Big Bang, Black Holes, No Math

ASTR/PHYS 109

Dr. David Toback

Lectures 15, 16 & 17
Was Due for Today – L17

- Reading:
  - (Unit 2)
- Warmup Quizzes:
  - (Warm-up Quiz Part 4/Peerceptiv)
- Pre-Lecture Reading Questions Quiz:
  - (Unit 2 Text Submission and Unit 2 Quiz)
- End-of-Chapter Quizzes
  - (Chapter 6)
- Papers
  - The text of Paper 1 will be due in TurnItIn (in eCampus) and Peerceptive by 11:55PM on Friday Feb 21\textsuperscript{st}
  - Reviews and back-evaluations will be available as your fellow Aggies move through the system.
  - You are required to finish each Review within 72 hours after being assigned it. You are required to finish each Back-evaluation within 72 hours of it being completed for you. Not doing them on time will cause you to get a zero, and you’ll have to start over.
  - You need to pass the Review and Back-Evaluation stage to get a grade
  - You can submit a revision at any time, but you have to do a new set of Reviews and Back-evaluations for it to count
Paper 1

- Abbreviated description: What is the evidence for Dark Matter?
  - More detail on Peerceptiv, you REALLY need to read ALL the instructions
- Explain it to someone who isn't taking the class (no jargon)
- Follow the required Format:
  - Introduction paragraph
    - Lawyers opening arguments at a Trial
  - ~1 paragraph per piece of evidence/talking point
    - The case at a Trial
  - Conclusion paragraph that ties it together
    - Lawyers closing arguments at a Trial
- Help:
  - Example of good paper

http://people.physics.tamu.edu/toback/109/WritingAssignments/samplepaper.shtml

Holes, No Math  Topic 3: Quantum Mechanics and Atoms
Assignment Description

All the writing assignments have components that are very similar (for example you need to submit to both Peerceptiv AND to Turnitin), but there are parts that are particular for only this paper. We begin with the details of this paper.

Overview of Paper 1: Representative Bill Flores is meeting with a high school class in Waco to talk about science. He needs a short and sweet description of the evidence for dark matter. He has asked his Chief of Staff to help him prepare for his presentation.

The Assignment: You are working in the Chief of Staff’s office as a summer intern. The Representative is going to a hearing from a prominent cosmologist later and wants to know basic information about Dark Matter beforehand. Because you have taken a course that discusses this question, you are tasked with this assignment. Your job is to create a “short and sweet” paper that summarizes and explains the reasons/evidence for dark matter in plain language so that both the Chief of Staff and the representative can understand them. Said differently, based on your report, both need to be able to answer this important question quickly and intelligently.

Big Picture of how your paper should be organized (Note: This portion is identical for all assignments):

- Your document needs to include the important pieces of evidence. Follow the above and below instructions about what structure it needs to be in as well as include the things we are explicitly requiring for this paper (see below). You will be graded on your ability to do it all.
- Your introduction must make it clear what it is really about (in this case providing the evidence for dark matter), mention the evidence/talking points to be discussed as well as outline the argument that will be used in the paper.
- The paper must be clear and concise, with a proper essay format. It should be between 400-750 words, although you are allowed to make it longer, more

Some additional comments particular to this assignment (including some, but not all, of what you WILL need to do in the paper):

- If you are going to use words or phrases like “dark matter” you need to explain them clearly.
- You need to clearly describe some of the aspects of gravity and how objects orbit around each other due to the attraction of gravity. Note: This is NOT a paper about the difference between Newton and Einstein, or their theories. This is not about a proof of General Relativity. It is about Dark Matter and the evidence for it. You may assume that General Relativity is correct, but you cannot assume that your reader knows anything about it. You do not need to use the phrase General Relativity explicitly.
- Since this is NOT a paper about Einstein’s version of gravity vs. Newton’s, nor the history, neither a description of the people or history are needed. Indeed they should be avoided as they will take away from the “short and sweet” nature of the paper and the main point, which is about evidence for dark matter.
- You need to clearly describe how objects orbit the Sun as evidence for our understanding of gravity.
- You need to clearly describe how stars orbit in the outer reaches of galaxies and how this provides evidence.
- You need to clearly describe how the lensing of galaxies provides evidence.
- While you may choose your number of body paragraphs, the typical writer will choose one paragraph per piece of evidence; you could also include a setup paragraph explaining why physics then the reference to that evidence paragraph.
- Notes: The above is not THE evidence, but is part of what you need to help describe the evidence. Said differently, if you do NOT have those things, you have not provided the evidence.
Reminders about Papers

Re-read pages 48-52 of the Course Organization Document

Overview of the story

- Big things are made from LOTS of small things
- Small things: The Fundamental Building Blocks of Nature
  - What is the “stuff” in atoms
- ElectroMagnetism (electric charge)
  - What holds electrons and protons together
- Quantum Mechanics
  - Why atoms form the way they do
  - Electron in orbits
  - Atoms absorbing and emitting photons (light)

- Different TYPES of Atoms
  - The Strong Force
  - Keeping protons and neutrons together (atomic nuclei)
  - Nuclear Physics and Chemistry
  - Different atoms → Different light...
- Studying the Stars using their light
  - Spectral lines of the atoms
  - Atomic “fingerprints”
  - The light we see from the stars
Quantum Mechanics

• How do we explain these weird features that we observe about Atoms?

• Quantum Mechanics!

• LOTS we COULD say about QM, but since we could spend years on this we’ll focus only on the most important points you need
Quantum Mechanics

- All particles are both particles AND waves
  - Saw this for photons
  - Turns out to be true for electrons also!
Energy of Electron Waves

Small energy electron have large wavelengths.
Small wavelength electrons have large energy.
Quantized Numbers

- This has big implications for electrons in atoms
- The electron “wave” has to go all the way around an exact number of wavelengths
  - Whole (Integer) number of wavelengths

http://bigbang.physics.tamu.edu/Animations/SignWave_atom.gif
Only Orbits with Specific Wavelengths Work

- The electron “wave” has to go all the way around
- Can have one peak/trough, two peaks/troughs, three peaks/troughs etc...
  - A quantized number
  - The **Quantum** in **Quantum Mechanics**
Only certain wavelengths work?

- If only certain wavelengths work, only certain energies are allowed.
- This means electrons can ONLY be in one of the available energy states, and at certain distances from the nucleus.
  - Keep atoms from collapsing! (Good!)
  - “Quantizes” the interactions with light i.e. only some energy photons interact with atoms.
Only Orbits with Specific Wavelengths Work

- **Lower Energy** and closer to the nucleus
- **Higher Energy** and further away from the nucleus

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Physics We Need

Topic 3: Quantum Mechanics and Atoms
Energy and Distance from The Nucleus

Higher Energy and further away from the nucleus

Lower Energy and closer to the nucleus

Permitted Radii

Only these levels are allowed!
Next:
How we “SEE” atoms
How Photons Interact with an Atom

• To understand better how photons interact with the stuff in an atom, “how we’ll SEE atoms”, we need to say a bit more about Energy and about Quantum Mechanics

• Lots of different ways they can interact... start with the simple interactions
Simple: Photon-Atom Collision

- **Before**: Start with a high energy photon and a low energy atom
- **After**: Lower energy photon, higher energy atom (like two billiard balls colliding)
- Same TOTAL energy before and after collision
  - Conservation of Energy
Clicker Question

After a collision with a stationary atom, the energy of a photon is

a) Higher
b) Lower
c) Same
Clicker Question

After a collision with a stationary atom, the speed of a photon is

a) Higher  
b) Lower  
c) Same
Clicker Question

After a collision with a stationary atom, the wavelength of a photon is

a) Longer
b) Shorter
c) Same
Prep For Next Time - L17

- **Reading:**
  - (Unit 2)
- **Warmup Quizzes:**
  - (Warm-up Quiz Part 4/Peerceptiv)
- **Pre-Lecture Reading Questions Quiz:**
  - (Unit 2 Text Submission and Unit 2 Quiz)
- **End-of-Chapter Quizzes**
  - If we finished Chapter 7 then End-of-Chapter Quiz 7a & 7b (else, just through Chapter 6)
- **Papers**
  - The text of Paper 1 will be due in TurnItIn (in eCampus) and Peerceptive by 11:55PM on Friday Feb 21st
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Full set of Readings So Far

- **Required:**
  - BBBHNM: Chap 1-9

- **Recommended:**
  - BHOT: Chap. 1-6, 9 and 11 (117-122)
  - SHU: Chap. 1-3, 6 and 7 (up-to page 153)
  - TOE: Chap. 1