PHY 375
Homework 3
(Due by beginning of class on Wednesday, April 25, 2012)

Submit neat work, with answers or solutions clearly marked by the question number. Unstapled, untidy work will be charged a handling fee of 20% penalty. Writing only an answer without showing the steps used to get to that answer will fetch very few points, even if the answer is correct. Late homework will not be accepted.

1. The cosmological constant has come under renewed scrutiny in recent years (with a different value from Einstein's, of course), because it may be a contributor to the dark energy that is responsible for the acceleration of the expansion of the Universe.

(a) Calculate the energy density of the cosmological constant in the current epoch, assuming $\Omega_\Lambda = 0.7$ and $H_0 = 70$ km s^{-1} Mpc^{-1}.

(b) What is the total energy of the cosmological constant within a sphere 1 AU in radius?

(c) What is the rest energy of the Sun ($E_\odot = M_\odot\, c^2$)?

(d) Comparing your answers above, do you expect the cosmological constant to have a significant effect on the motion of planets within the Solar System?

2. Suppose the mass density of the universe was $\rho = 3 \times 10^{-27}$ kg m^{-3}.

(a) What would be the radius of curvature R_0 of Einstein's static universe?

(b) How long would it take a photon to circumnavigate such a universe?

3. In a *flat universe* with $H_0 = 70$ km s^{-1} Mpc^{-1}, you observe a galaxy at a redshift $z = 7$. Carry out calculations to find the current proper distance to the galaxy, $d_p(t_0)$, in each of the following 3 cases. Also, carry out calculations to find the proper distance at the time the light was emitted, $d_p(t_e)$, again in each of the following 3 cases.

(a) Show your calculations for $d_p(t_0)$ and $d_p(t_e)$ if the universe contains *only radiation*?

(b) Show your calculations if the universe contains *only matter*?

(c) Show your calculations if the universe contains *only a cosmological constant*?

(d) Put all your answers for $d_p(t_0)$ and $d_p(t_e)$ for the three cases above in a table.