Astro 321: CMB Final Helper Problem Set 3

Initial Conditions

Take the initial conditions for a given k-mode to be $\zeta(\eta_i) = 1$ where η_i is the initial time step for the integration (we will choose this to be sufficiently early that the mode is well outside of the horizon and the time is well before matter radiation equality). We will scale this back to an appropriate scale invariant spectrum later. We will take a system of CMB photons γ, baryons b and cold dark matter c. Since we will ignore neutrinos, the anisotropic stress π is negligible in the initial conditions.

- From the relation
$$\Phi = \frac{3+3w}{5+3w}\zeta\,, \tag{1}$$
$w = 1/3$, the Poisson equation
$$k^2\Phi = 4\pi G a^2 \sum_i \rho_i \Delta_i \tag{2}$$
and the adiabatic condition
$$\Delta_c = \Delta_b = \frac{3}{4}\Delta_\gamma \tag{3}$$
find the initial conditions at η_i for the three comoving density perturbations.

- Again with the adiabatic condition $v_c = v_b = v_\gamma$ and the continuity equation for $\dot{\Delta}$ derived in PS 5. Find the initial conditions for the velocities at η_i.

- Since the anisotropic stress vanishes, the initial conditions for the Newtonian potential $\Psi = -\Phi$.

These are the IC's for your Runge-Kutta integration.