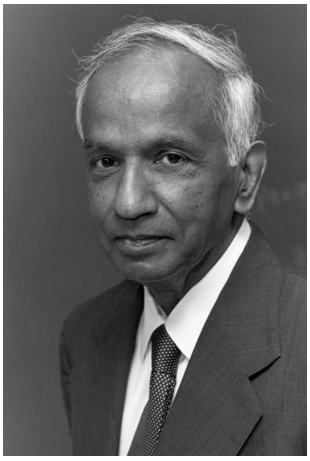
PENNSYLVANIA SCIENCE OLYMPIAD

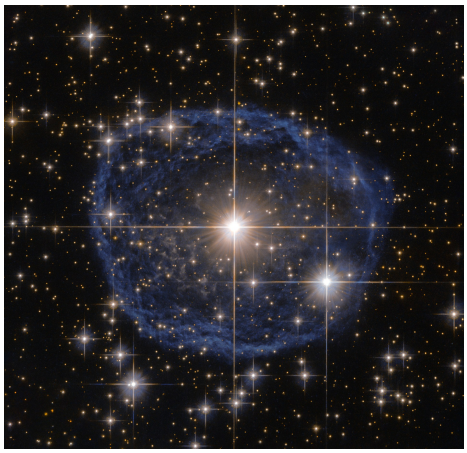
DIVISION C

ASTRONOMY REGIONAL EXAM FOR 2023

REGIONAL TOURNAMENT 2023

ASTRONOMY C DIVISION EXAM





SCHOOL:_____ **TEAM NUMBER:**_____

NAMES:_____

_____

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. You may write in the exam.**

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

4. **Include school name and school code number at the bottom of the answer sheet. 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. **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 20 tiebreakers.**

6. **When the time is up, *the time is up*. Teams continuing to write after the time is up will incur a penalty of 10 points.**

7. **As per the 2023 Division C Rules Manual, each team is permitted to bring "i. a computer/tablet and a three-ring binder; ii. two computers/tablets of any kind; or, iii. Two three ring binders" and "two stand-alone calculators of any type."**

8. **In the bonus box on the answer sheet, write the name of the gentleman shown on the cover of the exam. Correct response is worth a bonus point.**

PA Regional Science Olympiad **Astronomy C** **Team Number_____**

Questions 1-40 refer to the objects listed in section 3c, page C6, of the 2023 Science Olympiad Division C Rules Manual. "Identify and answer questions relating to the content areas … for the following objects."

1. Which object is shown in image 1?


Image 1

A. NGC 7027
B. AG Carinae
C. W Virginis
D. SS Cygni
E. RS Puppis

2. Which of the following classifications best applies to the object shown in image 1?

A. Luminous blue variable
B. Cephied variable
C. Dwarf nova
D. Wolf-Rayet star
E. Planetary nebula

3. The nebulosity around the central object in image 1 is due to which of the following?

A. Previous thermonuclear outbursts
B. The interstellar medium
C. Wind-driven mass loss
D. Leftover material from the star's original molecular cloud
E. Gravitational waves

4. Which object is shown by the white arrow in image 2?

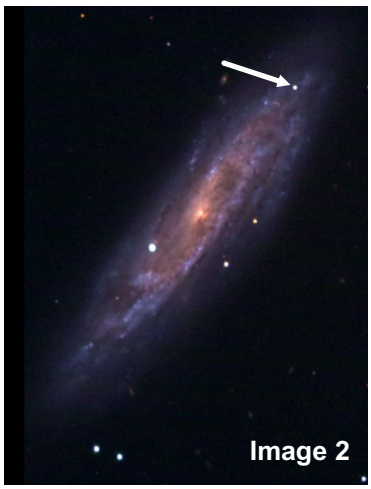


Image 2

A. SS Cygni
B. G344.7-0.1
C. X9
D. SN 2008D
E. E0102-72.3

5. (T9) In what galaxy is the object specified by question number 4?

A. NGC 2770
B. NGC 7027
C. NGC 7220
D. NGC 2072
E. NGC 2702

6. What is the nature of the object specified by question number 4?

A. black hole X-ray binary
B. neutron star merger
C. type Ia supernova
D. type II supernova
E. type Ibc supernova

7. Which object is shown in image 3?

A. NGC 7027
B. SN 2008D
C. 47 Tucanae
D. AG Carinae
E. G344.7-0.1

8. What is the nature of the object shown in image 3?

A. irregular galaxy
B. open cluster
C. globular cluster
D. OB association
E. elliptical galaxy

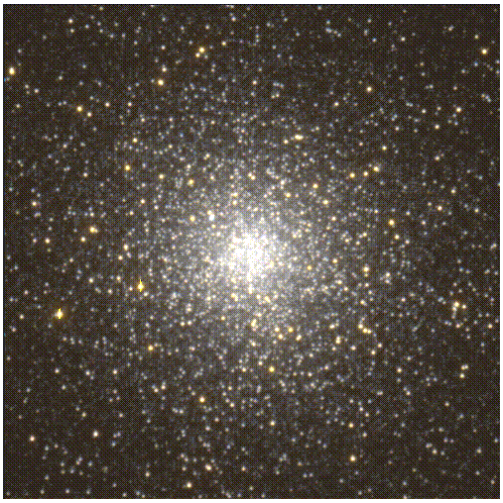
9. (T19) The stars in the object shown in image 3 are likely to be:

A. young and metal-rich
B. young and metal-poor
C. old and metal-rich
D. old and metal-poor
E. a combination of all four categories listed above

10. Which of the following is FALSE regarding the object in image 3?

A. The object has a very low frequency of gas planets
B. The object has a high rate of star formation
C. The object displays mass segregation
D. The object likely contains an intermediate black hole at its center
E. The object contains K-type variable giant stars

Image 3



11. Which object is shown in image 4?

A. R Aquarii
B. G344.7-0.1
C. NaSt 1
D. HD 184738
E. W Virginis

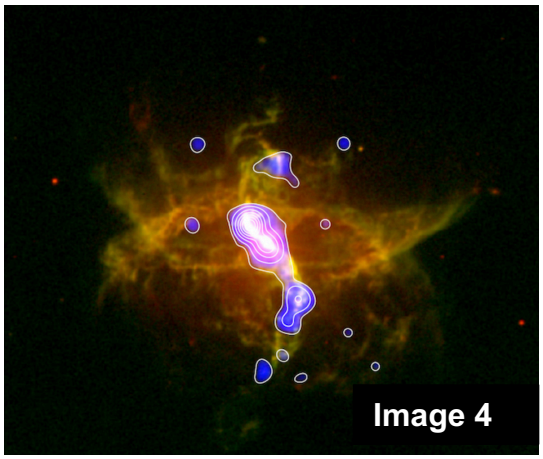


Image 4

12. The threadlike filamentary structures in image 4 are most likely:

A. collimated jets
B. shocked interstellar medium
C. instrumental noise
D. light echoes
E. remnants of past nova-like outbursts

13. What is indicated by the overlaid contour lines?

A. X-ray emission
B. Density anomalies
C. Radio sources
D. Dark matter
E. [O III] concentration

14. (T4) Which object's light curve is shown in image 5?

A. RS Puppis
B. R Hydrae
C. W Virginis
D. AG Carinae
E. SS Cygni

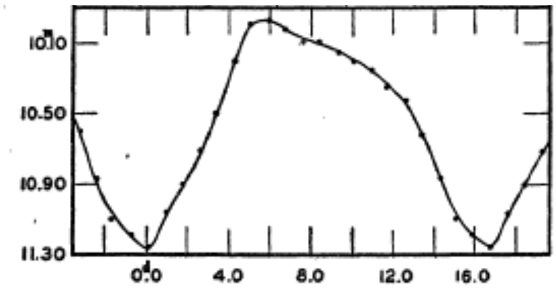


Image 5

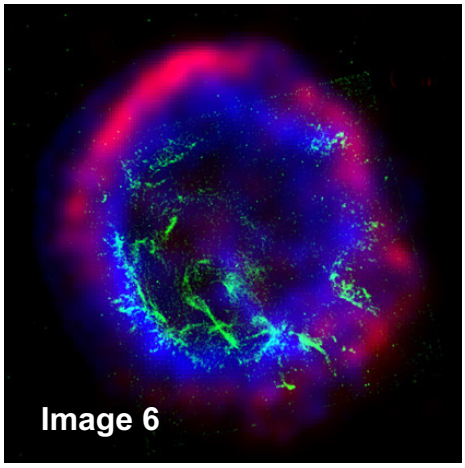
15. In which region of the H-R diagram would you likely find the object that created the light curve in image 5?

A. On the main sequence
B. On the asymptotic giant branch
C. In the white dwarf region
D. On the Hayashi track
E. On the horizontal branch

16. In what region of a spiral galaxy would you be likely to find an object such as the one producing the light curve in image 5?

A. in the extreme UV disk
B. in the globular clusters of the halo
C. in the spiral arms
D. in the thin disk
E. in the galactic center

17. Which object is shown in image 6?



A. NGC 7027
B. G344.7-0.1
C. AG Carinae
D. SN 2008D
E. E0102-72.3

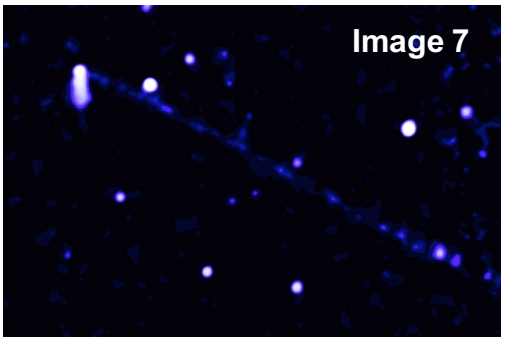
18. What is located just below the center of image 6?

A. neutron star
B. white dwarf
C. black hole
D. very hot gas
E. nothing

19. (T15) What is most notable about the object shown in image 6?

A. the neon abundance is much more than is normal for this type of object
B. the X-ray pattern of the explosion was observed in real time
C. the remnant is the first of its kind to be identified outside the Milky Way
D. the age of the remnant is such that the "reverse shock" has moved all the way through the debris
E. the helium hydride ion was detected for the first time (in space) in this object

20. Which object is shown in image 7?



A. E0102-72.3
B. GW170817
C. HD 184738
D. PSR J2030+4415
E. SS Cygni

21. What is the nature of the object shown in image 7?

A. supernova remnant
B. isolated neutron star
C. hydrogen star
D. binary white dwarf merger
E. dwarf nova

22. What is indicated by the line of blue dots extending from the upper left to the lower right in image 7?

A. a stream of electrons and positrons
B. a stream of neutrinos
C. high energy light echoes
D. background X-ray noise
E. an instrumental artifact

23. Which object is shown in image 8?

A. R Hydrae
B. NaSt1
C. AG Carinae
D. NGC 7027
E. R Aquarii


Image 8

24. What is the nature of the object shown in image 8?

A. Wolf-Rayet star
B. Mira-type variable
C. Luminous Blue variable
D. Planetary nebula
E. Symbiotic binary

25. Which star classification could also be used to describe the object in image 8?

A. S Doradus
B. Delta Scuti
C. Gamma Doradus
D. FU Orionis
E. UV Ceti

26. Which object is shown in image 9?

A. AG Carinae
B. W Virginis
C. NGC 7027
D. R Hydrae
E. HD 184738

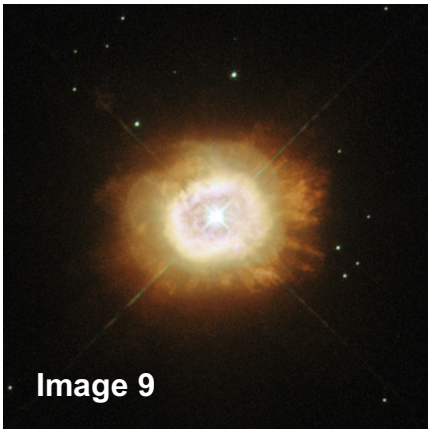


Image 9

27. What is the nature of the object shown in image 9?

A. Wolf-Rayet star
B. Mira-type variable
C. Luminous Blue variable
D. Planetary nebula
E. Symbiotic binary

28. How would the object in image 9 be characterized by the GCVS4?

A. M
B. PN
C. CW
D. WR
E. LB

29. (T10) Which object is shown in image 10?

A. NaSt1
B. RS Puppis
C. NGC 7027
D. G344.7 – 0.1
E. R Hydrae

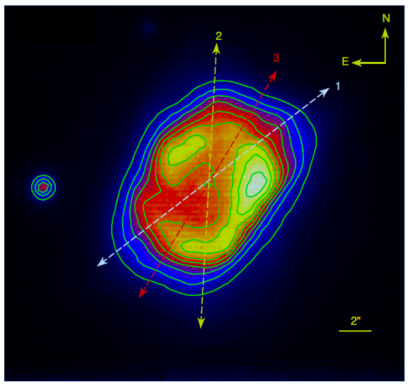


Image 10

30. What is indicated by the white, yellow, and red dotted arrows labeled 1, 2, and 3?

A. axial precession
B. outflow directions
C. instrumental lines of sight
D. surface brightness gradients
E. radial, proper motion, and true space velocities

31. The object in image 10 was recently studied in order to:

A. determine chemical abundances in Type Ia supernovae
B. match luminosity variation with radial pulsation in W Vir stars
C. verify precession of the rotation axis of WR stars
D. spatially differentiate photon and X-ray dominated regions of planetary nebulae
E. calibrate mass-loss rates of Mira-type stars

32. (T3) Which object produced the light curve in image 11?

A. SS Cygni
B. PSR J2030+4415
C. X9
D. R Aquarii
E. W Virginis

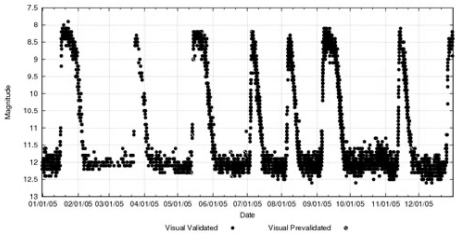


Image 11

33. What is the cause of the variation in the luminosity of the object producing the light curve in image 11?

A. rapid rotation and the "lighthouse effect"
B. the κ mechanism and the opacity of ionized hydrogen
C. disturbance of equilibrium between accretion, mass loss, and photoionization
D. accretion disk instability and a change in the mass flow rate
E. hard X-ray reflection from an optically thick accretion disk

34. How would the object in image 11 be classified by the GCVS4?

A. BCEP
B. XND
C. SRB
D. CWA
E. UGSS

35. Which object is shown in image 12?

A. RS Puppis
B. NaSt1
C. R Hydrae
D. R Aquarii
E. HD 184738

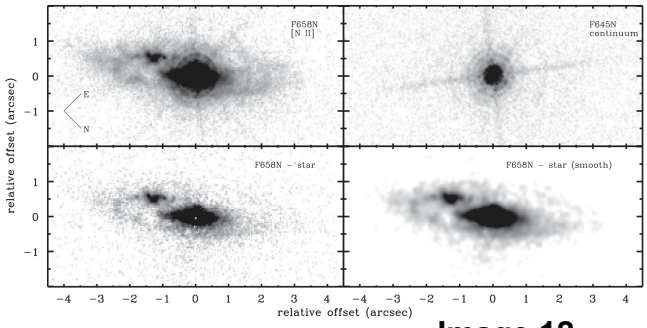


Image 12

36. The object in image 12 is "shrouded" in a pancake-shaped cloud of dust. What does this imply about its nature?

A. it is still forming and has not started fusing hydrogen
B. mass transfer to a companion star
C. high-velocity WR stellar winds
D. it is a carbon-sequence WR star
E. the pulsation period is increasing

37. (T20) Which object created the light curve shown in image 13?

A. SS Cygni
B. R Aquarii
C. R Hydrae
D. RS Puppis
E. W Virginis

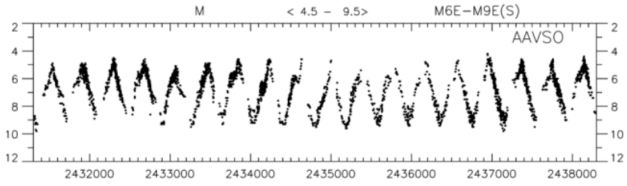


Image 13

38. What type of variable star is indicated by the light curve in image 13?

A. Type II Cepheid
B. Classical Cepheid
C. dwarf nova
D. symbiotic
E. Mira

39. Which object appears in the constellation shown in image 14?

A. G344.7-0.1
B. PSR J2030+4415
C. HD 184738
D. NGC 7027
E. E0102-72.3

40. What type of object is referred to in question 39?

A. pulsar
B. type II supernova remnant
C. type Ia supernova remnant
D. planetary nebula
E. hydrogen star

Questions 41-80 refer to the concepts listed in section 3a, page C6, of the 2023 Science Olympiad Division C Rules Manual.

Consider the H-R diagram shown in image 15 for questions 41 – 49.

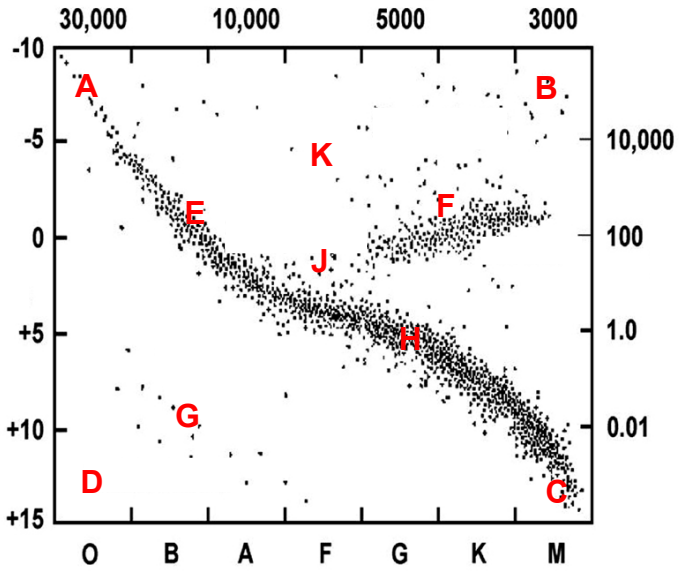


Image 15

Match the numbered axis with the lettered description for questions 41 – 44.

41. top horizontal axis	**A. luminosity**
42. bottom horizontal axis	**B. temperature**
43. left vertical axis	**C. spectral class**
44. right vertical axis	**D. absolute magnitude**

45. Which of the following red-lettered regions would contain the brightest, coolest stars?

A. A B. B C. C D. D

46. In which red-lettered region would our Sun be located?

47. Which red-lettered region shows the white dwarf sequence?

48. Which red-lettered region includes the red giants?

49. (T11) Consider a star at location E. Which description of this star is accurate?

A. It is about half as bright as the Sun.
B. It is of comparable brightness to the Sun.
C. It is about 10 times brighter than the Sun.
D. It is about 100 times brighter than the Sun.
E. It is more than 10,000 times brighter than the Sun.

50. In which location would population II stars be most likely to be found?

A. in the spiral arms of a galaxy
B. in a globular cluster
C. in an OB association
D. in the thin disk of a galaxy
E. in an open cluster

51. Which is the *primary* determinant for where a star meets the ZAMS?

A. chemical composition
B. metallicity
C. temperature
D. hydrostatic pressure
E. mass

52. How would the General Catalog of Variable Stars classify a semiregular giant star with spectral type K, a period of about 300 days, and an amplitude of 2 magnitudes?

A. SRA
B. SRB
C. SRC
D. SRD
E. SRS

53. Which of the following stellar classifications would have the highest surface temperature?

A. A5
B. B0
C. B7
D. F5
E. F0

54. A particular star has a spectrum that is described as B1Veq. Which description best fits this star?

A. surface temperature around 25000 K, blue main-sequence star with P-Cygni profile emission
B. surface temperature around 20000 K, blue giant with forbidden emission lines
C. surface temperature around 15000 K, blue dwarf with unspecified peculiarity
D. surface temperature around 20000 K, blue subgiant with broad absorption features
E. surface temperature around 25000 K, blue hypergiant with hydrogen lines in emission and absorption

Below are several different sub-types of variable stars listed in section 3a, questions 55 – 59. Match the numbered types of variable stars with the lettered description. Each letter is used once.

55. AM Herculis	**A. Cataclysmic variables with normal and "supermaxima" outbursts**
56. (T2) Delta Cep – type	**B. Long-period pulsating variables with large amplitudes**
57. SU Ursae Majoris	**C. Pulsating horizontal-branch stars, also called "cluster variables"**
58. Omicron Ceti – type	**D. Binary system with accreting white dwarf with a strong magnetic field**
59. RR Lyrae – type	**E. Relatively young stars evolving through the instability strip**

60. An X-ray burster indicates that:

A. the accretor must be a neutron star
B. the accretor must be a black hole
C. the donor must be a white dwarf
D. the donor must be a main-sequence star
E. the donor must be a supergiant

61. (T16) In the event that an X-ray binary also displays radio emission from a collimated jet, it would be classified as:

A. a BL Lac object
B. a fast X-ray transient
C. a soft X-ray transient
D. a pulsar
E. a microquasar

62. Which of the following would most likely be the end product of a WC star of initial mass of 25 solar?

A. Type Ia supernova
B. Type Ib supernova
C. Type Ic supernova
D. Type IIn supernova
E. Type IIb supernova

63. (T18) If Classical Cepheid variable stars do not all have the same luminosity, how can they be used as standard candles?

A. The mass-luminosity relation is strongest in the instability strip.
B. The period-luminosity relation can be used to determine the luminosity.
C. The radius-luminosity-temperature relation is consistent with the pulsation mechanism.
D. This is a trick. Classical Cepheid stars cannot be used as a standard candle.
E. This is a trick. All Classical Cepheid stars have very nearly the same luminosity.

64. Consider a Classical Cepheid and a Type II Cepheid, each with the same period of about 40 days. Which of the two stars is intrinsically brighter, and by how much?

A. The Type II Cepheid is 1.6 times brighter than the Classical Cepheid
B. The Type II Cepheid is 4.4 times brighter than the Classical Cepheid
C. The Classical Cepheid is 1.6 times brighter than the Type II Cepheid
D. The Classical Cepheid is 4.4 times brighter than the Type II Cepheid
E. Neither is intrinsically brighter, they have the same luminosity

65. Consider the numbered "events" listed below, and select the letter of the arrangement that places these events in order from least luminous to most luminous.

1. kilonova 2. supernova 3. nova 4. hypernova

A. 3 – 1 – 2 – 4 B. 3 – 4 – 1 – 2 C. 1 – 3 – 4 – 2 D. 2 – 3 – 1 – 4

Consider the standard model of a pulsar shown in image 16 for questions 66 – 68.

66. (T5) Which dotted line indicates the rotation axis?

A. A – A B. B – B C. C – C D. D – D

67. Which dotted line indicates the magnetic axis?

A. A – A B. B – B C. C – C D. D – D

68. What is the nature of the gray ball in the center?

A. It is an accretion disk
B. It is a white dwarf
C. It is a black hole
D. It is a neutron star
E. It is a main-sequence star

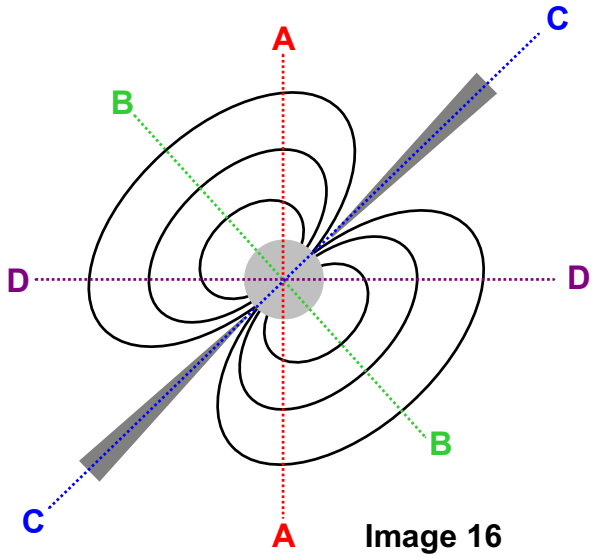


Image 16

Consider the P – Pdot pulsar plot shown in image 17 for questions 69 – 71.

69. (T14) What quantity is shown on the vertical axis?

A. period
B. linear momentum
C. angular momentum
D. spin down rate
E. mass accretion rate

70. Which data points indicate the millisecond pulsars?

A. red
B. green
C. pink
D. blue

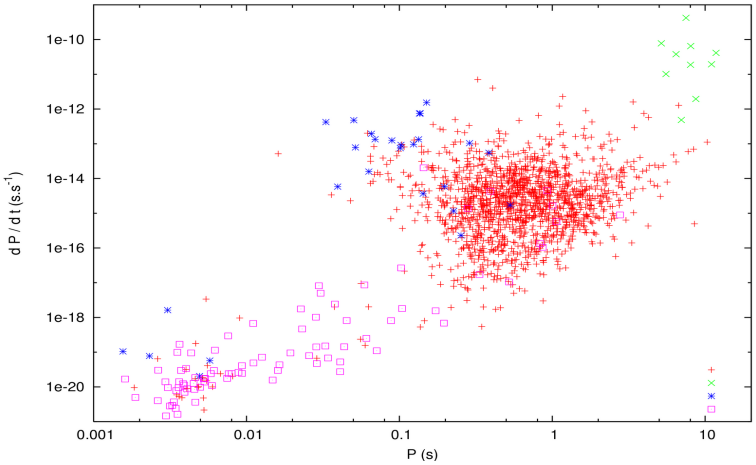


Image 17

71. Which of the following statements applies to the pulsars indicated by the red data points?

A. they are associated with soft gamma repeaters (SGR)
B. they are powered by the decay of a strong magnetic field
C. they are rotation-powered, meaning their luminosity is supplied by loss of rotational energy
D. they are likely to experience a loss of orbital energy due to gravitational waves
E. they are accretion powered by mass transfer from a binary companion

Consider the HR diagram shown in image 18. Various locations for variable stars appear as red-lettered regions on the diagram.

Match the numbered variable star types with the appropriate red-lettered region for questions numbered 72 – 76.

72. Beta Cephei variables

73. Mira

74. (T1) Type I Cepheid

75. Semiregular variables

76. RR Lyrae

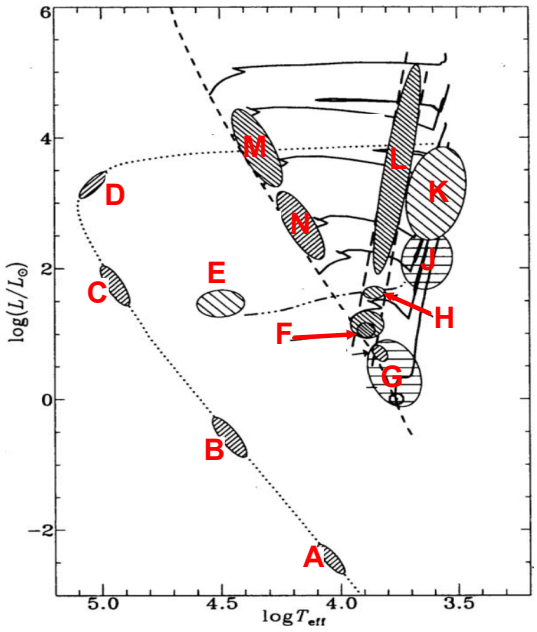


Image 18

77. What is the approximate surface temperature of stars in region C?

A. 5000 K
B. 10000 K
C. 25000 K
D. 50000 K
E. 100000 K

78. What is the approximate luminosity of stars in region H, in solar luminosities?

A. 3.8
B. 32
C. 1.5
D. 6300
E. 5.7

79. Which of the following is NOT associated with thermal pulses in a Mira-type star?

A. electron degeneracy
B. strong convection
C. dredge-up
D. mass loss
E. Helium shell flash

80. (T12) LIGO specializes in detecting gravitational waves. Which type has it actually detected?

A. stochastic gravitational waves
B. burst gravitational waves
C. continuous gravitational waves
D. inspiral gravitational waves

Questions 81- 100 refer to the concepts listed in section 3b, page C6, of the 2023 Science Olympiad Division C Rules Manual.

Consider the light curve shown in image 19. This star has a period of 15.1 days. The associated period-luminosity relation appears in image 20, and the mathematical best fit appears below image 20. Use these images for questions 81 – 84.

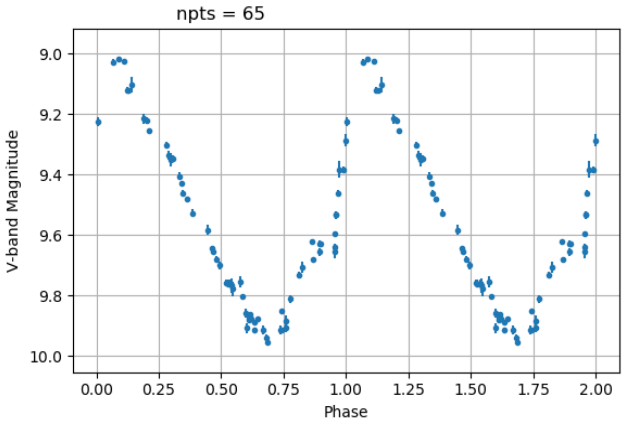


Image 19

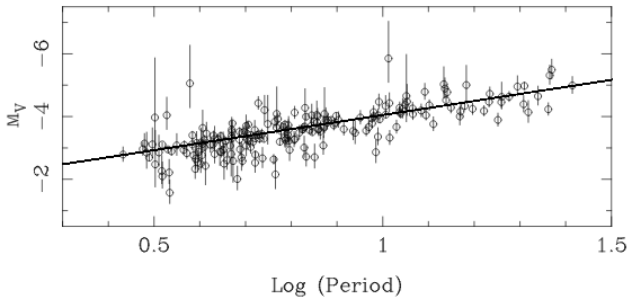


Image 20

$$M_v = -2.20 \log_{10}[Period] - 2.05$$

81. What is the mean apparent visual magnitude of this star?

A. 9.0 B. 9.2 C. 9.5 D. 9.8 E. 10.0

82. (T6) What is the absolute visual magnitude of this star?

A. -4.20 B. -4.64 C. -6.01 D. -8.02 E. -2.05

83. What is this star's distance modulus?

A. 14.14 B. 17.82 C. 15.01 D. 15.21 E. 12.05

84. How far away is this star?

A. 2570 parsec B. 10050 parsec C. 36640 parsec D. 6730 parsec E. 11020 parsec

85. This star has a surface temperature at maximum of around 6650 K. What is the peak wavelength in its SED at maximum?

A. 1503 nm B. 4511 nm C. 792 nm D. 656 nm E. 436 nm

86. (T17) Star A has an apparent magnitude of 12. Star B has an apparent magnitude of 16. Which star appears brighter, and by how much?

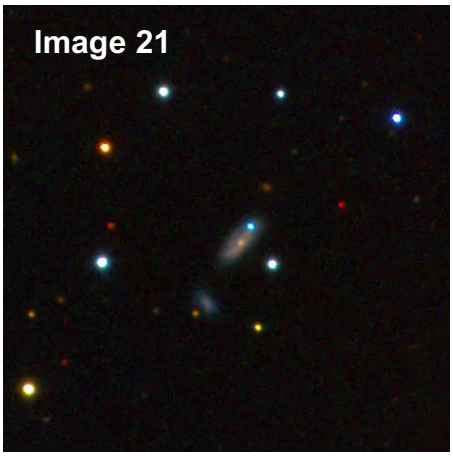
A. Star A appears about 1.8 times brighter than star B
B. Star A appears about 4 times brighter than star B
C. Star A appears about 16 times brighter than star B
D. Star A appears about 40 times brighter than star B
E. Star B appears about 1.8 times brighter than star A
F. Star B appears about 4 times brighter than star A
G. Star B appears about 16 times brighter than star A
H. Star B appears about 40 times brighter than star A

87. The Gaia satellite was launched in 2013. It provided precise measurements for over a billion stars. One such star has a parallax of 41.6 milliarcseconds. How far away is this star in light years?

A. 78.4 ly B. 24.0 ly C. 577 ly D. 194 ly E. 41.6 ly

88. (T13) Astronomers were able to image a type Ia supernova in a distant galaxy (see image 21, the blue dot near the center of the image). The apparent magnitude of this supernova was 17.3. How far away is this galaxy?

A. 17.3 Mpc B. 25.5 Mpc C. 28.8 Mpc D. 457 Mpc E. 209 Mpc



89. A particular red giant star has an effective surface temperature of 2750 K and a radius of 1.57E11 m. The sun has an effective surface temperature of 5778 K and a radius of 6.96E8 m. What is this red giant star's luminosity, in solar luminosities?

A. 581 $L_\odot$ B. 225 $L_\odot$ C. 2600 $L_\odot$ D. 11470 $L_\odot$ E. 115 $L_\odot$

90. A particular star has an absolute magnitude of 2.5. What is its luminosity in solar?

A. 0.518 $L_\odot$ B. 1.93 $L_\odot$ C. 2.33 $L_\odot$ D. 8.55 $L_\odot$ E. 3.73 $L_\odot$

The Sloan Digital Sky Survey entered routine operations in 2000. Among its many mission objectives was a survey of symbiotic variables, one of which consists of a compact object and a main sequence star. The stars have an orbital separation of 4.28E7 km and an orbital period of 16.38 days. The stars' radial velocity curves are as shown below in image 22. Assume the system is viewed edge-on. Use for questions 91 – 97.

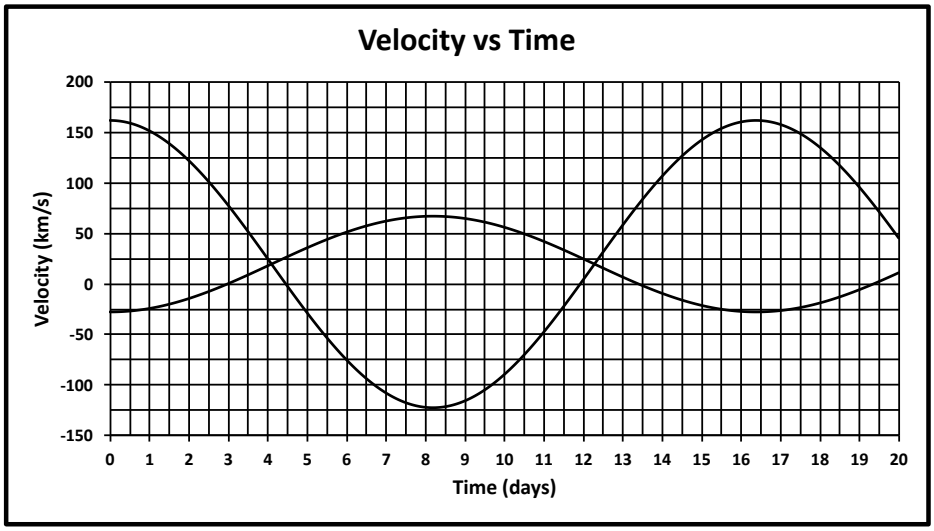


Image 22

91. What is the recessional velocity of this system?

A. 20 km/s B. 27.5 km/s C. 47.5 km/s D. 67.5 km/s E. 142 km/s F. 162 km/s

92. What is the orbital velocity of the primary star?

A. 20 km/s B. 27.5 km/s C. 47.5 km/s D. 67.5 km/s E. 142 km/s F. 162 km/s

93. What is the orbital velocity of the secondary star?

A. 20 km/s B. 27.5 km/s C. 47.5 km/s D. 67.5 km/s E. 142 km/s F. 162 km/s

94. (T7) What is the mass of the system in solar masses?

A. 1.83 $M_\odot$ B. 2.11 $M_\odot$ C. 6.00 $M_\odot$ D. 8.66 $M_\odot$ E. 11.6 $M_\odot$ F. 13.8 $M_\odot$

95. What is the mass of the primary star in solar masses?

A. 10.4 $M_\odot$ B. 8.7 $M_\odot$ C. 6.5 $M_\odot$ D. 4.5 $M_\odot$ E. 1.58 $M_\odot$ F. 1.38 $M_\odot$

96. What is the mass of the secondary star in solar masses?

A. 2.9 $M_\odot$ B. 3.47 $M_\odot$ C. 1.5 $M_\odot$ D. 1.63 $M_\odot$ E. 0.46 $M_\odot$ F. 0.527 $M_\odot$

97. What is the orbital radius of the primary star in km?

A. 4.28E7 km B. 1.43E7 km C. 1.07E7 km D. 3.21E7 km E. 2.85E7 km F. 2.14E7 km

Consider a millisecond pulsar of mass 2.15 $M_\odot$. The pulsar has a rotational period of 17 milliseconds and a radius of 11 km. Consider it a uniform solid sphere. Use this information for questions 98 – 100.

98. (T8) Calculate the surface gravity of this neutron star.

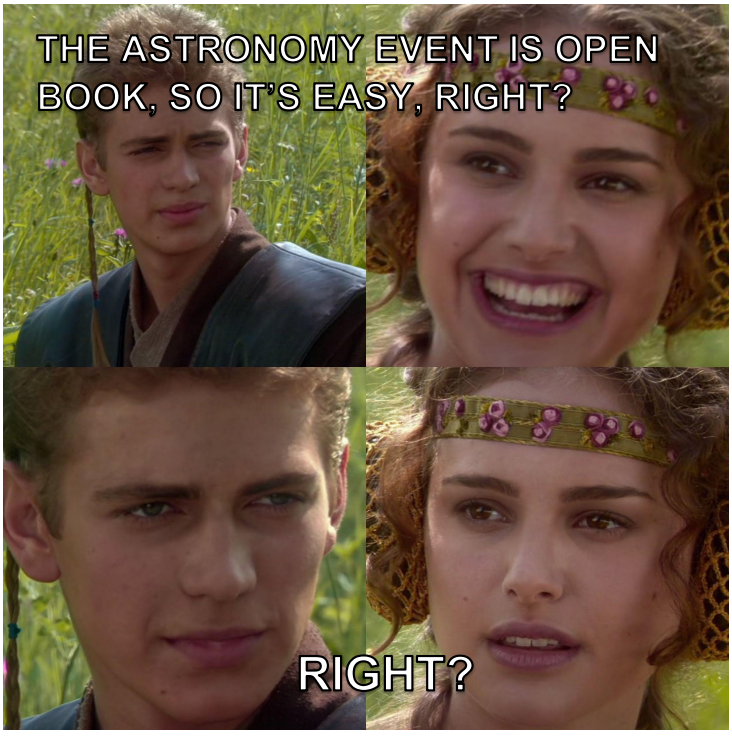
A. 1.61E8 m/s^2 **B. 2.37E12 m/s^2** **C. 1.22E4 m/s^2** **D. 1.49E8 m/s^2** **E. 1.77E13 m/s^2**

99. Calculate the linear velocity of a point on the surface of the neutron star at its equator.

A. 2.77E2 km/s **B. 6.50E3 km/s** **C. 1.35E3 km/s** **D. 6.47E2 km/s** **E. 4.07E3 km/s**

100. Calculate the angular momentum of the neutron star due to its rotation.

A. 6.33E39 kg m^2/s **B. 1.39E40 kg m^2/s** **C. 4.92E41 kg m^2/s** **D. 7.69E40 kg m^2/s**



Division C Astronomy

PA Regional Science Olympiad 2023
Answer Sheet

	1		26		51		76
	2		27		52		77
	3		28		53		78
	4	T10	29		54		79
T9	5		30		55	T12	80
	6		31	T2	56		81
	7	T3	32		57	T6	82
	8		33		58		83
T19	9		34		59		84
	10		35		60		85
	11		36	T16	61	T17	86
	12	T20	37		62		87
	13		38	T18	63	T13	88
T4	14		39		64		89
	15		40		65		90
	16		41	T5	66		91
	17		42		67		92
	18		43		68		93
T15	19		44	T14	69	T7	94
	20		45		70		95
	21		46		71		96
	22		47		72		97
	23		48		73	T8	98
	24	T11	49	T1	74		99
	25		50		75		100

Score

Place

Bonus

TEAM #

SCHOOL

NAMES

PA Regional Science Olympiad 2023
Answer Key

1	E	
2	B	
3	B	
4	D	
T9	5	A
6	E	
7	C	
8	C	
T19	9	D
10	B	
11	A	
12	E	
13	A	
T4	14	C
15	B	
16	B	
17	E	
18	A	
T15	19	C
20	D	
21	B	
22	A	
23	C	
24	C	
25	A	

26	E	
27	A	
28	D	
T10	29	C
30	B	
31	D	
T3	32	A
33	D	
34	E	
35	B	
36	B	
T20	37	C
38	E	
39	A	
40	C	
41	B	
42	C	
43	D	
44	A	
45	B	
46	H	
47	G	
48	F	
T11	49	D
50	B	

51	E	
52	D	
53	B	
54	A	
55	D	
T2	56	E
57	A	
58	B	
59	C	
60	A	
T16	61	E
62	B	
T18	63	B
64	B	
65	A	
T5	66	A
67	C	
68	D	
T14	69	D
70	C	
71	C	
72	M	
73	K	
T1	74	L
75	J	

76	H	
77	E	
78	B	
79	A	
T12	80	D
81	C	
T6	82	B
83	A	
84	D	
85	E	
T17	86	D
87	A	
T13	88	E
89	C	
90	D	
91	A	
92	C	
93	E	
T7	94	E
95	B	
96	A	
97	C	
T8	98	B
99	E	
100	D	

Score

Place

Bonus **Chandrasekhar**

TEAM #

SCHOOL

NAMES