

AS102 - Homework Assignment #8

Due: no later than 5:00pm on Friday, April 16, 2010

Be sure to put your homework in the right slot of the Homework Box

Chapter 21, pg. 677

Quick Quiz questions (8 points each): 23, 24, 25

Other Questions

Quick Quiz questions (8 points each)

1. In the late 1980's and early 1990's there was a raging debate between astronomers about the value of H_0 . A group of astronomers was convinced that $H_0 = 50$ km/s/Mpc and another group was equally convinced that the value was $H_0 = 100$ km/s/Mpc. How would this debate have affected our estimate of the age of the universe? (a) a universe with $H_0 = 100$ km/s/Mpc should be younger than a universe with $H_0 = 50$ km/s/Mpc, (b) a universe with $H_0 = 100$ km/s/Mpc should be older than a universe with $H_0 = 50$ km/s/Mpc, (c) the value of H_0 has nothing to do with the age of the universe, so it would have had no effect
2. Which of the following is not directly predicted by the Big Bang theory? (a) the universe had a specific beginning, (b) the universe is expanding, (c) the relative number of elliptical and spiral galaxies in the universe
3. Which of the following is a correct statement according to modern physical cosmology? (a) the universe is expanding to fill space, (b) time exists outside the universe, (c) space does not exist outside the universe
4. How large is "large enough" to guarantee that the Cosmological Principle applies in our universe? (a) 1,500 light years, (b) 1.5 million light years, (c) 1.5 billion light years

Quantitative Problems:

5. **Cold hydrogen gas.** Cold atomic hydrogen gas is known to emit radio light with a rest wavelength of 21 cm. Cold atomic hydrogen gas is also known to be found in many distant galaxies. Consider a galaxy that is located at a distance of 100 Mpc and which contains cold hydrogen gas. **(22 points)**

- a) To what frequency would you need to tune a radio telescope in order to detect the radiation that is emitted by the cold hydrogen gas in the galaxy? (Assume that $H_0 = 72$ km/s/Mpc for your calculation.)
- b) Suppose that last night you looked at this galaxy and noticed nothing out of the ordinary, but tonight you look at this galaxy and you see a supernova in the outskirts of the galaxy. How long ago did the star actually explode? How does this compare to the lifetime of a human (approximately 100 years)? How does this compare to the age of the earth (approximately 4.5 billion years)?

6. **Expanding Cosmologists.** If her body were not held together by chemical bonds, a cosmologist who is freely-floating in space would be subject to expansion due to Hubble's Law. Suppose that at the present day the cosmologist has a height of 1.65m, and further suppose that the expansion

rate of the universe is constant over time with a value of Hubble's constant equal to 71 km/s/Mpc . Your task in this problem is to estimate how long it would take the cosmologist's height to increase by 10%, simply due to expansion by Hubble's law. **(22 points)**

- a) Use Hubble's law to compute the speed of the cosmologist's toes, as seen from the top of her head, when the cosmologist is at her starting height of 1.65m. Express your final answer in meters per second
- b) How tall will the cosmologist be once her height has increased by 10%? Express your final answer in meters.
- c) Use Hubble's law to compute the speed of the cosmologist's toes, as seen from the top of her head, after her height has increased by 10%. Express your final answer in meters per second.
- d) Compute the average speed at which the cosmologist's toes are moving away, as seen from the top of her head (i.e., the average of the speeds that you found in parts a) and c).
- e) Compared to the starting distance of 1.65m, by how much have the cosmologist's toes moved as she stretched (again, as seen from the top of her head)?
- f) Use your answers from parts e) and d) to compute the length of time it has taken the cosmologist to grow by 10%. Express your final answer in units of years.
- g) On a "human" time scale is the expansion of the universe fast or slow? Why?

Notes:

- When you answer the Quick Quiz questions, write down the letter for your answer (e.g., "a", "b", or "c") **AND** explanation for why the letter you chose is the correct answer. Your explanation of your answer is worth 5 of the 8 points for each question.
- On the quantitative problems **show all of your work**. If you just write down an answer and don't show how you got it, you will receive a grade of zero.
- Be sure to include **units of measurement** as appropriate to your solution for quantitative problems.
- If a quantitative problem asks you to "compare" two values, you should **compute a ratio**.
- You may need to use the book to look up some numbers to solve the quantitative problems.