Earth."

- Air moves along with Earth.
- But why at same speed? (Anything less would be detectable.)

"..if they should say that the air is also carried around with the earth in the same direction and at the same speed, none the less the bodies contained in it would always seem to be outstripped by the movement of both. Or if they should be carried around as if one with the air, neither the one nor the other would appear as outstripping or being outstripped by the other. But these bodies would always remain in the same relative position... And yet we shall clearly see all such things taking place as if their slowness or swiftness did not follow at all from the earth's movement."

(3) "Cosmological" argument:

- According to Aristotle's theory of motion:
  - Natural motion of element earth is in a straight line toward the center (not in a circle about the center).
  - *And*: The Earth is made primarily of the element earth and thus *fundamentally different* from the planets.
  - *And*: Copernicus offers no alternative theory.

(4) Problem of the Moon:

- *Suppose*: The air is "glued" to the Earth and thus keeps up with it.
- *So*: All objects embedded in the atmosphere (birds, clouds, etc) keep up with the Earth.
- *But*: What about the moon: Why does it keep up with the Earth?