

Astro 242: Problem Set 5

Due Feb 24

1 Problem 1: Units that Define Cosmological Scales

Convert the following quantities by inserting the appropriate factors of c , \hbar , k_B and unit conversions.

- $H_0 = 100 \text{ km s}^{-1} \text{ Mpc}^{-1}$ 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.]
- $\rho_{\text{crit}} = 3H_0^2/8\pi G$ into (a) g cm^{-3} , (b) GeV^4 , (c) eV cm^{-3} , (d) protons cm^{-3} , (e) $M_\odot \text{ Mpc}^{-3}$. If the cosmological constant, has $\rho_\Lambda = 2\rho_{\text{crit}}/3$, 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.
- $T_{\text{CMB}} = 2.728 \text{ K}$ 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 (a) eV cm^{-3} (b) g cm^{-3} , and $\Omega_\gamma = \rho_\gamma/\rho_{\text{crit}}$.