HW8

1. a) $E_o = 300 \text{ keV}$ \hspace{1cm} (from literature)

$$E_{cm} = \frac{1}{2} \mu \nu^2 = \frac{1}{2} \frac{m_A m_Ze}{m_A + m_Ze} \cdot V$$

$$E_{lab} = \frac{1}{2} m_A \nu^2$$

$$\frac{E_{cm}}{E_{lab}} = \frac{12}{4 + 12} \hspace{1cm} \rightarrow \hspace{1cm} E_{lab} = E_{cm} \cdot \frac{16}{12} = 400 \text{ keV}$$

1. b) $S = 165 \text{ keVb}$

$$b = \frac{1}{E} \cdot e^{-\frac{b}{E}} \cdot S \hspace{1cm} b = 31.28 \cdot 2.2 \times 10^{-12} \frac{A^{12} \text{ keV}^{-7}}{E = 300 \text{ keV}}$$

Use center of mass energy $E = 300 \text{ keV}$!

$$A = \frac{A_{ac} \cdot A_k}{A_{ac} + A_k} = 3$$

$$= 2.75 \times 10^{-17} \times 10^{-24} \text{ cm}^2 \hspace{1cm} b_0 = 6.50 \times 10^{-17} \text{ keV}$$

Event rate per second $R$

$$R = I_{particle} \cdot n_n \cdot d \cdot \sigma \cdot \varepsilon$$

Particle current $I_{particle} = \frac{I_{elastic}}{Q_{A} \cdot e} = 3.12 \times 10^{15} \text{ pps}$

Target number density $n_n = \frac{S \cdot N_A}{m_{nole}} = 2.25 \times 10^{23} \text{ pps}$

Target thickness $d = 10^{-4} \text{ cm}$

Efficiency $\varepsilon = 0.5$
2. Sequence of core collapse supernova:

1. Inner core begins to collapse when iron core exceeds Chandrasekhar mass limit (either by adding mass or by decreasing electron fraction due to weak interaction).
2. Collapse of inner core halts when about nuclear density is reached (it overshoots) leading to a bounce, that launches an outward going shock (pressure wave).
3. Outer core falls in while shock moves through it and dissociates iron into protons and neutrons. This takes energy out of the shock so that it stalls.
4. Some mechanism revives the shock so it continues to move outward and eventually initiates a reversal of the matter flow (mass cut).
5. From there on shock moves to surface and accelerates material behind it leading to an explosion.
6. Material within the mass cut falls back on collapsed core, which begins to form a proto neutron star and later a neutron star.
2.1. \[ U = -\frac{3}{5} \xi \frac{\xi^2}{R} = -3.10 \cdot 10^3 \frac{1}{R} \text{ erg J} \]

\[ \tau_\xi = 10^6 \text{ cm} \]
\[ \gamma_\xi = 10^6 \text{ cm} \]
\[ AE = U_c - U_p = -3.1 \cdot 10^3 \left[ \frac{1}{10^3} - \frac{1}{10^6} \right] = 3 \cdot 10^3 \text{ erg J} \]

2.2. \[ X_O = 0.5 \]
\[ X_C = 0.5 \]
\[ E = \sum \frac{Y_i \Delta_i}{N_i} \left[ \text{MeV/nu} \right] \]
with mass excess in MeV (A)
\[ \text{initial abundance} \quad \text{first abundance} \quad \text{this gives energy in MeV/nu} \]
\[ = \frac{0.5}{10} (-4.339) + \frac{0.5}{12} \cdot 6 - \frac{1}{56} (-5.39) \]
\[ = 0.814 \text{ MeV/nu} \]
\[ E_{\text{tot}} = E \left[ \text{MeV/nu} \right] \cdot M \cdot N_A \cdot 10^{13} \text{ e} = 2 \cdot 10^{51} \text{ erg} \]

HW8 Solution

4) Same equation as for SNIa

\[ E \left[ \text{MeV/nu} \right] = \sum \frac{Y_i \text{ initial} \Delta_i}{N_i} - \sum \frac{Y_i \text{ final} \Delta_i}{N_i} \]
\[ \Delta (^{56}\text{Fe}) = -56.252 \]
\[ \Delta (^4\text{He}) = 7.289 \]
\[ \Delta (^4\text{He}) = 8.0713 \]
\[ E = -56.252 \cdot \frac{1}{56} - \left[ \frac{26}{54} \cdot 7.289 + \frac{28}{54} \cdot 8.0713 \right] \]
\[ = -8.73 \text{ MeV/nu} \]
\[ E_{\text{tot}} = 0.4 M_\odot \cdot N_A \cdot E \cdot 10^{13} = 6.77 \cdot 10^{51} \text{ erg} \]