Neutroneum – Applications of the Half-Phenomenological Approach

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Abstract

The formalism of the half-phenomenological theory of the exotic electroweak processes is described. The unusual aspects of exonuclear reaction and its application to biophysics are discussed.

1. Introduction

The existence of the metastable quasi-bound (unbound) state of the electron and proton (so called neutroneum - neutrinos exoatom) as a result of the underthreshold induced electrons capture in the inelastic $eu \to \nu d$ quantum transition was proved in [1].

The aim of this paper is to formulate the adequate half-phenomenological formalism, which one can use to calculate lifetime of the neutroneum and its creation cross-section at the low-energy region and use it to explain the bionucleosynthesis phenomena in the framework of the theory of the exotic electroweak processes and exonuclear reactions.

2. Main formalism

The Hamiltonian of the self-consistent neutrino atoms includes weak lepton and weak nucleon currents [1]

$$\begin{cases} j_l^\lambda(\vec{r},t) = \left(\bar{\psi}_e(\vec{r})\gamma^\lambda(1-\gamma_5)\psi^k_{j_\nu m_\nu}(\vec{r})\right)\cdot\exp\left(-i(\varepsilon_\nu - \varepsilon_e)t\right) \\ j_N^\mu(\vec{r},t) = \left(\bar{\psi}_n(\vec{r})[\tilde{f}_1 + \tilde{g}_1\boldsymbol{\gamma}_5]\boldsymbol{\gamma}^\mu\psi_p(\vec{r})\right)\cdot\exp\left(-i(\varepsilon_p - \varepsilon_n)t\right) \end{cases}, \quad (1)$$

where

$$\psi^k_{j_\nu m_\nu}(\vec{r}) = \begin{pmatrix} g_k(r)\ \chi^k_{lj_\nu m_\nu} \\ if_{-k}(r)\chi^{-k}_{l'j_\nu m_\nu} \end{pmatrix}, \quad (2)$$

where g and f are the Dirac radial wave function (WF) of the discrete spectrum of the leptons. More detail see in [1].

Change the ideology and system of designations of the relativistic quantum theory of the field to the formalism and a conceptual framework used for the description β - processes in the low energies nuclear physics, is as follows.

1) Time integration of the Hamiltonian $h_{e+p\leftrightarrow n_\nu}$ [1] instead of the Hamiltonian $h_{p+e\to n+\nu}$ leads to change the final expressions for probability of neutroneum decay and creation cross-section reactions. Thus matrix elements for $p+e\to n+\nu$ reaction contains δ- functions $\delta(\varepsilon_e+\varepsilon_p-\varepsilon_\nu-\varepsilon_n)$. It means that the energy conservation law is carried out automatically. In our case $\left|in\right\rangle$ or $\left\langle out\right|$ states designate as neutroneum – the real particle lying on the mass surface. If to treat it as the quasi-bound state of two quasi-particles, than in the energy conservation law

in expressions for probabilities of decay and creation cross-sections appear δ-function $\delta(\varepsilon_e + \varepsilon_p - \varepsilon_{n_\nu})$.

2) The Hamiltonian of creation and decay of the neutroneum is the sum of two Hermite-conjugated terms:

$$h_{e+p\leftrightarrow n_\nu} = h_{e+p\to n_\nu} + h_{n_\nu\to e+p}, \tag{3}$$

where

$$h_{e+p\to n_\nu} = [h_{n_\nu\to e+p}]^+. \tag{4}$$

3) In the framework of δ- forces approximation, traditionally used in the low energies nuclear physics, the Hamiltonian (4) has a form

$$h_{n_\nu\to e+p} = \frac{G}{\sqrt{2}}\gamma_\lambda(1-\gamma_5)[(\tilde{f}_1 + \tilde{g}_1\boldsymbol{\gamma}_5)\boldsymbol{\gamma}^\lambda]^+\tau_+\delta(\vec{r}_\nu - \vec{r}_n)\delta(\vec{r}_e - \vec{r}_p)\delta(\vec{r}_p - \vec{r}_n). \tag{5}$$

The isospin operators $\tau_\pm$ are defined by ratios

$$\begin{cases}\tau_+ = (\tau_1 + i\tau_2)/2 = -\tau_{+1}/\sqrt{2}\\ \tau_- = (\tau_1 - i\tau_2)/2 = \tau_{-1}/\sqrt{2}\end{cases} \Rightarrow \begin{cases}\tau_+\chi_{1/2} = 0;\ \tau_+\chi_{-1/2} = \chi_{1/2}\\ \tau_-\chi_{-1/2} = 0;\ \tau_-\chi_{1/2} = \chi_{-1/2}\end{cases}, \tag{6}$$

where $\chi_{1/2}(\vec{T})$ ($\chi_{-1/2}(\vec{T})$) - isospin WF of a proton (quasi-neutron), and operators $\tau_\pm$ are expressed through Pauli matrixes τ_1 and τ_2 (τ_{+1}, τ_{-1}) [2].

4) The states $\left|in\right\rangle$, and $\left|out\right\rangle$ for a Hamiltonian (5) are:

$$\begin{cases}\left|in\right\rangle = \left|n_\nu\right\rangle = \sum\limits_{m_n, m_\nu} C^{j_{n_\nu} m_{n_\nu}}_{1/2\, m_n\, 1/2\, m_\nu}\left|\hat{\nu}_e\right\rangle \otimes \left|\hat{n}\right\rangle\\ \left|out\right\rangle = \left|H^*\right\rangle = \left|e\right\rangle \otimes \left|p\right\rangle\end{cases}, \tag{7}$$

where $\left|\hat{\nu}_e\right\rangle$ and $\left|\hat{n}\right\rangle$- WF of a quasi-neutrino and quasi-neutron, respectively. Further "hat" $\frown$ over WF we omit as it cannot result in ambiguity of interpretation of the text. Neutroneum has whole spin $j_{n_\nu} = 0\ or\ j_{n_\nu} = 1$, i.e. is a boson.

5) In a coordinate representation the lepton WF-s are

$$\begin{cases}\psi_e(\vec{r}_e) = \dfrac{1}{\sqrt{V}}\cdot\exp(i\vec{k}_e\vec{r}_e)u_e(\vec{k}_e)\\ \psi_\nu(\vec{r}) = \begin{pmatrix} g_k(r)\ \chi^k_{ljm_j}\\ if_{-k}(r)\chi^{-k}_{l'jm_j}\end{pmatrix}\end{cases}, \tag{8}$$

and nucleon WF-s are

$$\begin{cases}\psi_p(\vec{r}_p) = V^{-1/2}\cdot\exp(i\vec{k}_p\vec{r}_p)u_p(\vec{k}_p)\chi_{1/2}(\vec{T})\\ \psi_n(\vec{r}_n) = V^{-1/2}\cdot\exp(i\vec{k}_n\vec{r}_n)u_n(\vec{k}_n)\chi_{-1/2}(\vec{T})\end{cases}. \tag{9}$$

6) The Dirac - conjugated electron WF in matrix elements (ME) of $n_\nu \to e + p$ - transition is

$$\bar{\psi}_e(\vec{r}_e) = V^{-1/2}\cdot[\exp(i\vec{k}_e\vec{r}_e)u_e(\vec{k}_e)]^+\gamma^0. \tag{10}$$

7) The nonrelativistic limit in the nucleon's space is reduced to neglecting small components of bispinor $u(\vec{k})$. At the same time bispinor $u(\vec{k})$ are replaced with Pauli spinor χ:

$$u(\vec{k}) \to \chi_m(\vec{s}), \tag{11}$$

where $\vec{s}$ - spin of the corresponding nucleon, and m - projection of the spin.

8) At substitution (11) Dirac matrix $\boldsymbol{\gamma}^0$ it is replaced by the Pauli matrix $\boldsymbol{\sigma}_0 = 1$, and Dirac matrix $\vec{\boldsymbol{\gamma}}$ are replaced by the Pauli matrixes $\vec{\boldsymbol{\sigma}}$.

Isospin ME of a Hamiltonian (5) is

$$M_{isospin} \equiv \left\langle out \left| h_{n_\nu \to e+p} \right| in \right\rangle_{isospin} = \left\langle \chi_{1/2}(\vec{T}) \left| \tau_+ \right| \chi_{-1/2}(\vec{T}) \right\rangle = 1. \tag{12}$$

Spatial ME of the Hamiltonian (5) is equal

$$\begin{aligned} M_{space} &= V^{-3/2} \cdot \int d\vec{r}_e d\vec{r}_p d\vec{r}_\nu d\vec{r}_n e^{-i\vec{k}_e\vec{r}_e - i\vec{k}_p\vec{r}_p + i\vec{k}_n\vec{r}_n + i\vec{k}_\nu\vec{r}_\nu} \times \\ &\times \delta(\vec{r}_\nu - \vec{r}_n)\delta(\vec{r}_e - \vec{r}_p)\delta(\vec{r}_p - \vec{r}_n) b_\lambda(\vec{r}_\nu - \vec{r}_n) \end{aligned}. \tag{13}$$

The value of radius $\vec{r} = \vec{r}_\nu - \vec{r}_n = 0$ in (13) is fixed by translation invariance of the Hamiltonian (5). It allows us to get the general multiplier in spatial ME $(2\pi)^3 \delta(\vec{k}_{n_\nu} - \vec{k}_e - \vec{k}_p)$:

$$M_{space} = V^{-3/2} \cdot (2\pi)^3 \delta(\vec{k}_{n_\nu} - \vec{k}_e - \vec{k}_p) b_\lambda(\vec{r} \approx 0), \tag{14}$$

where $\vec{k}_{n_\nu} = \vec{k}_n + \vec{k}_\nu$. At the same time momentum conservation law, and $\vec{r}$ - dependence of $b_\lambda(\vec{r})$ is absent; ME b_λ depend only on the spin projections of an electron and a quasi-neutrino.

The components of 4- vector of spin ME b_λ in the lepton sector are:

$$\left\langle out \left| (h_{n_\nu \to e+p})^l_\lambda \right| in \right\rangle_{spin} \equiv b_\lambda(\underline{m}_e, \underline{m}_\nu) = \left(\overline{u}_e \gamma_\lambda (1 - \gamma_5) u_\nu \right), \tag{15}$$

where $\underline{m}_e, \underline{m}_\nu$ - are the electron and neutrino spin projections. These ME in cyclic basis at the low energies limit are equal

$$\begin{cases} b_0(\underline{m}_e, \underline{m}_\nu) \approx g_{-1}(r_N)(4\pi)^{-1/2} \delta_{\underline{m}_e \underline{m}_\nu} - i f_1(r_N) \sum\limits_{m_l} C^{1/2 \underline{m}_\nu}_{1m_l \; 1/2 \underline{m}_e} Y_{1m_l}(\vartheta, \varphi) \\ b_k(\underline{m}_e, \underline{m}_\nu) \approx \sqrt{3} \left[g_{-1}(r_N)(4\pi)^{-1/2} C^{1/2 \underline{m}_e}_{1k \; 1/2 \underline{m}_\nu} - i f_1(r_N) \sum\limits_{m_l, \sigma} C^{1/2 \underline{m}_\nu}_{1m_l \; 1/2\sigma} C^{1/2 \underline{m}_e}_{1k \; 1/2\sigma} Y_{1m_l}(\vartheta, \varphi) \right] \end{cases}, \tag{16}$$

where $\underline{m}_p, \underline{m}_n$ - are the proton and quasi- neutron spin projections, channel radius $r_N \approx 0.86\, fm$. The components of the spin ME in the nucleons space are similar:

$$\left\langle out \left| (h_{n_\nu \to e+p})^N_\lambda \right| in \right\rangle_{spin} \equiv d^\lambda(\underline{m}_p, \underline{m}_n). \tag{17}$$

The full transition $n_\nu \to e + p$ ME in the spin space is the linear combination of scalar products of the two 4- vectors

$$M_{spin} = \sum_{\underline{m}_n, \underline{m}_\nu} C^{j_{n_\nu} \underline{m}_{n_\nu}}_{1/2 \underline{m}_n \, 1/2 \underline{m}_\nu} b_\lambda(\underline{m}_e, \underline{m}_\nu) \cdot d^\lambda(\underline{m}_p, \underline{m}_n). \tag{18}$$

As a result we receive ME of the Hamiltonian (5):

$$\left\langle out \left| h_{n_\nu \to e+p} \right| in \right\rangle = \frac{\hat{G}_\beta}{\sqrt{2}} \cdot V^{-3/2} \cdot (2\pi)^3 \delta(\vec{k}_{n_\nu} - \vec{k}_e - \vec{k}_p) \cdot M_{spin}, \tag{19}$$

where $G_\beta = f_1 G$ (G_β - constant for nuclear β - processes), and spin ME is equal

$$M_{spin} = \sum_{\underline{m}_n, \underline{m}_\nu} C^{j_{n_\nu} \underline{m}_{n_\nu}}_{1/2 \underline{m}_n 1/2 \underline{m}_\nu} \left\langle \chi_{\underline{m}_p} \left| b_0(\underline{m}_e, \underline{m}_\nu) + \lambda \cdot (\vec{b}(\underline{m}_e, \underline{m}_\nu) \cdot \vec{\sigma}) \right| \chi_{\underline{m}_n} \right\rangle, \tag{20}$$

where $\lambda = g_1 / f_1 \approx 1.23$.

3. Biophysics

The nuclear transmutation in biological systems was discovered by C.L. Kervran [4]. He investigated the potassium transmutation into calcium in the biological system containing hydrogen (see fig. 1). For more details and references see [5].

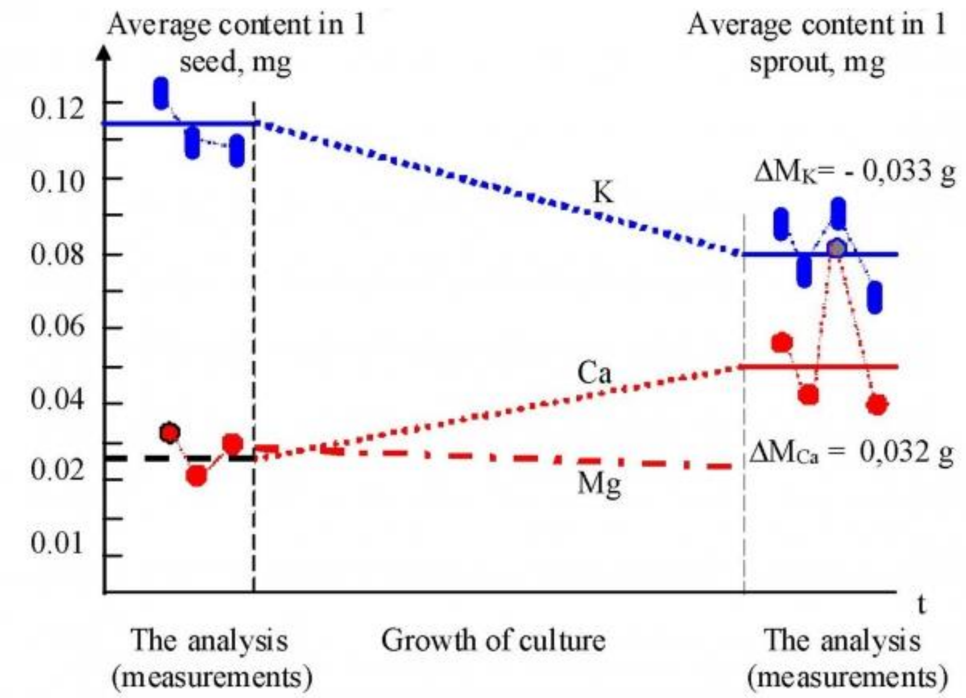

Fig. 1. *The left and the right parts of figure show the measurement results by three series and average results. There are the decrease of potassium* K and the *increase of calcium* Ca $(\Delta M_{Ca} = 0.032\, g)$ *[4].*

Evidently that exonuclear reactions in the biological objects takes place only in the presence of the heavy water (D_2O) because of the extremely low threshold of the reaction

$$e^- + {}^2_1H \to e^- + D_\nu, \tag{21}$$

where symbol D_ν designates the dineutroneum (the bound state of the neutron and neutroneum). The charge conservation low is valid according to ${}^2_1H$ and D_ν in (21) are the neutral atoms [1]. The threshold of the reaction (21) is about $0.1\ eV$ and abundance of the deuterium $(a \sim 1.5\cdot 10^{-4})$ is enough to enough to realize Kervran's reaction.

Thus the exit channel of the simplest exonuclear reaction with dineutroneum and carbon is open

$$ {}_{6}^{12}C + D_{\nu} \to ({}_{6}^{14}C)_{\nu} \to {}_{6}^{14}C + \nu_{e} + 10.9\ MeV . \quad (22)$$

This result says: we need to check out our knowledge on the radiocarbon analysis.

Let's consider another extremely interesting example – so-called radio-calcium analysis.

One of the more probable reactions inside the cells is

$$ {}_{19}^{39}K + D_{\nu} \to ({}_{20}^{41}Ca)_{\nu} \to {}_{20}^{40}Ca + p + e^{-} + \tilde{\nu}_{e} + \nu_{e} + \Delta E_{K\to Ca} - \varepsilon_{d} \quad (23)$$

with the free proton in the continuous spectrum. According to (21) transformation deuteron – dineutroneum is possible and reaction (23) is not forbidden.

Alternative reaction is

$$ {}_{19}^{39}K + D_{\nu} \to ({}_{20}^{41}Ca)_{\nu} \to {}_{20}^{41}Ca + e^{-} + \tilde{\nu}_{e} + \nu_{e} + \Delta E_{1} \quad (24)$$

with proton bound in calcium. The branching ratio for the reaction (23) and (24) is

$$ {}_{19}^{39}K + D_{\nu} \to ({}_{20}^{41}Ca)_{\nu} \to \left\{ \frac{{}_{20}^{40}Ca + p + e^{-} + \tilde{\nu}_{e} + \nu_{e}}{{}_{20}^{41}Ca + e^{-} + \tilde{\nu}_{e} + \nu_{e}} \right. \approx 1.4\cdot 10^{5}. \quad (25)$$

The nucleus ${}_{20}^{41}Ca$ is unstable. As a result the comparison of the calcium isotope abundances from the reactions (23) and (24) in the ancient bones permits one to find the age of the bones. This fact could be extremely useful for archeologists.

Hypothetical reactions (22)-(24) are supported by the data of A.A. Kornilova [5]. In the works of the Kornilova's group the hypothetical reaction in the biological objects

$$ p({}_{55}^{137}Cs, {}_{56}^{137}Ba)n \quad (26)$$

was investigated. Isotope barium-137 was found.

But we have to remember, that

$$ \varepsilon_{b}({}_{55}^{137}Cs) = 1149.286072\ MeV; \quad \varepsilon_{b}({}_{56}^{137}Ba) = 1149.680299\ MeV . \quad (27)$$

As a result

$$ \varepsilon_{b}({}_{56}^{137}Ba) - \varepsilon_{b}({}_{55}^{137}Cs) < m_{n} - m_{p} = 1.3\ MeV \quad (28)$$

and charge-exchange reaction (26) forbidden, i.e. reaction (26) has the threshold. Thus we have to search alternative mechanisms of nuclear reactions in the living cells (see (22) – (24)).

4. Conclusion

- The early lifetime calculation [3] for the neutroneum was essentially improved.
- The short description of the formalism [1] may be useful as a base of the theory of bionucleosynthesis.
- The new explanation of the calcium method of the age measurements in the archeology is given.
- New and very promising mechanism of the radiocarbon synthesis is proposed.
- We can consider the results of this paper as a way to explain the dominancy of the abundance of the odd-odd isotope ${}_{7}^{14}N$ in Nature instead of odd-even isotope ${}_{7}^{15}N$.

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