Ch. 10: Stellar Structure

Ex. 10.1

$M_{\odot} = 1.989 \times 10^{30}$ kg.

$m_{^1H} = 1.67 \times 10^{-27}$ kg , $m_{^4He} = 6.64 \times 10^{-27}$ kg.

we know: $\approx 70\%$ of Sun's mass is ^1H.

28% " " " is ^4He

$\Rightarrow$ mass of all ^1H in the Sun $= \frac{70}{100} * 1.989 \times 10^{30}$ kg

$= 1.39 \times 10^{30}$ kg

Numer of ^1H atoms $= \frac{1.39 \times 10^{30}}{1.67 \times 10^{-27}} = 8.34 \times 10^{56}$ atoms of ^1H

mass of all ^4He in the sun $= \frac{28}{100} \times 1.989 \times 10^{30}$ kg $= 5.57 \times 10^{29}$ kg

Number ^4He atoms in the sun $= \frac{5.57 \times 10^{29}}{6.64 \times 10^{-27}} = 8.39 \times 10^{55}$ atoms of ^4He

Ratio

$\frac{\#\text{ of } ^1H \text{ atoms}}{\#\text{ of } ^4He \text{ atoms}} = \frac{8.34 \times 10^{56}}{8.39 \times 10^{55}} \approx 10$ atoms

Ex: 10.2 p-p reaction:

$$4\,{}^{1}H \longrightarrow 1\,{}^{4}He$$

How many p-p reactions take place in the SUN every second.

$$m_H = 1.00728 \text{ amu}, \quad M_{^4He} = 4.001514 \text{ amu}$$

$$1 \text{ amu} = 1.6604 \times 10^{-27} \text{ kg}, \quad c = 3 \times 10^{8} \text{ m/s}$$

Energy from ONE p-p reaction

$$E = (\Delta m)\, c^2$$

$$= (4 * 1.00728 - 4.001514) \times 1.6604 \times 10^{-27} \times (3 \times 10^{8})^2$$

$$E = 4.12 \times 10^{-12} \text{ J}$$ from one p-p reaction.

Luminosity of the Sun $= 3.9 \times 10^{26}$ W

i.e. 3.9×10^{26} J $\longrightarrow$ 1 sec.

$$\text{Number of p-p reactions/sec} = \frac{3.9 \times 10^{26}}{4.12 \times 10^{-12}} = 9.5 \times 10^{37} \text{ reactions}$$

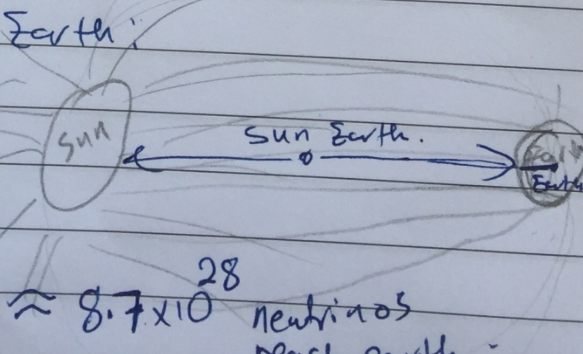
(b) Each reaction produces 2 neutrinos.

$\Rightarrow$ total Number of neutrinos $= 2 * 9.5 \times 10^{37}$

$= 1.9 \times 10^{38}$ neutrinos are produced every second.

Number of neutrinos that hit Earth:

$$= \text{total Number} \times \frac{\pi R_{\oplus}^2}{4\pi R^2_{SUN-Earth}}$$



$$= 1.9 \times 10^{38} \times \frac{(6.37 \times 10^{6})^2}{4(1.49 \times 10^{11})^2} \approx 8.7 \times 10^{28}$$ neutrinos reach earth.