Big Bang, Black Holes, No Math
ASTR/PHYS 109
Dr. David Toback
Lectures 7, 8 & 9
Prep For Today (is now due) – L9

No one in back 5 rows and no laptops or cellphones

We have gotten ahead of the tentative schedule, so we will extend due dates

- iClicker:
  - Make sure to register by clicking on the link in eCampus (will be in the Home area)
- Reading:
  - (BBBHNM Unit 2/Chapters 5-9)
  - Recommended Reading:
- Warmup Quizzes:
  - Warm-up Quiz Part 4 (Peerceptiv): Postponed – Will assign soon
- Pre-Lecture Reading Questions:
  - Unit 2 Text Submission: Postponed to be due today before class
    - Submit your 4 questions to TurnItIn in eCampus (under Turnitin Assignments) to “PLRQ Unit 2”
    - Only submission was required today. Submit ONLY 4, need all 4 to be excellent to pass
    - Pass/Revise assignment:
      - Most grades posted: 10 = Pass, 5 = Revise
      - If you don’t pass post to “PLRQ Unit 2 Revision”. If you don’t pass a second time, submit to “PLRQ Unit 2 – Revision 2”
      - Final due dates will be assigned soon. we will set up dates for Revisions after you get Feedback
  - Unit 2 Quiz: Will open up for you in eCampus AFTER they are graded and you get a Pass. Also requires Unit 1 and EOC 3. Final due date not yet assigned
- End-of-Chapter Quizzes
  - Chapter 4: Due date pushed back to be due before class today
The Topics

• Some stuff we need learn a little 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
• We won’t spend too long on each, just enough to get back to the big picture...
• Since there is no perfect way to present them (they all tie into each other) we’ll just start somewhere and get going...
Outline for Light

1. Light is a wave...
2. ...and a particle
3. Light is REALLY fast, but does have a finite speed
4. Doppler effect
Light is more than the colors we see

You may have thought of Radio Waves and X-rays as different things, but they are just light with different wavelengths.
What do we know about photons?

- Photons are a type of fundamental particle
  - Like an electron or a quark
- Higher energy → smaller wavelength
- Has no mass, but does have energy
  - Aside for those of you who are interested: It has momentum
A Particle **and** a Wave

- Actually it’s really more complicated than that
- Light is both a wave **and** a particle... can describe it as either... it has properties of both
Part 3: The Speed of Light

“Not just a good idea, it’s the law!”

SPEED LIMIT
3x10^8 MPS
SPEED CHECKED BY RADAR
Light has a Finite Speed

Light has been measured to have a specific speed

- $3 \times 10^8$ meters per second
- 186,000 miles per second
- 1 foot per nanosecond

- Really FAST
- The fastest speed allowed
Maxwell’s Theory

• 1865: James Clerk Maxwell and others showed light was a wave and calculated its expected speed

• Gave the observed speed of light!
  - Confidence that his theories were correct
  - We can now measure the speed of light to incredible precision

299,792,458 m/s
A Light-Year

- Some things are so far away that it’s easier to express their distance in light-years.
  - Light travels at $3 \times 10^8$ meters/second and there are about $3 \times 10^7$ seconds/year.
  
  $\Rightarrow \sim 10^{16}$ m in a light-year.
A Time Machine-Like Viewer

- The Sun is 8 light-minutes away, so we are seeing the Sun as it was 8 minutes ago.
- If a star is a light-year away and it must have taken a year for the light to get to us, we are observing the star the way it was a year ago.
- If we look at light from something billions of light-years away, we are “observing” things that happened billions of years ago.
Part 4: The Doppler Effect

• 1842: Christian Doppler

• What happens to waves when the “thing” creating the waves is moving towards us?

  – Or we’re moving towards it?
Example with Sound From a Stationary Car

The sound we hear is actually a wave

- Sound waves
Now the Car is Moving

Things moving away have their waves “stretched”

Things coming at us have their waves “scrunched up”
The Doppler “Effect” for Cars

A car blaring its horn and going past you will give the famous “Eeeeeeee-Yowwwwwww” sound

Hears a **Lower** Pitched Sound

Hears a **Higher** Pitched Sound
Prep For Next Time – L9

No one in back 5 rows and no laptops or cellphones

We have gotten ahead of the tentative schedule, so we will extend due dates

- iClicker:
  - Make sure to register by clicking on the link in eCampus (will be in the Home area)
- Reading:
  - (BBBHNM Unit 2/Chapters 5-9)
  - Recommended Reading:
- Warmup Quizzes:
  - Warm-up Quiz Part 4 (Peerceptiv): Postponed - Will assign soon
- Pre-Lecture Reading Questions:
  - Unit 2 Text Submission: Postponed to be due today before class
    - Submit your 4 questions to TurnItIn in eCampus (under Turnitin Assignments) to “PLRQ Unit 2”
    - Only submission was required today. Submit ONLY 4, need all 4 to be excellent to pass
    - Pass/Revise assignment:
      - Most grades posted: 10 = Pass, 5 = Revise
      - If you don’t pass post to “PLRQ Unit 2 Revision”. If you don’t pass a second time, submit to “PLRQ Unit 2 – Revision 2”
      - Final due dates will be assigned soon. we will set up dates for Revisions after you get Feedback
  - Unit 2 Quiz: Will open up for you in eCampus AFTER they are graded and you get a Pass. Also requires Unit 1 and EOC 3. Final due date not yet assigned
- End-of-Chapter Quizzes
  - (Chapter 4)