ASTR 121
Exam II
50 points
April 11, 2006
Do not open this exam until instructed to do so.

1. General Information

WRITE your NAME on your exam booklet.

SIGN the Honor Pledge.

It is a good idea to read the entire exam, then answer first the questions you are most certain about. Do not spend time on difficult problems before answering easier ones.

The value of each part of each question is noted. Answer written questions with concise, complete sentences. Show all work for quantitative problems.

All exams will be collected at 12:15 PM. You are welcome to leave early if you finish early. If you do so, please exit as quietly as possible so as not to disturb those still working.

2. Useful Numbers

$G = 6.67 \times 10^{-11}$ m^3 s^{-2} kg^{-1}
$c = 3 \times 10^8$ m s^{-1}
$g = 9.8$ m s^{-2}
$k_B = 1.38 \times 10^{-23}$ kg m^2 s^{-2} K^{-1}
$\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}
1 year $= 3.16 \times 10^7$ s
1 AU $= 1.5 \times 10^8$ km
1 radian = 206,265 arcseconds (so 1 pc = 206,265 AU)
The sun is a G2 **V** star with surface temperature $T = 5800$ K
1 $M_\odot = 2 \times 10^{30}$ kg
1 $L_\odot = 4 \times 10^{26}$ W
1 $R_\odot = 7 \times 10^5$ km
Absolute magnitude and color of the sun: $M^B_\odot = 5.48$; $(B-V)_\odot = 0.68$.

3. General Knowledge Questions

1. (4 points) Describe the structure of the Milky Way Galaxy. Provide a sketch that labels the basic components.

2. (4 points) What is the Chandrasekhar limit? What happens if a carbon white dwarf exceeds this limit? What happens if a neutron star exceeds the corresponding limit? Why do the results differ?

3. (4 points) Describe three distinct phases of the gas found in the interstellar medium. In which phase do new stars form?

4. (1 points) Describe the fatal problem of getting too close to a black hole, even if you don't fall in.

5. (1 points) Millisecond pulsars are observed to emit hundreds of pulses per second. Why are these objects thought to be neutron stars and not white dwarfs?

6. (2 points) What effect(s) does dust have on light as it traverses interstellar space?

7. (4 points) Sketch the Hubble 'tuning fork' galaxy classification scheme, indicating the types of galaxies along it.

8. (6 points) What are the characteristics that distinguish Population I and Population II stars?

9. (2 points) Describe the interior structure of a massive star shortly before it explodes as a Type II supernova.

4. Quantitative Questions

10. (3 points) A G2 **V** star is observed to have a B-band apparent magnitude $m_B = 15.48$ and color $B - V = 0.93$.
    What is the distance to this star?
    Why is the answer *not* 1 kpc?

11. Betelgeuse — most dangerous star in the sky?

    The bright red star Betelgeuse in the constellation Orion is a type M2 **I**ab supergiant (surface T = 3600 K). It has a parallax $p = 0.0076''$ and a bolometric apparent magnitude of -1.6.

    a) (4 points) Betelgeuse is a highly evolved massive star. As such, it could be ready to go supernova. Whether that will happen tomorrow, or in a million years, is hard to say. Supposing it happens tomorrow, in the sense that we see the light of the explosion then, how long will it be before any material ejected by the explosion reaches us? Suppose the ejecta travels at 10,000 km/s.

    b) (4 points) When the shock wave from this explosion reaches us, will it pose a danger? To quantitatively judge the risk, compute the mass of ejected material that will strike the earth. You may assume that Betelgeuse will eject 10 $M_\odot$ of material into a thin, spherically symmetric, expanding shell. It helps to know that the radius of the Earth is 6,378 km. Put this number in context to answer the question posed, clearly explaining your reasoning.

12. X-ray binary

    One of the more accurately measured X-ray binaries known is GRO J1655-40. The visible component is an F star of 2.34 $M_\odot$. Its orbit has a period of 2.4 days at a velocity of 336 km/s.

    a) (3 points) What is the total mass of the binary system?

    b) (1 point) What is the mass of the X-ray source?

    c) (2 points) What type of object would you infer the X-ray source to be? Why?

    d) (2 points) Calculate the Schwarzscild radius of an object of the mass you found in (b).

13. (4 points) The first extrasolar planet was discovered around the star 51 Pegasus, 15.36 pc away. You'd like to visit this planet, but don't want the trip to age you more than ten years. At what speed must you travel to accomplish this?