PHYS 2D
PROBLEM SESSION

2012/4/19

2.15

Q: Electron accelerated by ΔU=50000V, speed?

- Energy conservation: kinetic & potential energy

  Potential energy: $q\Delta U$ ($q<0$)

  Kinetic energy: $\gamma mc^2 - mc^2$ or $mv^2/2$
- Acceleration: electron losing potential energy
- $E_{start}=0$
- $E_{end}=q\Delta U+\gamma mc^2-mc^2=E_{start}=0$ or $q\Delta U+mv^2/2=0$
- $\gamma-1=0.0977$, $v_{rel}=0.412c$
- $v_{classical}=1.33*10^8 m/s=0.442c$

2.18

Q: m_{Cr}=54.9279u decays into m_{Mn}=54.9244u+m_e, find mass difference & maximum electron E_k

Energy conservation: kinetic energy & rest energy

- $E_{before}=m_{Cr}c^2$
- $E_{after}=E_{k,Mn}+m_{Mn}c^2+E_{k,e}+m_ec^2$,
- $E_{k,Mn}+E_{k,e}=(m_{Cr}-m_{Mn}-m_e)c^2$, constant
- v_{Mn} will be very small, so all kinetic energy goes to e
- $m_{Cr}c^2=54.9279*1.67*10^{-27}*(3*10^8)^2/(1.6*10^{-19})$
  $=5.15979*10^4$ MeV
- Similarly $m_{Mn}c^2=5.15946*10^4$ MeV, $m_ec^2=0.511$ MeV
- $E_{k,e}=(51597.9-51594.6-0.511)=2.8$ MeV

2.20

Q: Beta decay: $n \rightarrow p + e^- + \nu$, measured total E_k of products=0.781±0.005 MeV, show that this agrees with relativistic energy conservation

- Assume neutron was at rest
- Energy conservation:

  E_{before}=rest energy of n

  E_{after}=rest energy of products+ E_k of products
- $E_k=(m_n-m_p-m_{e-}-m_{\nu})c^2$

  $=939.565-938.272-0.511-0=0.782$MeV

2.23

Q: Particle at rest with $m=3.34*10^{-27}$ kg decays into 2 with $v_1=0.987c$ & $v_2=-0.868c$, m_1 & m_2=?

- Energy & momentum conservation
- Equations: $\sum_i E_i^{before} = \sum_i E_i^{after}$, $\sum_i P_i^{before} = \sum_i P_i^{after}$
- 2 equations with 2 unknowns

Momentum conservation:

$p_{before}=0$, $p_{1,after}=\gamma_1 m_1 v_1$, $p_{2,after}=\gamma_2 m_2 v_2$

so, $0=\gamma_1 m_1 v_1+\gamma_2 m_2 v_2$, $m_1=-\gamma_2 m_2 v_2/\gamma_1 v_1$

2.23

- m_1 in terms of m_2: $m_1 = -\gamma_2 m_2 v_2 / \gamma_1 v_1$

Energy conservation:

$E_{before} = mc^2$, $E_{1,after} = \gamma_1 m_1 c^2$, $E_{2,after} = \gamma_2 m_2 c^2$,

so, $mc^2 = \gamma_1 m_1 c^2 + \gamma_2 m_2 c^2$,

Substitute m_1

- $mc^2 = -\gamma_2 m_2 c^2 (v_2/v_1) + \gamma_2 m_2 c^2 = \gamma_2 m_2 c^2 (1 - v_2/v_1)$
- $\gamma_2 = 2.014$, $(1 - v_2/v_1) = 1.879$
- $m_2 = m/3.785 = 8.82*10^{-28}$ kg
- $\gamma_1 = 6.222$
- $m_1 = -\gamma_2 m_2 v_2 / \gamma_1 v_1 = 2.51*10^{-28}$ kg

2.26

Q: m_1=900 kg, v_1=0.85c, m_2=1400 kg, v_2=0, stick together after (inelastic) collision, v & m after collision?

- Energy & momentum conservation again
- $p_{before}=\gamma_1 m_1 v_1+\gamma_2 m_2 v_2 = p_{after}=\gamma m v$ (1)
- $E_{before}=\gamma_1 m_1 c^2+\gamma_2 m_2 c^2=E_{after}=\gamma m c^2$ (2)

Solution for v: (1)*c^2/(2)

- $v=(\gamma_1 m_1 v_1+\gamma_2 m_2 v_2)/(\gamma_1 m_1+\gamma_2 m_2)$
- $v_2=0$, $\gamma_2=1$, $\gamma_1=1.898$
- $v=\gamma_1 m_1 v_1/(\gamma_1 m_1+m_2)=0.467c$

Solution for m: (2)/c^2

- $\gamma=1.131$, $m=(\gamma_1 m_1+m_2)/\gamma=2748$ kg > (900+1400) kg