Nuclear Isomerism:

There are nuclei which have the same atomic and mass numbers (A and Z). but different from one another in their nuclear energy states and exhibit differences in their internal structure. These are called nuclear isomers.

The existence of nuclear isomers is called nuclear isomerism. The excited nucleus ${}_{38}Sr^{87*}$ is an isomer of ${}_{38}Sr^{87}$. The difference between the nuclear isomers is attributed to a difference of nuclear energy states.

One isomer represents the nucleus in its ground state, whereas the other is the same nucleus in an excited state of higher energy.

The phenomenon of nuclear isomerism was discovered by O. Hahn in 1921. He found that UX_2 and UZ both have the same atomic number and the same mass number but have different half-lives and emit different radiations.

UX_2 has 0.394 Mev more energy in its nucleus than UZ. Both there nuclei are formed out of UX_1 by β decay. UX_2 has half life of 1.17 minutes and UZ has a half-life of 6.7 hours.

The higher energy isomer UX_2 may directly decay to UII by a β emission with a half life of 1.17 minutes (or) it may first come to the lower energy isomer by emitting a γ-ray of energy 0.394 Mev and then decay to U_{II} by β - emission with a half - life of 6.7 hours.

Nuclear isomerism has also been detected in artificial radioactive substances many isomeric pairs have been produced by bombarding radio nuclides with neutrons.

Transition Probability :-

The One - Step transition Probability is the probability of transitions from One State to another is a Single Step. The Markov chain is said to be time homogeneous it the transition probabilities from One State to another are independent of time index.

$$P_{ij} = P_r \{X_n = j \mid X_{n-1} = i\}$$

The transition Probability matrix, P is the matrix Consistens of the One step transition Probability P_{ij}.

The m-Step transition probability is the probability of transition from State i to State j in m Step,

$$P_{ij}(m) = P_r \{X_{n+m} = j \mid X_n = i\}.$$

The m- Step transition matrix whose elements are the m-step transition Probabilities $P_{ij}(m)$ is denoted as $P(m)$.

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The m-Step transition probability can be found the single step transition Probabilities as follows:~

The transition from i to j in m-step the process can first transition from r to i in m-k step. Where then transition from r to j is k step. Where $0 < k < m$.

$$P_{ij}(m) = \sum P_{ir}^{m-k} P_{rj}^{k}$$

In matrix from this becomes,

$$P^m = P(m-k)\, P(k)$$

Setting,

$$k = m-1 \text{ yields}$$

$$\text{I} \leftarrow P(m) = P \cdot P(m-1)$$

from the equ, we can

$$\text{II} \leftarrow P(m-1) = P \cdot P(m-2)$$

Substituting these back into previous equ. yields,

$$P(m) = P \cdot P \cdot P(m-2)$$

Continues these Substitution,

$$P(m) = P \cdot P \cdot P \cdot \ldots \ldots P = P^m$$

These Step transition probability matrix multiply. The single Step Probability m times the State Vector m(0). We also find interm of transition probability matrix on the initial State Vector.

first,

$$\pi_j(m) = \sum_i \pi_i (m-1) P_{ij}$$

In Vector as matrix from,

$$\pi(m) = \pi(m-1) P$$

We also find that Substitutes,

$$\pi(m-1) = \pi(m-2) P \quad \text{(or)}$$

$$\pi(m) = \pi(m-2) P^m$$

Continuting the Subsituting yields

$$\pi(m) = \pi(0) P^m$$

Where $\pi(0)$ is the Vector Containing the initial Probability of being in each State time.

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Gamma Emission Selection Rules :~

1. The Conservation energy implies that the difference of energy in initial and final States should be given by $\hbar\omega$ - the photon energy.

2. The Conservation of charge requires that initial and final State should have the same charge, Since none is Carried off photons.

3. The Conservation of angular momentum requires the difference of angular momenta I_i of initial State and I_f of final State should be equal to $l\hbar$. The difference between two momenta ranges from $|I_i - I_f|$ to $|I_i + I_f|$. Hence the selection rules for angular momentum for both electric and magnetic radiations can be written as,

$$|I_i + I_f| \geq l \, |I_i - I_f|$$

Thus, if transitition is between $I_i(4^+)$ to $I_f(2^+)$, then l can have values $|4-2|$ to

14+2l, i.e., from 2 to 6. It is seen that disintegration Constant falls* rapidly with increasing l and therefore, the values of l greater than 2 are normally ignored.

4. Now if initial and final States have the same parity electric multipoles of even l and magnetic multipoles of odd l are allowed. If initial and final States have opposite parities electric multipoles of odd l and magnetic multipole of even l are allowed. Thus, in the above example E2, M3, E4, M5 and E6 are allowed radiations.

The Summary of selection rules is given in table,

Type of Radiation	Angular momentum Carried away ($\hbar$)	Does the parity Change?
E_1	1	yes
M_1	1	no
E_2	2	no
M_2	2	yes
E_3	3	yes
M_3	3	no
E_4	4	no
M_4	4	yes

It has been seen that smallest value of l is 1. The transition 0 → 0 is completely forbidden. It is so because a photon must carry one unit of angular momentu

It should also be remembered that when one of the two states involved in a transition has $I=0$ and allowed transition of lowest order is a magnetic multipole then next higher electric multipole is strictly forbidden.

Internal Conversion:~

While studying the theory of α and β decay, we have seen that either case, the nucleus is left in an excited state. The transition from an excited state is accomplished by the emission of γ-rays. Thus the emission of an α-particles (or) a β-particle is mostly accompanied by a γ-ray photon. The energy of excitation is directly transferred to a bound $\bar{e}$ of the same atom. The nuclear energy difference W is converted to energy of an atomic electron which is ejected from the atom with a kinetic energy E_i given by,

$$E_i = W - E_i \longrightarrow (1)$$

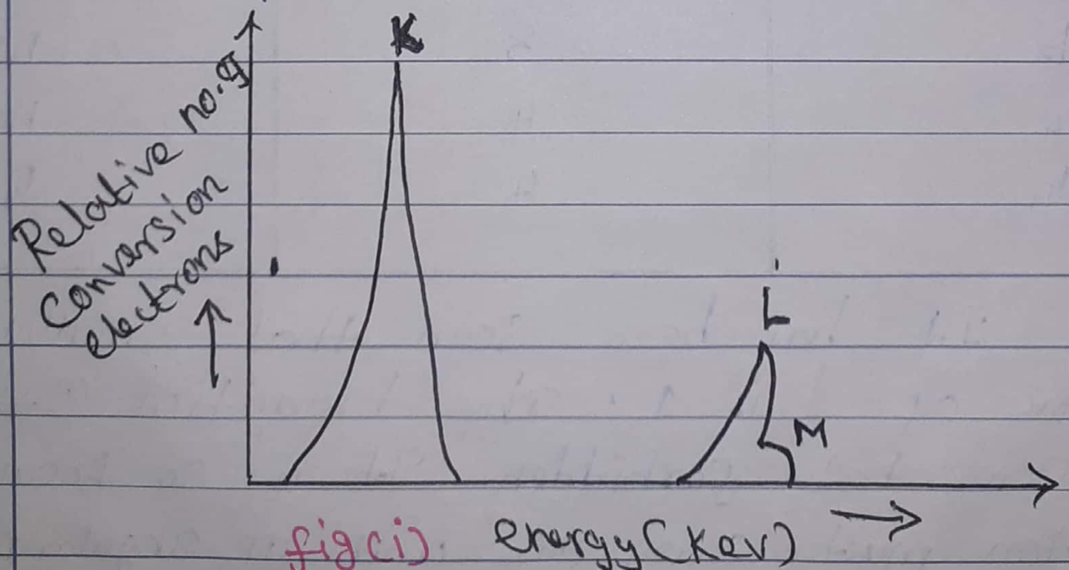


fig (i)

Where E_i is the original atomic binding energy of the electron. The fig (i) shows the spectrum of conversion electrons which are ejected from the K, L and M shells of indium by internal conversion of the 392 KeV transition in In^{113}.

These conversion electrons carry away the spins and parity changes of the nuclear states. The K.E of conversion electron escaping from an atom is given as,

$$E_i = W - B_K \longrightarrow (2)$$

(or) $W - B_L$

(or) $W - B_M$ etc

Where B_K, B_L, and B_M represent the binding energy of an electron in the K, L, M etc.

Internal Conversion Coefficient :~

Let the decay constant λ_γ represent the probability per unit time for the emission of a photon whose energy is $W = h\nu$. Let the decay constant λ_e represent the probability per unit time for the internal conversion phenomenon to takes place: then excluding other possible modes of decay. We can write,

$$\lambda = \lambda_\gamma + \lambda_e \longrightarrow (3)$$

The internal conversion co-efficient is defined as,

$$\alpha = \frac{\lambda_e}{\lambda_\gamma} + \frac{N_e}{N_\gamma} \longrightarrow (4)$$

Where N_e and N_γ are the numbers of conversion electrons and photons emitted in the same interval from the samp sample, in which identical nuclei are undergoing the same nuclear

nuclear transformation characterised by the energy W. The total transition probability λ is given by,

$$\lambda = \lambda_\gamma (1+\alpha) \longrightarrow (5)$$

and total no. of nuclei transforming is $N_\gamma + N_e$.

The theoretical value of internal conversion co-efficient is found to depend on,

W → the energy of the transition.

Z → atomic number of the transforming nucleus.

I → the multipole order of the transition.

atomic shell (K, L, M etc) in which conversion takes place.

and electric multipole (or) Magnetic multipole.

Fermi theory of Beta decay:~

When a nucleus emits a β-Particle, its charge changes by one unit while its mass practically remains unchanged. When the ejected β-particle is an electron, the no. of protons in the nucleus is increased by one and the no. of neutrons is decreased by one. In poistron emission; the reverse process takes place ie, protons decrease and the neutrons increase by one. β-transformations may be represented by the following processes.

$$n \rightarrow p + \beta^- + \bar{\nu} \longrightarrow (1)$$

$$p \rightarrow n + \beta^+ + \nu \longrightarrow (2)$$

ν and $\bar{\nu}$ represents neutrino and Antineutrino. The wave function ψ_β and ψ_ν. Let us assume that these are functions for plane waves with momenta P_β and P_ν repectively.

$$\left.\begin{aligned} \psi_\beta &= N_\beta \cdot e^{ik_\beta \cdot r} \\ \psi_\nu &= N_\nu \cdot e^{ik_\nu \cdot r} \end{aligned}\right\} \longrightarrow (3)$$

$N \Rightarrow$ Normalization factor.

$K \Rightarrow \hbar/2$, space co-ordinates

The probability of emission can be assumed to depend upon the expectation value for the electron and neutrino to be at the nucleus, ie, on the factor.

$$|\psi_\beta(0)|^2 \cdot |\psi_\nu(0)|^2 \longrightarrow (4)$$

Matrix element $\Rightarrow M$, taken between the initial and final states of the nucleus. We get,

$$M = \int \psi_p * \psi_N' \, d\tau \longrightarrow (5)$$

$\psi_N \rightarrow$ the initial state of the nucleus

$\psi_P \rightarrow$ the final state of the proton state.

We can also take M to be a vector having x-component is given by,

$$M_x = \int \psi_P^* \sigma_x \psi_N \, d\tau \rightarrow (6)$$

$\sigma_x \rightarrow$ x component of a spin operator, Then,

$$|M|^2 = |M_x|^2 + |M_y|^2 + |M_z|^2 \rightarrow (7)$$

M in equ (5) (or) (7) depends of the selection rules.

Thus the probability of emission per unit time,

$$= \frac{2\pi}{\hbar} \left(|\psi_\beta(0)| \, |\psi_\nu(0)| \, . |M| . g \right)^2 . \frac{dn}{dE} \rightarrow (8)$$

$g \Rightarrow 9 \times 10^{-5}$ Mev fm^3 ; const factor.

$\frac{dn}{dE} \Rightarrow$ energy of density to final states to Initial refers to the location of the nucleus.

$\Omega \Rightarrow$ volume of the big box, normalization purpose then,

$$\int_\Omega \psi^* \psi \, d\tau = 1 \quad ; \quad \therefore N = \frac{1}{\sqrt{\Omega}} \rightarrow (9)$$

$$\left.\begin{aligned} \psi_\beta &= \frac{1}{\Omega^{1/2}} e^{i k_\beta . r} \\ \psi_\nu &= \frac{1}{\Omega^{1/2}} e^{i k_\nu . r} \end{aligned}\right\} \rightarrow (10)$$

ie,

$$K_\beta = \frac{P_\beta}{\hbar} \quad ; \quad K_\nu = \frac{P_\nu}{\hbar}$$

at $r=0$, at the nucleus

$$\psi_\nu(0) = \frac{1}{\sqrt{\Omega}} = \psi_\beta(0) \rightarrow (11)$$

Momentum P and P+dP the particles in the volume is Ω given by,

$$\frac{P^2 dP\,\Omega}{2\pi^2\hbar^3} \rightarrow (12)$$

$$\therefore dn = \frac{P_\beta^2 dP_\beta}{2\pi^2\hbar^3} \times \frac{P_\nu^2 dP_\nu\,\Omega^2}{2\pi^2\hbar^3}$$

$$= \frac{\Omega^2 P_\beta^2 P_\nu^2\, dP_\beta\, dP_\nu}{2\pi^2\hbar^6} \rightarrow (13)$$

$$dP_\beta . dP_\nu = J\, dP_\beta\, dE \rightarrow (14)$$

Where J is Jacobian.

Using the relation $E = E_\nu + E_\beta = Cp_\nu + E_\beta$; J is found to equal to $1/c$ then,

$$\frac{dn}{dE} = \frac{\Omega^2 P_\beta^2 P_\nu^2 . dP_\beta}{4\pi^4\hbar^6 . c} \rightarrow (15)$$

Sub in (8) the probability of emission per unit time $P\ (P_\nu . P_\beta)\, dP_\beta$ is

$$P(P_\nu, P_\beta)\, dP_\beta = \frac{2\pi}{\hbar}\left(\frac{1}{\Omega} . |M| . g\right)^2 \frac{\Omega^2 P_\beta^2 P_\nu^2\, dP_\beta}{4\pi^4\hbar^6 . c} \rightarrow (16)$$

When,

$$P_\nu . c = E_\nu = E_\beta max - E_\beta$$

eliminate P_ν and replacing P_β by simply P, we get

$$P(p)\, dp = \frac{g^2 |M|^2}{2\pi^3\hbar^7 c^3} (E_\beta max - E_\beta)\, p^2 dp \rightarrow (17)$$

Using

$$E_\beta^{max} = \sqrt{m^2c^4 + c^2 P_{max}^2} \rightarrow (18)$$

We get,

$$P(p)\, dp = \frac{g^2 |M|^2}{2\pi^3} \left(\sqrt{m^2c^4 + c^2 P_{max}^2} - \sqrt{m^2c^4 + c^2 p^2}\right)^2 p^2 . dp \rightarrow (19)$$

β - decay Life Time :-

The decay constant λ is equal to mean decay life time τ is obtained by

Calculating the probability per unit time for emission of a $\beta-$ particle with momentum values between 0 and P_{max}. Thus.

$$\boxed{\lambda = \frac{1}{T} = \frac{g^2|M|^2}{2\pi^3 c^3 \hbar^7} \int_0^{P_{max}} \left(\sqrt{m^2c^4 + c^2P^2_{max}} - \sqrt{m^2c^4 + c^2p^2}\right)^2 p^2\, dp} \rightarrow 20$$

Let us define,

$mc\eta = p$ and $mc\eta_0 = P_{max}$. Integral in terms of η and η_0 and calling it $F(\eta_0)$, we get,

$$\frac{1}{T} = \frac{g^2|M|^2 \cdot m^5 \cdot c^4}{2\pi^3 \hbar^7} \cdot F(\eta_0) \rightarrow 21$$

and,

$$F(\eta_0) = \int_0^{\eta_0} \left(\sqrt{(1+\eta_0^2)} - \sqrt{(1+\eta^2)}\right) \cdot \eta^2\, d\eta \rightarrow 22$$

$F(\eta_0)$ should be written as $F(z, \eta_0)$, But z is small.

$$F(z, \eta_0) \approx F(\eta_0)$$

The find expression for T is,

$$\frac{1}{T} = \frac{g^2|M|^2 m^5 c^4}{2\pi^3 \hbar^7} F(z, \eta_0) \rightarrow 23.$$

and

$$F(z, \eta_0) = \text{Constant} \rightarrow 24$$

equ 20 we get,

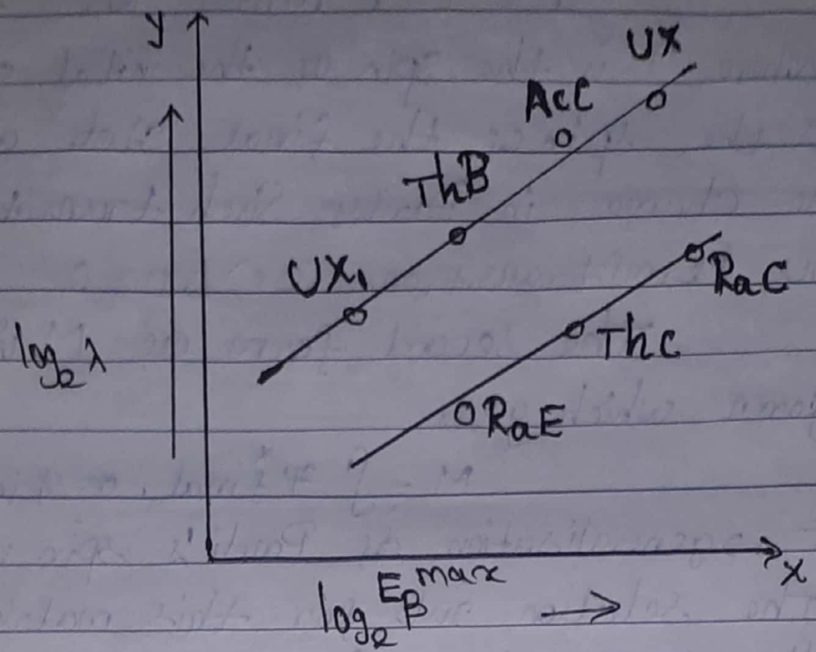
$\lambda \Rightarrow$ decay constant is found to be proportional to fifth power of the end point energy $E_{\beta\, max}$.

i.e,

$$\lambda = K (E_\beta\, max)^2$$

(or)

$$\log_e \lambda = \log_e K + 5 \log_e E_\beta^{max} \rightarrow 25$$



This equ. is found to hold good fairly with Sargent's Curves as shown above. This Confirms the Validity of Fermi's theory.

Selection Rules In Beta Spectrum:~

The action of the nucleus on the field is to create the electron and neutron. We also known that β-decay process is a weak interaction. Spin for a nucleus is defined as I = Angular Momentum.

The wave function ψ changes sign, or not when the space co-ordinates (x, y, z) are transformed by inversion to $(-x, -y, -z)$. If the wave function changes sign, the parity is odd (or) negative and if not, the parity is even (or) positive. Of the various possible forms of M, the one form i.e, the scalar one is given as,

$$M = \int \psi^*_{final} \cdot \psi_{initial} \cdot d\tau \rightarrow (1)$$

This gives the following selection rule for allowed transitions

$$I = I' , \text{ Parity 'No'} \rightarrow (2)$$

Where I is the spin of the inital state and I' is the spin of the final state and 'No' means no change in Parity. Such transitions are known as Fermi transitions (or) $\Delta I = 0$

The second form of M is the 'tensor' form which gives,

$$M = \int \psi^*_{final} \cdot \sigma \cdot \psi_{initial} \cdot d\tau \rightarrow (3)$$

$\sigma \rightarrow$ generalisation of Pauli's spin matrices.

The selection rule for this matrix element for allowed transition is

$$I' = \begin{cases} I+1 \\ I \\ I-1 \end{cases} \quad \text{Parity 'No'} \rightarrow (4)$$

(or) in other words,

$$\Delta I = 0 \quad (\text{or}) \ \pm 1$$

$I=0$ to $I'=0$ transition, is not allowed because the spin momentum must be carried away.

This type of transition is known as Gamow-Teller (G-T) transition and the rule is known as Gamow Teller Selection rule. The following is the example of Gamow Teller allowed transition:

$$He^6 \rightarrow Li^6 + \beta^- + \bar{\nu}$$

There is spin change of 1.

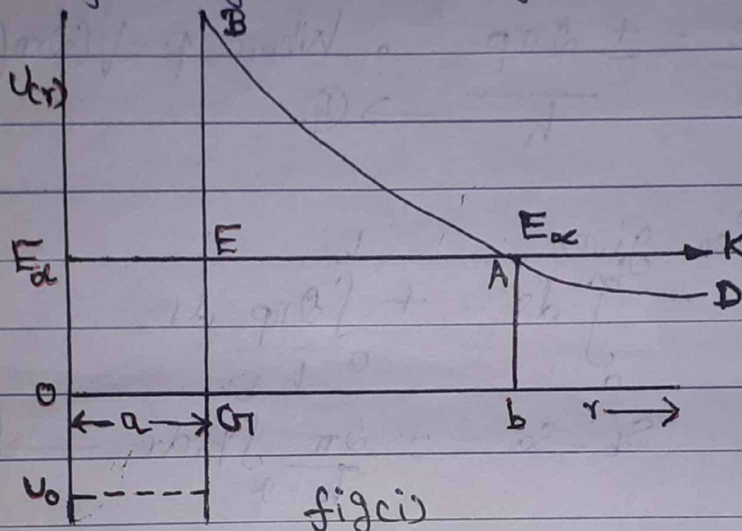
The selection rules for the allowed transitions are given below:

Assumed Interaction	Nuclear spin change	Nuclear parity change	Name of rules
S (or) V	0	No	Fermi rules
P	0	Yes	
A (or) T.	0, ±1	No	Gamow-Teller rules.

Gammow Teller Transition (0 → 0 not allowed).

Gamow's Theory Of Alpha Decay:-

In Order to Calculate the probability of α-particles outside the nucleus, it is supposed that the potential energy $U(r)$, is a function of distance r from the centre of the nucleus and is of the form given below fig(i).



fig(i)

The Schrodinger equation for the particle between the region $r > a$ and $r < b$ can be written as,

$$\frac{d^2\psi}{dr^2} + \frac{8\pi^2 m}{h^2}\left(E - \frac{2Ze^2}{r}\right)\psi = 0 \longrightarrow (1)$$

$\psi = e^S$, where S is a function of r, Then we have,

$$\frac{d\psi}{dr} = e^S \cdot \frac{dS}{dr}$$

$$\frac{d^2\psi}{dr^2} = e^S \cdot (dS/dr)^2 + e^S \cdot \frac{d^2S}{dr^2}$$

$$\therefore \frac{d^2\psi}{dr^2} = e^S\left[\frac{d^2S}{dr^2} + \left(\frac{dS}{dr}\right)^2\right] \longrightarrow (2).$$

$(\because \psi = e^S)$

(2) in (1) we get,

$$e^S\left[\frac{d^2S}{dr^2} + (dS/dr)^2\right] + \frac{8\pi^2 m}{h^2}\left(E - \frac{2Ze^2}{r}\right)e^S = 0$$

$$\frac{d^2s}{dr^2} + \left(\frac{ds}{dr}\right)^2 + \frac{8\pi^2 m}{h^2}\left(E - \frac{2Ze^2}{r}\right) = 0 \longrightarrow (3)$$

For an approximate solution of the above equ. we have neglecting the first term:

$$\left(\frac{ds}{dr}\right)^2 + \frac{8\pi^2 m}{h^2}\left(E - \frac{2Ze^2}{r}\right) = 0$$

(or)

$$\left(\frac{ds}{dr}\right)^2 = \frac{8\pi^2 m}{h^2}\left(\frac{2Ze^2}{r} - E\right)$$

(or)

$$\boxed{\frac{ds}{dr} = \pm\frac{2\pi p}{h}} \longrightarrow (4), \quad \text{Where } p = \sqrt{\left\{2m\left(\frac{2Ze^2}{r} - E\right)\right\}}$$

integration gives,

$$\int_a^b ds = \pm \int_a^b \frac{2\pi p}{h}\,dr$$

$$S_b - S_a = \pm \frac{2\pi}{h}\int_a^b p.dr \longrightarrow (5)$$

The chance of finding it at $r=b$ to the chance of finding at $r=a$ is the same as $\psi_b^2 : \psi_a^2$, the number of times it escapes in a second will be,

$$N = \frac{v\,\psi_b^2}{2a\,\psi_a^2} \longrightarrow (6)$$

$$= \frac{v}{2a} \cdot \frac{e^{2S_b}}{e^{2S_a}} = \frac{v}{2a} \cdot e^{2(S_b - S_a)}$$

$$= \frac{v}{2a}\, e^{\frac{4\pi}{h}\int_a^b p.dr} \longrightarrow (7)$$

The average life T of the α-particle inside the nucleus will be reciprocal of this, so that

$$T = \frac{1}{N} = \frac{2a}{v}\, e^{-\frac{4\pi}{h}\int_a^b p.dr} \longrightarrow (8)$$

If $\frac{1}{2}mv^2 = E$, so that, $f_1 2 = V_1 . V_2$

$$v = \sqrt{(2E/m)}$$

$$T = 2a \cdot \sqrt{(m/2E)} \cdot e^{-4\pi/h \int_a^b p \cdot dr}$$

$$\therefore T = a \sqrt{\left(\frac{2m}{E}\right)} e^{-4\pi/h \int_a^b p\, dr} \longrightarrow (9)$$

In the integral

$$P = \sqrt{\left\{2m\left(\underbrace{\frac{2Ze^2}{r} - E}\right)\right\}}$$

~~at~~ Since at $r = b$, the potential energy becomes equal to the K.E is E, so that,

$$E = \frac{2Ze^2}{r} = \frac{2Ze^2}{b}$$

(or)

$$b = \frac{2Ze^2}{E}$$

$$\therefore P = \sqrt{\left\{2mE\left(\frac{2Ze^2}{Er} - 1\right)\right\}} = \sqrt{\left\{2mE\left(b/r - 1\right)\right\}}$$

$$\therefore \int_a^b P \cdot dr = \int_a^b \sqrt{\{2mE(b/r - 1)\}}\, dr \rightarrow (A)$$

$$= \sqrt{(2mE)} \int_a^b \left(b/r - 1\right) \cdot dr$$

Put $r = b\cos^2 u$ and $a = b\cos^2 u_0$.

$$\therefore dr = -2b\cos u \cdot \sin u \cdot du \quad (B)$$

$$\therefore \int_a^b P \cdot dr = \sqrt{(2mE)} \int_{u_0}^{0} \left(\frac{b}{b\cos^2 u} - 1\right) \cdot (-2b\cos u \sin u\, du)$$

$$= -2b\sqrt{(2mE)} \int_{u_0}^{0} (1 - \cos^2 u)^{1/2} \sin u \cdot du$$

$$= -2b\sqrt{(2mE)} \int_{u_0}^{0} \sin^2 u \cdot du$$

$$= -2b\sqrt{(2mE)} \int_{u_0}^{0} \frac{1}{2}(1 - \cos 2u)\, du$$

$$= -2b\sqrt{(2mE)} \left(-\tfrac{1}{2}u - \tfrac{1}{2}\frac{\sin 2u}{2}\right)_{u_0}^{0}$$

$$= -2b\sqrt{(2mE)} \left(-\tfrac{1}{2}u_0 + \frac{1}{4}\sin 2u_0\right)$$

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$$= b\sqrt{(2mE)}\,[u_0 - \sin u_0 \cos u_0]$$

Since $a = b\cos^2 u_0$; $\cos^2 u_0 = a/b$;

$\cos u_0 = \sqrt{a/b}$; $u_0 = \cos^{-1}\sqrt{a/b}$

$\therefore \sin u_0 = \sqrt{(1 - a/b)}$

We get,

$$\int_a^b p.dr = b\sqrt{(2mE)} \cdot \left[\cos^{-1}\sqrt{a/b} - \sqrt{\{a/b\,(1 - a/b)\}}\right] \rightarrow (10)$$

Sub in equ (9) we get,

$$\boxed{T = a\sqrt{(2m/E)} \cdot e^{-4\pi/h \cdot b\sqrt{(2mE)} \cdot \left[\cos^{-1}\sqrt{a/b} - \sqrt{\{a/b\,(1 - a/b)\}}\right]} \rightarrow (11)}$$

This shows that the mean life of a radioactive atom between two successive disintegrations is inversely proportional to energy.

E and T for a natural radioactive Substance are taken to be Known and Substituted in equ (11) we can find out a and from this the nuclear radius constant $(R_0 = RA^{-1/3})$ can be Calculated. Value of R_0 for some important nuclides is shown below:

Parent nucleus	Decay energy E (Mev)	R_0 in fermi
Pb^{208}	5.24	1.43
Po^{214}	7.83	1.56
Ra^{232}	6.62	1.59
Th^{226}	6.41	1.58

equ. (8) can be transformed into,

$$\log_e T = A - B\log_e E \quad \text{approximately},$$

Where A and B constants. This is Known as Geiger Nuttal Law and is in agreement with theoretical results.

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Neutrino Hypothesis:~

Once the continous beta-ray spectrum is ascertained, Only the two alternatives are left open and they are:

(i) the conservation laws donot hold,

(ii) the conservation laws hold good but part of energy and momentum are imparted to some form of undetected radiations.

The first hypothesis was proposed by Bohr and Rutherford but did not find much favour due to fact that,

(i) Conservation laws have been successful in explaining the phenomena known so far.

(ii) The Scientists Conservation laws an articles of faith and therefore did like to prefer some other alternative

(iii) It would make impossiable the treatment of nuclear phenomena in the scheme of quantum mechanics.

(iv) Sargent Verified the conservation of energy laws using end point energy.

Thus, Only second hypothesis is left and is preferred now adays. The hypothesis was put forward by W. Pauli in 1933, While resolving the impass created by the troubles mentioned in art. He suggested that in each Beta disintegration an additional particle is omitted to maintain the Conservation laws. As the Particle was assumed neutral to maintain the conservation of charge, the name the neutrino ("little neutral") was given. The neutrino

(Symbol ν) was assumed, a fermion with intrinsic spin 1/2, and it is thought to carry an appropriate amount of energy and Momentum in each beta process to conserve these quantities. Further, in beta decay parent and product nuclei have the same mass number and electron Obey F.D. Statistics, So to conserve Statistics ν as assumed to obey F-D-Statistics.

To account for the fact neutrinos were taken almost undetectable. It is further, assumed that they have a very small (or) Zero rest mass and a very small (or) Zero magnetic moment.

Under, neutrino hypothesis the Continuous beta-ray spectrum amount of energy released is equal to the end point energy. This energy is shared by recoil nucleus, the emitted electron and the neutrino. The energy carried by neutrino is not fixed and it varies Continuously, leaving there by a Continuously varying energy to the beta particle and hence the Continuous Spectrum. At end point, total energy is carried away by the beta particle and the neutrino carries Zero energy.

Now the question is, "Whether the two neutral Particles emitted in β^- and β^+ decays are identical?" To resolve this statement, the analogy is taken from the fact that β^- and β^+ are antiparticles; therefore, the particles emitted together with β^- and β^+ particles in two processes should be antiparticles. This and other evidences support this idea and by convention the particle emitted in β^- decay is taken as antineutrino ($\bar{\nu}$) and in β^+ decay the neutrino (ν).

In this way, Pauli's hypothesis proved successful in interpreting the continuous beta spectrum.

Non-Conservation of parity:~

The Conservation of parity was also established by use of Schrodinger equation. But, now it has been shown that in weak interaction of beta decay type, the law of Conservation of parity is not obeyed.

The principle of the experiment used for the demonstration of parity violation was suggested by Lee and Yang. The first experiment to demonstrate parity violation was performed in 1957, by Wu, and others by using Lee-Yang proposal, the sketch of which is shown in fig (a); They used Co^{60} grown on the surface of cerium magnesium nitrate. Co^{60} under normal condition, the spins are randomly oriented, because of thermal motions, and beta particles are emitted in all directions. Co^{60} was cooled below 0.01°K and an external magnetic field of few hundred gauss was applied. As a result, the thermal motion was reduced to minimum and spins was reduced to minimum and spins were aligned the direction of magnetic field. The magnetic field aligns the atoms of Cerium magnesium nitrate. The alignment produces internal magnetic field which aligns the spins.

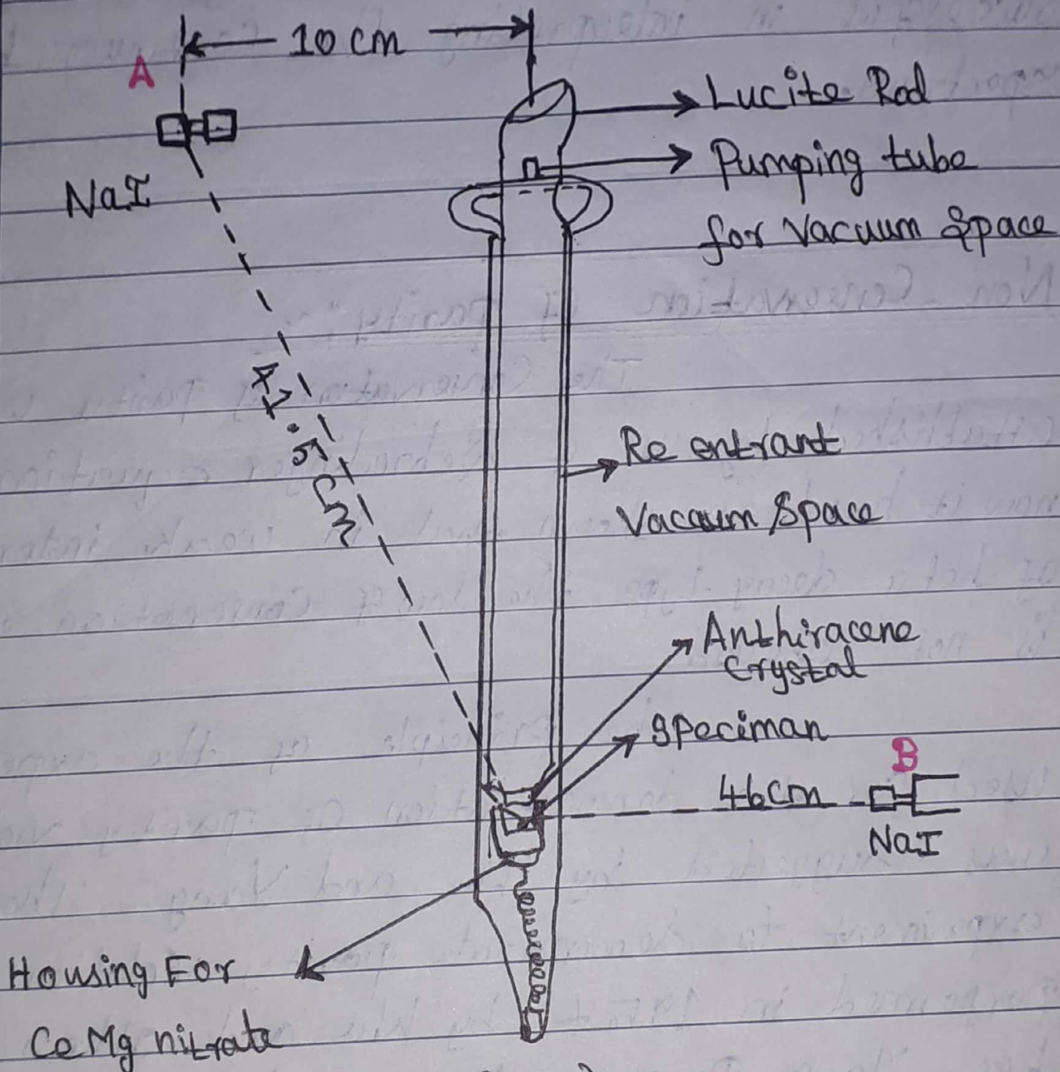
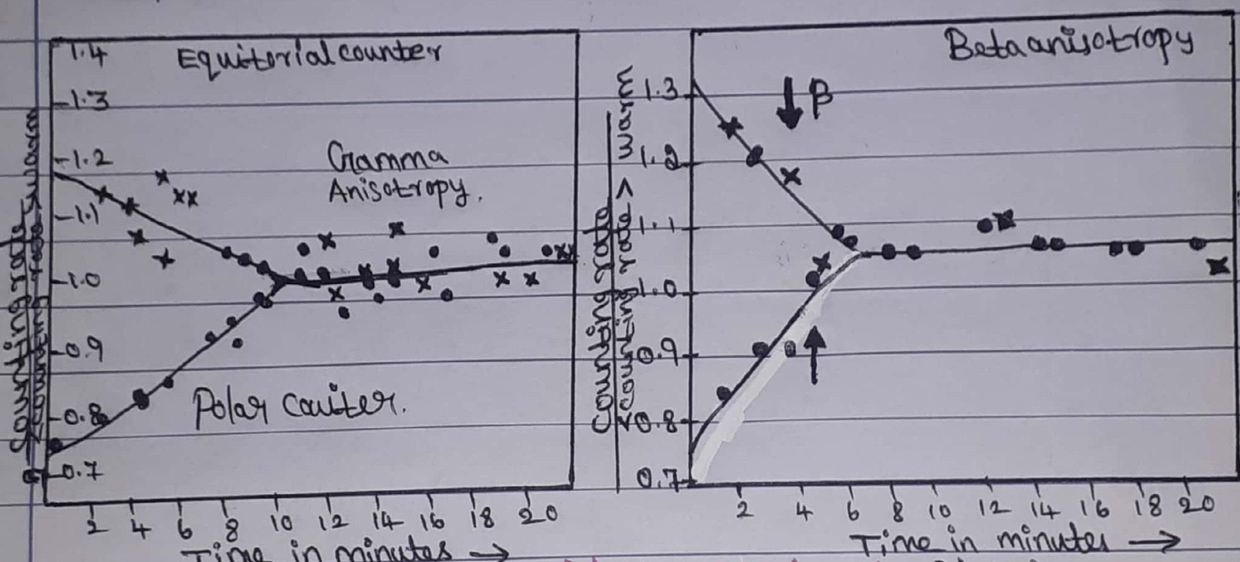


fig (a).

Experimental arrangement used to demonstrate Parity violation in beta decay.

The beta particles emitted by Polarised nuclei were detected by an anthreecene Crystal mounted 2.cm above the source. The scintillation were transmitted to a photo-multiplier located at the top of the cryostat. To measure the extent of polarisation of Co^{60} nuclei, two NaI, γ-ray counters were used one in the equitorial plane and other near the polar position. The observed anisotropy fig(b). provided a measure of polarisation and hence of the temperature of the source. After almost 8 minutes the anisotropy disappeared and indicated that alignment had disappeared.



fig(b). Results for Parity violation experiment fig(c).

The counting rate for beta particles were first determined with the field up and then with the field down. The results as show in fig(c); the results indicate that more $\bar{e}$'s are emitted in the direction opposite to that of the magnetic field, i.e., in the direction opposite to that in which nuclei are aligned. It implies that $\bar{e}$'s are emitted in preferred direction and principle of right-left symmetry is violated and hence parity is not conserved. In terms of the pseudoscalar quantity $I_i \cdot P_\beta$, we can say that is average

Value is -ve. Here, I_i is angular momentum of Co^{60} which does not change sign in parity operation and P_β is linear momentum of beta particle which changes in parity operation.

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