UCSD Physics 162 *Cosmology* Assignment 1

Prof. B. Keating Assigned: April 7, 2009 Due: April 14 In Class

1 Expansion laws

Draw a ~ 1" radius disk on a piece of paper. Imagine that the disk is composed of a very large number of points. Consider two different versions of Hubble's Law which hold for a time, t:

- Version 1: Constant velocity. All particles separate from each other at the same rate, i.e., $v = a = constant$
- Version 2: Hubble's law. Particles move according to $v = \dot{a}/ar$, where r is the separation between them.

Sketch the initial distribution of particles and the final distribution after time t, from the point of view of an observer at the center (using the cosmological principle this is as good a location as any).

2 Relativistic Redshift

The velocity-redshift law discussed in class is not correct at velocities approaching the speed of light, c. The full relativistic formula is:

$$1 + z = \sqrt{\frac{1 + v/c}{1 - v/c}}.$$

Expand this equation in powers of v/c to obtain the non-relativistic formula used in class.

3 Planck function

(a) Write down and sketch both the Planck function for the occupation number (number of photons per spatial mode) and the energy density in a frequency interval df as a function of blackbody temperature T and frequency f.

(b) Is there a peak in the occupation number? In one sentence, why does the energy density peak?

(c) Expand the formula for the energy density when $h\nu/k_bT << 1$.

4 Ryden HW Problem 2.2

5 Ryden HW Problem 2.3

6 Ryden HW Problem 2.4