Astron 211 Problem Set 11

Given: Dec 6. Due: Dec 13 at the beginning of class

Homework Policy: You can consult class notes and books. Always try to solve the problems yourself; if you cannot make progress after some effort, you can discuss with your classmates or ask the instructor. However, you cannot copy other's work: what you turn in must be your own. Make sure you are clear about the process you use to solve the problems: partial credit will be awarded.
Reading: Kutner Chapter 17, 18, 19

Problem 1 Quasar number densities and lifetimes

From deep galaxy counts, it is estimated that there are about 40 billion galaxies in the observable universe (not including probable multitudes of dwarf galaxies too faint to observe). Assuming that the mean age of these galaxies is 10 Gyr, and that each one goes through an AGN episode once, with a mean duration of 10^8 yr, estimate the total number of quasars that we can see at any one time.

Problem 2 Matter and Energy Density in the Universe

Suppose that all of the baryonic (non-dark) matter in the universe were converted into energy in the form of blackbody radiation. Take the average density of matter to be $\rho = 4.17 \times 10^{-28}$ kg m^{-3}; this is the baryonic matter density found by the Wilkinson Microwave Anisotropy Probe (WMAP) studies of the cosmic microwave background radiation.

a. What would the temperature of the universe be in this situation? (Hint: Consider the energy density of blackbody radiation. You can then convert the energy density into a temperature using $u = aT^4$, with a on your sheet of constants.)

b. At what wavelength would the blackbody spectrum peak? Would we be able to see the sky glow due to this radiation?

Problem 3 Baryonic dark matter

Suppose that the universe were full of cats, each of mass $m_{\text{cat}} = 4$ kg and radius $r_{\text{cat}} = 0.3$ m.

a. If the cats were distributed uniformly throughout the universe, what mass density ρ of cats would be required to make the density equal to the current critical mass density? (Assume nonrelativistic cats.)

b. Given this mass density of cats and the average cat mass, what is the number density n of cats?

c. Given this number density of cats, how far on average would you be able to see in any direction before your line of sight intersected a cat?

d. In fact, we can see galaxies at a distance $d \approx c/H_0 \approx 4300$ Mpc. Does the transparency of the universe on this length scale place useful limits on the number density of intergalactic cats?