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Neutron as a Consequence of “Photon as a Basic Unit”

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Abstract Since neutrons and protons are the main components of the atomic nucleus and studying their nature helps in understanding the nature of the atomic nucleus and its properties, this study has done to reveal some of the properties of neutrons depending upon the postulated properties of electron and proton in the previous study (photon as a basic unit), in this study; it was postulated that electron and proton are the main components of the neutron, based on this postulation some basic properties of neutron like structure, mass, lifetime, beta decay, and magnetic moment have been deduced and also the nature of neutrino and anti-neutrino has been illustrated as a result of studying beta decay.

Keywords Neutron structure, Neutron mass, Free neutron lifetime, Beta-Decay, Neutrino, Anti-neutrino, Proton magnetic moment, Electron magnetic moment, Neutron magnetic moment, Continuous energy spectrum of beta particles

1. Introduction

Rutherford In 1920 postulated that the nucleus consists of neutral particles and positive protons then he suggested that this neutral particle is formed from a proton and an electron combined in some way because beta radiation consists of electrons emitted from the nucleus [1]. In 1932 James Chadwick discovered the neutron [2] which is the neutral particle within the nucleus which was described by Rutherford. The mass of the free neutron was reported to be 939.565413±0.000006meV/c^2 [3] with a mean square radius of about 0.8×10^{-15} m [4], the free neutron is unstable and undergoes a process called beta decay which is a type of radioactive decay at which the free neutron decays into a proton, electron, and antineutrino with a mean lifetime of (885.7±0.8 s) [3]. Beta-decay is a process at which a Beta particle (electron or positron) is emitted from the atomic nucleus; it can be classified into 3 types either by emission of an electron and an anti-neutrino, a positron and a neutrino, or by the capture of an electron with the emission of neutrino [5]. Hughes and Burgy In 1949 reported that the angular distribution of the reflected neutrons from a ferromagnetic mirror was consistent with spin 1/2 [6]. Neutron’s magnetic moment value was measured by Luis Alvarez and Felix Bloch in 1940 [7] to be −1.93(2) μN which indicates that it has a substructure.

In the previous study (photon as a basic unit) [8]; a model for photon was suggested and it was postulated to be the basic component of subatomic particles with a sperm structure composed from three parts: head, separator plus the spiral tail with a mass $m_o = 4.59x\,10^{-32}kg$ and length $L_o = 4.8\times10^{-11}m$, then it was suggested that electron and positron are formed from photons in a tree form structure with one condensed spiral tail and branches of photons heads with radius $r_e = 8.06\times10^{-13}m$, also proton was suggested to be formed from positrons in a tree form structure with one condensed spiral tail and branches of positrons’ heads with radius $r_p = 0.8779\times10^{-15}m$, then electron was deduced to has 2 states; bounded electron with mass $9.1859\times10^{-31}Kg$ which can be converted into free electron with mass $9.1094\times10^{-31}kg$ by losing one photon’s head with a mass $(m_o/6)$, the same with proton there is a bounded proton with mass $1.672772078\times10^{-27}Kg$ which can be converted into a free proton with mass $1.67261898\times10^{-27}Kg$ by losing one positron’s head $(m_e/6)$, then charge was interpreted to be the time taken by a particle to pass a certain point, and the direction motion of the spiral tail for the particle is responsible for charge sign, also a formula for spin property for subatomic particles was deduced to be $K_E\times t = (1/2)mc\lambda = (1/2)h$ where K_E is the spin kinetic energy and t is the time of one spin.

This study was done to theoretically explain and deduce some of the neutron's properties like structure, mass, beta decay, half lifetime, and magnetic moment.

2. Neutron Structure

According to the quark model for hadrons, the neutron is composed of one up quark with a charge +2/3 *e* and two down quarks with a charge −1/3 *e* [9].

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Based on the mentioned properties of neutron and the postulated structures for proton and electron in the previous study [8]; another point of view will be introduced for neutron structure. The neutron is postulated to be formed from the interaction and complete unification between the 2 opposite phases' tales of electron and proton canceling the charge effect of each other resulting in a neutral particle with 3 additional postulated criteria:

1-electron's radius will be compressed to equal proton's radius.

$$r_p = r_e = 0.8779 \times 10^{-15} m$$

2-the length r_n of the tail connecting the centers of proton and electron will be compressed to be.

$$r_n = 2r_p = 1.7558 \times 10^{-15} m$$

3-the proton and the electron within the neutron are in free form.

The resulted structure can be postulated to be

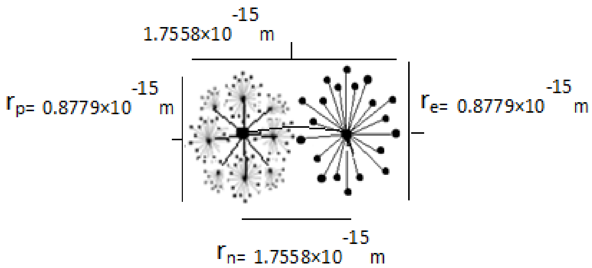

Figure 1. an approximation for neutron structure

3. Neutron Mass

Neutron mass can be measured by the subtraction of proton mass from deuteron mass, which gives also the binding energy of deuterium; which can be obtained by measuring the energy of gamma-ray emitted when a proton captures a neutron forming a deuteron, in 1948 Bell and Elliot measured the energy of this gamma-ray by X-ray diffraction techniques and the neutron mass is given by Greene, et al. to be 1.008644904(14) Da [10] which equals $1.674894241 \times 10^{-27}$ Kgm.

In this study according to the suggested structure for neutron; its mass m_n can be calculated by the summation of the masses of proton m_p, electron m_e, and the mass m_s equivalent to the energy E_s stored in the compressed tail between proton and electron which can be calculated by coulomb's law;

$$E_s = K\frac{q_1 q_2}{r_n} = m_s c^2$$

$$m_s = 1.458024832 \times 10^{-30} kg$$

The total mass of the neutron

$$m_n = m_p + m_e + m_s$$
$$= 1.67261898 \times 10^{-27} + 9.1094 \times 10^{-31}$$
$$+ 1.458024832 \times 10^{-30} = 1.674987945 \times 10^{-27} kg$$

4. Free Neutron Lifetime

The exact value of the mean lifetime for the neutron is still uncertain; this problem is called the "neutron lifetime puzzle". This is due to conflicting results from experiments e.g. lifetime value from the magnetic trap with permanent magnets [11] was measured to be 878.2±1.9s. In the MAMBO II experiment [12] the result was obtained to be 880.7±1.8s, and the results of the experiments with room temperature fomblin were reported to be 882.5±2.1s [13] and 881.6±2.1s [14] then another experiment gave the value for neutron lifetime to be 880.2±1.2s [15]. The analyses of neutron lifetime value from different experiments are with asymmetry data from Particle Data Group 885.7±0.8 s [3].

In order to solve this enigma; we have to configure the decay process for the free neutron. According to the current study; the gained energies stored in the compressed electron and the connecting tail between proton and electron within the free neutron make it unstable and tend to decay by separating the electron from the proton. The kinetic energy KE_e required for the electron to escape from the proton has to equal the gravitational energy of the mass m_s stored in the connecting tail;

$$KE_e = \frac{1}{2} m_e V_e^2 = \frac{G m_e m_s}{r_n}$$

$$V_e = \sqrt{\frac{2Gm_s}{r_n}} = 3.329320768 \times 10^{-13} m/s \cdot$$

V_e, m_e and G are the electron's escaping velocity, electron mass, and universal gravitational constant respectively.

So it can be concluded that free neutron decay depends on electron escaping velocity V_e and the distance d which the electron has to pass, this distance has to be greater than the longest available distance between a nucleus and its outer shell atomic electron e.g. if an electron escapes with a velocity $V_e = 3.329320768 \times 10^{-13} m/s$ and passes a distance $d = 295 \times 10^{-12} m$, the time t taken will be $t = \frac{d}{V_e} = 886.06s$; which is the time required for a free neutron to decay.

So we can conclude that there is no solid number for the neutron lifetime but it depends upon the distance (d) which the electron within the neutron has to pass and overcome the attraction force with the proton and the decay process occurs.

5. Beta-Decay

The next types of beta decay can be illustrated based on the suggested models of electron, proton, and neutron.

5.1. Emission of an Electron e^- and Anti-Neutrino $\bar{\nu}$

In this type of beta decay neutron is converted into a proton by emission of an electron and an antineutrino

$$n \to p^+ + e^- + \bar{\nu} \tag{1}$$

This type of decay can be illustrated by the next figure

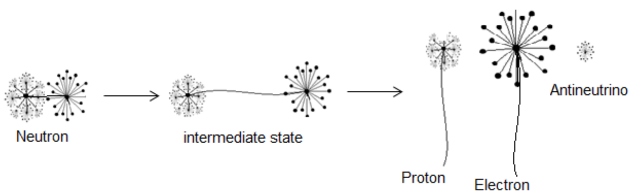

Figure 2. an approximation for neutron decay

The gravitational force F_g between electron and proton within the neutron

$$F_g = \frac{Gm_e m_p}{r_n^{\,2}} = 3.298588283 \times 10^{-38} N$$

The gravitational force F_m between one positron head with a mass ($m_e/6$) within a proton and the center of the proton

$$F_m = \frac{G(\frac{m_e}{6})m_p}{(r_p - \frac{r_p}{6})^2} = 3.166644751 \times 10^{-38} N$$

F_g is the minimum force required by an electron to escape from the gravitational force of a proton within the neutron. According to the third law of newton; the proton will counter this effect with the same amount of force which is sufficient to overcome the force F_m which results in releasing a mass $m_e/6$ (one positron head) from the proton, the difference between the two forces F_g and F_m will be used in proton recoil.

The neutron decay equation can be written as

$$n \to p^+ + e^- + \frac{m_e}{6} \tag{2}$$

By equating equations (1) and (2); the antineutrino $\bar{\nu}$ can be considered to be one positron head.

5.2. Emission of a Positron e^+ and Neutrino ν

In this type of beta decay, a proton is converted into a neutron by the emission of a positron and a neutrino

$$p^+ \to n + e^+ + \nu \tag{3}$$

This type of decay can be illustrated by the next figure

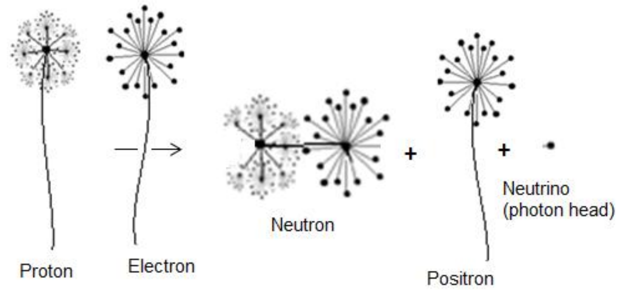

Figure 3. an approximation for conversion of a proton into a neutron

According to the current study; conversion of a proton into a neutron requires an electron. since the proton is formed from positrons in a tree form structure; so if the proton loses a positron the proton will compensate this loss in mass by attracting an equivalent mass from the surrounding medium which will be a bounded electron to form a neutron, according to role number 3 in neutron structure section; the bounded electron within the new neutron will be converted into free-electron by losing one photon head with mass $(m_o/6)$.

And the decay equation can be written as

$$p^+ \xrightarrow{e^-} n + e^+ + \frac{m_o}{6} \tag{4}$$

In this equation, electric charge conservation was obeyed where the left side of the equation resulted in a positively charged atom. By equating equations (3) and (4); the neutrino ν can be considered as one photon head $(m_o/6)$.

5.3. Capture of an Electron with the Emission of a Neutrino

In this type of beta decay, a proton is converted into a neutron by attracting an electron from the inner shell and emitting a neutrino

$$p^+ + e^- \to n + \nu \tag{5}$$

This type of decay can be illustrated by the next figure

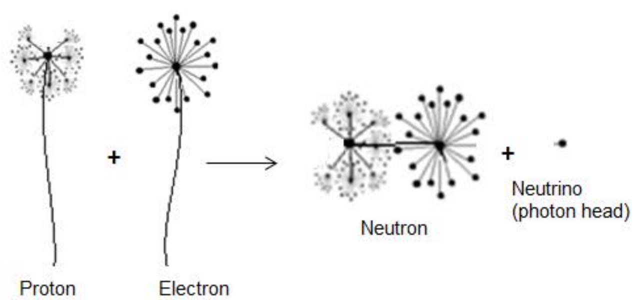

Figure 4. An approximation for the Capture of an electron with the emission of a neutrino

Based on this study, in proton-rich nuclei; the free proton will capture bounded electrons from a near electron shell to form a neutron by releasing photon head with a mass ($m_o / 6$) from the electron to be in free form within the nucleus

$$p^+ + e^- \rightarrow n + \frac{m_o}{6} \tag{6}$$

By equating equations (5) and (6); the neutrino ν can be considered as one photon head $(m_o / 6)$.

It can be deduced that in the 3 previous beta decay types 2 byproducts have been resulted ($\frac{m_o}{6}$ and $\frac{m_e}{6}$) which can be used to explain the inverse beta decay e.g. in KamLAND experiment [16]; neutrinos were detected by inverse beta decay with threshold energy of about 2.6 MeV

$$\bar{\nu}_e + p^+ \rightarrow n + e^+ \tag{7}$$

Since $\bar{\nu}_e$ represents positron head $(m_o / 6)$, upon collision in an energy level of about 2.6 MeV which is greater than the Coulomb force between one positron head and the center of the proton; the proton will counter this action by repelling one positron from that proton, hence to compensate the loss in proton mass it will attract a bounded electron from the surrounding medium converting it into a free electron by losing photon head $(m_o / 6)$ and forming a neutron.

$$\frac{m_e}{6} + p^+ \xrightarrow{e^-} n + e^+ + \frac{m_o}{6} \tag{8}$$

Also in this equation, electric charge conservation was obeyed where the left side of the equation resulted in a positively charged atom.

6. Proton and Electron Magnetic Moments

The recommended values for the magnetic moment of the proton and electron according to CODATA [17] are 1.410 606 797 36 x 10^{-26} J T^{-1} and -9.284 764 7043 x 10^{-24} J T^{-1} respectively.

According to the current study; in order to derive the values of the magnetic moment for electron and proton we have to follow the assumption that electron and proton are not point-like particles and have a definite structure [8], so during their orbital motion they form a cone structure with the orbiting center with an area

$$A = \pi r r_c \tag{9}$$

r is the subatomic particle radius and r_c is the lateral radius of the formed cone, as shown in the next figure.

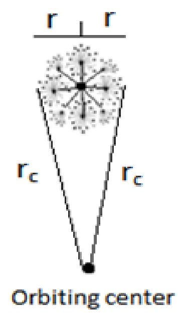

Figure 5. a cone structure formed by the orbital motion of a subatomic particle

The rate of change of angular momentum of a subatomic particle

$$\tau = \frac{p}{\omega} = \frac{F.d}{2\pi} = m.B = m.\frac{F}{qv} \tag{10}$$

$\tau, p, \omega, d, m, \mathrm{B}, q, \mathrm{F}$ and v are torque, power, angular velocity, linear distance, magnetic moment, external magnetic field, charge, force, and tangential velocity respectively.

It was postulated that charge q is the time taken by a particle to pass a certain point [8] and distance=time x velocity

$$qv = L \tag{11}$$

from equations (10), (11) magnetic moment m can be deduced to be

$$m = \frac{d.L}{2\pi} \tag{12}$$

L will be postulated to be a length in meter unit of the circumference of the orbital motion

So the lateral radius of the formed cone $r_c = \frac{L}{2\pi}$

$$m = d.r_c \tag{13}$$

By equating equations (9) and (13)

If $m = A$ so $d = \pi r$

$$m = \pi r r_c \tag{14}$$

According to this equation, the magnetic moment can be identified to be the area of the cone made by the subatomic particle during its orbital motion around the orbiting center.

Lateral radius can be calculated by calculating orbital kinetic energy and the velocity of the particle. The formula for spin kinetic energy SK_E for stable particles [8] with charge $1.6 \times 10^{-19} c$ is

$$SK_E \times t_s = \frac{1}{2} h \tag{15}$$

time of one spin $t_s = \frac{1}{\upsilon_s} = \frac{2\pi r}{c}$

r, υ_s and c are the particle radius, frequency of spin kinetic energy, and light velocity respectively.

$$SK_E \times \frac{1}{\upsilon_s} = \frac{1}{2}h \quad (16)$$

According to plank's black body radiation formula $E = h \times \upsilon_t$ where E, h and υ_t are energy, plank's constant, and frequency respectively. Multiply both sides of equation (16) by υ_t.

$$SK_E \times \frac{\upsilon_t}{\upsilon_s} = \frac{1}{2}h \times \upsilon_t \quad (17)$$

For electron

$$SK_{Ee} \times \frac{\upsilon_{te}}{\upsilon_{se}} = \frac{1}{2}h \times \upsilon_{te} \quad (18)$$

for proton

$$SK_{E\,p} \times \frac{\upsilon_{tp}}{\upsilon_{sp}} = \frac{1}{2}h \times \upsilon_{tp} \quad (19)$$

since electron and proton and most stable particles have the same charge and frequency $\upsilon_c = \frac{1}{t} = \frac{1}{q} = 6.25 \times 10^{18}\,Hz$.

To verify that concept for two different particles like electron and proton; equations (18, 19) have to be multiplied by the reciprocal $\frac{\upsilon_t}{\upsilon_s}$ of the other particle, which will result in the orbital kinetic energy formula OK_E.

Orbital kinetic energy for electron OK_{Ee}

$$OK_{Ee} = SK_{Ee} \times \frac{\upsilon_{te}}{\upsilon_{se}} \times \frac{\upsilon_{sp}}{\upsilon_{tp}} = \frac{1}{2}h \times \upsilon_{te} \times \frac{\upsilon_{sp}}{\upsilon_{tp}}$$
$$= 9.806495427 \times 10^{-15}\,J = \frac{1}{2}m_e v_e^{\,2} \quad (20)$$

v_e is the tangential velocity of the electron

$$v_e = 2\pi\upsilon_c r_{ce} = 1.467327397 \times 10^8\,m/s$$
$$r_{ce} = 3.736518543 \times 10^{-12}\,m \quad (21)$$

Electron magnetic moment

$$m_e = \pi r_e r_{ce} = 9.4613 \times 10^{-24}\,J/T \quad (22)$$

Orbital kinetic energy for proton $OK_{E\,p}$

$$OK_{E\,p} = SK_{E\,p} \times \frac{\upsilon_{tp}}{\upsilon_{sp}} \times \frac{\upsilon_{se}}{\upsilon_{te}} = \frac{1}{2}h \times \upsilon_{tp} \times \frac{\upsilon_{se}}{\upsilon_{te}}$$
$$= 3.601138499 \times 10^{-11}\,J = \frac{1}{2}m_p v_p^{\,2}$$

$$v_p = 2\pi\upsilon_c r_{cp} = 2.075085621 \times 10^8\,m/s$$
$$r_{cp} = 5.284162142 \times 10^{-12}\,m \quad (23)$$

v_p is the tangential velocity of the proton

Proton magnetic moment

$$m_p = \pi r_p r_{cp} = 1.457374133 \times 10^{-26}\,J/\mathrm{T} \quad (24)$$

The deduced values for the derived magnetic moments of electron and proton are close to the values stated in CODATA.

7. Neutron Magnetic Moment

According to CODATA, the magnetic moment value of neutron is (-9.662 3651 x 10^{-27} J T^{-1}) [17], the magnetic moment value for neutron was puzzling until the development of the quark model which stated that neutron is composed from three quarks and its magnetic moment is the summation of these three particles [9].

In this study another point of view will be introduced; neutron structure is a problem between 2 particles (electron and proton) so its orbital motion lateral radius r_{cn} can be concluded to be a reduced radius

$$r_{cn} = \frac{r_{ce} \times r_{cp}}{r_{ce} + r_{cp}} = 2.188789352 \times 10^{-12}\,m$$

According to structure (1); neutron root mean square radius (r.m.s) r_{nu}

$$r_{nu} = \sqrt{\frac{(1.7558 \times 10^{-15})^2 + (0.8779 \times 10^{-15})^2}{2}}$$
$$= 1.388081779 \times 10^{-15}\,m$$

Neutron magnetic moment m_n

$$m_n = \pi r_{nu} r_{cn} = 9.54484528610^{-27}\,J/T \quad (25)$$

And this value is close to the value stated in CODATA 2018.

This rule could be applied for other subatomic particles e.g. muon.

8. Muon Magnetic Moment

Muon is a subatomic particle similar to the electron in charge and a spin with a mass $m_u = 105.6583745\,MeV\ c^2$ [3].

And magnetic moment (-4.490 448 30 x 10^{-26} J T^{-1}) according to CODATA [17].

Its radius can be calculated as the same as electron radius in the previous study [8] as follows;

$$\frac{1}{3}m_o \times \frac{1}{3}L_o = \frac{1}{3}m_u \times \frac{1}{3}L_u$$
$$r_u = \frac{1}{3}L_u = 3.904362801 \times 10^{-15}\,m$$

$m_o, L_o, \mathrm{m}_u, L_u$, and r_u are photon mass, photon length, muon mass, muon length, and muon radius respectively.

Muon orbital kinetic energy OK_{Eu}

$$OK_{Eu} = \frac{1}{2} h \times \upsilon_{tu} \times \frac{\upsilon_{sp}}{\upsilon_{tp}} = 2.024913881 \times 10^{-12} = \frac{1}{2} m_u v_u{}^2$$

$$v_u = 2\pi\upsilon_c r_{cu} = 1.467327394 \times 10^8 m/s$$
$$r_{cu} = 3.736518527 \times 10^{-12} m \quad (26)$$

v_u is the tangential velocity of the electron

Muon magnetic moment

$$M_u = \pi r_u r_{cu} = 4.583182796 \times 10^{-26} J/\mathrm{T} \quad (27)$$

Magnetic moment sign (positive or negative) depends upon the direction motion of the orbital kinetic energy of the subatomic particle (clockwise or anticlockwise).

9. Continuous Energy Spectrum of Beta Particles

It was postulated in the first decade of the twentieth century that beta particles emitted in radioactive decay were mono-energetic after that it was discovered to have continuous energy spectrum which was explained by Pauli's hypothesis [18] by the presence of a neutral and zero mass particle that is emitted with the beta particle and is sharing it in momentum and energy. Then Fermi formulated a theory of beta decay on the basis of this idea [19].

In this study another point of view for the continuous energy spectrum of the beta particles will be introduced:

Since the continuous energy spectrum of beta particles is an indication for the different velocities of the emitted beta particles during beta decay so the continuous energy spectrum can be explained by showing the factors which control the velocities of the electrons during beta decay.

It was mentioned in the neutron structure section that electron radius r_e within neutron was compressed from $r_e = 8.06 \times 10^{-13} m$ to $r_e = 0.8779 \times 10^{-15} m$

Using equations (21), (22)

$$v_e = 2\pi\upsilon r_{ce} \text{ and } M_e = \pi r_e r_{ce}$$

$$v_e = 2M_e \left(\frac{\upsilon}{r_e}\right) \quad (28)$$

In the case of the constant magnetic moment of the electron, it can be deduced that the velocity v_e of the escaped electron in beta decay will not be constant and will depend on the ratio of the electron frequency to its radius where the electron tends to retain its original radius during escaping, as a result, the electrons will have different velocities and continuous energy spectrum.

10. Conclusions

Based on the previous study (photon as a basic unit), some postulations about neutron's intrinsic fundamental properties like structure, mass, radius, lifetime, beta decay, and the magnetic moment have been introduced. Neutron was postulated to be formed from the interaction and complete unification between the 2 opposite phases' tales of electron and proton, electron's radius was compressed to equal proton's radius, neutron mas was calculated from the summation of the masses of proton, electron, and the mass equivalent to the energy stored in the compressed tail between proton and electron to be $1.674987945 \times 10^{-27} kg$.

Due to the gained energies within the neutron which are stored in the compressed electron and the connecting tail between proton and electron; the free neutron became unstable and tends to decay, its decay depends on the electron's escaping velocity and the distance which the electron has to pass for escaping.

Three types of beta decay were studied and resulted in postulation that neutrino and anti-neutrino are one photon head and one positron head respectively.

The magnetic moment was deduced to be the area of the cone made by the subatomic particle during its orbital motion around the orbiting center, and according to this postulation magnetic moment values for electron, proton, neutron, and muon were deduced to be $9.4613 \times 10^{-24} J/T$, $1.457374133 \times 10^{-26} J/\mathrm{T}$, $9.54484528610^{-27} J/T$, and $4.583182796 \times 10^{-26} J/\mathrm{T}$ respectively.

The velocity of the escaped electron in beta decay was deduced to not be a constant and depends on the ratio of the emitted electron frequency to its radius during escaping resulting in a continuous energy spectrum for the emitted beta particles.

Based on this study and the previous study (photon as a basic unit); the area for a new nuclear model study will be opened.

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