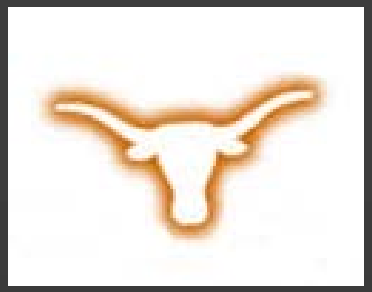
Astronomy 350L

(Spring 2005)



The History and Philosophy of Astronomy

(Lecture 5: Middle Ages II)

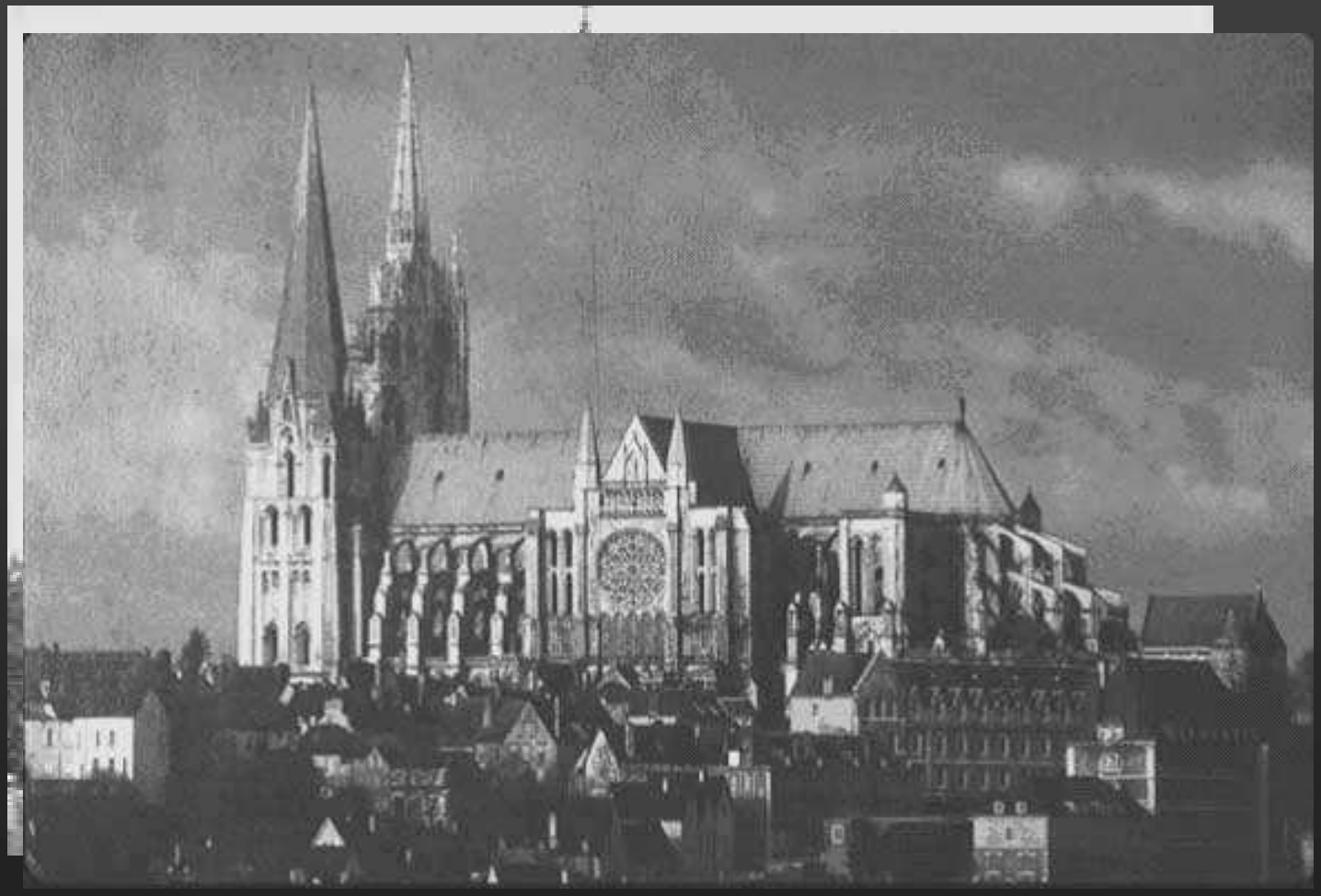
Instructor: Volker Bromm
TA: Amanda Bauer

The University of Texas at Austin

Medieval Astronomy and Cosmology

- Middle Ages I (Jan. 27)
  - Decline of Western (Mediteranean) Civilization
    - Early Middle Ages (“Dark Ages”): 500 – 1000 AD
  - Ascendancy of Islamic Astronomy (800 – 1400 AD)
    - Preservation and transformation of ancient knowledge
- Middle Ages II (Feb. 1)
  - Recovery of European Civilization
    - High and Late Middle Ages (c. 1000 – 1450 AD)
  - Setting the Stage for the Copernican Revolution
    - Recasting of the Ancient Tradition

Europe Recovers: Later Middle Ages (c. 1000 – 1450)



- Romanesque: e.g., Dome in Speyer (1030-1061)
- Gothic: e.g., Chartres cathedral (1145-1220)

Europe Recovers: Later Middle Ages (c. 1000 – 1450)

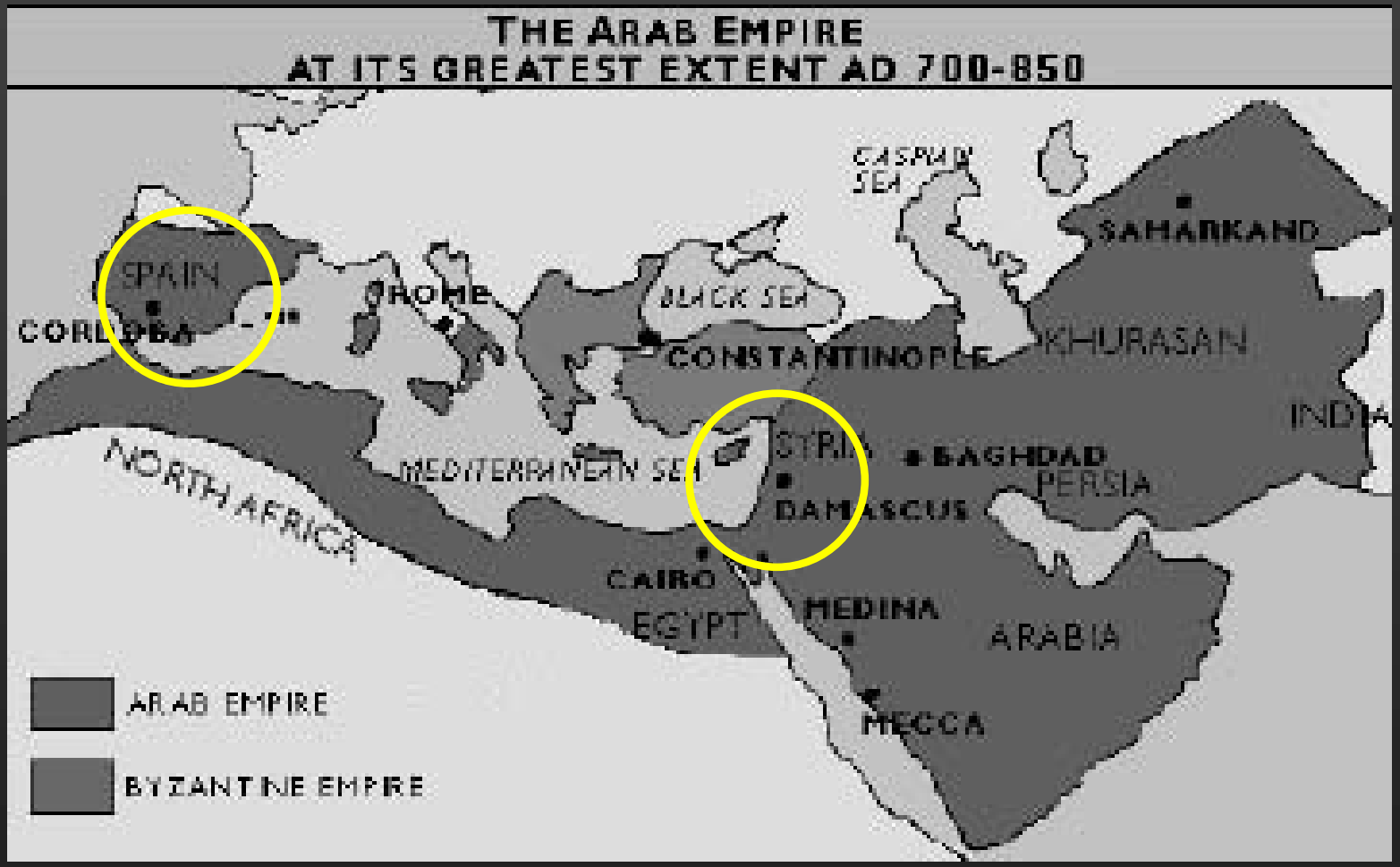
- Art in the Age of Chivalry

Europe Recovers: New Spirit of Exploration

Marco Polo
(1254-1324)

Journey to China: 1271-95

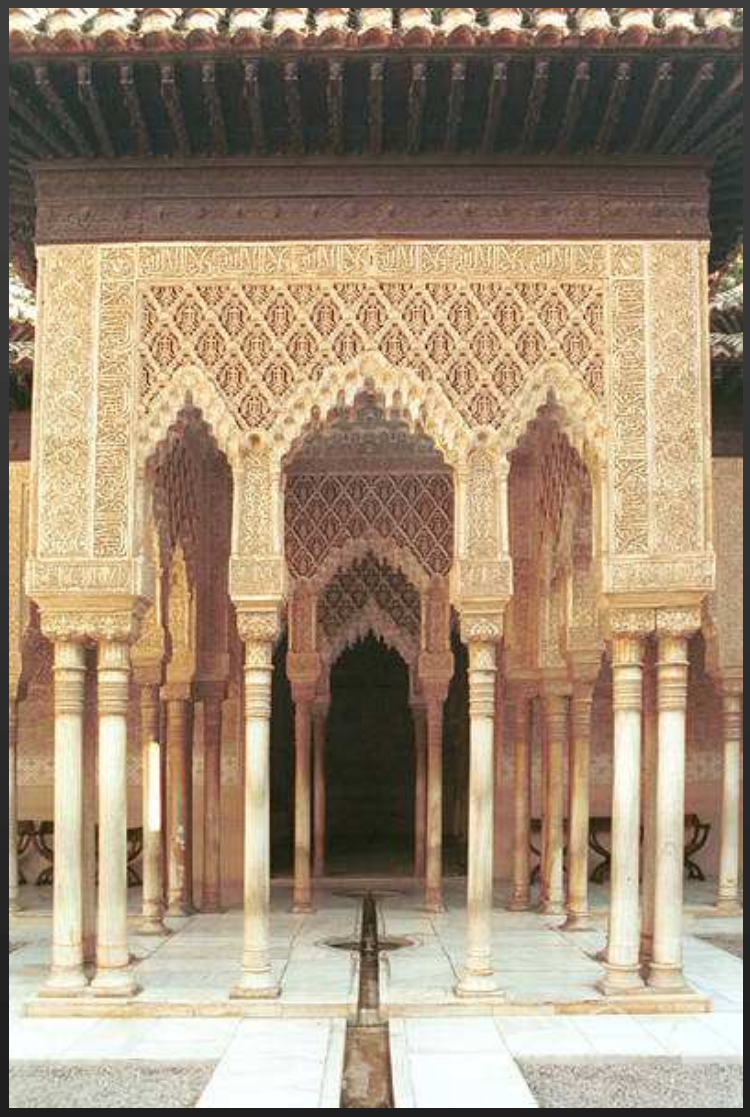
Rediscovery of Ancient Knowledge: Arabic Transmission



- multiple sources: e.g., Spain, Crusades

Rediscovery of Ancient Knowledge:

- via Moorish Spain



Alhambra, Granada

- Translations:
  Arabic → Latin
- Later: directly
  Greek → Latin
- Transfer of know-how:
  - computation
  - astrolabes

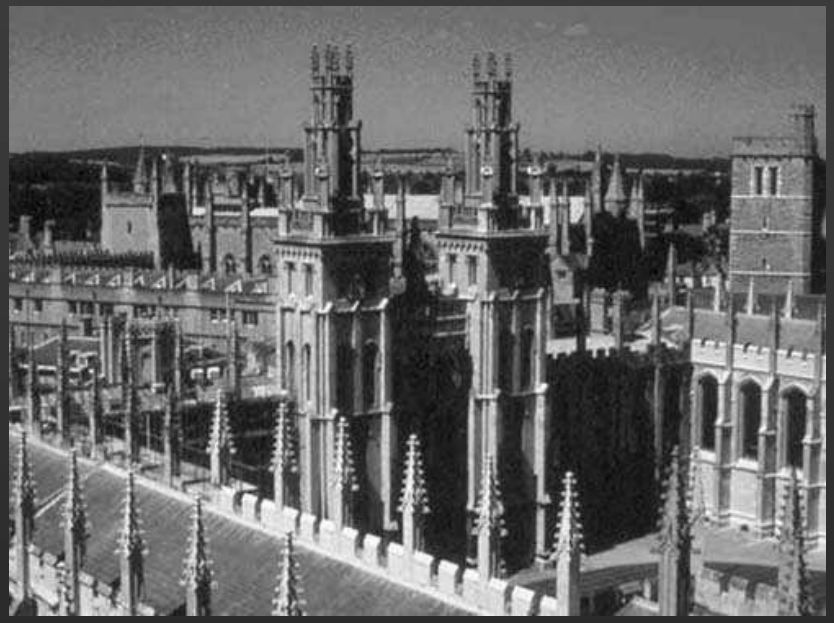
Rediscovery of Ancient Knowledge:

- via Crusades

Siege of Antioch, 1098 AD

- Europe becomes aware of high level of Islamic civilization

Rediscovery of Ancient Knowledge:
Emergence of the University



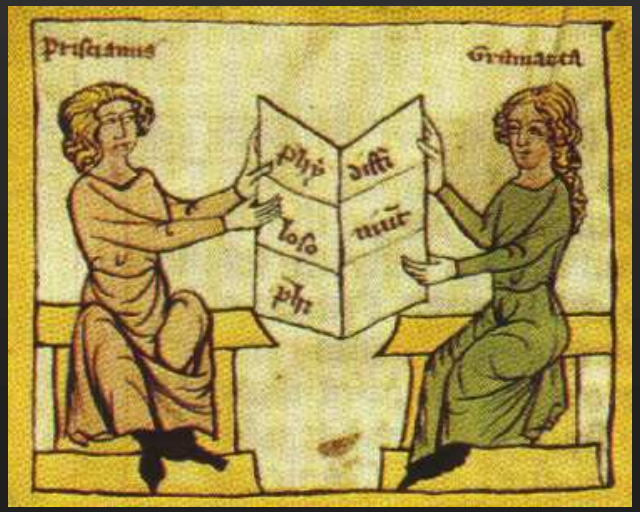
Oxford University

- Universities: A European Invention (12th and 13th cent.)
- Objective: Understand ancient, rediscovered texts!

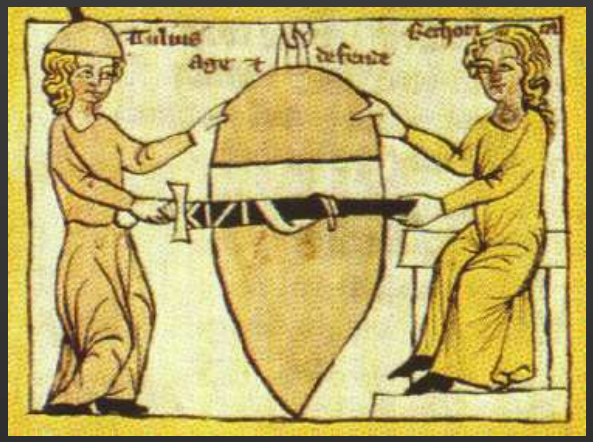
Structure of Medieval University

Seven liberal Arts (Septes Artes Liberales): Trivium

Logic (Dialectic)



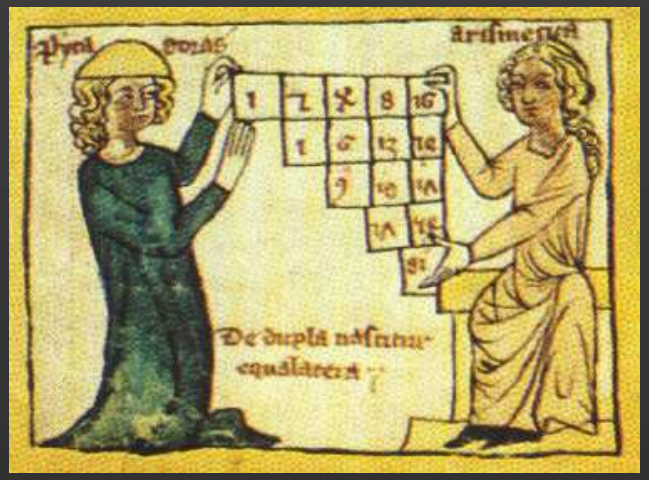
Grammar



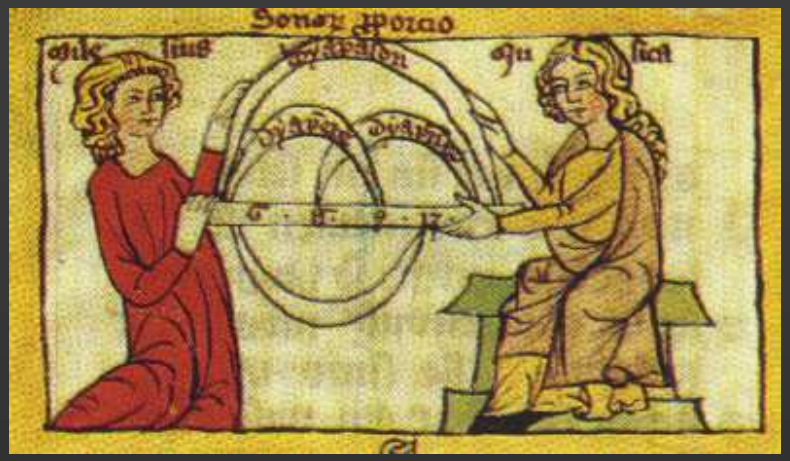
Rhetoric

Structure of Medieval University

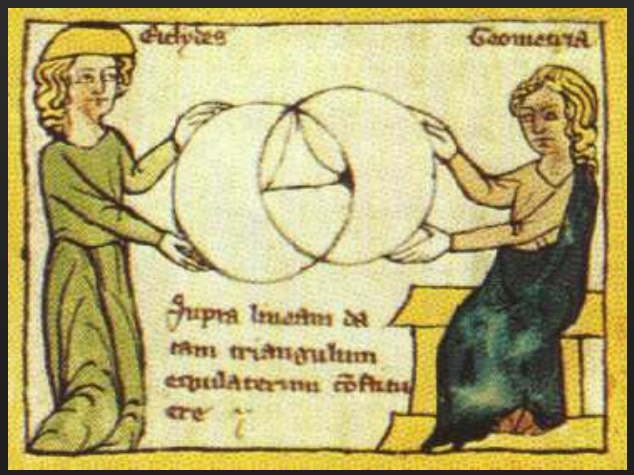
Seven liberal Arts (Septes Artes Liberales): Quadrivium



arithmetic



music



geometry

astronomy

Scholasticism: inconsistencies in ancient astronomy

- Aristotle and Ptolemy:
  - 500 years apart in real time
  - scholastics rediscover it at same instant
  → Fiction of unified body of “ancient wisdom”

- But: two systems are inconsistent!
  - Aristotelian concentric spheres vs Ptolemy’s deferent/epicycle system
  - Aristotle wants to explain ***real mechanism*** behind planetary motion (“physics’)
  - Ptolemy (“mathematical astronomy”) wants to predict motions, but does not claim that planets ***really*** move according to his constructions!

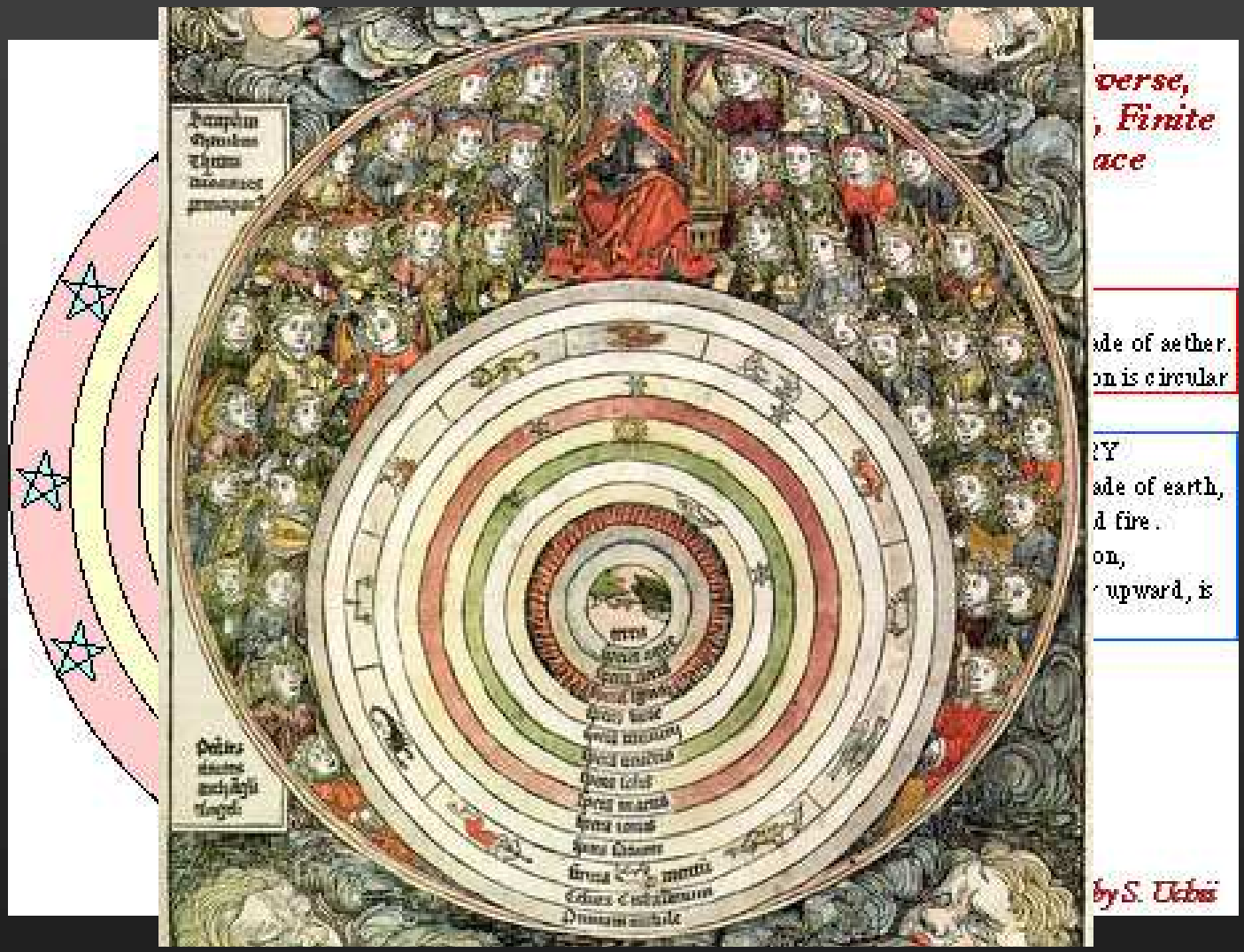
Adopting Ptolemy's Almagest: Sacrobosco

- John of Holywood (d. 1256)
  Sacrobosco
- taught in Paris
- wrote *De Sphaera (Sphere)*
- standard textbook for 400 yrs
- simplified version of Almagest

The Christian Universe: Thomas Aquinas

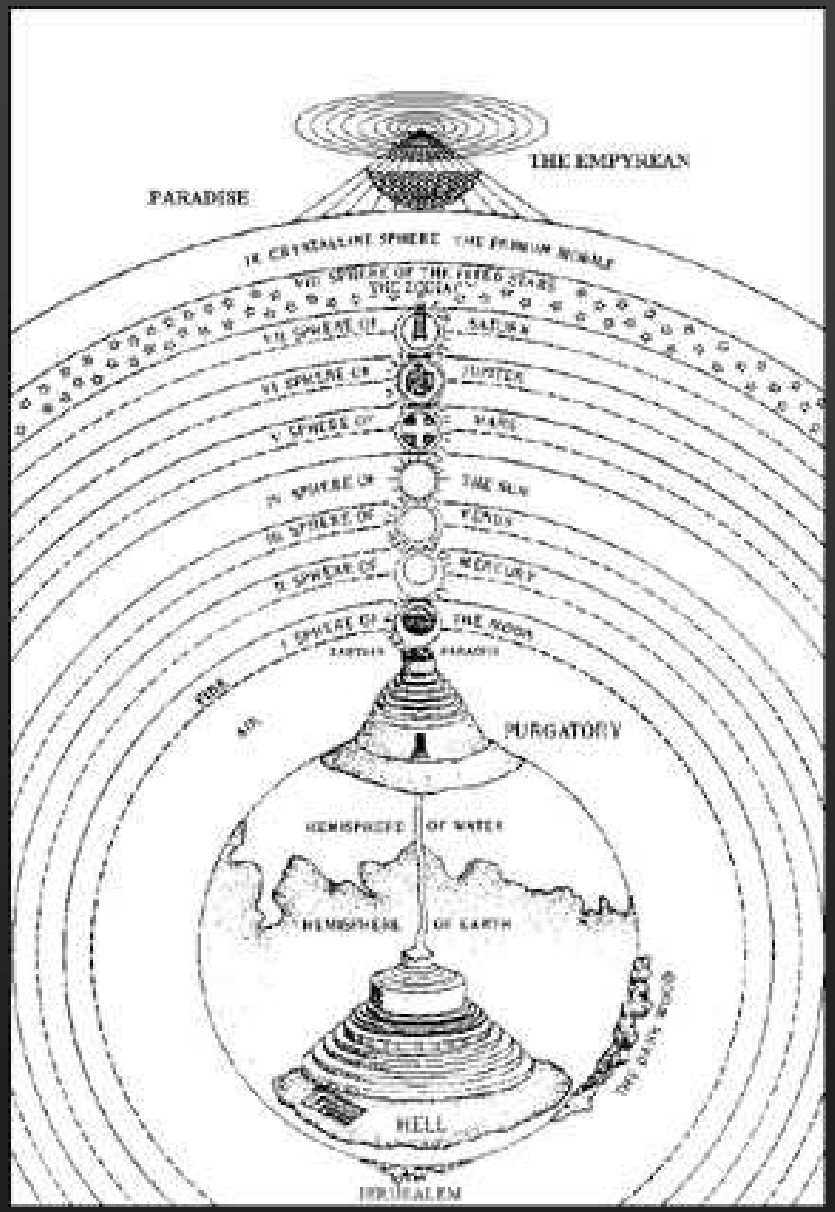
- St. Thomas (1225-74)
- Dominican monk
- Reconciled Aristotle with Christian Theology
- *Summa Theologiae*

The Christian Universe: Thomas Aquinas



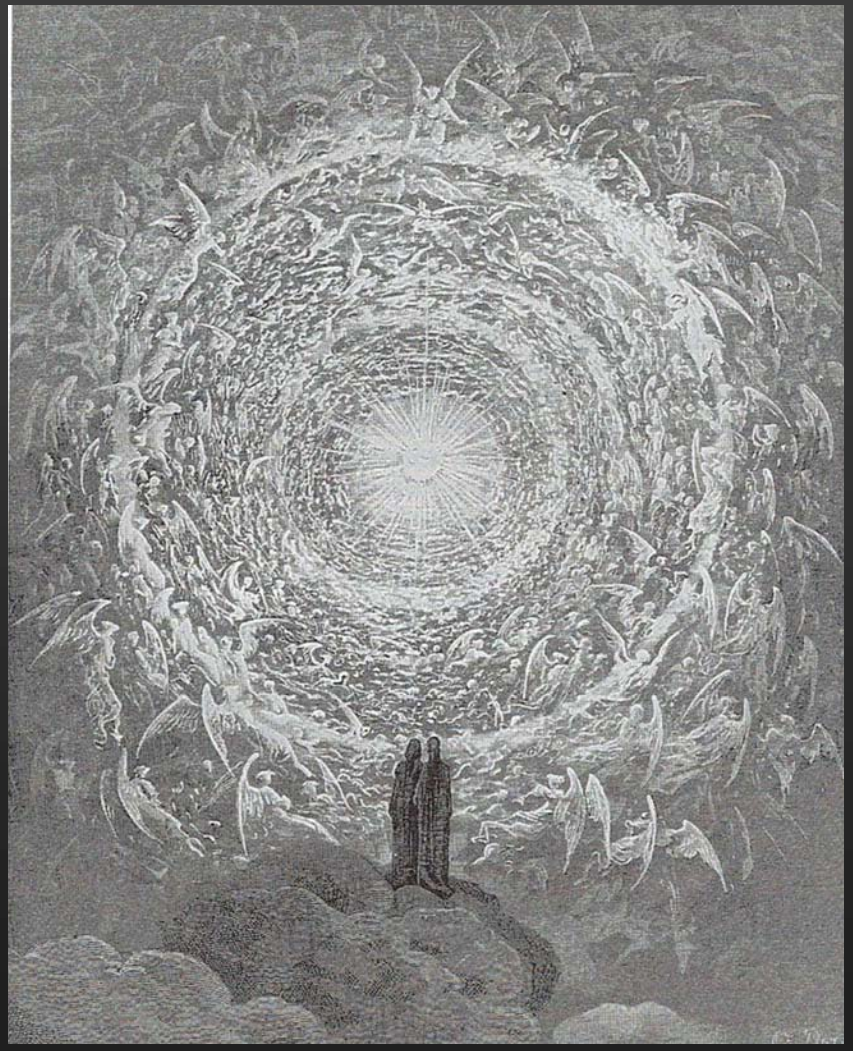
Aristotelian cosmology Christian cosmology

The Christian Universe: Dante's *Divine Comedy*



- Astronomy = Theology
- Central Earth becomes essential ingredient of Christian Theology

The Empyrean: Dante and Beatrice behold Paradise



Scholastic Critique of Aristotle:

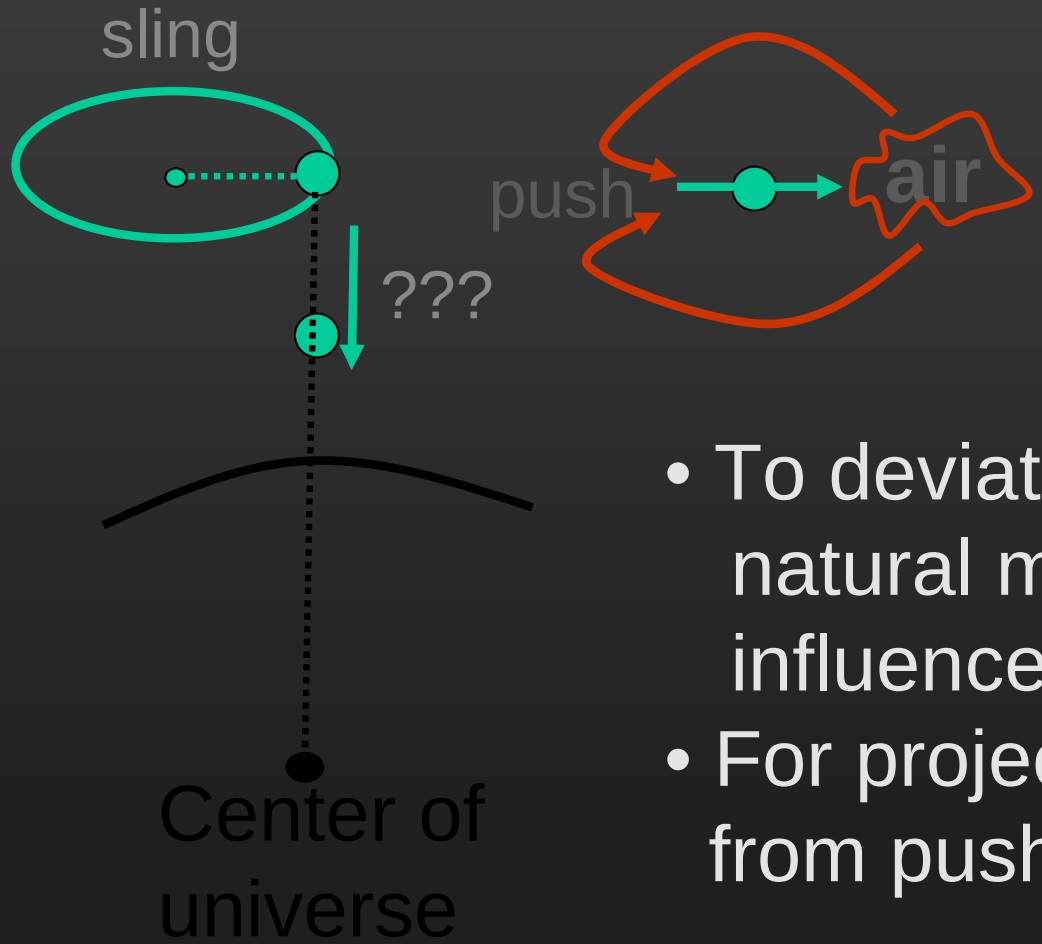
Motion of Projectile (Impetus Theory)

Buridan's Ass

- Jean Buridan (14th cent.)
- taught in Paris
- member of Nominalists
- Buridan's ass:
  The Tyranny of Choice

Projectile Motion: Aristotle's Theory

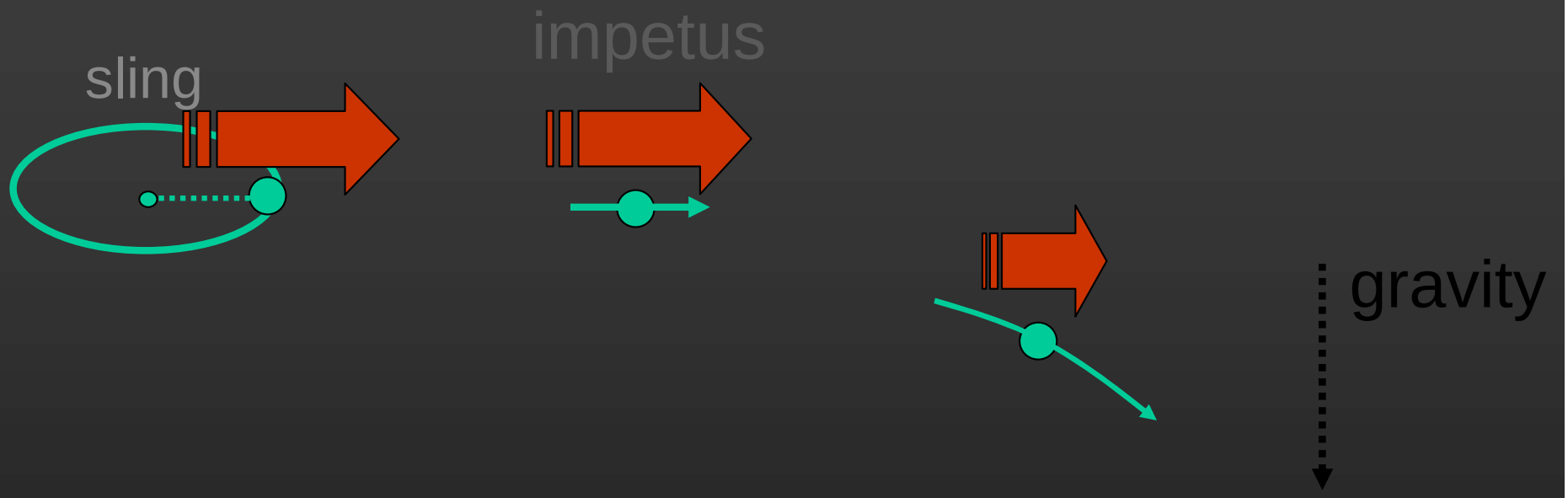
- Basic principle: heavy bodies (elements earth or water) are at rest or move straight to center of Earth (= center of universe)



- To deviate from Aristotelian natural motion: need external influence!
- For projectile: influence comes from pushed-aside air bubble!

Projectile Motion: Buridan's Theory

- Basic principle: heavy bodies are at rest or continue to move according to *impetus* initially imparted to them



- impetus = (modern) momentum (Galileo, Newton)

(mass x speed)

- crucial step in allowing Earth to move!

Scholastic Critique of Aristotle:

Demonstrating Possibility of Earth's Motion

Nicole Oresme

- Nicole Oresme (14th cent.)
- taught in Paris
- pupil of Buridan
- demonstrates logical possibility of Earth's motion

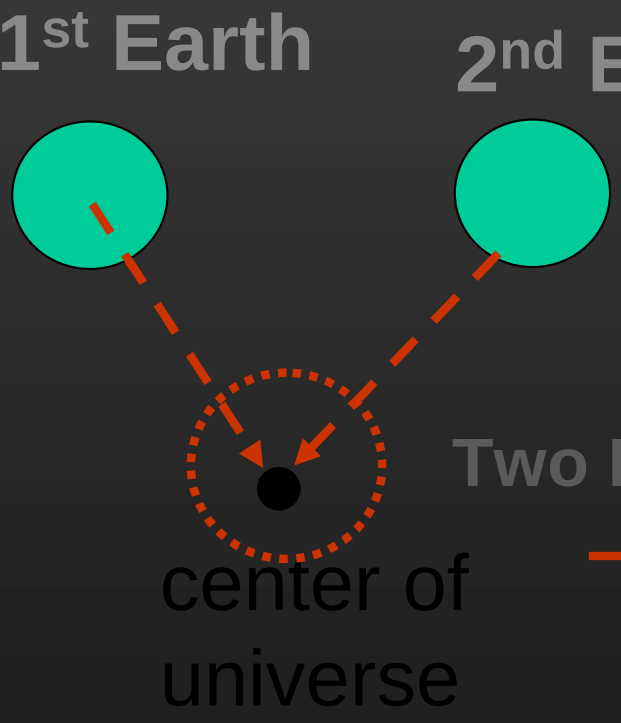
Motion of Earth is possible: Nicole Oresme

- Idea 1: Earth could move in circles around center of universe!

→ then Earth would be a planet, one among many!

Q: What would happen?

Aristotle:



Two Earth's would collide:

→ **Earth is unique!**

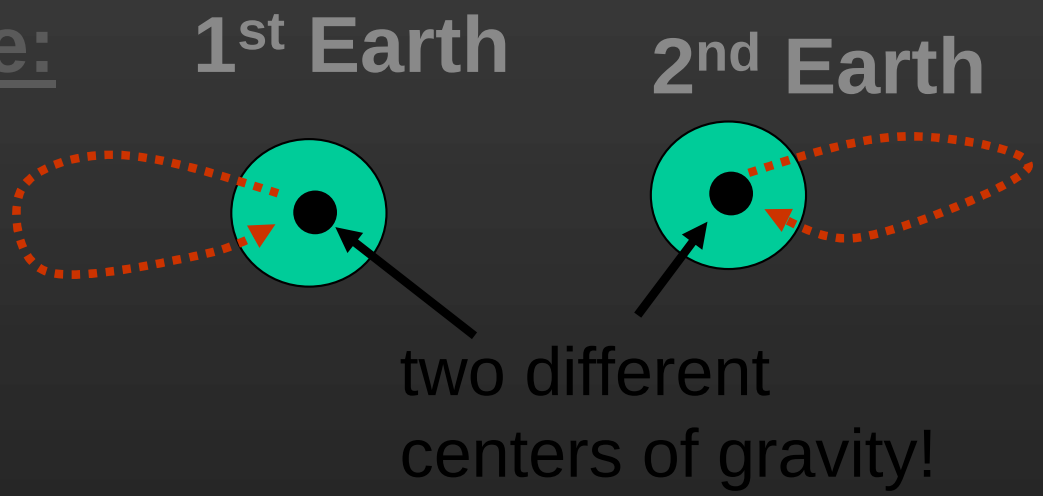
Motion of Earth is possible: Nicole Oresme

- Idea 1: Earth could move in circles around center of universe!

→ then Earth would be a planet, one among many!

Q: What would happen?

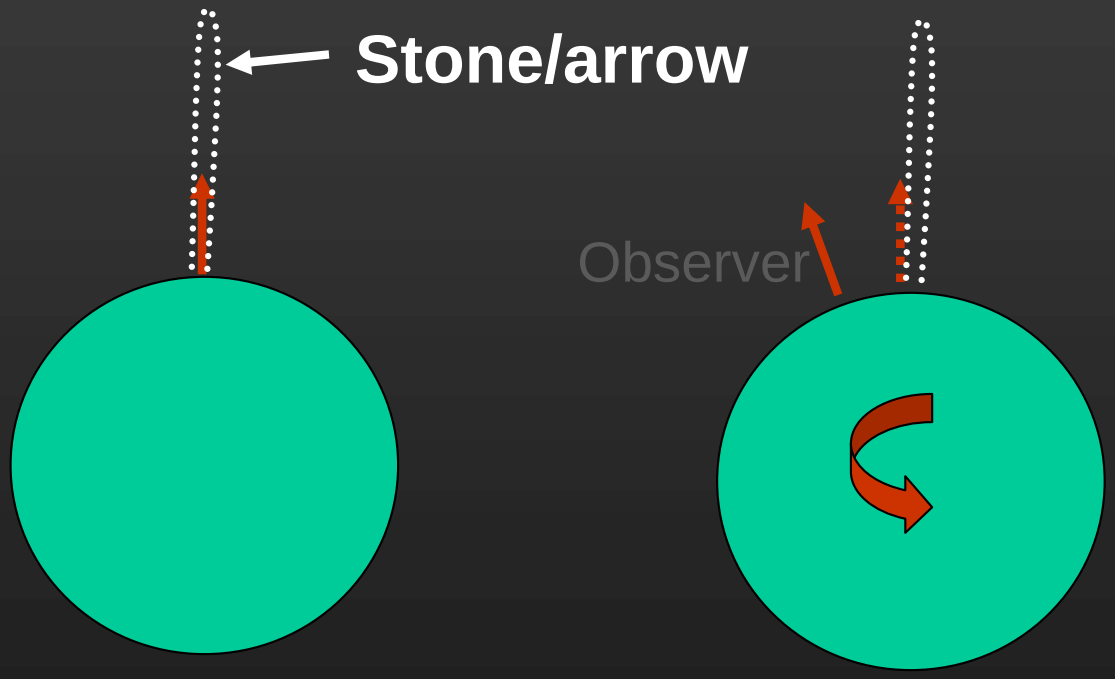
Oresme:



Each heavy body (e.g., planet) has its own center of attraction: → Earth *could* be a planet!

Aristotelian Argument against Earth's Rotation:

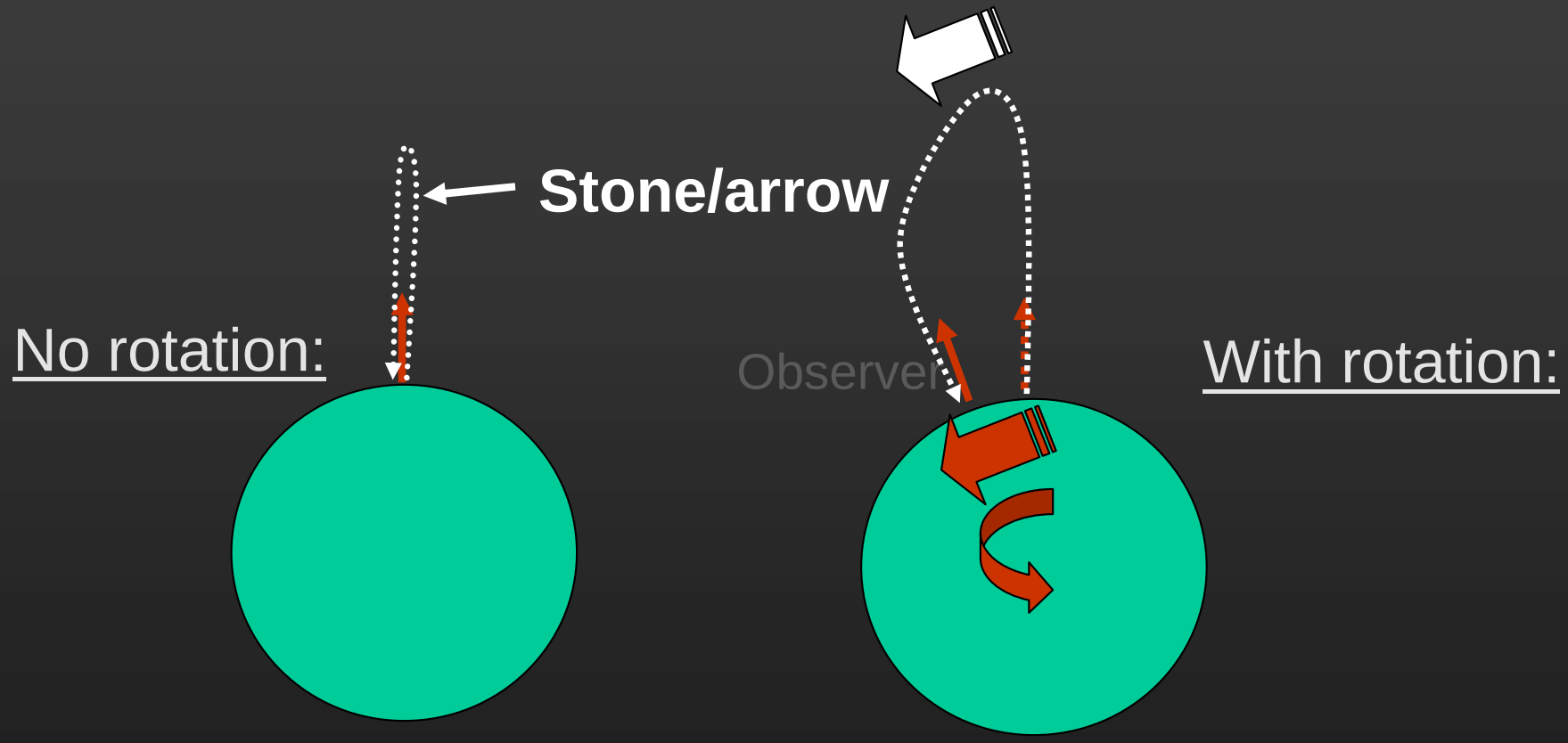
- **Basic principle:** heavy bodies follow natural motion
  towards center of Earth = cent. of universe



Aristotle argued: Stone would be left behind if Earth rotated!

Oresme's Argument for Earth's Rotation:

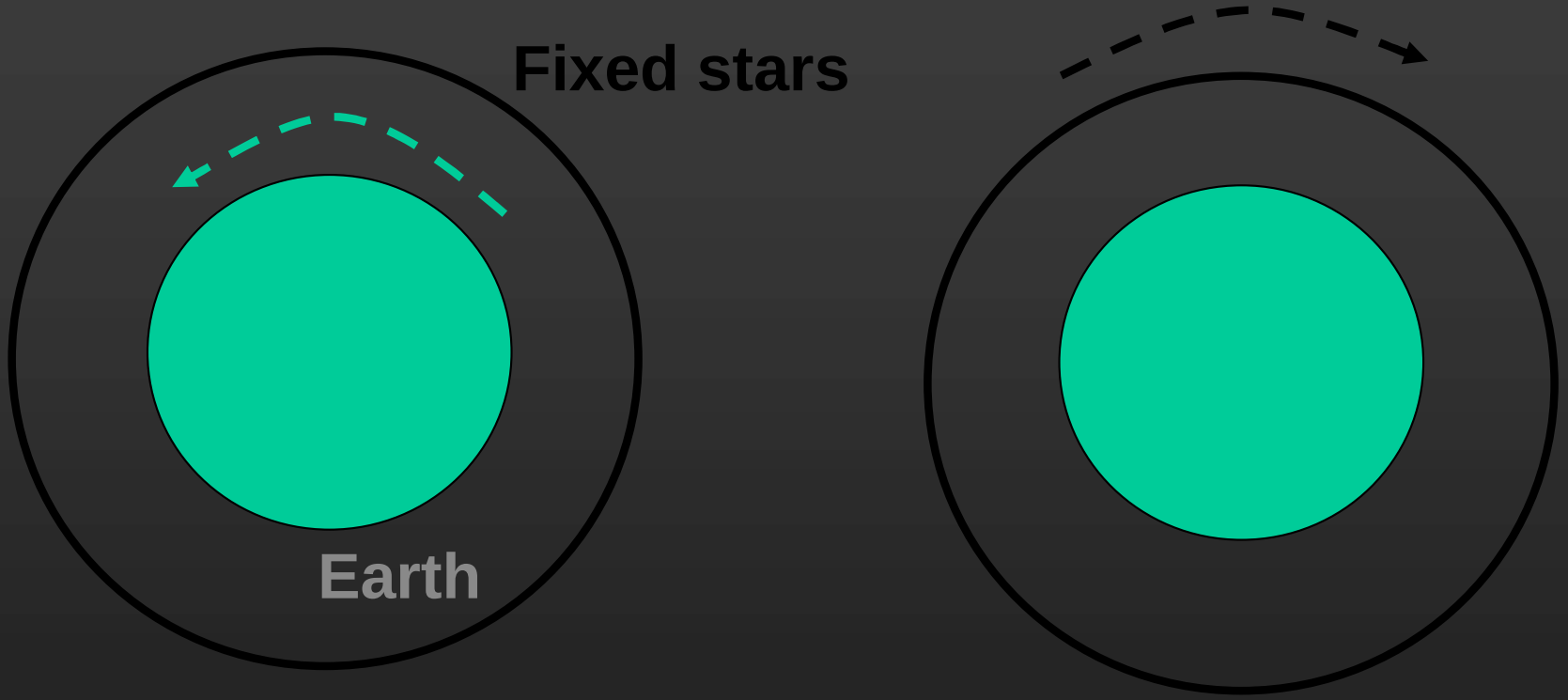
- **Basic principle:** impetus theory!
  - stone or arrow has sideways impetus → stone follows Earth



Oresme argued: Stone would *not* be left behind if Earth rotated!

Oresme's Argument for Earth's Rotation:

- **two equivalent ways to understand daily motion of fixed stars!**



A: Earth rotates!

B: Fixed stars rotate!

- Optical relativity: both models can explain appearance

A Universe without limit: Nicolaus of Cusa

- Cusanus (1401-64 AD)
- lived in Southern Germany
- was a Cardinal of Roman Catholic Church
- *Of Learned Ignorance (De Docta Ignorantia)*

A Universe without limit: Nicolaus of Cusa

- **<u>Basic principle:</u> Opposites coincide (become the same) in the process of going to infinity (coincidential oppositorum)**

  - E.g., curve and straight line

- But also: Center and circumference
  - Coincide in the limit of the absolute smallest

- The realm of the absolute is God!
  - material universe cannot attain this!

→ **Universe has no center and no edge!**

Astronomy in the Middle Ages (Scholastic Period)

- Rebirth of intellectual, scientific activity
- Rediscovery of ancient texts (via Arabic transmission)
- Founding of Universities (Scholastic Philosophy)
- Recasting of tradition at Dawn of Copernican Revol.:

  - Aristotelian-Ptolemaic system incorporated into Christian theology → opposes Copernicus!
  - New theory of motion → establishes plausibilty of Earth's motion → crucial precondition for Copernicus!