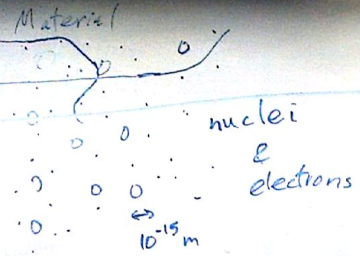
α-decay $O\ {}^4_2He$

β-decay e^+ or e^-

γ-decay photons

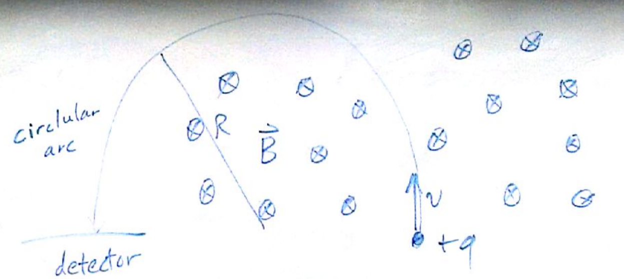
have very high energy

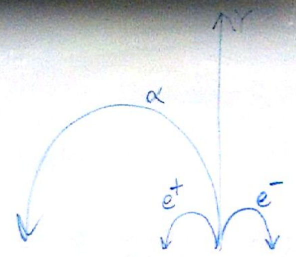


$$\lambda = \frac{h}{p} \qquad \lambda_{photon} = \frac{h}{p} = \frac{h}{E/c} = \frac{hc}{E} = \frac{hc}{K}$$

$$v \ll c \Rightarrow K \approx \frac{1}{2}mv^2 \ \& \ p \approx mv = \sqrt{2mK} \Rightarrow \lambda \approx \frac{h}{\sqrt{2mK}}$$

more kinetic energy ⇒ smaller wavelength





$$a = \frac{v^2}{R} \qquad F = \frac{mv^2}{R} \qquad F = qvB$$

$$m_{e^+} = m_{e^-}$$

$$q_{e^+} = -q_{e^-}$$

Dectector finds m & v given q, B, R

or m & q given v, B, R

more mass ⇒ bigger radius

γ-rays are

A) photons ✓

B) electrons

C) positrons

$m(^1_1H) = m_e + m_p - 13.6\ eV/c^2$

$m_\alpha = m(^4_2He) = 2m_p + 2m_n - 28.30\ MeV/c^2$

protons

#protons & nuetrons

$E = \gamma mc^2 = \underbrace{mc^2}_{\text{rest energy}} + \underbrace{(\gamma-1)mc^2}_{\text{kinetic energy}}$

rest energy includes interaction energy between parts

$(\gamma - 1)c^2 \approx \frac{1}{2}v^2$ for $v \ll c$

$\longleftrightarrow$

order of magnitude

10^{-15} m

at atomic scales, the wave-particle duality matters; the picture is not physical

mass unit: $eV/c^2 = \frac{1.6022\times10^{-19}\,J}{(3.00\times10^8\,m/s)^2} = 1.78\times10^{-36}\,kg$

$eV = 1.6022\times10^{-19}\,J$

$m_e = 9.1094\times10^{-31} = 5.11\times10^5\,eV/c^2$

$m_e = 0.511\ MeV/c^2$

$m_p \approx 938\ MeV/c^2$

$m_n \approx 940\ MeV/c^2$

$E = m(^1_1H)c^2 = E_e + E_p + U$

$m(^1_1H) = m_e + m_p - 13.6\,eV/c^2$

13.6eV = ground state electron-proton energy

proton + electron far away $\longrightarrow \underbrace{^1_1H}_{\text{p \& e close together}} + \underbrace{13.6eV}_{\text{energy released, as photon(s)}}$

emit α particle

α-decay $^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$

β^--decay $^{14}_{6}C \rightarrow {}^{14}_{7}N + e^- + \bar{\nu}$

β^+-decay $^{19}_{10}Ne \rightarrow {}^{19}_{9}F + e^+ + \nu$

K-capture $^{7}_{4}Be + e^- \rightarrow {}^{7}_{3}Li + \nu$

weak nuclear force involved

4 protons
3 neutrons

1 electron

7 protons
4 neutrons

1 neutrino

Conservation of $\#\overbrace{(\text{protons} + \text{neutrons})}^{\text{nucleons}}$

Conservation of charge: # protons − # electrons + # positrons

Conservation of energy, momentum, angular momentum

γ-rays/γ-decay: emission of high energy photon(s) because nucleus goes from higher to lower energy state

X-rays: emission of high energy photon(s) because electron goes from higher to lower energy state

$A(t) = A(0)e^{-kt}$

$\tau = \frac{1}{k} = T_{1/e}$

$T_{1/2} = \frac{\ln 2}{k}$ = half-life

$T_{1/3} = \frac{\ln 3}{k}$ = third-life

Problem 80a) Show that mean life $= \tau$.

$$\frac{1}{k} = \tau \stackrel{?}{=} \frac{\int_0^\infty t\,A(t)\,dt}{\int_0^\infty A(t)\,dt} = \frac{\int_0^\infty t e^{-kt}\,dt}{\int_0^\infty e^{-kt}\,dt} = \frac{-\frac{t}{k}e^{-kt}\Big|_0^\infty - \int_0^\infty \left(-\frac{1}{k}e^{-kt}\right)dt}{\int_0^\infty e^{-kt}\,dt}$$

$$\checkmark\ \frac{1}{k} = \frac{\frac{1}{k}\int_0^\infty e^{-kt}\,dt}{\int_0^\infty e^{-kt}\,dt}$$