PH 105 Tutorial Solution

Rohit Giri

20) $\nu + n \rightarrow \tau + \rho$

Conservation of momentum 4 vector gives

$$\vec{p}_{\nu} + \vec{p}_{n} = \vec{p}_{\tau} + \vec{p}_{\rho}$$

Since the neutron is at rest $p_n=0$.

$$(p_{\nu}, i(E_{\nu} + E_{n})/c) = (p_{\tau} + p_{\rho}, i(E_{\tau} + E_{\rho})/c)$$

Squaring both sides,

$$p_{\nu}^2 - (E_{\nu} + E_{n})^2/c^2 = (p_{\tau} + p_{\rho})^2 - (E_{\tau} + E_{\rho})^2/c^2 \quad \text{--(2)}$$

For the neutrino to possess minimum energy, the products should also possess minimum energy. This occurs when the products are at rest.

i.e. $p_{\tau} = 0$ and $p_{\rho} = 0$ ----(3)

also, E_{τ} and E_{ρ} is simply the rest mass energy.($\gamma=1$)

i.e. $E_{\tau} = 2\text{GeV}$ and $E_{\rho} = 1\text{ GeV}$ -----(4)

Substitute (3) and (4) into (2)

On solving,

$E_{\nu} = 4$ GeV.

In the COM frame net momentum of products =0.

Also E_{τ} and E_{ρ} the respective rest mass energies.

$p_n + p_{\nu} = 0$ ---(5)

and

$E_{\nu} + E_{n} = E_{\tau}\,(2\text{GeV}) + E_{\rho}\,(1\text{ GeV})$ ---(6)

Also note that $E_{\nu} = p_{\nu}c$ (zero rest mass) ----(7)

Solving (5) and (6) using (7)

$p_n = -4/3$ (GeV/c)

$$E_n^2 = p_n^2c^2 + m_n^2c^4$$

$E_n = 5/3$ GeV

i.e $\gamma_n = 5/3$

$V_n = -0.8c$ (since $p_n<0$)

From (5)

$p_\nu = 4/3$ (GeV/c)

$E_\nu = p_\nu c = 4$ GeV

$V_\nu = c$ (A neutrino has zero rest mass and moves at the same speed as light. 'c' is a universal constant and is independent of the frame of observation.)