Astronomy 323
Homework 1
Due: Wednesday, 17 January 2018

1. Measurements of the radial recession velocities of five galaxies in a cluster yield 9.700, 8,600, 8,200, 8,500, and 10,000 km s^{-1}. What is the distance to the cluster if the Hubble constant is $H_\circ = 70$ km s^{-1} Mpc^{-1}?
2. You live in an old, infinitely large universe where the average stellar density is $n_* = 10^9$ Mpc^{-3} and each star has radius $R_\odot$. How far, on average, could you see in any direction before your line-of-sight strikes a star? If stars are clumped in galaxies with $n_g = 1$ Mpc^{-3} and average radius $R_g = 2{,}000$ pc, how far, on average, could you see in any direction before your line-of sight hits a galaxy?
3. The *tired light* hypothesis asserts that the Universe is not expanding. Rather, photons lose energy as they move through space with energy loss per unit distnace

$$\frac{dE}{dr} = -KE \tag{1}$$

where K is a constant. Show that the *tired light* hypothesis gives a distance-redshift relation that is linear in the limit $z \ll 1$. Recall that for photons, $E = h\nu$. What must K be in order to have $H_\circ = 70$ km s^{-1} Mpc^{-1}?
4. You are composed primarily of water which is very efficient at absorbing microwave radiation. If you live in intergalactic space, approximately how many CMBR (cosmic microwave background radiation) photons would you absorb per second? Due only to absorption of CMBR photons, how long would it take to raise your temperature by one nano-Kelvin, 10^{-9} K? Assume that your heat capacity is the same as pure water, 4,200 J kg^{-1} K^{-1}.
5. Suppose you are a two-dimensional being, living on a spherical surface of radius R. An object of width $ds \ll$ R is at distance r from you. What angular width $d\theta$ will you measure for the object? Explain the behavior of $d\theta$ as $r \to \pi$R.