Homework 6, Astro 1

Due November 15th, 2019

1. (U11-18.12) In the direction of a particular star cluster, interstellar extinction allows only 15% of a star's light to pass through each kiloparsec (1,000 pc) of the interstellar medium. If the star cluster is 3.0 kpc away, what percentage of its photons survive the trip to Earth?

2. (U11-18.28) (a) Determine the radius of the circumstellar accretion disk in Figure 18-16 (Figure 18-15 in U10). (You will need to measure this image with a ruler. Note the scale bar in this figure.) Give your answer in astronomical units and in kilometers. (b) Assume that the young star at the center of this disk has a mass of 1 $M_\odot$. What is the orbital period (in years) of a particle at the outer edge of the disk? (c) Using your ruler again, determine the length of the jet that extends to the right of the circumstellar disk in Figure 18-16 (Figure 18-15 in U10). At a speed of 200 km/s, how long does it take gas to traverse the entire visible length of the jet?

3. (U11-18.42) From the information given in the caption for Figure 18-28 (Figure 18-26 in U10), calculate the average speed at which the shock wave has spread away from the site of the supernova explosion. Give your answer in kilometers per second and as a fraction of the speed of light (*Hint:* There are 3.16×10^7 seconds in a year and the speed of light is 3.00×10^5 km/s.

4. (U11-18.46) At one stage during its birth, the protosun had a luminosity of $1000L_\odot$ and a surface temperature of about 1000K. At this time, what was its radius? Express your answer in three ways: as a multiple of the Sun's present-day radius, in kilometers, and in astronomical units. (*Hint:* See Box 17-4 in U11 & U10.)

5. (U11-19.8) **Box 19-2 in U11 & U10** The earliest fossil records indicate that life appeared on Earth about a billion years after the formation of the solar system. What is the most mass that a star could have in order that its lifetime on the main sequence is long enough to permit life to form on one or more of its planets? Assume that the evolutionary processes would be similar to those that occurred on Earth.

6. (U11-19.12) Why does helium fusion require much higher temperatures than hydrogen fusion?

7. (U11-19.35) The apparent brightness of δ Cephei (a Cepheid variable star) varies with a period of 5.4 days. Its average apparent brightness is 5.1×10^{-13} that of the Sun. Approximately how far away is δ Cephei? (Ignore interstellar extinction)

8. (U11-19.46) Calculate the escape speed from (a) the surface of the present-day Sun and (b) the surface of the Sun when it becomes a red giant, with essentially the same mass as today but with a radius that is 100 times larger. (c) Explain how your results show that a red giant star can lose mass more easily than a main-sequence star.