

ASTRONOMY 9: HISTORY OF COSMOLOGY
Handout #12

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Cosmology in the Middle Ages

I. Early Middle Ages (approx. 200–1200 AD)

- Background
 - Rise in power of Christianity as state religion
 - Instituted by Emperor Constantine (324 AD)
 - Roman Empire divided into West (Latin) and East (Greek, Byzantine)
 - Time of great turmoil (invasion, social decay, corruption ...)
 - Attempts to repulse Germanic and Persian invaders fail; Rome falls in 400s, start of European “Dark Ages”
 - Catastrophic, fatalistic world-views mirrored in salvational themes of Christianity
- Greek curiosity about nature and love for reason are lost
- Natural philosophy no longer of interest, concern only with abstract theological questions
- Very few Greek writings survive
- Plato’s *Timaeus* still widely read, also encyclopedic works of Latin compilers (Pliny, Macrobius, Capella, Chalcidius)
- Literal interpretation of scripture generally the final authority on cosmology
- Scholarly works all in Latin, knowledge of Greek fades
- Loss of Greek knowledge near total; from about 300–1000 AD, most “educated” western Europeans believe in **flat Earth!**
- Neo-Platonism generally dominates during this period
- St. Augustine (354–430)
 - Leads a wild, pleasure-seeking life until age 31, then adopts Christianity after trying many other philosophies
 - Philosophy seen as mere handmaiden to theology, not a distinct path to truth
 - Strongly influenced by Platonic ideas
 - Division of world into Forms vs. imperfect, shadowy reality, parallels the Christian “Fall” from grace
 - Plato’s ideas wedded to Christian dogma
 - *The Confessions*: amplifies Plato’s distrust of knowledge gained through the senses
 - Curiosity about the world, knowledge for its own sake, seen as an inherently sinful pleasure
 - Ideas further amplified by Augustine’s followers
- St. Lactantius
 - Demolishes “pagan” idea of spherical Earth in *Divine Institutions* (written 302–323)
 - Earth believed flat for first time in almost 1000 years!
 - Argues against possibility of the antipodes
- Cosmas
 - First detailed description of early medieval cosmological system, in *Christian Topography* (written 535–547)
 - Cosmos as a giant Tabernacle
 - * Much like earlier Babylonian/Hebrew views
 - * Earth as flat rectangle or disc at the bottom of the universe
 - * Cosmos was widely traveled, should have known better!
 - * Earth surrounded by waters, also celestial waters above
 - * Heavens are not spherical because Isaiah says God “laid them out like a tent”
 - * Earth is tilted so the sun can go literally “down”
 - * Tabernacle divided into two Aristotelian zones by firmament
 - * Angels carry stars daily below the firmament

- Philoponus (6th c.)
 - Argues *against* the common abuse of scriptures to prove non-spherical heavens
 - Ideas have little influence on dominant Church
- Isidore (570–636)
 - Bishop in western Church
 - Also mentions spherical heavens and earth, going against the orthodoxy
- Bede (approx. 673–735, English monk)
 - Another unorthodox teacher of spherical Earth
 - Moves Earth from cosmic bottom back to center
 - Influenced by Pliny
- Virgil or Fergil (8th c., Irish ecclesiastic)
 - Threatened with expulsion from Church for teaching of spherical Earth
 - But not much happens; condemnation of cosmological heresy not at all strict
- Gerbert
 - Noted scholar and astronomer, becomes Pope Sylvester II in 999 AD
 - Spherical Earth now firmly reinstated
- Immutability of the Heavens
 - Like Aristotle, believed in perfect, unchanging celestial realm for Moon and above
 - Appearance of supernovae in 1006 and 1054 barely even noted, though 1006 as bright as quarter Moon!
 - As evidence of celestial change, clashed with medieval world-view
 - Chinese astronomy reached high-point, left records of many celestial events including the SNe
- By 1000, European knowledge roughly same as 500 BC Greece!

II. Cosmic Innovation in Arabia (approx. 700–1250 AD)

- Preservation and translation of many important Greek works (Ptolemy, Aristotle, Euclid, ...)
 - Significant contributions to mathematics (algebra, numerals, sin function, ...)
 - Re-introduction of Greek texts to Europe via Islamic Spain starting in 1200s
 - Sparked rebirth of scientific curiosity in Europe at end of Middle Ages
 - Built large, organized observatories for new tables of planetary motion
- A) Adalusian school (Iberian peninsula)
- Followers of Aristotle’s physics: uniform, geocentric, circular motion is only natural possibility
 - Rejected Ptolemaic equant (non-uniform), epicycles and eccentric (not geocentric) as against physical principles
 - Reverted to Aristotelian model with concentric spheres
 - Predictions for planets off by up to 21°!
- B) Maragha school (Persia)
- Desired to improve accuracy of Ptolemaic model with new data and mathematical tricks
 - al-Tusi (d. 1274) invented Tusi couple
 - Combination of two circles, one smaller inside the other
 - Can produce variety of motion, even linear!
 - Ptolemy’s eccentric and equant replaced with Tusi couples
 - Back to uniform circular motion, with little loss of accuracy

III. Late Middle Ages and Early Renaissance (approx. 1200–1500)

- By mid 1200s, translations of Aristotle and Ptolemy come to Europe via Arabia and Spain
- Philosophers comment on ancient Greeks, add few new ideas
- Aristotle’s influence eclipses Plato’s
- St. Thomas Aquinas (1227–1274)
 - Marriage of Aristotelian ideas and Christian dogma

- Revelation still most important source of knowledge, but natural philosophy recognized as a distinct path to truth, followed when not directly contradicting scripture
- Aristotelian physics instituted as dogma, not challenged
- Believed Aristotle already contained all that could be known about the world, nothing left to discover!
- Problems uniting Aristotle with Christianity:
 - A) Eternal vs. created cosmos
 - B) Only one world—a limit on God’s power?
- Roger Bacon (1214–1294)
 - Unlike most, did not follow Aristotle as dogma
 - Stressed use of *experiment* as path to truth
 - Establishment of scientific method
 - Imprisoned for two years for promoting “dangerous novelties”
- Dante (approx. 1300)
 - *Divine Comedy* presents dominant medieval view of cosmos
 - Hierarchical chain of being, walled-in, finite cosmos
 - Aristotelian lunar/sub-lunar division subdivided into many concentric shells
 - Outer shell is most perfect, angelic; Lucifer at center of Earth
- Nicolas of Oresme (1323–1382, France)
 - Wrote *Book of the Heavens and the World*
 - Familiar with Heraclides’ idea of rotating Earth
 - Notes *relative* nature of motion
 - Argues rotation of Earth more natural than rotation of heavens!
 - Refutes his own ideas at the end of the work
- Nicolas of Cusa (1401–1464, France)
 - Argues for unbounded, eternal universe in *On Learned Ignorance*
 - Earth moves!
 - Forced to write apology, quotes ancient philosophers
- Regiomontanus (1436–1476)
 - Completes Peuerbach’s translation of Ptolemy’s *Almagest* from original Greek
 - Discovers errors up to 2° in planetary motions, eclipse ends one hour early
- Columbus (1492 trans-Atlantic voyage)
 - Did not have to convince anyone of spherical Earth (fiction invented by American writer Washington Irving)
 - Knew of accurate 9th c. Arabic computation of circumference
 - Got value 25% too small by assuming Arabic mi = Roman mi
 - Wrong Ptolemaic geography, thought Asia extended far east
 - Used to justify voyage
 - Europe not at cosmic center