PHYS 475 (F 14): PROBLEM SET 4

DUE THU Oct 16, 2014 (at the beginning of class)

Consider the list of cosmological models consisting of matter and vacuum energy ($w = -1$) only (neglect radiation), all with $H_0 = 70$ km/s/Mpc.

Name	$\Omega_{m,0}$	$\Omega_{v,0}$
Concordance	0.3	0.7
Critical Matter	1.0	0.0
Low Density	0.3	0.0
Empty	0.0	0.0
Vacuum Only	0.0	1.0
Loitering	0.30	1.713
Bounce	0.1	3.0
Crunch	3.0	0.0
Crunch with Vacuum	3.0	0.1

Numerically solve the necessary equations to obtain $a(t)$. You may use any method you like (code such as Python, C++ or MATLAB, or Maple/Mathematica). Include a printout of your code with your results.

Tip: It may be easiest to start at $t = t_0, a = 1$ and work in both directions: backwards to earlier t and forwards to later t and then paste both solutions together.

1. Generate plots of a as a function of t (in Gyr) where all models intersect at t_0 and $a = 1$. For each of the following sets of models, plot all $a(t)$ curves in the set on the same plot and label them.

   (a) Concordance, Critical Matter, Empty, Low Density & Bounce. This plot's axis should range from $t_0 - 15$ Gyr to $t_0 + 10$ Gyr.

   (b) Critical Matter, Empty, Vacuum Only & Loitering. This plot should range from $t_0 - 80$ Gyr to $t_0 + 10$ Gyr.

   (c) The two "Crunch" models. This should range from $t_0 - 10$ Gyr to $t_0 + 50$ Gyr.

2. From your numerical solutions:

   (a) What is the age of the Universe for each model that has a bang (i.e. $a = 0$ is part of the solution). Give your answers in a table. What about the Vacuum-only Universe?

   (b) For the Bounce/Crunch models, at what time do these solutions reach maximum and minimum? What are the corresponding values of a?

   (c) For each Universe: Suppose that a galaxy is observed at redshift $z = 1$. How long ago in the past was the light from that galaxy emitted? Give your answers in a table.

BONUS: include a model where $\Omega_m = 0.3$, and $\Omega_{DE} = 0.7$, but where the "Dark Energy" component has $w = -0.9$.