→ **Continued Nuclear Model:-**

5) **α- decay:-** Since α- decay involves emission of a Helium nucleus consisting of two protons and two neutrons. Nuclides with 128 neutrons would be favoured position in regard to α decay, as the resulting daughter would be ~~fot~~ left with a magic number of neutrons.

$${}^{212}_{84}Po_{128} \xrightarrow{\alpha} {}^{208}_{82}Pb_{126} \; ; \; T = 46\,s; \; E_\alpha = 8.78 \text{ MeV}$$

$${}^{210}_{84}Po_{128} \xrightarrow{\alpha} {}^{206}_{82}Pb_{124} \; ; \; T = 138.4\,d; \; E_\alpha = 5.31 \text{ MeV}$$

$${}^{213}_{85}At_{128} \xrightarrow{\alpha} {}^{209}_{83}Bi_{126} \; ; \; T = 0.11\,\mu s, \; E_\alpha = 9.08 \text{ MeV}$$

$${}^{211}_{85}At_{126} \xrightarrow{\alpha} {}^{207}_{83}Bi_{124} \; ; \; T = 7.2\,h, \; E_\alpha = 5.87 \text{ MeV}$$

6) **β- decay:-**

Similar situation occurs in β- emitters. The energy of the β would be specially high and the half life will be relatively short if the ~~relatively short~~ resulting product has Z or N equal to a magic number.

The discontinuity energy is around 2 MeV i.e. about

25% of mean binding energy in β-disintegrations in the neighbourhood of magic numbers.

7) **Neutron Absorption Cross-section:-**

A study of the variation of neutron absorption cross section with the neutron numbers of nuclides brings out very well the significance of the magic number. The absorption cross section for 1 MeV neutrons is lower by a factor of 50-100 for nuclides containing 20, 50, 82 and 126 neutrons compared to their neighbour nuclides containing one short of magic numbers.

8) **Seperation energy of a neutron:**

The binding energy of last neutron in a nuclide is known as its separation energy, this is determined by measuring the net energy of a reaction of the type (γ, n) or (d, t).
The energy needed to extract a neutron from a nucleus is much higher if it happens to be magic number neutron.
Energy needed to remove the 127th neutron from $^{209}_{82}Pb_{127}$ is only 3.87 MeV.

The salient features of the Shell Model

The periodicity observed in the nuclear properties occuring at definite intervals with increasing protons or neutron numbers, that the closed shell or the independant particle model was proposed.

Maria Goeppert-Mayer and Jensen, Haxell and Suess independently developed this model.

similar to 2, 10, 18, 36, 54 and 86 electrons, it was argued that neutrons and protons also form (separate) closed shells when their numbers equals 2, 8, 20, 50, 82 and 126 referred to as the magic numbers

(a) **Weak Nucleon-Nucleon Interaction:**

On the shell model neutrons or protons are believed to pair amongst themselves and these paired nucleons are packed into separate shells within the nucleus.

Each shell capacity is limited to certain maximum number of protons or neutrons in, accordance with quantum rules and Pauli's principle of exclusion, the nucleons being all fermions. A completely filled shell represents a particularly stable configuration of low energy.

Every nucleon is assumed to move in its own orbit independent of other nucleons, but governed by a common potential due to the interaction of all the nucleons.

This common potential is the spherical average of the potential energy of ~~nucleons~~ nucleus produced by all the nucleons. In the case of protons, to this common potential gets added the Coulomb Potential (V_c) of the other protons.

The Coulomb potential is given by

① $$V_c(r) = \frac{(Z-1)e^2}{4\pi\epsilon_0 r} \quad \text{for } r > R$$

② $$V_c(r) = \frac{(Z-1)e^2}{4\pi\epsilon_0 R}\left[\frac{3}{2} - \frac{r^2}{2R^2}\right] \quad \text{for } r < R$$

ϵ_0 being the permittivity of free space:-

$$\epsilon_0 = 8.85 \times 10^{-12}\ J^{-1} C^2 m^{-2}$$

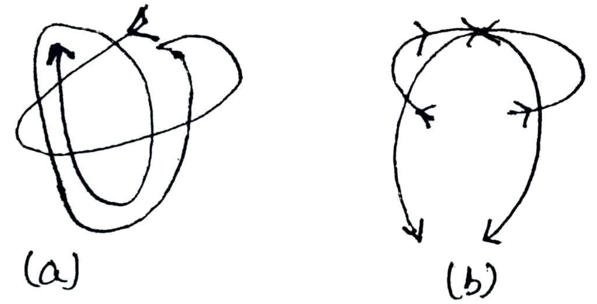
This implies that in ground state or in some of the lowest excitation states, the nucleon-nucleon interaction is absent or is very feeble.

This in its turn implies that the mean free path of nucleon in the ground state is the order of a nuclear diameter or more, so that a nucleon is able to the orbit around about once before colliding with one-another nucleon.

However, experimental results on nucleon-nucleon scattering do not support this concept.

The scattering data suggest strong interaction and more frequent elastic collisions implying a mean free path very much shorter than the nuclear radius.

According to Weisskopf, ~~who~~ explained the weak interaction paradox by invoking Pauli's principle of exclusion, that not more than two protons or neutrons may be in the same orbit. It severely restricts the frequency of collisions amongst the nucleons in a nucleus.



Nucleons-nucleons collision and nucleon mean free path λ : two models (a) λ = nuclear radius (b) λ << nuclear radius.

The character of strong nucleon-nucleon interaction valid for free nucleons, does not apply to the nucleons bound in nucleus.

In the ground or very low excitation states, they interact only feebly.

<b> **The Nuclear Potential:-**

The orbit or the quantum state of a nucleon is analogous to the quantum state of an electron in the outer ~~sphere~~ sphere, with the difference that the orbit of the nucleon is determined by the nuclear potential which is the average total effect of the interactions of all the nucleons with one-another.

All the nucleons, irrespective of their charge, attract one another and this attractive force is of short range operative inside the nucleus, falling rapidly to zero outside the nuclear boundary within a distance of a fermi.

Notice:- M.Sc. Sem II students can resume their online classes. Kindly drop a mail on

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