ASTRO 301 (50405) : HOMEWORK 3

Assigned on Tu 24/06. Due on Tu Oct 31 at 11 am in class

Instructions:
(1) The number of points for each question is indicated in brackets. **In order to get full credit, you must show the method that you used to derive the answer**. See the class website (*http://www.as.utexas.edu/~sj/a301-fa06/*) for the grading policy.
(2) See Appendix A of your textbook for the value of constants. A few are are listed here: 1 AU $\sim 1.5 \times 10^{11}$ m; 1 $M_\odot \sim 2 \times 10^{30}$ kg; Speed of light c is 3×10^8 m s^{-1}; Wien's constant $W = 2.9 \times 10^{-3}$ m K; Stefan-Boltzmann constant $= 5.7 \times 10^{-8}$ J s^{-1} m^{-2} K^{-4}.

1a. During the fusion of helium into carbon, three helium nuclei fuse to give a carbon nucleus. Calculate the amount of fusion energy released using the fact that each helium nucleus has a mass of 6.643×10^{-27} kg and each carbon nucleus a mass of 19.9162×10^{-27} kg. Express your answer in units of joules (J). **[10 pts]**

1b. What is the total energy stored in the mass of the three helium nuclei? Express your answer in units of joules (J). **[5 pts]**

1c. In practice, only a fraction f of this total stored energy is released as fusion energy during the fusion of helium into carbon. What is f? **[10 pts]**

1d. For the fusion of hydrogen into helium, the efficiency factor f is 0.007. Which fusion process converts mass into energy more efficiently: the fusion of hydrogen into helium or the fusion of helium into carbon? **[5 pts]**

1e. Consider a star with a luminosity of 4×10^{27} J s^{-1}. If the star is powered by the fusion of helium into carbon, estimate how many kg of helium it must fuse per second in order to generate the above luminosity. (Hint: Use your answer to part (c)). **[10 pts]**

2. The light that we receive from a distant star allows us to estimate the luminosity (energy output per second), the surface temperature, and even the radius of the star.

2a. An observer on Earth measures a total flux of 2×10^{-6} J s^{-1} m^{-2} from a star located at a distance of 1 pc. What is the luminosity of the star in J s^{-1}? **[10 pts]**

2b. When the total flux from the star is split into components different wavelengths, the resulting spectrum peaks at a red wavelength of $\sim 8 \times 10^{-7}$ m. Estimate the temperature T at the surface of the star using Wien's law. **[10 pts]**.

2c. Determine the radius of the star (in m) using the Stefan-Boltzmann law. **[10 pts]**

END OF ASSIGNMENT