Midterm Exam **Name:**
ASTR 122, Birth and Death of Stars
University of Oregon **Seat Number:**
D. E. Soper
November 15, 2007 **Signature:**

There are 30 multiple choice questions, worth 1 point each. Please mark your answers on the answer sheet provided. There are also two short answer questions, worth 4 points each. Please write your answers to these in the space provided in this test booklet.

Please note that sometimes part of a question and the possible choices appear on one page and part on the following page.

Please carefully write your name both on this test booklet, in the space provided above, and on the answer sheet. Please also sign this test booklet in the space provided above. By your signature, you represent that your work on this exam is your own. The answers that you give are supposed to come from your own knowledge. You may not use books, notes, or calculators.

There will be fifty minutes from the time that we begin to complete the test. You may be done before that. I will accept completed tests any time after thirty minutes after the beginning of the test. (This is a courtesy to your fellow students. Having people leave on a continuous basis is disruptive for those who are still working.) If you are done before the thirty minutes, I recommend that you go over your answers to make sure that you have chosen the answers that you really wanted. I will announce when you can begin to submit completed tests.

When you are done, you can turn in your test at the front of the room. Please insert your answer sheet into the test booklet.

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Some formulas that may prove useful

- Let p be the parallax angle of a star. Then we can determine the distance d to the star using

$$d = (\text{arc second} \times \text{pc})\ \frac{1}{p}$$

- Suppose that two stars are in orbit about their center of mass in approximately circular orbits. The masses of the two stars are M_1 and M_2. The distance of star 1 from the center of mass is a_1 and the distance of star 2 from the center of mass is a_2. Then the ratio of the stars' masses can be determined from

$$\frac{M_1}{M_2} = \frac{a_2}{a_1}$$

- Let P be the period of the orbit and let $a = a_1 + a_2$. Then we can determine the sum of the masses of the stars using

$$M_1 + M_2 = \frac{4\pi^2}{G} \times \frac{a^3}{P^2} = \frac{(1\ \text{year})^2\ M_{\text{sun}}}{(1\ \text{AU})^3} \times \frac{a^3}{P^2}$$

  where G is a constant ("Newton's constant"). The second form given makes the units simple.

- The luminosity L of a star is related to its apparent brightness b and its distance d to us by

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

  or

$$L = 4\pi\, d^2\, b$$

  or

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

- The luminosity L of a star is related to its radius R and its temperature T by

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

  where σ is a certain constant.

1. A certain star is observed to have a parallax angle of 0.01 arc seconds. We conclude that its distance from us is

   (a) 0.01 pc.

   (b) 0.1 pc.

   (c) 1 pc.

   (d) 10 pc.

   (e) 100 pc. **Correct** **[= 1/0.01.]**

2. For the neutrinos made in the main energy producing cycle in the sun, we know how many neutrinos should cross a square meter surface on earth each second because

   (a) we know that each neutrino produced in the sun will eventually be attracted to our neutrino experiment.

   (b) we know how much energy from the sun crosses a square meter surface on earth each second and we know how many neutrinos are made for each unit of energy. **Correct**

   (c) we know that for each neutrino produced in the sun an antielectron is also created and we can count the number of antielctrons arriving at earth by looking for the tracks they create when they ionize atoms.

   (d) we can measure how much the neutrinos from the sun disrupt the magnetic field of the earth.

   (e) actually, no one had any idea how many neutrinos would be coming from the sun until this quantity was measured.

3. We know that for each reaction that produces a He nucleus from H nuclei in the main energy production cycle in the sun, two neutrinos and 4.3×10^{-12} J of energy are produced. If a small volume of the sun produces 10 J of energy each second, how many neutrinos does it create in 1 s?

   (a) 5×10^{-12} neutrinos

   (b) 5×10^{3} neutrinos

   (c) 5×10^{12} neutrinos **Correct** **[That's $(2/(4.3 \times 10^{-12}\text{ J})) \times 10$ J.]**

(d) 5×10^{14} neutrinos

(e) 5×10^{16} neutrinos

4. In the Homestake Gold Mine experiment looking for neutrinos from the sun, not as many neutrinos as expected were found. After many more experiments, scientists now conclude that

   (a) the temperature in the middle of the sun is a lot smaller than originally thought.

   (b) the experiment miscounted neutrino interactions because argon is more chemically reactive than originally thought.

   (c) some of the neutrinos coming from the middle of the sun turned into another kind of neutrino on their way to earth and the other kind does not have the same reactions with chlorine. **Correct**

   (d) the neutrinos from the core of the sun are swept away by the solar wind.

   (e) the source of the energy of the sun is nuclear fission rather than nuclear fusion.

5. Two stars in a binary star system orbit about their center of mass in orbits that are approximately circular. The distance of star A from the center of mass is quite a lot bigger than the distance of star B from the center of mass. We can conclude that

   (a) star A is heavier than star B.

   (b) star A is hotter than star B.

   (c) star A is lighter than star B. **Correct**

   (d) star A is cooler than star B.

   (e) star A is likely to explode.

6. Suppose that we observe two stars for which we can get the distance to the stars from their parallax angles. We directly observe their apparent brightnesses. We determine that star A and star B have the same apparent brightnesses, but star A is further away from us than star B. We conclude that

(a) the luminosity of star A is bigger than the luminosity of star B. **Correct**

(b) the luminosity of star A is less than the luminosity of star B.

(c) star A is hotter than star B.

(d) star A is cooler than star B.

(e) star A is likely to explode.

7. We can tell if a star is moving towards us because if it is,

   (a) the lines in its spectrum will disappear.

   (b) its spectral lines are shifted to longer wavelengths.

   (c) its spectral lines are shifted to shorter wavelengths. **Correct** **[That is, blueshifted.]**

   (d) we can see the trail of dust that it leavest in its wake.

   (e) it emits x-rays.

8. We can sometimes tell if a star is moving in the direction perpendicular to our line of sight because

   (a) the lines in its spectrum disappear.

   (b) in photographs taken several years apart, we notice that the star is in a different position relative to background stars. **Correct**

   (c) its spectral lines are shifted to shorter wavelengths.

   (d) we can see the trail of dust that it leaves in its wake.

   (e) if it is not moving, it gathers a coating of moss, so if we see no moss, it must be moving.

9. Two stars in a binary star system orbit about their center of mass in orbits that are approximately circular. The distance of star A from the center of mass is 2.5 AU. The distance of star B from the center of mass is 7.5 AU. We can conclude that the ratio of the mass of star A to the mass of star B is

   (a) 1/3.

   (b) 3. **Correct**[$= 7.5/2.5$]

(c) 25.

(d) 75.

(e) 100.

10. For the same two stars as in the previous question, we observe that the period of the orbit is 10 years. We can conclude that the sum of the masses of the two stars is **[Use** $a_1 + a_2 = 10$ AU **from previous problem.]**

    (a) 0.1 $M_{\rm sun}$.

    (b) 1 $M_{\rm sun}$.

    (c) 10 $M_{\rm sun}$. **Correct** [$= (10)^3/(10)^2$]

    (d) 100 $M_{\rm sun}$.

    (e) 1000 $M_{\rm sun}$.

11. Two stars, Alice and Bob have the same temperature at their photospheres, but the radius of star Alice is three times as big as the radius of star Bob. We can conclude that **[need** $L = 4\pi R^2\ \sigma T^4$**, where in this case the temperatures are the same.]**

    (a) the luminosity of star Alice is 1/9 times the luminosity of star Bob.

    (b) the luminosity of star Alice is 1/3 times the luminosity of star Bob.

    (c) the luminosity of star Alice is the same as the luminosity of star Bob.

    (d) the luminosity of star Alice is 3 times the luminosity of star Bob.

    (e) the luminosity of star Alice is 9 times the luminosity of star Bob. **Correct**[$= 3^2$]

12. The pattern of absorption lines in the spectrum of the light from a star can indicate its temperature. For example, if you see the line associated with a certain kind of atom absorbing a photon and jumping from its first excited state to its second excited state, you know that

    (a) the star must be very cool, so that all the atoms are in their ground state.

(b) the star must be very hot, so that all the atoms are completely ionized.

(c) the star must be hot enough so that some of the atoms are in their first excited state. **Correct**

(d) the star must be made of iron.

(e) the star must be hot enough so that all of the atoms of this kind are in their second excited states or states that have higher energy than that.

13. Suppose that we observe two stars for which we can get the distance to the stars from their parallax angles. We directly observe their apparent brightnesses. We want to determine their luminosities. Star Alice has is at a distance of 40 pc and has an apparent brightness of 2×10^{-9} W/m^2. Star Bob has is at a distance of 80 pc and has an apparent brightness of 2×10^{-9} W/m^2. We conclude that **[Use $L = 4\pi\, d^2\, b$, noting that the apparent brightnesses b are the same for both stars.]**

    (a) the luminosity of star Alice is 1/4 times the luminosity of star Bob. **Correct** [$= (40/80)^2$]

    (b) the luminosity of star Alice is 1/2 times the luminosity of star Bob.

    (c) the luminosity of star Alice is the same as the luminosity of star Bob.

    (d) the luminosity of star Alice is 2 times the luminosity of star Bob.

    (e) the luminosity of star Alice is 4 times the luminosity of star Bob.

14. Suppose that we observe two stars that are so far away that we cannot get the distance to the stars from their parallax angles. We directly observe their apparent brightnesses. We can determine their luminosities approximately because from the spectra we can see that they are main sequence stars with temperatures that we determine. We want to determine their distances. Star Alice has a luminosity of $1 \times L_{\text{sun}}$ and has an apparent brightness of 2×10^{-9} W/m^2. Star Bob has has a luminosity of $4\times L_{\text{sun}}$ and has an apparent brightness of 2×10^{-9} W/m^2. We conclude that the ratio $d_{\text{A}}^2/d_{\text{B}}^2$ of the squares of the distances to the two stars is **[use $d^2 = L/(4\pi\, b)$, noting that the apparent brightnesses b are the same for both stars.]**

(a) 1/4. **Correct** [$= L_A/L_B = 1/4$.]
(b) 1/2.
(c) 1.
(d) 2.
(e) 4.

15. The spectral type of the sun is

(a) O.
(b) S.
(c) G. **Correct**
(d) K.
(e) M.

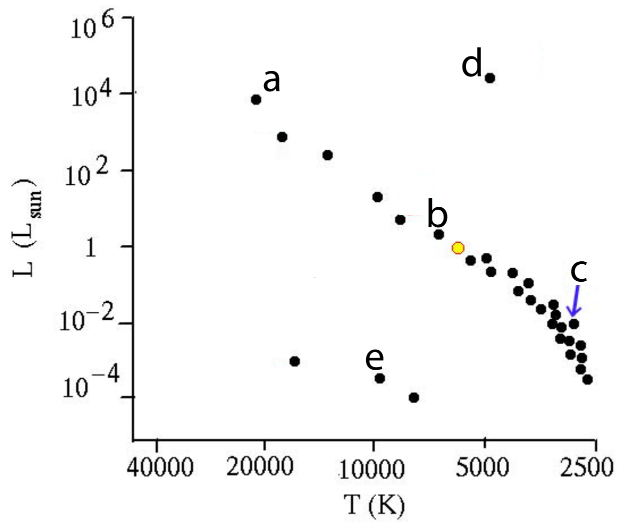
16. Compared to the sun, a type K star is

(a) hotter, bigger in radius, and more massive.
(b) cooler, bigger in radius, and more massive.
(c) cooler, smaller in radius, and more massive.
(d) hotter, smaller in radius, and less massive.
(e) cooler, smaller in radius, and less massive. **Correct**

17. If star A is a second magnitude star and star B is a third magnitude star then

(a) star A appears so bright that it outshines the sun, while star B is pretty dim.
(b) both stars appear to be of medium brightness and star A appears brighter. **Correct**
(c) both stars appear to be of medium brightness and star B appears brighter.
(d) star B is pretty bright, but star A is too dim to see without a telescope.
(e) star A and star B appear equally bright.

The next few questions refer to the Hertsprung Russell diagram that follows.



18. Star "a" is

    (a) hotter than star "b" and less luminous.
    (b) hotter than star "b" and more luminous. **Correct**
    (c) cooler than star "b" and less luminous.
    (d) cooler than star "b" and more luminous.
    (e) the same temperature as star "b" and more luminous.

19. Star "d" is

    (a) hotter than star "e" and less luminous.
    (b) hotter than star "e" and more luminous.
    (c) cooler than star "e" and less luminous.
    (d) cooler than star "e" and more luminous. **Correct**
    (e) the same luminosity as star "b" and hotter.

20. The stars on the main sequence are

    (a) "a", "b", and "c". **Correct**
    (b) "c", "d", and "b".
    (c) "d", "a", and "e".
    (d) "a", and "e".
    (e) just "b".

21. Using the relation among the luminosity of a star, its temperature, and its radius, we find that the stars on the low temperature end of the main sequence are

    (a) bigger in size than the sun.
    (b) smaller in size than the sun. **Correct**
    (c) the same size as the sun.
    (d) older than the sun.
    (e) more prone to sunspots than our sun.

22. In order to find the relation between the masses and luminosities of main sequence stars, we need to determine the masses of some stars. We may be able to determine the mass of a star for this purpose if

    (a) the star is of spectral type G.
    (b) the star is very luminous.
    (c) the star is part of a binary star system. **Correct**
    (d) the star is on a collision course with another star.
    (e) the star that is very hot.

23. Suppose that you find an eclipsing binary, in which two stars are in orbit and we see the plane of the orbit edge on. The spectral lines from the stars shift as the stars orbit each other. Additionally, when the two stars are lined up with our line of sight

    (a) the light from the binary system disappears.
    (b) the redshift becomes bigger.

(c) the blueshift becomes bigger.

(d) the total brightness of the binary system increases.

(e) the total brightness of the binary system decreases. **Correct**

24. A molecular cloud is

    (a) mainly made of water droplets and is very hot.

    (b) mainly made of hydrogen ions and is very cold.

    (c) mainly made of hydrogen atoms and is very hot.

    (d) mainly made of hydrogen molecules and is very cold. **Correct**

    (e) mainly made of small crystals of silicon dioxide and is very cold.

25. A good way to look for a cool cloud of hydrogen atoms in the galaxy is to look for

    (a) x-ray emissions.

    (b) glowing red hydrogen-alpha light.

    (c) radio emissions with a wavelength of 21 cm. **Correct**

    (d) neutrino emissions.

    (e) glowing blue light from the forbidden emission line of oxygen.

26. A cloud in the galaxy that contains a lot of dust may be noticed because

    (a) the dust particles emit photons with a wavelength of 21 cm.

    (b) the dust particles glow with red hydrogen-alpha light.

    (c) the dust cloud blocks all the light from stars in the background. **Correct**

    (d) the dust emits x-rays.

    (e) the dust glows with blue light from the forbidden emission line of oxygen.

27. When there is a cloud of dust between us and a star,

    (a) the star may look quite blue because the blue photons are scattered away by the dust.

(b) the star may look quite blue because the red photons are scattered away by the dust.

(c) the star may look quite red because the red photons are scattered away by the dust.

(d) the star may look quite red because the blue photons are scattered away by the dust. **Correct**

(e) the star may look a lot brighter because of hydrogen fusion in the dust.

28. If gravity compresses some gas and no energy can escape, the gas gets

(a) cooler and less dense.

(b) hotter and less dense.

(c) cooler and more dense.

(d) hotter and more dense. **Correct**

(e) hotter, but its density stays the same.

29. If a gas like hydrogen or helium gets hotter and more dense

(a) its pressure decreases.

(b) its pressure increases. **Correct**

(c) it starts emitting radio photons with a wavelength of 21 cm when the temperature gets over 1000 K.

(d) it starts emitting x-rays when the temperature gets over 1000 K.

(e) it turns into a solid when the temperature gets over 1000 K.

30. When a star is forming from a dense cloud of gas and dust

(a) the gas in the center cools to form planets, while stars form on the outside.

(b) the gas forms a rotating disk, with the protostar in the middle. **Correct**

(c) the gas in the center cools and contracts until it reaches approximately the density of water.

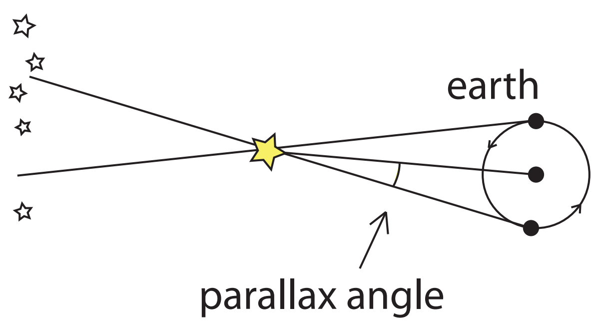
(d) the center is too hot for a star to form, but the cooler, less dense outer edges of the gas cloud form an ideal nursery for new stars.

(e) magnetic fields push the gas together in a ring about the center.

Please answer the following two questions in the space provided on the following page.

31. What do astronomers mean by "parallax angle"? Please explain with a picture. Why do astronomers measure the parallax angle?

As the earth moves around the sun, the apparent position of a nearby star compared to background stars that are much further away changes. One can see this change in photographs taken at different times of the year. Half of the total angular change is the parallax angle. Astronomers use the parallax angle to determine the distance to the nearby star.



32. What evidence to we have that argues against the hypothesis that stars start their lives at the cool, dim end of the main sequence and evolve to the hot, bright end as more hydrogen fuel starts to burn.

For some stars on the main sequence, it is possible to measure the mass of the star. This has been done for a substantial number of stars. One finds that the hot, bright main sequence stars have substantially more mass than the cool, dim main sequence stars. Since there is no way for a star to gain a lot of extra mass as it evolves, we conclude that the cool, dim main sequence stars cannot evolve into the hot, bright main sequence stars.

[See next page for comments.]

Another good argument is that there are clusters of stars that, it seems likely, were formed at the same time. Under the hypothesis that the cool, dim end of the main sequence and evolve to the hot, bright end as more hydrogen fuel starts to burn, there would be no cool, dim stars in such a cluster because they would have evolved to hotter and brighter stars. But the stars in these clusters are spread out in at least part of the main sequence, including the cool, dim part.

Another possible argument is that models of stellar evolution that take into account the physics of pressure, gravity, nuclear fusion, etc., predict the existence of the main sequence, with stars remaining at approximately the same spot on the Hertsprung-Russell diagram for most of their lives, not moving from one end to the other of the main sequence.