# How Galileo finished the Copernican revolution

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What follows draws heavily from

- Thomas S Kuhn, The Copernican Revolution, Harvard University Press (1957)
- Arthur Koestler, The Sleepwalkers, Penguin (1964)

There are more recent sources, but I want to emphasise the link with Kuhn in the second talk of this pair.

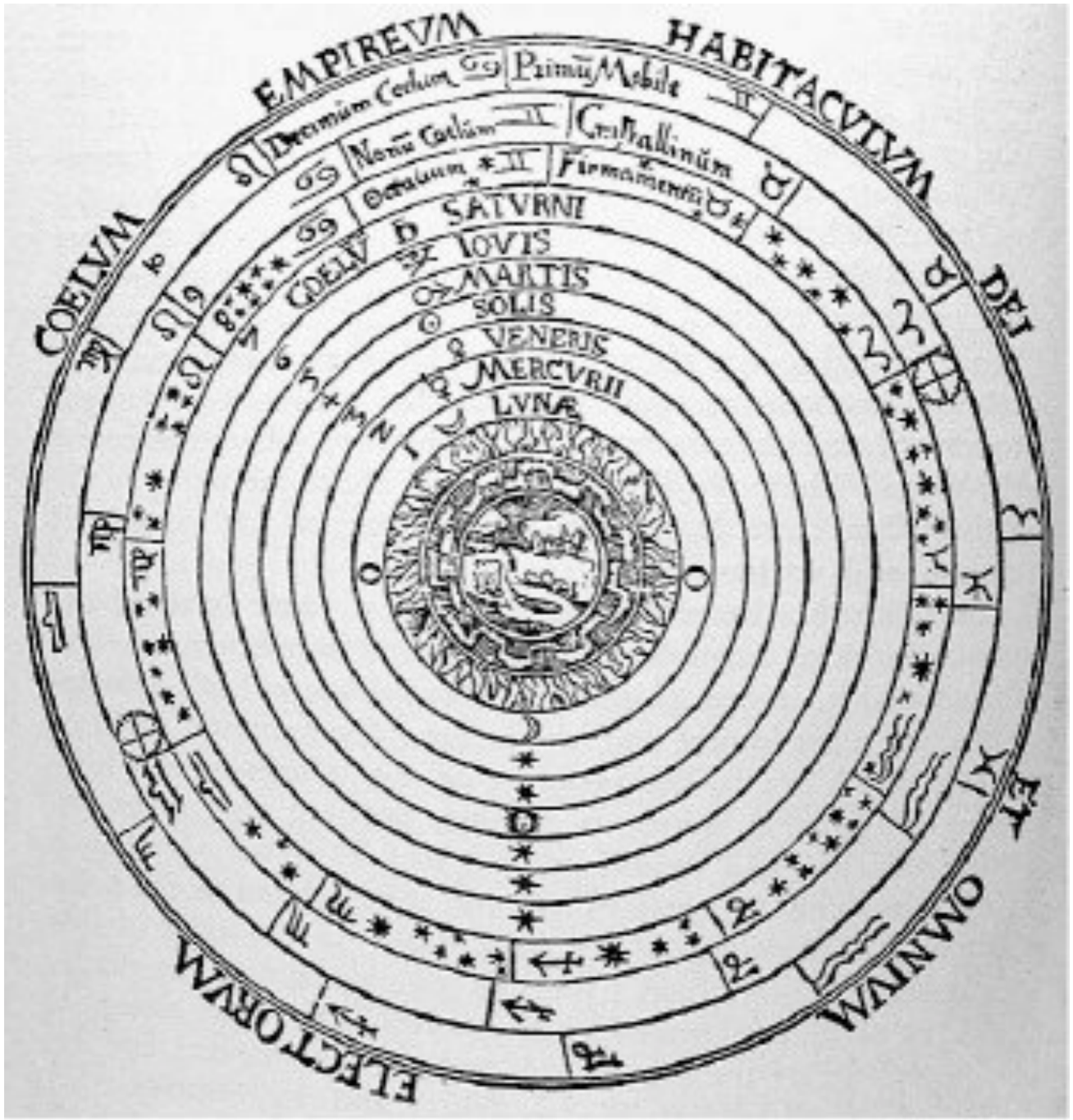
# The Aristotelian and Ptolemaic world view

# pre-ptolemaic cosmologies

- There were multiple pre-Hellenic cosmologies
  - Leucippus and Democritus had centreless universes
  - Pythagoras and Aristarchus had heliocentric ones

Motivated principally for aesthetic and philosophical reasons

# ptolemy's 'two-sphere' universe

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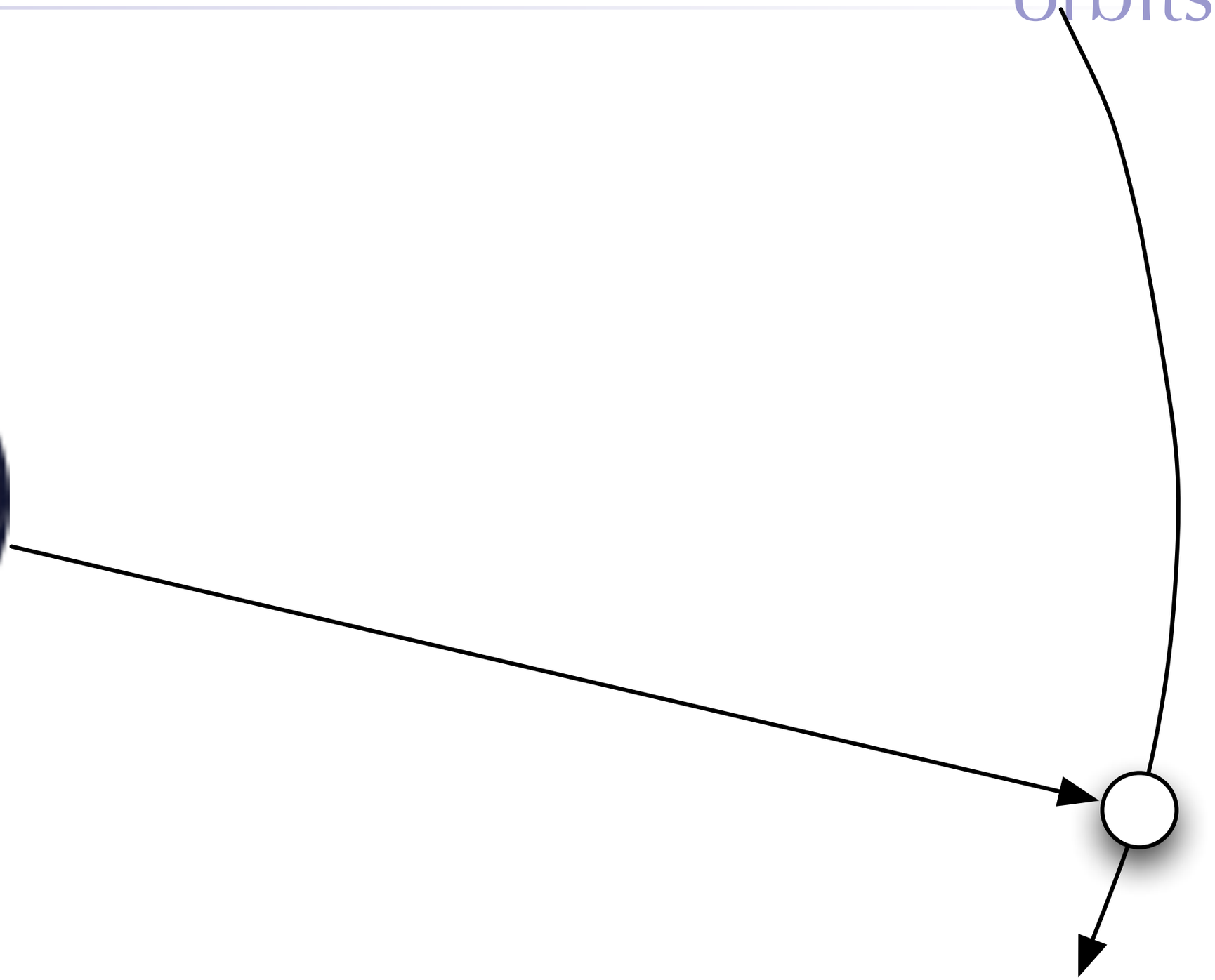
# the history of the model

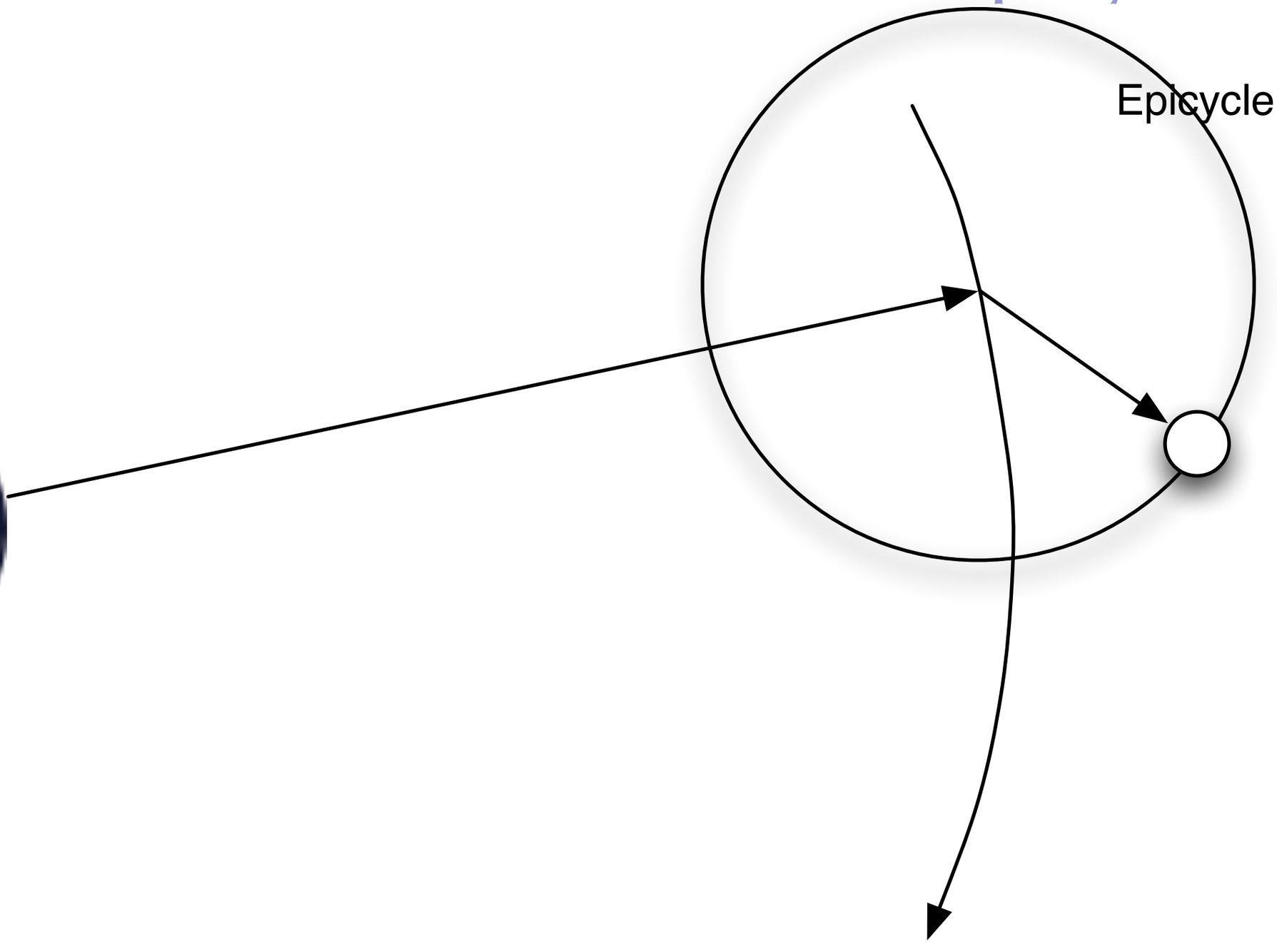
- This isn't Ptolemy's model
- It was associated with Anaximander (6th BCE)
- Elaborated by Apollonius and Aristotle (4th & 3rd BCE)
- 'Finalised' by Ptolemy (90–160CE)

# why was this a good model?

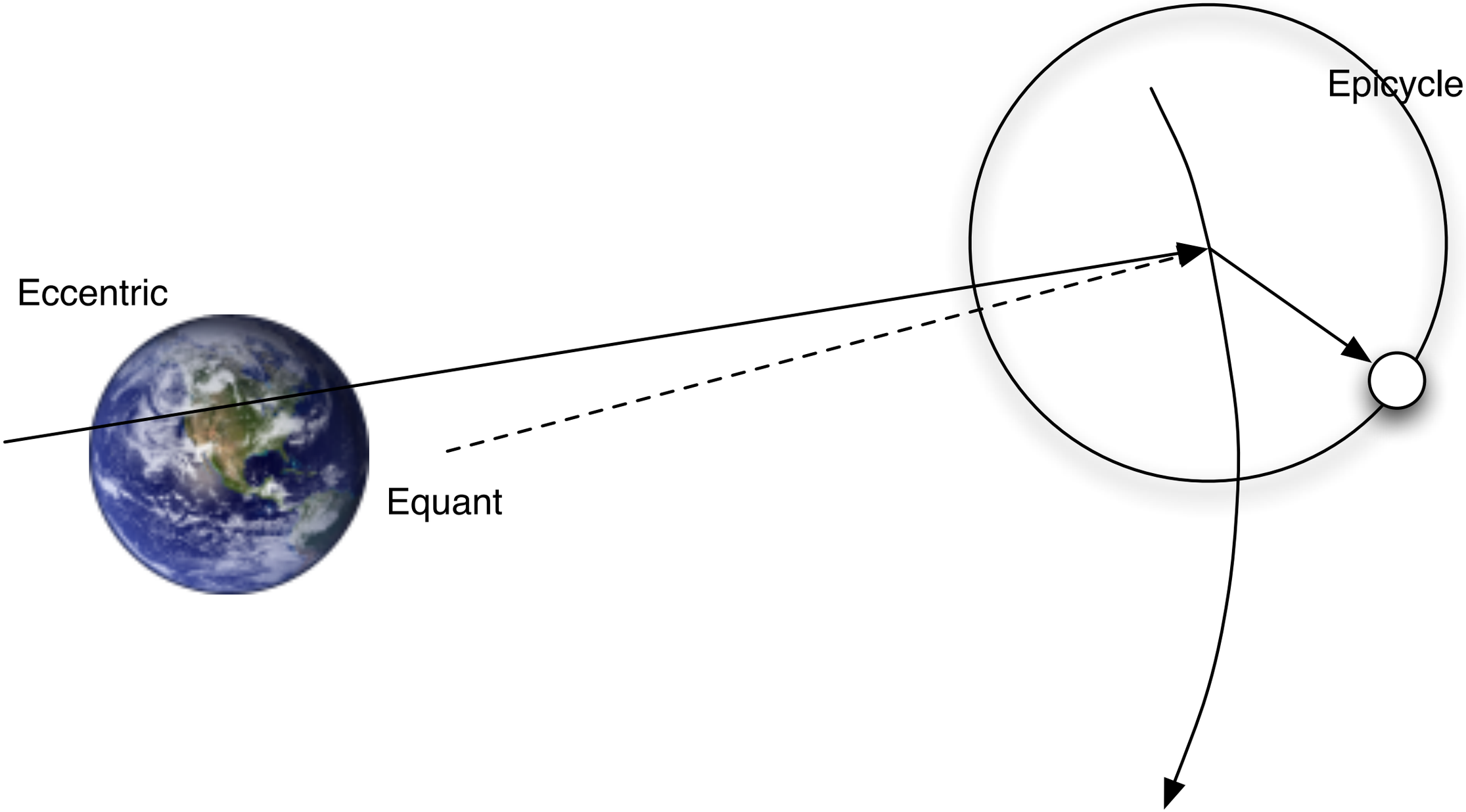
- It provides explanations rather than just stories
- It has great conceptual economy
- It's quantitative and predictive



# epicycles



# eccentrics and equants



# ptolemy's universe as science

- Ptolemy turned astronomy into a highly technical precise science, with predictive power
- Fundamental theories: space tells matter how to move; natural motions
- Can predict eclipses, positions and retrograde motion
- For a thousand years, astronomy becomes parameter fitting
- ...and it's still in use today

# the mediaeval astronomical tradition

# mediaeval astronomy

- The European intellectual tradition declined, and the Islamic one grew, in the 7th century
- 10th to 13th centuries: universities emerged in Europe, and learned Islamic astronomy
- For the Islamic and European scholars, this was ‘ancient wisdom’, recovered bit by bit
- 14th century: Buridan and Oresme’s close readings of Aristotle
- By the 15th century: a very sophisticated intellectual tradition

# Copernicus, Brahe and Kepler

Copernicus's main motivation was to get rid of equants!

# copernican astronomy

- Copernicus wasn't a crank, but was widely respected
- He had a neoplatonic bias which led him to focus on the ugliness
- It's a technical development
- ...but still uses circles, epicycles and eccentrics
- ...and isn't much more accurate
- 'A second Ptolemy'

# copernican corroboration

- *De Revolutionibus* (1543)
- Book 1 is a popularisation, and unconvincing, but in print, rather than manuscript
- Retrogression is natural, but otherwise little support
- Erasmus Reinhold's *Prutenic Tables* (1551)

- The Tychonic model is geometrically identical to Copernicus's, but he insisted it wasn't a fudge
- Brahe was an observer, who produces lots and lots of *good* data, accurate to 4′ of arc

# kepler

- Strongly neoplatonist/mystical, and very interested in astrology
- Inherited Tycho's data, and tried very hard to fit it, getting errors no bigger than 8′ of arc
- Published *On the Motion of Mars* in 1609
- Three laws of planetary motion
- *Rudolphine Tables* in 1627

- Arguing for Copernicus: *Dialogue Concerning the Two Chief World Systems* is effective, but strongly rhetorical
- Introduces *Galilean Relativity*: we only perceive relative motion; only relative motion matters
- Principle of circular inertia

# galileo and the telescope

- The first qualitatively new data since antiquity
- *The Starry Messenger* rushed into print in March 1610
- Observes phases of Venus, and changes in size of Mars and Venus (well known problems)

# galileo and physics

- He produces terrestrial arguments for cosmological problems
- Galileo's mechanics doesn't have a huge impact in detail, only relativity
- But he arguably paves the way for Newton
- Early modern science examines the cracks opened by mediaeval scholasticism, and paves the way for Newton

# legacy

- Mid-17th century: it's hard to find a non-copernican professional astronomer
- End-17th century: ...it's impossible
- Mid-18th century: lectures on Tycho and Ptolemy are dropped from the curriculum
- Books on copernicanism are removed from the Index in 1822

# links

http://www.astro.gla.ac.uk/users/norman/lectures/galileo/