October 2, 2006

Astronomy 102: Sample Review Exam 2

Possibly Useful Constants and Formulae

$$R_\odot = 6.96 \times 10^5 \text{ km}$$
$$M_\odot = 1.99 \times 10^{30} \text{ kg}$$
$$L_\odot = 3.8 \times 10^{26} \text{ W}$$
$$c = 3.00 \times 10^8 \text{ m s}^{-1}$$
$$h = 6.626 \times 10^{-34} \text{ J s}^{-1}$$
$$1\,\text{pc} = 3.26 \text{ lyr}$$
$$1\,\text{pc} = 206,265 \text{ AU}$$
$$1\,\text{pc} = 3.086 \times 10^{16} \text{ m}$$
$$1\,\text{AU} = 1.496 \times 10^{11} \text{ m}$$
$$1\,\text{km} = 1,000\,\text{m}$$

$$E = m\,c^2$$
$$\lambda\,f = c \qquad f = \frac{c}{\lambda} \qquad \lambda = \frac{c}{f}$$
$$E = h\,f$$
$$L = A\,\sigma\,T^4$$
$$L = (4\pi\,R^2)\,\sigma\,T^4$$
$$B = \frac{L}{4\pi\,d^2}$$
$$z = \frac{\Delta\lambda}{\lambda} = \frac{\lambda_{\text{obs}} - \lambda_{\text{orig}}}{\lambda_{\text{orig}}}$$
$$z = \frac{v}{c} \quad \text{(for v} \ll \text{c)}$$

Age of Solar System:	4.6×10^9 years
Age of Universe:	13.7×10^9 years
Lifetime of 1 $M_\odot$ star (type G on main sequence):	10^{10} yr (10 Gyr)
Lifetime of 3 $M_\odot$ star (type A on main sequence):	4×10^8 yr (400 Myr)
Lifetime of 8 $M_\odot$ star (type B on main sequence):	4×10^7 yr (40 Myr)
“High-mass” star (will go supernova):	$M > 8\,M_\odot$

1. A cluster of stars is formed all at once. As the stars all reach the main sequence, there is a mix of star types: massive, hot, O and B type stars, solar-mass G type stars, and cooler K and M type red dwarf stars.

(a) One billion years after the cluster of stars is formed, are all, most, about half, a few, or none of the O and B type stars still around?

(b) One billion years after the cluster of stars is formed, are all, most, about half, a few, or none of the solar-mass G type stars still around?

(c) One billion years after the cluster of stars is formed, are all, most, about half, a few, or none of the red dwarfs still around?

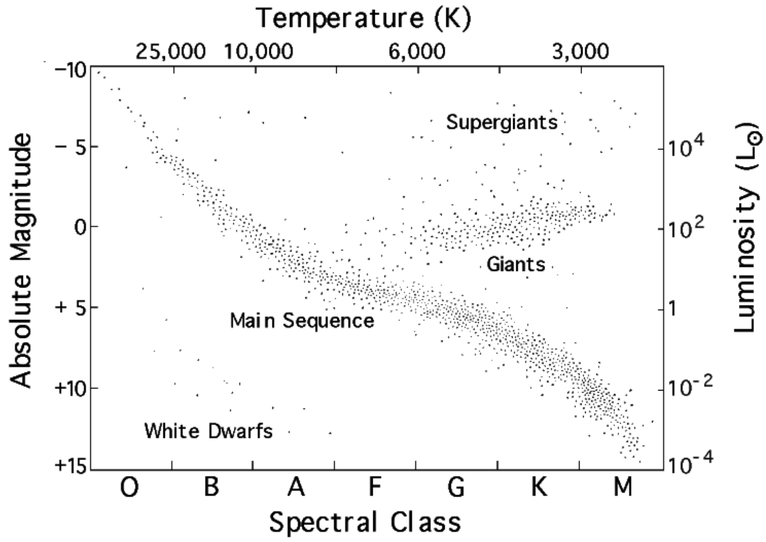
(d) Assume this cluster forms a distribution of stellar masses (how many high, vs. how many medium, vs. how many low-mass stars) that is typical for stars observed in our Galaxy. Over time, do you expect the number of red giants in the cluster to decrease, stay the same, increase, or fluctuate up and down? Explain.

2. When it is up, Sirius is the brightest star in the sky at night. (Think: what is the brightest star in the sky during the day?) In fact, Sirius is a binary star system. Sirius A, the brighter star, has a surface temperature of about 10,000 K. Sirius B, the dimmer star, has a surface temperature of about 30,000 K. Because it is a binary star, the two components are very close to the same distance away from us.

(a) Sirius A appears about 9,200 times brighter than Sirius B to an Earthbound observer. (For comparison, on a clear, dark night from a good site, the very dimmest star you can see with your naked eye is about 500–1,000 times dimmer than Sirius A. You will never see stars that dim from Nashville.) What is the ratio of the radius of Sirius A to the radius of Sirius B?

(b) Sirius is about 8.6 light-years away from our Solar System. If Sirius A is 25 times as luminous as the Sun, what is the ratio of the brightness of Sirius A to the brightness of the Sun?

3. Consider the following H-R diagram:



(a) Indicate the spot where the Sun falls on this H-R diagram with a small circle; label that circle with the letter "A".

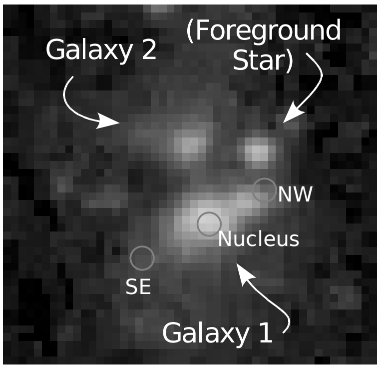
(b) Later in its life, the Sun will cool to about 3,000K, and will swell to 100 times its current radius. Indicate the spot where it will be on the diagram at this stage in its life with a small circle labelled "B". Be sure to show calculations you made (if any) in the space below.

(d) If you pick a random star out of the galaxy, without regard to how easy it is to observe from any spot, where on the diagram is it likely to be found? Outline and label this region with "D". Your region should be no more than an inch across.

(e) If you go outside at night, look up into the sky, and pick out a random star that you can see, where on the diagram is it likely to be found? Circle and label this region with “E”. Your region may be as large as you like, but should encompass no *more* than half the diagram.

(f) What, physically, is the sequence OBAFGKM a sequence of?

4. In July, 2006, Prof. Knop and TA Chynoweth observed interacting galaxies with the WIYN telescope at Kitt Peak National Observatory in Arizona. One of the galaxies they observed was MCG +12-02-001, pictured below:



They obtained spectra at several different positions on this galaxy. Three positions are shown: the nucleus, a position to the northwest, and a position to the southeast. One of the emission lines they were looking at was Hα, which has a normal (rest) wavelength of 6562.8Å. These were the wavelengths that Hα was observed at in the three positions indicated above:

Position	**Wavelength**
Nucleus	6665.5Å
SE	6664.8Å
NW	6667.4Å

The overall redshift of the galaxy (i.e. the redshift of the nucleus) is really due to the expansion of the Universe; but we haven’t talked about that yet. It turns out to that for galaxies with a low enough redshift (like this one), it is OK to pretend that the overall redshift is a Doppler Shift, even though that’s not really what it is. We shall make that approximation in this problem.

(a) What is the redshift z measured for the nucleus of the galaxy?

(b) Is this galaxy coming towards us, or moving away from us? How fast is it moving?

(c) How fast is the Hα-emitting gas SE of the nucleus moving *relative to the nucleus*? Is it, *compared to the nucleus*, coming towards us or moving away from us?

(d) How fast is the Hα-emitting gas NW of the nucleus moving *relative to the nucleus*? Is it, *compared to the nucleus*, coming towards us or moving away from us?