Physics 3002
Problem Set 1, due 2/4/09
Lam Hui

1. In class, we discussed several ways in which the Olber's paradox can be resolved. In our universe, it turns out the resolution is mainly through the finite age of the universe. This is actually discussed in Ryden section 2.3. Let's make sure you understand the arguments. You could easily copy the answers to the following questions from the book. Well, don't! Try to do the math yourself.
a. Given that the age of the universe is about H_0^{-1} where $H_0 = 100$ km/s/Mpc, what is the furthest you can possibly see (in Mpc)?
b. We know from observations that the luminosity density (i.e. energy per unit time per unit volume) of galaxies in our local neighborhood is $nL \sim 2 \times 10^8 L_\odot \, \text{Mpc}^{-3}$. Here, luminosity is measured in units of the luminosity of the Sun $L_\odot$. Let us assume this luminosity density is constant, independent of both position and time. What is the total flux we can see from all galaxies in our *observable* universe (integrated over all directions in the sky and to the furthest we can see)? In making this estimate, as a rough approximation, ignore the redshifting of photons – the fact that photons lose energy as they travel towards us due to the expansion of the universe (including redshifting would only go in the direction of strengthening our resolution of the paradox). Express your answer in units of $L_\odot \, \text{AU}^{-2}$. This basically tells us the total flux we should see in the night sky.
c. During the day, the flux we see is dominated by that from the Sun. What is the flux from the Sun in units of $L_\odot \, \text{AU}^{-2}$? Now, you are ready to compare the flux at night and the flux during the day. What is the ratio? This shows why the night sky is so much darker.

2. We learned in class that the cosmic microwave background has a temperature today of about 2.7 K. What does this imply about the typical frequency of a microwave background photon (in Hz)? Compare this to typical frequencies of your radio stations.

3. Ryden problem 2.2: Suppose you are in an infinitely large, infinitely old universe in which the average density of stars is $n_* = 10^9 \, \text{Mpc}^{-3}$ and the average stellar radius is equal to the Sun's radius: $R_* = R_\odot = 7 \times 10^8$ m. How far, on average, could you see in any direction before your line of sight struck a star? (Assume standard Euclidean geometry holds true in this universe.) If the stars are clumped into galaxies with a density $n_g = 1 \, \text{Mpc}^{-3}$ and average radius $R_g = 2000$ pc, how far, on average, could you see in any direction before your line of sight hit a galaxy?