Northview Invitational -- Astronomy

15 December 2012

Team Name: Key

Team #: _____

Instructions: *Using resources as outlined in the 2013 rules, answer the following questions. If the answer asks for a number, you must include appropriate units to be granted credit. In addition, your answer must be in one of the unit(s)--or a reasonable multiple, e.g. pc,kpc,Mpc;m/s, km/s--requested.* ***Show your work!*** *Partial credit will be given for proper procedures.*

You might find the following useful.

Data for the Sun

Mass ≅ 2×10^{30} kg

Radius ≅ 7×10^{5} km

Luminosity ≅ 3.8×10^{26} W

Temperature = 5778 K

Spectral Type = G2V

Absolute V band magnitude $M_V = 4.83$

B−V color = 0.66

Other Information

1 Astronomical Unit ≅ 1.5×10^{8} km

Hubble's Constant ≈ 73 (km/sec)/Mpc

Stefan-Boltzmann constant = $\sigma = 5.67 \times 10^{-8}$ J s^{-1} m^{-2} K^{-4}

Score: _____*/100*

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1. The following questions refer to the image below.

a. Identify the star found in the left of this image: Arcturus (2)

b. What larger structure is this star associated with? Rho Ophiuchus cloud (2)

c. This star has a parallax angle of 5.89 mas. What is the distance to the star? *(pc OR ly OR m)*(3)

$d = \frac{1}{p}$ $d = \frac{1}{0.00589''}$ = 169.8 pc

= 5.2×10^{18} m

= 553.8 ly

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d. This star is actually two stars. This table gives the properties of the stars.

	A	B
Mass	12.4 $M_\odot$	10 $M_\odot$
Radius	883 $R_\odot$	4 $R_\odot$
Temperature	3400 K	18500 K

Calculate the luminosities of the two stars. *($L_\odot$ OR W)* (4)

$\frac{L}{L_\odot} = \frac{R^2}{R_\odot^2} \times \frac{T^4}{T_\odot^4}$ & $\frac{L_A}{L_\odot} = \frac{883^2 L_\odot}{1 L_\odot^2} \times \frac{3400K^4}{5778K^4} = 779689 \times 0.119$

$L_A = 93481\ L_\odot$

$= 5.9 \times 10^{31}$ W

$\frac{L_B}{L_\odot} = \frac{4^2 L_\odot}{1 L_\odot^2} \times \frac{18500^4}{5778^4} = 16 \times 105 =$ 1680 $L_\odot$ = 6.38×10^{29} W

e. The estimated physical separation between the two stars is 574 AU. Estimate an orbital period from this information. *(years OR seconds)* (4)

$M_1 + M_2 = \frac{a^3}{p^2}$ $\quad 22.4\ M_\odot = \frac{(574\ AU)^3}{p^2}$

$p^2 = \frac{4\pi^2}{G(M_1+M_2)} a^3$ $\quad p^2 = \frac{(574\ AU)^3}{22.4}$

$p = \sqrt{\frac{189\,119\,224\ AU^3}{22.4}}$

$p = 2905$ yr

$= 9.1 \times 10^{10}$ sec

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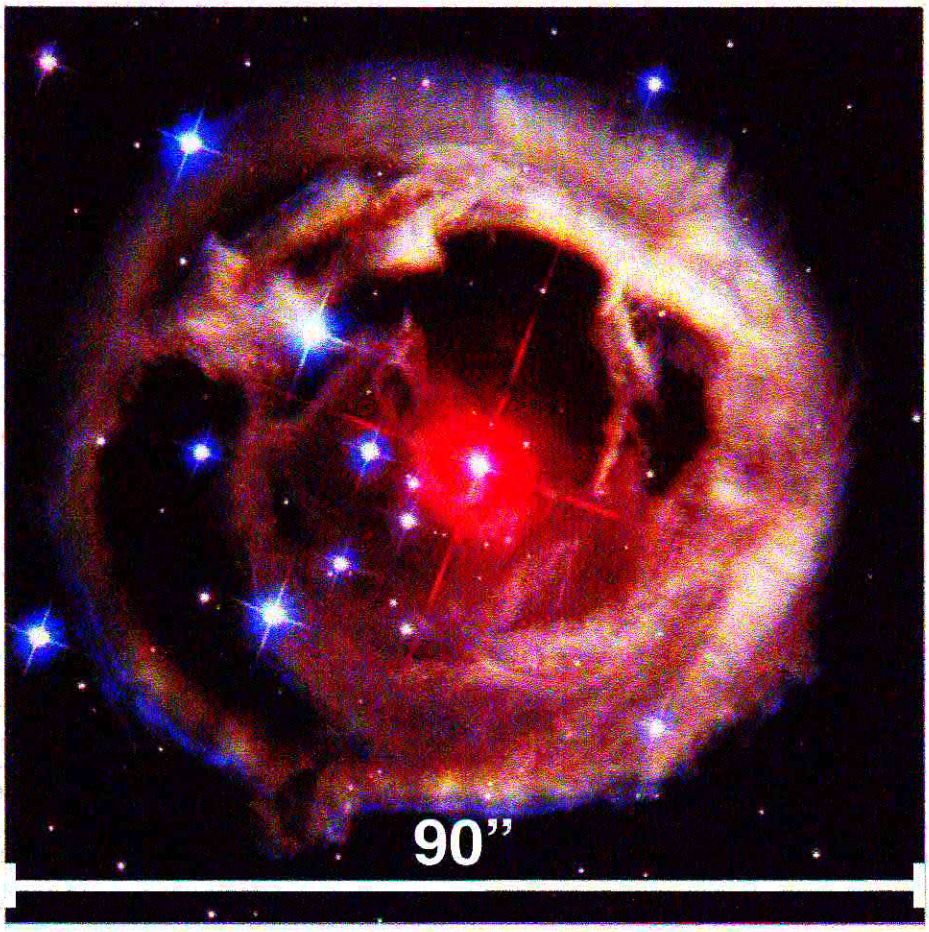
2. The following questions refer to the image below.



a. Name this object: V838 Monocerotis (3)

b. The image above was taken on 17 December 2002, and shows the light echo from the outburst of the star. If the outburst began on 6 January 2002, estimate the distance to this object using the fact that the image is ~90 arcsec on a side. *(pc OR ly OR m)* (12)

Assume center to edge = 35"

Assume ~~Bjorko~~ ~ 1/12 year = 2.8×10^7 s x 3×10^8 m/s = 8.635×10^{15} m

$$\frac{35''}{206265''} = \frac{8.635 \times 10^{15}\ m}{D} = 5.08 \times 10^{19}\ m$$

= 5370 ly

= 1646 pc

Short Answer (2 points each)

a. The final stage of evolution for a star like the Sun is a white dwarf.

b. Main sequence stars fuse hydrogen into helium in their cores.

c. The maximum mass for a white dwarf (~1.4 solar mass) is known as the Chandrasekhar limit.

d. Stars burning helium-4 into carbon-12 in the triple-alpha process reside on what part of the H-R diagram? horizontal branch.

e. A class of variable stars that have a relationship between their period and luminosity are known as Cepheids (or) RR Lyrae.

f. Supernovas with strong Hydrogen lines in their spectra are what type of supernova? Type II.

g. A white dwarf is supported by what force? electron degeneracy pressure.

h. When the remaining matter in a star collapses beyond the Schwarzchild radius, it forms a black hole.

i. Pulsars emit radiation most strongly in what wavelength band? radio.

j. This exploration mission successfully landed on Mars in August 2012. Curiosity.

4. Vega is the brightest star in the constellation Lyra. It has a parallax angle of 130.23 mas.

a. What is the distance to Vega? *(pc OR ly OR m)* (2)

$d = \frac{1}{p}$ $d = \frac{1}{0.13023''}$ $d = 7.67$ pc $= 25.02$ ly $= 2.367 \times 10^{17}$ m

b. Vega is historically the zero point of the apparent magnitude system. What is its absolute magnitude? *(magnitudes)* (3)

Assume $m = 0$ $d = 7.67\,pc$

$m - M = 5 \log d - 5$

$0 - M = 5 \log 7.67\,pc - 5$

$-M = 5 \times 0.88479 - 5$

$-M = -0.576$ $\boxed{M = 0.6}$

c. Imagine that Vega magically replaces the Sun in our solar system. What is its apparent magnitude? Compare to the Sun. Why might this number not be what you expect? *(magnitudes)* (10)

~~M = 0.6~~

$m - M = 5 \log d - 5$

$m = 5 \log \left(\frac{1}{2.0626 \times 10^{-5}}\right) - 5 + 0.6$

$m = -30.97$

4.2 mg diff

$M_{Sun} = -26.7$

$M_{Sun} = 4.83$

4.2 mg diff

$M_{Vga} = 0.6$

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5. The period-luminosity relationship for Type II Cepheids in the J-band is

$$M_J = -2.23 * \log P - 0.864$$

a. Use the following to calculate the distance to the globular cluster M14. *(pc OR ly OR m)* (10)

log P	Star	Period (d)	m_J	M_J
1.2729	A	18.743	11.83	-3.70
0.4462	B	2.794	13.65	-1.85
1.1335	C	13.599	12.24	-3.39
0.2764	D	1.890	13.98	-1.48

d

$m - M_A = 15.53$

$B = 15.5$

$C = 15.63$

$D = 15.46$

$avg = 15.53$

$d = 12.74 \text{ pc}$

$= 41\,420 \text{ ly}$

$= 3.919 \times 10^{20} \text{ m}$

b. The actual distance to M14 is 9.3 kpc. Why might the value that you found be different? (5)

Reddening!

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6. Quick Identification (20 points, 4 per object)

Object	Name(s)	Wavelength band(s)
A	NGC 6888	optical
B	IC 1396	IR
C	Cas A	IR
D	SXP 1062	x ray
E	M1 (Crab)	optical