Astro 242: Problem Set 5

1 Problem 1: Units that Define Cosmological Scales

Convert the following quantitites by inserting the appropriate factors of c, $\hbar$, k_B and unit conversions. Note that h in the formulae below is the reduced Hubble parameter not the Planck constant.

- $H_0 = 100h$km s^{-1} Mpc^{-1} into (a) eV, (b) Mpc^{-1}, (c) Gyr^{-1}. [Corresponds to upper limit on the mass of a dark energy particle, the inverse Hubble length, inverse approximate age of Universe. Keep h in your formulae.]
- $\rho_{\rm crit} = 3H_0^2/8\pi G$ into (a) g cm^{-3}, (b) GeV^4, (c) eV cm^{-3}, (d) protons cm^{-3}, (e) $M_\odot$ Mpc^{-3}. If the cosmological constant, has $\rho_\Lambda = 2\rho_{\rm crit}/3$, what is its energy scale in eV (i.e. $\rho_\Lambda^{1/4}$). Compare that to the Planck mass; that these numbers are so different is the cosmological constant problem.
- $T_{\rm CMB} = 2.728$K to (a) eV. Assuming a black body distribution, convert this to number density n_γ in photons cm^{-3} and energy density ρ_γ in (b) eV cm^{-3} (c) g cm^{-3}, and (d) $\Omega_\gamma = \rho_\gamma/\rho_{\rm crit}$.