Ay 21 – Winter 2008 – Homework #2

Posted on Jan. 25, due by 1 pm on Friday, Feb. 1

(Return to the Prof., the TA, or to the Astronomy office, 211 Robinson)

As usual, the honor system applies as follows: You can discuss the problems among yourselves, how to go about them, but not derive the solutions jointly – everyone should work out their own.

Problem 1 (up to 50% of the credit in this homework):

For this problem you can either use Ned Wright's web calculator (linked on the class webpage),

http://www.astro.ucla.edu/~wright/CosmoCalc.html

or, for an *extra credit* (we'll increase your score for this problem by 50%), write your own program to integrate the appropriate equations from Friedmann-Lemaitre models. Either way, use your favorite graphing package to plot the results. Assume H_0 = 70 km/s/Mpc.

a. Compute the total comoving volume (in Gpc^3) and the present age (in Gyr) for a universe with $\Omega_\Lambda = 0$ (what Wright calls Ω_{vac}), as a function of Ω_m, in the range from 0 to 2, with a step of 0.1.

b. Ditto, but for a universe with $\Omega_m = 0$, as a function of Ω_Λ, in the range –1 to 1, with a step 0.1.

c. Ditto, but for a spatially flat model, as a function of Ω_Λ, in the range 0 to 1, with a step of 0.1.

d. Compute the *R(t)* curves, where *t* is the time since the big bang at a given redshift, for the universes with $[\Omega_m, \Omega_\Lambda] = [0,0]$, $[1,0]$, $[0,1]$ and $[0.3,0.7]$, each with about 10 – 15 time steps spaced roughly uniformly from here to the big bang.

Problem 2 (up to 30% of the credit in this homework):

a. Compute the energy density today, due to the cosmological constant, in erg/cm^3, assuming Ω_Λ = 0.7, and H_0 = 70 km/s/Mpc.

b. Compute the total amount of the corresponding energy enclosed within the sphere circumscribed by the Earth's orbit, and within the orbit of Pluto (taken here to be the rough boundary of the Solar system, despite its sad demotion), say R_{PL} = 40 au.

c. Compare (a) with the average energy density of sunlight with these two spheres.

d. Compare (b) with the potential energies of Earth and Pluto due to the Sun's gravity. Do you expect the cosmological constant to play a significant role in the dynamics of the Solar system?

Problem 3 (up to 20% of the credit in this homework):

The surface brightness Σ of an astronomical object is defined as its observed flux divided by its observed angular area; thus, $\Sigma \propto f/(\delta\theta)^2$. For a class of objects which are both standard candles and standard yardsticks, what is Σ as a function of redshift? Would observing the surface brightness of this class of objects be a useful way of determining the value of the deceleration parameter q_0? Why or why not?