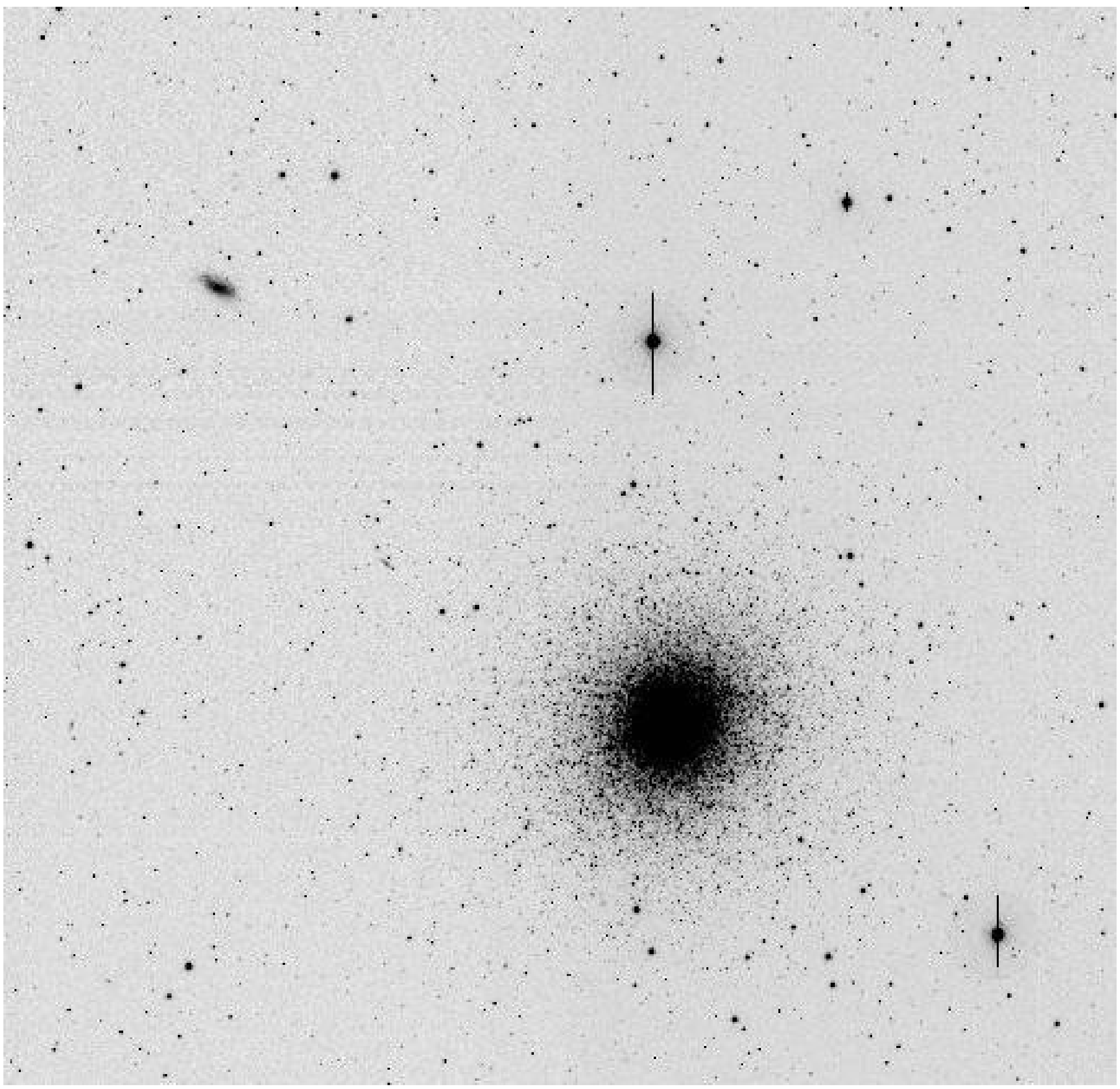
Science Olympiad
Division C - Astronomy (Variable Stars)

February 23, 2008

Team Number ________



DSO ID section:

1. What is the name of the object in DSO A, on the DSO images page?
2. What type of object is this?
3. What is the bright source of light at the (exact) center of this object?
4. When did the event occur that created this object, and who saw it?
5. What is the name of the object in DSO B, on the DSO images page?
6. What type of object is this?
7. What is the name of the object in DSO D?
8. Which telescope made this observation of this object?
9. This object is a large cloud of dust and gas being illuminated by a central star. The light propagates through the object at c, 3 x 10^8 m/s. Given the (fictional) scale on the image and the distance to the object (20,000 light years, 6 kiloparsecs), calculate how long ago the central star sent out its pulse of light.

HR Diagram questions

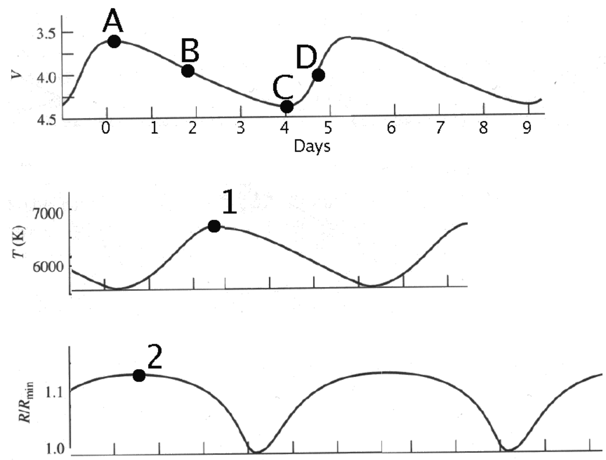
Identify (by letter) where the following stars fall on the HR diagram (attached at the end):

10. White dwarfs:
11. Supergiants:
12. Giants:
13. Our Sun:

14. Which letter/letters is/are the coolest stars in the HR diagram?
15. Which letter/letters is/are the hottest stars in the HR diagram?
16. Which letter/letters is/are the intrinsically brightest stars in the HR diagram?
17. Which letter/letters is/are the largest stars?
18. How many times brighter are stars around the letter A than stars around the letter K?

Light Curves I

Given below is the light-curve of a variable star. The top plot shows the apparent magnitude (in the V-band, of visual light) over 10 days of observation.



19. What is the period of this variable star, in days?
20. What type of variable star is this (most probably)?

An astronomer was also measuring the variations in (surface) Temperature and in Radius (size) of this variable star, and these are shown below the light curve. Unfortunately, these measurements were not taken at the same time, and she doesn't know how the temperature and radius curves should line up with the light curve. How should these second two curves be shifted to match the light curve?
21. Point "1" on the temperature curve should be located at the same time as which of the letters on the light curve?
22. Point "2" on the radius curve should be located at the same time as which of the letters on the light curve?

More questions:

23.Why is the spectral sequence of stars not alphabetical?

A) The letters refer to the initials of the original discoverers.

B) The original alphabetical labeling did not correspond to surface temperature and thus had to be reordered.

C) They were chosen to fit a mnemonic

D) Because there is still uncertainty over what generates the energy in stellar cores.

E) Because it refers to stellar masses and these were difficult to measure accurately.

Match the following terms to their definitions.

A) Visual binary

B) Spectroscopic binary

C) Eclipsing binary

24. A pair of stars that we can determine are orbiting each other only by measuring their periodic Doppler shifts

25. A pair of stars whose orbital plane is oriented along our line of sight

26. A pair of stars that appear to change positions in the sky, indicating that they are orbiting one another

Name the spectral type best described by each of the following statements.

27. The stars with the largest radii are type ___.

28. The most common type of stars are type ___.

29. Type ___ stars are on the main sequence for approximately 2 million years.

30. Type ___ stars have the longest main-sequence lifetimes.

31. Which of the following properties can be observationally determined for an eclipsing binary system? (you may select more than one)

A) radius

B) age

C) absolute magnitude

D) relative mass

E) period

F) total mass

G) orbital inclination

H) distance

32. Suppose that the star Betelgeuse were to supernova tomorrow (as seen here on earth). What would it look like to the naked eye?

A) Betelgeuse would remain a dot of light, but woudl suddenly become so bright that, for a few weeks, we'd be able to see this dot in the daytime.

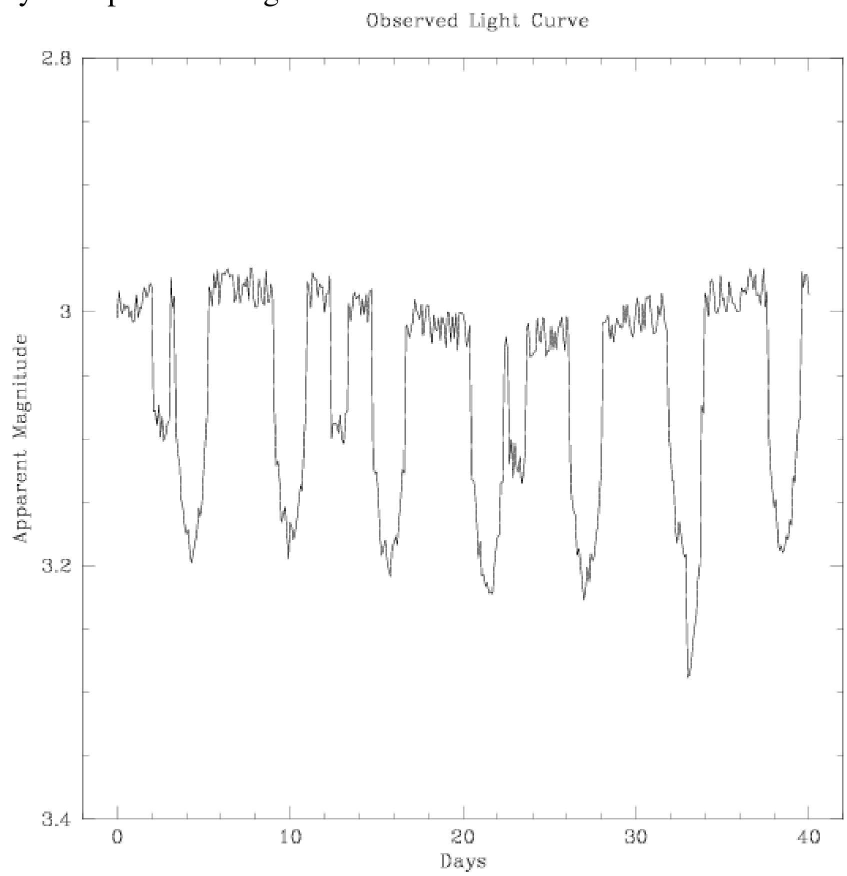
B) We'd see a cloud of gas expanding away from the position where Betelgeuse used to be. Over a period of a few weeks, this cloud would fill our entire sky.

C) Because the supernova destroys the star, Betelgeuse would suddenly disappear from view.

D) Betelgeuse would suddenly appear to grow larger in size, soon reaching the size and brightness of the full Moon.

Long question 1:

By extreme fortuitousness, you are able to acquire Hubble observations of a sun-like star over a 40 day time period. Its light curve is shown below:



33. How many planets does this star have?

A) 0

B) 1

C) 2

D) 2 or more

E) 8

34. For each of the transiting planets obvious in this light curve, estimate their period in hours:

35. Using Kepler's laws and these periods, calculate the average radius of each planet's orbit in AU:

36. Of these planets, which is the largest?
A) The longest period planet is largest
B) The shortest period planet is largest
C) The middle-period planet is largest
D) All of the planets are the same size

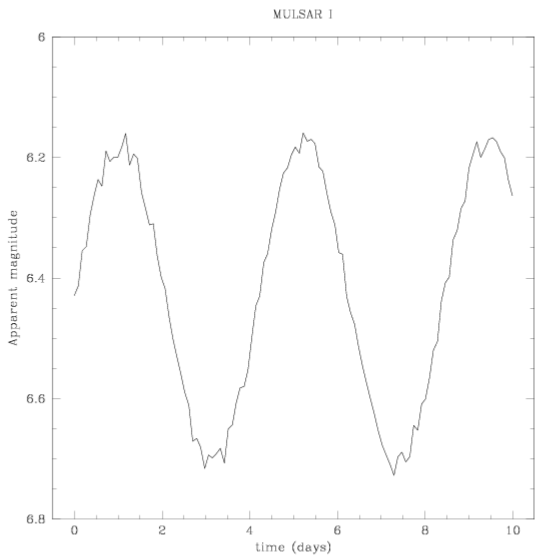
37. Now notice the longer-period variations in the star itself. What is the period of the star's variations?

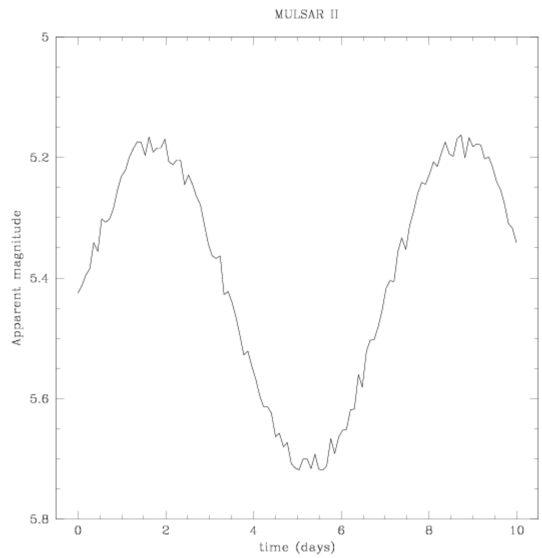
38. Do you believe that this is really a sun-like star?
A) Yes. Sun-like stars can have transiting planets, and can sometimes be variable.
B) No. Sun-like stars can have transiting planets, but are not likely to be be variable on these time-scales.
C) No. Sun-like stars cannot have transiting planets, but can sometimes be variable.
D) No. Sun-like stars cannot have transiting planets, and cannot be variable.

39. How would changing the star's mass affect these estimates?
A) An increase in the star's mass would increase the radii of the orbits
B) An increase in the star's mass would decrease the radii of the orbits
C) An increase in the star's mass would not change the radii of the orbits (they are set only by the properties of the planet)

Long question 2:

Congratulations, you've just discovered a new kind of variable star, and you name it a MULSAR. The first two you discover are in an open cluster that is 100 light-years (30 parsecs) away. Here are their light curves:





40. What is the period of MULSAR I, in days:

41. What is the average apparent magnitude of MULSAR I:

42. What is the period of MULSAR II, in days:

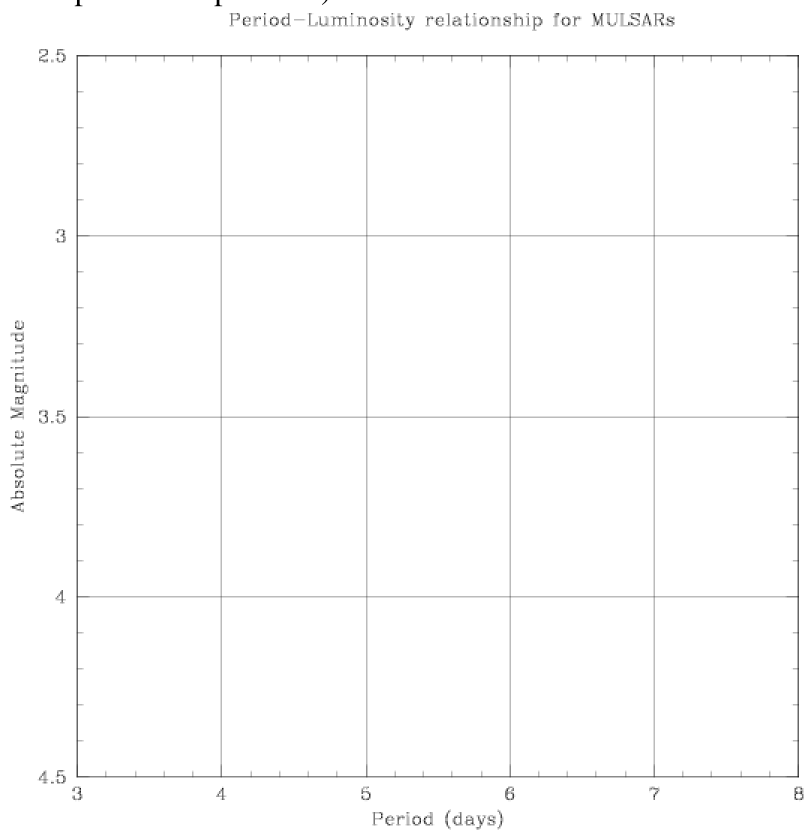
43. What is the average apparent magnitude of MULSAR II:

44. Given the distance to this cluster of 100 light-years (30 parsecs), what is the absolute magnitude of MULSAR I:

45. What is the absolute magnitude of MULSAR II:

(continued on the next page)

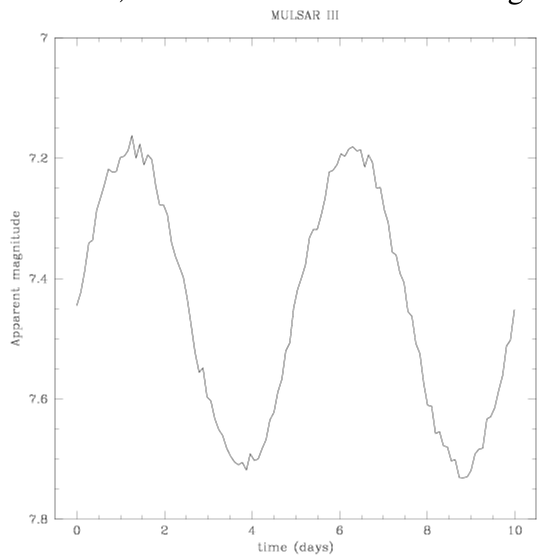
On the following graph, plot out the Period and Absolute Magnitudes of these two MULSARs, and draw a straight line connecting them. (note: plot is not graded - you will need it in the next part of the problem)



You've now calibrated the Period-Absolute Magnitude (or Luminosity) relationship for MULSARS!

(continued on next page)

Next, you observe MULSAR III, at an unknown distance. Its light curve is shown below:



46. What is the period of MULSAR III?

47. Using the Period-Absolute Magnitude graph above, what is the predicted absolute magnitude for this measured period? (Find its position on the graph along the straight line you drew)

48. What is the average apparent magnitude of MULSAR III?

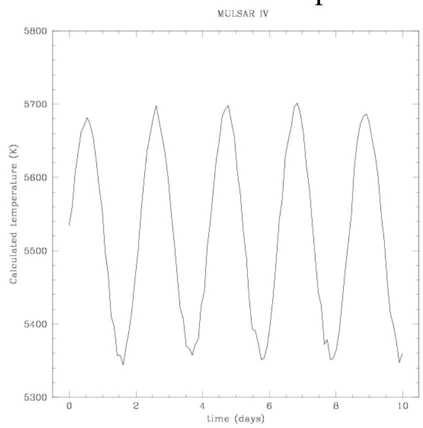
49. Given the calculated absolute magnitude (from the period) and the observed apparent magnitude, calculate the distance to MULSAR III:

50. What would the parallax for MULSAR III be?

51. Would we be able to measure this parallax from a ground-based optical telescope?

(one more page, keep going!)

Finally, you discover MULSAR IV, but this time not from the light-curves, but from spectroscopic observations. From the spectra, you are able to calculate the star's temperature throughout your observations. This temperature curve is shown below:



52. What is the period of MULSAR IV, in days?

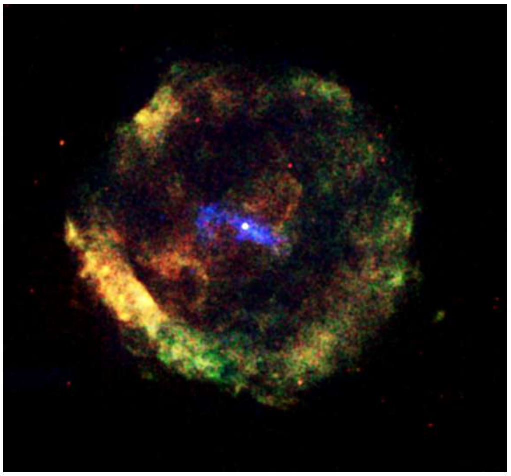
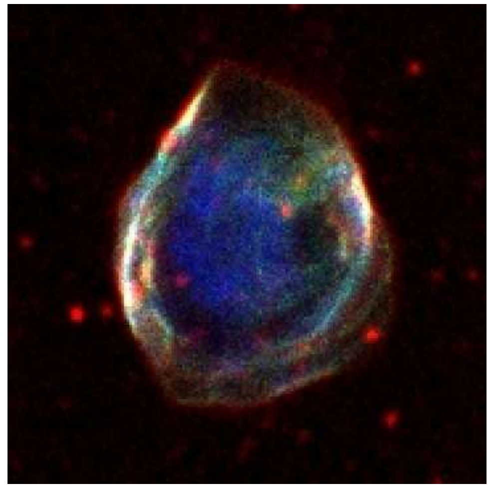
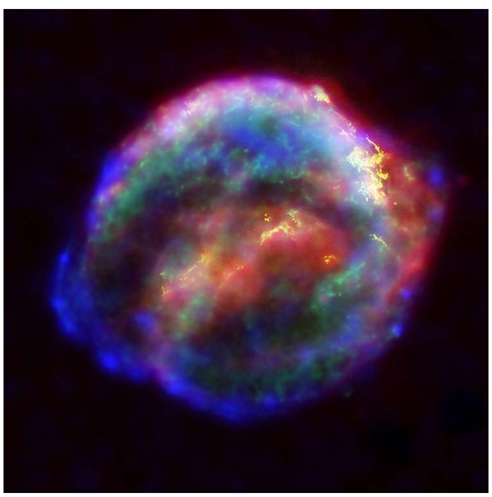
53. What are the minmum, average, and maximum calculated temperatures (in Kelvins):

54. How much will the luminosity change from maximum-brightness to minimum-brightness given these temperature changes? That is, if the temperature changes from 5300K to 5700K, that is a 5% change, so by what percentage will the luminosity change? (HINT: use the Stefan-Boltzmann Law...)

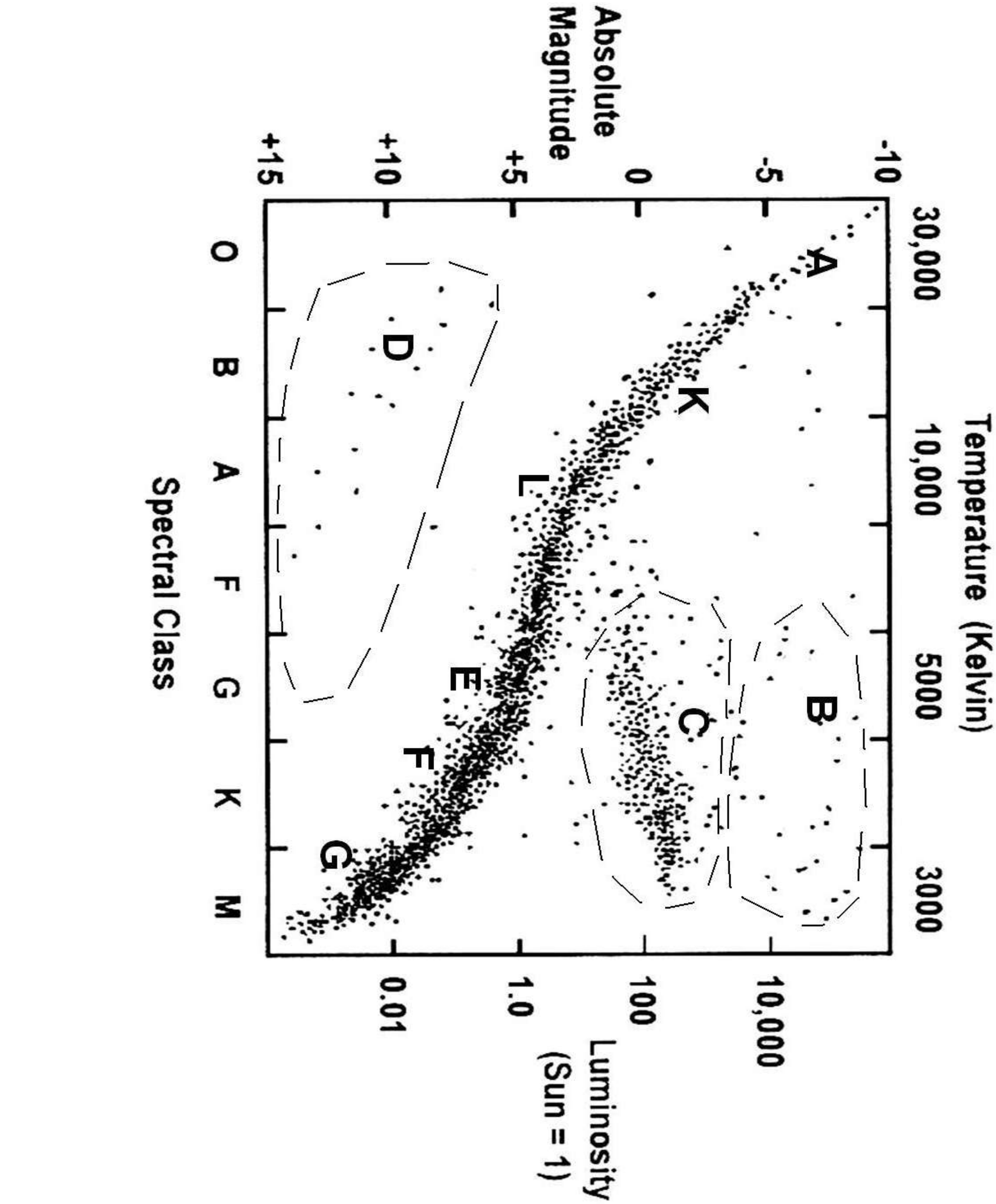
55. When MULSAR IV is at its maximum temperature, at what wavelength will the emitted energy peak? That is, where is the wavelength of maximum emitted light. Answer in angstroms.

56. What type of light is this? i.e. Infrared, visible (red, yellow, green, blue, etc), Ultraviolet, x-ray, etc...

DSO Images

A	***B***
	
C	***D***
	 |--------------10"---------------|

HR Diagram


Temperature (Kelvin)
30,000
10,000
5000
3000
Absolute Magnitude
-10
-5
0
+5
+10
+15
Luminosity (Sun = 1)
10,000
100
1.0
0.01
Spectral Class
O
B
A
F
G
K
M
A
B
C
D
E
F
G
K
L