

Problem set 3

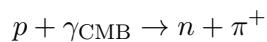
Problem 1

The net reaction in the pp cycle is $4p + 2e^- \rightarrow {}^4\text{He}^{++} + 2\nu_e + Q$. Knowing that the binding energy (\mathcal{B}) for ${}^4\text{He}$ is 28.3 MeV, show that the Q -value of the reaction (energy produced in the process) is 26.7 MeV.

Given the solar luminosity $L_\odot = 3.828 \times 10^{26}\text{W}$ and the Earth orbit radius of $150 \times 10^9\text{ m}$, compute the flux of solar neutrinos on Earth.

Problem 2

Compute the minimum energy (“GZK cutoff”) at which a proton interacting with the cosmic microwave background (CMB) at 2.725 K can produce pions in the reaction:



Problem 3

Assuming a total absorption cross-section of $\sigma \approx 10^{-44}\text{ cm}^2$ for neutrinos in matter, constant with neutrino energy.

- Determine the thickness of a wall of lead ($\rho = 11\text{ g/cm}^3$) able to reduce the flux of a beam of neutrinos by 50%.
- Estimate how many solar neutrinos are absorbed in your body every day, knowing that the flux of solar neutrinos from the pp cycle is $6 \times 10^{10}\text{ cm}^{-2}\text{ s}^{-1}$.