



Exploring the World of Science

**PENNSYLVANIA SCIENCE OLYMPIAD
SOUTHEAST REGIONAL TOURNAMENT 2014
ASTRONOMY C DIVISION EXAM**

MARCH 5, 2014



SCHOOL: _____ **TEAM NUMBER:** _____

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. **BY WRITING YOUR NAME YOU AGREE TO THE GENERAL RULES AND CODE OF ETHICS AS STATED IN THE DIVISION C RULES MANUAL.**
5. Be prepared to display your wristband to the supervisor when asked.
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 12 tiebreakers.
7. When the time is up, *the time is up*. Continuing to write after the time is up risks immediate disqualification.
8. In the BONUS box on the answer sheet, name the gentleman depicted on the cover for a bonus point.
9. As per the 2014 Division C Rules Manual, each team is permitted to bring “either two laptop computers OR two 3-ring binders of any size, or one binder and one laptop” and programmable calculators.
10. Nonsensical, mocking, or inappropriate answers **WILL RESULT IN DISQUALIFICATION.**

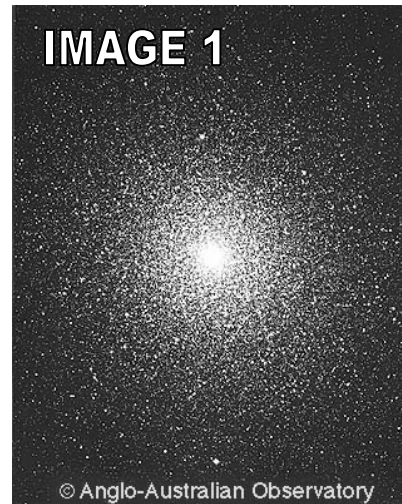
Questions 1-32 refer to the objects listed in section 3c, page C2, of the 2014 Science Olympiad Division C Rules Manual. "Identify, know the location and answer questions relating to the content areas for the following objects."

1. Which object is shown in image 1?

- A. Trapezium
- B. NGC 1846
- C. Abell 30
- D. 47 Tucanae
- E. SS Cygni

2. Which of the following most accurately describes the object in image 1?

- A. Supernova remnant
- B. Planetary nebula
- C. Open Cluster
- D. Stellar nursery
- E. Globular cluster



3. What type of astronomical object is found in higher numbers in image 1 than in any other object of this type?

- A. Radio pulsar
- B. Type II supernova
- C. blue straggler
- D. Type Ia supernova
- E. Stellar-mass black hole

4. Which object is shown in image 2?

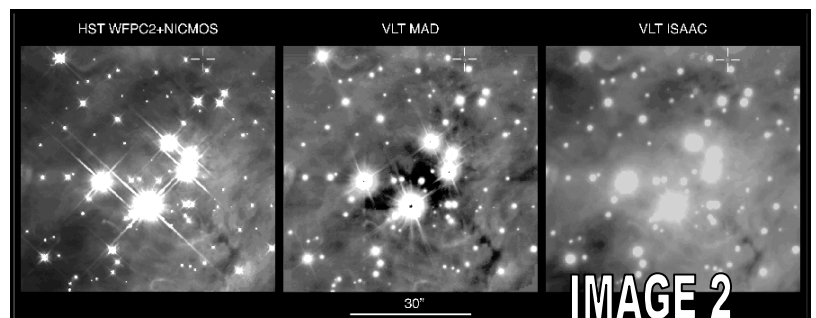
- A. The Trapezium
- B. SS Cygni
- C. T Tauri
- D. V1
- E. T Pyxidis

5. The object in image 2 is part of a larger region known as:

- A. Cygnus (the swan)
- B. M31
- C. Pyxis (the Mariner's Compass)
- D. the Hyades
- E. Orion Nebula

6. What is the brightest object in image 2?

- A. Red giant
- B. Recurrent nova
- C. Classical nova
- D. O class main sequence star
- E. Classical Cepheid



7. (T12) Which object is indicated by the light curve in image 3?

- A. Mira
- B. T Tauri
- C. Abell 30
- D. SS Cygni
- E. Eta Carinae

8. What type of object is indicated by this light curve?

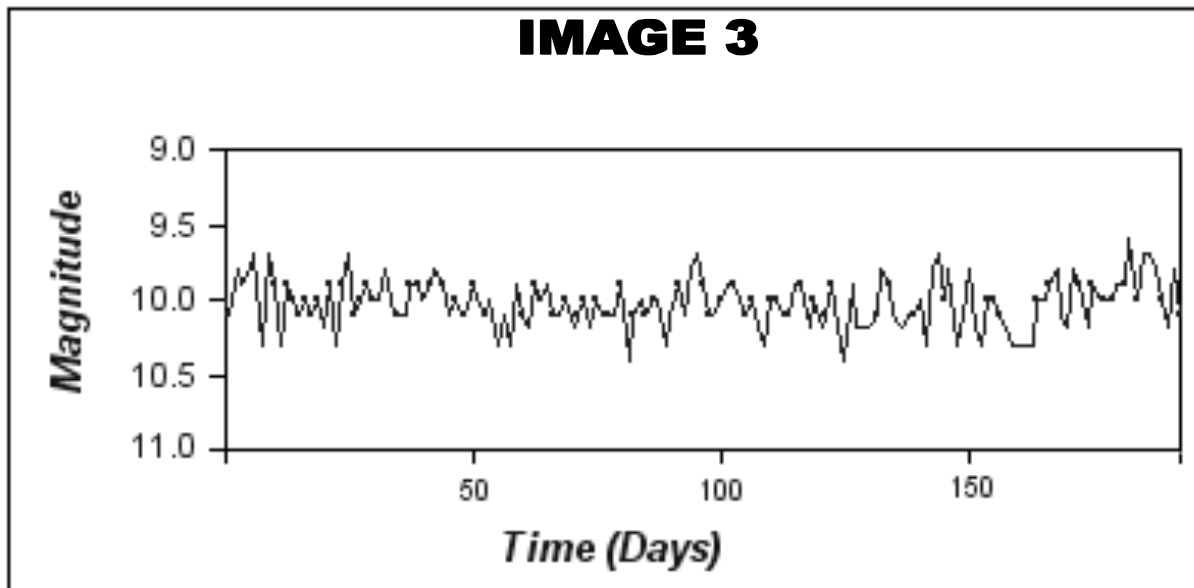
- A. Luminous Blue Variable
- B. Type Ia supernova remnant
- C. Red giant in a symbiotic pair
- D. Recurrent nova
- E. Protostar

9. Which of the following is NOT commonly associated with an object of this type?

- A. Debris disk
- B. Runaway thermonuclear explosion
- C. Herbig-Haro object
- D. Strong stellar wind
- E. High Lithium abundance

10. (T6) What is this object's designation in the Henry Draper Catalogue?

- A. 30
- B. 14386
- C. 284419
- D. 93308
- E. 206697

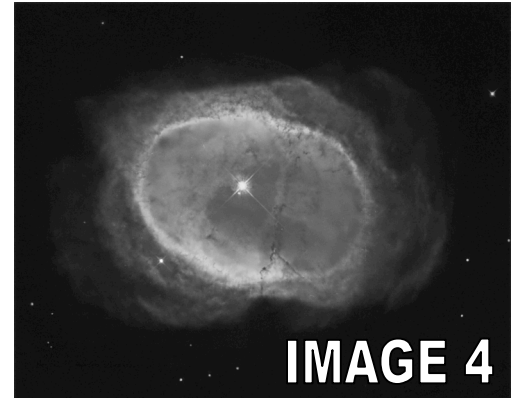


11. Which object is shown in image 4?

- A. Vela SNR
- B. Abell 30
- C. NGC 3132
- D. G1.9+03
- E. W49B

12. In which constellation is this object found?

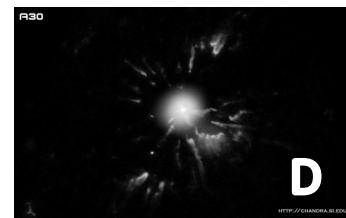
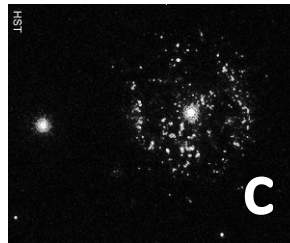
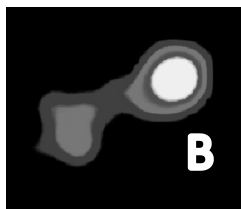
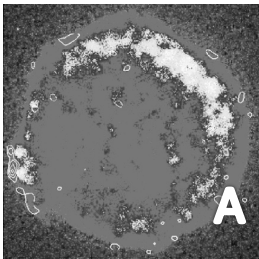
- A. Cancer
- B. Aquila
- C. Sagittarius
- D. Vela
- E. Cetus



13. About how far away is the object in image 4?

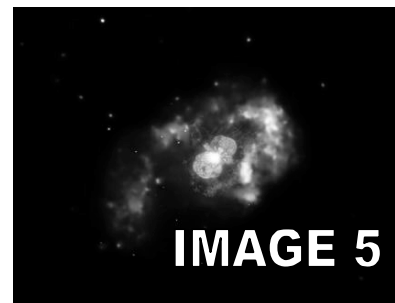
- A. 5500 ly
- B. 8000-10000 ly
- C. 26,000 ly
- D. 2000 ly
- E. 160,000 ly

14. Which image below shows the “wonderful star”?



15. Which object is shown in image 5?

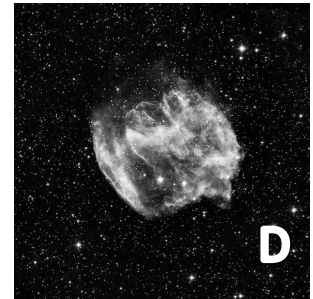
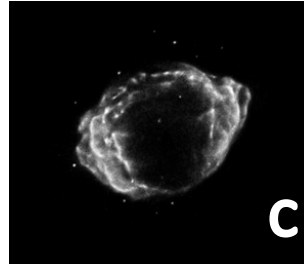
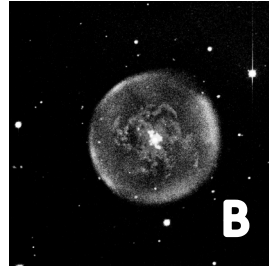
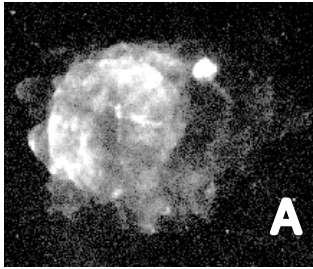
- A. Eta Carinae
- B. Mira
- C. T Pyxidis
- D. SS Cygni
- E. W49B
- F. Abell 30



16. What is this object's designation in the Smithsonian Astrophysical Observatory Star catalogue?

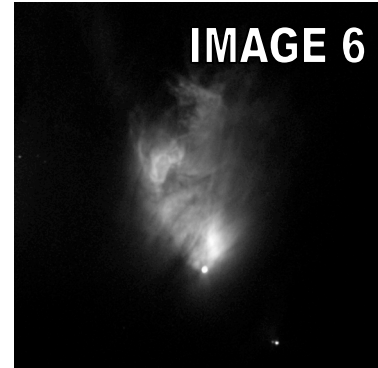
- A. 129825
- B. 398
- C. 206697
- D. 1890
- E. 30
- F. 238429

17. Which of the following images shows the youngest known SNR in the Milky Way Galaxy?



18. What type of object is shown in image 6?

- A. T Tauri protostar
- B. Supernova remnant
- C. Planetary nebula and white dwarf
- D. FU Orionis protostar
- E. Luminous blue variable star
- F. Recurrent nova

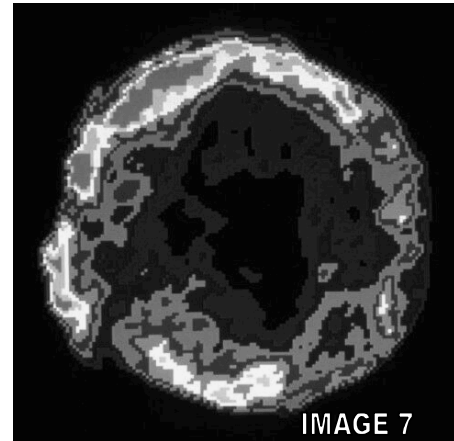


19. (T7) What is the name for the nebulosity surrounding this object?

- A. Vela SNR
- B. Homunculus Nebula
- C. W49B
- D. McNeil's Nebula
- E. born-again planetary nebula
- F. Andromeda

20. (T1) Which object is shown in image 7?

- A. Vela SNR
- B. W49B
- C. Abell 30
- D. J0806.3+1527
- E. NGC 3132
- F. Tycho's SNR



21. The object in image 7 would best be classified as a:

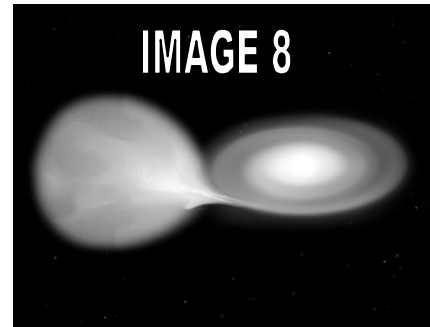
- A. Type Ia supernova
- B. Type Ib supernova
- C. Type Ic supernova
- D. Type IIn supernova
- E. Type IIL supernova
- F. Type IIP supernova
- G. Type IIb supernova

22. This type of supernova typically results from which of the following?

- A. Core collapse of a Wolf-Rayet star of type WO
- B. Core collapse of a Wolf-Rayet star of type WC
- C. Accretion of mass onto a white dwarf in a mass-transfer binary
- D. Accretion of mass onto a white dwarf due to high stellar winds
- E. Core collapse of a supergiant star within a cloud of expelled material
- F. Core collapse of a hydrogen-depleted supergiant

23. Consider image 8. The star is red. This image could apply to which object(s) listed?

- A. SS Cygni
- B. Mira
- C. T Pyxidis
- D. A and B
- E. B and C
- F. A and C
- G. A, B, and C



24. Which of the following is a recurrent nova?

- A. V1
- B. Abell 30
- C. SS Cygni
- D. T Pyxidis
- E. Mira
- F. GRS 1915+105

25. Which object could appear in image 9?

- A. RX J0806.3+1527
- B. GRS 1915+105
- C. V1
- D. W49B
- E. V1647 Ori
- F. Abell 30
- G. NGC 1846



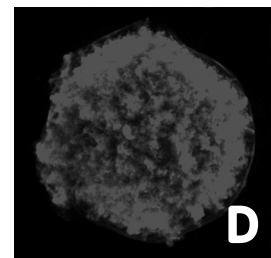
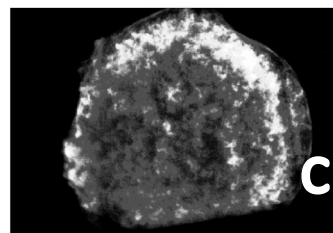
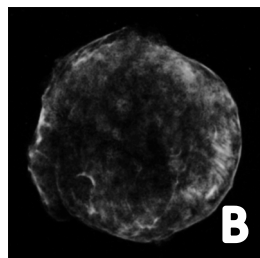
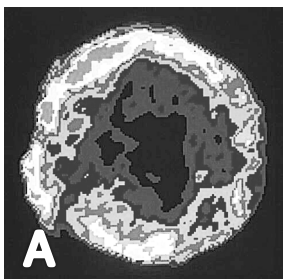
26. (T8) What is the significance of the object referenced in #25?

- A. It verified that gamma-ray bursts are associated with supernova remnants
- B. It showed that instabilities in a protostar accretion disk can generate X-ray hot spots
- C. It showed the presence of a secondary, small-scale planetary nebula inside the original
- D. It verified the presence of strong stellar wind in an X-ray binary
- E. It solidified the distance to M31, supporting Hubble's theory that galaxies were outside the Milky Way
- F. It verified the presence of gravitational waves in a double-white-dwarf binary

27. Where would the object referenced in #25 be found on the H-R diagram?

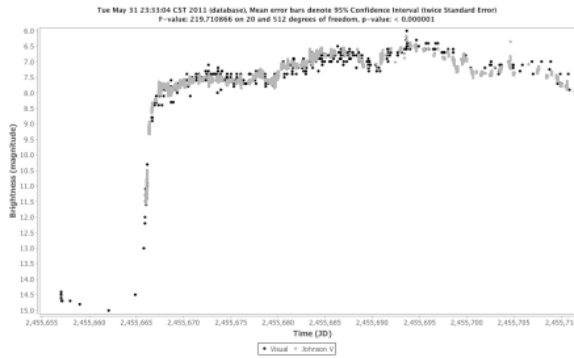
- A. On the Main Sequence, to the lower right
- B. On the Main Sequence, to the upper left
- C. In the asymptotic red giant branch
- D. In the white dwarf region below the Main Sequence
- E. In the instability strip, above the Main Sequence

28. Which of the following images was made in the radio band?



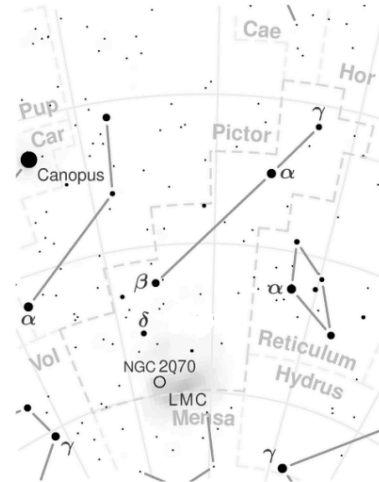
29. Which object produced the light curve shown below?

- A. V1
- B. W49B
- C. SS Cygni
- D. T Pyxidis
- E. V1647 Ori
- F. RX J0806.3+1527
- G. GRS 1915+105



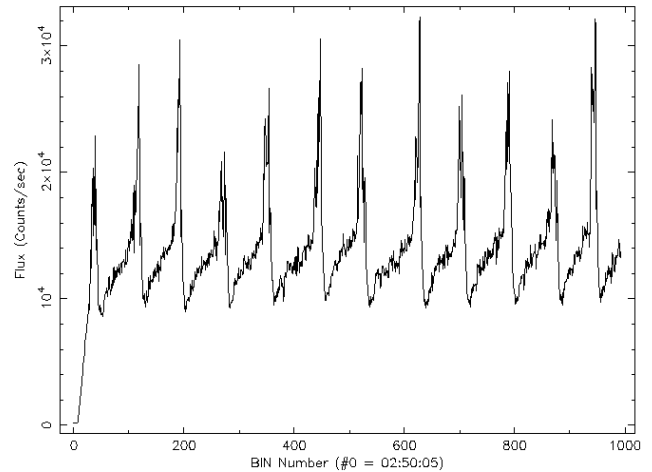
30. Which object appears in the constellation shown?

- A. NGC 3132
- B. NGC 1846
- C. Vela SNR
- D. 47 Tucanae
- E. Abell 30
- F. SS Cygni
- G. Eta Carinae



31. Which object produced the light curve shown at right?

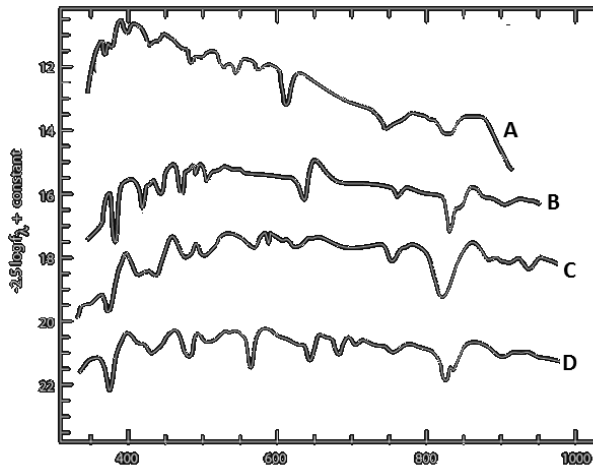
- A. V1
- B. Mira
- C. G1.9+0.3
- D. SS Cygni
- E. T Tauri
- F. RX J0806.3+1527
- G. GRS 1915+105



32. Which is the best explanation for the nature of this light curve?

- A. Pulsations of a Cepheid variable star
- B. Convection causing pulsation in a red giant
- C. Instabilities in the accretion disk of a protostar leading to periodic outbursts
- D. Mass transfer binary showing outbursts due to hydrogen fusion on the surface of the white dwarf
- E. X-ray variation due to mass accretion onto a black hole

33. Which of the following spectra belongs to a Type Ia supernova?



34. In the Type Ia supernova spectrum shown above, which spectral feature is notably absent?

- A. Ca II
- B. Si II
- C. O I
- D. Fe II
- E. Fe III
- F. H α
- G. Mg II

35. In a Type Ia supernova, the white dwarf collapses under the influence of:

- A. gravitational waves
- B. neutron degeneracy pressure
- C. electron degeneracy pressure
- D. stellar wind from the companion
- E. exhaustion of nuclear fuel, leading to loss of thermal pressure

36. Type Ia supernovae tend to be found in:

- A. locations of recent star formation
- B. primarily elliptical galaxies
- C. in the arms of spiral galaxies
- D. in starburst galaxies
- E. in galaxies with active galactic nuclei
- F. in all types of galaxies

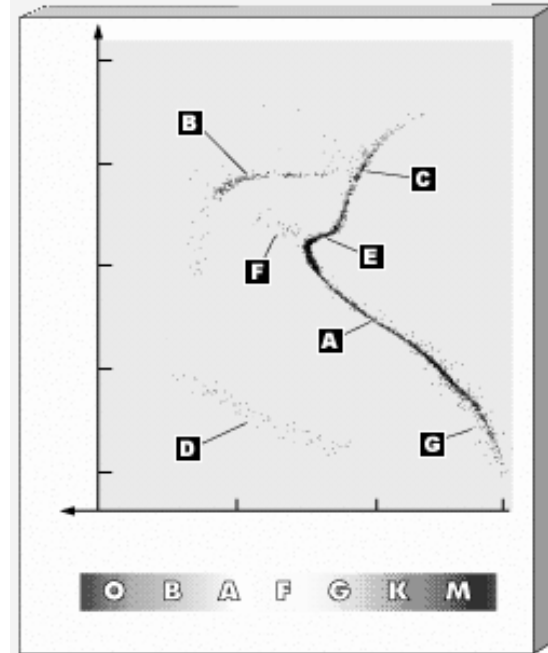
37. (T5) A type Ia supernova is observed in a distant galaxy, and its apparent magnitude is 14.0. How far away is this galaxy, assuming an absolute magnitude of -19.6 for type Ia supernova?

- A. 52.5 Mpc B. 25.1 Mpc C. 14.0 Mpc D. 75.9 Mpc E. 19.6 Mpc

38. The remnant of a type Ia supernova is typically which of the following?

- A. Neutron star
- B. White dwarf with planetary nebula
- C. Black hole
- D. The remnant could be A or C depending on the star's mass at collapse
- E. There is no remnant

For questions 39 – 45, associate the numbered locations and/or objects with the appropriate lettered location on the HR diagram shown below. Questions 46 – 50 also refer to this diagram.



- 39. Red dwarfs
- 40. White dwarfs
- 41. Subgiant branch
- 42. Main Sequence
- 43. Horizontal branch
- 44. Red giants
- 45. Blue stragglers

46. The H-R diagram shown above most likely is that of:

- A. an open cluster
- B. an OB association
- C. a spiral galaxy
- D. a globular cluster
- E. an elliptical galaxy

47. Where are objects of this type most likely to be found?

- A. In the arms of spiral galaxies
- B. In the central bulge of spiral galaxies
- C. In the galactic halo of a spiral galaxy

48. (T2) What type of object is most likely to be found at location B in the H-R diagram above?

- A. An RR Lyrae star
- B. A red giant star
- C. A white dwarf
- D. A planetary nebula nucleus variable
- E. A blue straggler
- F. A subgiant star

49. The stars shown on this H-R diagram are likely to be which of the following?

- A. Young and metal-rich
- B. Young and metal-poor
- C. Old and metal-rich
- D. Old and metal-poor

50. The object represented by this H-R diagram probably has:

- A. a supermassive black hole at the center
- B. numerous active star-forming regions
- C. very little gas and dust in the interstellar medium
- D. T-Tauri protostars with debris disks
- E. associations of bright, massive O and B stars

51. Dwarf novae are also referred to as which of the following?

- A. U Geminorum stars
- B. Delta Cephei stars
- C. Delta Scuti stars
- D. S Doradus stars
- E. AM Herculis stars

52. What is the primary difference between dwarf novae and recurrent novae?

- A. Dwarf novae do not recur
- B. Dwarf novae typically have greater magnitude
- C. Dwarf novae have longer periods between outbursts
- D. Dwarf novae outbursts are associated with instability in the accretion disk
- E. Dwarf novae do not accrete mass from a companion star

53. (T3) Which of the following describes a Herbig-Haro object?

- A. A rapidly rotating neutron star with twisted magnetic field lines
- B. An X-ray binary in which the visible star has evolved off the main sequence
- C. Bipolar jets of material ejected from a protostar
- D. Eclipsing binary stars in which the orbit is inclined from the line of sight
- E. An intermediate-mass black hole, between stellar mass and supermassive

54. Which of the following is(are) TRUE?

- A. Some T Tauri stars are FU Orionis stars
- B. All T Tauri stars are FU Orionis stars
- C. Some FU Orionis stars are T Tauri stars
- D. All FU Orionis stars are T Tauri stars
- E. A and C
- F. B and D
- G. A and D
- H. B and C

55. T Tauri stars exhibit P-Cygni profiles in their spectra. What does this indicate?

- A. Circumstellar disk instability
- B. Synchrotron radiation
- C. Magnetic field variation
- D. Mass loss
- E. Convection in the stellar atmosphere

56. Which of the following descriptions best fits the S Doradus variables?

- A. Symbiotic binary systems in which one star has evolved off the main sequence
- B. Luminous blue variables that exhibit long, slow changes in brightness
- C. Pulsating variables in the instability strip just above the main sequence
- D. Nova-like objects with periodic but irregular outbursts
- E. Yellow supergiants with odd chemical compositions

57. Which subclass of RR Lyrae variables has the longest relative period?

- A. RRa
- B. RRb
- C. RRc
- D. RRd

58. A symbiotic binary star system consists of a large red giant star of 1.8 solar masses and a companion of 0.7 solar masses that orbits the red giant every 388 years. What is the orbital radius in astronomical units?
- A. 72.2 AU B. 31.1 AU C. 54.9 AU D. 12,100 AU E. 155.2 AU
59. The stars in an OB association would tend to be:
- A. Old, hot, and bright
B. Old, cool, and bright
C. Old, cool, and dim
D. Young, hot, and bright
E. Young, cool, and bright
F. Young, cool, and dim
60. (T9) Semiregular variable stars would tend to be found:
- A. on the Hayashi track of stellar formation
B. on the main sequence
C. below the main sequence
D. on the subgiant branch
E. in the instability strip
F. on the asymptotic giant branch
61. What is the absolute magnitude of an RR Lyrae star?
- A. It depends on the period
B. Approximately +0.5
C. Approximately -0.5
D. Approximately +15
E. Approximately -15
62. A particular RR Lyrae star has an apparent magnitude of +12. What is its distance modulus?
- A. 11.5 B. 12.5 C. -3 D. 27 E. can't tell without the period
63. What is the name for the maximum mass of a neutron star?
- A. Chandrasekhar limit
B. Tolman-Oppenheimer-Volkoff limit
C. Roche limit
D. Schwarzschild limit
E. Natarajan-Treister limit
64. (T10) An X-ray binary that is also a radio source is also called a(n):
- A. Algol system
B. symbiotic binary
C. microquasar
D. RS Canum Venaticorum system
E. AM Herculis system

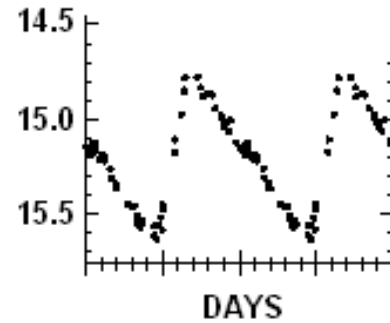
Use the light curve shown for numbers 65 – 71. Each small division on the axis is one day.

65. What type of variable star is this?

- A. S Doradus
- B. Mira variable
- C. RR Lyrae
- D. Cepheid
- E. T Tauri

66. What is this star's apparent magnitude at maximum?

- A. 14.2
- B. 15.3
- D. 15.7
- D. 15.2
- E. 14.8



67. What is this star's apparent magnitude at minimum?

- A. 14.2
- B. 15.3
- C. 15.6
- D. 15.2
- E. 14.8

68. What is this star's period in days?

- A. 5
- B. 10
- C. 15
- D. 20
- E. 1

69. What is this star's absolute magnitude?

- A. -4.24
- B. 15.2
- C. -3.39
- D. 5.08
- E. -19.6

70. (T4) How far away is this star in parsecs?

- A. 2.12E4
- B. 5.23E4
- C. 7.73E4
- D. 9.70E4
- E. 1.14E5

71. Which of the following accurately describes the driving force behind the variability in image 10?

- A. The opacity of once-ionized helium
- B. Convective turbulence in the star's outer layers
- C. The Stellar Dynamo Effect
- D. Limb darkening
- E. Runaway thermonuclear reactions on the surface

For questions numbered 72 – 79, match the numbered sub-class of x-ray binary with the description.

72. HMXB A. Binary star system with a compact object and an intermediate-mass stellar companion
73. (T11) LMXB B. Generates very low-energy x-rays, usually through *steady* fusion by an accreting white dwarf in a binary system
74. IMXB C. High-mass binary systems in which the compact object orbits a very massive companion with periods of a few days, emitting hard x-rays
75. BeXRB D. Binary star system with a compact object and a low-mass star; shows changing levels of soft x-ray emission probably due to variable mass transfer
76. SXT E. Binary star system with a compact object and a massive, O or B type companion; much of the x ray emission results from strong stellar winds captured by the compact object
77. SSXB F. High-mass binary systems in which a neutron star is in a highly elliptical orbit that passes through a disk-shaped stellar wind, showing hard x-ray flare-ups
78. SFXT G. Exotic source of hard x-rays associated with massive O and B type stars; flare ups are brief and show very fast rise times
79. SGXB H. Binary system with a compact object and a low mass companion; the accretion disk is the brightest object in the system

80. What principle is verified by the behavior of double neutron star binaries?

- A. Pauli Exclusion
- B. Hawking radiation
- C. the Faber-Jackson relation
- D. neutron degeneracy
- E. General Relativity
- F. Special Relativity