ENERGY OF BETA DECAY AND SIZE OF NEUTRON

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ABSTRACT

Let as assume that the neutron is similar to hydrogen atom, and that the weight of a particle, as well as electrostatic interaction, is dependent on velocity. Taking the analytical relation between velocity and interaction force from Ampere's law, one may estimate the size of neutron and energy of beta decay from mass defect. Neglecting the movement of proton, r = 1.319331×10^{-15} m and E = 289.7695 keV.

INTRODUCTION

Neutron is uncharged unstable elementary particle. The life-time of neutron is about 15 min. The products of decay are proton and electron. The decay electrons, moving with velocities close to speed of light, are called "beta-particles". The mass defect at beta decay of neutron is 0.83265 g per kg of neutrons. In accordance with relation $E = \Delta mc^2$, this is equivalent to 75 TJ or 18 kt in TNT equivalent (1 g in TNT equivalent is 4184 J).

As expected, by a half and more, the nuclei of all atoms consist of neutrons. Thus, the energy of decay of neutrons of average inhabitant of the Earth is about of 30 Hiroshimas. Fortunately, neutron in nucleus is stable. Thus, "neutron in nucleus" is not neutron at all. Because the neutron is evidently unstable particle.

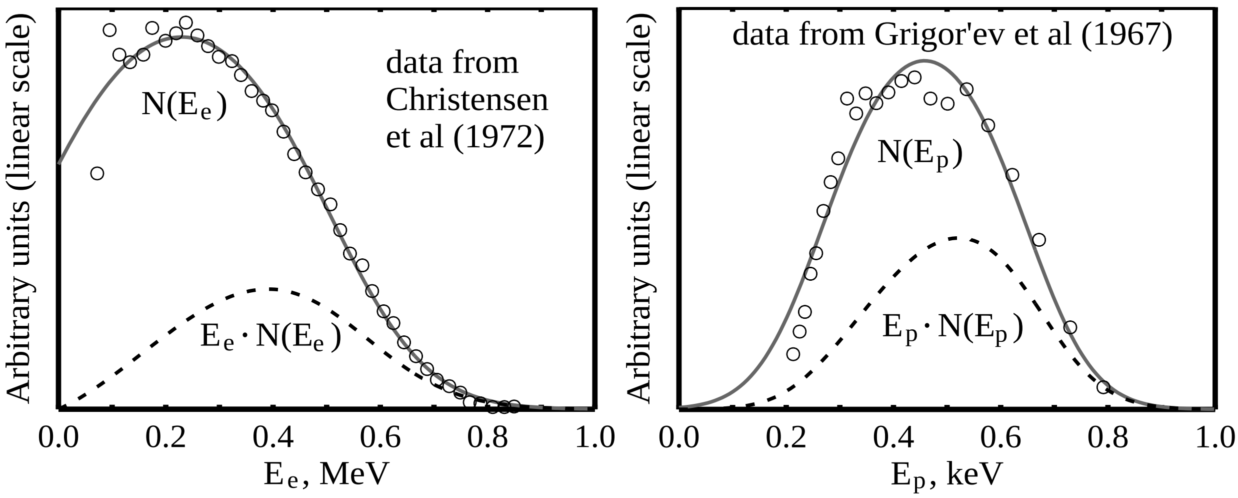

Fig. 1. Energetic spectrum of beta particles (left) and protons (right) at decay of neutron. Data from Christensen et al (1972) and Grigor'ev et al (1967), correspondingly.

In reality, the energy of beta decay of neutron is smaller than $\Delta m_n c^2$. Beta particles and protons have continuous energetic spectra. The value of intensity N(E) (see **Fig. 1**) is number of particles with energies between E-0.5Δ and E+0.5Δ, counted by detector per unit of time (Δ is energetic resolution of detector). The dependence of intensity on energy may be approximated by some empirical function, e.g.:

$$N(E) = 2N_{max}/[1+\exp\{(E- E_{Nmax})^2/E_\sigma^2\}] \quad (1)$$

Here N_{max} is maximum intensity, E_{max} is energy at maximum intensity, and E_σ is semi-wide of peak. Arithmetic mean energy of the decay particle may be found via division of area below the curve E·N(E) by area below the curve N(E). From data in **Fig. 1**, one may obtain the following estimates: arithmetic mean energy of beta particle is 289±15 keV, and that for decay proton is 458±10 eV. Thus the overall energy of beta decay of neutron is, practically, energy of beta particle. In units of mass defect, the energy of beta decay of neutron is $(0.37\pm0.02)\Delta m_n c^2$.

The idea that the neutron consists of proton and electron (Rutherford, 1920) is older than experimental discovery of neutron (Chadwick, 1932). However, the neutron has permanent magnetic moment, and thus, neutron is elementary particle. From the other hand, the atom of hydrogen also has almost permanent magnetic moment, although it consists of two elementary particles. In the hydrogen atom, magnetic moment of electron is ~ 660 times larger than that of proton. Thus, magnetic moment of the hydrogen atom is (± 0.15 %) equal to that of electron. The system of two different elementary particles may have permanent magnetic moment, and this is experimental fact. Therefore, the idea of Rutherford, at least, may be true.

HYPOTHESIS

So, let us assume that the neutron looks like hydrogen atom. However, the radius of electron orbit is much smaller, whereas the orbital velocity of electron is much higher. With high accuracy, hydrogen atom may be described by the Coulomb's and Newton's laws. However, in case of neutron, the contribution of magnetic forces should be significant. Thus, it is necessary to consider the Ampere's law.

In accordance with the Ampere's law, the force between two endless parallel currents with strengths I_1 and I_2 (A = C/s) is described by:

$$F_M/\Delta L,\ N/m = \{1/10^7\}2I_1I_2/r \quad (2)$$

This is attraction, if the currents flow in the same direction, and repulsion, if the currents flow in opposite directions. One may see, that the Eq. (2) is similar to the Coulomb's law for two parallel needles with linear charges η_1 and η_2 (C/m):

$$F_C/\Delta L\ ,\ N/m = - \{c^2/10^7\}2\eta_1\eta_2/r \quad (3)$$

Here c is speed of light. The Ampere's law for two parallel elements I_1dL_1 and I_2dL_2 (A×m = C×m/s), orthogonal to distance r, is:

$$F_M\ ,\ N = \{1/10^7\}\{I_1dL_1\}\{I_2dL_2\}/r^2 \qquad (\text{at } \vec{I}_1 \parallel \vec{I}_2;\ \vec{I} \perp \vec{r}\ ) \quad (4)$$

In this case, the force is directed along the distance r. This equation is similar to Coulomb's law for point charges q_1 and q_2 (C):

$$F_C\ ,\ H = - \{c^2/10^7\}q_1q_2/r^2 \quad (5)$$

Note that the analogy between the Coulomb's and Ampere's laws fails at breach of $\vec{\imath} \perp \vec{r}$.

One may easily be convinced that Eq. (4) is equivalent to:

$$F_{C+M}\text{, N} = -\{c^2/10^7\}\{q_1q_2/r^2\}\{1 + 0.5v_{12}^2/c^2\} \qquad (\text{at } \vec{v}_{12} \perp \vec{r}\,) \qquad (6)$$

Here v_{12} is velocity of charge q_1 relative to charge q_2 (e.g., velocity of electron in conductor 1 relatively to electron or metal ion in conductor 2). If $\vec{v}_{12} \perp \vec{r}$, the force between charges is directed along the distance r, and action is equal to contra-action. Summing up the forces between electrons on conductance, and immovable metal ions of two metallic conductors, one may obtain Eq. (4) from Eq. (6). However, there is no elegance. For esthetic reasons, let us change Eq. (6) to:

$$F_{C+M}\text{, N} = -\{c^2/10^7\}\{q_1q_2/r^2\}\{1 + v_{12}^2/c^2\}^{0.5} \qquad (\text{at } \vec{v}_{12} \perp \vec{r}\,) \qquad (7)$$

At small v_{12}, Eq. (7) coincides with Eq. (6), and thus with Eq. (4). At v_{12}, comparable with speed of light, Eq. (7) gives smaller magnet interaction than Eqs. (6) and (4).

It is likely that the Nature manages with few relations. Thus, the force of gravity, applied to, e.g., moving automobile, should be consistent with similar relation:

$$F_g\text{, N} = gm\{1 + v^2/c^2\}^{0.5} \qquad (\text{at } \vec{v} \perp \vec{g}\,) \qquad (8)$$

Here g is acceleration of gravity. Calling the value $m\{1 + v^2/c^2\}^{0.5}$ as "weight", one may define the mass defect as difference between weight and mass:

$$\Delta m = m\{1 + v^2/c^2\}^{0.5} - m \qquad (\text{at } \vec{v} \perp \vec{g}\,) \qquad (9)$$

This relation is probably valid for the horizontal and uniform movement. In general case, the weight is probably more complex function, dependent on direction of movement and acceleration. Perhaps, at the movement of electron around the proton, the weight of electron changes in time. However, it is possible that the time-average weight of electron is consistent with Eq. (9). In this case, orbital velocity of electron may be found from:

$$\Delta m_n = m_e\{1 + v_e^2/c^2\}^{0.5} - m_e \qquad (10)$$

Table 1. Some World constants (Mohr et al, 2012).

Property	Symbol/Relation	Value
Neutron mass	m_n	$1674.927351\times10^{-30}$ kg
Proton mass	m_p	$1672.621777\times10^{-30}$ kg
Electron mass	m_e	$0.910938291\times10^{-30}$ kg
Mass defect at beta decay of neutron	$\Delta m_n = m_n - m_p - m_e$	1.394636×10^{-30} kg
- in electron masses	$\Delta m_n/m_e$	1.530988
- energy equivalent	Δm_nc^2	1.253436×10^{-13} J
- energy equivalent in electron-Volts	$\Delta m_nc^2/e$	782333.3 eV
Elementary charge	e	$1.602176565\times10^{-19}$ C
Speed of light in vacuum	c	299792458 m/s

From Eq. (10) and $\Delta m_n/m_e = 1.530988$ (see **Tab. 1**), one may obtain the orbital velocity and kinetic energy of electron:

$$v_e = 2.325059c \quad (11)$$

$$E_k = m_e v_e^2/2 = 1.765494\Delta m_n c^2 \quad (12)$$

The centrifugal force is:

$$F_{cent} = m_e v_e^2/r_e \quad (13)$$

Because the condition $\vec{v}_{12} \perp \vec{r}$ is satisfied, the force of attraction between electron and proton may be found from Eq. (7), i.e.:

$$F_{C+M} = \{c^2/10^7\}\{e^2/r_e^2\}\{1 + v_e^2/c^2\}^{0.5} = 2.530988\{c^2/10^7\}\{e^2/r_e^2\} \quad (14)$$

The orbital stability is defined by $F_{cent} = F_{C+M}$, and thus:

$$m_e v_e^2 = 2E_k = 2.530988\{c^2/10^7\}\{e^2/r_e\} = 2.530988E_p \quad (15)$$

From this equality, the potential energy E_p and orbital radius r_e are:

$$E_p = 1.395103\Delta m_n c^2 \quad (16)$$

$$r_e = 1.319331\times10^{-15}\ \text{m} \quad (17)$$

Thus, energy of beta decay of neutron is:

$$E = E_k - E_p = 0.3703914\Delta m_n c^2 = 289.7695\ \text{keV} \quad (18)$$

As may be seen, consistence with experiment is excellent. For the movement around the center of masses, changes are not too significant: $r_e = 1.319550\times10^{-15}$ m, and E = 289.3958 keV. Interestingly, that the calculated orbital radius of electron in neutron is close to estimates for radius of neutron. Based on sizes of nuclei (various methods), from volume per nucleon, $r_n \approx 1.2\div1.5\times10^{-15}$ m (Karyakin et al, 1962).

CONCLUDING REMARKS

Of course, the considerations above are wrong, and this is not due to contradictions with various theories. For instance, in accordance with present model, the deuteron, considered by analogy with ion H_2^+, should be heavier than two protons and one electron, which does not correspond to the fact. This reduces "theory" down to unexplainable correlation between the World constants. From the other hand, as happens very often, several consecutive errors may eliminate each other. Thus, there is possibility that the present model gives exact result. In any way, the proton-electron model of neutron seems to be more profitable than "neutron-as-is" model.

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