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 ~ 1.5 × 10^{11} m; 1 M_{\odot} ~ 2 \times 10^{30} kg; Speed of light c is 3 \times 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 \times 10^{-27} kg and each carbon nucleus a mass of 19.9162 \times 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 \times 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 \times 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