Astrophysics and Cosmology (77501 : Fall Term 20056)

Problem Set 1

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Problem 1:

Go to the course home page (http://www.phys.huji.ac.il/∼hoffman/AstroCourse/) and enjoy the links to Monty Python's "The Galaxy Song". The lyric is given here.

Whenever life gets you down, Mrs. Brown
And things seem hard or tough
And people are stupid, obnoxious or daft
And you feel that you've had quite enough

Just remember that you're standing on a planet that's evolving and revolving at 900 miles an hour
That's orbiting at 90 miles a second, so it's reckoned, the sun that is the source of all our power
The Sun and you and me, and all the stars that we can see are moving at a million miles a day
In an outer spiral arm, at 40,000 miles an hour, of a galaxy we call the Milky Way

Our Galaxy itself contains a hundred billion stars, it's a hundred thousand lightyears side to side
It bulges in the middle,16,000 lightyears thick but out by us it's just 3,000 lightyears wide
We're 30,000 lightyears from galactic central point, we go round every 200 million years
And our galaxy is only one of millions of billions in this amazing and expanding universe

The universe itself keeps on expanding and expanding, in all of the directions it can whizz
As fast as it can go, the speed of light you know, twelve million miles a minute,
and that's the fastest speed there is
So remember when you're feeling very small and insecure how amazingly unlikely is your birth
And pray that there's intelligent life somewhere up in space coz there's bugger all down here on Earth

Based on the profound Monty Python's text and the data given calculate the following:

1. What is the mass of the sun? (Recall that the mean earth-sun distance is $1AU = 1.5 \times 10^{13} cm$.)

2. *We're 30,000 lightyears from galactic central point, we go round every 200 million years*: Assume that the mass distribution in the Milky Way is spherical, calculate its mass.

3. Using the mass you have derived in (b) what is the mean stellar mass in the Galaxy? Compare it with the estimate you got in (a).

4. What are the errors (if any) in the song?

5. Draw the schematic picture of the Galaxy, viewed edge-on. Express the typical scales of the Galaxy in kpc.

Problem 2:

Explain how the Big Bang model resolves the Olber's paradox? (Note, it does it in more than one way.)

Problem 3:

A hypothesis once used to explain the Hubble law is the 'tired light hypothesis'. The hypothesis states that the universe does not expand, but rather that photons simply lose energy as they travel through space (by some unexplained means). The energy loss rate is give by

$$\frac{\mathrm{d}E}{\mathrm{d}r} = -KE,$$

where K is a constant and E is the photon energy. Show that this hypothesis gives a distance-redshift relation that is linear in the limit of $z \ll 1$. What must the value of K be in order to yield a Hubble constant of $H_0 = 70 \ km \ s^{-1} Mpc^{-1}$?