Fall 2005 ASTR 1120-001 General Astronomy: Stars & Galaxies.
Problem Set 6. Due T 6 Dec

Your name:

Your ID:

Except for the tutorial, for which you should submit answers on line, please write your answers on this sheet, and make sure to *show your working*. Attach extra sheets if you need them. If you mess up, you can get another copy of the problem set at `http://casa.colorado.edu/~ajsh/astr1120_05/prob.html`.

1. Tutorial on Fate of the Universe

Go to `http://www.astronomyplace.com`, press on the Cosmic Perspective 3rd Edition icon, log in. You should already have joined our class 'cm651430', so that you can record your work and submit it for grade on line. Click on Tutorials, and do the tutorial on Fate of the Universe. You can redo the tutorial as often as you like, to improve your grade.

Your score should be recorded automatically, but as a double check against your score disappearing into a black hole:

My score was _____.

If you like, you can comment here on the tutorial:

2. Your space in the Universe

If the Universe is spatially flat, as suggested by the Cosmic Microwave Background, then its density equals the critical density, which according to the tutorial is about $10^{-26}\,\mathrm{kg\,m^{-3}}$. Estimate approximately how much volume you personally would fill if you were spread out to critical density. If this volume were a cube, roughly how long would be the side of the cube? Compare this distance to that of some familiar object.

I would occupy a volume of about _____ m^3.

This corresponds to a cube of side about _____ m.

This is about _____ times as big as _____ .

3. Recombination

The Cosmic Microwave Background is thought to have come to us from the epoch of Recombination, when hydrogen and helium in the Universe changed from being ionized to neutral atoms.

(a) Size of the Universe at Recombination

Wien's law states that the peak wavelength $\lambda_{\rm peak}$ varies inversely with the temperature, $\lambda_{\rm peak} \propto 1/T$. General relativity shows that the wavelength stretches in proportion to the cosmic scale factor, $\lambda_{\rm peak} \propto a$. If the temperature of the Cosmic Background was 3,000 K at Recombination, and is now 2.73 K, by what factor has the Universe expanded since Recombination?

Since Recombination, the Universe has expanded by a factor of _____ .

(b) Age of the Universe at Recombination

The cosmic scale factor a varies with time t approximately as $a \propto t^{2/3}$. If the current age of the Universe is about 14 Gyr, approximately how old was the Universe at the time of Recombination? [Hint: You will need to use your answer from part (a). Note that $a \propto t^{2/3}$ is strictly true only for a matter-dominated Universe, but it is not too bad an approximation in the real Universe.]

At Recombination, the Universe was _____ years old.