Problem Set #7

Astro 2: Spring 2012

Due: May 22, 2012 (in class)

Problem 1

(a) In order to determine Hubble's Consant, we need to know the true distance, obtained from a method other than its redshift, as well as the value of the redshift. Explain.

(b) Part of the purpose of the Hubble Space Telescope (HST) was to study Cepheid variables in distant galaxies, in order to get their distances. Suppose that a certain Type-I Cepheid in a distance galaxy was found to have a period of variation of 30 days.

What is the luminosity of the star? Use Fig. 19-18 in the book.

(c) Suppose the flux (apparent brightness) is measured to be 3×10^{-20} (J/s)/m^2 at Earth. What disance do you calculate using the inverse square law? (Answer: about 100 Mpc)

(d) Now suppose you measure the redshift as 0.024. Find Hubble's constant. (Answer: about 70 (km/s)/Mpc)

(e) Calculate the age of the universe using Hubble's consant. Show all the steps. (Note that this calculationg assumes constant expansion speed, which is a false assumption. Nevertheless, the answer is quite close to the actual value.)

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Problem 2

Take a look at these awesome pictures of the Cygnus A radio galaxy:

`http://chandra.harvard.edu/photo/2000/0216/`

`http://images.nrao.edu/110`

The redshift of Cygnus A is 0.056.

(a) What is the velocity of recession from Earth? (Answer: $\approx 1.7 \times 10^7$ km/sec.)

(b) What is the distance? (Answer $\approx$ 240 Mpc, or 800 million light years)

(c) The apparent brightness (flux) of radio waves from Cygnus A is measured to be about 10^{-14} (J/s)/m^2/ What is the luminosity? (Answer: $\approx 6 \times 10^{36}$ J/s.)

(d) The angular size of Cygnus A is about two arcminutes. What is its physical size? (Answer: $\approx$ 180 kpc)

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Problem 3

Neutrinos are produced copiously in the first second of the Big Bang. Since neutrinos have very little mass and tend to not interact with normal matter, they were a candidate for unexplained dark matter. This is an example of the WIMP hypothesis that the dark matter is made of weakly interacting massive subatomic particles. Explain the 'phase space' argument that has disproved the idea that electron-neutrinos constituted the dark matter in galaxies?

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Problem 4

If MACHOs account for some of the dark matter in the Milky Way, can you guess their approximate speeds? How fast would WIMPs be going in the Milky Way halo?

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