PHYC 581/480, HW 2

Due: 29-Sep-16

(I) The great riddle of the Darkness at Night.

(a) Take all stars to be the same as the Sun,
(5) hence:

$$L = L_\odot = 3.8 \times 10^{26}\ J/s$$
$$R = R_\odot = 7 \times 10^{8}\ m.$$

Assume that the Universe is uniformly distributed with stars with a density n. Don't worry yet about expansion!

The number of stars in a spherical shell of radius r, (with us at the origin) and thickness dr is given by what expression?

What is the flux, Φ, of radiation arriving to us from a typical star at distance r from us?

If we integrate the flux Φ from all the stars in each spherical shell around us from $r=0$ to ∞ what do we get?

(b) The answers you got in (a) should tell you that
(10) there's a problem with the calculation. An obvious problem is that one should NOT integrate the flux Φ from each spherical shell from $r=0$ to $r=\infty$ because out to some distance, R, the sky becomes so

covered by stars that we cannot see the stars further than R. If the stars are uniformly distributed with a density n, and have a cross-sectional area A, and all are similar to the Sun, then what is R? (Derive this!)

So now, instead of integrating the flux from $r=0$ to ∞ in (a) we integrate from $r=0$ to R. What do you get? (express your answer in units of the Sun's luminosity and radius).

So what does this tell you about the night sky's brightness?

(c) Hopefully, your answer is still unsatisfactory.

(10) Take the mean density of the universe to be the critical density,

$$\rho_c = 2.8 \times 10^{11} h^2 M_\odot / Mpc^3$$ and take $h = 0.5$.

Calculate a number for R from part (b) in units of light years. This is the distance beyond which you cannot see stars, because the stars in between fill the sky and block the view.

(d) Now we put it all together. The real universe

(10) has a finite age. The real stars have a finite

age. Take both to be of order 10^{10} yrs. This is the longest time that photons can travel to get to us, hence, in light years this is the farthest out we can see.

Compare the finite lifetime of stars with the "lookout limit" R. If our universe was static (No expansion) and all the stars started to shine at the same time and we were seeing stars shinning around us out to a distance 10^{10} light years, what would we be seeing between 10^{10} light years and R? When the stars closest to us die out after their 10^{10} year lifetime ends explain what you would see then?

In terms of your answer for the night sky's brightness in part (b) how bright is it in this new picture with ~~stard~~ stars having a finite lifetime?

Please note that the resolution of the paradox did NOT require an expanding Universe! Briefly summarize your thoughts as to why the night sky is dark and what this is telling you about your Universe.

SHOW ALL OF YOUR WORK, DERIVATIONS, CALCULATIONS, ETC! NO CREDIT GIVEN OTHERWISE!