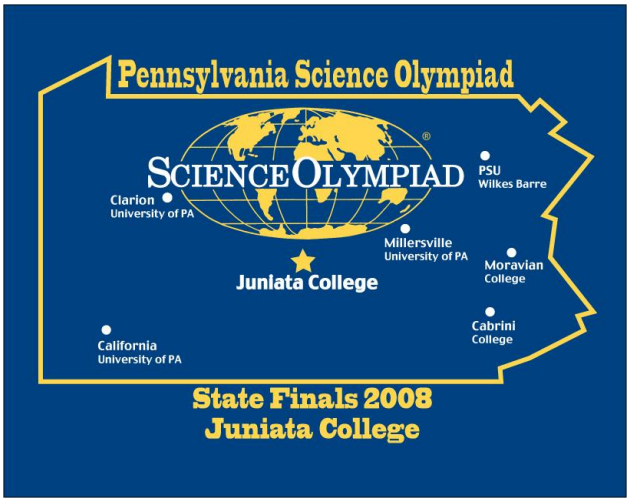


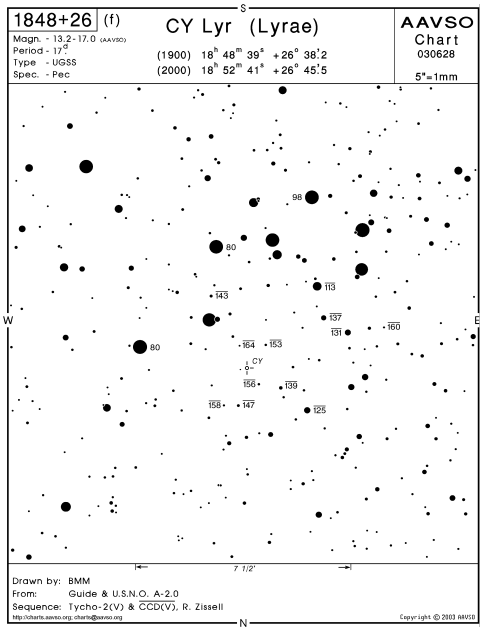

JUNIATA COLLEGE

# PENNSYLVANIA SCIENCE OLYMPIAD

# STATE FINALS 2008

# ASTRONOMY C DIVISION EXAM

# APRIL 25, 2008




**SCHOOL CODE _____ SCHOOL NAME_____**

# INSTRUCTIONS:

**1. Turn in all exam materials at the end of this event. *Missing exam materials will result in immediate disqualification of the team in question*. There is an exam packet as well as a blank answer sheet.**

**2. You may separate the exam pages. Re-staple them as you submit your materials to the supervisor. Keep the answer sheet separate.**

**3. *Only* the answers provided on the answer page will be considered. Do not write outside the designated spaces for each answer. You may write in the exam booklet.**

**4. Include school name and school code number at the bottom of the answer sheet as well as on the title page. Indicate the names of the participants *legibly* at the bottom of the answer sheet. Be prepared to display your wristband to the supervisor when asked.**

**5. Point values for each question are in parentheses. Tiebreaker questions are indicated with a (T#) in which the number indicates the *order of consultation* in the event of a tie. Tiebreaker questions count toward the overall raw score, and are only used as tiebreakers when there is a tie. In such cases, (T1) will be examined first, then (T2), and so on until the tie is broken. There are eight tiebreakers.**

**6. Pay close attention to the units given in the problem and the units asked for in the answer.**

**7. When the time is up, *the time is up*. Continuing to write after the time is up risks immediate disqualification.**

**8. The numbers used to refer to specific images are located *above* the associated image.**

**9. On the *back* of the answer sheet, name the gentleman depicted on the cover and note his major contribution to astronomy. 5 bonus points!**

**10. Nonsensical, mocking, or inappropriate answers WILL RESULT IN DISQUALIFICATION.**

**11. Use the following constants where applicable.**

**$M_{SUN}$ = 2E30 kg**
**$R_{SUN}$ = 696000 km**
**$L_{SUN}$ = 3.85E26 W**
**1 AU = 1.5E11 m**

**Questions 1-25 refer to image page 1, image page 2, and the DSO list as published in the Science Olympiad Student Manual.**

**(2) 1. What is the name of the object in image 6 on image page 1? Which light curve from image page 2 is associated with it?**

**(2) 2. Which two images on image page 1 show the remnants from type 1a supernovae?**

**(2) 3. Which image on page 1 shows an R Coronae Borealis star? What is its name?**

**(2) 4. Which image shows a flare star? Which image shows a close up of the flare mechanism?**

**(2) 5. Image 11 shows an artist's conception of what particular event? Which DSO from the list would qualify as one of these?**

**(1) 6. Roughly how massive is (or *was*) the object referred to in number 5?**

**(1) 7. In what host galaxy (new general catalogue number) is the object referred to in number 5?**

**(1) 8. Which image shows a microquasar?**

**(2) 9. (T3) One of the objects on the DSO list has changed from a population II Cepheid into a semi-regular red giant in less than one hundred years. What object is it? Which light curve from image page 2 is associated with it?**

**(1) 10. What is the object referred to in number 9 "doing" in terms of the HR diagram?**

**(1) 11. What is the name of the DSO shown in image 1?**

**(1) 12. What *should* be produced by the object in image 1 according to Einstein's general relativity?**

**(1) 13. What is the orbital period of the objects shown in image 1?**

**(2) 14. Which object on the DSO list is the prototypical population II Cepheid? Which light curve from image page 2 would be associated with it?**

**(1) 15. What astronomer established the existence of populations I and II during World War II?**

**(1) 16. Relative to its host galaxy, where would a population II star tend to be found?**

**(1) 17. Which image shows an artists' conception of a dwarf nova?**

**(2) 18. What object from the DSO list probably looks like the image referred to in number 17? Which light curve from image page 2 would be associated with it?**

**(3) 19. (T8) What class of variable star is shown in image 10? Which DSO from the list is in this class? Which light curve from image page 2 is associated with it?**

**(2) 20. What is the name of the object shown in image 8? What type of object is it?**

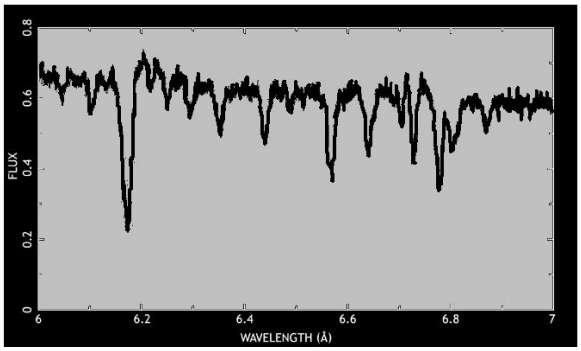
**(1) 21. What is the name of the object from the DSO list that may show the modes of vibration in image 12?**

**(1) 22. What is the name of the object shown in image 5?**

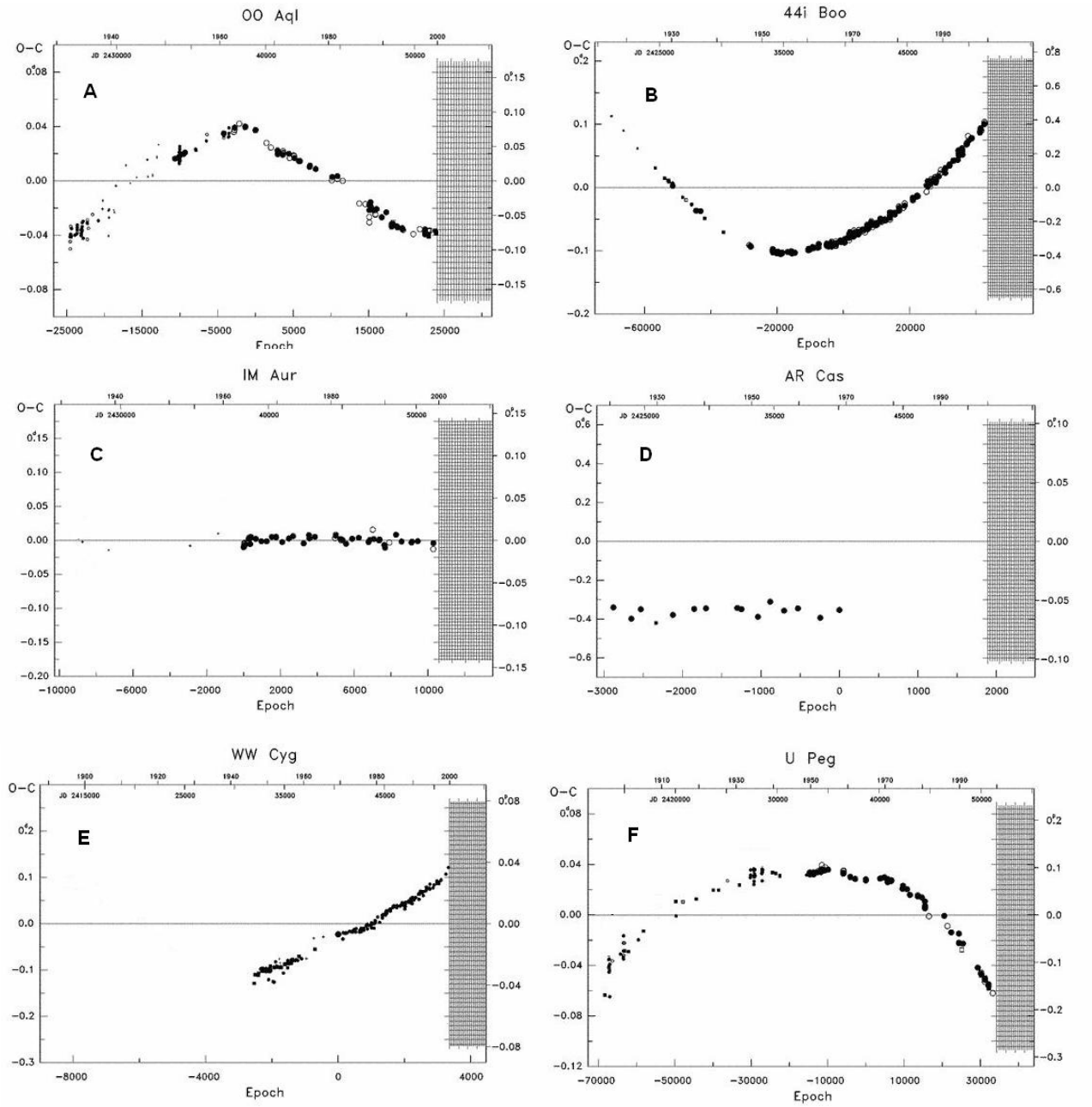
**(1) 23. Which light curve from image page 2 would be associated with image 1 on image page 1?**

**(1) 24. Which object from the DSO list is shown in image 2 on image page 1?**

**(1) 25. From which object on the DSO list does the spectrum shown below originate?**



**Questions 26-30 refer to the following O-C diagrams.**




**(2) 26. In which graphs is the estimated period correct? C D**

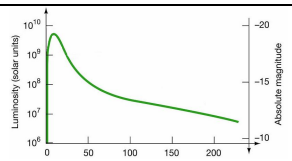
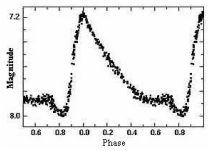
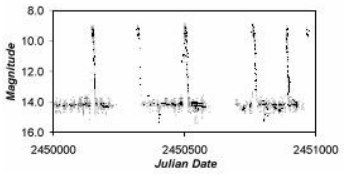
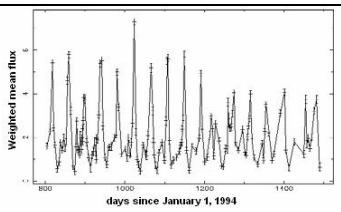
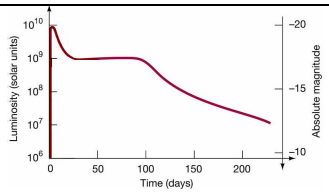
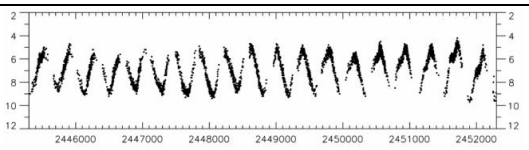
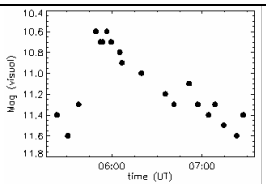
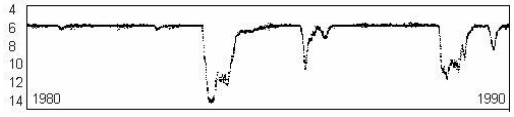
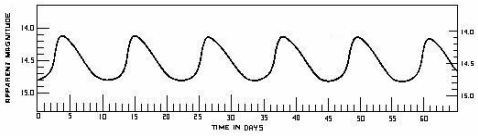
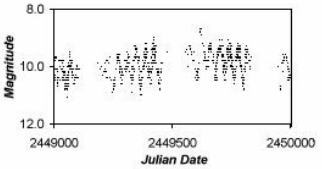
**(1) 27. In which graph is the period increasing? B**

**(1) 28. In which graph is the period decreasing? F**

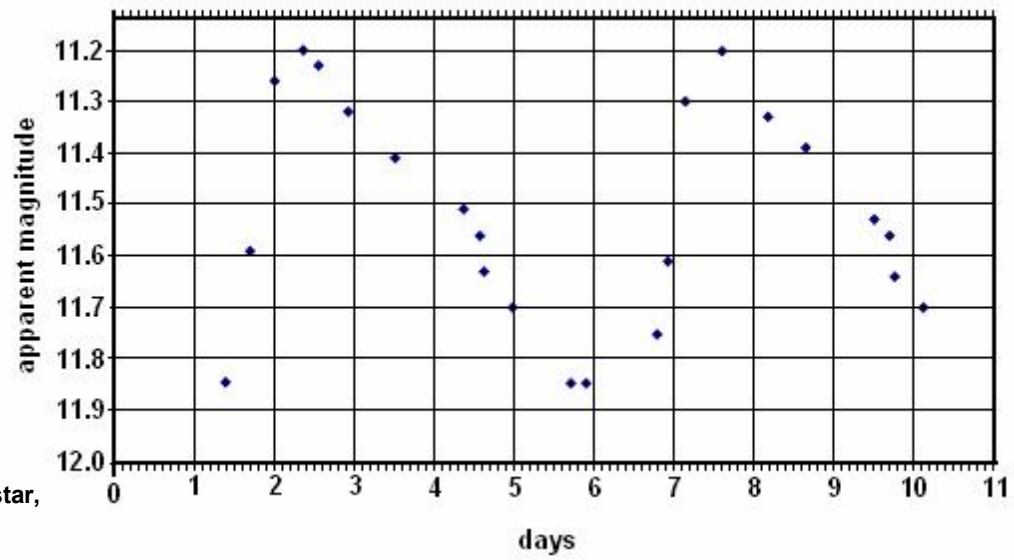
**(1) 29. In which graph is the period underestimated? E**

**(1) 30. In which graph does the period change suddenly? A**

**There are three columns in the table below. In the first column there is a numbered list of variable star types. The second column lists a series of descriptions. The third column features a series of light curves. Associate a letter from *each* of the second and third columns with each numbered entry in the first column. Each associated letter is 1 point (so each *number* is worth two points); answers on the answer sheet should be in the form "X Y ". Each letter is used only once.**

| | | |
|---|---|---|
| **31. Dwarf Novae** | **A. One of the components of the system is a hot compact object (white dwarf, neutron star, or possibly a black hole). Emission is caused by matter falling onto the compact object or its accretion disc, which then irradiates the companion star.** | **K.**   |
| **32. R Coronae Borealis** | **B. Red giants with emission spectra and well-defined periods from 80 to over 1000 days. Variations do not repeat exactly from one cycle to the next.** | **L.**   |
| **33. Cepheids** | **C. Close binary systems with an accretion disc around the white dwarf component. Outbursts from 2 to 9 magnitudes, lasting for a day or two, occur at quasi-periodic intervals of days to years.** | **M.**   |
| **34. Long Period Variables** | **D. Radially pulsating yellow to red supergiants with alternating primary and secondary minima.** | **N.**   |
| **35. RR Lyrae** | **E. Sudden catastropic outburst of 20+ magnitudes in less than a week, caused by the total detonation of a white dwarf.** | **O.**   |
| **36. Type Ia Supernovae** | **F. Dim red dwarfs that can undergo unpredictable dramatic increases in brightness for a few minutes.** | **P.**  |
| **37. Type II Supernovae** | **G. Pulsating horizontal branch stars, with a mass of around half the Sun's.** | **Q.**   |
| **38. X-Ray Binaries** | **H. Hydrogen-poor, helium and carbon-rich stars showing small cyclic pulsations; and irregular fades up to 9 magnitudes lasting for weeks/months caused by carbon ejection.** | **R.**   |
| **39. RV Tauri** | **I. Sudden catastrophic outburst caused by the core collapse of a massive star.** | **S.**   |
| **40. Flare Stars** | **J. Radially pulsating white to yellow giants with variations up to 2 magnitudes and periods from 1 to over 100 days.** | **T.**   |

**The image at below right shows a light curve from a variable star. Use the graph for questions numbered 41 - 48.**




**(1) 41. What is the apparent magnitude of this star at maximum?**

**(1) 42. What is the apparent magnitude of this star at minimum?**

**(2) 43. What is the period of this star's pulsation?**

**(1) 44. Based on the period, what type of variable star is this?**

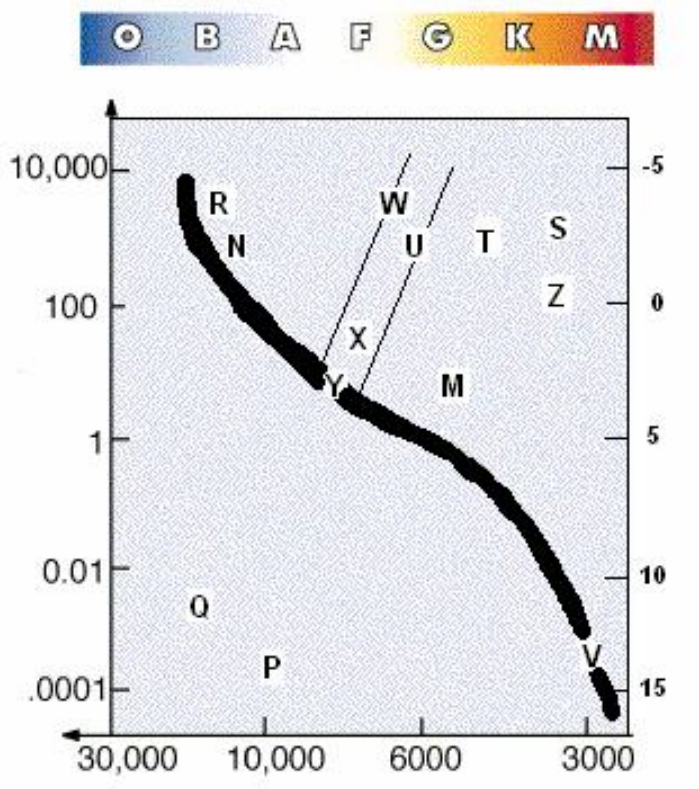
**(2) 45. What is the mean absolute magnitude of this star?**

**(2) 46. (T2) What is the luminosity of this star, in solar luminosities?**

**(2) 47. (T4) What is the distance to this star in parsecs?**

**(2) 48. What is the distance to this star in light years?**

**Questions numbered 49 – 64 refer to the HR diagram shown.**




**(1) 49. What are the units across the bottom of the diagram?**

**(1) 50. What are the letters across the top of the diagram?**

**(1) 51. What are the units on the left side of the diagram?**

**(1) 52. What are the units on the right side of the diagram?**

**(1) 53. Where would you find a δ-Scuti star?**

**(1) 54. Where would you find a β-Cephei star?**

**(1) 55. Where would you find a classical Cepheid?**

**(1) 56. Where would you find an RR-Lyrae star?**

**(1) 57. Where would you find an RV-Tauri star?**

**(1) 58. (T5) Where would you find a ZZ Ceti star?**

**(1) 59. Where would you find a flare star?**

**(1) 60. Where would you find a long-period variable?**

**(1) 61. Where would you find a slowly pulsating B star?**

**(1) 62. Where would you find a W-Virginis star?**

**(1) 63. Where would you find a solar-mass T-Tauri star?**

**(1) 64. What is the name of the region bound by the diagonal lines and containing regions X, Y, W and U?**

**For problems 65 – 80, choose from the following options. The number of points available for each number indicates the number of correct responses.**

| | | | |
|---|---|---|---|
| **A. RV Tauri** | **B. T-Tauri** | **C. Mira type** | **D. Type Ia SN** |
| **E. RR Lyrae** | **F. Dwarf novae** | **G. Recurrent novae** | **H. Classical novae** |
| **I. Classical Cepheids** | **J. BY Draconis** | **K. W Virginis** | **L. $\delta$-Scuti** |
| **M. $\beta$-Cephei** | **N. UV Ceti** | **O. Z Andromedae** | **P. ZZ Ceti** |
| **Q. R Coronae Borealis** | **R. Type II SN** | **S. S Doradus** | **T. Wolf-Rayet** |

**(8) 65. In which of the options listed above is the variability due to pulsation only?**

**(6) 66. In which of the options listed above is the variability cataclysmic?**

**(3) 67. In which of the options listed above is the variability eruptive?**

**(1) 68. In which of the options listed above is the variability eruptive and pulsating?**

**(2) 69. In which of the options listed above is the variability due to rotation?**

**(2) 70. A red dwarf with variability due to cool spots *and* flare activity could belong to which two classes?**

**(1) 71. Stars in this class lie in the region where the instability strip crosses the main sequence.**

**(1) 72. Stars in this class are pulsating white dwarfs with short periods of up to 30 minutes.**

**(1) 73. Stars in this class are hot, massive, and luminous, and show mass loss and strong stellar winds.**

**(1) 74. Stars in this class are also known as "Population II Cepheids."**

**(1) 75. Stars in this class are hot enough for the opacity of iron to drive the pulsation mechanism.**

**(1) 76. (T6) Stars in this class can display the Blazhko Effect, a modulation of the amplitude of the lightcurve.**

**(1) 77. Stars in this class are pulsating red giants with visual amplitudes greater than 2.5.**

**(1) 78. Stars in this class demonstrate sudden *decreases* in brightness superimposed on a pulsation period.**

**(1) 79. The spectra of this cataclysmic variable has virtually *no* hydrogen lines present.**

**(1) 80. Stars in these close binary systems are also called "U Geminorum" stars.**

**Use the following information for questions numbered 81 – 89.**

**A particular binary system consists of a main-sequence star (A) and what is commonly called a "compact object" for a companion (B). The following information is available about star A: its apparent magnitude is 0.11, its parallax is 425 milliarcseconds, and the peak wavelength of its radiation is 255 nm. Object B has a Scwarzschild radius of 28.4 km. The system has an orbital period of 11.087 days at a separation distance of 0.29 AU.**

**(2) 81. What is the surface temperature of star A?**

**(2) 82. What is the distance to the system in parsecs?**

**(1) 83. What spectral class is star A?**

**(2) 84. (T1) What is the absolute magnitude of star A?**

**(2) 85. What is the luminosity of star A, in solar?**

**(2) 86. (T7) What is the mass of the system in solar masses?**

**(2) 87. What is the mass of the compact object (B) in solar masses?**

**(2) 88. What is the mass of star A in solar masses?**

**(2) 89. What is the compact object, and how do you know?**