Astro 243: Problem Set 3

1 Accelerating expansion

(1) Consider light propagation in a universe with a "de Sitter" universe where H=const. and $K = 0$ and the expansion is accelerating. Write down the expression for how far a photon travels in comoving coordinates during a small interval a_1 to $a_1 + \Delta a$ - what happens as $a_1 \to 0$? what happens at $a_1 \to \infty$. Explain.

(2) In this exponential expansion, write down the expression for cosmic time $t(a)$ assuming $t = 0$ corresponds to $a = a_i$. Compare this to conformal time $\eta(a)$ with $\eta(a_i) = 0$ and discuss the differences as $a \to \infty$ and relate this to light propagation in comoving vs physical coordinates

2 Standard rulers

Now consider a decelerating expansion with $H(a) = H_0 a^{-3/2}$ and $K = 0$ (which we will later see is a matter dominated expansion). Write down the expression for the horizon, the distance a photon travels from $a = 0$ to a. Now suppose I had an "object" that was the size of the horizon at $a = 10^{-3}$. What angle would that object subtend on the sky today at $a = 1$, does it depend on H_0? (We will see that this object corresponds the acoustic peaks in the cosmic microwave background and galaxy clustering and its measurement allows us to infer the expansion history beyond the matter dominated limit).