



Astronomy 350L

(Fall 2006)



The History and Philosophy of Astronomy

(Lecture 7: Middle Ages/Islam II)

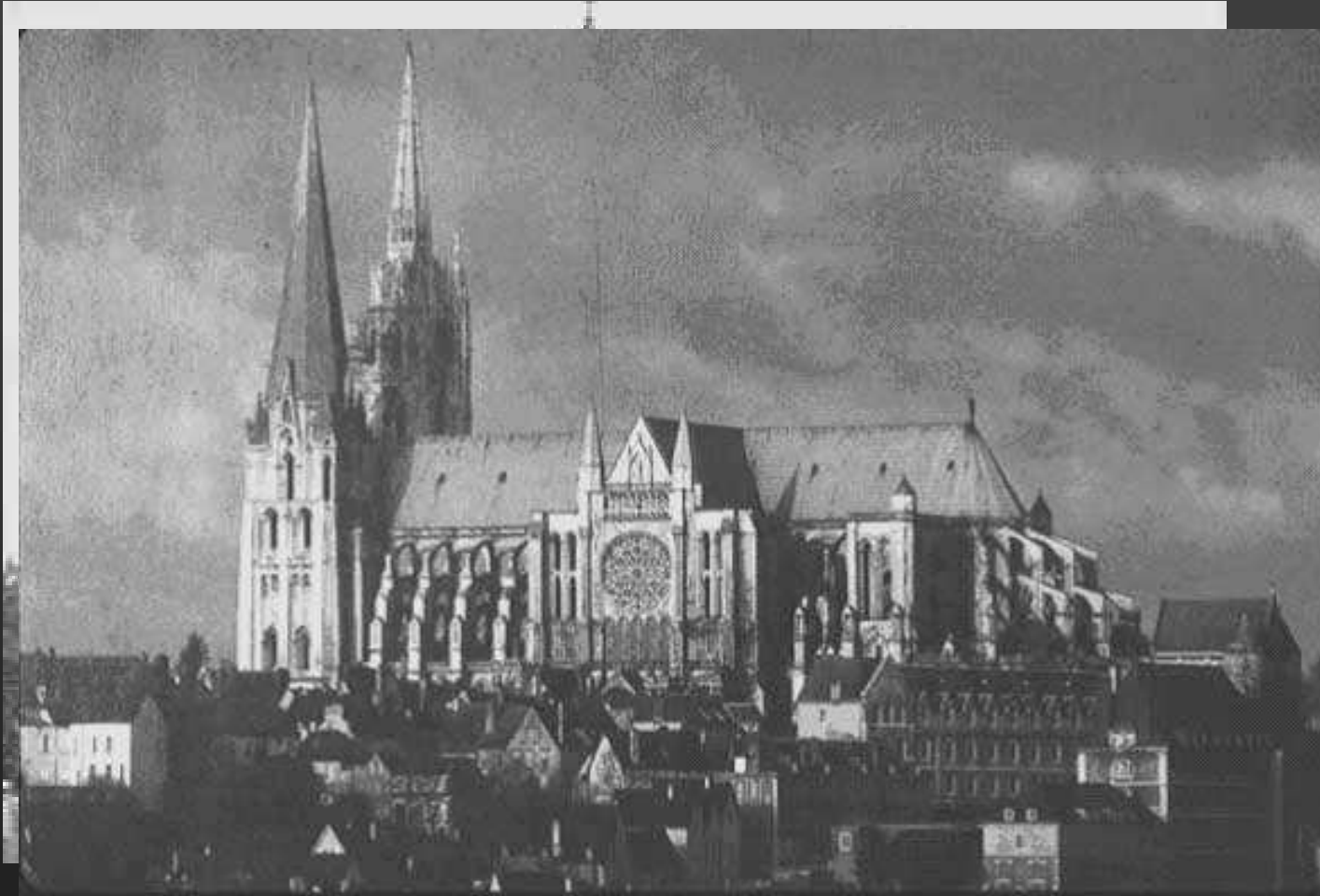
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TA: Jarrett Johnson

The University of Texas at Austin

Medieval Astronomy and Cosmology

- Middle Ages I (Sep. 19)
 - Decline of Western (Mediterranean) 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 (Sep. 21)
 - 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

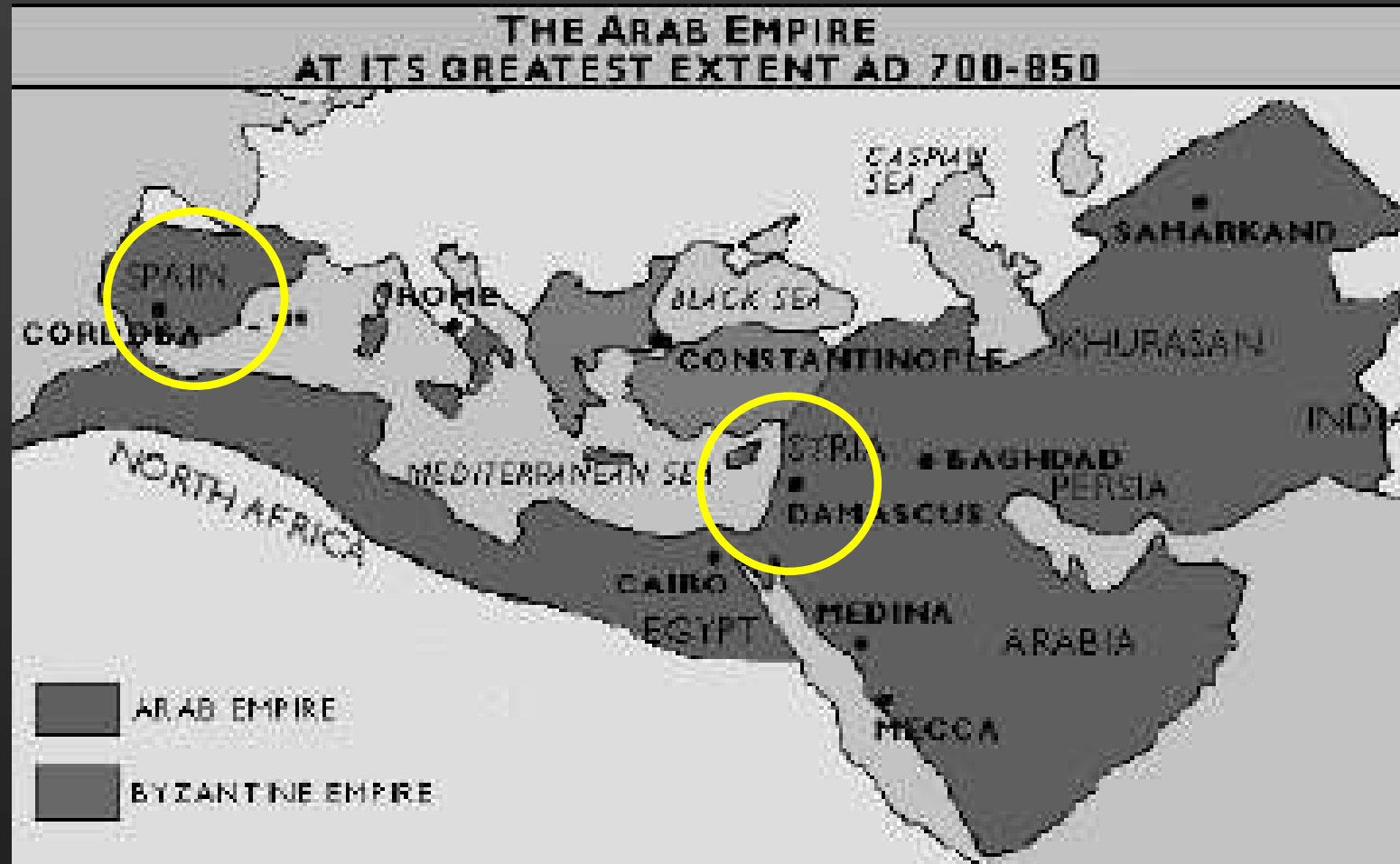


Marco Polo
(1254-1324)



Journey to China: 1271-95

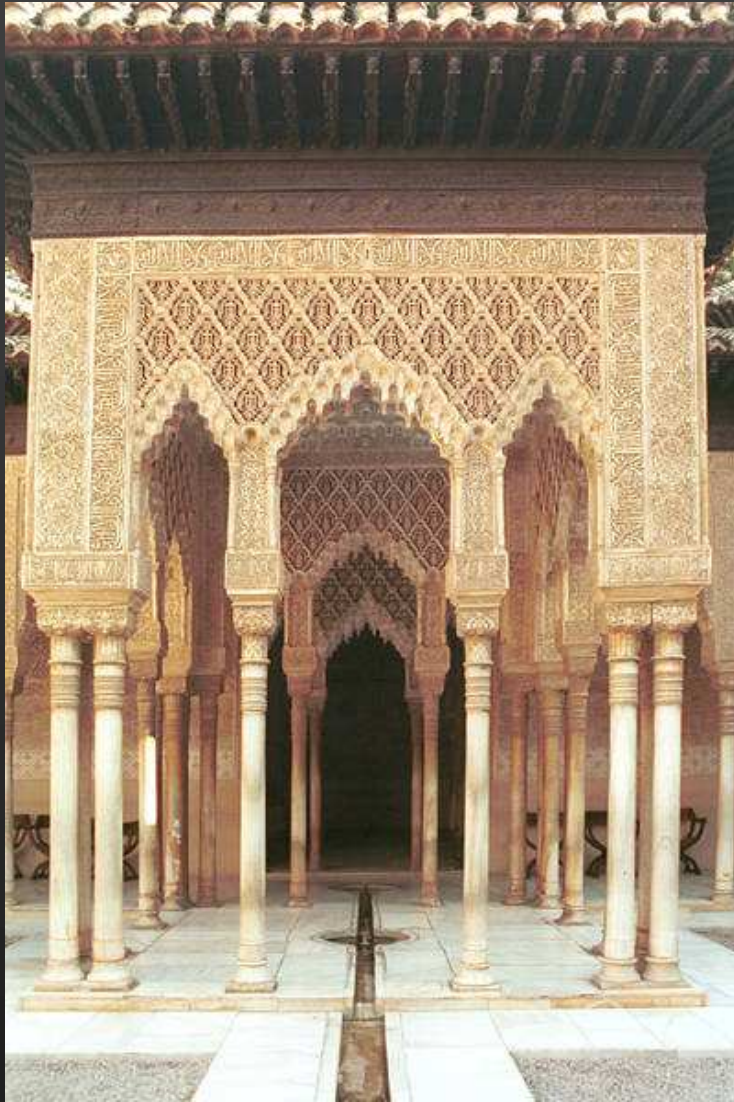
Rediscovery of Ancient Knowledge: Arabic Transmission



- 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:

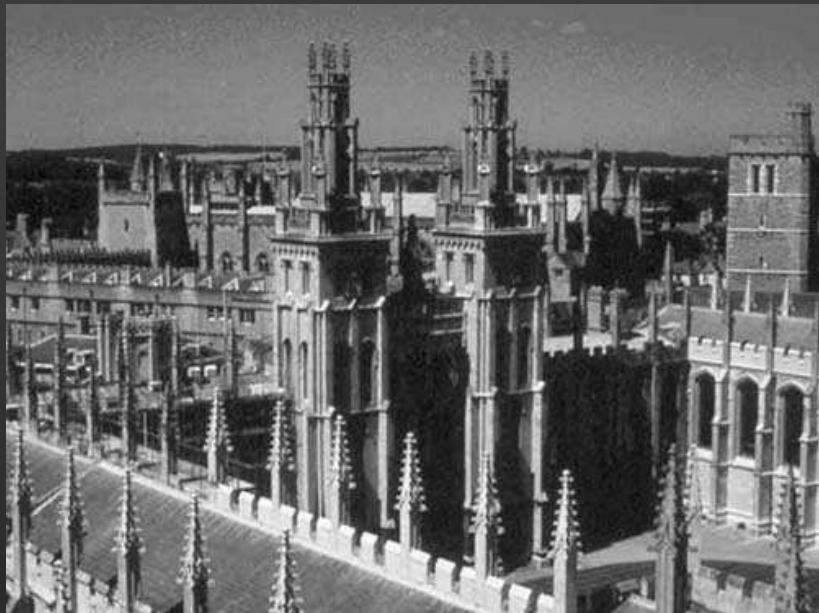
- via Crusades



Siege of Antioch, 1098 AD

- Europe becomes aware of high level of Islamic civilization

Rediscovery of Ancient Knowledge: Emergence of the University



Oxford University



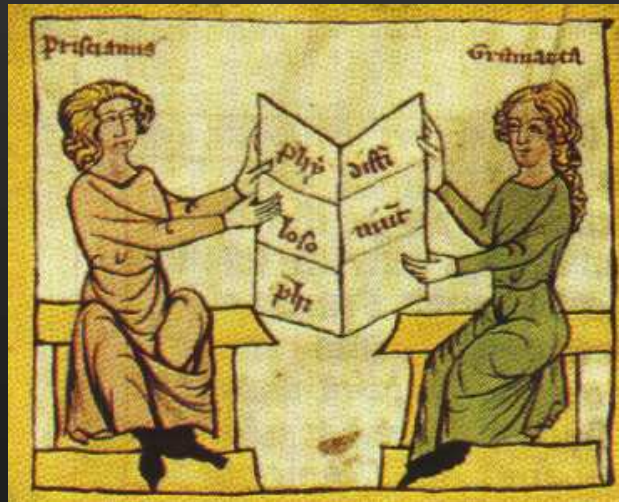
- Universities: A European Invention (12th and 13th cent.)
- Objective: Understand ancient, rediscovered texts!

Structure of Medieval University

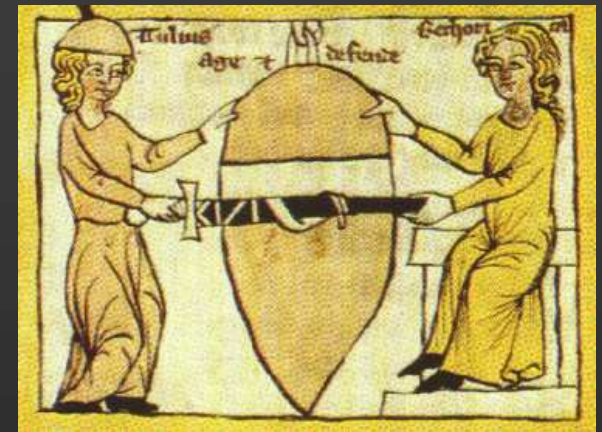
Seven liberal Arts (Septes Artes Liberales): Trivium



Logic (Dialectic)



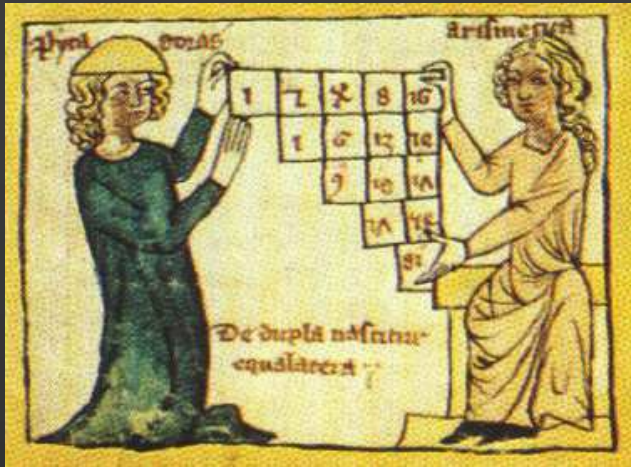
Grammar



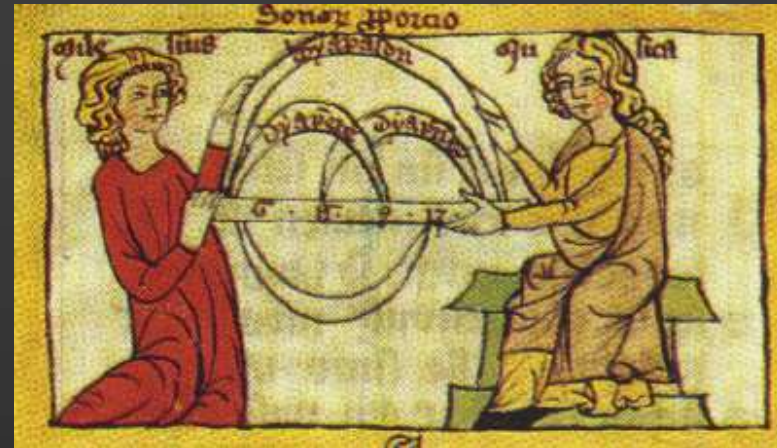
Rhetoric

Structure of Medieval University

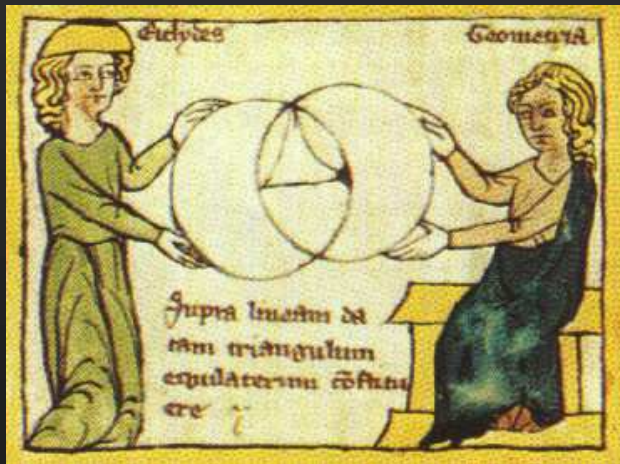
Seven liberal Arts (Septes Artes Liberales): Quadrivium



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



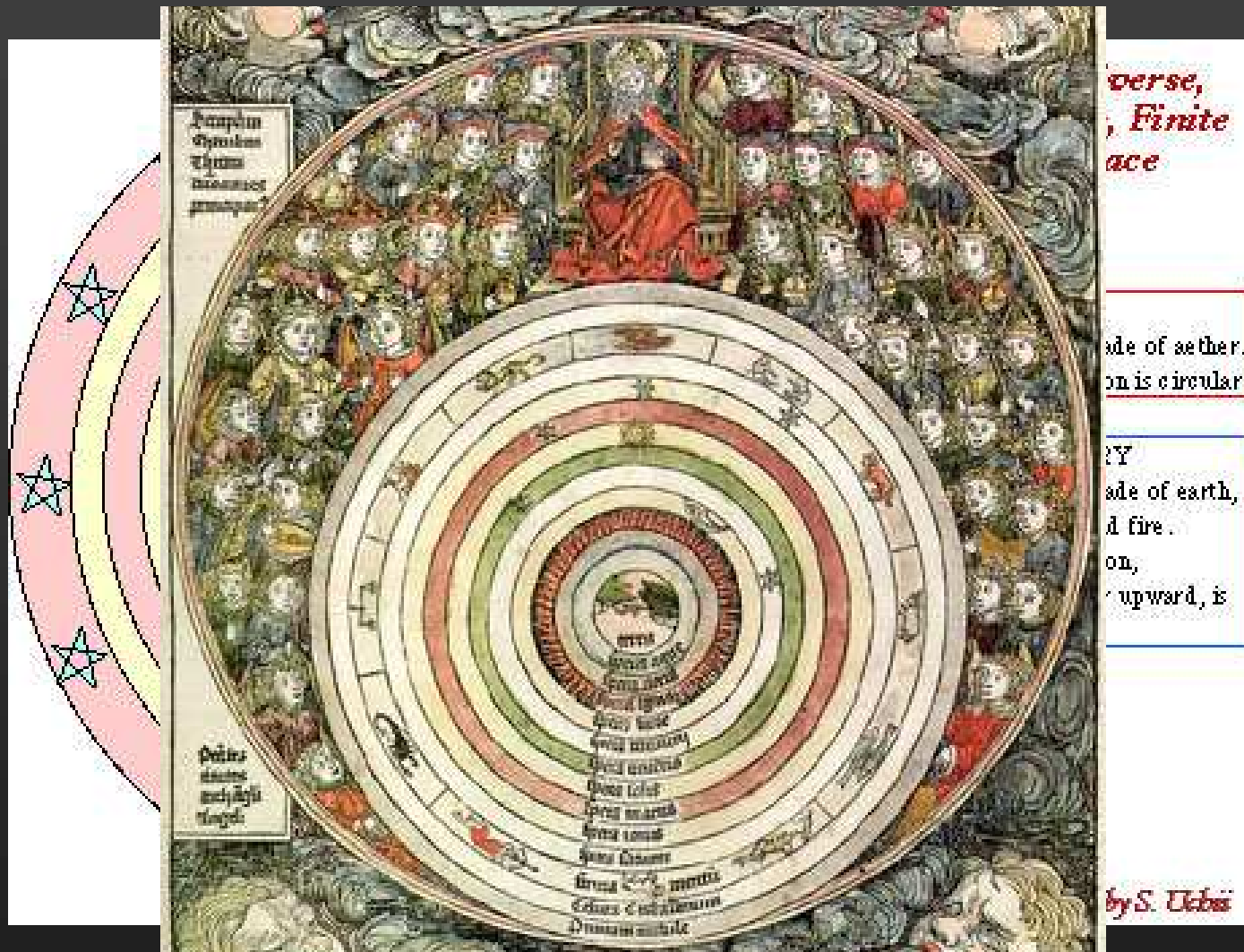
- John of Holywood (d. 1256)
Sacrobosco
- taught in Paris
- wrote *De Sphaera (Sphere)*
- standard textbook for 400 yrs
- simplified version of Almagest

The Christian Universe: Thomas Aquinas



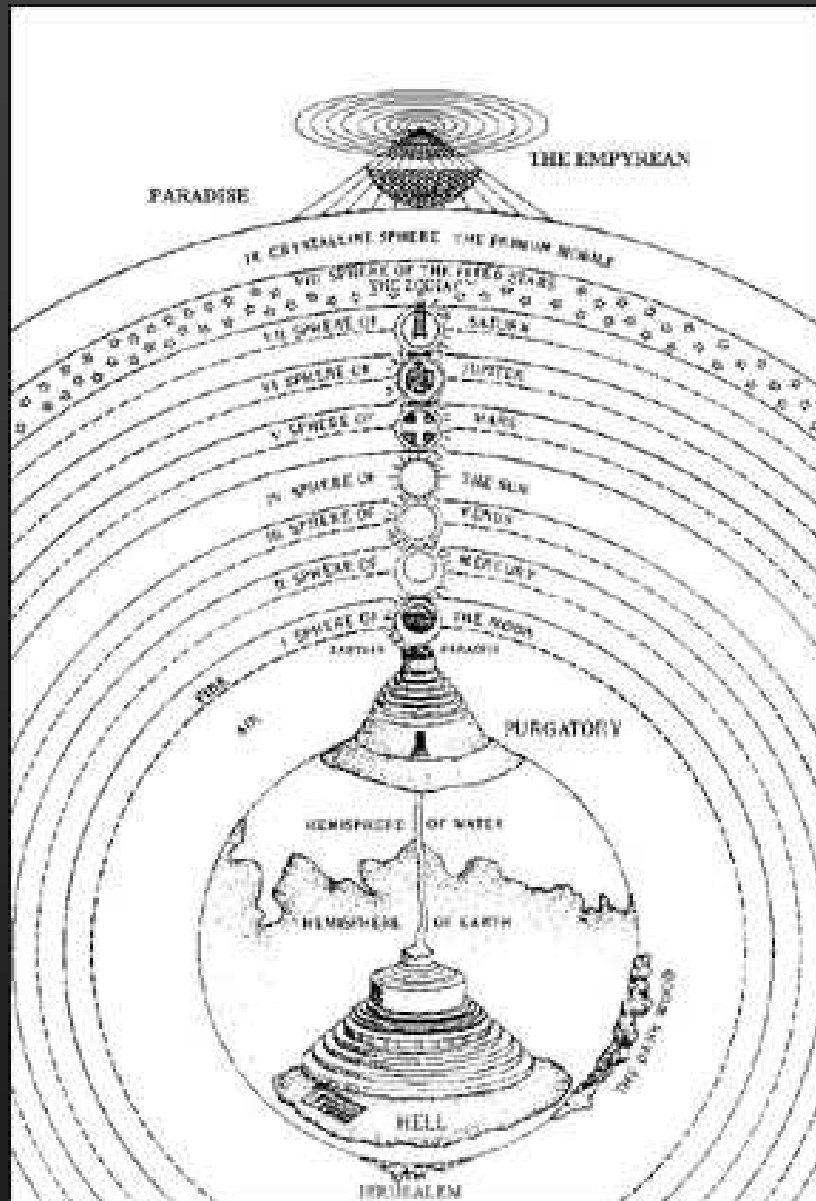
- St. Thomas (1225-74)
- Dominican monk
- Reconciled Aristotle with Christian Theology
- *Summa Theologiae*

The Christian Universe: Thomas Aquinas



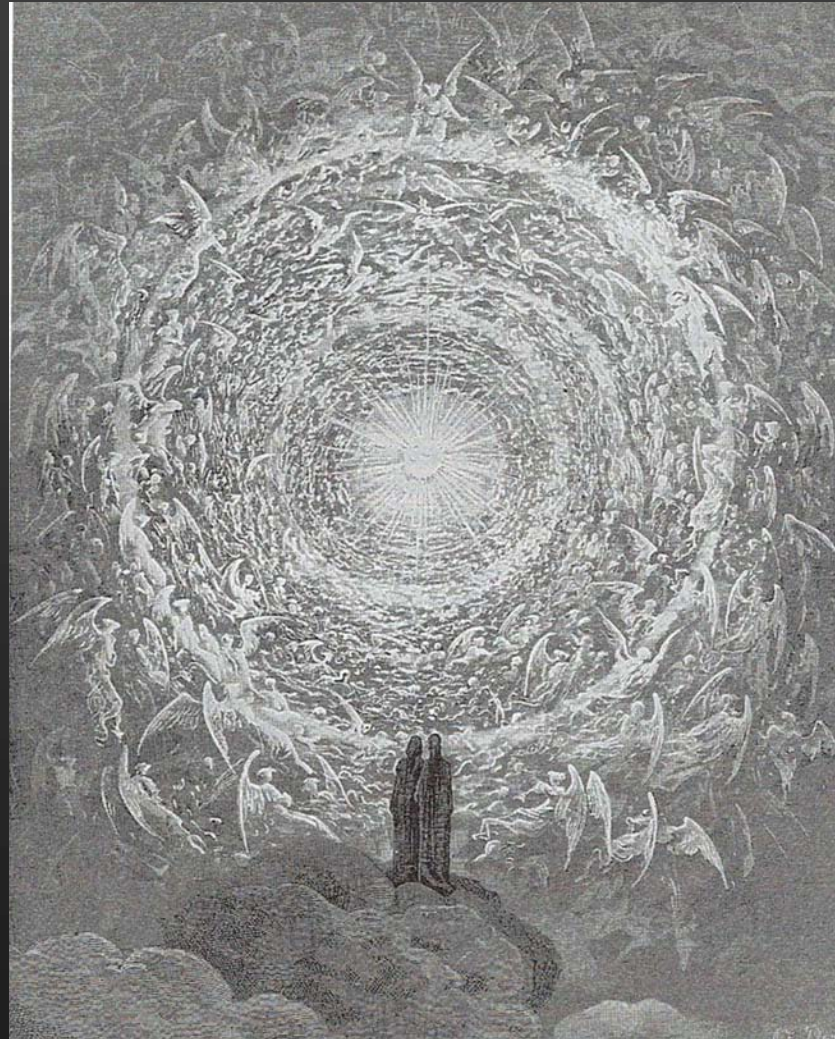
AristoChristianCosmology

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)

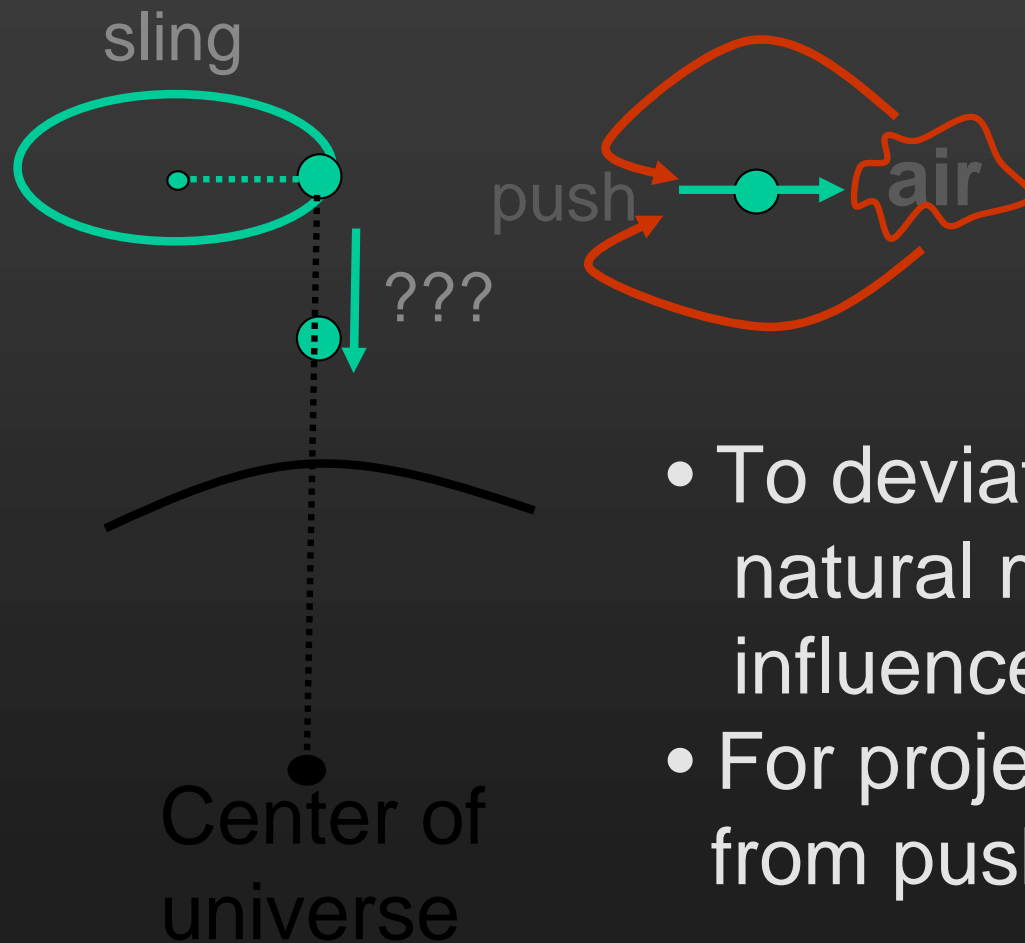


Buridan's Ass

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

Projectile Motion: Aristotle's Theory

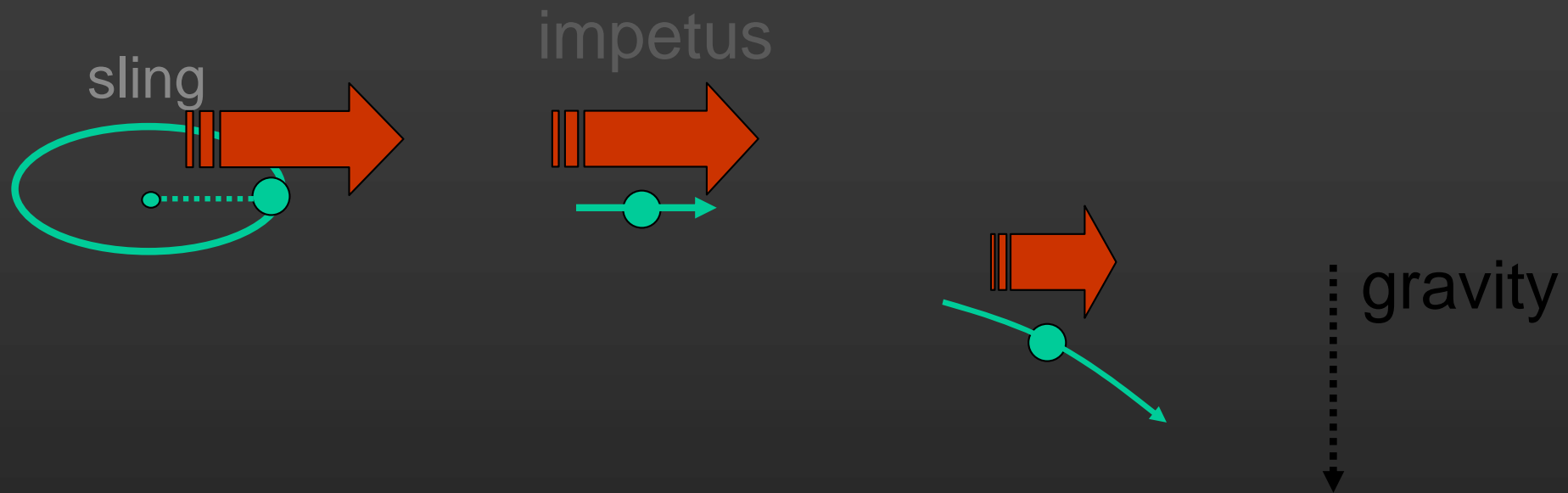
- Basic principle: heavy bodies (elements earth or water) are at rest or move straight to center of Earth (= center of universe)



- 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



- $\text{impetus} = (\text{modern}) \text{ momentum (Galileo, Newton)}$
(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

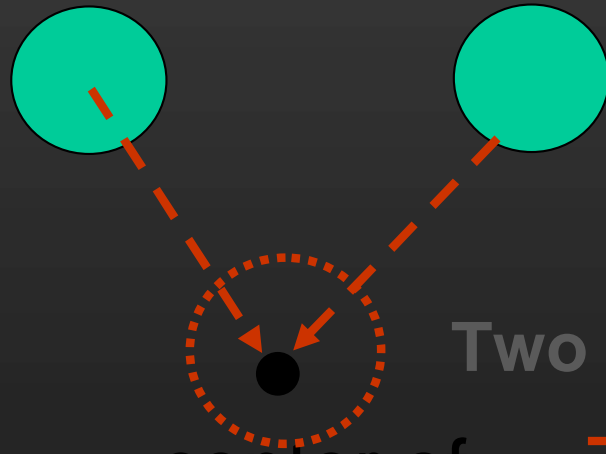
- Idea 1: Earth could move in circles around center of universe!
→ then Earth would be a planet, one among many!

Q: What would happen?

Aristotle:

1st Earth

2nd Earth



center of
universe

Two Earth's would collide:
→ Earth is unique!

Motion of Earth is possible: Nicole Oresme

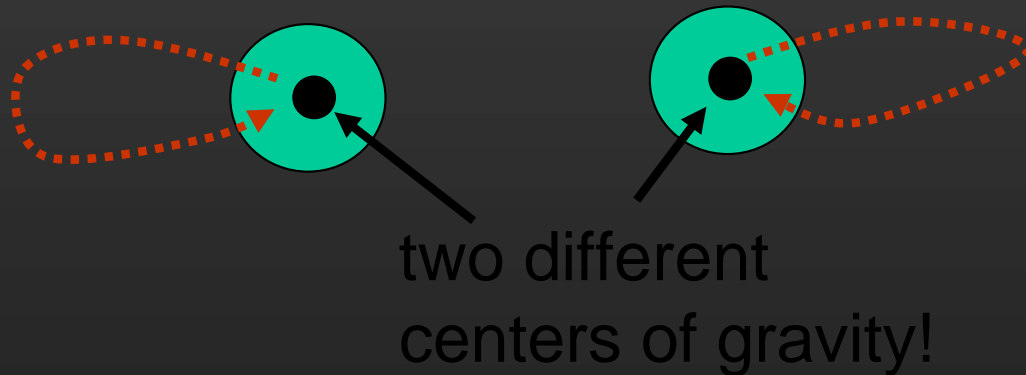
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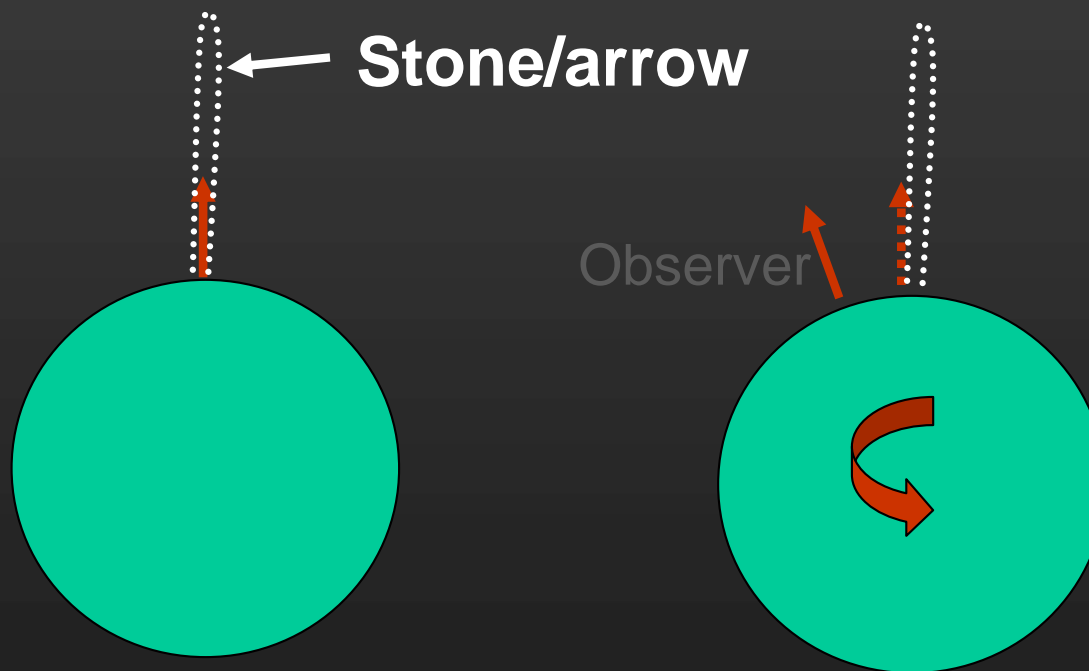
2nd Earth



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

Aristotelian Argument against Earth's Rotation:

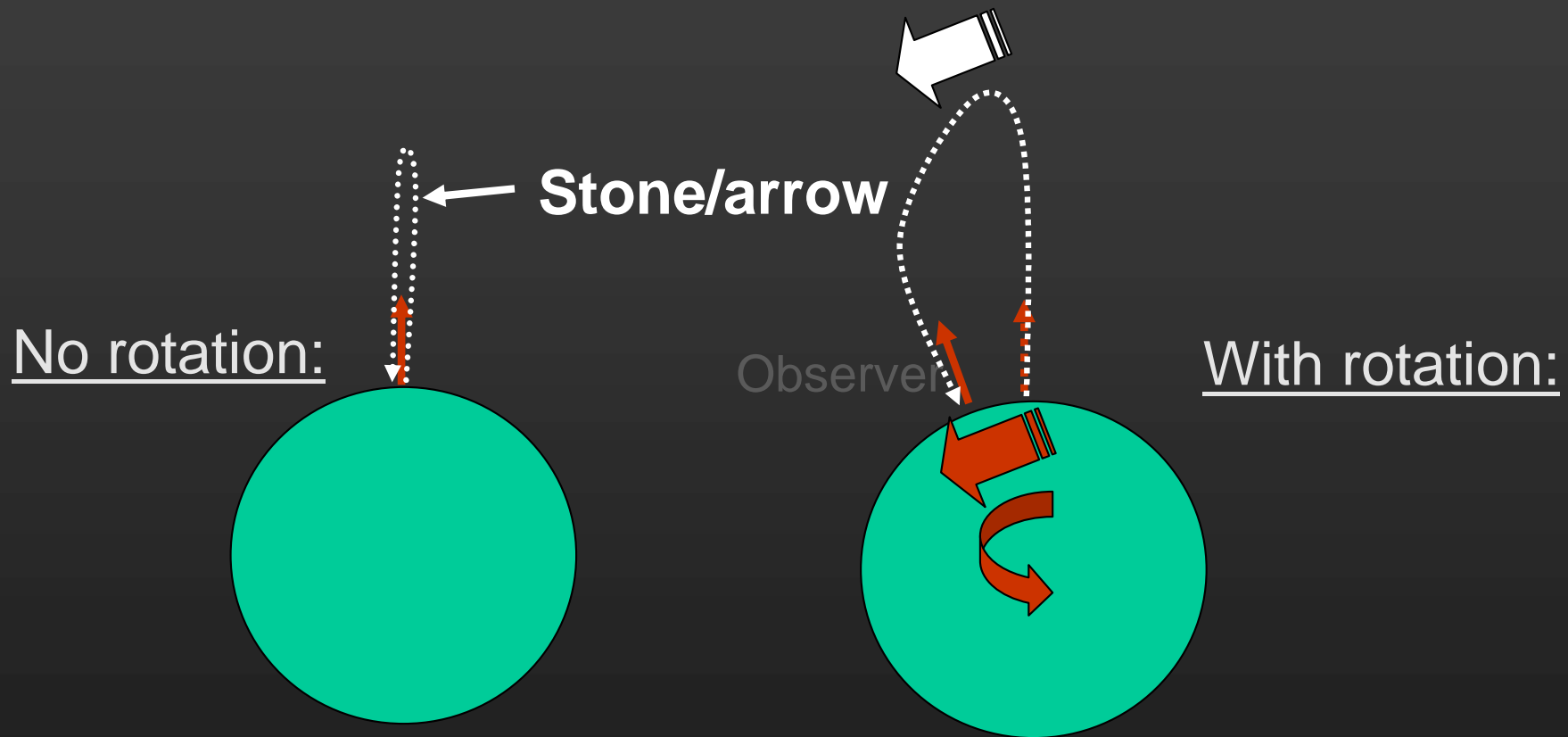
- **Basic principle**: heavy bodies follow natural motion
→ towards center of Earth = cent. of universe



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



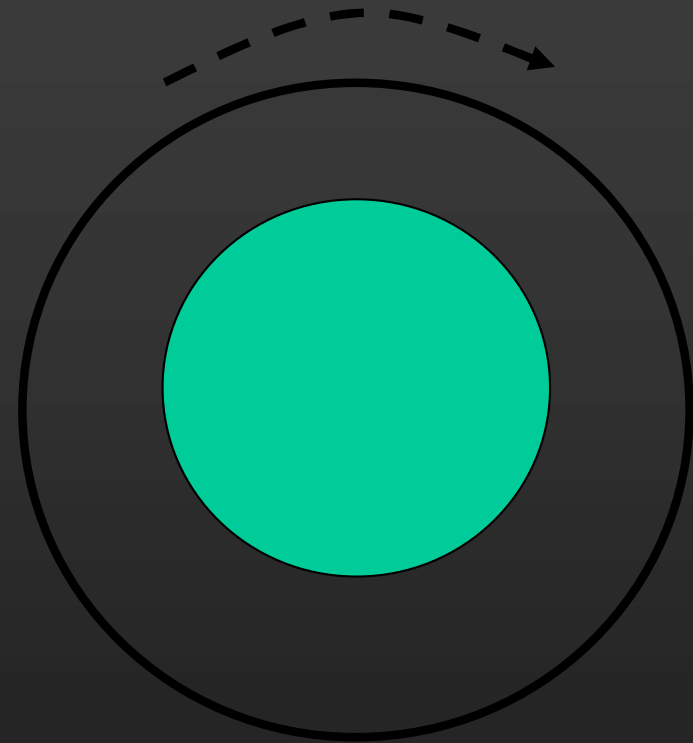
Oresme argued: Stone would *not* be left behind if Earth rotated!

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



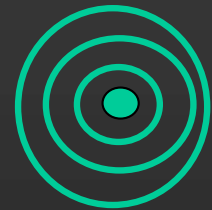
- Cusanus (1401-64 AD)
- lived in Southern Germany
- was a Cardinal of Roman Catholic Church
- *Of Learned Ignorance*
(*De Docta Ignorantia*)

A Universe without limit: Nicolaus of Cusa

- Basic principle: Opposites coincide (become the same) in the process of going to infinity (coincidental 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 plausibility of Earth's motion → crucial precondition for Copernicus!