UNIVERSITY OF CALIFORNIA, SANTA BARBARA
Department of Physics
2014 Winter Quarter

GALAXIES AND COSMOLOGY Professor Treu

HOMEWORK #6
COSMOLOGICAL PARAMETERS

Problem 1: **Expanding atoms and other dark matters**

Consider a sphere of radius the Bohr radius, and compare the energy enclosed in the following components: i) a single proton at the center; ii) uniformly distributed dark energy for the benchmark model. Which of the two will affect the Bohr radius the most? Consider now a galaxy of mass $10^{12} M_\odot$ and radius 100 kpc and compare the matter energy density within the radius with that of the CMB and that of the dark energy. What about for a cluster of mass $10^{15} M_\odot$ and radius 10 Mpc?.

Problem 2: **Mini black holes:**

Ryden 8.1.

Problem 3: **Dark matter halos of clusters**

The hot intracluster medium of a galaxy cluster is well described by a so-called Navarro Frenk & White (1996) mass density profile:

$$\rho_{\rm gas}(x) = \frac{\rho_{\rm gas,0}}{x(1+x)^2}$$

where x is the radial coordinate in units of the break radius r_b $x = r/r_b$, and $\rho_{\rm gas,0}$ is a density scale. The temperature of the gas is constant with radius $T(r) = T_0$. Assuming hydrostatic equilibrium compute the total mass enclosed in a sphere of radius r and the total mass density profile.

Problem 3: **Draco Dwarf galaxy**

Ryden 8.2