Introductory Astronomy 2012

Homework Set 4

Part A:

1. Assume the Sun has been converting Hydrogen to Helium at its current rate for 4.5 billion years. Assume that the Sun was initially 27% Helium (by mass) and relatively uniform (not chemically differentiated due to convective mixing), and that all of the newly formed Helium is still in the Solar core where it was created, since the layer outside the core is not heavily convective. Estimate the fraction of the solar core comprised of Helium (by mass) today. Express your answer as a number between 0 and 1 and round to two significant figures.

2. Repeat our calculation of escape velocity and thermal velocity for the case of a Hydrogen ion (a proton) in the Solar corona at a distance $2R_\odot$ from the center of the Sun and a temperature of 2 million K. The correct expression for this is

$$\langle \frac{mv^2}{2} \rangle = \frac{3k_BT}{2} \ .$$

   Your answer should be **two** numbers, separated by one or more spaces, the first being the escape velocity and the second the average thermal velocity, in m/s. Round to two significant figures.

These are a set of linked questions investigating Kapteyn's star to illustrate how we know what we do about stars.

3. Kapteyn's star has a parallax angle of 0.255 arcseconds. What is the distance to Kepteyn's star in pc? Round your answer to two significant figures.

4. Kapteyn's star is observed to have a *proper motion* of 8.67 arcsecond per year. What is the star's tangential (in the plane perpendicular to the line of sight from Earth) velocity? Express your answer in km/s and round to two significant figures.

5. Spectroscopic measurements using the neutral Sodium line with wavelength 592nm find that in the spectrum of Kapteyn's star this line appears at a wavelength of 592.48nm. Find the radial velocity of Kapteyn's star. Note that this is a positive number if the star is receding from Earth and a negative number if it is approaching Earth. Express your answer in km/s and round to two significant figures.

6. Sirius is an A1V main sequence star. Use the H-R diagram to find the luminosity and surface temperature of Sirius. Your answer should be two numbers separated by one or more spaces. The first is the luminosity of Sirius in terms of the Solar luminosity. The second is its surface temperature in K.

7. Use your answer from Q6 above to find the radius of Sirius in terms of the Solar radius.

8. Sirius has a parallax angle of 0.379 arcseconds. Find the brightness of Sirius in terms of the Solar constant. Round to two significant figures.

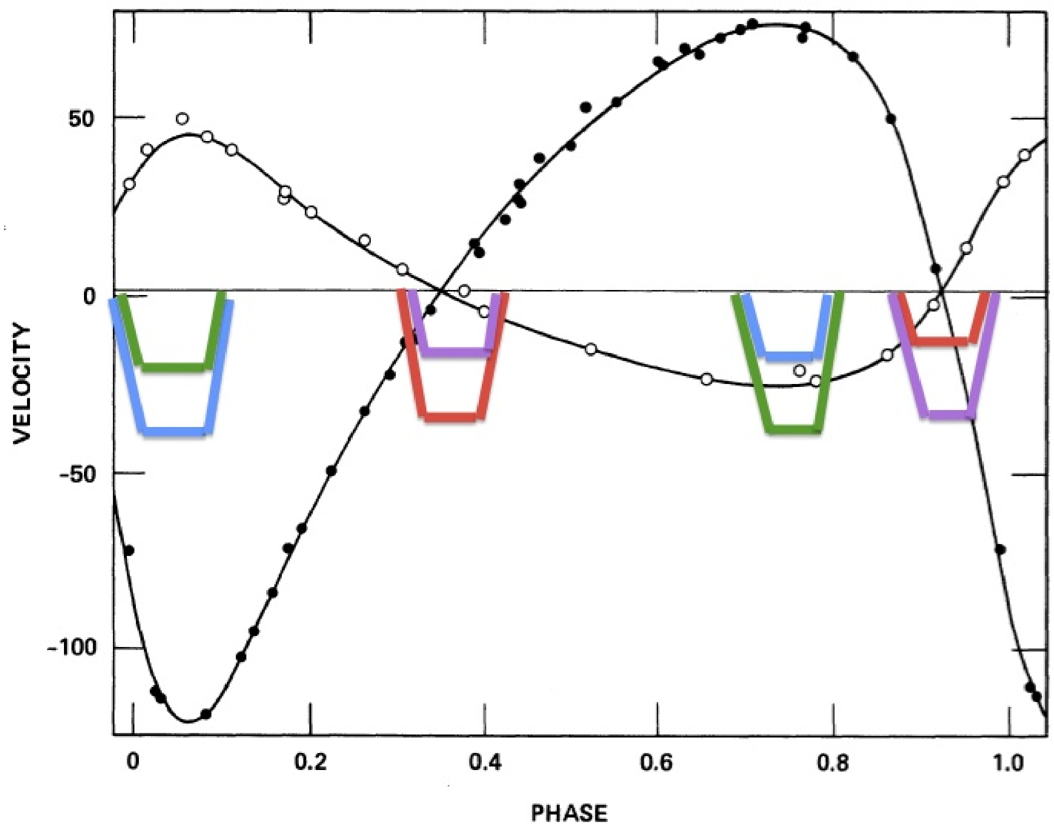
Part B:

1. The α Centauri system mentioned in Clip 11 has a period of 79.9 years and a semimajor axis of 17.57 arcsecond. The system has a parallax angle of .747 arcsecond. Find the total mass of the system in terms of the Solar mass. Round to two significant figures.

2. Measurements of the orbital motions of the two partners show that their orbital motions are related by $v_B/v_A = 1.213$. Use this information to find the masses of α Centauri A and B separately, in terms of the Solar mass. Round to two significant figures. Your answer should be **two** numbers separated by one or more spaces. The first is the mass of α Centauri A (the primary, more massive star) and the second the mass of α Centauri B.

The following set of linked problems follows up on the discussion of Alphecca (α Coronae Borealis) in Clip 13, using data from the article cited there (link on site)

3. The figure below shows the radial velocity measurements for the two stars. The more massive star in this system is the hotter, more luminous primary. The colored lines are each a simplified caricature of a possible light curve for the system, aligned to the radial velocity measurements in timing. Each exhibits two eclipses at which the total luminosity dips. Which of the curves is qualitatively closest to the actual light curve of the system?



A) The blue curve

B) The green curve

C) The red curve

D) The purple curve

4. Lets try to estimate the dip we expect in luminosity. The surface temperatures of the two stars are 9700 K and 5800 K, and their radii are 3.04 and 0.90 $R_{\odot}$, respectively. Estimate the factor by which the apparent brightness of the system dips when the dimmer, cooler secondary eclipses the hotter primary, and the factor by which it dips when the primary eclipses the secondary. Your answer should be two numbers, each between zero and one indicating the ratio between brightness during each eclipse and brightness between eclipses, separated by one or more spaces. The first refers to the secondary eclipsing the primary and the second to the primary eclipsing the secondary. To compute the first case, you may assume that we see the primary as a uniformly bright disk.

5. The speeds of the two stars are measured as 35 km/s and 99 km/s. Use this along with the information in the previous question to estimate the length in seconds of the horizontal segment of the dip in total luminosity during an eclipse, and the length in seconds of the segment of the light curve during which the luminosity decreases to its minimum value during an eclipse. Your answer should be two numbers, separated by one or more spaces. Round to two significant figures.