PHYSICS 160: Stellar Structure

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Homework no. 2
Due Thurs. Nov 12

1

Assuming 10 eV could be released by every atom in the Sun through chemical reactions, estimate how long the Sun could shine at its current rate through chemical processes alone. For simplicity, assume that the Sun is composed entirely of hydrogen. Is it possible that the Sun's energy is entirely chemical? Why or why not?

2

At what stellar radius will the energy available from the decrease in gravitational binding energy of a $1M_\odot$ star be comparable to the energy available from the fusion of $_1\text{H}^1$ into $_2\text{He}^4$?

3

Two stars with the same mass, $M=M_\odot$ and radius $R=R_\odot$, have different chemical compositions. Star 1 is composed entirely of hydrogen and star 2 of helium.

(a) Compare the central temperatures, pressures, and luminosities of the two stars.

(hint: If a gas consists of particles with average mass $< m >$, then the number of free particles $n = \rho/< m >$ As a result, the equation of state $P = nkT$ is given by $P = \rho kT/\mu m_\text{H}$ where the mean molecular weight $\mu = \rho/n m_\text{H}$, and where m_H is the mass of the hydrogen atom. As a result μ is the number of H masses per free particle. Keep in mind that both H and He are ionized in the stellar interior so the number of free particles includes the liberated electrons.)

(b) now suppose star 3 has $M=M_\odot$, $R=R_\odot$, and chemical composition X=0.7, Y=0.28, and Z=0.02. Compare the central temperature, pressure, and luminosity of this star with the stars in part(a)

(hint: The mean molecular weight for the ionized gas in the solar interior is given by

$$\frac{1}{mu} = 2X + (3/4)Y + (1/2)Z$$

4 Carroll & Ostlie 10.4

5

(a)Find the classical distance of closest approach for two protons with an energy of 2 Kev.

(b) Estimate the probability that the protons penetrate the Coulomb barrier tending to keep them apart.

(c) Compare this probabiity with the corresponding probability for two $_2\text{He}^4$ nuclei with the same energy.