Neutron Decay and its Relation to Nuclear Stability[1]

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This paper argues that neutron decay leads in the atomic nucleus to a rapid sharing of the massless charge $(-e_*)$ between nearest-neighbor neutrons and protons, thereby reducing the disruptive effect of the nuclear charge (Ze) on the nuclear binding energy.

1 Introduction

The electron and proton and their antiparticles are related to the negative-energy Planck vacuum (PV) via the following string of Compton relations [1] [2]

$$r_e m_e c^2 = r_p m_p c^2 = r_* m_* c^2 = e_*^2 = c\hbar \tag{1}$$

where r_e and r_p are the electron-positron and proton-antiproton Compton radii respectively, r_* and m_* are the Planck particle Compton radius and mass, $(-e_*)$ is the massless bare charge, and $\hbar$ is the (reduced) Planck constant.

The electron and positron are denoted by

$$(-e_*, m_e) \qquad \text{and} \qquad (+e_*, -m_e) \tag{2}$$

where $-e_*$ and m_e are the bare electron charge and mass, and $+e_*$ and $-m_e$ are the positron (a PV hole) effective charge and effective mass [2]. Similarly, the proton and anti-proton are denoted by

$$(+e_*, -m_p) \qquad \text{and} \qquad (-e_*, m_p) \tag{3}$$

where it is noted that the proton, being a hole in the PV, has an effective charge $(+e_*)$ and an effective mass $(-m_p)$. The negative masses in (2) and (3) are a reflection of the fact that the positron and proton are holes in a *negative-energy* vacuum state.

2 Neutron Decay and the Electron Mass

The neutron is denoted by $(+e_*, -m_p)(-e_*)$ and consists of some unknown combination of the proton and the massless bare charge — the neutron is *not* assumed to be a proton-electron composite. How the neutron decays into the proton in the PV paradigm is also unknown. Thus the decay mode discussed below is a best guess that preserves the PV model of the proton as a vacuum hole and the neutrino as a phonon-like disturbance of the PV state [3].

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Assume for example that the unstable neutron is a distorted PV hole with a bare charge inside, thus creating a neutral particle. This distortion perturbs the PV in such a way that the neutron-PV interaction forces the neutron to decay into the stable proton by ejecting its bare charge into free space. In the process the PV suffers a phonon-like disturbance that is represented as an antineutrino "particle". After being ejected into free space, the bare charge is driven by the random zero-point electric field, thus quickly becoming an electron. The diagram for this two-step decay mode is

$$(+e_*, -m_p)(-e_*) \longrightarrow (+e_*, -m_p) + \overline{\nu}_e + \overbrace{(-e_*)}^{10^{-40}\text{sec}} \tag{4}$$

$$\longrightarrow (+e_*, -m_p) + \overline{\nu}_e + (-e_*, m_e) \tag{5}$$

where the first step lasts roughly 10^{-40}sec while the bare charge becomes, in the final step, a massive electron.

In a nonrelativistic calculation Puthoff [4] [5] shows that the electron mass

$$m_e = \frac{4r_e e_*^2}{9r_*^2}\frac{\langle \dot{r}^2 \rangle}{c^2} = \frac{e_*^2}{r_e c^2} \tag{6}$$

results from the bare charge being driven by the zero-point electric field [see the Appendix of the present paper], where $\dot{r}$ is the instantaneous random velocity of the charge about its average position. Calculating $\langle \dot{r}^2 \rangle$ leads to

$$\left(\frac{< \dot{r}^2 >}{c^2}\right)^{1/2} = \frac{3}{2}\frac{r_*}{r_e} \sim 10^{-22} \tag{7}$$

showing that the rms charge velocity is about twenty-two orders of magnitude less than the speed of light. This small magnitude is due to the large number ($\sim 10^{99}$ per cm^3) of agitated Planck particles in the PV contributing simultaneously to the zero-point field whose rapid fluctuations prevent a build up of the charge velocity.

3 Nuclear Stability

It is hard to believe that the neutron is unstable in free space and yet stable in the atomic nucleus. There is also the question of why there are so many neutrons in the nucleus. Consequently this section argues that the massless bare charge $(-e_*)$ associated with the neutrons in the nucleus is freely exchanged, back and forth, between near-neighbor nuclear protons for the express purpose of reducing the disruptive Coulomb force within the nucleus arising from the positive nuclear charge $Ze = Z\alpha^{1/2}e_*$, where α is the fine structure constant [1]. In other words the neutrons and protons are continuously "changing places"

$$[(+e_*, -m_p)(-e_*)] + (+e_*, -m_p) \longleftrightarrow (+e_*, -m_p) + [(+e_*, -m_p)(-e_*)] \tag{8}$$

to reduce or eliminate the Coulomb repulsion between the protons. The nature of the nucleus tends to support this idea [6, pp.551-553]: the specifically *nuclear* properties of protons and neutrons appear to be identical; and those nuclei having the greatest stability have equal numbers of protons and neutrons. Furthermore, there appear to be no free electrons within the nucleus. The absence of nuclear electrons suggests that the bare-charge exchange between neutrons and protons takes place between nearest-neighbor particles so that the bare charge has insufficient time ($<10^{-40}$sec) to develop an electron mass in its travel between the neutron and proton.

A rough estimate for the minimum shift-frequency of the bare charges between neutrons and protons can be obtained from a crude heuristic model for the ^{4}He atom, an atom containing two protons and two neutrons. Suppose a set of opposing neutrons and a set of opposing protons have the centers of their respective spheres located at the corners of a square with the surfaces of the neutrons just touching the proton surfaces, the particles being held in place by the nuclear strong force. If a is the radius of the spheres, then the length of the sides and diagonals of the square are $2a$ and $2\sqrt{2}a$ respectively. Subtracting the side of the square from its diagonal leads to the distance $2(\sqrt{2}-1)a$ along the diagonals between the inner surfaces of the opposing spheres. Now suppose that the two neutrons have just lost their bare charges to their neighboring protons — the neutrons have turned into protons and vice versa. Then the time interval required for the Coulomb fields of the newly formed protons to reach the opposing proton is $2(\sqrt{2}-1)a/c$, where c is the speed of light. So the shift-frequency is the reciprocal of this time, $f = c/2(\sqrt{2}-1)a$. For $a = 1.2 \times 10^{-13}$cm, $f = 3 \times 10^{23}$hertz. That is, the two bare charges must be shifting back and forth between the neutrons and protons at a rate of 3×10^{23} times per second to nullify the disruptive Coulomb force between the protons of the ^{4}He atom. Since the same process takes place only between nearest-neighbor sets of nucleons within the heavier atoms, this frequency shift is assumed to apply to those atoms also.

The question of 'how the two electrons in the ^{4}He atom react to the on-off protons in the nucleus' naturally arises. The first Bohr orbit of an electron in the field of the nucleus is given by [6, p.74]

$$r_1 = \frac{\hbar^2}{m_e(2e)^2} = \frac{r_e}{4\alpha} = 1.3 \times 10^{-9}\,[\text{cm}] \tag{9}$$

while the nuclear radius is [6, p.551]

$$R = 1.2 \times 10^{-13}\,A^{1/3} = 1.9 \times 10^{-13}\,[\text{cm}] \tag{10}$$

so $r_1/R = 6800$. Thus, since one of the two possible sets of opposing protons is always turned on and perturbations on the nuclear surface are practically indistinguishable by the distant electrons, the Bohr electrons see only a far-distant nucleus with the constant Coulomb field of a $2e$ nuclear charge.

Besides providing the driving force that creates the electron mass, the zero-point electromagnetic field may also be the stimulus that drives the neutron-trapped bare charges to the protons to reduce the internal Coulomb repulsion energy, maximizing the nuclear binding energy. Boyer [7] has shown that, in the electron case, the energy radiated by the bare electron charge just replaces that being absorbed from the zero-point background fields on a detailed-balance basis, leaving the background unchanged. Thus the bare-charge shifting mechanism may be an equilibrium phenomenon taking place between the bare charges and the zero-point background radiation.

4 Conclusion

Nuclear forces are orders-of-magnitude stronger than the electromagnetic forces; thus it is difficult to find experimental verification for the bare-charge exchange process described above, but the Weizsäcker semiempirical formula for nuclear binding energy [6, p.551]

$$E_B(Z,N) = 15.7A - 17.8A^{2/3} - \overbrace{\frac{0.712Z(Z-1)}{A^{1/3}}}^{\text{Coulomb effect}}$$
$$-\frac{23.6(N-Z)^2}{A} \pm \frac{132}{A}\begin{cases}\text{even–even}\\ = 0,\ A\ \text{odd}\\ \text{odd–odd}\end{cases} \qquad [\text{MeV}] \tag{11}$$

can provide some perspective. Z and N are the atomic and neutron numbers and $A\,(=Z+N)$ is the mass number. The constant nuclear density leads to the first two terms that are analogous to the volumetric energy (minus the reduction in that energy due to the reduced surface-tension energy of the surface nucleons) in a chemical bond which exists only between a limited number of nearest-neighbor atoms. The third term is the Coulomb work required to bring Z protons into the nucleus. The hypothesis that the nuclear properties of neutrons and protons are the same and that the two tend to go into their respective nuclear energy states in pairs with opposing spins leads to the deduction that the nuclear binding energy is maximum if $N = Z$. This leads in part to the fourth and fifth terms.

The coefficient 0.712 of the Coulomb term, derived *theoretically* from a simple electric-field model of the nuclear charge [6, p.553], should be discarded if the bare-charge-exchange mechanism described above is fully operative. Furthermore, for $A = 1$ this coefficient is only 4.5% of the of the next smallest constant 15.7 appearing in the formula; so data fitting the other coefficients without the third term would have little effect on those other coefficients and the resulting binding energy.

In effect, the Weizsäcker formula (11) is of little help in deciding whether or not the bare-charge exchange idea is valid. In closing then, while the exchange mechanism is an appealing speculation, it may be difficult to prove experimentally.

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Appendix: Bare Charge to Electron Mass

The nonrelativistic zero-point electric field driving the bare charge is [4] [5]

$$\mathbf{E}_{\mathrm{zp}}(\mathbf{r},t) = \mathrm{Re}\sum_{\sigma=1}^{2}\int d\Omega_k \int_0^{k_{c*}} dk\, k^2\, \widehat{\mathbf{e}}_\sigma \left\{A_k\right\} \exp\left[i\left(\mathbf{k}\cdot\mathbf{r} - \omega t + \Theta\right)\right] \qquad \text{(A1)}$$

where $k_{c*} = \sqrt{\pi}/r_*$ and $A_k = \sqrt{e_*^2 k/2\pi^2}$. The $e_*^2 = (-e_*)(-e_*)$ in A_k refers to the charge on the separate Planck particles constituting the PV. This stochastic field can be expressed in the more revealing form [1]

$$\mathbf{E}_{\mathrm{zp}}(\mathbf{r},t) = \left(\frac{\pi}{2}\right)^{1/2} \frac{e_*}{r_*^2}\, \mathbf{I}_{\mathrm{zp}}(\mathbf{r},t) \qquad \text{(A2)}$$

where $\mathbf{I}_{\mathrm{zp}}$ is a random variable of zero mean and unity mean square; so the factor multiplying $\mathbf{I}_{\mathrm{zp}}$ in (A2) is the root-mean-square zero-point field. Since e_* and r_* are PV parameters, the PV must be the source of this zero-point field.

It can be shown that combining (A1) and (A2) leads to

$$\left\langle \mathbf{I}_{\mathrm{zp}} \cdot \mathbf{I}_{\mathrm{zp}}^* \right\rangle^{1/2} = \frac{2r_*^2}{\pi}\left[\int_0^{k_{c*}} k^3 dk\right]^{1/2} = \frac{2}{\pi\omega_*^2}\left[\int_0^{\omega_{c*}} \omega^3 d\omega\right]^{1/2} = 1 \qquad \text{(A3)}$$

where $\omega = ck$ and $\omega_{c*} = \sqrt{\pi}\omega_* = \sqrt{\pi}c/r_*$. Splitting the integral in the final bracket yields

$$\left\langle \mathbf{I}_{\mathrm{zp}} \cdot \mathbf{I}_{\mathrm{zp}}^* \right\rangle^{1/2} = \frac{2}{{\omega_{c*}}^2}\left[\left(\int_0^{\omega_1} + \int_{\omega_1}^{\omega_{c*}}\right)\omega^3 d\omega\right]^{1/2} \qquad \text{(A4)}$$

$$= \left(1 - \frac{\omega_1^4}{{\omega_{c*}}^4}\right)^{1/2}\left[1 + \frac{\omega_1^4/{\omega_{c*}}^4}{1 - \omega_1^4/{\omega_{c*}}^4}\right]^{1/2} \approx 1 - \frac{(\omega_1/\omega_{c*})^4}{2} \qquad \text{(A5)}$$

for small ω_1/ω_{c*}. The cutoff frequency $\omega_{c*} = 3.3 \times 10^{43}$ rad/sec; so the magnitude of the ratio in (A5) is less than 10^{-10} for $\omega_1 = 1.2 \times 10^{41}$ rad/sec, implying that the first integral in (A4) contributes little to the vacuum field in (A1) or (A2).

The previous paragraph implies that the mass of the electron depends predominately on that part of the electric-field spectrum within the range $(\omega_1, \omega_{c*}) \sim (10^{41}, 10^{43})$; i.e., the final two extremely high-frequency decades of the spectrum. These limiting frequencies can be expressed as

$$\omega_1 \approx \frac{2\pi}{5 \times 10^{-41}} \qquad \text{and} \qquad \omega_{c*} \approx \frac{2\pi}{2 \times 10^{-43}} \,. \tag{A6}$$

so the average mass-producing cycling time for the fields in the above range is roughly 10^{-42}sec (the average denominators). Thus, even though it may take a hundred cycles of the upper zero-point-field spectrum to establish the electron mass, the process still only lasts about 10^{-40}sec (100×10^{-42}). In other words, it takes 10^{-40}sec for a bare charge injected into free space to develop the mass m_e and become an electron. It is noted that the mass-forming process is isotropic because of the random nature of the zero-point field.

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