Ohanian Solutions #4

11) $E = mc^2 \qquad \Delta m = \frac{E}{c^2} = 4.3 \times 10^9$ kg.

17.a) $2 \times 938.3 + 2 \times 939.6 = 3755.8$ MeV/c^2.

$\Delta M = 26.4$ MeV/c^2.

Binding energy = 26.4 MeV.

b) Energy released $= -(E_f - E_i) = 23.8$ MeV.

19) $\pi \leftarrow K \rightarrow \pi$

$\vec{P}_\pi = (250 \frac{MeV}{c}, \gamma m v_x) = (\gamma mc, \gamma m v_x)$

$|\vec{P}| = 140$ MeV $= mc$

$= \sqrt{\gamma^2 m^2 c^2 - \gamma^2 m v_x^2}$

$= \sqrt{250^2 - \gamma^2 m^2 v_x^2} \qquad \gamma m v_x = 207 \frac{MeV}{c}$

Thus, $\frac{v}{c} = \frac{207}{250} = 0.83$.

in K frame.

In Lab frame, we need to Lorentz Transform $(250, \pm 207) = \vec{P}_\pi$ with $v/c = 0.9$. $\gamma = 2.3$.

$P'_t = \gamma (P_t - \frac{V P_x}{c}) = 2.3 (250 \pm 0.9 \cdot 207) = 1092.5 \frac{MeV}{c}, \; 146.5 \frac{MeV}{c}$

$P'_x = \gamma (P_x - V P_t) = 2.3 (\pm 207 - 0.9 \cdot 250) = 994 \frac{MeV}{c}, \; 41.4 \frac{MeV}{c}$

Both π move forward! forward π "backward" π.

8) Compton Scattering. $\bar{\lambda} - \lambda = \frac{h}{m_p c}(1 - \cos\theta)$

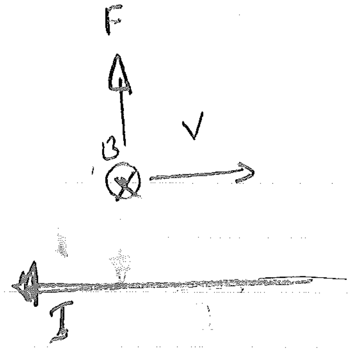
$\lambda_{c,e} = \frac{h}{m_e c} = 2.43 \times 10^{-12}$ m so $\frac{h}{m_p c} = \lambda_c \cdot \frac{m_e}{m_p} = 1.324 \times 10^{-15}$ m

with $\theta = 30°$

$\bar{\lambda} - \lambda = 1.774 \times 10^{-16}$ m $\qquad \lambda = \frac{c}{\nu} = \frac{hc}{h\nu} = \frac{2 \times 10^{-25}\, J m}{20\, MeV} = \frac{1.25\, eV\, \mu m}{20\, MeV}$

$= 6.25 \times 10^{-8}\, \mu m \qquad \bar{\lambda} = 6.268 \times 10^{-8}\, \mu m \qquad E_f = 19.94$ MeV.

14) a) $\vec{F} = q\vec{v}\times\vec{B} = \frac{qv\mu_0 I}{2\pi r}$



$a = \frac{qv\mu_0 I}{2\pi r m}$

b) $F' = \gamma F$ (because moving clocks run slowly.)
primed = ptcl frame.

$F' = qE'$ $\quad E' = \frac{\gamma v\mu_0 I}{2\pi r}$ $\quad a' = \frac{F'}{m'} = \frac{qv\mu_0 I}{2\pi r}\frac{\gamma^2}{m}$

($m' = m/\gamma$.)

c) from Gauss.

$\frac{\lambda'}{2\pi r\epsilon_0} = E' = \frac{\gamma v\mu_0 I}{2\pi r}$ $\quad \lambda' = \gamma v\mu_0\epsilon_0 I = \frac{\gamma v}{c^2} I$

d) If $I = \lambda v$ (for simplicity, $v_e = v_q$)

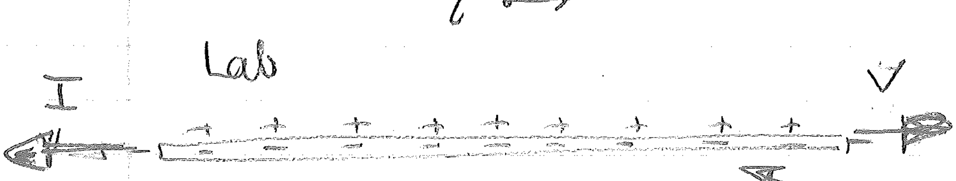
Then $\lambda'_{net} = \gamma\frac{v^2}{c^2}\lambda = \lambda'_\oplus - \lambda'_\ominus$

$\lambda'_\ominus = \lambda/\gamma$ $\quad \lambda'_\oplus = \lambda\cdot\gamma$ $\quad \lambda'_{net} = (\gamma - \frac{1}{\gamma})\lambda$

$= \gamma(1 - \frac{1}{\gamma^2})\lambda = \gamma\frac{v^2}{c^2}\lambda$ ✓

$q \rightarrow$

Lab



⊖ charge lorentz contracted in Lab frame

q-frame

q •

⊕ charge lorentz contracted in Q frame