Your name: ________________________

Arvind Borde

AST 10: Homework 11

1. In class we pondered (slide/page 9 in printed notes) the $\diamondsuit$ equation:

$$\frac{3\dot{a}^2(t)}{a^2(t)} + \frac{3k}{a^2(t)} = \frac{8\pi G}{c^4}\rho. \qquad \diamondsuit$$

It turns out that the Hubble constant $H_0 = \dot{a}(t)/a(t)$.

a) Re-express the $\diamondsuit$ equation using H_0 in place of $\dot{a}(t)/a(t)$.

b) Then rewrite the equation by solving for ρ.

c) Finally, in the case when $k = 0$ (zero spatial curvature) what is ρ? Call that value ρ_c.

d) When $k = 1$ do you think the energy density ρ needs to be greater or less than ρ_c?

e) When $k = -1$ do you think the energy density ρ needs to be greater or less than ρ_c?

2. In the $\heartsuit$ equation,

$$\frac{3\ddot{a}(t)}{a(t)} = -\frac{4\pi G}{c^4}(\rho + 3P) \qquad \heartsuit$$

we have seen that $\ddot{a}(t) < 0$ when $\rho > 0$, $P > 0$. Suppose that we have $\rho > 0$, but $P = -\rho$. Would $\ddot{a}(t)$ still be negative? What shape would that graph of $a(t)$ have in this situation? Would there be implications for the *necessity* of a birth for the Universe?

3. What is the difference between a static Universe and a steady state Universe?

4. Why was the discovery of quasars a problem for steady state cosmology?