

Big Bang, Black Holes, No Math

ASTR/PHYS 109

Dr. David Toback
Lecture 5 & 6

Prep For Today (is now due) - L6

- **Reading:**
 - BBBHNM Unit 2 (Chapters 5-9)
- **Pre-Lecture Reading Questions**
 - eCampus Quizzes 1-6
 - Check these, some were fixed and changed scores
 - Unit 2: Stage 1
 - Unit 1 Revision (if needed) Stage 1:
Due Wed before class
- **End-of-Chapter Quizzes**
 - Chapter 3

Next Topic: Scientific Methods

Unit 1:

1. Introduction ← Done
2. Going Big ← Done
3. Going Small ← Done
4. Evidence and the Scientific Method

Today we move on to the *Questions*
and *How* we go about answering
them

Plan for the Next Few Weeks

1. More on the Questions and How we go about answering them
 2. Some of the history to teach us about the *method*
 3. Need to learn some physics
-
- Today
- Next Unit

Next few Weeks Continued...

To learn Cosmology will need to learn a bit about:

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

Won't spend too long on these, just enough to get back to the big picture...

Evidence and The Scientific Method

- *What are the clues at the scene of the crime?*
- *How can we use the clues to figure out what happened? Any WHY?*
- **Scientific Method**
 - *How do we know what we know?*
 - *What is the evidence for some of the "true things" we heard growing up?*
 - *E.g .Earth goes around the Sun*

How do we know what we know?

- We have a lot of experience in the world around us
- Unfortunately, our experience is really lousy in guiding us to really understanding the bigger (and smaller) world around us unless we're really careful
 - We can misinterpret the clues
- As you've already seen, the world is incredibly complex and much of it is different from what we experience
 - Good clues are hard to find, sometimes hard to interpret

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

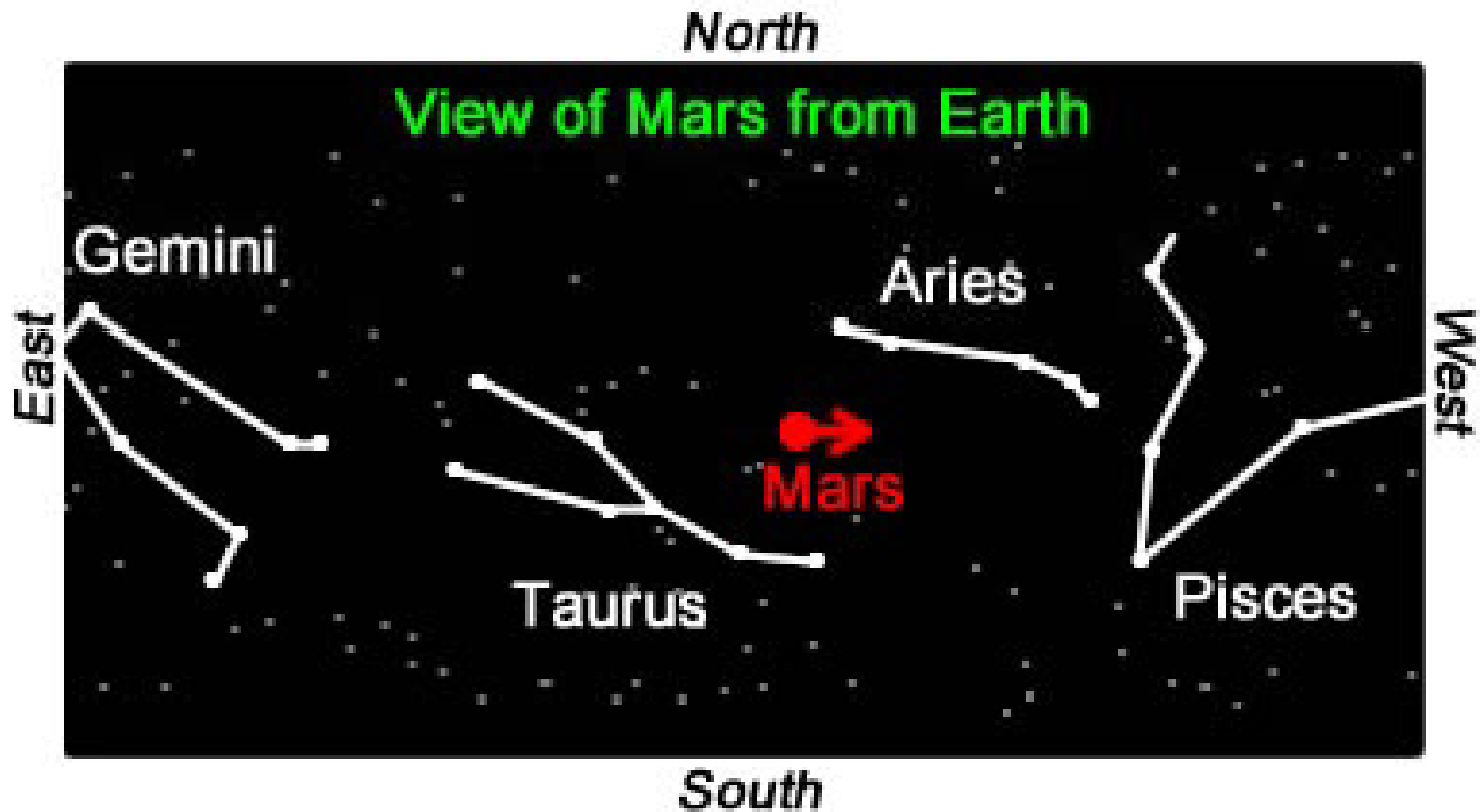
Every so often the planets move backward through the stars for awhile

Hypothesis: They orbit the Earth in mostly circular paths

Best guess: these are mini-orbits way out there (epicycles)... Hmmmm...



Looking at Mars in the Stars



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

<http://bigbang.physics.tamu.edu/Figures/StolenAnimations/ptolemy.model.swf>

Cracks in the 'early cosmology'

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

Much simpler in some ways

→ no epicycles

More complicated in others

→ Says Earth is *rotating*



Epicycles???

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)

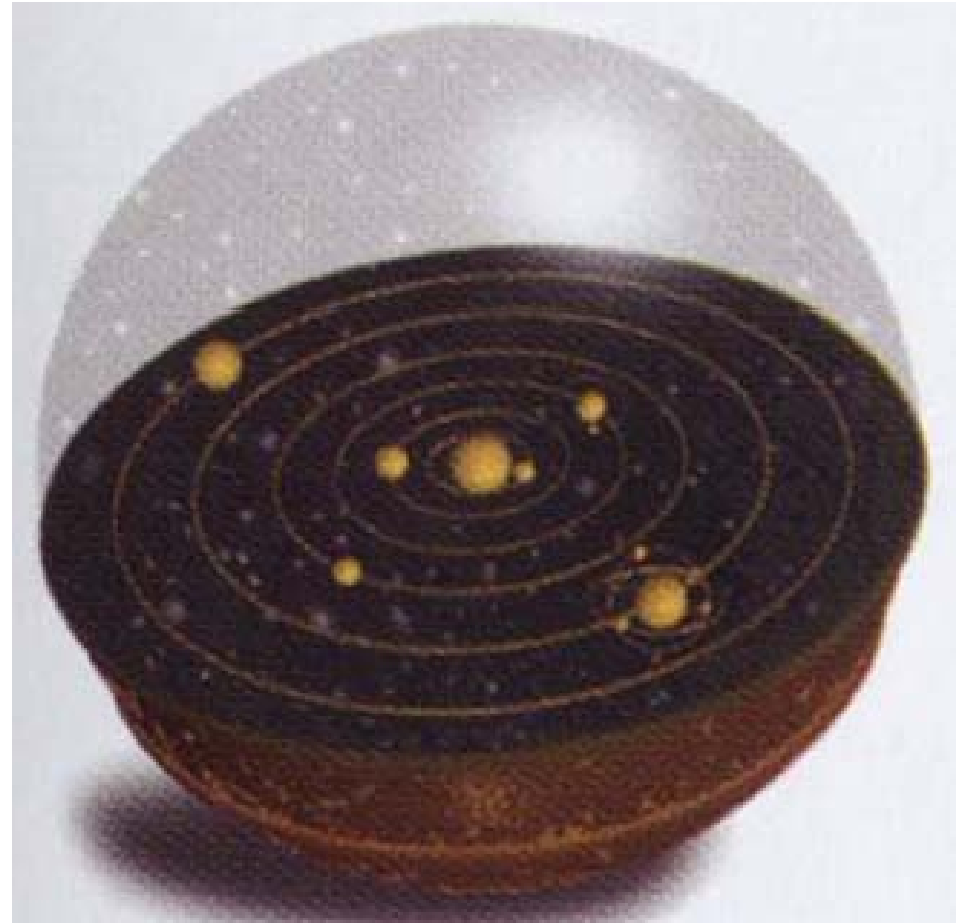
How would this explain the epicycles that people saw?

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

If we lived in the 1500's, should we believe 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 it rotate under us 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



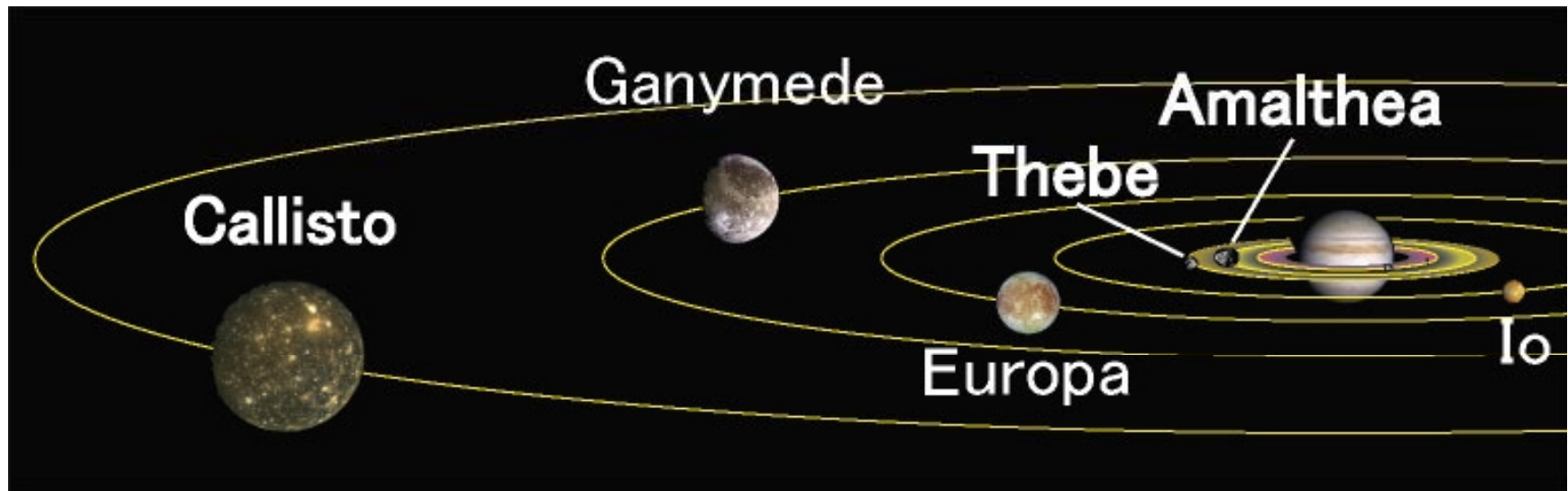
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Holes, No Math

Topic 4: Scientific Methods

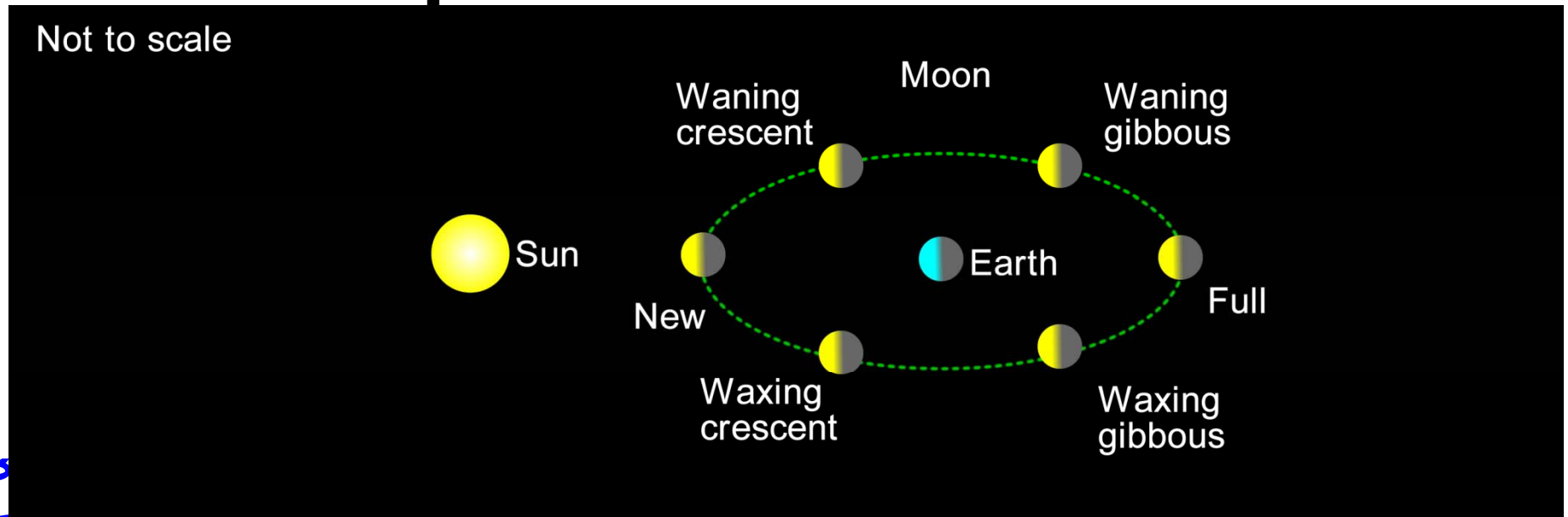
Data Provides Evidence

- Discover moons orbiting Jupiter! → Solid evidence that not EVERYTHING orbits the Earth!



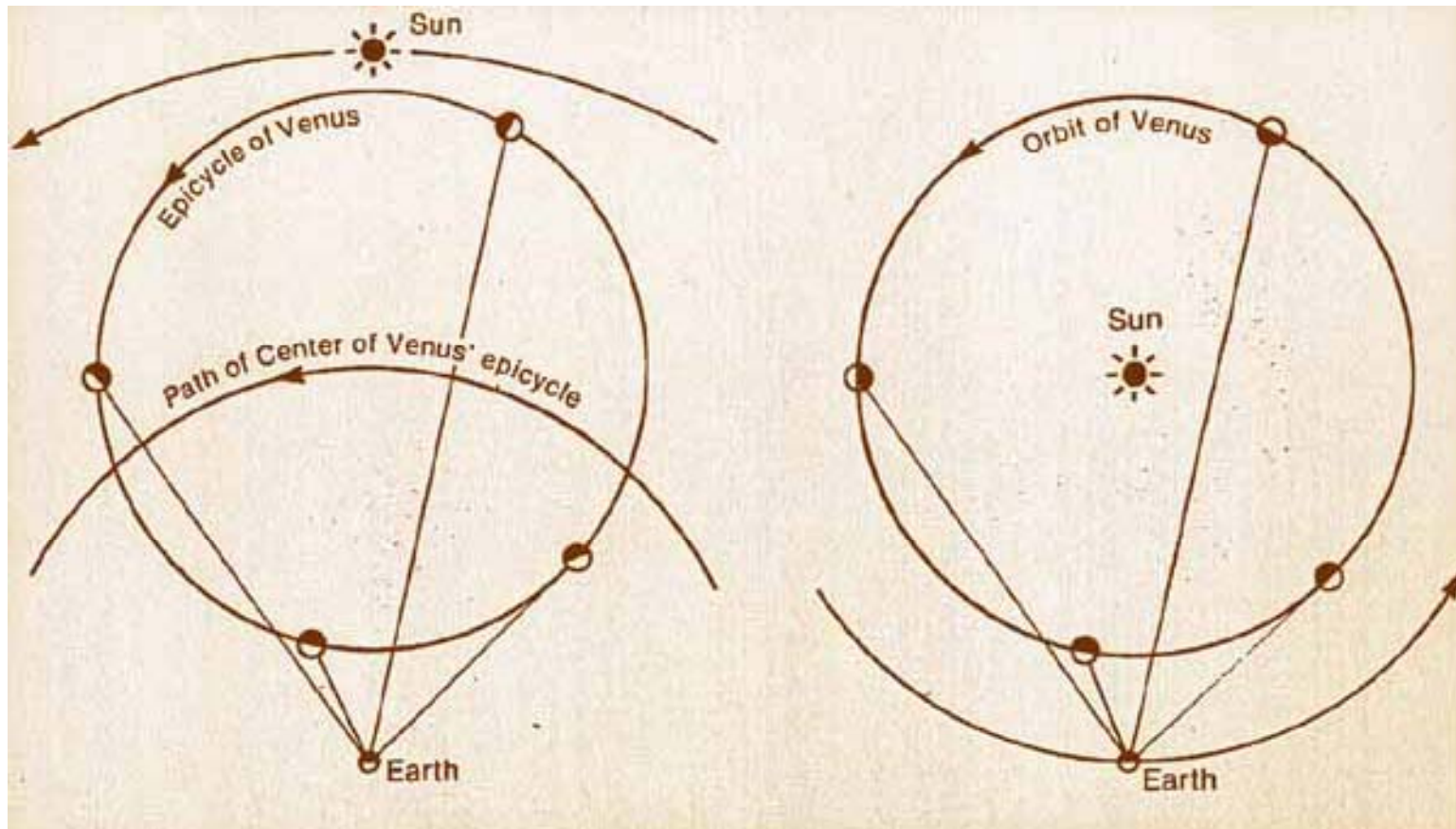
Another Piece of Evidence

- Can understand the phases of the Moon because of the locations of all three
- Not eclipses



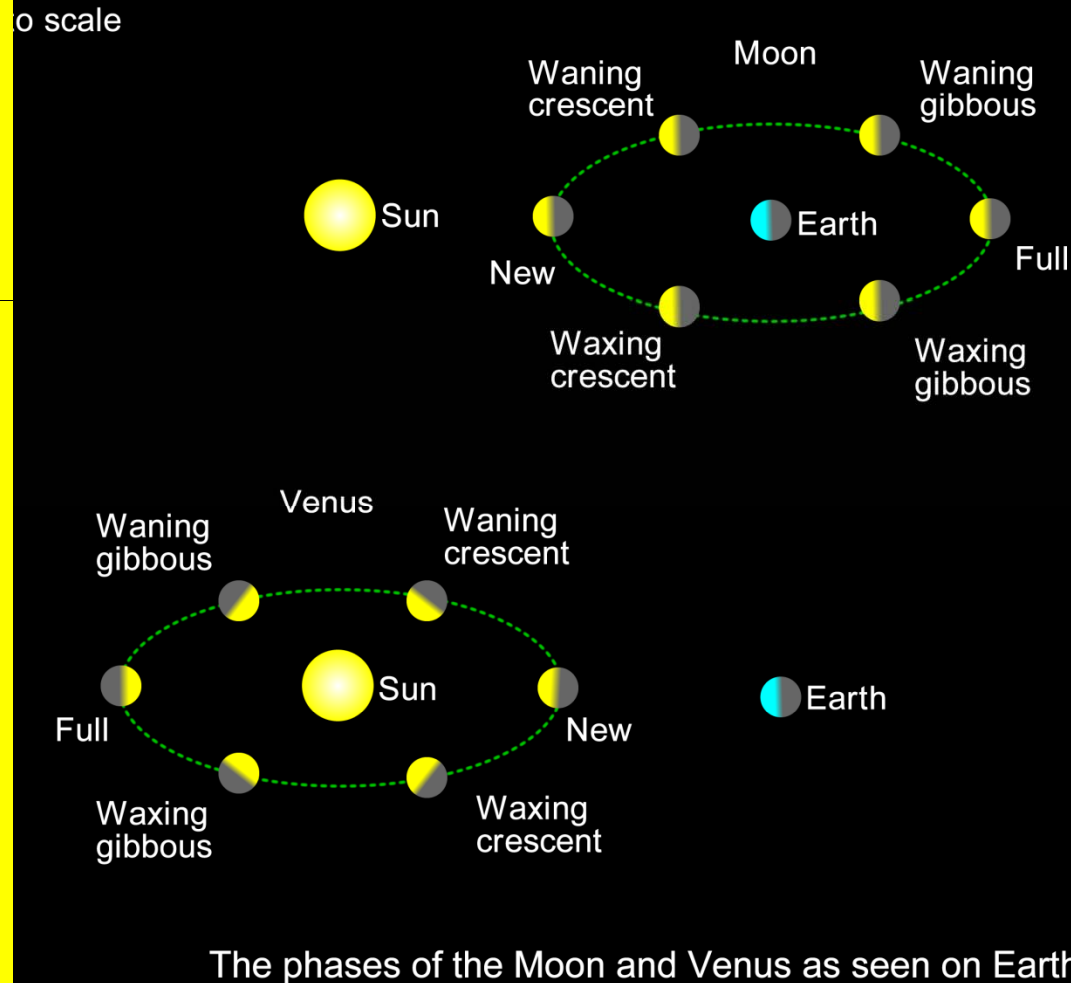
Venus

- Consider the two different versions of how Venus is predicted to move 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



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Topic 4: Scientific Methods

More data

- With better data Kepler realizes an even better description of the data is that all planet orbit the Sun in an ellipse, not a circle
- Sun-centered model now agrees with the high-quality observed data, Earth centered 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”)

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

B

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

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

PLRQ Unit 1 Grades

- Criteria for Pass/Revise grades for CPR Unit 1 are described in the FAQ and the Lecture notes
- Will post the grades in eCampus *after* we are done with re-grade requests
 - You should go to eCampus to make sure you got the grade you think you did. Many people are surprised.
- Let us know if you think you were misgraded or we gave you the wrong grade
- *What do you do if your eCampus grade says "Revise"?*
 - See <http://people.physics.tamu.edu/toback/109/109FAQ.shtml#CPRGrades>

Prep For Next Time - L5

- **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**

- Stage 1 for Unit 2 due before Class
- Stage 1 in CPR for Unit 1 Revision will be assigned after grades are posted

- **End-of-Chapter Quizzes**

- If we finished Chapter 4 then End-of-Chapter Quiz 4 (else just Chapter 3)

Prep For Next Time - L6

- **Reading:**
 - BBBHNM Unit 2
- **Pre-Lecture Reading Questions**
 - eCampus quizzes (all 6)
 - Unit 1 Revision (if needed): Stage 1 before Class
 - Let us know if you were misgraded
 - Unit 2: Stage 2 due before class
- **End-of-Chapter Quizzes**
 - If we finished Chapter 4 then End-of-Chapter Quiz 4 (else just Chapter 3)



End of Lecture

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Introduction
Topic 4: Scientific Methods

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Clicker Quiz

A muon is observed to decay into an electron and two different neutrinos. Is a muon considered a fundamental particle?

- a) No, because it has the electrons and neutrinos inside it so it can't be fundamental.
- b) Yes, because it isn't composed of electrons and neutrinos, it just decays into them
- c) No, because fundamental particles can't decay