Physics 131: Survey of the Universe
Spring 2004
Prof. Michael S. Vogeley
Homework assignment 8 (LAST ONE!)

Due at the beginning of class, 12:30 p.m. Thursday, June 3. Please write your work and answers on a separate sheet of paper, with your name at the top and all pages stapled together.

DON'T FORGET TO TURN IN PROBLEM 5 FROM HW 7.

1. Expansion of the Universe

(a) At what distance (in Mpc) are galaxies receding from us at half the speed of light? (Assume that the Hubble constant $H_0 = 70\mathrm{km/s/Mpc}$).

(b) Suppose you observe a supernova in a spiral galaxy that is 10 Mpc away. At the location of the supernova, the galaxy rotates with a circular velocity $v = 200$km/s. What is the apparent recession velocity v AND redshift z of the supernova? (Hints: Assume that you see the galaxy edge-on, with the supernova rotating away from you in the disk of the galaxy. Use the approximation $v = cz$ together with Hubble's law and combine the effects of the orbital and cosmological velocties.)

2. Age of the Universe

The Hubble constant, H_0, measures the expansion rate of the universe. It also gives us a rough estimate of the age of the universe, if put into the right units.

(a) What is the age of the universe if $H_0 = 70\mathrm{km/s/Mpc}$? (Hints: Read section 26.2 and rewrite Hubble's constant in consistent units. That is, convert Mpc to km.)

(b) What is the age of the universe if $H_0 = 500\mathrm{km/s/Mpc})$, as Hubble first incorrectly measured it?

(c) Before Hubble discovered the expansion of the universe, geologists had used radioisotope dating to estimate that the Earth is 4.5 billion years old. Compare that age to your answer in (b). What problem do you notice here?

3. Cosmic Microwave Oven

We are bathed in a Cosmic Microwave Background, which we measure to have a temperature of $T = 2.7$K. This is the average temperature of the universe today. How much smaller (by what factor) was the universe when the background radiation was hot enough to boil water? (Hints: Recall that the expansion of the universes stretches wavelengths of light. Next, recall a formula that relates temperature and wavelength of light. And note that $0\mathrm{C} = 273\mathrm{K}$, thus the boiling point of water is 373 K.)

4. Evidence for the Big Bang

Write a couple of sentences that describe how each of the following observations support the big bang theory. Be specific: What do we observe in each case? What does the Big Bang theory predict in each case?

(a) Redshifts of distant galaxies

(b) Cosmic Microwave Background

(c) Abundances of Light Elements

5. Future of the Universe

Last homework problem of the course: Write a brief (one paragraph) story about what you think will happen in the *future* of the universe. Extrapolate as far into the future as you dare and be creative.