



ASTRONOMY C DIVISION EXAM

APRIL 29, 2005



SCHOOL CODE _____ SCHOOL NAME _____

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 (pages are printed front and back), as well as 3 image pages and a blank answer sheet.
2. You may separate the exam and image pages. Re-staple them as you submit your materials to the supervisor. Keep the answer sheet separate.
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 team number at the top of the answer sheet as well as on the title page. Indicate the names of the participants at the bottom of the answer sheet.
5. Point values for each question are in parentheses. Tiebreaker questions are indicated with an asterisk and a superscript indicating the first, second, third, etc.
6. Pay close attention to the units given in the problem and the units asked for in the answer.
7. If you read the announcement on the State Tournament website *and have a stamped, self-addressed envelope*, submit it with your answer sheet. Include the school code on the back to ensure you get the correct answer sheet returned to you. An exam and answer key will also be provided.
8. When the time is up, *the time is up*. Continuing to write after the time is up risks immediate disqualification.
9. The numbers used to refer to specific images are indicated *above* the associated image.
10. Use the following constants where applicable.

$$H_0 = 70 \text{ km/s/Mpc}$$

$$c = 3E8 \text{ m/s} = 3E5 \text{ km/s}$$

$$M_{\text{sun}} = 2E30 \text{ kg}$$

$$T_{\text{sun}} = 5800 \text{ K}$$

$$R_{\text{sun}} = 696000 \text{ km}$$

$$1 \text{ AU} = 1.5E11 \text{ m}$$

Locate image 18 on Image Page 2. Questions numbered 1-14 refer to this diagram.

1. (1) What are the units listed on the left-side vertical axis?
2. (1) What are the units listed on the top horizontal axis?
3. (1) What are the letters on the bottom horizontal axis?
4. (1) What are the units listed on the right-side vertical axis?

For questions numbered 5-14, select the appropriate red lettered region from image 18 and list the letter on the answer sheet.

5. (1) Where on the diagram would the *remnant* from a sun-like star be found?
6. (2) Which region would contain a main-sequence star 121 ly away with an apparent magnitude of +0.85?
7. (1) Where on the diagram would you find a star with spectral class K and luminosity class III?
8. (1) Which lettered region would contain stars with the largest radius?
9. (1) Which lettered region would contain stars with the highest luminosity?
10. (1) Which lettered region would contain stars with the highest surface temperature?
11. (1) Which lettered region would contain main-sequence stars with the least mass?
12. (2) Which lettered region would be associated with a variable star with a period of 11 hours?
13. (2) Which lettered region would contain the star producing the light curve in image 17 on Image Page 1?
14. (2) Which region would have the luminosity class V star with the spectrum in image 16 on Image Page 1?
15. (2) The Hipparcos mission has catalogued thousands of stars' stellar parallax. One such star, HIP 9955, has a parallax of 9.43 milliarcseconds. How far away is it, in light years?
16. (2) A star identical to the sun has an apparent magnitude of +8.56. How far away is it in light years?

A particular star has a redshift of 0.0001803 and has shown 3.00 arcseconds of proper motion in 15 years. The star is 20 pc away, has 160 solar luminosities, and has a surface temperature of 4000 K. Questions numbered 18-25 refer to this star.

17. (1) What is the wavelength (in Angstroms) at which this star radiates the most energy?
18. (2) What is this star's recessional velocity, in km/s?
- 19.^{*3rd} (4) What is this star's transverse velocity, in km/s?
20. (2) What is this star's true space motion, in km/s?
21. (2) What is this star's absolute magnitude?
22. ^{*10th} (2) What is this star's apparent magnitude?
23. (2) What is this star's radius, in solar radii?
24. (1) What is this star's parallax in arcseconds?
25. (1) What is this star's spectral class?

Image 20 on Image Page 2 shows an object called Abell 39. The white scale bar to the right and below the image indicates a distance of 1.70 ly., and this object is 7000 ly away. Questions numbered 26-29 pertain to this image.

26. (1) What type of object is this?
27. (2) What is the object's angular diameter in arc seconds?
- 28.* ^{1st} (4) This object began to expand 24000 years ago. Find the speed (in km/s) of the leading edge of the ring.
29. (4) The spherical shell has an angular thickness of $10.1''$. The density of matter in the shell is $4.94E-20 \text{ kg/m}^3$. Calculate the mass of the shell *in solar masses*.

The spectrum shown in image 21 on Image Page 2 shows a prominent Lyman α emission line. This line appears in laboratory spectra at 1215 Angstroms. Questions numbered 30-35 pertain to this image.

30. (1) What is the apparent wavelength of the Lyman α emission line in this object's spectrum?
31. (2) What is the Z value for the object generating this spectrum?
32. (2) What is the recessional velocity (in km/s) of this object?
- 33.* ^{6th} (2) How far away is this object in Mpc?
34. (1) By what type of object is this spectrum generated?
35. (1) Which division of the electromagnetic spectrum contains the laboratory Lyman α emission line?

Questions 36-66 deal primarily with the objects on Image Page 1 and the DSO list from the Science Olympiad Student Manual.

36. (1) What is the name of the object shown in image 1?
37. (1) What are the reddish areas in image 1?
38. (1) What are the bright blue areas in image 1?
39. (1) What type of object is shown in image 2?
40. (1) Image 2 is a composite image. What wavelengths are shown?
41. (1) Where in the local group is the object in image 2 located?
42. (1) What is the name of the object shown in image 5?
43. (1) What is the bright spot near the left eye of the "skull"?
44. (1) What is the name of the object in image 8?
45. (1) Which object from Image Page 1 lies near the center of image 8 (list the image number)?
46. (1) What is the name of this object?
47. (1) What is this object's approximate mass?
48. (1) What is the name of the object in image 12?

49. (1) What type of galaxy is image 12?
50. (1) How far away is this object in ly?
51. * 8th (1) What is the cause of the “jet” visible in image 12?
52. (1) What is the name of the object in image 7?
53. (1) What constellation is it in?
54. (1) What is this object’s approximate age?
55. (1) In which lettered region of image 23 would image 7 be found?
56. (1) Which object on Image Page 1 would produce a lightcurve like the one in image 19 on Image Page 2?
57. (2) Which 2 objects show the core collapse of a massive star?
58. (1) In which lettered region of image 23 would image 10 be found?
59. (1) What is the Messier catalogue number of image 10?
60. (1) What type of object is image 10?
61. (1) What is the approximate age in years of the object in image 10?
62. (1) What is the name of the object in image 15?
63. (1) Which image shows the Trifid nebula?
64. (1) Which image shows a once-spiral galaxy being ripped apart as it moves through a galaxy cluster?
65. * 9th (1) Which image shows a planetary nebula with an unusually high expansion rate and high iron concentration, indicating particular violence in the ejection?
66. (1) What is the New General Catalogue number for the object in image 13?

Image 22 shows a nearby binary system called Kruger 60. The central star (Kruger 60A) is an M-class star of mass $5.6E29$ kg, and the years listed around the orbital path indicate the associated position of Kruger 60B. The image shown is $4.26E12$ m wide by $4.68E12$ m high. Questions numbered 67-72 refer to this image.

67. (1) What is the orbital period (in years) of Kruger 60B?
68. (2) What is the semi-major axis (in AU) of Kruger 60B’s orbit?
69. (1) What is the mass of Kruger 60A in solar masses?
70. *4th (2) What is the mass of Kruger 60B in solar masses?
71. (1) Calculate the number of years Kruger 60A will spend on the main sequence.
72. (1) What will happen if Kruger 60A swells into a red giant and exceeds its Roche lobe?
73. (1) What is the Schwarzschild radius (in meters) for Kruger 60A?

Image 19 on Image Page 2 shows a lightcurve for a distant object. Questions numbered 74-79 refer to this diagram.

74. (1) What kind of object produced this lightcurve?
75. (1) What is the apparent magnitude of this object when it is at its brightest?
76. (1) What is the absolute magnitude of this object when it is at its brightest?
77. * 7th (1) How far away (in Mpc) is this object?
78. (1) Which other image on Image Page 2 could generate such a lightcurve at some future point?
79. (1) What is the minimum star mass (in solar masses) necessary to produce such an event?

Locate images 26 and 27 on Image Page 3. Questions numbered 80 –86 refer to these diagrams.

80. (1) What are the units on the horizontal axis of image 27?
81. (1) What are the units on the vertical axis of image 27?
82. (1) What type of object is indicated by image 27?
83. (2) What is the spectral class of the stars currently at main-sequence turnoff in image 27?
84. (1) What is the apparent magnitude of the stars currently at main-sequence turnoff in image 27?
85. *5th (2) How far away in parsecs is the object that created this diagram?
86. (2) What two features that are *typically* associated with this type of object are conspicuously absent?

Locate Image 24 on Image Page 2. Questions numbered 87 - 89 pertain to this image.

87. (1) What is the phenomenon producing this image?
88. (2) What two types of objects are visible in this image?
89. (1) What is this object called?
90. *2nd (2) An astronomer suggests using broadening of the 21-cm neutral Hydrogen radio emission line to calculate the distance to a giant elliptical E2 galaxy. Why is he wasting his time?