Quiz4

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electron and positron have mass $0.511\ MeV/c^2$

$KE_e^i + KE_p^i = 2GeV + 2GeV = 4GeV$

$E_i = KE_e^i + KE_p^i + 2M_e c^2 = 4GeV + 1.022MeV \approx 4.001\ GeV$

$E_f = E_i = 4.001\ GeV$

$KE_\tau^f + KE_{\bar{\tau}}^f + 2M_\tau c^2 = E_f = 4.001\ GeV$

$$KE_\tau^f = \frac{4.001\ GeV - 2(1777\ MeV/c^2)\,c^2}{2}$$

$$= \frac{4001\ MeV - 3554\ MeV}{2}$$

$$= 223.5\ MeV$$

$$KE_\tau^f = M_\tau c^2 (\gamma - 1) = (1777\ MeV/c^2)\,c^2 \left(\frac{1}{\sqrt{1-(v/c)^2}} - 1\right)$$

$$\Rightarrow \quad 223.5\ MeV = \frac{1777\ MeV}{\sqrt{1-(v/c)^2}} - 1777\ MeV$$

$$2000.5\ MeV\sqrt{1-(v/c)^2} = 1777\ MeV$$

$$1-(v/c)^2 = \left(\frac{1777}{2000.5}\right)^2$$

$$\left(\frac{v}{c}\right)^2 = 1 - \left(\frac{1777}{2000.5}\right)^2$$

$$V = \sqrt{1 - \left(\frac{1777}{2020.5}\right)^2}\ c$$

$$V = 0.4593\ c$$

life time: $T_0 = 2.9 \times 10^{-13}\ s$

by time dilation. let T be the life time of the particle in lab frame. we can write:

$$T = \gamma T_0 = \frac{T_0}{\sqrt{1-(V/c)^2}}$$

$$= \frac{2.9 \times 10^{-13}\ s}{\sqrt{1 - 0.4593^2}} = 3.2647 \times 10^{-13}\ s$$

Then the distance d traveled by the particle τ in lab frame is given by the following:

$$d = T v = (3.2647 \times 10^{-13}\ s)(0.4593c)$$

$$= (3.2647 \times 10^{-13}\ s)(0.4593)(3 \times 10^8\ m/s)$$

$$= 4.498 \times 10^{-5}\ m$$