Exercise sheet 1

Exercise 1

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a)

$$\begin{aligned} Z(Th) = 90 \quad &\Rightarrow \quad N(^{232}Th) = 142 \\ Z(U) = 92 \quad &\Rightarrow \quad N(^{235}Th) = 143 \end{aligned}$$

b)

$$^{20}Ne$$

c)

$$^{82}Kr$$

d)

Noone

e)

Decay mode

Exercise 2

Suppose that an elementary particle a is a bound state of two other particles b and c respectively with parities π_b and π_c. Then we can assign a parity to the particle a as

$$\pi_a = \pi_b \pi_c \left(-1\right)^{l_a} \tag{1}$$

where l the denotes the total angular momentum number of the particle a. In general, if we have a decay process of the type

$$a + b \to c + d$$

it can be proved that parity is conserved, so that the following equality holds

$$\pi_a \pi_b \left(-1\right)^{l_{a,b}} = \pi_c \pi_d \left(-1\right)^{l_{b,c}} \tag{2}$$

where $l_{a,b}$ and $l_{c,d}$ denotes respectively the total angular momentum number of the couple a, b and c, d.

a)

Since the fermions have conventionally intrinsic parity $+1$, the corresponding antiparticles should have parity -1. The pion spin is 0, hence

$$\pi_\pi = \pi_u \pi_{\bar{d}} \left(-1\right)^0 = -1$$

b)

The product of the two intrinsic parities is +1, while the contribute of the total angular momentum is −1, hence

$$\pi_f = -1$$

Exercise 3

a)

In the mass radius we have to keep track of two effects: the repulsion between the charged protons and the proton-neutron attraction. The first effect makes the protons to spread widely, while the second provides a strong attraction causing the neutrons to stick to the protons, hence explaining the equality in the two radii (in first approximation).

b)

The nuclear force is strong for very short ranges (r < 1f) but decays rapidly as the distance increases. As a consequence, for heavy and large atoms, the nuclear attraction force is just enough to counteract the proton-proton repulsion. Accoroding to quantum mechanics, each *alpha* particle can be seen as a particle subject to a wall potential, and the probability to be found outside the wall is non-zero and in particular depends on the atomic radius. Hence, an analysis of such probability provides an estimation for radius value.
The reason why this phenomenom is more likely to occur for α particles rather than protons is explained by the binding energy, presented later in the notes

Exercise M&S

Referring tothe formula that relates W_r to J (see notes) we proceed by calculating explicitly each term. In this case thought, we multiply both member of the formula by $1cm^2$ so that $[W_r] = [J] = s^{-1}$

$$W_r = \text{particles scattered per second} = 20$$
$$J = \text{particles per second in the beam} = \frac{10nA}{2e} \approx 3.121 \cdot 10^{10}$$
$$N = \text{particles per second illuminated in the target} =$$
$$= \frac{1\, mg/cm^2}{24.3uma \cdot 1.66^{-21} mg/uma} \approx 4.116 \cdot 10^{19}\, cm^{-2}$$

so that

$$\sigma = \frac{W_r}{JN} = 1.567 \cdot 10^{-29} cm^2$$