PHY1033C/HIS3931/IDH 3931 : Discovering Physics: The Universe and Humanity’s Place in It
Fall 2016

Prof. Peter Hirschfeld, Physics
Announcements

• HW 1 due Tuesday
• Lab 1 on Tuesday during class – need notebook
• HITT clicker points start Tuesday-practice today. Have you registered your clicker?
• Reading: Almagest, simulations, Physical Cosmos (all online from syllabus links)
Last time
Aristotle 384-322 BCE

- founded Lyceum most famous ancient school
- foundations of Greek philosophy, science influenced educated thought for 2000 years
- approach to physical science distinctly not modern although he used some practical arguments, mostly dialectical in nature
- objects had natural place, sought to return there
- elements: earth, air fire and water
- objects fell with speed $\propto$ mass, inversely $\propto$ to resistance
- natural vs. violent motion. Stone’s natural motion is to fall, to return to earth, its origin; can be endowed with violent motion by throwing it.
- planets natural motion (celestial realm) was to go in circles (5th elements: quintessence or “ether”
Q1: Aristotle taught that a falling body dropped from rest

A) Fell upward if it was made mostly of fire or air, downward if it was made mostly of water or earth
B) Fell at a rate proportional to its weight
C) Did not ever really fall, but rose to the heavens to join the gods
D) Both A) and B)
E) Both B) and C)
Q2: Which of the following did the ancient Ionian Greeks not believe?

A. The Earth is round
B. The stars were fixed on a sphere that rotated around earth every 24 hours
C. The Earth rotated around the Sun
D. All celestial movements are at uniform speed
E. The Sun rotated around the Earth
Falling objects: what Aristotle couldn’t know (but might have figured out with a bit of observation)

Recall Aristotle reasoned that heavier objects fell faster, so $v \propto W$

Brian Cox visits world’s biggest vacuum chamber

https://www.youtube.com/watch?v=E43-CfukEgs

Q: How might Aristotle have figured out he was wrong?
Solar system terms (modern)

Plane of ecliptic: plane containing sun, earth’s orbit around it, and most planetary orbits
Failure of Aristotelian models

Observations over 100s of years – deviations accumulate

Simplified observational table of position of Jupiter (numbers invented!)

<table>
<thead>
<tr>
<th>Time of observation</th>
<th>Angle in plane of ecliptic relative to Polaris</th>
<th>Angle relative to horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Predicted</td>
<td>Observed</td>
</tr>
<tr>
<td>Midnight, January 1, 300 BCE</td>
<td>30°</td>
<td>30°</td>
</tr>
<tr>
<td>Midnight, January 1, 295 BCE</td>
<td>44°</td>
<td>45°</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Midnight, January 1, 200 BCE</td>
<td>137°</td>
<td>141°</td>
</tr>
<tr>
<td>Midnight, January 1, 195 BCE</td>
<td>151°</td>
<td>155°</td>
</tr>
</tbody>
</table>
Two innovations introduced between Aristotle (384-322 B.C.) and Ptolemy (90-168 A.D.) - to improve fit

1. The eccentric circle

Attributed to Apollonius of Perga ~20 - 190 BC)
Accounts for 1) variation in brightness of planets
2) changes in angular speed
Two innovations introduced between Aristotle and Ptolemy to improve fit

2. The epicycle on deferent

Accounts for changes in acceleration, retrograde motion
Simulation: http://astro.unl.edu/naap/ssm/animations/ptolemaic.swf
Claudius Ptolemy (90-169 A.D.)

- Greek mathematician/astronomer of Alexandria (currently Egypt)

- Author of *Almagest*: review of astronomical knowledge in ancient world.

- *Almagest* reviews arguments about geo- vs. heliocentrism, comes down in favor of Earth not moving.

- Ptolemy moved E off center, used epicycles, introduced “equant point”
Euant point-the epicycle has constant angular speed moving around this point.

Orbit of planet (Ptolemy)

Center point of deferent

Deferent-the large circle carrying the epicycle

Sun

Planet

Epcycle-the small circle carrying the planet

Simulation:
http://astro.unl.edu/naap/ssp/animations/ptolemaic.swf
Questions for discussion

• Why do you think moving the Earth away from the center of the orbit allowed for a better fit to the data, e.g. for the Sun’s position?

• Why do we have seasons? Is it because Earth is sometimes closer, sometimes farther from the sun?

• What problem would people from another solar system where theirs was the only planet orbiting around a star have deducing which was in the center?