Astronomy 301 - Introduction to Astronomy

Homework 5

Due Tuesday, November 17, 2015.

- **Attempt all questions in Part A and 1 of the questions in Part B. Please write all answers to Part A on these sheets.**

- **With a few exceptions, Part B questions call for a paragraph of coherent English. Points will be deducted if your sentences are incomplete and reduced to a list of items or a phrase or two. Do not, however, pad your answers by rewriting the question, by rewriting one sentence in several different ways, etc.**

Review session: Monday, November 16 (details on web)

PART A

A1. Which of the following lists the remnants of stellar evolution in order of decreasing maximum mass?
   a. neutron star, white dwarf, black hole
   b. black hole, neutron star, white dwarf
   c. white dwarf, black hole, neutron star
   d. black hole, white dwarf, neutron star
   e. They all have approximately the same mass.

A2. In AD 1054, Chinese astronomers observed the appearance of a new star. Its location is now occupied by
   a. a supernova remnant
   b. a pulsar
   c. a neutron star
   d. all of the above
   e. none of the above

A3. What kind of "corpse" will be left at the end of the Sun's life?

A4. As a massive star collapse, the gravitational field on the stellar surface
   a. doubles
   b. increases strongly
   c. decreases with the square of decreasing size
   d. remains the same

A5. The Schwarzschild radius of a black hole is
   a. the radius of the star when it is on the main sequence.
   b. the distance from a black hole inside of which light cannot escape.
   c. the theoretical size of the smallest possible white dwarf.
   d. the size of a star when it begins hydrogen burning just prior to reaching the main sequence.
   e. the size of the early protosun.

A6. Suppose you wish to search for low-mass main sequence stars using a space telescope. Will you design your telescope to detect light in the ultraviolet or the infrared part of the spectrum? Why?

A7. Of the following stages of evolution, pick out those that the Sun has experienced or probably will experience. List them in the order in which they occur.

black dwarf	planetary nebula	black hole
red giant	cepheid variable	supernova
main-sequence star	white dwarf	neutron star

A8. Of the following stages of evolution, pick out those that a 20 $M_\odot$ star will experience. List them in the order in which they occur.

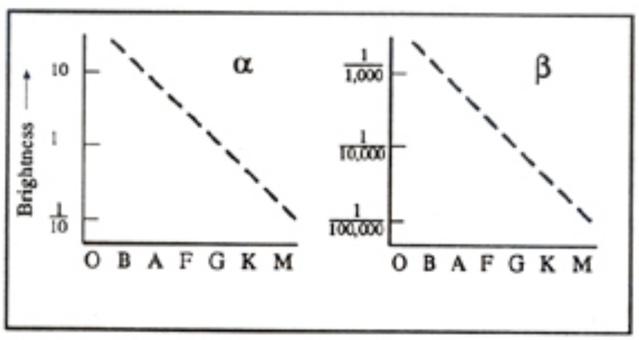
Supernova Type Ia	planetary nebula	black hole
red super giant	Cepheid variable	supernova Type II
main-sequence star	white dwarf	neutron star

A9. What is the Chandrasekhar limit?

A10. As observed from Earth, it often happens that only the brightest stars in a cluster are observable.

- What type of stars will these be in a very young cluster?
- In a very old one?

A11. The diagrams show **brightness** – spectral type diagrams for 2 open clusters.



If cluster α is 200 parsecs from us, how far is cluster β? Answer in parsecs.

A12. The solar system is located within

a. the galactic halo
b. the galactic disk
c. the galactic nucleus
d. none of the above; the solar system is not located in a galaxy.

A13. Astronomers of the 18th and 19th centuries thought that the Sun was near the center of the Milky Way galaxy since they counted the same number of stars in the disk of the Galaxy in every direction.

The reason they were not correct is the Galaxy

- is an irregular galaxy with a chaotic shape
- contains dust that obscures its distant regions
- has the shape of a tube with the Sun near one end
- has two kinds of Cepheid variables, so that all distance measurements until recently were incorrect
- has a giant black hole at its center

A14. The position of the Sun in the Galaxy was determined by Shapley by measuring positions of
- supergiants
- galactic (open) clusters
- radar
- globular clusters
- T Tauri stars

A15. A cluster of stars with a main sequence turn-off at spectral type F5 is _______ a cluster with its turn-off at B2.
a. younger than
b. older than
c. the same age as
d. more distant than
e. less distant than

A16. Arrange the following in order of decreasing size:

centimeter	white dwarf	light year	kilometer	atomic nucleus
kiloparsec	our Galaxy	hydrogen atom	neutron star	a 50 solar mass black hole
Betelgeuse				

A17. Arrange the following in order of increasing average density:

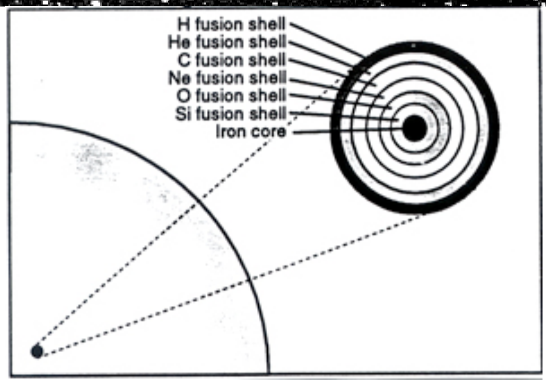
- the air in the classroom
- Betelgeuse
- Sirius B
- the Crab Pulsar
- Sirius A

Part B

B1. a. Describe how a white dwarf is produced from a red giant.
b. Why have none of the white dwarfs we see been produced by the deaths of the lowest mass ($M< 0.4M_{\odot}$) stars?
c. White dwarfs are the commonest stars in the Galaxy. Not one of the 6000 stars visible to the naked eye is a white dwarf. Explain why the second statement is not inconsistent with the first.

B2. a. Describe two key observed differences between Supernovae of Type Ia and II.
d. In a spiral galaxy, supernovae occur at the rate of 1 every 100 years. If you were given access to a small telescope, describe how you would check this estimate.
e. Our Galaxy is a typical spiral galaxy. The last recorded supernovae occurred about 300 years ago. We would expect several supernovae to have exploded in the last 300 years. How is it possible to miss so many so close (the Galaxy is a mere 40 kpc in diameter) supernovae?

B3. a. Describe why a massive star develops an onion skin structure (see diagram from Seeds Fig. 13-11) before finally exploding.
b. Explain why an iron core marks the end of a massive star's life.
c. Betelgeuse, a red giant, supergiant, is a massive star in the constellation of Orion. Why do you think it quite likely that Betelgeuse is burning He in its core?



B4. a. Describe a neutron star. Include remarks on the mass, radius, and composition of such a star.
b. What do we mean when we say "Every pulsar is a neutron star, but not every neutron is an observable pulsar"?
c. Why is there an upper limit to the mass of neutron stars? And why is that upper limit not well known?

B5. a. Describe the two likely structures for the final form attained by very massive stars.
Your description should include remarks on the mass, size, composition, temperature, and any other pertinent properties. Do **not** describe a star's evolution from the main sequence to the final form.
b. For one of the final forms described above, explain clearly why it is the **final** stage in the star's life.
c. Describe how black holes are detected in our Galaxy. Be sure that your description is consistent with the fact that light cannot escape from a black hole. Also explain why the observations you describe point to a black hole rather than a neutron star or a white dwarf.

B6. a. Main sequence stars are referred to as 'metal-poor.' What is meant by the words 'metal' and 'metal-poor'?
b. Young main sequence stars are referred to a 'metal-rich' or as having roughly the same metal content as the Sun.
Explain why our Galaxy contains both metal-rich and metal-poor M-type main sequence stars, but NO metal-poor O-type main sequence stars. All the O-type main sequence stars are metal-rich.
c. Discuss <u>one</u> piece of observational evidence in support of the idea that stars synthesize metals.

B7. a. How is the 21 cm line of hydrogen produced by interstellar clouds of cold hydrogen gas?
b. Suppose you had access to a radio telescope with high angular resolving power. Describe how you would determine the speed and rotation of a nearby and well-resolved spiral galaxy.
c. Spiral galaxies contain large amounts of dark matter. Suppose you observed a spiral galaxy that had no dark matter and another that, like our Galaxy, had substantial amounts of dark matter. How would you distinguish the two through observation of their speed of rotation?