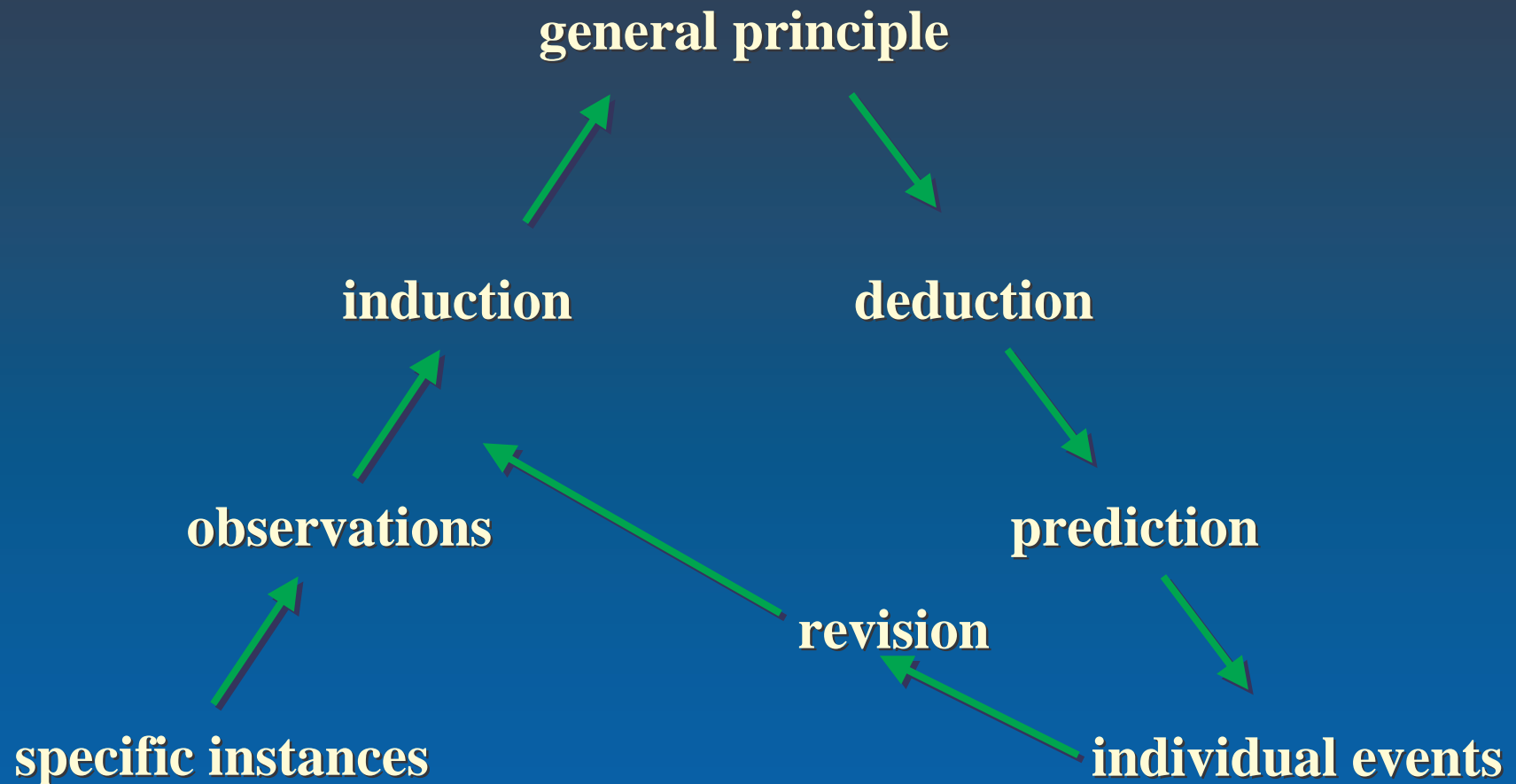


Lecture 3:

History of Cosmology I

Greek Cosmology

The Scientific Method

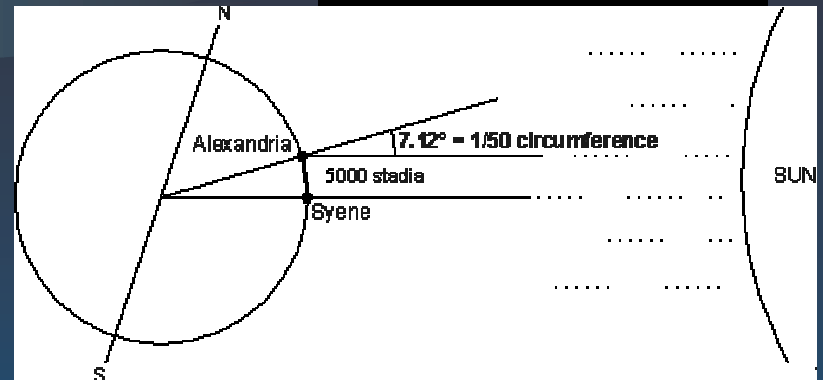


⇒ Science is a history of corrected mistakes (Popper)

Key elements of Greek science

- Principle of cause and effect
- Observe a natural phenomenon and seek an explanation for it
- It is possible to understand nature in precise, geometrical terms
⇒ World is ordered and predictable
- supremacy of theory, i.e. pure rational thought over observation
- Application of “Earth science” to understand the heavens

Main discoveries in Greek science



- Curved lunar terminator \Rightarrow Moon is a sphere (Pythagoras ~520 B.C.)
- Round shadow of the Earth during lunar eclipses \Rightarrow Earth is a sphere (Anaxagoras ~ 450 B.C.)
- Crescent phases of the Moon \Rightarrow Moon between Earth and Sun (Aristotle ~ 350 B.C.)
- First precision measurement of the circumference of the Earth (Eratosthenes ~200 B.C.)

Eudoxus' Universe (~350 B.C.)



Eudoxus' Universe (~350 B.C.)

- Circle and sphere are the most perfect geometric forms
 - perfect symmetry
 - enclose largest possible volume (area) for given surface (circumference)
- Spherical shape of Earth and Moon proof for the geometrical design of the Universe
- Sun, Moon, planets and the celestial sphere revolve the Earth on circular orbits.

Problem: inconsistent with observations

Aristotle (~350 B.C.): First coherent physical model

- Everything on Earth composed of four elements: earth, water, air and fire
- Each of these elements moves differently: earth toward the center of the Universe, fire away from the center, water and air occupy the space between.
- Earth at the center of the Universe
- Objects of different composition fall differently
- Concept of force: Motions that deviate from the natural motion of the element must be sustained by a force.

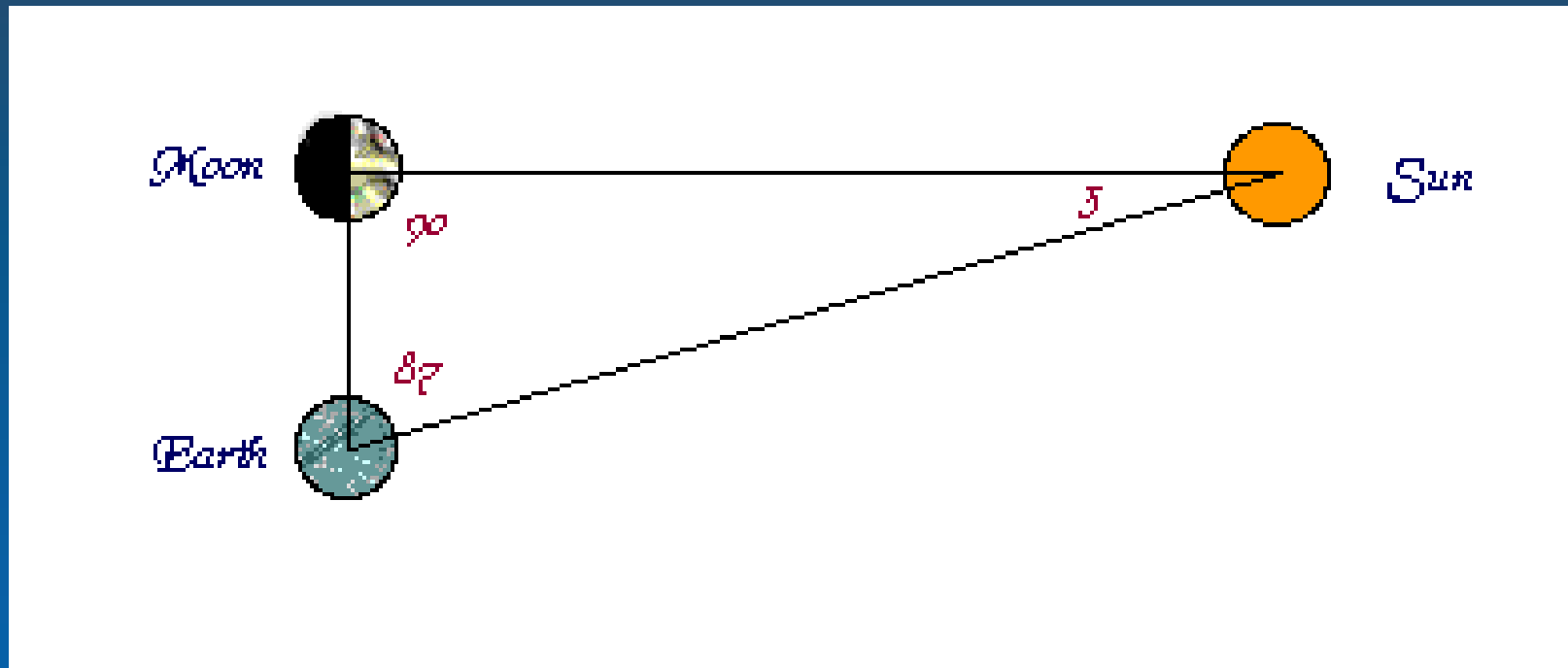
Aristotle's cosmology

- In contrast to Earthly motions, celestial motions do continue indefinitely \Rightarrow two types of motion: limited, straight towards/away from the center (Earthly realm) and continuing on circles in the heavens
- Celestial bodies cannot be composed of Earthly elements \Rightarrow ether as a fifth element
- limited motion on Earth/indefinite motion in the heavens reflect imperfect Earth/perfect heavens
- eternal and unchanging heavens \Rightarrow Universe without beginning or end
- Universe has a finite size

Aristarchus (~250 B.C.): the Sun at the center

- He knew the size of the Earth (roughly)
- He knew the size of the Moon and the distance between the Moon and the Earth (from lunar eclipses)
- Using basic geometry, he was able to determine the size and distance of the Sun
- Result: The Sun is 19 times [today's value: 390 times] more distant than the Moon and (because it has the same apparent size on the sky) is 19 times larger than the Moon (and also much larger than Earth)
- Conclusion: the Sun (i.e. the largest object) is at the center of the universe

Aristarchus: Measuring the distance of the Sun



Aristarchus: Why was his model never accepted by his contemporaries?

- He was considered a mathematician, not an astronomer
- He stood against the two main authorities of his time, Aristotle and Hipparchus
- His model was in conflict with the physics of his time, in particular Aristotle's physics
 - no evidence for the Earth rotating
 - no evidence for the Earth moving