

# ASTRONOMY 020

Problem Set #13

Due: January 23, 2004

1. The brightest star in the night sky is Sirius, which has a radius  $R = 1.17 \times 10^9$  m and mass  $M = 4.26 \times 10^{30}$  kg.
  - (a) What is the free-fall time of Sirius?Now assuming Sirius is in equilibrium, estimate the following:
  - (b) The average pressure within Sirius. (Hint: use the virial theorem)
  - (c) The average temperature within Sirius.
2. If a star is characterized by a mass  $M = 2.0 \times 10^{32}$  kg and luminosity  $L = 4.0 \times 10^{32}$  W, how long can it shine if it is composed initially of pure hydrogen, and is able to convert 10% of its mass into helium.
3. The Sun releases energy at the rate of  $3.90 \times 10^{26}$  W. By how much has the Sun's mass decreased during its lifetime of  $5 \times 10^9$  yr? Express this as a fraction of the Sun's current total mass. (Hint: use the relativistic mass-energy relation.)

Practice Problems:

1. Estimate the age of the Sun if it has been releasing energy due to slow gravitational contraction.  
Answer:  $t \approx 2.3 \times 10^7$  yr (see class notes). This is too short compared to the estimated age of the solar system.
2. Estimate the lifetime of the Sun if it is undergoing fusion of hydrogen into helium in its core, and if the core comprises 10% of the Sun's mass.  
Answer:  $t \approx 10^{10}$  yr (see class notes). This is consistent with independent estimates of the age of the solar system.