Astro 321: Problem Set 3

Due April 21

1 Problem 1: Angular Scale of the Horizon

- In a flat $\Omega_m = 1$ universe, with no radiation, calculate the horizon scale at $z = 1000$. What is the angular scale subtended by this scale today? express your result in degrees and angular frequency $\ell = 2\pi/\theta$. That the CMB is smooth above this scale is known as the horizon problem; causal physics generates anisotropies below this scale – in particular the CMB acoustic peaks.

2 Problem 2: Predict the CMB Temperature

- Assume that deuterium forms when the background temperature is $T = 10^9$K. Require that neutron capture be efficient enough to form light elements but not so efficient as to leave no deuterium so that $\langle \sigma v \rangle n_b t \sim 1$. (a) With $\langle \sigma v \rangle = 4.6 \times 10^{-20}$ cm^3 s^{-1}, and the age of the universe at $T = 10^9$K (calculated from assuming the photons and neutrinos are the only contributors to the Friedmann equation at these epochs with an energy density ratio given in the first problem set), estimate the baryon density n_b under this condition. (b) Assuming a current baryon number density corresponding to $\Omega_b h^2 = 0.02$, what is the scale factor at $T = 10^9$? (c) What is the temperature of the background today?