PHYSICS 160: Stellar Structure

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Homework no. 4
Due: Tues. Nov. 20

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 ${}_1\mathrm{H}^1$ into ${}_2\mathrm{He}^4$?

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.

(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)

4

In class we worked out the effective energy E_0 at which fusion reactions in the solar interior occur. Consider the reaction

$$ {}_1\mathrm{H}^1 \ + \ {}_6\mathrm{C}^{12} \rightarrow {}_7\mathrm{N}^{13} \ + \gamma $$

Compare E_0 to the mean thermal energy of a proton for a central temperature, $T_c{=}1.5{\times}10^7$ K.

5

Compute the amount of energy released of absorbed in the following reactions (answers should be expressed in Mev).

$$ {}_6\mathrm{C}^{12} + {}_6\,\mathrm{C}^{12} \rightarrow {}_{12}\mathrm{Mg}^{24} + \gamma $$

$$ {}_6\mathrm{C}^{12} + {}_6\,\mathrm{C}^{12} \rightarrow {}_8\mathrm{O}^{16} + 2\,{}_2\mathrm{He}^4 $$

$$ {}_9\mathrm{F}^{19} + {}_1\,\mathrm{H}^1 \rightarrow {}_8\mathrm{O}^{16} + {}_2\,\mathrm{He}^4 $$

The mass of ${}_6\mathrm{C}^{12}$ is $12.000u$ by definition, and the masses of ${}_8\mathrm{O}^{16}$, ${}_9\mathrm{F}^{19}$, and ${}_{12}\mathrm{Mg}^{24}$ are $15.9949u$, $18.9984u$, and $23.98504u$ respectively. Are these reactions exothermic or endothermic. Note, $1u{=}931.494013$ Mev/c^2.