

Homework 2: Due Thursday Sept. 21
WWW links at www.astro.psu.edu/users/charlton/Astro20/HW

READING 1: <http://imagine.gsfc.nasa.gov/YBA/M31-velocity/intro.html>

READING 2: <http://www.sciam.com/article.cfm?chanID=sa007&articleID=0009F0CA-C523-1213-852383414B7F0147&pageNumber=1&catID=2>

1. (4 points) Age of the Universe

a) If $H_0 = 75 \text{ km s}^{-1} \text{ Mpc}^{-1}$ and if we assume a constant value over all past time, what is the age of the Universe? Give your answer in years.

b) In a universe with accelerating expansion (Hubble constant increasing with time) is the age larger or smaller than for part a? Explain why.

2. (8 points) The Distance Scale - for this problem please go to the page listed as READING 1 and fully explore the three experiments listed. The goal is to explore three techniques and to determine which one is best for determining the distance to the Andromeda galaxy, M31. Once you have explored the page, answered the quiz questions, and succeeded with each activity please answer the following:

a) How long does it take light to travel from the Andromeda galaxy to the Milky Way galaxy?

b) Walking into your basement one night, you notice that you can see only 10 feet with your trusty 50 Watt flashlight. How strong must your flashlight be in order to see the full 20 feet of your basement?

c) While driving your car you are stopped for running a red light. You tell the police officer that because of the Doppler shift, the red light (6500 \AA) was blueshifted to a green light (4700 \AA) as you drove towards the stop light. How fast would you have to be going in order for this to be true?

d) Traveling in your spaceship, you observe a distant galaxy that is 870 million light years away and is moving away from you at a speed of 20,000 km/s. How fast would you have to travel in order to be able one day to catch up to a galaxy twice as far away?

e) Which of the three techniques to measure velocity is the best technique to determine the recessional velocity of M31.

f) Explain what was wrong with the first of the other two techniques.

g) Explain what was wrong with the second of the other two techniques.

3. Expansion of the Universe (Based on READING 2)

a) Are there extra dimensions in our universe and are these dimensions necessary to accommodate our expanding three dimensional space?

b) Was the entire universe ever the size of a grapefruit or just the observable universe? What is meant by the term observable universe?

c) Why doesn't it violate Einstein's Special Theory of Relativity that distant galaxies are receding at velocities greater than the speed of light?

d) The most distant object we can see is 46 billion light years away. The age of the universe is about 14 billion years. How is this possible since light can only travel at the speed of light?

4. (6 points) Essay Question. The universe is expanding because space is being added everywhere in between the galaxies. But what is the universe expanding into? Is there a center of the universe and where is it? Is there a boundary of the universe and, if so, what is beyond it? Is it easier for you to visualize a boundary with no matter or space beyond it or to imagine infinite space and matter? Your answer should be 1-2 pages.

FINALLY, YOU MUST WRITE A QUESTION TO THE PROFESSOR!

5. (4 points) Question to the professor. Write a question about something that you are still wondering about. This is required. I will answer your question on your graded homework.