Prep For Today (is now due) - L7

• Reading:
  - Required: BBBHNM Unit 2 (Chapters 5-9)
  - Recommended Reading:
    • See P3 of http://people.physics.tamu.edu/toback/109/Syllabus.pdf
• Pre-Lecture Reading Questions:
  - If you were misgraded, need help or an extension let me know
  - Unit 1:
    • Pass/Revise: You must get a 10/10
    • If you haven't gotten a 10/10 submit a Revision. If you don't pass that, send revised questions to 109help
  - Unit 2: Was due before class
• End-of-Chapter Quizzes
  - Chapter 3 (if not done already)
• Papers
  - Paper 0 (Reviewer Training): Not yet assigned. May assign today
    • Nothing to write!
    • Reviews likely due before class Monday
    • Back-Evaluations likely due before class Wednesday
  
Bi
Holes, No Math

Topic 4: Scientific Methods
Single example to Show the Scientific Method in Action

- People have watched the sky and noticed that the stars (the dots of light in the sky) basically all move together over the course of the night and over years
- Five of them behave differently
  - Start this story in the 2nd century
Fun Videos of Just the Stars

Start with things you can see with your own eyes!

Video of stars moving with Polaris (north star) at the center
https://www.youtube.com/watch?v=XTTDWhky9HY

Video of stars moving, including the Milky Way (from Chile)
https://www.youtube.com/watch?v=JEHm-XUHwNw
Ptolemy’s Universe (2nd century)

The Sun, Moon and Stars go around once a day, but a few (the planets) change their position relative to the other stars a little every night.

Every so often the planets move backward through the stars for awhile.

Hypothesis: They orbit the Earth in mostly circular paths.

Best guess: these are mini-orbits way out there (epicycles)… Hmmm…
Looking at Mars in the Stars

![Diagram of Mars in the Stars](http://bigbang.physics.tamu.edu/Figures/StolenAnimations/MarsRetrograde_top.mp4)
How Ptolemy envisioned it

• The big circle is the main orbit, and the little circle is the epicycle
• This explains why the planets seem to go back and forth out there in space (retrograde motion) every so often
Cracks in the `early cosmology'

In 1514, Copernicus hypothesized that the Planets and the Earth orbit the Sun

Much simpler in some ways

→ no epicycles

More complicated in others

→ Says Earth is rotating


**Copernicus’s “Hypothesis”**

A more modern view of the motion of the Earth and Mars and the stars behind them (from the point of view of the center)

http://bigbang.physics.tamu.edu/ Figures/StolenAnimations/mars_retrograde_motion.swf

How would this explain the epicycles that people saw?
If we lived in the 1500’s, should/would we have believed Copernicus?

The Earth isn’t at REST and rotates?

• Shouldn’t we FEEL this?

• If the Earth is rotating, why don’t we fall off like an ant on a bicycle wheel?

• Why don’t we feel a wind as we rotate?

• Why doesn’t the rotating Earth move under our feet when we jump?
Cracks in the `early cosmology'

Should his view have just “been accepted”?

Perhaps his theory was just a “different interpretation” of the same data?

- Both models are consistent with observations

Need more evidence!

Need a better TOOL to test, experimentally, which is correct

Early 1600’s: Kepler and Galileo started gathering data from telescopes
Data Provides Evidence

Discover moons orbiting Jupiter! 
Solid evidence that not EVERYTHING orbits the Earth!
Another Piece of Evidence

- Can understand the phases of the Moon because of the locations of all three

- Not eclipses
Venus

- Consider the two different predictions of how Venus moves in space
The Phases of Venus

- Venus has a full set of phases, like the moon
  - Sunlight shining off Venus and to our eyes
- No good way to explain this if Venus goes around the Earth

Big Bang, Black Holes, No Math
More data

- With more accurate data Kepler realizes an even better description of the data is that all planets orbit the Sun in an **ellipse**, not a circle
- Sun-centered model now agrees with the high-quality observational data, Earth centered model does not
- No good REASON for ellipses though... then again, no good reason they should be circles (except people LIKE circles, and they are more “perfect”)
Need to separate the issues

• The fights at this point were about **HOW** the planets move
• There was no good explanation of **WHY** they move that way
• If some one could explain **WHY** they move that way, then maybe we can learn something close to the truth about the universe/nature
The next generation... Newton

- Newton puts forward his theory of **Gravity** and describes it as a **Force**
- **So what?** The same force that pulls an apple to the ground from a tree **ALSO** pulls the planets towards the Sun and keeps them in orbit
- This “explains” why both the orbits are ellipses **AND** why we don’t fall off a spinning Earth

Isaac Newton
1687
Scientific Method

The history is fun, but we have a problem:

- *How do we separate true stories from stories we'd like to believe, but aren't actually true?*

- *Need EVIDENCE and a good Scientific THEORY*
  - Good hypothesis testing
Lecture on Chapter 4 now complete
Outline for Unit 2: Physics We Need

Topics

1. Light and Doppler Shifts
2. Gravity, General Relativity and Dark Matter
3. Atomic Physics and Quantum Mechanics
4. Nuclear Physics and Chemistry
5. Temperature and Thermal Equilibrium
Prep For Next Time - L7

- **Reading:**
  - If you haven't already: Unit 2 (Chapters 5-9)
- **Pre-Lecture Reading Questions:**
  - If you were misgraded, need help or an extension let me know
  - Unit 1:
    - Pass/Revise: You must get a 10/10
    - If you haven't gotten a 10/10 submit a Revision. If you don't pass that, send revised questions to 109help
  - Unit 2:
    - Was due before class. Will try to post grades soon
    - Can submit revision if desired
- **End-of-Chapter Quizzes**
  - Chapter 4
- **Papers**
  - Paper 0 (Reviewer Training): Assigned when we finish Chapter 4
    - Nothing to write!
    - Reviews due before 11:55PM Monday
    - Back-Evaluations due before 11:55PM Wednesday
    - You are required to do all the parts of this assignment