Astronomy (Div C)
CPS Invitational at Westinghouse
February 4, 2017

School Name: _____

Team Number: _____

"We learn about the stars by receiving and interpreting the messages which their light brings to us. The message of the Companion of Sirius when it was decoded ran: "I am composed of material 3,000 times denser than anything you have ever come across; a ton of my material would be a little nugget that you could put in a matchbox." What reply can one make to such a message? The reply which most of us made in 1914 was—"Shut up. Don't talk nonsense."

DIRECTIONS

1. Write your names, team number, and school on the answer sheet before the test begins.
    a. Only the answer sheet will be graded, anything written on the test WILL NOT receive credit!
2. PLEASE WRITE LEGIBLY!!
3. You will have 50 min to complete the test. When time is called, put your writing utensils down and raise your tests in the air. Writing anything down after time is called will result in disqualification (hence writing your names before beginning the test).
    a. We will call out when there are 25, 10, and 5 minutes remaining.
4. If you have a question or any issues arise during the test, please raise your hand and someone will come over.
5. Show all your work for the math section and where applicable on the answer sheet--partial credit will be rewarded where due!
6. If you finish early, turn in your test to us and you are free to go. Please take all your belongings with you.
7. Good Luck!

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Few Helpful Equations:

Wien's Law:

$$\lambda_{max} = \frac{2.897 \times 10^{-3}\, m \cdot K}{T_{(in\,Kelvin)}}$$

where λ_{max} represents the peak wavelength of a star (i.e., the wavelength at which a star is the brightest)

Redshift/Doppler (non-relativistic):

$$\frac{v}{c} = z = \frac{\lambda_{observed} - \lambda_{emitted}}{\lambda_{emitted}}$$

where z is the redshift parameter.

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Part I:

(23 points)

1) Binary white dwarfs were predicted to be a potential source of what phenomenon? (1pt)
    a) Neutrino oscillation
    b) Gravitational Waves
    c) Dark Energy
    d) Dark Matter

Use image 1 on the image sheet to answer questions 2-4

2) Write the name of this object as stated in the official Science Olympiad rule-book for astronomy (1pt)
3) What type of object is this? (Be as specific as you can!) (2pts)
4) Why is this object shaped asymmetrically? (2pts)

Use the image 2 on the image sheet to answer questions 5-8

5) What is the brighter of the two objects in the image? (1pt)
6)
    a) What wavelength was this image taken in? (1pt)
    b) Write in the correct answer choices: The wavelength this picture was taken in has a (shorter/longer) wavelength and a (higher/lower) frequency than visible light. (2pts)

7) Calculate the total mass of this system from Newton's version of Kepler's third law. Show all your work!! (3pts=1pt answer, 1pt units, 1pt work shown, no credit for correct answer if no work is shown)

8) Where on an HR diagram would the object you identified in question 5 be found? (2pts)

Use image 3 on the image sheet to answer questions 9-13

9) Write the name of this object as stated in the official Science Olympiad rule-book for astronomy (1pt)
10) What type of object is this? (1pt)
11) Compared with the white stars, the red and blue stars (1pt)
    a) are younger
    b) contain more hydrogen
    c) are cooler
    d) are older

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12) The zoomed-in image at the bottom right shows an object that (choose all that apply) (2pts, take off up to 2 points for incorrect selections)

a) is at the beginning of its life cycle

b) is at the end of its life cycle

c) was or will be a high mass star (>8 solar masses)

d) was or will be a lower mass star (<8 solar masses)

e) is a supernova remnant

f) can undergo a nova in its current position

g) contains an accretion disk

h) contains a neutron star

13) Why does the zoomed-in image at the bottom right look green? (2pts)

14) Where are the type of objects you identified in question 9 typically found? (1pt)

a) near the middle of galaxies

b) orbiting within the halo of galaxies

c) randomly dispersed throughout space

d) in the arms of spiral galaxies

<u>Part II</u>:

(40 points: 2 point per question with fractional points for partial credit)

Don't worry about significant figures, but do try to provide at least two.

15) A Type Ia Supernova is observed to have magnitude of -9.

a. How far is the Supernova away from the Earth?

b. What would the apparent magnitude be from twice that distance?

c. Usually when objects are pretty far away, the interstellar medium blocks some of the light from us, and the objects appear slightly darker. This is known as interstellar extinction. Suppose there's a similar Type Ia Supernova with an apparent magnitude of -9, but this time we can assign one magnitude of extinction to the star. How far is this supernova from the Earth?

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16. Consider a star called Star A with a radius of 1 Solar Radius (not to be confused with Sag A* !). Let its apparent magnitude be +5, and suppose from Earth we observe a parallax of 0.05" throughout the year.

a. How far is Star A from Earth?

b. What's the absolute magnitude of Star A?

c. What's the luminosity of Star A?

d. What's the temperature of Star A?

e. What's the peak wavelength of Star A?

f. To an observer 40 pc away from Star A, what would be the apparent magnitude?

g. How about the parallax?

17) Image 4 is a light curve of a variable star.

a. What is its period? (approximately)
b. What type of variable is this?

18) Binary systems

a. In a binary system, two stars are revolving around each other with a period of 7 Earth years. If the closest the separation is 7 AU, and the farthest they are 19 AU apart, what is the combined mass of the stars in Solar Masses?

b. Pluto orbits the sun with a semi-major axis of 39.5 AU and an eccentricity of 0.249. What is the ratio of the Pluto's velocity at the perihelion (closest) to its velocity at its aphelion (farthest)?

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c. A white dwarf and its companion have masses of 0.5 and 7 Solar Masses, respectively. If the companion is measured to have a radial velocity of 1.7 km/s (relative to the center of mass of system), what is the radial velocity of the white dwarf?

d. In a similar setup, a white dwarf and a main sequence star (orbiting about each other) have masses of 0.8 and 2 Solar Masses, respectively. If the latter star is observed to have a redshift parameter z ranging between 0.0010 and 0.0011, what is the velocity of the white dwarf relative to the center of the system? (You can ignore relativistic effects for redshift)

19) Star B has a spectral line caused by iron with a wavelength of 495.761 nm, but we observe the line to be at 495.762 nm.

a. How quickly is the star receding?

b. Assuming that the recession is purely caused by the expansion of the universe, how far away is Star B?

20) Suppose we're looking at a galaxy and observe that its 21 cm line is redshifted by 1 μm.

a. How fast is it moving away from us? (Use the value 21.106 cm for the initial value of the 21 cm line)

b. At the same speed, what would 656.28 nm (the H-alpha line) look like?

Bonus Questions! (Tie Breaker)

1. Who is the man pictured on the cover of this test?
2. Who is the author of the quote on the cover of this test?