Science Olympiad
Astronomy C Division Event
National Exam

University of Central Florida

May 17, 2014

Team Number: _____

Team Name: _____

Instructions:
1) Please turn in all materials at the end of the event.
2) Do not forget to put your team name and team number at the top of all answer pages.
3) Write all answers on the answer pages. Any marks elsewhere will not be scored.
4) Please do not access the internet during the event. If you do so, your team will be disqualified.
5) The test will be uploaded at: www.aavso.org/science-olympiad-2014.
6) Good luck! And may the stars be with you!

Section A: Use Image/Illustration Set A to answer Questions 1-20.

1. (a) What is the name of the object and number of the image that shows a dwarf nova binary system?
   (b) What letters on the H-R diagram show the locations of the two objects in this system?
   (c) Which image shows the behavior of this system?

2. (a) The letter Z on the H-R diagram indicates a region that displays what type of variability?
   (b) What is the number of the image that contains this type of object, and what is the number of the image that shows the behavior of this object?

3. (a) What is the name and type of object in Image 5?
   (b) What is the number of the light curve that displays the behavior of several stars located in this object?

4. (a) The light curve in Image 25 is produced by what type of object?
   (b) Which number on the H-R diagram shows the location of this object, and what is this region called?

5. Which of the following H-R diagram transitional sequences for an individual star are possible?
   (a) Z to Q
   (b) H to Q
   (c) J to L
   (d) L to J

6. (a) What specific type of behavior is represented in the graph in Image 21?
   (b) What is the name and image number of an object exhibiting this behavior?

7. (a) What is the name of the object in Image 15?
   (b) What letter shows the location of this object on the H-R diagram?

8. (a) Which image(s) contain objects that resulted from the core collapse of a massive star?
   (b) Which image(s) contain objects that resulted from the thermonuclear explosion of a white dwarf?

9. (a) What is the gap on the horizontal branch of the H-R diagram in Image 18 called?
   (b) Which image(s) contain objects that reside in this gap?

10. A spectral type A star evolving from the main sequence to its final end products can exhibit what sequence of specific types of variability?

11. (a) What is the name of the object and number of the image which exhibits the behavior in the light curve in Image 22?
    (b) What type of system is this object a part of?

12. (a) Which image(s) show situations that will most likely lead to Type Ia supernova events?
    (b) Which image(s) show situations that will most likely lead to the formation of a neutron star?

13. (a) Which images contain objects that resulted from the collapse of a red giant?
    (b) Which locations on the H-R diagram show the final evolution of the stellar core within these objects?

14. (a) What images show pre-main sequence stellar objects?
    (b) Which graph shows the typical behavior for these types of objects?

15. Arrange the following images into a chronological evolutionary sequence: 2,4,11,12,13.

16. What are the possible final end products for stars exhibiting the behavior shown in Image 26?

17. (a) What are the locations on the H-R diagram of the two objects in Image 11?
    (b) What will be the final location on the diagram of the larger object?

18. Which region(s) are the pulsating variable stars located on the H-R diagram?

19. Which of the following H-R diagram transitions is possible?

    (a) YTJCDA
    (b) FJCPAS
    (c) YTJCLA

20. (a) Which two light curves are useful in calculating galactic distances?
    (b) Where are the stars producing these light curves located on the H-R diagram?

Section B: Use Image/Illustration Set B to answer Questions 21-30.

21. Image 30 shows a color-color diagram of a portion of the main sequence of 47 Tucanae.
    (a) What feature of this cluster's H-R diagram is shown here?
    (b) What is the cause of this feature?

22. Image 31 shows a color-magnitude diagram of a globular cluster.
    (a) Which quantity is plotted on the y-axis?
    (b) What is the approximate temperature of stars at the turnoff point, in Kelvin?
    (c) What is the age of this cluster to the closest power of ten, in years?

23. Image 32 shows a planetary nebula.
    (a) Which object does this planetary nebula reside in?
    (b) It is unknown whether or not this nebula is a member of the object. What study could be performed to determine membership?

24. A supernova remnant is shown in Image 33.
    (a) Which object is shown in this Image?
    (b) What distinguishes this object from other supernova remnants of its type?

25. A nearby galaxy is shown in Image 34.
    (a) What is the Messier catalog number of this galaxy?
    (b) Which variable star object is located in this galaxy?
    (c) What is the period of this variable star, in days?

26. RR Lyrae variable stars can be separated into types (a,b,c,d) based on their light curves. What distinguishes Type D RR Lyraes from the rest of the class?

27. SS Cygni is a prototype dwarf nova.
    (a) Which type of dwarf novae does SS Cygni belong to?
    (b) What are the three components of its system?
    (c) SS Cygni was found to lie at a distance of 114 parsec from Earth in 2013, substantially closer than previous estimates of 160 parsec. What problem did this solve?

28. Bolometric light curves for Type II supernovae with different quantities of a given isotope are shown in Image 35. Which isotope is causing the large increase in luminosity, proportional to the quantity of the isotope?

29. Mira is the prototype of the Mira class of variable stars.

    (a) In which part of the electromagnetic spectrum do Mira variables emit the most energy?

    (b) In which part of the electromagnetic spectrum do Mira variables have the largest variability?

    (c) What is the key difference between Mira and Semiregular variables?

30. Image 36 shows the neutron star mass-radius relationship.

    (a) What insightful observation can you make from this diagram?

    (b) What makes a given neutron star a pulsar?

    (c) The Vela pulsar in the Vela supernova remnant has powerful winds of charged particles, forming a specific type of nebula around it. What are these nebulae called?

    (d) Magnetars are neutron stars with a very large luminosity, implying the presence of strong magnetic fields. Magnetars are observed to "glitch" more often than normal neutron stars. What is a neutron star "glitch"?

Section C: Use Image/Illustration Set C to answer Questions 31-34.

31. Star A is a main-sequence star 15 parsecs away with a radius of 7 solar radii. Image 38 shows Star A's blackbody spectrum.

    (a) What is the parallax of Star A, in arcseconds?

    (b) What is the effective temperature of Star A, in Kelvin?

    (c) What is the spectral type of Star A? Be specific.

    (d) What is the luminosity of Star A, in solar luminosities?

    (e) What is the apparent visual magnitude of Star A, assuming that all radiation from Star A is in the visible part of the electromagnetic spectrum?

32. Star B and Star C are variable stars with the same apparent visual magnitude. Image 39 shows a light curve of Star B, and Star C is a Cepheid with a period of 20 days. The period-luminosity relationship (visual luminosity vs. period) is shown in Image 37. Star B is at a distance of 5,000 parsecs from Earth.

    (a) What is the apparent visual magnitude of both stars?

    (b) What is the distance to Star C, in kiloparsecs?

33. Image 40 shows the radial velocity curve of a binary system 500 parsec away, consisting of Star D and Star E. The stars are separated by 8 AU.

    (a) What is the total mass of the system, in solar masses?

    (b) What is the distance of Star E from the center of mass of the system, in AU?

    (c) What is the mass of Star D, in solar masses?

    (d) What will the end state of Star D be?

    (e) What is the recessional velocity of the system, in km/s?

    (f) What is the true space speed of the system, in km/s, if its observed proper motion is 0.01 arcseconds per year?

34. Images 41 and 42 of SN 1572 were taken in 2003. SN 1572 had a peak apparent visual magnitude of -6. The crosshairs on the images are placed in order to enable measurement of the diameter of the object. The scale of the image is 0.015 arcminutes per pixel (see "Image" values).

    (a) What area of the sky does this object cover, in square arcminutes?

    (b) Assuming that the object has expanded at a uniform rate, what is its speed of expansion, in km/s?

    (c) Assuming that the progenitor star shed 1 solar mass when it went supernova, how much kinetic energy was released in the event, in ergs?

    (d) What caused the feature circled in both images?