

Homework Set 4

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4.1) Cross Section

The reaction ${}^3\text{H}(d, n){}^4\text{He}$ is investigated with deuterons of an energy $E_{\text{kin}} = 5 \text{ MeV}$ that are perpendicularly incident upon a tritium target with a mass occupation density $\mu_t = 0.2 \frac{\text{mg}}{\text{cm}^2}$.

- 4.1.1) [5] How many neutrons per second pass through a detector with a receptive area of $A = 20 \text{ cm}^2$ that is placed at a distance $R = 3 \text{ m}$ from the target and under an angle $\vartheta = 30^\circ$ with respect to the deuteron beam direction, if the differential cross section $\frac{d\sigma}{d\Omega}$ at this angle is $13 \frac{\text{mb}}{\text{sr}}$ and the deuteron current is $I_d = 2 \mu\text{A}$?
- 4.1.2) [2] How many neutrons per second reach the detector, if the target is tilted by 10° ?

4.2) Absorption Length

A beam of particles n_a is incident upon a thick layer of an absorbing material with n_b absorbing particles per unit volume. How large is the absorption length $\lambda = \frac{1}{\sigma n_b}$, that means the distance in which the intensity of the beam is reduced by a factor of $\frac{1}{e}$, in the following cases?

- 4.2.1) [2] Thermal neutrons in cadmium with $\rho = 8.6 \text{ g/cm}^3$ and $\sigma = 24506 \text{ barn}$.
- 4.2.2) [2] 2 MeV -photons in lead with $\rho = 11.3 \text{ g/cm}^3$ and $\sigma = 15.7 \text{ barn}$.
- 4.2.3) [3] Antineutrinos from a nuclear power plant in the earth with $\rho = 5 \text{ g/cm}^3$ and $\sigma = 10^{-19} \text{ barn}$ for the neutrino electron interaction by neglecting the neutrino nuclei interaction and an estimated $\frac{Z}{A} = 0.5$.

4.3) Lorentz Scalars

- 4.3.1) [6] Calculate the photon threshold energy for coherent η -photoproduction in ${}^{12}\text{C}$. Use $m_\eta = 547.45 \frac{\text{MeV}}{c^2}$, $m_{{}^{12}\text{C}} = 11178.02 \frac{\text{MeV}}{c^2}$ and that ${}^{12}\text{C}$ in the reaction ${}^{12}\text{C}(\gamma, \eta){}^{12}\text{C}$ remains in the groundstate.

4.4) Radon Activity

- 4.4.1) [GS] [5] Calculate the activity A of ${}^{222}\text{Rn}$ created in the decay chain of ${}^{238}\text{U}$ as a function of the decay constants λ of the *feeding* parent ${}^{226}\text{Ra}$ and the *draining* daughter ${}^{222}\text{Rn}$.
- 4.4.2) [GS] [2] After a lecture theater, whose walls, floor, and ceiling are made of concrete ($10 \cdot 10 \cdot 4 \text{ m}^3$) has not been aired for several weeks, a specific activity $A = 100 \text{ Bq/m}^3$ of ${}^{222}\text{Rn}$ is measured. How high is the concentration of ${}^{238}\text{U}$ in the concrete, if the effective thickness, from which the ${}^{222}\text{Rn}$ can diffuse, is 1.5 cm ?