Ay 21 – Winter 2008 – Homework #3

Posted on Feb. 1, due by 1 pm on Friday, Feb. 8

(Return to the Prof., the TA, or to the Astronomy office, 211 Robinson)

As usual, the honor system applies as follows: You can discuss the problems among yourselves, how to go about them, but not derive the solutions jointly – everyone should work out their own.

Problem 1 (up to 70% of the credit in this homework):

It is the year 2020, and President Huckabee is giving you $ 100 billion (or about $ 1 billion Canadian, to use a real money) to establish once and for all the distance scale of the universe, and prove that the world was created around year 4000 BC. While not fudging the data to get the desired answer (thus risking a burning at the stake, followed by an eternal damnation), how would you spend it?

a. Build a space interferometer to measure parallaxes in Andromeda galaxy (assume distance $D \sim$ 700 kpc)? How large would it have to be, assuming a working wavelength of $\lambda = 500$ nm, and recalling that the diffraction limited resolution is given by a formula $\Delta\theta \sim 1.2\ \lambda/D$? Assume that you can detect well enough whatever objects you are measuring. [15 points]

b. Build a new large space telescope and use it to measure Cepheids down to $m_V \sim 37$ mag. Assuming a Hipparcos calibrated period-luminosity relation $M_V = -2.81\ \log_{10} P - 1.43$, where the period P is measured in days, and periods ranging up to 20 days, how far would you be able to measure distances? [15 points]

c. OK, so you decided to do (b), and found a Cepheid in galaxy at a redshift $z = 0.31$, with a mean magnitude $m_V = 36.2$ mag, and a period $P = 15.6$ days. What is the Hubble constant? Ignore the effects of dust and K-correction, but think about other possible effects of the universal expansion. [15 points]

d. Assuming that you can use your new telescope to measure redshifts down to $m_V = 32$ mag, how far can you measure Supernovae of type Ia? Assume the corrected peak absolute magnitude $M_{peak} = -19.7$ mag in the corresponding bandpass. [15 points]

e. Discuss all this, and pick a method of your choice. Justify your reasoning. [10 points]

Problem 2 (up to 30% of the credit in this homework):

Assume that the rotation curve of our Galaxy is flat, with the circular speed $V_c = 220$ km/s. Ignore the contribution of the visible stuff. Assume that we are at $R_\odot = 8$ kpc.

a. What is the total mass of the Galaxy within the Solar circle? What is it within a 100 kpc radius, assuming that the flat rotation curve extends that far? [10 points]

b. What is the density of the dark halo in this neck of the woods, in g/cm^3 and $M_\odot$/pc^3? [10 points]

c. If the dark matter consists of axions with $mc^2 = 1$ GeV, how many are there per cm^3? [5 points]

d. If it consists of brown dwarfs with $M_{bd} = 0.05\ M_\odot$, how many are there per pc^3? How far on average should be the nearest one? [5 points]