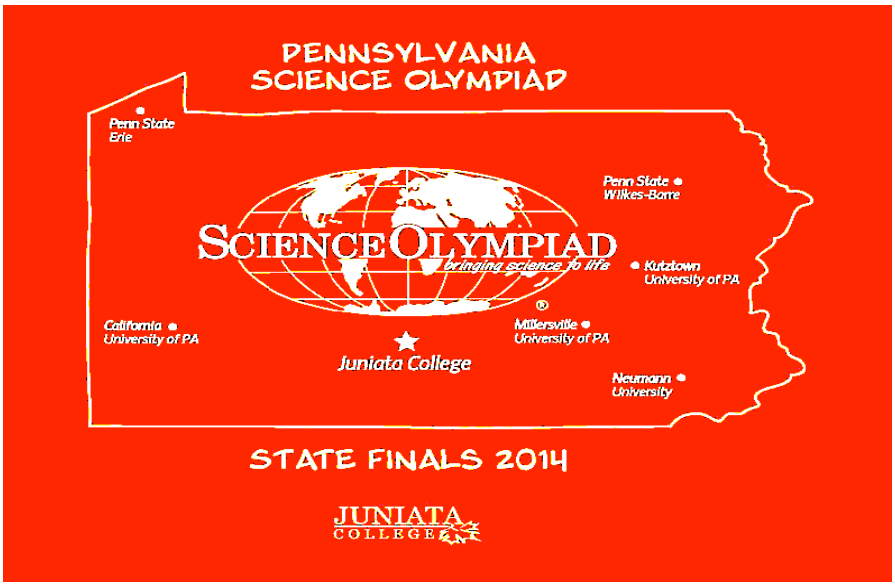


PENNSYLVANIA SCIENCE OLYMPIAD

STATE FINALS 2014

ASTRONOMY C DIVISION EXAM

MAY 2, 2014

TEAM NUMBER _____ **SCHOOL NAME**_____

PARTICIPANTS_____

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, an image packet, and two blank answer sheets.**

2. **You may separate the exam pages.**

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. **Write your team number, school name, and participants' names on the title page of the test booklet*. By writing your participants' names, you agree to the General Rules, Code of Ethics, and Spirit of the Problem as defined in the 2014 Division C Rules Manual*.**

5. **Write your team number, school name, and participants' names in the appropriate spaces on the answer sheets.**

6. **Each question is worth one point. 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 15 tiebreakers.**

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

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

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

10. **In bonus box 1 on your answer sheet, indicate the name of the gentleman shown in the image on the *lower left side* of the cover sheet.**

11. **In bonus box 2 on the answer sheet, write the title of the ditty our friend Joseph Ducreaux has translated.**

12. **Staple the answer sheets together before submitting.**

Questions numbered 1-45 refer to image pages 1, 2 and 3, and the Object list as published in section 3c of the Astronomy rules in the 2014 Science Olympiad Student Manual. "Object" means one of the objects from the list.

1. One of the images (image pages 1 and 2) shows a microquasar. Which image is it?
2. What phenomenon is indicated by this image?
3. This object's designation contains letters and numbers. What do the letters indicate?
4. What do the numbers in the designation indicate?
5. Which curve (image page 3) indicates the microquasar?
6. Consider image 11. Which Object is shown (list the common name)?
7. What are the galactic coordinates of this Object?
8. Image 11 has 2 "exploded" views. What is shown in the 2nd inset view?
9. Which two images show protostars?
10. (T7) What is the Henry Draper Catalogue number of the prototypical protostar discovered in 1852 by John Russell Hind?
11. Which curve (image page 3) indicates this prototypical protostar?
12. The other protostar on the Object list recently underwent an increase in brightness, illuminating the surrounding dust as a reflection nebula. What is the name of this reflection nebula?
13. What is the classification of such a protostar outburst, which results in an extreme change in spectral type and magnitude?
14. One of the images shows a globular cluster that displays evidence of multiple stellar populations. Which image is it?
15. What irregular galaxy is this Object associated with?
16. Which curve (image page 3) is associated with the other Object of this type?
17. Which images (image pages 1, 2, and 3) show an Object that could end its life in an exotic hypernova?
18. (T6) How is this Object currently classified?
19. How might it have been classified in the past (in the 1970s)?
20. What extremely energetic, extragalactic events are associated with hypernovae?
21. (T8) Which image shows a "reborn" planetary nebula?
22. What is this Object's designation in the Perek-Kohoutek Catalogue?
23. In what band of the E-M spectrum is the image of Tycho's SNR?
24. What is the term for the radiation that is evidenced by this image?
25. What is its designation in the 3rd Cambridge Catalog of Radio Sources?
26. Which image (image pages 1 and 2) shows a jet-driven, core collapse supernova?
27. (T12) What elements are indicated by the colors in this image?

28. What is indicated by this asymmetrical distribution of elements?

29. Which curve (image page 3) indicates the spectrum of this Object?

30. Which image (image pages 1 and 2) shows an Object that was named by Johannes Hevelius in 1642?

31. Where would this Object be found on the H-R diagram? Be specific.

32. What did the GALEX Space Telescope recently reveal regarding this Object?

33. Which image (image pages 1 and 2) shows an Object that is losing energy at a rate consistent with that predicted by Einstein's Theory of General Relativity?

34. What mechanism is responsible for the energy loss of this Object?

35. (T1) One of the Objects was instrumental in settling a long-standing debate regarding the status of "spiral nebulae." Which image (image pages 1 and 2) shows this Object?

36. Which light curve (image page 3) also indicates this controversial Object?

37. Who were the players in this debate, and who was vindicated after the discovery of this Object?

38. Which image (image pages 1 and 2) shows an object of GCVS4 classification NR?

39. (T13) When did this Object undergo its most recent outburst?

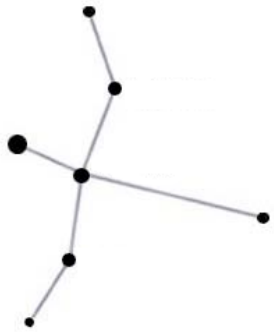
40. How will this Object most likely end its stellar lifetime?

41. Which image (image pages 1 and 2) shows an open cluster?

42. What is the designation for the brightest star in this open cluster?

43. Which image (image pages 1 and 2) shows an Object that appears in the constellation shown below?

44. What is the GCVS 4 classification of this Object?

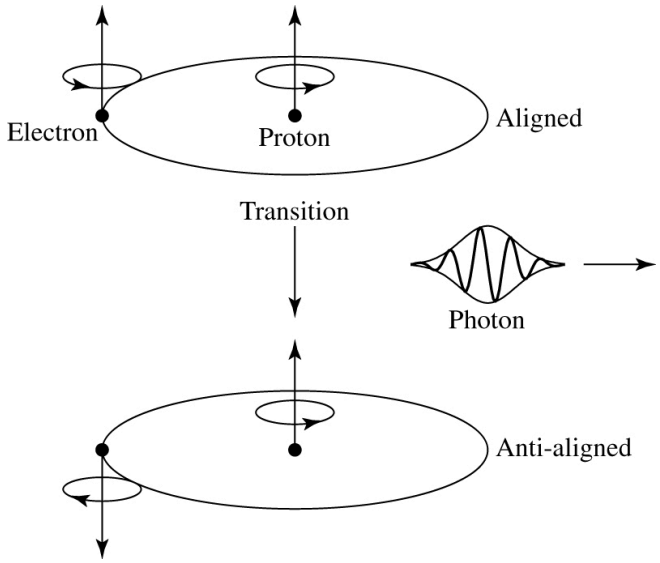


45. What is the significance of the object shown in image 18?

46. Consider the image shown at right. What is the wavelength of light associated with the photon?

47. What frequency is associated with this photon?

48. (T9) What component of the ISM is this photon used to identify?



Consider the following evolutionary track of a 1.0 solar mass star for questions 49 – 56.

49. (T10) What takes place at location E?

50. In what stage of evolution is the star at location J?

51. In what stage of evolution is the star at location C?

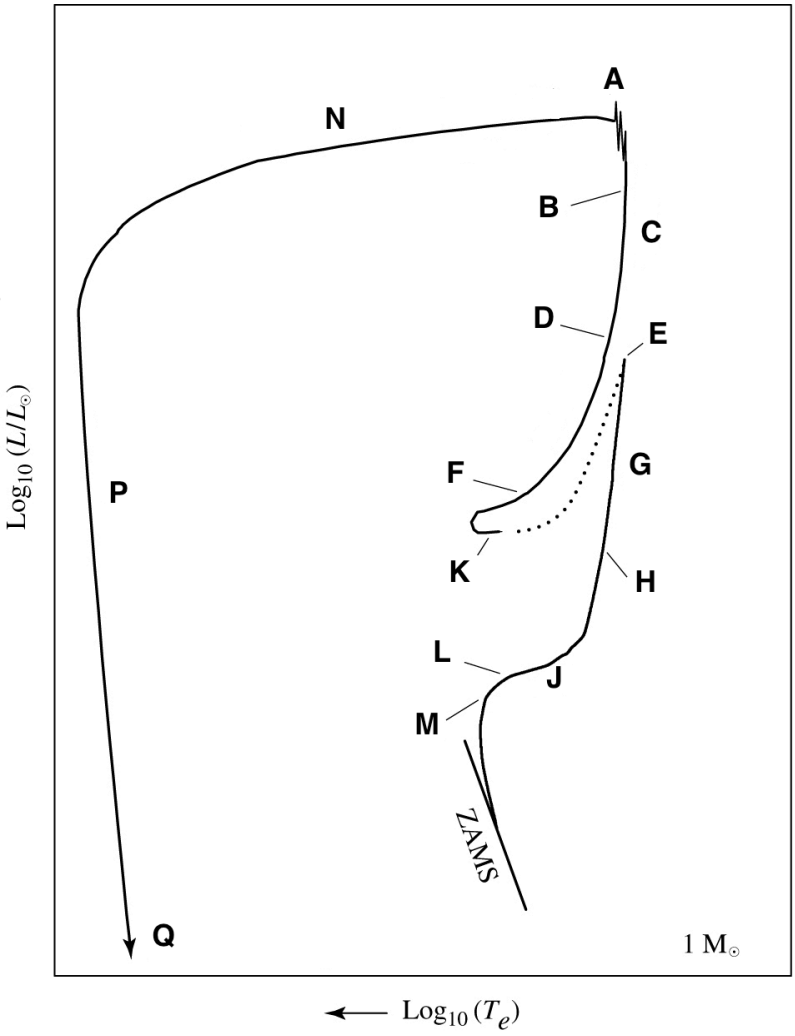
52. At which lettered location is the star undergoing He core burning?

53. What happens at location N?

54. To what stage does the arrow point at location Q?

55. What takes place at locations H and D?

56. What happens between locations A and B?



A particular star has a parallax of 37.4 milliarcseconds and a proper motion of 173 milliarcseconds/year. Its peak wavelength is 415 nm, its apparent magnitude is 5.6, and its z value is 1.12E-4. Use this information for questions 57 – 65.

57. (T5) What is the distance to this star in parsecs?

58. What is the effective surface temperature of this star?

59. What is the radial velocity of this star in km/s?

60. What is the transverse velocity of this star in km/s?

61. What is the star's absolute magnitude?

62. What is the star's luminosity in solar units?

63. What is the star's mass in solar units?

64. What is the star's radius in solar units?

65. (T14) What is the star's spectral class?

66. Mass loss during pre-main sequence stellar evolution can produce jets of gas that are ejected in opposite directions. These jets expand into the ISM and produce emission-line spectra. What are such objects called?

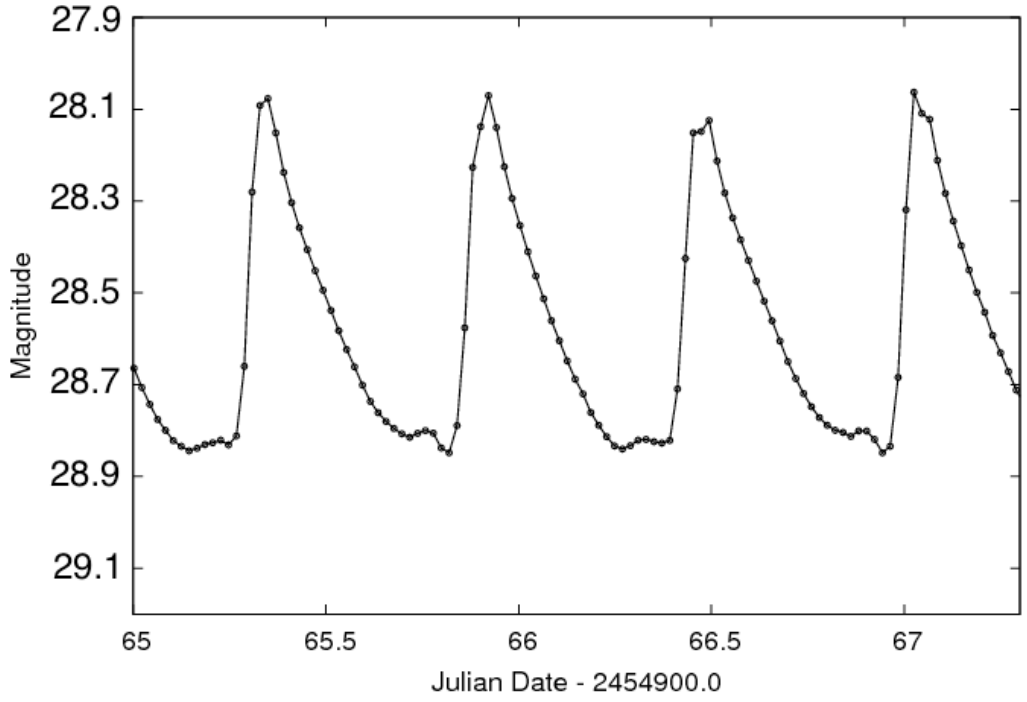
67. What is the spectral class of a methane dwarf?

68. What is the term for a broad emission peak with a superimposed blueshifted absorption trough, indicating mass loss?

69. What code is attached to the spectral type to indicate the presence of the spectral feature referenced in #68?

70. Bright, young O and B class stars can light up surrounding gases to produce brilliant red emission nebulae. These nebulae are also called:

Consider the following light curve, generated from a star in a galaxy in the Sculptor group.



71. (T2) What kind of star generated this light curve?

72. How would the GCVS 4 classify this star?

73. Based on this light curve, how far away is this galaxy in Mpc?

74. In which lettered location would this star be found in the H-R diagram shown at right?

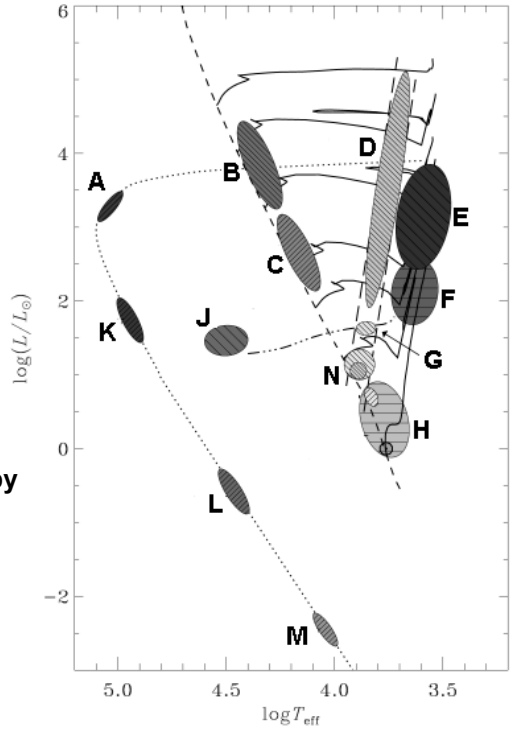
75. What general classification is indicated by ALL of the lettered regions on the H-R diagram shown at right?

76. What type of star would be found in region E?

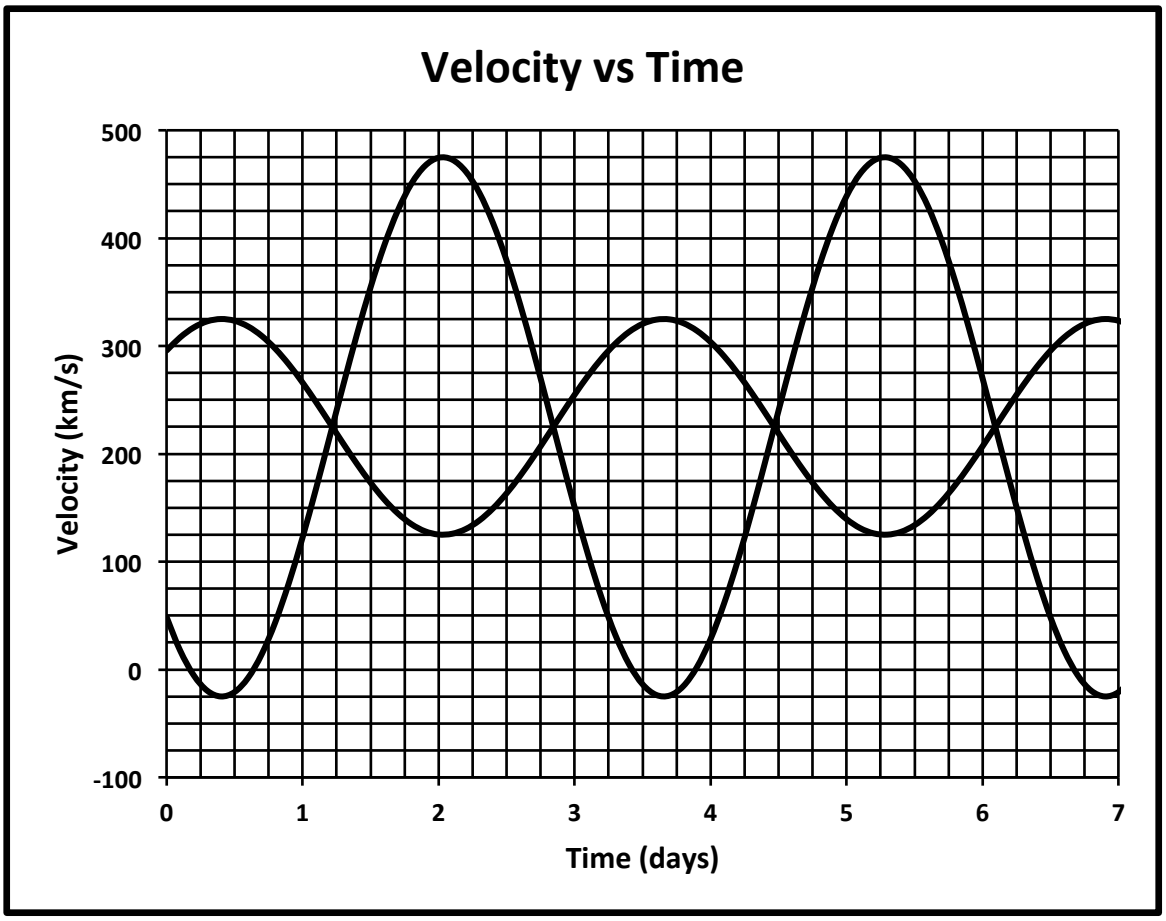
77. (T15) The star type found in region E has a spectrum characterized by particular molecular bands. What molecule produces these bands?

78. What is the approximate color index of stars found in region E?

79. What is the effective surface temperature of a star in region L?



Consider the following velocity curve for a binary star system for questions 80 – 85. Positive velocities are radially away from the observer. The stars in the system are separated by 2.17E10 m and the observer is in the plane of the orbit.



80. What is the recessional velocity of the system?

81. What is the period of the binary system?

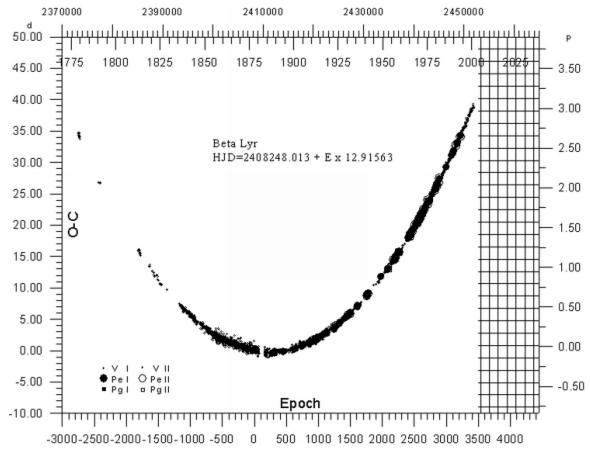
82. (T3) What is the total mass of the binary system, in solar masses?

83. What is the orbital velocity of the more massive of the two stars?

84. What is the orbital radius of the more massive of the two stars, in m?

85. What is the mass of the more massive of the two stars, in solar masses?

Consider the O-C diagram for Beta Lyrae at below right. Beta Lyrae is a semidetached binary star system. The system is too far away for the individual stars to be visually resolved in a telescope.



86. According to the diagram, what is happening to the period of Beta Lyrae?

87. What does O-C mean?

88. What does semidetached mean?

89. What is Beta Lyrae's binary classification?

For questions numbered 90-100, provide the term, acronym, or phrase that best fits the description provided.

90. Stellar designations that used a number and the Latin genitive of its constellation. Numbers were originally assigned in order of increasing right ascension within the constellation.

91. The collapse of a spherical molecular cloud of uniform density, such that all parts of the cloud take the same amount of time to collapse

92. (T4) Convective transport of material from the core to the surface of a star, changing the observable composition of the photosphere during post main sequence evolution

93. The code for transient x-ray nova-like systems in the GCVS 4

94. A method for classifying globular clusters based on the properties of fundamental-mode RR Lyrae stars and metallicity in the cluster

95. These pulsating variables lie in the region where the instability strip crosses the main sequence

96. Double mode pulsator RR Lyrae variables are frequently shown such that the period ratio (P_1/P_0) is graphed against the fundamental (P_0). These graphs are called:

97. This subclass of the dwarf novae is characterized by supermaxima – brighter and longer maxima interspersed among normal maxima

98. Equipotential surface around a binary system that contains the inner Lagrangian point

99. A mass-transfer binary system that contains a white dwarf with a very strong magnetic field, causing the infalling matter to form an accretion stream (NOT an accretion disk) and to emit cyclotron radiation

100. (T11) This sets the time for the collapse of a protostar onto the main sequence, and accounts for the power source of contracting protostars before they begin nucear fusion