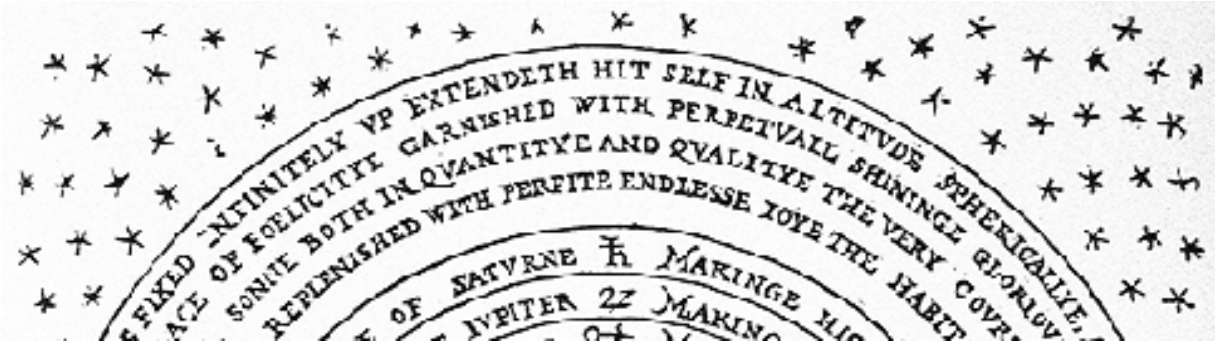



# PHY1033C/HIS3931/IDH 3931 : Discovering Physics:

## 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

($5^{th}$ elements: quintessence or "ether"

# Clicker quickies

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)

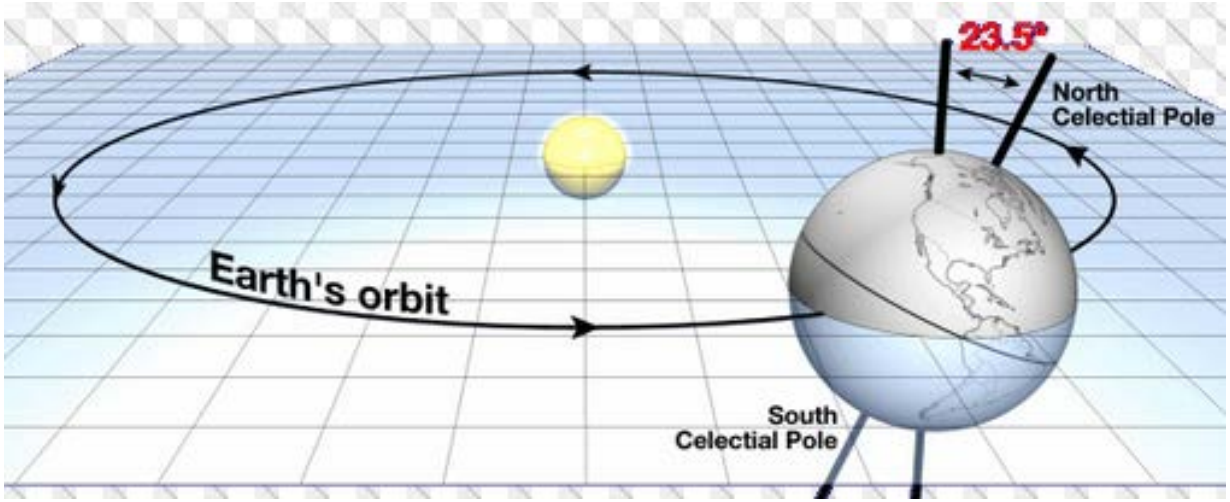
Recall Aristotle reasoned that heavier objects fell faster, so $v \propto W$

Brian Cox visits world's biggest vacuum chamber

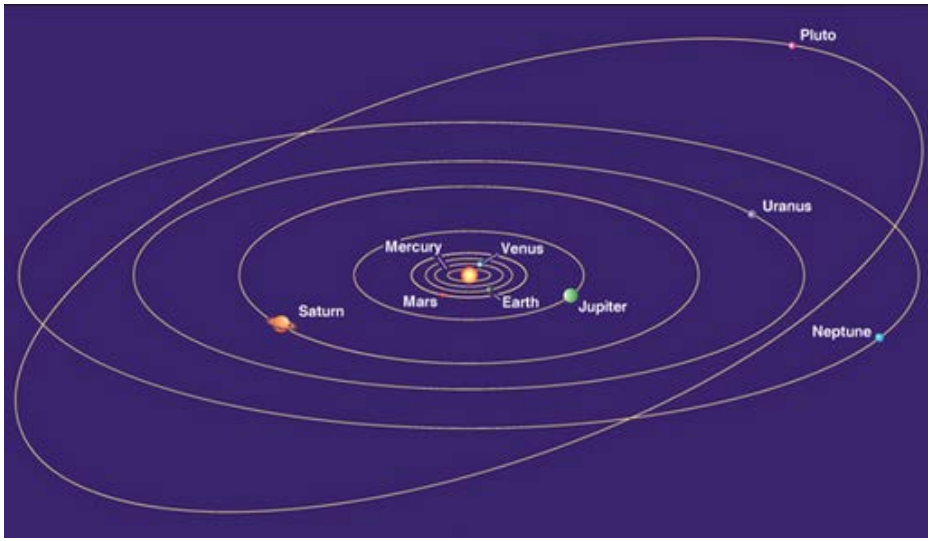
https://www.youtube.com/watch?v=E43-CfukEgs

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



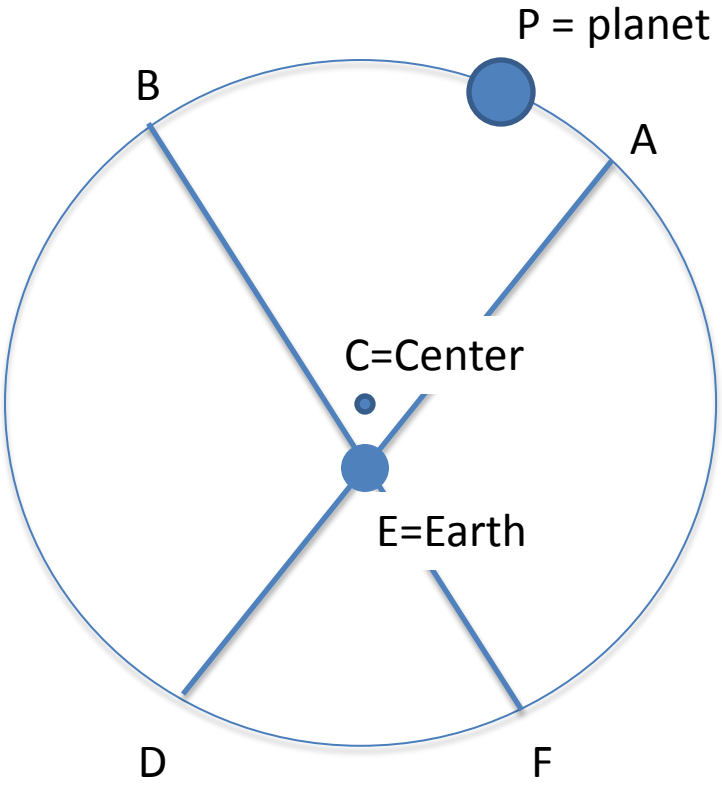
# Failure of Aristotelian models

Observations over 100s of years – deviations accumulate

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

| Time of observation | Angle in plane of ecliptic relative to Polaris | | Angle relative to horizon | |
|---|---|---|---|---|
| | Predicted | Observed | Predicted | Observed |
| Midnight, January 1, 300 BCE | 30° | 30° | | |
| Midnight, January 1, 295 BCE | 44° | 45° | | |
| … | | | | |
| Midnight, January 1, 200 BCE | 137° | 141° | | |
| Midnight, January 1, 195 BCE | 151° | 155° | | |

# Two innovations introduced between Aristotle (384-322 B.C.) and Ptolemy (90-168 A.D.) - to improve fit



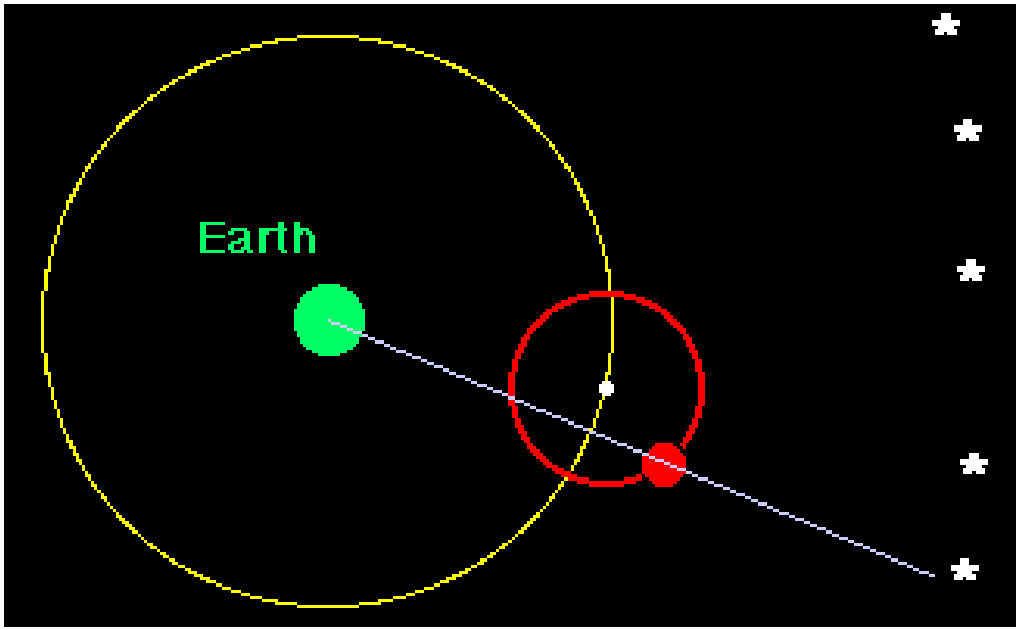

*1. The eccentric circle*

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



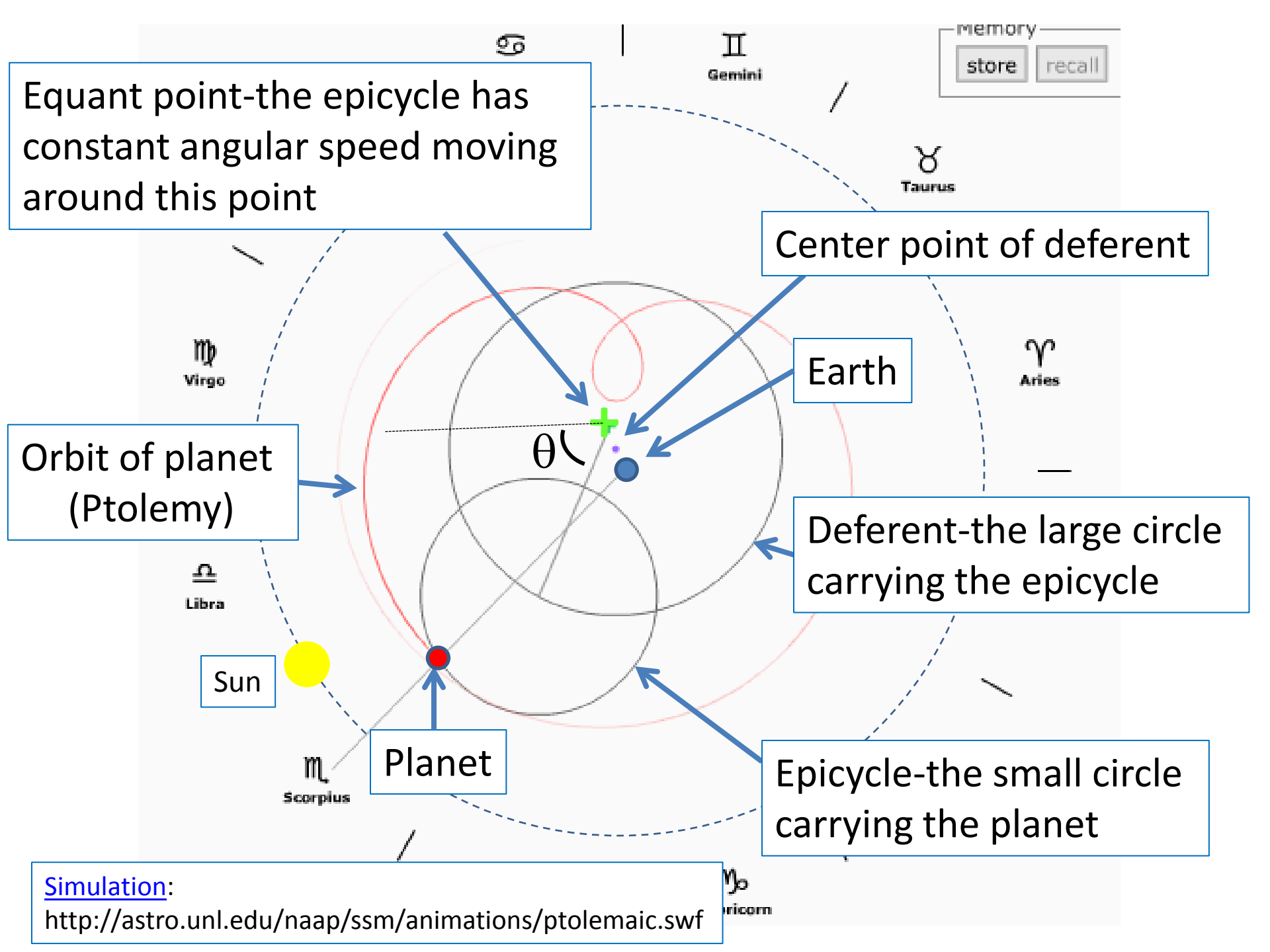

*2. The epicycle on deferent*

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”


Equant point-the epicycle has constant angular speed moving around this point
Center point of deferent
Earth
Orbit of planet (Ptolemy)
Deferent-the large circle carrying the epicycle
Sun
Planet
Epicycle-the small circle carrying the planet
Simulation:
http://astro.unl.edu/naap/ssm/animations/ptolemaic.swf
Gemini
Taurus
Virgo
Aries
Libra
Scorpius
memory
store
recall

# 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?