The optical model of quasi-confinement of a neutrino

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Abstract

It is shown that the hypothesis of existence of an exotic electroweak resonance "neutroneum" does not contradict the laws of physics. The optical model of quasi-confinement of a neutrino in a quasi-neutron is considered. Microscopic justification of this model within the QCD and Standard Model of electroweak interaction is given.

Introduction

It was shown that almost all "abnormal", "strange" and otherwise unexplained experimental data one can explain if we accept the hypothesis of existence of an exotic electroweak resonance of "neutroneum"[1] – [8]. But according to the expert community, the hypothesis of existence of neutroneum is wide open to criticism because of the following reasons:

- existence of the bound state of neutrino and neutron is strictly forbidden by Heisenberg's uncertainty principle;
- calculations within the Standard Model of electroweak interaction shows that the depth of *νn*- potential does not exceed 10 *keV*, while the mass of neutroneum is almost 1 *MeV* less than the mass of neutron;
- should one choose a very deep νn- potential, the depth of which is sufficient to bind a neutrino and a neutron, then a violation of stability of electroweak vacuum takes place alongside with the spontaneous generation of $\nu\tilde{\nu}$- pairs; this effect leads to violation of the energy conservation law.

At first sight, any of the above mentioned undisputable facts would be enough to draw the obvious conclusion: the hypothesis of existence of a neutroneum has to be rejected. However the detailed analysis of each of these counterarguments showed that any of them is not fatal to the hypothesis of existence of an exotic electroweak resonance of "neutroneum".

The aim of this work is to justify of the strong assertion: the hypothesis of existence a neutroneum does not contradict the known physical laws.

1. Heisenberg's Uncertainty Principle and Difference between Quasi-Bound state and Bound State

It was shown that for the induced e- capture (without a neutrino's emission) the asymptotic of the wave functions (WF) of a neutrino and an electron are [1] - [8]:

$$\psi_e(\vec{r}) = V^{-1/2} \cdot \exp(i\vec{k}_e\vec{r})u_e(\vec{k}_e); \quad \psi_\nu(\vec{r}) = \begin{pmatrix} g_k(r)\ \chi^k_{ljm_j} \\ if_{-k}(r)\chi^{-k}_{l'jm_j} \end{pmatrix} \tag{1.1}$$

It is known that the boundary conditions (1.1) are forbidden by Heisenberg's uncertainty principle. We must ban the boundary conditions (1.1) due to the fact that Compton's wavelength of a neutrino is much more than the neutron "size"

$$\lambda_C^{(\nu)} \gg r_N \approx 0.86\, fm \tag{1.2}$$

But this conclusion is premature.

According to Heisenberg's uncertainty principle

$$\Delta p \cdot \Delta x \geq \hbar \tag{1.3}$$

The radius of potential is always used as the estimate of uncertainty of coordinates of the particle in a three-dimensional potential [9]. From this standpoint (1.2) and (1.3) are in an unresolved logical contradiction, and forbid the bound state of a neutrino and a neutron. However this statement belongs only to truly bound states. For long-living resonances in coupled channels systems the inequalities (1.2) and (1.3) do not contradict each other (see [10]). Thus, the first and main counterargument to the theory of a neutroneum is invalid.

2. Relativistic Optical Model of the Quasi-Bound State

Let's prove that for the metastable state created in the induced electron capture[1] reaction the boundary condition

$$\lim_{r\to\infty}\psi_\nu(r)=0 \tag{2.1}$$

corresponds to the quasi-bound state of a quasi-neutrino and a quasi-neutron. The "quasi" means that we deals with the quasi-particles. A long delay of a neutrino inside the quarks matter which is a part of a nucleon leads to the following [8]:

- quarks "plunge into neutrino's matter";
- potential of *qq*- interaction "in the matter" differs from *qq*- potential in vacuum, and its renormalization leads to the decrease of the quasi-neutron mass compared to the mass of a neutron;
- *νq*- interaction leads to "massing" of a neutrino in a perfect analogy to physics of a solid state.

Let's consider a quasi-neutrino in the central optical potential $V(r)$. The equations for radial wave functions (WF) of a quasi-neutrino are:

$$\begin{cases}\dfrac{\partial g_k(r)}{\partial r}+\dfrac{1+k}{r}g_k(r)=[E-V(r)+\widehat{m}_\nu(r)]f_{-k}(r)\\ \dfrac{\partial f_{-k}(r)}{\partial r}+\dfrac{1-k}{r}f_{-k}(r)=-[E-V(r)-\widehat{m}_\nu(r)]g_k(r)\end{cases} \tag{2.2}$$

Dependence $\widehat{m}_\nu=\widehat{m}_\nu(r)$ takes into account that the mass of a quasi-neutrino in intra-nucleon matter is other than the mass of a neutrino in vacuum:

$$\lim_{r\to\infty}\widehat{m}_\nu(r)=m_\nu \tag{2.3}$$

where m_ν is the mass <u>of a neutrino</u>. The effect of renormalization of mass at the transition of a proton into a quasi-neutron (a quasi-nucleus of neutroneum) is included in the binding energy E.

We enter the radial WF $w=rg_k(r)$, $w_1=rf_{-k}(r)$ according to [11]

Due to the fact that the qualitative picture of the phenomenon is of the greatest interest we consider the potential:

$$\begin{cases}V(r>r_0)=0\\ V(r<r_0)=-V_0-iW_0\end{cases} \tag{2.4}$$

and $V_0>0$, $W_0\geq 0$. Imaginary part of potential $V(r)$ there corresponds to decay of the neutroneum on an electron and a proton.

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[1] Electron's capture by a proton without neutrino's emission.

We estimate the contribution of various mechanisms of forming a metastable state. If we consider the case of optical potential without mass renormalization ($W_0 = 0$, $\widehat{m}_\nu = m_\nu$, see [11]) than

$$\left(\frac{w_1}{w}\right)_{r=r_0-0} = \left(\frac{w_1}{w}\right)_{r=r_0+0} \tag{2.5}$$

If $\left|E\right| < m_\nu$ we get the self-energy equation [11]

$$1-(\alpha_\nu r_0)\cdot \mathrm{ctg}(\alpha_\nu r_0) = \frac{m_\nu r_0\sqrt{1-E^2 m_\nu^{-2}}+1}{1+Em_\nu^{-1}}\left[1+\sqrt{1+\alpha_\nu^2 m_\nu^{-2}}\right]. \tag{2.6}$$

where $\alpha_\nu^2 = (E+V_0)^2 - m_\nu^2 > 0$.

The results of the analysis of properties of solutions of the equation (2.6) depending on the potential depth are described in [11]. Our case differs only the sort of a particle in the bound state. Therefore difficulties of the theory in case of a neutrino are just the same, as well as in case of an electron.

If $\widehat{m}_n = m_n$, and potential radius V is equal to the electromagnetic radius of a proton $r_0 = 0.86\,fm$, for its depth we get: $\pi / r_0 \approx 721\,MeV$.

It means that the bound state of a neutrino and a neutron requires a very deep potential. As $m_\nu < 1\ eV$, and $m_n - m_p - m_e = 782.32\ keV$, therefore a deep potential spontaneously generates $\nu\tilde{\nu}$- pairs, that contradicts the energy conservation law. For this reason the formation of a quasi-stationary quasi-bound state of a neutrino and a neutron is impossible if $r_0 = 0.86\ fm$, $W_0 = 0$, $\widehat{m}_n = m_n$ and $\widehat{m}_\nu = m_\nu$.

In the case $W_0 \geq 0$, $\widehat{m}_\nu \neq m_\nu$, $\widehat{m}_n \neq m_n$, $r_0 \gg 0.86\ fm$ we can estimate the effect of renormalization of mass of a neutron and a neutrino in a neutroneum exoatom. In this case the values of masses of a neutron and a neutrino are different from those to vacuum values. Due to it we can consider a neutroneum as a quasi-bound state of a quasi-neutron and a quasi-neutrino.

According to this we assume that the "quasi-neutron" being a part "neutroneum" has a mass that is more than proton mass, but is less, than the mass of a neutron, and the mass of a "quasi-neutrino", on the contrary, is more than the mass of a neutrino:

$$\begin{cases} m_p < \widehat{m}_n < m_n \\ \widehat{m}_\nu > m_\nu \end{cases}, \tag{2.7}$$

Where $\widehat{m}_n$ is the mass of a "quasi-neutron", $\widehat{m}_\nu$ is the mass of a "quasi-neutrino", m_p is the mass of a proton, and m_n is the mass of a neutron.

If we assume what a "neutroneum" exists and is metastable, then the ban on spontaneous generation of $\nu\tilde{\nu}$- pairs at the violation of stability of electroweak vacuum in intensive weak fields means that the mass of a "quasi-neutrino" which is a part a neutroneum is rather large. The large value of the attached mass $\delta\widehat{m}_\nu = \widehat{m}_\nu - m_\nu$ is caused that the weak interaction sticks the u- and d- current quarks with masses ~2 MeV and 5 MeV to the quasi-bound neutrino.

The solution of the Sturm-Liouville problem for the Dirac's equation are the depths V_0 and W_0 of the optical potential V at the known ε and γ.

Equations (2.2) for the ground state $k=-1$ look like:

$$\begin{cases} \dfrac{d^2w}{dr^2}+\widehat{k}_\nu^2 w=0 \\ \dfrac{d^2w_1}{dr^2}-\dfrac{2}{r^2}w_1+\widehat{k}_\nu^2 w_1=0 \end{cases} \tag{2.8}$$

where $\widehat{k}_\nu^2=[E-V(r)]^2-\widehat{m}_\nu^2(r)$. At $r>r_0, \widehat{m}_\nu=m_\nu$ and $E=\varepsilon-i\gamma/2$ by definition:

$$\widehat{k}_\nu^2(r>r_0)\equiv-\kappa_\nu^2=(\varepsilon-i\gamma/2)^2-m_\nu^2=\varepsilon^2-i\gamma\varepsilon-\gamma^2/4-m_\nu^2 \tag{2.9}$$

If $\mathrm{Re}\,\widehat{k}_\nu^2(r>r_0)<0$ than the quasi-bound state is resolved. For quasi-stationary state $\gamma>0$. Therefore the energy ε satisfies the inequality

$$-\sqrt{m_\nu^2+\gamma^2/4}<\varepsilon<0 \tag{2.10}$$

If we use the approximation $\gamma\ll|\varepsilon|<m_\nu$, than $\kappa_\nu^2\approx m_\nu^2-\varepsilon^2+i\gamma\varepsilon$. Thus

$$\kappa_\nu\approx(m_\nu^2-\varepsilon^2)^{1/2}+i\varepsilon(\gamma/2)(m_\nu^2-\varepsilon^2)^{-1/2} \tag{2.11}$$

At $r<r_0$

$$\widehat{k}_\nu^2\equiv K_\nu^2=(\varepsilon-i\gamma/2+V_0+iW_0)^2-\widehat{m}_\nu^2 \tag{2.12}$$

and

$$\begin{cases} \mathrm{Re}\,\widehat{k}_\nu^2\equiv K_{1\nu}^2=(\varepsilon+V_0)^2-(W_0-\gamma/2)^2-\widehat{m}_\nu^2>0 \\ \mathrm{Im}\,\widehat{k}_\nu^2\equiv K_{2\nu}^2=(\varepsilon+V_0)(W_0-\gamma/2)\gtrsim 0 \end{cases} \tag{2.13}$$

The solution of the first equation (2.1) is evident:

$$w(r)=\begin{cases} A\cdot\sin K_\nu r & r<r_0 \\ B\cdot\exp(-\kappa_\nu r) & r>r_0 \end{cases} \tag{2.14}$$

and

$$w_1=\widehat{k}_+^{-1}\cdot\left[\frac{dw}{dr}+\frac{k}{r}w\right] \tag{2.15}$$

The continuity of logarithmic derivative WF w at $r=r_0$ leads to the equation

$$K_\nu r_0\cdot\mathrm{ctg}K_\nu r_0=-\kappa_\nu r_0 \tag{2.16}$$

If $\kappa_\nu\approx-0$ than

$$\mathrm{ctg}K_\nu r_0=-0 \tag{2.17}$$

Thus we get

$$K_\nu r_0=3\pi/2 \tag{2.18}$$

If $V_0\gg W_0,\widehat{m}_\nu,\varepsilon,\gamma$ than

$$V_0 r_0=3\pi/2 \tag{2.19}$$

Therefore, the consideration of renormalization of the mass of a neutrino in a neutroneum leads to the fact that the quasi-bound states appear in a potential not at $V_0 r_0=\pi-3\widehat{m}_\nu r_0$, and at $V_0 r_0 = 3\pi / 2$, but at $V_0 r_0 = \pi + \widehat{m}_\nu r_0$ (i.e., at $\widehat{m}_\nu r_0 = \pi / 2$) process of spontaneous generation of confined quasi-particle $\widehat{\nu}\widehat{\widetilde{\nu}}$ - pairs starts as there is enough potential depth for this. At the same time, the boundary condition (2.1) guarantees the neutrinos confinement since the mass of a quasi-neutron is nearly 1 MeV less than the mass of a neutron.

As follows from (2.19) the reaction of exotic electronic capture differed from the usual electronic capture only neutrino's quasi-confinement and recoil gluons generation, the bremsstrahlung radiation of which generates a many $q\tilde{q}$ - and $\widehat{\nu}\widehat{\widetilde{\nu}}$ - pairs in the volume of a neutroneum. As a result the ultra-cold quark-gluon plasma is formed.

In the framework of Standard Model of electroweak interaction estimated potential depth $V_0 < 10\ keV$. According to it $r_0^{min} \sim 10^5\ fm = 1$ Å. Thus the "sizes" a neutroneum are commensurable with the Bohr radius.

Value $V_0 \sim 10\ keV$ is the upper limit of the depth of optical potential. Realistic value V_0 is slightly less, therefore the effective radius of a neutroneum is equal approximately to $r_0 \sim 3$ Å. In this case the mass $\widehat{m}_\nu \lesssim 1\ keV$. Quasi-neutrino with the mass $\widehat{m}_\nu \gg m_\nu$ quasi-bound inside the sphere of radius $r_0 \sim 3$ Å is nonrelativistic.

The standing wave of a "quasi-neutrino in a quasi-neutron" arise when:

$$K_{2\nu}^2 = (\varepsilon + V_0)(W_0 - \gamma / 2) = 0 \tag{2.20}$$

Physical interpretation of (2.21) is trivial. Absorption of a quasi-neutrino in a quasi-neutron is impossible. The exotic electroweak resonance "neutroneum" decaying onto electron and proton. Transition "quasi-neutron $\to$ proton" takes place at the channel radius. Thus $W_0 = \gamma / 2$. The microscopic estimation of $\gamma \approx 1.6 \cdot 10^{-11}\ eV$ [1] - [8]. In this case $W_0 \approx 0.8 \cdot 10^{-11}\ eV$. We can't calculate the mass of neutroneum $m_{n_\nu} = m_p + m_e + U_{n_\nu}$. But the results of experiments [12] allow us to estimate the value $U_{n_\nu} \sim 10\ eV$.

All the above shows that "the optical model of the quasi-bound state of a quasi-neutrino in a quasi-neutron" is self-consistent, and explains the reason of generation the ultra-cold quark-gluon plasma in the neutrino exoatoms though the model itself is too rough for the quantitative description of real processes. At the same time, the clear understanding of distinction between the bound and quasi-bound states allows to use the correct boundary condition for WF neutrino without conflict with Heisenberg's uncertainty principle.

3. Neutron and Neutroneum from the QCD and Standard Model

Let's consider the reaction $eu \to \nu d$ due to exchange of a charged W- boson. Diagrams given in fig. 1 correspond to this reaction:

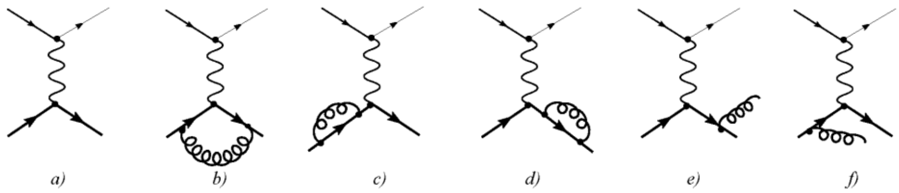

Fig. 1. Reaction $e^- + u \to \nu_e + d$ in the first order on α_s: a) - the Born term, b)-d) - virtual gluons emission, e) - f) - real gluons emission.

For the massless quarks approximation and equalities of mass of the charged and neutral calibration bosons diagrams fig. 1 corresponds to the cross section

$$-\frac{d\sigma_{u(e,\nu)d}}{dt} \approx -\left(\frac{d\sigma_{u(e,\nu)d}}{dt}\right)_{Born} + C_F \frac{\alpha_w^2 \alpha_s}{s^2}(f_2 + f_3) \tag{3.1}$$

where

$$-\left(\frac{d\sigma_{u(e,\nu)d}}{dt}\right)_{Born} = \frac{2\pi\alpha_w^2}{s^2}\left(\frac{s^2 + u^2}{t^2}\right) \tag{3.2}$$

where s, t and u - are the Mandelstam's variables, and $\varepsilon \to +0$. Diagrams b)-d) give us the contribution of gluon emission [13]. The functions of Mandelstam variables f_2, f_3 see in [13].

The term proportional to α_s has a singularity at $t \to -0$ since $f_2 \to \infty, f_3 \to \infty$. However because of smallness of Mandelstam's variable s its role will be considered separately. And here Born's cross section of reaction $u(e,\nu_e)d$ behaves absolutely unusually. Let's demonstrate it.

First we shall notice that at $t \to -0$ cross section (3.2) has the Breit-Winger resonance form when $\vec{p}_e \approx -\vec{p}_u$ and $p_d \to 0$. In this case $p_\nu \sim p_d, u \approx m_e^2$, the neutrino "is smeared" on the volume of a neutroneum, and, as a result, we get:

$$u^2 \ll s^2 \tag{3.3}$$

Cross section (3.2) is the analytical function of Mandelstam's variables, and its analytical continuation to the low energies is lawful.

Variable θ lies at $0 \le \theta \le \pi$ (integration are limited by the condition $t < 0$). Thus neglecting terms $\sim u^2 / s^2$ we get

$$\sigma_{u(e,\nu)d}^{Born} \approx 2\pi\alpha_w^2(1 + m_e^4 / s^2)\int_{t_{\min}}^{t_{\max}} \frac{dt}{t^2} \approx 2\pi\alpha_w^2\left[\frac{1}{t_{\min}} - \frac{1}{t_{\max}}\right] \tag{3.4}$$

For massive quarks Mandelstam's variable t is equal

$$t = (E_e - E_d)^2 - (\vec{p}_e - \vec{p}_d)^2 = m_e^2 + m_d^2 - 2E_eE_d + 2\vec{p}_e\vec{p}_d \tag{3.5}$$

From (3.5) follows that

$$t_{\max} = m_e^2 + m_d^2 - 2E_eE_d + 2p_ep_d;\; t_{\min} = m_e^2 + m_d^2 - 2E_eE_d - 2p_ep_d \tag{3.6}$$

It is evident that for $2E_e > m_d$ and $p_d \to 0$ takes place inequalities $t_{\max}, t_{\min} < 0$ and cross section (3.4) is regular. At small p_d the cross section of $u(e,\nu_e)d$- reaction in Born's approximation equal

$$\sigma_{u(e,\nu)d}^{Born} \approx \frac{2\pi\alpha_w^2}{m_d^2} \cdot \frac{p_ep_d}{(E_e - m_d / 2)^2 + \gamma^2 / 4} \tag{3.7}$$

where $\gamma^2 \approx 16 m_e^2 m_d^{-2} p_d^2$. The resonance (3.7) has Breit-Winger's form, however the contribution of Born's term to the cross section of electroproduction of a neutroneum is rather small (see below).

Let's consider the contribution of processes with the birth of a real gluon for $|t| \ll s$. In this approximation (3.7) looks as follows:

$$f_2(t)+f_3(t)\approx\frac{s}{16t}\left[\log^2(-t/s)-19.75\log(-t/s)-6.5\right] \tag{3.8}$$

The radiative corrections is equal

$$\Delta\sigma^{tot}_{u(e,\nu)d}\approx C_F\frac{\alpha_w^2\alpha_s}{16s}\frac{p_ep_d}{E^2_{eff}}[-4\log^2(E^2_{eff}/s)+79\log(E^2_{eff}/s)+26] \tag{3.9}$$

where $E^2_{eff}=2E_em_d-m_d^2,\ p_d\approx\gamma m_dm_e^{-1}/4$.

The deep non-perturbativity of QCD at ultra-low energies leads to paradoxical results. For example, for eq- scattering at high energies the radiative corrections $\Delta\sigma^{tot}_{u(e,\nu)d}<0$ because $(f_2+f_3)<0$ [13].

The analytical continuation of the running coupling constant α_s to the extremely small Mandelstam's variable s leads to an unexpected result.

According to [14]

$$\alpha_s(s)=\frac{2\pi}{b_0\ln(s^{1/2}/\Lambda)} \tag{3.10}$$

where $b_0=11-(2/3)n_f$.

To explain the nature of paradoxical experimental data on nuclear reactions at ultralow energies, we shall consider a problem of interaction of an electron and a proton. Let us consider that the energy of an electron is positive and very small, and its WF is localized in the neighbourhood of the first Bohr orbit.

Within the used approximations the energy conservation law for the closed system "electron plus proton" taking into account Coulomb interaction looks like:

$$T_e+m_e+T_p+m_p+U_{ep}=E_{ep} \tag{3.11}$$

In our case takes place the strong inequality

$$T_p\ll T_e\ll m_e\ll m_p \tag{3.12}$$

Thus at $r_N\approx 0.86\ fm$

$$T_e\approx U_{n_\nu}-U_{ep}\approx 1.67\cdot 10^6\ eV \tag{3.13}$$

and the contribution of U_{n_ν} is negligibly small compared to the kinetic energy of an electron, accelerated in the Coulomb field of a proton. As a result

$$E_e\approx 2.181\ MeV \tag{3.14}$$

If $\vec{p}_e\approx-\vec{p}_u$ than Mandelstam's variable s it is equal to

$$s=(p_e+p_u)^2\approx(E_e+m_u)^2\approx m_d^2 \tag{3.15}$$

in an accordance to [15]

$$\begin{cases} m_u=2.25\pm0.75\ MeV \\ m_d=5.00\pm2.00\ MeV \end{cases} \tag{3.16}$$

In other word

$$s^{1/2}\approx 4.431\ MeV\approx 2E_e\sim m_d \tag{3.17}$$

At the ultralow energies the minimal number of quark flavors takes part in the exotic electroweak processes ($n_f = 2, b_0 \approx 9.67$) than

$$\alpha_s(s) \approx -0.17 \qquad (3.18)$$

The most amusing is that at so small absolute value of coupling constant the perturbative approach is quite efficient, and here its sign became "abnormal". However this result well keeps within the logic of analytical continuation of the theory. Coming back to (3.9) we come to the fact that when $2E_e m_d > m_d^2$ and $\alpha_s < 0$ than radiative corrections to eq - scattering cross section corresponds to the birth of gluons, become positive.

To clarify the logic of the theory we shall restore Lorentz invariance of all cross sections and its analyticity. Rewrite E_{eff}^2, p_e and p_d as the functions of s.

$$E_{eff}^2 \approx (s^{1/2} - m_d)^2;\; p_d \approx \gamma m_d / (4m_e);\; p_e \approx (s/4 - m_e^2)^{1/2} \qquad (3.19)$$

As a result $u(e,\nu_e)d$ - reaction cross section looks like

$$\sigma_{u(e,\nu)d}^{tot} \approx \frac{\alpha_w^2 \gamma}{m_e \Delta s_d} \left\{ \pi + C_F \frac{\alpha_s}{32} \left[-\log^2\left(\frac{\Delta s_d}{m_d^2}\right) + \frac{79}{4} \log\left(\frac{\Delta s_d}{m_d^2}\right) + \frac{13}{2} \right] \right\} \qquad (3.20)$$

where $\Delta s_d = E_{eff}^2 + \gamma^2$. Thus as the result of reaction $u(e,\nu_e)d$ the metastable state with a width γ is formed. At $\Delta s_d \to \gamma^2 \sim +0$ the contribution of reaction $u(e,\nu_e)d$ to the cross section of elastic ep - scattering is no small.

The neutrino confinement at low energies looks like: $\vec{p}_\nu \approx 0$, and the difference of momentum of a neutrino and a "newborn" d - quark is small as its p_d momentum is small owing to the resonant nature of reaction $u(e,\nu_e)d$. Therefore, the most part of the momentum brought by an electron in a proton is carried away by a gluon. It follows from QCD perturbativity at $|\alpha_s(s)| \approx 0.17$, and the possibility of carrying out calculations caused by this fact in the first order of the perturbations theory on $\alpha_s(s)$. However unlike a habitual situation when the leading diagram corresponds to the first Born approximation, in the case under consideration the main contribution to $u(e,\nu_e)d$ - reaction cross section gives the radiative corrections. Let's demonstrate it by a numerical example.

The width of the resonance of a "neutroneum" is $\gamma_{n_\nu} \sim 10^{-11}\, eV$. Assuming that $C_F = 4/3$ and considering $\gamma \sim \gamma_{n_\nu}$, we receive the ratio of Born cross section to the radiative corrections of order $4\pi : 266 \sim 0.05$. This result was in advance since at small momentum of "newborn" neutrino and d - quark the main part of the recoil momentum is carried out by a gluon.

The features of reaction described above $u(e,\nu_e)d$ allow to restore in details the dynamic picture of neutroneum production and to establish its most characteristic properties essentially different from earlier known properties of elementary particles, nuclei and atoms.

Change of sign of the coupling constant corresponds to qualitative change of character of qq - interactions: potential $V_{qq}(r) \approx -\alpha_s(s)/r + \kappa r$ becomes repulsive. As a result all quarks which are a part of an exotic electroweak resonance begin to scatter with the growing acceleration. Mandelstam's variable s at the same time quickly increases. However at ultralow energies, unlike the high energies, growth of s, caused by qq - collisions, leads to the increasing of running coupling constant in absolute magnitude, and $|\alpha_s(s)| \to \infty$ at $s^{1/2} \to \Lambda$. Movement of quarks in powerful repulsive qq - potential leads to "swelling" of a neutroneum to "sizes" commensurable with Bohr radius.

"Having slipped passed" singularity point $s_p^{1/2} = \Lambda - i\gamma / 2$ at the expense of finite lifetime of exotic resonance ($\tau_d = 1 / \gamma$), quarks brakes by intensive attractive forces and to produce the bremsstrahlung gluons annihilating to $q\tilde{q}$ - pairs. As a result of the above mentioned processes jets of virtual mesons are born inside a neutroneum, and a huge volume of an exotic electroweak resonance is filled with ultra-cold quark-gluon plasma "diluted" by $\nu\tilde{\nu}$ - pairs.

4. Conclusion

1. Relativistic optical model of the quasi-bound state of a neutrino in a quasi-neutron is constructed and identified.
2. Microscopic justification of optical model of a quasi-confinement of a neutrino in nucleons is given.
3. It is shown that neutroneum production takes place when neutrino stopped inside a nucleon with simultaneous transition of u - quark into d - quark.
4. It is shown that the difference of masses of current's d - quark and u - quark with a great degree of accuracy is equal to $m_d - m_u \approx 2.181\ MeV$.
5. It is shown that neutroneum production takes place in the natural «eq -collider». Colliding electron and u - quark has equal momentum value, but this momentum has an opposite signs.
6. It is proved that weak interaction can induce a temporary neutralization of proton's charge and can act as a catalyst of nuclear reactions at low energies.

References

[1] Ratis Yu.L. *Controlled "Thermonuclear Fusion" or Cold Synthesis? Drama of Ideas.* (SSC RAS Publishing House, Samara, 2009), 92 p.

[2] Ratis Yu.L. Neutrino-Bound di-neutrons as an exotic metastable atom. http://es.arxiv.org/abs/0909.5561.

[3] Ratis Yu.L. Neutrino catalysis of nuclear synthesis reactions in cold hydrogen. The Old and New Concepts of Physics, **VI**, N4, 525 (2009). http://www.conceptsofphysics.net/VI_4/525.pdf

[4] Ratis Yu.L. A neutrino catalysis of reaction of nuclear fusion in cold hydrogen. Applied physics (rus), **1**, 21 (2010), 21–30.

[5] Ratis Yu.L. Neutrino catalysis of nuclear fusion in cold hydrogen. Proceedings of the LXII International Conference NUCLEUS-2012, Voronezh-2012. Ed. by A.K. Vlasnikov, (Saint-Petersburg University, Saint-Petersburg, 2012), p.62.

[6] Ratis Yu.L. An exotic long-living particle "neutroneum". Proceedings of the XXI International Seminar on Interaction of Neutrons with Nuclei, Dubna: JINR, 2014, p.73–84.

[7] Ratis Yu.L. Experimental confirmation of the existence of the neutron-like exoatom "neutroneum". Engineering physics (rus), No.**11**, 2014, pp. 8–17.
[8] Ratis Yu.L. Physics of exotic electroweak processes and exonuclear reactions. Abstracts of XIV international conference "Safety of the NPP and Training", Obninsk, IATE NIY MEPhI, 2015, pp. 158–159.
[9] Landau L.D., Lifshits E.M., *Quantum mechanics. The nonrelativistic theory. Course of theoretical physics,* v.3, (Science, Moscow, 1989), 768 pages.
[10] Zhigunov V.P., Zakharyev B.N. Strong coupled channels methods in the quantum theory of scattering, M.: Atomizdat, 1974, 224 p.
[11] Akhiyezer A.I., Berestetsky V.B. Quantum electrodynamics.-M.: Science,1981, 428 p.
[12] Urutskoyev L.I., Liksonov V.I., Tsinoyev V.G. Experimental detection of "strange" radiation and transformation of chemical elements//Applied physics (rus), 2000, No. 4, pp. 83–100.
[13] Kozakov D.I. Radiative corrections, divergence, regularization, a renormalization, a renorm-group and so on in examples of the quantum theory field. Course of lectures. LTF JINR, 2008, 93 p.
[14] Peskin M.E., Schröder D.V. Introduction to the quantum field theory. Addison-Wesley Publishing Company, 1995, 784 p.
[15] Amsler C. *et al.* (Particle Data Group) of the Review of Particle Physics. Phys. Lett. **B667**, 1 (2008).