

Galaxies and Cosmology Test 2

Due – Tuesday, March 4, 2008, 3:00 PM CST

You can use your notes and the book for this test and any other resource you can think of. You may also consult with others about the answers to questions. However, all answers, especially those where you have to write out explanations, should be in your own words. Any obvious similarities to the work of others will result in no points. Be careful about formulas - make sure you use the right units and constants for them. You should number and write your answers neatly on some other sheets of paper - and make sure you include your work so that I can at least give you partial credit where appropriate. If you need to use a constant, use those that are in the SI system – kg, meters, Joules, etc.

1. (10 points total) a. If the Cosmic Microwave background radiation (CMBR) has a temperature of 2.725 K, what is the energy of a photon of that temperature (use $E=kT$)?

b. 400 photons of the CMBR are in each cubic centimeter of space (the density of photons could also be given as 4.0×10^8 photons/m³). If you were to assume that the universe is a sphere 13.7 billion lightyears in radius, what is the total number of photons of the CMBR in the Universe? Use for the radius of the Universe $R=1.30 \times 10^{26}$ m and the volume of the Universe to be that of a sphere volume = $\frac{4}{3} \pi R^3$

c. Based on your answers above, what is the total energy of the Universe tied up in the CMBR?

d. What is the equivalent mass for the energy that is in the CMBR (use $E=mc^2$ to determine the mass equivalent)?

e. Is this very massive? Why or why not?

2. (4 points) What effects on the properties of the Universe would there be if the early Universe (times between 0 and 1 year) expanded at a much greater rate than the current theories suggest? What about if it expanded at a slower rate during these times- what would be the effects of that?

3. (10 points) It was just announced that the most distant quasar was discovered. It has a redshift = $z = 15.9$ (actually I'm making this up – but that's what test questions are all about).

a. What velocity does this correspond to? Use the relativistic redshift formula from the first set of formula to figure out the velocity.

b. If the Hubble Constant equals 72 km/s/Mpc, and we assume a constant expansion of the Universe, what would the distance for this quasar be?

c. The apparent magnitude (m) of this quasar is around 21. What is the quasar's absolute magnitude (M)?

d. Determine the luminosity of the quasar. You'll want to determine its luminosity value in terms of the Sun's luminosity.

e. What is the mass that this quasar could have if its luminosity is close to the Eddington Luminosity?

The Evil #4. (8 points). The Friedmann equation was derived based upon a tally of the amount of energy in the Universe, where

$$TE = PE + KE$$

where TE = total energy, PE=potential energy (gravity) and KE = kinetic energy.

We can define the following

$$KE = \frac{1}{2} m v^2$$

$$PE = -GM_u m/R$$

Where m=an arbitrary mass in the Universe

M_u = mass of the Universe

R= scale of the Universe.

Assume a spherical shaped Universe with a uniform density.

We also make use of Hubble's Law, ($v = HR$, where R=distance or scale) in this problem.

a. Using the above information come up with the Friedmann formula as it is given in the notes and determine what "k" is equal to. Make sure you include all of your steps clearly.

b. If you set $k=0$, you have a flat Universe, and you can solve the formula for the critical density. What is the critical density for a Friedmann Universe, that is flat and has no acceleration (no cosmological constant)? Use a reasonable value for the Hubble constant.

5. (8 points) When quasars were first discovered, some people did not think that they were very distant objects (as is implied by Hubble's law) but fast moving, nearby objects, possibly ejected from the cores of galaxies.

a. How would the various physical characteristics of quasars change if they in fact were nearby objects (these would be the characteristics that we determine based upon assuming that they are at a great distance from us)?

b. There are several reasons why we know that quasars are in fact very distant objects, and none of these reasons have to do with the Hubble law. List a few of them (these are certain observations that we make of quasars that indicate great distances).

6. (2 points) a. How are the globular clusters in the Magellanic Clouds different from those in the Milky Way?

b. How are these differences useful to astronomers?

7. (2 points) Give at least two reasons why the Large Magellanic Cloud is better than the Small Magellanic Cloud for calibrating distances.

7. (4 points) How is the distribution of the gas in the Andromeda galaxy (M31) different from our galaxy?

8. (2 points) In the book, what does the statement "Dogs have fleas, but fleas don't have fleas" refer to?