4 Team Name_____ Team Number_____

a Given the temperature of the object, what would be the wavelength of the peak of the object's spectrum. _____

$\lambda_{max} = \frac{3000000}{T}$ in Nm so $\frac{3000000}{3100} = 968nm \sim 9680\text{Å}$

b Would this peak be included in the band that the image was made in? No

And why? 968nm ~ 9680 Å is in the IR. We are observing in the Visual

c What is the absolute magnitude of the object? _____

$m_v - M_v = -5 + 5 \log d$ d in parsecs (pc) $d = 1/\pi$ → parallax

$d = \frac{1}{.00763}$" (arc seconds) $m_v = .58$

$M_v = 5 + .58 - 5(\text{Log } \frac{1}{.00763}) = \sim -5.0$

d What is the star's radius in km? $d = 1/\pi = 131$ pc

1" at 1pc = 1AU

1" at 131 Pc = 131AU

.06" at 131 Pc = .06 × 131 au = 7.86 au = diameter!

7.86/2 = 3.93 au = Radius!

3.93 au × 1.5×10^8 km/Au = 590×10^8 km

Between the orbits of Mars and Jupiter

5 Team Name_____ Team Number_____

e Find the ratio of the luminosities of Betelgeuse and the Sun by comparing their absolute magnitudes.

$L_1/L_2 = 10^{(M_2 - M_1)/2.5}$

$= 10^{(4.83 - (-5.0))/2.5}$

$= 10^{3.932}$

$= 8550$

f Now find the ratio of the luminosities of Betelgeuse and the Sun by comparing their radii and measured temperatures.

$L_1/L_2 = \left(\frac{R_1}{R_2}\right)^2 \left(\frac{T_1}{T_2}\right)^4$

$= \left(\frac{5.9 \times 10^8}{7 \times 10^5}\right)^2 \times \left(\frac{3100}{5778}\right)^4$

$= (710.00)\ (.083)$

$= 58,900$

6 Team Name_____ Team Number_____

g Look at your answers for parts e and f. Are the same? NO

Are they close (in an astronomers sense)? NO, order of Magnitude off

h We now have two derived (calculated from experimental measurements) for the value of the ratio of the luminosities of Betelgeuse and the Sun. Assume that we have the values for the Sun measured correctly. Given that any measurement will have some error associated with it, which of the following measured quantities for Betelgeuse would make the largest contribution to the overall error in our determination absolute magnitude assuming that the error in each measurement was 5%.

1 Angular Diameter _____

2 Distance _____

3 Temperature X

4 Apparent Magnitude _____

i Support your answer for part h (i.e show some work) _____

for Angular diameter we will get the Ratio of the Luminosities with and without the error $\frac{L \pm \text{Error}}{L} = \left(\frac{1.05 R_B}{R_\odot}\right)^2 / \left(\frac{R_B}{R_\odot}\right)^2$

$\frac{L_{Error}}{L} = \left(\frac{6.2\times10^8}{7\times10^5}\right)^2 / \left(\frac{5.9\times10^8}{7\times10^5}\right)^2$

$= (793000) / 710000 = 1.1$

Back Through L → M Formula → $M_1 - M_2 = -2.5 \log \frac{L_1}{L_2}$

$M_1 - M_2 = .16$ mag

For Distance we work in parallax and the difference in calculated Magnitude is just the difference in the $5 \log d$ terms $\pi'_{Error} = 1.05\pi$ (π is Parallax)

$1.05 \times .00763 = .008$ $5 \log\left(\frac{1}{.00763}\right) - 5 \log\left(\frac{1}{.008}\right) = .10$ mag

For Temp work as we did for Radius

$L_{Error}/L = \left(\frac{3255}{5778}\right)^4 / \left(\frac{3100}{5778}\right)^4 = 1.22$

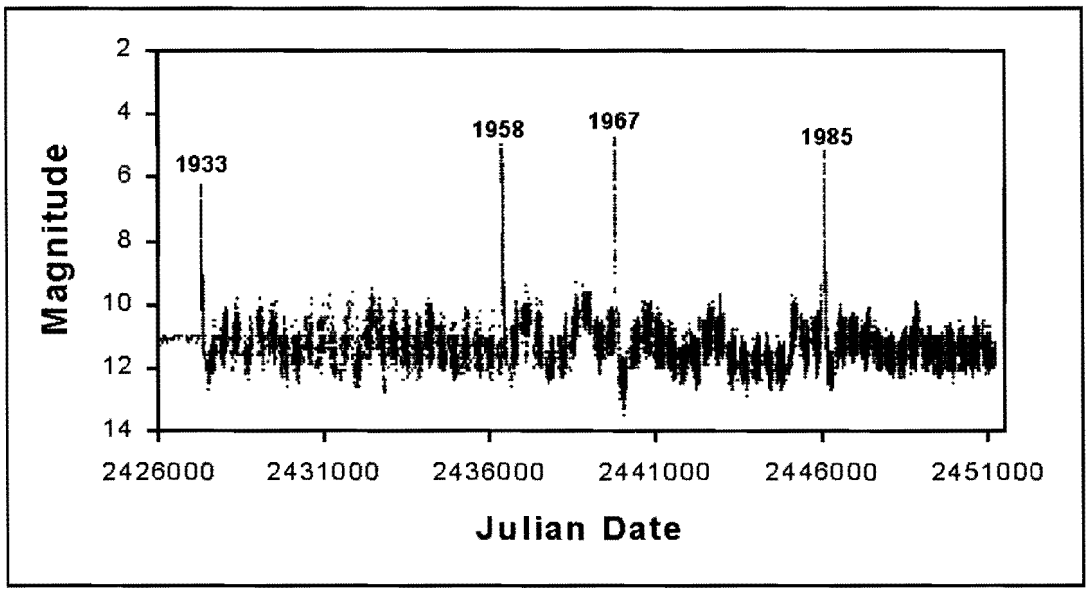
Back through gives $= -2.5 \log(1.22) = -.21$ mag

For magnitude $1.05 \times .58 = .61$ $.61 - .54 = -.03$ mag

a good guess is Temperature as the dependency is T^4

7 Team Name_____ Team Number_____

2 This is a spectrum of one of the DSO's for this year.



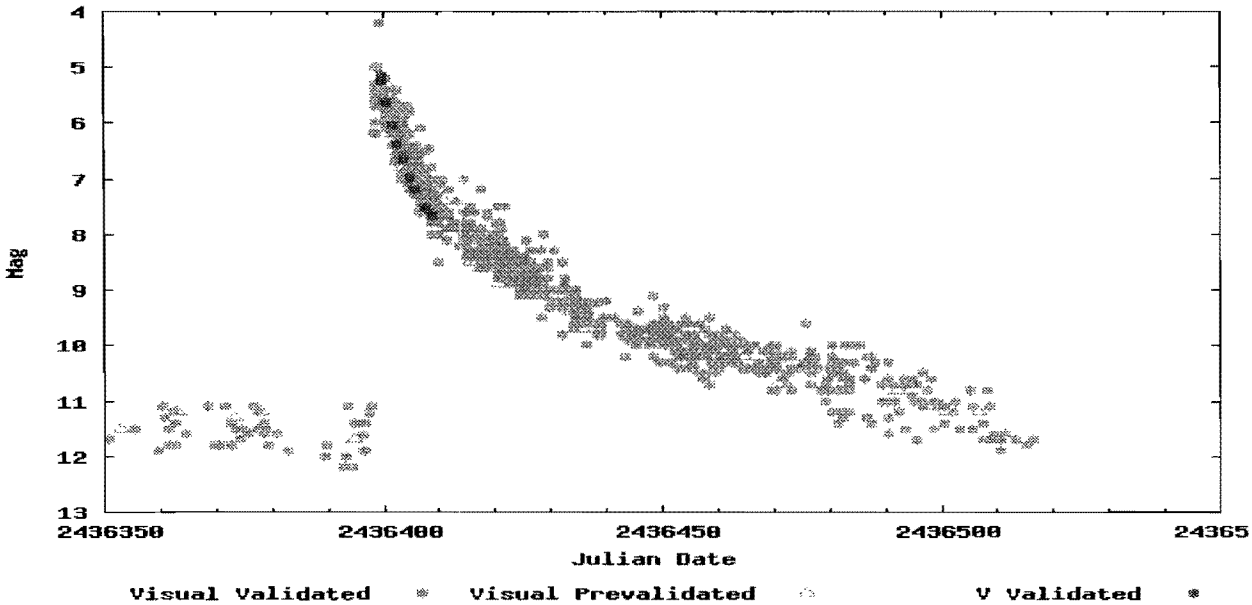
a Which of our DSOs is shown here? RS Ophiuchi

b What sort of variable star is this DSO? recurrent Nova

c At a maximum, could an observer see this object with the naked eye? yes

d Would this object be observable from Mentor High School (assuming a power outage took out all of those nasty city lights and some thoughtful lumberjack had cleared all of the trees from the southern horizon)? Yes, Ophiucus is near the ecliptic
The declination RS Oph is -6°

Here is a closer look at the 1958 outburst



e Looking at the rapid rate of the increase (less than 1 day) do you think a change of temperature or a change of size caused most of the observed change? Temperature

f Why. work the Δ magnitude to Δ Luminosity

$\frac{L_1}{L_2} = 10^{(m_2-m_1)/2.5} = 10^{(11.5-5)/2.5} = 398$

$\left(\frac{R_1}{R_2}\right)^2 = 398$ $\frac{R_1}{R_2} = 20$

$R_1 = R_2 + \Delta R$ $\frac{R_2+\Delta R}{R_2} = 20$

$R_2 + \Delta R = 20R_2$

$\Delta R = 19R_2$ ←

For Temperature

$\left(\frac{T_1}{T_2}\right)^4 = 398$ $\frac{T_1}{T_2} = 4.46$

$T_2 + \Delta T = 4.46\,T_2$

$\Delta T = 3.46\,T_2$ ←

A change of ~ 19 times for just Radius

Vs A change of 3.46 times for Temp

Again T^4 wins

9 Team Name_____ Team Number_____

3 This is a false color image of the field of one of this years DSOs.

a Which object is in this field? RX J0822 -4300

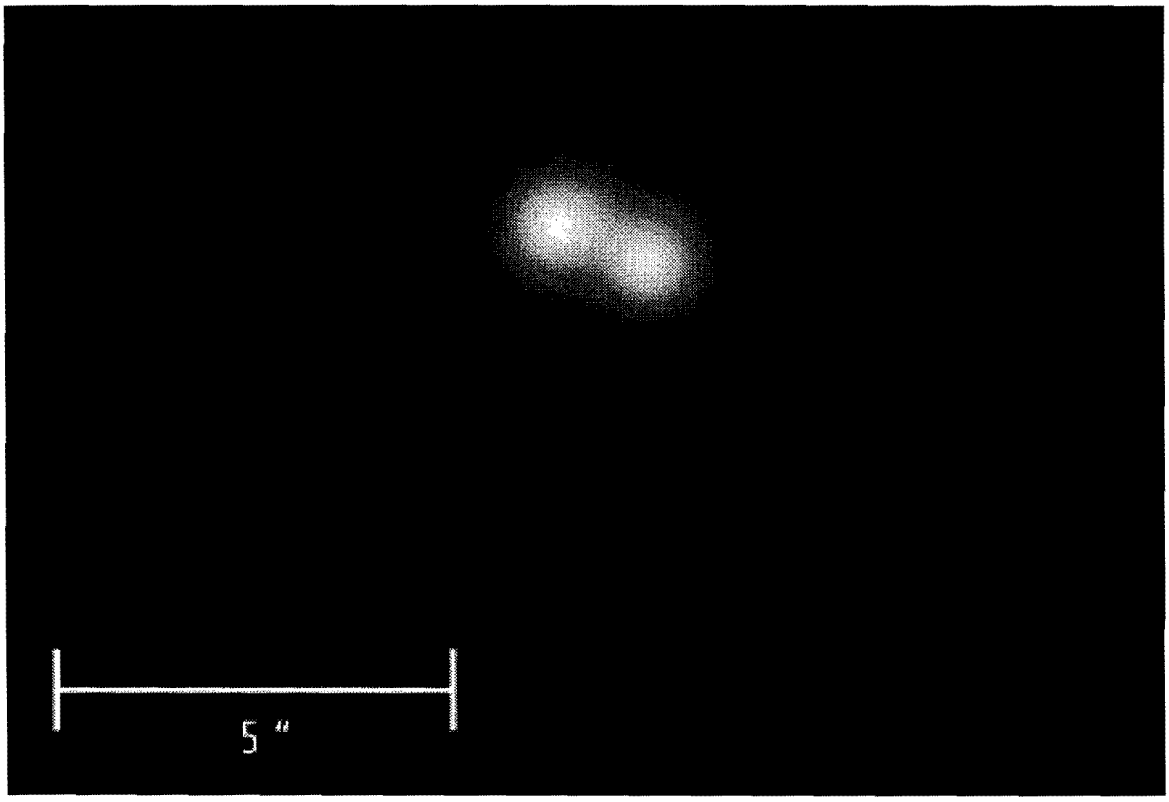
b What sort of object is this? Super Nova Remnant / Neutron Star

c What part or parts of the electromagnetic spectrum are represented in this false color image?

X-Ray and Visual

This is a close-up of an overlay of two images of the DSO, taken 12/21/1999 and 04/25/2005, with a scale bar.

A radial velocity measurement of the object give a value of +1350 km/sec.

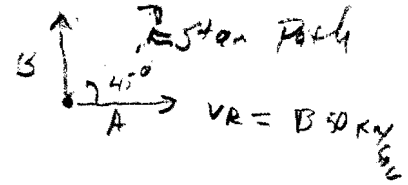


d Estimate the distance to the object, assuming that the motion of the object is along a line at 45° to the line of sight. Measure the Angular motion of the object by estimating. I get ≈ 1" (one second) Calculate the time difference I get 5 years plus ~20 weeks convert to seconds 20 weeks is .38 years so we have $5.38 \times (3.1 \times 10^7 \text{ sec/year}) \approx 1.6 \times 10^8$ seconds

distance traveled is $1.6 \times 10^8 \text{ sec} \times 1350 \text{ KM/sec} \times \frac{1 \text{ AU}}{1.5 \times 10^6 \text{ KM}} = 1440 \text{ AU}$

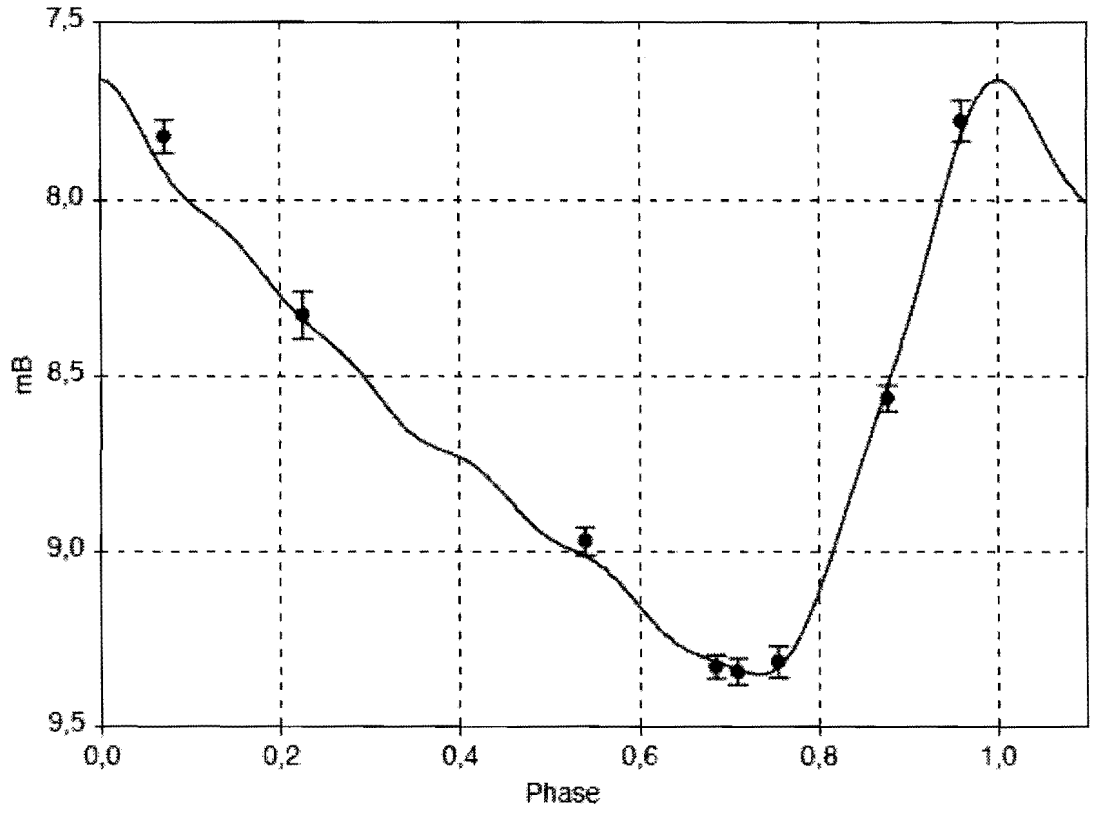
This 144 AU is away from us. The 45° assumption implies that the Transverse distance is Also 144 AU.

We end up with 1" = 1440 AU So using a similar triangle where 1" = 1 AU at 1 PC if 1" = 144 AU then the distance is 1440 pc



11 Team Name_____ Team Number_____

4 This is a light curve for one of the DSOs



The period of the variable is 41.5 days. The ligh curve given is in the B band. A visual magnitude for this object is $m_V = 7.0$.

a Which of our DSOs is this? R S Puppis

b What type of variable star is this? classical cepheid

c Calculate the distance to this object from the data given.

First find the Absolute Magnitude. use the P/L Relationship

$M_V = -2.8 \log P - (1.43)$ with P in days

$= -2.8 \log(41.5) - 1.43$

$= -5.96$

Now use $m_v - M_v = -5 + 5 \log d$

$7.0 - (-5.96) + 5 = 5 \log d$

$3.992 = \log d$ $\quad d = 3900$ pc

12 Team Name_____ Team Number_____

5 This is a picture of two of our DSOs.

Which two DSO's are represented in this picture?

a T Tauri } either order

b Hinds Variable Nebula

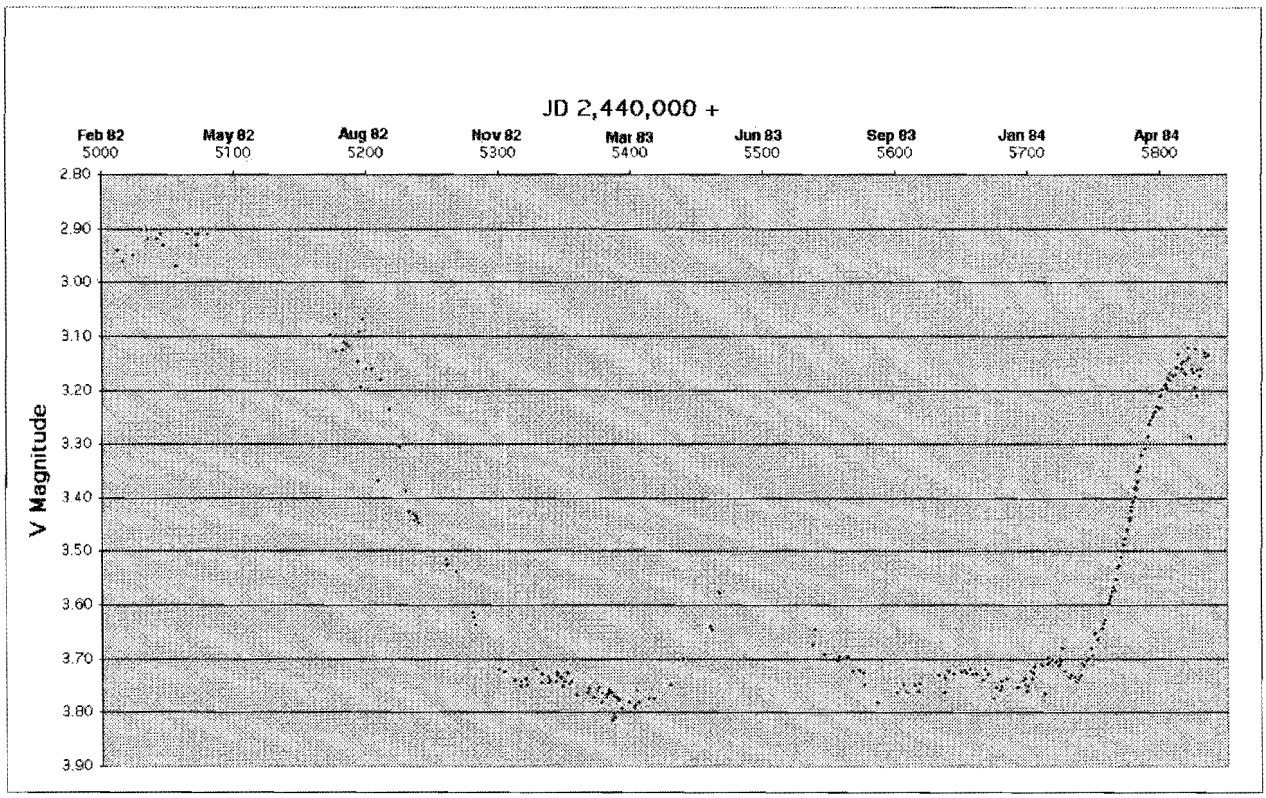
c Label two objects in the picture. An arrow with an a or b at the end will do.

d Describe what we are seeing here in terms of the life of a star. A T Tauri star is just collapsing from a dust cloud It has just started to burn hydrogen The nebulosity is material that remains from the Protostellar cloud

e Assuming clear weather (never a good assumption in February in Northeast Ohio), could we observe this object from Mentor after dark tonight? Yes Taurus is high in the sky at this time of year

13 Team Name_____ Team Number_____

6 This is a light curve for one of the DSOs.



a Which DSO is this? Epsilon Aurigae

b What sort of variable star is this? Eclipsing Binary

c This plot only shows the "Interesting" part of the light curve. If you have answered part a and/or part b correctly, you should be able to tell me about the rest ("Boring" part) of the light curve. Do so. The rest of the light curve will be flat at the Bright Level.

d If you were paying attention to this year's event description, you should be able to tell me why this DSO is particularly topical. Do so. There is a Nationwide observing Program for this Star in conjunction with the "Year of Astronomy" which celebrates the 400th Anniversary of Galileo's use of a Telescope for Astronomical observations. Also Epsilon Aurigae is about to enter the eclipse phase which only happens every 27 years.