Homework Set 4

DUE: Tuesday February 11th

1. (a) Starting from the Friedmann equation in Perkins eq (5.11), derive eqs (5.37) and (5.39). Take $\Omega_k(0) = 0$. Please write down every step explicitly. (4 pts)

(b) For the remaining parts of this problem, assume that at the present epoch ($z = 0$), $\Omega_r = 4.84 \times 10^{-5}$, $\Omega_m = 0.31$, $\Omega_\Lambda = 0.69$, and $H_0 = 67.8$ km/s/Mpc. Now find the redshift where the matter density becomes equal to the radiation density. (3 pts)

(c) Do the same when the dark energy density becomes equal to the matter density. (3 pts)

(d) As you can see the universe was radiation dominated at first then it became matter dominated and very recently it became dark energy dominated. Although the age of the universe can't be computed analytically using equation (5.39). We can still estimate the age of the universe by only taking the dominant part of the density in each era, the radiation-dominated era, the matter-dominated era, and the current cosmological constant era. Compute the age of the universe in each era by setting the $\Omega_m = \Omega_\Lambda = \Omega_k = 0$, $\Omega_r = \Omega_\Lambda = \Omega_k = 0$, and $\Omega_m = \Omega_r = \Omega_k = 0$ during radiation dominated, matter dominated, and dark energy dominated era respectively, and then add them up. (10 pts)

2. Fill in the details in the derivation of the analytic formula for the age of the universe t_0 in Perkins Example 5.3. Use the analytic formula to determine the value of t_0 for a flat universe with $\Omega_m = 0.31$ and $H_0 = 67.8$ km/s/Mpc. Check your answer against Ned Wright's Cosmology Calculator (www.astro.ucla.edu/∼wright/CosmoCalc.html), and determine the Particle Horizon for this cosmology. (10 pts)

3. Perkins Problem 5.5 (10 pts)

4. How long does it take for light from a galaxy at redshift $z = 2$ to reach us? Assume that the universe is flat($k = 0$) and matter dominated, i.e. the Einstein-de Sitter cosmology. (10 pts)

5. Perkins Problem 5.12 (10 pts) (Worked out in the back of the book.)

The open book Midterm Exam will be in class on Thursday February 13.