A Tour of Cosmology–II

(1) You will work your way to the profond implicatons of a sky being dark at night. You'll see that what seems to be *natural* state of affairs (the sky being dark at night) has some important consequences.

(a) What is meant by *luminosity* of stars?

(b) What is *flux*? Using luminosity, come up with a definition for the flux from a single star that is received by an observer a distance r away.

(c) Integrate the flux in part (b) overall space. What does the result tell you? Discuss at your table

(2) At your table discuss how the proposed resolution does solve Olber's paradox and discuss the consequences of the fact that the night is dark.

(3) We just defined what isotropy and homogeneous mean as applied to the universe. Let's probe these a bit.

(a) Sketch a universe that is homogeneous but *not* isotropic.

(b) Sketch a universe that is isotropic but not homogeneous

(c) At your table, come up with some reasons as to why isotropy and homogeneity are important in cosmology.

(4) In 1929, Edwin Hubble found that galaxies, generally, were redshifted more as a function of distance. Specifically, he found Hubble's law:

$$z = \frac{H_o}{c} r$$

where c is speed of light, r the distance to the galaxy, and H_o a constant (now called the Hubble constant.) The data turned out to be quite problematic because r is very difficult to obtain, however the functional relationship turned out to be correct.

(a) What are the units of H_o?

(b) What kind of function is z vs r?

(c) In the lecture it was stated that $v = z \times c$. Use this relationship and Hubble's law to find an expression relating the velocity of galaxy to its distance.

(d) The following table contains observational data. Create a plot of the data and then use the plot to find an estimate for the Hubble constant.

Distance (MPC)	Velocity(k/sec)	Distance (Mpc)	Velocity (k/sec)
2.0	94	19.5	1811
4.1	176	20.8	1923
6.0	271	25.0	2509
6.7	374	27.4	1611
7.2	753	29.3	2408
8.0	493	34.4	2568
18.5	1616	37.4	3238
18.7	1303	39.2	3822
19.0	1782	39.4	2629

(5) We just saw that galaxies are moving faster the further they are from each other via the relationship $v = H_o r$. Using $H_o = 70$km/(s Mpc), find the age of the universe in Gy.(1 Mpc $= 3.09 \times 10^{19}$ km; 1Gyr $= 3.2 \times 10^{16}$ seconds)

(6) Recap the important topics covered today. Compare and constrast your results with others at your table

Homework 01–Due Friday Jan 17

All Students

1. Problem 2.2
2. Problem 3.3
3. Problem 3.5

Additional Grad Student Problem(s)

4. Problem 2.4
5. The critical energy density at the present time is,

$$\epsilon_{c,o} = \frac{3c^2}{8\pi G} H_o^2.$$

   (a) Calculate $\epsilon_{c,o}$ in SI units using $H_o = 70$ km s^{-1} Mpc^{-1}. Since H_o is known to within 10%, express your answer for $\epsilon_{c,o}$ to with in 20% limits.

   (b) Convert your answer to units more often used in cosmology, GeV m^{-3}.

   (c) Find the equivalent mass density, $\rho_{c,o} = \epsilon_{c,o}/c^2$ in SI units.

   (d) Convert your answer to solar masses per Mpc^{-3}. A solar mass, $M_\odot = 1.99 \times 10^{30}$ kg