AST376 (Spring 2014)
COSMOLOGY
Problem Set 4
Due in class: Thursday, April 24, 2014
(worth 10/100)

1. Inflating-away the Monopole Problem

In class, we estimated that at the time of grand-unified (GUT) symmetry breaking, $t_{\mathrm{GUT}} \sim 10^{-36}\,\mathrm{s}$, the number density of magnetic monopoles should have been of order $n_{\mathrm{mono}} \sim 10^{76}\,\mathrm{cm}^{-3}$. We also argued that the mass of a monopole should be of order the GUT mass-energy scale, $m_{\mathrm{mono}} \simeq 10^{15}\,\mathrm{GeV}/c^2$.

Now, current observational limits on the density of magnetic monopoles in the present-day universe indicate that their (present-day) density parameter is: $\Omega_{\mathrm{mono}} < 10^{-6}$.

If monopoles formed at t_{GUT}, how many e-foldings (i.e., the number N in e^N) of inflation would be required to drive the current monopole density below the observational bound given above? Assume that inflation took place immediately after the creation of the monopoles.

2. Size of Post-inflation Universe

Consider our present-day observable universe (all the space inside the current horizon), and figure out the size of this spherical region at the time just after inflation ended, $t_{\mathrm{final}} \simeq 10^{-34}\,\mathrm{s}$.

Remember that when you extrapolate back in time, cosmic expansion was most recently dominated by a cosmological-constant dark energy, before that by matter, and before that by radiation.