Big Bang, Black Holes, No Math

ASTR/PHYS 109

Dr. David Toback

Lectures 2 & 3
Prep For Today (is now due) - L3

- Reading (If you haven’t already):
  - Required: BBBHNM: Chapter 1-4
  - Recommended: (BHOT: Chap. 1-3, SHU: Chap. 1-2, TOE: Chap. 1)

- Pre-Lecture Reading Questions:
  - PLRQ Unit 1: Was due before class
    - 4 questions from Unit 1 (Chapters 1-4) or recommended reading
    - Submit to TurnItIn. Make sure you get an email receipt!
    - Send mail to 109help if you need an extension

- eCampus Stuff:
  - All Warm-up quizzes (including AMS): Was due before class
    - Extensions granted if needed. Email 109help
  - If you need additional attempts, follow the instructions or fill out the worksheet
    - [How to get to your old submission information](http://people.physics.tamu.edu/toback/109/ECampus_Quiz_Instructions_and_Help.pdf#page=3)
  - We did not finished Chapter 2. Will assign End-of-Chapter quiz 2 at the end of class
Introduction

Topic 2: Going Big

Big Bang, Black Holes, No Math

The Outer Planets

• Jupiter, Saturn, Uranus and Neptune

• Again all move in the same direction!

Look from the side: All move in the same plane!

Another clue?

10^{13} meters!
The Whole Solar System

• Mostly empty space, but some stuff
• Typically only 1 hydrogen atom per cubic centimeter (size of a standard die)
• There is other stuff we’ll talk about like cosmic background radiation and dark matter

10^{14} meters!
Mostly Empty Space

- More interstellar space
- The small circle is the orbit of Pluto

$10^{15}$ meters!

$\sim$ trillion miles

Big Bang, Black Holes, No Math

Introduction

Topic 2: Going Big
More Empty Space

On this scale the solar system is a tiny dot

10^{16} meters!
The Nearest Stars

- Alpha Centauri A, Alpha Centauri B and Proxima Centauri
- Proxima Centauri is the closest at $4.0 \times 10^{16}$ meters from the sun
- Same as 4.2 light-years away
  - (it takes light 4.2 years to get there)
  - 1 light-year is about 25 trillion miles

10$^{17}$ meters!
The Brightest Stars in Our Sky

- Only the brightest stars are shown
- Almost 2000 in reality

10^{18} meters!
\sim Quadrillion miles
Next Round...

• Again, only the brightest

• \( \sim 2 \) million total in this space

10^{19} \text{ meters!}
The Milky Way

So many stars that they appear to be “clouds” of stars.

Much of the space between stars contains “Dark Matter” we can’t see directly.

- About 5 times more mass in Dark Matter than the stars.

10^{20} meters!
Our Galaxy

- Central Bulge
- Spiral arms
- The sun is in one of the spiral arms, ~1/3 of the way inward from edge of the disk towards the center

10^{21} meters!
~Quintillion Miles

Our Galaxy

• Central Bulge
• Spiral arms
• The sun is in one of the spiral arms, ~1/3 of the way inward from edge of the disk towards the center

10^{21} meters!
~Quintillion Miles
Two Different Views of our Galaxy

Looking down at the center

100,000 ly

Looking at it from the side

50 times wider than tall!

2000 ly

Our Sun

Our Sun

Very flat... like our Solar system. Outer stars rotating the same direction... like our solar system

Could the galaxy and the solar system have something in common? Created in similar ways?

Big Bang, Black Holes, No Math
Looking at the “Mass” in the Galaxy

- In the previous picture, we showed the location of the stars.
- There is a LOT more mass in the dark matter than in the stars.
  - More on dark matter in Chapter 6.
Our Neighbor Galaxies

- There are dwarf galaxies just outside our own
- Didn’t even know there were other galaxies until the 1920’s

10^{22} meters!
The Full Size Neighbors

• Many galaxies nearby
• Galaxies are often found in “clusters”
  - Can be just a few, up to thousands

Big Bang, Black Holes, No Math

Introduction
Topic 2: Going Big
The Local Group

• Our galaxy (the Milky Way) is part of a cluster of galaxies called the “Local Group”

• These distant galaxies are moving away from us VERY quickly
  - Big Bang

10^{24} meters!
~Sextillion miles
Our “Observable” Universe

• $10^{11}$ galaxies (about the same number of stars in our galaxy)

• We’re on the fringe of a very large cluster of galaxies called the “Local Supercluster”

• Don’t know the true shape and size of the universe so we can’t go any further

10^{25} meters or 10^{22} miles across
Lecture on Chapter 2 now complete
Prep For Next Time - L3

- Reading (If you haven’t already):
  - Required: BBBHN: Chapter 1-4
  - Recommended: (BHOT: Chap. 1-3, SHU: Chap. 1-2, TOE: Chap. 1)

- Pre-Lecture Reading Questions:
  - PLRQ Unit 1: Was due before class
    - 4 questions from Unit 1 (Chapters 1-4) or recommended reading
    - Submit to TurnItIn. Make sure you get an email receipt!
    - Send mail to 109help if you need an extension
    - Will start grading soon

- eCampus Stuff:
  - All Warm-up quizzes (including AMS): Was due before class
    - Extensions granted if needed. Email 109help
  - EOC 2
  - If you need additional attempts, follow the instructions or fill out the worksheet
    - How to get to your old submission information
      http://people.physics.tamu.edu/toback/109/ECampus_Quiz_Instructions_and_Help.pdf#page=3
Useful Links

- Course Website
  http://people.physics.tamu.edu/toback/109
- Course Organization
- Class Schedule
- eCampus Instructions
  http://people.physics.tamu.edu/toback/109/ECampus_Quiz_Instructions_and_Help.pdf
- PLRQ Instructions
- Lecture Notes
  http://people.physics.tamu.edu/toback/109/Lectures/
- Papers and Peerceptiv
  http://people.physics.tamu.edu/toback/109/WritingAssignments/Papers_and_Peerceptiv.pdf
- FAQ Page
Full Set of Readings So Far

- **Required:** BBBHNM: Chap 1-4
- **Recommended:**
  - BHOT: Chap. 1-3
  - SHU: Chap. 1-2
  - TOE: Chap. 1