Ay 21 – Winter 2017 – Homework #2
Posted on Jan. 20, due by 3 pm on Friday, Jan. 27
(Return to the Prof., or to the TA)

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 (5/10 points):
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 extra 3 points), 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 $\Omega = 0$ (what Wright calls $\Omega_{vac}$), as a function of $\Omega_m$, in the range from 0 to 2, with a step of 0.1. [1 point]
b. Ditto, but for a universe with $\Omega_m = 0$, as a function of $\Omega_{\Lambda}$, in the range $-1$ to 1, with a step 0.1. [1 point]
c. Ditto, but for a spatially flat model, as a function of $\Omega_{\Lambda}$, in the range 0 to 1, with a step of 0.1. [1 point]
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. [2 points]

Problem 2 (5/10 points):

a. Compute the energy density today, due to the cosmological constant, in erg/cm$^3$, assuming $\Omega = 0.7$, and $H_0 = 70$ km/s/Mpc. [1 point]
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. [1 point]
c. Compare (a) with the average energy density of sunlight within these two spheres. [1 point]
d. Compare (b) with the potential energies of Earth and Pluto due to the Sun’s gravity (look up their masses on line). Do you expect the cosmological constant to play a significant role in the dynamics of the Solar system? [2 points]