DINEUTRONEUM PHOTOPRODUCTION AS “EXPERIMENTUM CRUCIS”

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PREDICTION

A few years ago existence of the exotic neutrinos atoms "neutroneum" and "dineutroneum" (bound state of the neutron and neutroneum) was predicted.

Neutroneum is quasi-bound state of neutron and neutrino.

PROBLEM

The bound state of neutron and neutrino is strictly forbidden by Heisenberg uncertainty principle.

1. **Heisenberg uncertainty principle**

$$\Delta p \cdot \Delta x \geq \hbar \tag{1}$$

2. **Neutrinos Compton wavelength**

$$\lambda_C^{(\nu)} \gg r_N \approx 0.86\ fm \tag{2}$$

EVERY KNOW: (1) - (2) ARE IN UNRESOLVED LOGICAL CONTRADICTION

THE END OF THE OWFUL MISTAKE

Formula (1) – (2) contradicts each other only for the authentic bound states, not for resonances. For the exotic electroweak resonances in the coupled channels quantum systems the boundary conditions $\psi(\infty) = 0$ **is not forbidden!!!**

QUASI-BOUND STATES. WHAT IS IT? METHODICAL EXAMPLE.

$\begin{cases} -\frac{\hbar^2}{2m_1}\frac{d^2u_1}{dr^2} + V_1u_1 + V_{12}u_2 = E_1u_1 \\ -\frac{\hbar^2}{2m_2}\frac{d^2u_2}{dr^2} + V_2u_2 + V_{21}u_1 = E_2u_2 \end{cases}$	$V_1 = \begin{cases} -V_{10} & r < a \\ 0 & r > a \end{cases}$ $V_2 = \begin{cases} -V_{20} & r < a \\ 0 & r > a \end{cases}$ $V_{12} = \begin{cases} V_{12} \neq 0 & r < a \\ 0 & r > a \end{cases}$	$\begin{cases} V_{10} > \frac{\pi^2\hbar^2}{8m_1a^2} \\ V_{20} < \frac{\pi^2\hbar^2}{8m_2a^2} \end{cases}$

Differences between the quasi-bound state and the state of the continuous spectrum

$V_{12} = -V_{21} \neq 0$	$E_1 > 0,\ E_2 < 0$	$u_2(0) = u_2(\infty) = 0$
$V_{12} = -V_{21} = 0$	$E_1 > 0,\ E_2 > 0$	$u_2(0) = 0;\ \ u_2(\infty) \neq 0$

THEORY

HAMILTONIAN

$$H' = \frac{G}{\sqrt{2}} \int J^{\lambda+}(\vec{r}) \cdot J_{\lambda}(\vec{r}) \mathrm{d}\vec{r} \tag{3}$$

$$h'(\vec{r},t) = \frac{G}{\sqrt{2}} \; i\beta[\tilde{f}_1\gamma_\lambda + \tilde{f}_2\sigma_{\lambda\rho}k_\rho + (\tilde{g}_1\gamma_\lambda + i\tilde{g}_2k_\lambda)\gamma_5]^{+} j^{\lambda}(\vec{r},t) + h.c. \tag{4}$$

$$j_\lambda(\vec{r},t) = \; i\overline{\psi}_e(\vec{r})\gamma_\lambda(1+\gamma_5)\psi_\nu(\vec{r}) \; \cdot \exp\left(-\frac{i}{\hbar}(E_\nu - E_e)t\right) \tag{5}$$

WAVEFUCTIONS IN THE LEPTON V-A CURRENT

Investigated cases:

1. Neutron decay, muon decay and so on

$$\begin{cases} \psi_e(\vec{r}) = (2\pi)^{-3/2} \cdot \exp(i\vec{k}_e\vec{r})u_e(\vec{k}_e) \\ \psi_\nu(\vec{r}) = (2\pi)^{-3/2} \cdot \exp(i\vec{k}_\nu\vec{r})u_\nu(\vec{k}_\nu) \end{cases} \quad (6)$$

2. Electron capture

$$\begin{cases} \psi_e(\vec{r}) = \begin{pmatrix} g_k(r)\ \chi^{k}_{jm_j} \\ if_{-k}(r)\chi^{-k}_{jm_j} \end{pmatrix} \\ \psi_\nu(\vec{r}) = (2\pi)^{-3/2} \cdot \exp(i\vec{k}_\nu\vec{r})u_\nu(\vec{k}_\nu) \end{cases} \quad (7)$$

NON-INVESTIGATED CASE

3. Exotic induced electron capture (the lost possibility)

$$\begin{cases} \psi_e(\vec{r}) = (2\pi)^{-3/2} \cdot \exp(i\vec{k}_e\vec{r})u_e(\vec{k}_e) \\ \psi_\nu(\vec{r}) = \begin{pmatrix} g_k(r)\ \chi^k_{jm_j} \\ if_{-k}(r)\chi^{-k}_{jm_j} \end{pmatrix} \end{cases} \tag{8}$$

CROSS-SECTION OF NEUTRONEUM ELECTROPRODUCTION

$$\begin{cases} \dfrac{d\sigma_{H(e,e')n_\nu}}{d\Omega_{n_\nu}} = \sigma^{(0)}_{H(e,e')n_\nu} F_c^2(\eta_p) \cdot \sqrt{\xi^2_{n_\nu} - \xi^2_{\hat{n}_\nu}} \cdot \sum\limits_{+,-} \left\{ (x^{(\pm)}_{n_\nu})^2 \left| \Phi(x^{(\pm)}_{n_\nu}) \right|^2 \right\} \\ \sigma^{(0)}_{H(e,e')n_\nu} = \dfrac{2}{\pi} \dfrac{a_B^3}{V_{eff}^{n_\nu}} G_\beta^2 \tilde{\phi}^2_{ep}(j_{n_\nu}) m_e^2 \approx 2\ \mu barn \end{cases} \tag{9}$$

EXOTIC ELECTRONUCLEAR REACTION OF THE TRITIUM PRODUCTION

$$D_\nu + d \rightarrow t + n_\nu \qquad (10)$$

The sources of dineutroneum – exotic induced electron capture $D(e,e')D_\nu$, $D(\gamma,\gamma')D_\nu$

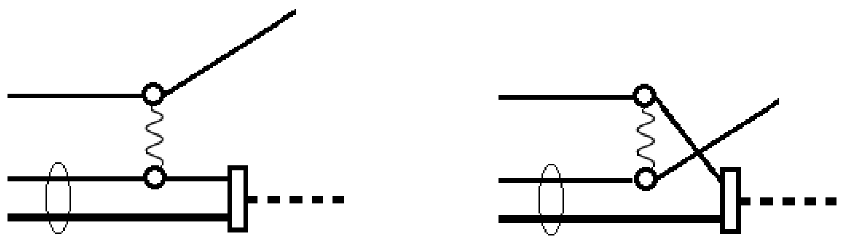


Fig. 1. Dineutroneum electroproduction in the inelastic electron-hydrogen scattering

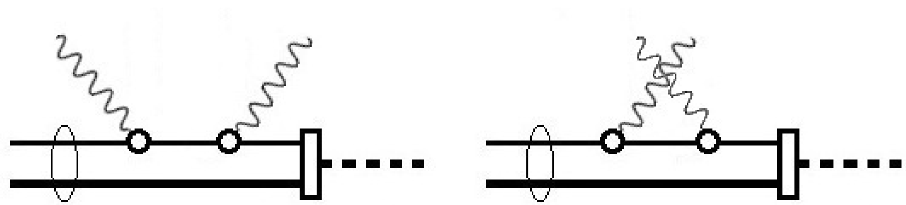


Fig. 2. Dineutroneum photoproduction in the inelastic photon-hydrogen scattering

Direct dineutroneum photoproduction in the inelastic photon-hydrogen scattering is suppressed by atomic formfactor.

PREDICTIONS [1], [2], [3]

(Yu. R. The Old and New Conc. of Phys., 2009, Yu. R. ISINN-21, 2013, Yu. R. ISINN-22, 2014)

Two-step dineutroneum photoproduction in gaseous molecular deuterium

$$\frac{dN_T}{dt} = j_\gamma \cdot N_{D_2} \cdot \sigma^{tot}_{D_2(\gamma,\gamma')DD_\nu} \cdot P_{d(D_\nu,n_\nu)t}$$

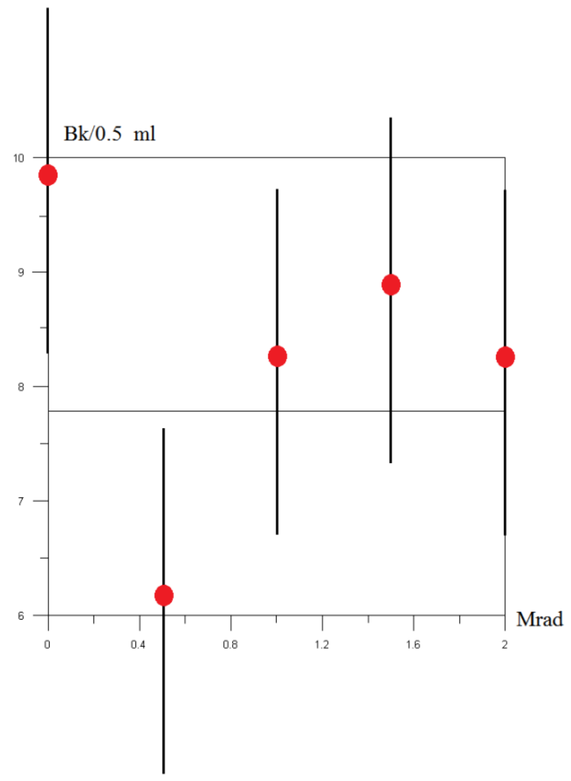
$$\sigma^{tot}_{D_2(\gamma,\gamma')DD_\nu} = \sigma_{Compt} S^{-1} N_{D_2} \left\langle \kappa_{ion} \right\rangle \left\langle \sigma^{tot}_{D(e,e')D_\nu} \right\rangle$$

$$\sigma_{Compt} = \frac{8\pi}{3}\left(\frac{\alpha}{m}\right)^2 = 65.7\ fm^2 \qquad (11)$$

$$\sigma^{tot}_{D(e,e')D_\nu} \sim 6\ mbarn$$

$\left\langle \kappa_{ion} \right\rangle$ - average part of the knocked-out electrons with the energy $T_e^{ko} > 20\ eV$

"EXPERIMENTUM CRUCIS"



Thus we receive the first experimental data (Yu.R. Inzh. Fis. (rus), 2014) [4] which evidently supported my hypothesis of the dineutroneum existence, but the width of error bars is too large to say either:

"Prediction is confirmed!" or "Prediction is not confirmed!"

References

1. Ratis Yu.L. The Old and New Concepts of Physics, Volume VI (2009), N 4, p.525-543 http://www.conceptsofphysics.net/VI_4/525.pdf
2. Ratis Yu.L., Proceedings of the XXI International Seminar on Interaction of Neutrons with Nuclei, Dubna: JINR, 2014.
3. Ratis Yu.L. Method of the “dineutroneum” existence confirmation. Abstracts of the XXII International Seminar on Interaction of Neutrons with Nuclei, Dubna: JINR, 2014. p.75
4. Ratis Yu.L. Experimental confirmation of the existence of the neutron-like exoatom “neutroneum”. Inzhenernaya fizika (rus). №11. 2014. c.8-17

THANK YOU!