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Nice

PHSX 343: Assignment 9

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+4 Problem 1

a) With conservation of momentum, not all the energy of the photon will go into the mass of the particle. $0.01Mc^2$ will go into the mass, but another batch will go in to bring the momentum of the particle up to the initial momentum of the photon.

b)

$$E_i = E_{Mi} + E_p = Mc^2 + P_p c$$

$$E_f = E_{Mf} = \sqrt{(P_p c)^2 + (1.01Mc^2)^2}$$

For conservation of momentum:

$$E_i = E_f \rightarrow (Mc^2) + (P_p c) = \sqrt{(P_p c)^2 + (1.01Mc^2)^2}$$

$$(Mc^2)^2 + 2(Mc^2)(P_p c) + (P_p c)^2 = (P_p c)^2 + (1.01Mc^2)^2$$

$$(1.01^2 - 1)(Mc^2)^2 = 2(mc^2)(P_p c)$$

$$\frac{1.01^2 - 1}{2} Mc^2 = P_p c = E_p = 0.01005Mc^2$$

Problem 2

+4 a) For the conservation of 4-momentum:
For the energy of the photon, $E^2 = (Pc)^2 + (Mc^2)^2 = (Pc)^2$ and for $E = P_t c$.

$$\begin{bmatrix} E_1/c \\ P_x \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} E_2/c \\ -P_x \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} P_p \\ P_p \\ 0 \\ 0 \end{bmatrix}$$

But it's evident that $P_x - P_x = 0 = P_p$, so the photon would have no momentum and have no energy, so there would be no photon actually created for a valid formula.

b) This time the 2nd mass will have no momentum:

$$\begin{bmatrix} E_1/c \\ P_x \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} Mc \\ 0 \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} P_p \\ P_p \\ 0 \\ 0 \end{bmatrix}$$

$$\frac{E_1}{c} = \frac{\sqrt{(P_x c^2) + (Mc^2)^2}}{c} = \sqrt{P_x^2 + (Mc)^2}$$

With conservation of momentum we can say that this P is the same as the momentum of the photon: $P_x = P_p$.

$$\frac{E_1}{c} + Mc = \sqrt{P_p^2 + (Mc)^2} + Mc = P_p$$

This is only true when $M = 0$. With that condition, we are not dealing with ~~elementary~~ particles, so this situation is brings up a contradiction and is invalid.

c) If we make the situation abstract, for any starting energy and momentum (kept in 1D), then:

$$\begin{bmatrix} E_1/c \\ P_{x1} \\ 0 \\ 0 \end{bmatrix} + \begin{bmatrix} E_2/c \\ P_{x2} \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} P_p \\ P_p \\ 0 \\ 0 \end{bmatrix}$$

Simpler than that: Just invoke the 1st postulate.

If be balance both the P_t and P_x equations:

$$\sqrt{P_{x1}^2 + (Mc)^2} + \sqrt{P_{x2}^2 + (Mc)^2} = P_p = P_{x1} + P_{x2}$$

This is only true when $(Mc)^2 = 0 \rightarrow M = 0$. This is the same issue as part ~~a~~ b

d) Equality is a symmetric operation, so any of these derivations can be done in reverse and it remains illegal in that direction.