Name:_____

Seat Number: _____

Astronomy 102: Stars and Galaxies

Examination 2

March 14, 2003

Do not open the test until instructed to begin.

Instructions: Write your answers in the space provided. If you need additional space, continue on the back of each page, but indicate clearly that you have done so. No books, notes, or assistance from anyone is allowed. You are allowed to use, and will need, a calculator. Please **write legibly and be brief and to the point!** The exam has 14 questions (eight multiple choice and six short answer); you have 50 minutes in which to answer them. All exams must be turned in at the end of the period. The number of points each question is worth is provided for your information; there are a total of 64 points.

Useful Constants and Formulae

$$f\,\lambda = c \qquad c = 3.00 \times 10^{8}\ \frac{\mathrm{m}}{\mathrm{s}}$$

$$E = h\,f \qquad h = 6.626 \times 10^{-34}\ \frac{\mathrm{J}}{\mathrm{Hz}}$$

$$d = \frac{1}{p}$$

where d is in pc and p is in $''$ (arcseconds)

$$F = \frac{L}{4\pi\,d^2}$$

$$L = (\sigma\,T^4)(4\pi\,R^2)$$

$$\text{if } y = x^4 \text{ then } x = \sqrt{\sqrt{y}}$$

$$L_\odot = 3.85 \times 10^{26}\,\mathrm{W} \qquad 1\,\text{Å} = 10^{-10}\,\mathrm{m}$$

Professor's cat

Multiple Choice Questions: The first eight questions are multiple choice. Except where explicitly noted, only one answer is correct for each question. Circle the letter of the correct answer. Each multiple choice question is worth **4 points**

1. An astronomer observes two stars in the sky. One, a red star, appears brighter than another, a blue star. What can the astronomer conclude about these two stars?
   (a) The blue star is more luminous than the red star.
   (b) The red star is more luminous than the blue star.
   (c) The blue star is bigger (larger radius) than the red star.
   (d) The red star is bigger (larger radius) than the blue star.
   (e) The astronomer cannot conclude anything about the size or luminosity of these two stars.

2. How do we know that the Sun produces energy through nuclear fusion? (**More than one answer may be right. Circle as many as apply.**)
   (a) We observe light at wavelengths we can associate directly with fusion.
   (b) We observe neutrinos from the Sun, which are a predicted by-product of fusion.
   (c) We see people protesting nuclear power around the Sun all the time.
   (d) No other known means of producing energy is able to sustain the Sun's luminosity for as long as we know it's been shining, given the size and mass of the Sun.
   (e) None of the above.

3. Which of the following statements is true? (Only one is true.)
   (a) Suppose two stars are in a binary system, so we know that they are the same distance away. If they have the same luminosity, then they have the same size (have the same radius).
   (b) Two stars which appear equally bright and which have the same luminosity but different temperatures must be at different distances.
   (c) Two stars of the same luminosity and the same temperature will be the same size (have the same radius).
   (d) Two stars of the same temperature which appear equally bright will be at the same distance.
   (e) No statement in (a) through (d) is true.

4. We can tell what kind of gas produced a spectrum with absorption lines by noting:
   (a) How many lines are in the spectrum
   (b) How strong the lines are
   (c) At what wavelengths the lines appear
   (d) How wide or narrow the lines are

5. When two light elements (like hydrogen) undergo nuclear fusion,

(a) The total mass involved increases

(b) The like charges in the nuclei attract, pulling the nuclei together faster and faster

(c) Some of the energy in their mass is released

(d) Only one survives; the other turns into a release of pure energy

(e) The result is always to make nuclei of carbon

6. Photon A is observed to be at a higher frequency than Photon B. Which of the following statements are true? **More than one answer may be correct; circle all that apply.**

(a) Photon A is moving faster than Photon B.

(b) Photon A is moving slower than Photon B.

(c) Photon A has a higher wavelength than Photon B.

(d) Photon A has a lower wavelength than Photon B.

(e) Photon A has more energy than Photon B.

(f) Photon A has less energy than Photon B.

(g) Photon A is redder in color than Photon B.

(h) Photon A is bluer in color than Photon B.

7. To determine some properties of a star, you must know the distance to that star; other properties may be measured without knowledge of the star's distance. Which properties below require knowledge of the distance to calculate? **More than one answer may be correct; circle all that apply.**

(a) Luminosity

(b) Flux at Earth

(c) Color

(d) Temperature

(e) Chemical composition

(f) Radius

(g) Classification (O, B, A, F, G, K, or M)

(h) Angular size

8. Two asteroids orbit the Sun. Asteroid A has a higher average surface temperature than Asteroid B. Which of the following is a possible reason for why this difference exists?

(a) The asteroids are at the same distance from the sun, but Asteroid B has a higher albedo (reflectivity) than Asteroid A.

(b) Asteroid A is larger than Asteroid B and thus absorbs more of the Sun's light, making it warmer.

(c) The asteroids are the same size as each other and Asteroid B is closer to the Sun.

(d) Asteroid B's axis is more tilted relative to its orbit than is Asteroid A's axis, which changes how direct the sunlight is on different parts of its surface at different places in its orbit.

(e) Asteroid A is more luminous than Asteroid B.

Short Answer Questions: Answer questions in the space provided. Indicate clearly if you must continue on the back of the page. Include any calculations or diagrams necessary. Some questions require only a word or a few words, others will require a sentence or two of explanation, and others will require a calculation. **Be brief and to the point.**

9. [5 points] For each situation or phenomenon below, indicate whether the energy transport mechanism most important is *radiation*, *conduction*, or *convection*.

(a) We can see the light of distant stars.

(b) Feeling a chill from a cool breeze.

(c) Your face feels warm when (eyes closed) you look at the Sun.

(d) Burning yourself by touching a hot iron.

(e) Sitting by a campfire warming yourself.

(f) The water in your tongue freezes when you lick a cold pipe and you get embarrassingly stuck to the pipe.

(g) Cooling off hot soup by blowing on it.

(h) Energy moves from the core to the interior (outside the core) of the Sun.

(i) On a cold, still night, the open ground outside will get a layer of frost, but the floor of a covered outdoor porch or gazebo will not.

10. [0 points] 0o09inmnfdjsa6t6tr56t6aszxzxzq276666678sfa32 (This problem was written by my cat. You do not need to answer it.)

11. A commonly observed astronomical emission line known as Hα is seen in red light at 6563Å.

(a) [1 point] What is the frequency of an Hα photon?

(b) [1 point] What is the energy of an Hα photon?

(c) [2 points] A fastball thrown by a baseball pitcher has about 120 Joules of kinetic energy. How many Hα photons would you need to equal this much energy?

(d) [1 point] If an object was emitting the number of Hα photons you found in part (c) every second, what would the luminosity of that object in Hα be compared to the total luminosity of the Sun? (In other words, what is the ratio of the hypothetical object's Hα luminosity to the Sun's total luminosity?)

12. [4 points] Star A has a measured parallax of $0.1''$, and Star B has a measured parallax of $0.02''$. Both stars appear equally bright in the sky. What is L_A/L_B, the ratio of the luminosity of Star A to the luminosity of Star B?

13. [5 points] Consider a star behind a cloud of dust that dims its brightness by a factor of 100. Suppose that you do not realize that the dust is there. If you determine its distance based on its apparent brightness (i.e. you know the stars true luminosity), will you get a value that is too large or too small compared to the actual distance? How much in error will your estimate of the distance of the star be (i.e. what is the ratio between your estimated distance and the true distance)?

14. [3 points] An astronomer observes a binary star system. He knows, somehow, that one star is more massive than the other. He also knows, somehow, that he's looking down on the plane of the orbit. (I.e., just as if you were looking down on the solar system "from above" so that you'd see the planets orbiting in circles.)

(a) The astronomer observes the stars orbit through one period. If the binary system is in a circular orbit, on the diagram below draw the two circles through which each star moves. (The larger circle indicates the more massive star.)

(b) Now that the astronomer has observed the period, there is one more physical quantity about the binary stars that he would need to know in order to estimate the masses of the stars. What would that be? (Also indicate the units in which the astronomer might want to measure this physical quantity.)

(c) What two quantities can be measured by the astronomer on Earth in order to allow the astronomer to calculate the physical quantity in part (b)?

15. [6 points] In the solar system, Pluto is the most distant planet from the Sun ($a = 40$ AU).

(a) What would be the advantage of making parallax measurements of stars from Pluto rather than from the Earth?

(b) Would there be a disadvantage? Explain.

16. [4 points] A star of spectral type B has a temperature of about 30,000 K, which is five times the temperature of the Sun. However, That same B-star is fifty thousand times as luminous as the Sun. What is the ratio of the radius of the B-star to the radius of the Sun?