October 24, 2006

Astronomy 102: Review Examination 3

Possibly Useful Constants and Formulae

$$R_\odot = 6.96 \times 10^5 \text{ km}$$
$$M_\odot = 1.99 \times 10^{30} \text{ kg}$$
$$L_\odot = 3.8 \times 10^{26} \text{ W}$$
$$c = 3.00 \times 10^8 \text{ m s}^{-1}$$
$$h = 6.626 \times 10^{-34} \text{ J s}^{-1}$$
$$1\,\text{pc} = 3.26 \text{ lyr}$$
$$1\,\text{pc} = 206,265 \text{ AU}$$
$$1\,\text{pc} = 3.086 \times 10^{16} \text{ m}$$
$$1\,\text{AU} = 1.496 \times 10^{11} \text{ m}$$
$$1\,\text{km} = 1,000\,\text{m}$$
$$\pi\,\text{rad} = 180^\circ$$
$$206,265\,\text{arcsec} = 1\,\text{rad}$$
$$3,600\,\text{arcsec} = 60\,\text{arcmin} = 1^\circ$$

$$d\,\text{Vega} = 7.76\,\text{pc}$$
$$L\,\text{Vega} = 130\,L_\odot$$

$$E = m c^2$$
$$\lambda f = c \qquad f = \frac{c}{\lambda} \qquad \lambda = \frac{c}{f}$$
$$E = h f$$
$$L = A \sigma T^4$$
$$L = (4\pi R^2)\,\sigma T^4$$
$$B = \frac{L}{4\pi d^2}$$
$$z = \frac{\Delta\lambda}{\lambda} = \frac{\lambda_{\text{obs}} - \lambda_{\text{orig}}}{\lambda_{\text{orig}}}$$
$$z = \frac{v}{c} \quad (\text{for v} \ll \text{c})$$
$$A = \frac{b}{d} \quad (\text{for } A \ll 1)$$
$$d = \frac{1}{p} \quad (d \text{ in pc}, p \text{ in arcsec})$$

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. Suppose you are measuring distances to stars using parallax, and using the Hubble Space Telescope (HST) to measure that parallax. The HST as a resolution (minimum angular separation detectable) of about $0.05''$.

(a) What is the distance to a star whose parallax can just barely be measured by the HST?

(b) Can the HST only measure parallaxes which are *greater than or equal to* the parallax of the star in (a), or which are *less than or equal to* the parallax of the star in (a)?

2. One type of standard candle used by astronomers is thermonuclear supernovae. This type of supernova has a luminosity of $5.8 \times 10^9 \, L_\odot$ at maximum light; it is this high luminosity that makes them visible to such great distances.

(a) You discover and observe a thermonuclear supernova in a distant galaxy. In your telescope, you observe it to have a brightness that is 1.6×10^{-7} times the brightness you observe for Vega. How far away is this galaxy (in Megaparsecs (Mpc))?

(b) If a second supernova explodes in this galaxy 200 million years after the supernova that you observed actually exploded, how long from now *or* how long ago does this second supernova explode? (Be sure to indicate whether it happens in the future or the past.)

(c) How long ago, or how long from now, will you *see* the light from the second supernova, observing here on Earth?

3. Consider the two supernova explosions from the previous problem. For both of the questions below, if there is more than one possible answer, indicate all that may apply.

(a) Suppose that the second supernova explosion is a core-collapse supernova, *not* a thermonuclear supernova. When the first supernova exploded, what sort of astronomical object (i.e. what kind of star, or what else) would you find at the position of the second supernova? Explain.

(b) Suppose that the second supernova explosion was also a thermonuclear supernova. When the first supernova exploded, what sort of astronomical object (i.e. what kind of star, or what else) would you find at the position of the second supernova? Explain.

4. Suppose we were to discover that we had, all this time, *over-estimated* the distance between the Earth and the Sun by about 10%. (That is, we find out that we're a bit closer to the Sun than we always thought.)

Consider a galaxy whose distance was measured by observing the brightness of a Cepheid variable star. Will the new information about the distance between the Earth and the Sun affect our estimate for the distance to this galaxy? Will we modify our distance estimate *up* or *down*? (That is, is the galaxy closer than we thought, or farther than we thought, or was our distance estimate to the galaxy good?) Explain.

(NOTE: we know the distance between the Earth and the Sun pretty well. If we made an error as big as this problem suggests, lots of spacecraft we have sent to other planets would have missed horribly. The re-estimate this problem asks you to consider is *not* likely to happen....)