PROBLEM SET 6
Physics 2022

1. At one stage during its birth, the protosun had a luminosity of 1000 $L_\odot$ and a surface temperature of about 1000 K. What was its radius then compared to today's?

2. Use the Sun's luminosity (3.84×10^{26} W) to calculate the mass of H it converts into He during one second.

3. Use the value of the Sun's luminosity to calculate what mass of hydrogen the Sun will convert into helium during its entire main-sequence lifetime of 1.2×10^{10} years. (Assume that the Sun's luminosity remains nearly constant during the entire 1.2×10^{10} years.) What fraction does this represent of the total mass of hydrogen that was originally in the Sun?

4. Calculate how much energy would be released if each of the following masses were converted *entirely* into their equivalent energy: (a) a carbon atom with a mass of 2×10^{-26} kg, (b) 1 kg, and (c) a planet as massive as the Earth (6×10^{24} kg).

5. Use the luminosity of the Sun and the answers to the previous question to calculate how long the Sun must shine in order to release an amount of energy equal to that produced by the complete mass-to-energy conversion of (a) a carbon atom, (b) 1 kg, and (c) the Earth.

6. (a) A positron has the same mass as an electron. Calculate the amount of energy released by the annihilation of an electron and positron. (b) The products of this annihilation are two photons, each of equal energy. Calculate the wavelength of each photon, and confirm that this wavelength is in the gamma-ray range.

7. Sirius is the brightest star in the night sky. It has a luminosity of 23.5 $L_\odot$, that is, it is 23.5 times as luminous as the Sun and burns hydrogen at a rate 23.5 times greater than the Sun. How many kilograms of hydrogen does Sirius convert into helium each second?

8. Sirius has 2.3 times the mass of the Sun. Compute its main sequence lifetime.

9. Main sequence star A is 5 times as massive as main sequence star B. How do the main sequence lifetimes of these two stars compare?

10. Calculate the main-sequence lifetimes (in years) of (a) a 9-$M_\odot$ star and (b) a 0.25-$M_\odot$ star. Compare these lifetimes with that of the Sun.