Orthopositronium: “on the possible relation of gravity to electricity”

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Abstract

The resolve of the ‘orthopositronium-lifetime puzzle’ needs more study of the “isotope anomaly” in gaseous neon and of the contribution $\sim 2 \cdot 10^{-3}$ of non-perturbative mode into orthopositronium annihilation.

The Michigan results (2003) are considered as the first supervision of relation between gravitation and electricity.

For the decision of alternative in interpretation of new and former results it is necessary to execute the program of additional measurements.

I. THE ORTHOPOSITRONIUM-LIFETIME PUZZLE IS NOT SOLVED: ON AN EFFECT OF NON-PERTURBATIVE CONTRIBUTION

As it known [1], a workgroup of Michigan University (Ann Arbor, USA) published their new experimental results of vacuum measurements of orthopositronium ($o$-Ps, $^3$Ps) annihilation decay rate $\lambda_T$ (lifetime, decay rate $1/\lambda_T$). They headed this article ‘Resolution of Orthopositronium-Lifetime Puzzle’.

‘Our new value for the $o$-Ps is then $\lambda_T = 7.0404(10)(8) \mu s^{-1}$, where the first error is the statistical error of 140 ppm and the second error of 115 ppm represents a combined systematic error $< . . . >$ our current value for $\lambda_T$ using a porous silica thin film for production of near-thermal Ps is in excellent agreement with theory at a combined level of precision of 180 ppm. It also agrees well with the Tokyo [2] experiment’, they wrote in the article [1].

This ‘excellent agreement with theory’ provides calculating the ground state of electron-positron atom according to the perturbative calculations in Quantum Electrodynamics (QED, perturbative dynamics). At the present, these calculations achieved to take into account total corrections of the order $\alpha^2$ and a precision of $1.6 \cdot 10^{-4}\%$ [3].

From the beginning of 1980’s and until the middle of 1990’s, this Michigan group arrives to a high graduate of precision to measure annihilation rates of the ($o$-Ps $\lambda_T$) and of the parapositronium ($p$-Ps, $^5$Ps; $\lambda_T$), go into details with [4-7]. It should be noted that they used unique experimental technique, which resulted the $\lambda_T$ precision of 0.02% [5] in buffer gases experiments and the precision of 0.023% using a vacuum technique. As a result they established a discrepancy between theory and experiment that was the experimental $\lambda_T$ exceeding on $\Delta \lambda_T$ its calculated value with 9.4$\sigma$ in the gaseous experiments [5] and with 6.2$\sigma$ in the vacuum experiments [6]. These experimental facts stimulated so much experimental statements and the QED large corrections calculation’s during the latest two decades, so those stimulated new approaches to solve the ‘orthopositronium-lifetime puzzle’.
The authors of [1] think that sources of previous experiments’ systematic measurement errors are founded and these have a real base [8, 9]. So the new measurement result finishes the problem to deviate the $\alpha$-Ps experimental annihilation rate with theory, they think. In this way, the previous results of Michigan group should be refused, so the all two decades’ attempts to solve the puzzle should be regarded without ground. The Tokyo group’s experimental result [2] also supported this conclusion.

However basing on facts that ‘isotope anomaly’ $\alpha$-Ps [10] and a non-perturbative contribution $\Delta \lambda_T/\lambda_T \approx 0.19\%$ into $\alpha$-Ps dynamic (where $\alpha$-Ps is derived from $\beta^+$-decay positrons [11-14] in the final state of the topological quantum transition) are exist, our opinion lead us to a critical analysis of the new measurements [1]. So the next our thesis needs to ground:

The rate of $\alpha$-Ps self-annihilation $\lambda_T = 7.0514(14)\mu s^{-1}$ was measured in the buffer gases experiments [5] and $\lambda_T = 7.0482(16)\mu s^{-1}$ in vacuum experiment [6], received earlier by Michigan group conserves real status.

The start point of the critical analysis is the statement contained in [1]:

‘The Michigan buffer gas experiment [5] has been shown to be subject to the problem of incomplete Ps thermalization [8] in low-pressure gases, and this value should be corrected downward by at least 700 ppm’.

To the contrary we have another opinion: the experimental method in the buffer gases [5] gave a possibility to measure the best value of the rate of $\alpha$-Ps self-annihilation, because this measurements in magnetic field produced complete experience that is measurements of $\alpha$-Ps and $p$-Ps self-annihilation rates at the same time, so the new data [1] do not change this situation because the data [1] were received in qualitative another experiment.

The point is that, from viewpoint of the contribution a non-perturbative dynamics in $\alpha$-Ps, formed by $\beta^+$-decay positrons ($^{22}\text{Na}, ^{68}\text{Ga}$) [11-14], 64% $\alpha$-Ps sub-state ($m=0$), annihilated into $2\gamma$-quantum (at $B=2.85$ kG [8,9]), are essentially different in the thermalization from 36% $\alpha$-Ps ($m=0$) sub-state and $\alpha$-Ps ($m=\pm 1$) sub-state, testing three-quantum annihilation. These latest have not even a term ‘kinetic energy’, because an additional factor of the ‘mirror Universe’ is included owing to presence at their dynamics the single-photon (virtual) annihilation. Or else, ‘kinetic energy’ of the $\alpha$-Ps ($m=\pm 1$) sub-states and 36% $\alpha$-Ps ($m=0$) sub-state are compensated by an exchange $\alpha$-Ps$\leftrightarrow p$-Ps’ with the ‘mirror Universe’, but the $\alpha$-Ps ($m=0$) sub-state ($2\gamma$-annihilation) in an exchange with the ‘mirror Universe’ does not participate [11, 12]. Therefore in the Doppler-broadening measurements of the 511 keV-annihilation line (2$\gamma$-annihilation) [8,9] it is possible to receive only information about thermalization of the short-lived share of the $\alpha$-Ps ($m=0$) sub-state, but not about its long-lived share and $\alpha$-Ps ($m=\pm 1$) sub-state. Thus, statement of the authors [1] that in work [8] regular mistake of their former measurement is experimentally proved [5] (i.e. excess of measured $\lambda_T$ size, ‘at least 700 ppm’), can be denied from positions of the account of a non-perturbative mode. Really, $\alpha$-Ps magnetic momentum is zero, and $p$-Ps magnetic momentum equals two Bohr magnetons, $\alpha$-Ps energy exceeds $p$-Ps energy on size

$$\Delta W = W_\alpha^2 \cdot \left(\frac{4}{3} + 1\right) \approx 8.4 \cdot 10^{-4} eV$$

(hyperfine splitting of the Ps ground states; $W \approx 6.8$ eV– binding energy of the Ps), so at $\alpha$-Ps birth (and collapse-reduction of its wave function at interactions in a gas) a very tiny energetic shift occurs.
\[ 3E(m=0) - 3E(m=\pm1) = \frac{\Delta W}{2} \cdot \left[ (1 + x^2)^{1/2} - 1 \right] \cong 10^{-6}\text{eV} \ (B=2.85 \ \text{kG}), \]

where
\[ x = \frac{2e\hbar}{m_e} \cdot \frac{B}{\Delta W} = 2.75 \cdot 10^{-2} \cdot B \ (B \text{ in kG}). \]

Because \( \alpha\)-Ps (m=\pm1) does not "sense" magnetic field and the 64% of \( \alpha\)-Ps (m=0) under \( B=2.85 \ \text{kG} \) does not ‘sense’ the “mirror Universe”, so energetic relaxation between \( \alpha\)-Ps sub-states is possible as a result of solely collisions in gas. However this process is difficult because of kinematics (see, for example, [15]). So, the Doppler-broadening measurements of the 511 keV-annihilation line do not produce information on the \( \alpha\)-Ps thermalization. At the present we have not a method to measure a kinetic energy (thermalization) of the \( \alpha\)-Ps (three-quantum annihilation, wide distribution of energy – from \( E_\gamma \sim 0 \) up to \( E_\gamma \sim 2m_e c^2 \)) produced by \( \beta^+\)-decay positrons in substance.

Actually, from standard QED viewpoint (perturbative dynamics) the supposed deviation of thermalization rates of \( \alpha\)-Ps (m=0) sub-state (2\( \gamma\)-annihilation) and \( \alpha\)-Ps (m=\pm1) substate (3\( \gamma\)-annihilation) is absent. However we are going to consider the experimental results [1], so any a priori considerations even "evidently" considerations shall be excluded.

As it was mentioned above, it was a principle methodical feat that the studies of 1982-89 [4,5] had got a non-beaten measurement precision and had excluded systematic errors to measure parameters of \( \alpha\)-Ps lifetime spectra annihilation under moderate magnetic fields of \( B = 3.5 \ \text{kG} \). The main goal of this method is that \( \alpha\)-Ps and \( p\)-Ps annihilation rates were measured in the same experiment. To realize full experiment implies to exclude an affect, which an environment does on wave function of Ps (the affect shall be excluded with high degree of precision). As it is evidently, such affect is unavoidable in substance (polarization forces). Tokyo group did not take into account this principle factor in their works. An observable rate of \( \alpha\)-Ps annihilation decay in substance is defined in [2] as follows
\[ \lambda_{\text{obs}}(t) = \frac{|\Psi_{\text{obs}}(t)|^2}{|\Psi(0)|^2} \cdot \lambda_T + \lambda_{\text{pickoff}}(t), \]

where \( |\Psi_{\text{obs}}(t)|^2 \) and \( |\Psi(0)|^2 \) are densities of the wave function in substance and vacuum, accordingly, \( \lambda_{\text{pickoff}} \) – the \( \alpha\)-Ps pickoff-annihilation rate, and the both sign of the inequalities are possible \( |\Psi_{\text{obs}}(t)|^2 / |\Psi(0)|^2 < 1 \) or \( |\Psi_{\text{obs}}(t)|^2 / |\Psi(0)|^2 > 1 \) (Ps is “swelling” or “compressed” by polarization forces in substance, see [15]). Therefore used in work of Tokyo group approximation [2] \( |\Psi_{\text{obs}}(t)|^2 / |\Psi(0)|^2 = 1 \) to describe \( \alpha\)-Ps annihilation in an aerogel powder had not ground, a systematic error these measurements made is much underestimated most likely (indirectly it is marked also in [1]). A physical mechanism of this distortion is an affect of electric field that is Stark effect. This displays itself in \( \alpha\)-Ps dynamics specific way: electric field selects some specific direction (linear polarization of \( \alpha\)-Ps) that excludes a possibility to realize supersymmetric mode (\( \sim 0.2\% \)) and hence annihilation with notoph (\( \gamma^o \) \( \alpha\)-Ps\( \gamma\)-Ps\( \gamma\)) is excluded. If \( \alpha\)-Ps is localized in pore of aerogel, then electric field (which the symmetry breaks) acts on the \( \alpha\)-Ps wave function in a double electrical layer on the boundary solid phase - vacuum in the pore. New more exact comparative measurements of the Tokyo group with use hydrophilic and hydrophobic samples of aerogel SiO\(_2\) [16] do not change a conclusion about suppression in these conditions of the contribution of non-perturbative (supersymmetric) mode.
Being ones developed the method [1], they targeted to arrive to a condition of $\sigma$-Ps thermalization. Having this task, they used an electric field $\sim 4 \cdot 10^3$ V/cm to deviate a positronium bunch 700 eV (produced by $\beta^+$-decay of $^{22}$Na) onto a porous target along 0.75 cm. The consideration to crush additional supersymmetric mode $\sigma$-Ps $\rightarrow$ $\sigma$-Ps($p$-Ps') with electric field we mentioned above give a possibility (viewpoint of non-perturbative dynamics) to prefer the Michigan group first experiment [6], because this first experiment had not contained an affect of electric field to $\sigma$-Ps annihilation in contrast to the new method [1].

In general, taking into account that non-perturbative dynamics give a contribution, the problem to thermalization $\sigma$-Ps is absent, so the first experiments Michigan group had made [4-6] give the rate of self-annihilation of $\sigma$-Ps, which includes an additional mode $\sim 0.2\%$ (derived from $\beta^+$-decay positrons in substance) completely adequate.

A problem statement that annihilation characteristics $\sigma$-Ps is linked to a $\beta^+$-decay nature of positrons was supposed in the second half of 1970’s and the beginning of 1980’s. A ground of the supposition were experimental observations of some peculiarities in lifetime spectra of annihilation of positrons that were derived from $\beta^+$-decay of $^{22}$Na ($^{22}$Na $\rightarrow$ $^{22}$Ne + $e^+ + \nu$) in gaseous neon. A “start” of the experiments (the moment of $\beta^+$-decay final state: daughter nucleus $^{22}$Ne, positron ($e^+$), neutrino ($\nu$), formation Ps in substance) was detected using a nuclear $\gamma$-quantum ($^{22}$Ne $\rightarrow^{22}$Ne + $\gamma_0$). In the middle of 1980’s the supposition was confirmed by observations of “isotope anomaly” of $\sigma$-Ps [10]. Independent discovery of $\lambda_T$-anomaly” and its confirmation [4-6] powered arguments in behalf of non-perturbative dynamics contribution into $\sigma$-Ps annihilation, because the old calculations [17] to contribute additional supersymmetric mode in $\sigma$-Ps annihilation gave a possibility to calculate a contribution of single-notoph annihilation contribution of single-notoph annihilation $\sigma$-Ps $\rightarrow$ $\gamma$ $\rightarrow \gamma$ ($0.19\%$) [11,12].

Taken into account the formed situation we considered above, the fact that Michigan group refused [1] their previous experimental conclusions [4-6] can be accepted as ‘resolution of orthopositronium-lifetime puzzle’, so we can formulate the next alternative:

1. If we be not left the frames of standard QED [3], then the new experiments Michigan group made [1] result only confirmation of a systematic error they had got in their experimental methods to measure the selfanihilation rate [4-6].

And to the contrary:

2. To accept that “isotope anomaly” in neon [10] and the non-perturbative dynamics’ contribution (0.19[5]÷0.14[6])% into $\sigma$-Ps annihilation [11,12] (where $\sigma$-Ps is derived from $\beta^+$-decay positrons) have a general nature, lead to accept that unique original methods and the obtained experimental results of “$\lambda_T$-anomaly” [4-6] are adequate to reality.

A way to solve “orthopositronium puzzle” (the orthopositronium problem) as whole is more to study ‘isotope anomaly’ $\sigma$-Ps in neon [10] and to set up experimentum crucis, a concept of which was formulated earlier [11, 12] as follows:

To found a contribution of supersymmetric single-notoph mode of the annihilation $\sigma$-Ps $\rightarrow$ $\gamma$ needs a method guaranteeing $4\pi$-geometry to detect notoph.

A similar method was realized in [18] before. So, these are necessary:

- to modify the method for positrons source $^{22}$Na in gaseous neon of sufficiently high pressure, and also
- to comparing measurements of neon tests of different isotope mix. Our supposition
based on observations of “isotope anomaly” of $o$-Ps (the contribution of non-perturbative dynamics) is that expected affect shall be selected on a background of a pick total energy of $o$-Ps annihilation under $E_{\gamma} \approx 2m_e c^2 \approx 1.022$ MeV, not under $E_{\gamma} \approx 0$ as the study [18] did it.

II. MODEL OF FUNDAMENTAL SPACE-LIKE STRUCTURE WITH TWO-DIGIT PLANCK MASS $M_\mu = \pm M_{PL}$

The citation in the preprint title repeats the appellation of the paragraph in “Experimental Researches in Electricity” by M. Faraday where negative results of the first experimental searches the relation of gravity and electricity are stated [19]. These searches were stimulated by ‘the long and constant < Faraday’s> persuasion that all the forces of nature are mutually dependent, having one common origin’ (Par. 2702). His comment full of self-respect, when the first experimental attempts to establish prospective relation did not give positive result, inspires today (Par. 2717): ‘Here end my trials for the present. The results are negative. They do not shake my strong feeling of the existence of a relation between gravity and electricity, though they give no proof that such a relation exists’.

We examine a new precision measurement of the orthopositronium selfannihilation decay rate $\lambda_T$ [1] as the first supervision of this relation between gravity and electricity.

A feature of a new technique of measurement $\lambda_T$ in comparison with the techniques realized earlier by Michigan group (1982-1994) is the introduction in the measuring chamber of electric field. This innovation and result received in the [1] allowing us to present an orthopositronium problem in a context of a relation between gravity and electricity. The base for such interpretation serves the phenomenology, advanced for the description ‘isotope anomaly’ and ‘$\lambda_T$-anomaly’ $o$-Ps, which are examined as manifestation of long-range for baryon charge [10-12]. Though the experiments made up to the middle of 90th, have excluded a hypothesis about stationary long-range for baryon charge (“fifth force”), it does not mention non-stationary aspect of similar long-range in $\beta^+$-decay, which is a source of the positrons forming Ps, and is examined by us as topological quantum transition (TQT) [10-12].

In this section the conception of a question are submitted. In following section (III) the offer of the crucial experiment is presented.

1. As it known [20] ‘...in the equations of the modern theory there is no equivalence of all speeds of movement as the whole (including super-light speeds). As symmetry of the equations can be higher than symmetry of the ground state, it is represented rather expedient to expand symmetry of the equations up to a full relativity, i.e. equivalence of all speeds (rule out the speed of light itself). In usual conditions to provide sub-light character of relative speeds, additional symmetry should be broken spontaneously’ (it is underlined by us).

This theory has opened a prospect to an alternative (more precisely, additional) interpretation of faster-than-light speeds as a space-like ‘zero-mass Goldstone field which in linear approximation in any way does not prove in classics and its unique macroscopical manifestation is presence non-electromagnetic long-range interactions of bodies with not disappearing average spin density, < ...> Restoration < the symmetry> should be accompanied by doubling of space-time dimension'.
In order to prevent the conflict with the general relativity (GR) additional Goldstone field (GF) cannot cover “all” space-time; GF should be limited, be peculiar “defect” of space-time. Besides, there is a problem of causality. Both these problems are solved in the following point.

2. ‘Physical interpretation of some algebraic structures of an energy-pulse tensor allows to assume, that the form of substance named $\mu$-vacuum, macroscopic possessing properties of vacuum is possible < ... > The homogeneous $\mu$-vacuum world has the de Sitter metrics’ [21].

The concept vacuum-like states of matter (VSM) is included in modern cosmology. In [21] VSM are submitted as the homogeneous spherical de Sitter worlds with positive curvature (K > 0 – de Sitter space of the 1st sort). Such world is ‘not empty’ also a sign on density of mass coincides with sign of K. Limitedness of the de Sitter space the major quality which allows to use this GR mathematical device for the description of space-like structures of TQT in final state of $\beta^+$-decay. De Sitter 2nd sort spaces (K < 0 – with negative density of mass) in basic work [21] are excluded from consideration as it seemed, that Riemann space of constant negative curvature has properties physical interpretation of which is rather difficult owing to infringement of physical causality (closed time-like geodesic line). Meanwhile, published year earlier the theory of a discrete scalar field with negative mass density (‘C-field’ [22]) allows, on the one hand, to use it as a field compensating VSM in final state of TQT, and with another – to structure GF (cellular structure of VSM).

The analysis executed soon after publication [21], has shown that probably ‘the simultaneous creation of quanta of fields of positive energy field and of the negative energy $C$-fields’ ([23], p. 90), because for a probe particle ‘there are closed timelike lines in this space; however it is not simple connected, and if one unwraps the circle $S'$ (to obtain its covering space $R'$) one obtains the universal covering space of anti-de Sitter space which does not contain any closed timelike lines’ ([23], p.131).

The opportunity of the development of the concept of a full relativity [20] contains in a hypothesis about additional realization of supersymmetry. As is known, double application of supertransformation – from fermion to boson and again to fermion – translates a particle in other point of space. It supposes additional treatment of mathematical structure of supersymmetry as structures of long-range of the new type (non-Newtonian, non-Coulombian) in final state of TQT [12]. All this concerns to a positron in o-Ps, because electron is in so-called entangled state with all electrons the observable Universe.

At last, also the problem of relativistic invariance (physical causality) for examined GF (VSM) ‘as a whole’ is solved naturally: non-locality in this context does not result to a breaking of the causality, because VSM cannot be a frame of reference (see [21]).

3. It is necessary to prove a presence at cells (‘units’) of VSM baryon charges: their exchange interaction with nucleus of atoms of matter in a gas phase (or in residual gas of technical vacuum) is the reason for ‘isotope anomaly’ and ‘$\lambda_T$-anomaly’ of the orthopositronium (see [10-12]). It is possible to see idea of long-range for baryon charge in the following fragment of the message of R.P. Feynman “The quantum theory of gravitation” at Warsaw conference in July, 1962 [24] (italics and underlining ours): ‘There is theory, more well-known to meson physicists, called the Yang-Mills theory, and I take the one with zero mass; it is a special theory that has never been investigated in great detail. It is very analogous to gravitation; instead of the coordinate transformation group being the source of everything, it’s the isotopic spin rotation group that’s the source of everything. It is a non-linear theory, that’s like the
gravitation theory, and so forth. At the suggestion of Gell-Mann I looked at the theory of Yang-Mills with zero mass, which has a kind of gauge group and everything the same; and found exactly the same difficulty. And therefore in meson theory it was not strictly unknown difficulty, because it should have been noticed by meson physicists who had been fooling around the Yang-Mills theory. They had not noticed it because they’re practical, and the Yang-Mills theory with zero mass obviously does not exist, because a zero mass field would be obvious; it would come out of nuclei right away. So they didn’t take the case of zero mass and investigate it carefully.

It is possible to think, that the mass-less field with a property of the long-range for baryon charge was really showed in the orthopositronium anomalies [10-12].

Polarization of the “ingredients” of its mass (M> 0 and M< 0) in ground laboratory gravitation field in conditions of a counteraction of an external electric field [1] and the further substantiation of new physics by old and later results of the fundamental theory will be considered in the following section (III).

So, on an experimental basis (“λτ-anomaly” and “isotope anomaly” o-Ps [10-12]) it is postulated here the compound nature and ambiguity of the fundamental space-like structure in the final state of β+-decay of nuclei-sources of positrons and equality of each of making mass on absolute value to the Planck mass

\[ M_\mu = \pm M_{Pl} = \pm \sqrt{\hbar c/G}, \]

so owing to infringement of a full relativity and scale invariance at length \( \sim 2R_\mu \) its resulting mass (“zero-mass Goldstone field” [20]) – not zero, but extremely small mass \( m_\mu = \hbar/2R_\mu \cdot c \sim 2 \cdot 10^{-10} \text{eV} \) (see lower – definition of macroscopical space-like structure radius \( R_\mu \)).

In known discussion of a maximon problem [25] only positive value Planck mass was taken into account, though the negative mass is formally also possible.

In QED the reality of o-Ps superfine structure level shift is established (‘new force of annihilation’ [26])

\[ (3/7) \cdot \Delta W = (3/7) \cdot W_{a}^{2} \approx 3.6 \cdot 10^{-4} \text{eV}, \]

where \( W \approx 6.8 \text{ eV} \) is a positronium binding energy; the attraction of an electron and a positron charges in o-Ps is weakened, as during time \( \Delta t_{v} \sim \hbar/(3/7) \cdot \Delta W \) the truly neutral triplet quantum system \( 3(e^{+}e^{-})_{1} \) exists in the form of one virtual photon, i.e. in ‘state’ without electric charges. In view of the additional version of the ‘mirror Universe’ (without breaking of \( CP \)-invariance, see [11,12]) and \( ^{1}\text{Ps} \leftrightarrow ^{1}\text{Ps'}(^{8}\text{Ps'}) \) oscillations (the stroke means an a belonging to the ‘mirror Universe’), this fact can be interpreted as the impossibility to locate the center of \( ^{1}\text{Ps} \leftrightarrow ^{1}\text{Ps'}(^{8}\text{Ps'}) \) in space of the real observer within the limits of volume, smaller \( \Delta^{3}; \Delta – \text{virtual fundamental length (‘shift’)} \)

\[ \Delta \sim c \cdot \Delta t_{v} = \frac{4}{\alpha^{4}} \left( \frac{\hbar}{m_{e}c} \right) \approx 5.5 \cdot 10^{-2} \text{cm}. \]

In standard QED negative mass relate to “pathological” states, which according to the taken roots representations are not realized physically, otherwise such physical state would be unstable in relation to a spontaneous birth of the big number of particles (disintegration of vacuum) [27]. It is shown below as, using (1) to postulate a natural boundary condition which limits disintegration of vacuum: there is a reorganization of vacuum in final state of β+-decay.
in the limited ‘volume’ of space-time (TQT). The substantiation assumed regularization, i.e. exception of the disintegration of the vacuum with a preservation of the direct interpretation of the negative sizes of energy and action in the “mirror Universe” can be received with attraction of M. Born’s “principle of reciprocity” [28]:

‘General relativity is concerned only with point transformations in the x-space < ... > It has struck me that the point transformations in the p-space might be considered in the same way. Thus one is led to a kind of inverted relativity formalism in the p-space in which everywhere space-time and momentum-energy are interchanged. The principle laws of quantum mechanics, such as the commutation laws, the relations of indeterminacy, etc., are symmetrical in \( x_k \) and \( p_k \).

These facts suggest very strongly the formulation of a ‘principle of reciprocity’, according to which each general law in the x-space has an ‘inverse image’ in the p-space, in the first instance the laws of relativity’.

Supersymmetric degeneration of the ortho- and parasuperpositronium (\( \Delta W \approx 0 \), see [11,12]) can be realized at enough big \( n=N \)

\[
W_N = \frac{e^4 m_e}{4 \hbar^2 N^2} \approx 0
\]  

where \( W_N \) is the binding energy of N-th positronium state. Expansion of a principle of reciprocity allows to formulate a natural boundary condition for the completely degeneracy Fermi-gas with boundary energy \( \varepsilon_F \) (Fermi’s level) [29] in the discrete \( x \)-space

\[
\varepsilon_F = (3\pi^2)^{2/3} \cdot \frac{\hbar^2}{2m_e} \left( \frac{N^{(3)}}{V} \right)^{2/3} = (3\pi^2)^{2/3} \cdot \frac{\hbar^2}{2m_e} \frac{1}{\Delta^2}
\]

in view

\[
\varepsilon_F = W_N, \tag{3}
\]

as \( N^{(3)} \) is number of cells in the \( p \)-space, displayed in the \( x \)-space in a volume \( V \) of the fundamental space-like structure. The condition (3) unifies standard quantization of the atom states and quantization of the \( x \)-space postulated here. This postulate a transition from linear sequence of the main quantum number in the atom (\( n = 1, 2, 3, ..., N \)) to number of the cells (“units”) of the 3-dimensional space-like structure (“atom of long-range”) \( N^3 \) – is a designated in formulas \( N^{(3)} \). From (2) and (3) we receive values:

1. 3-dimensional fundamental space-like structure cells number

\[
N^{(3)} = \frac{2^{9/2}}{3\pi^2 \cdot \alpha^9} \approx 1.302 \cdot 10^{19} \tag{4}
\]

2. the linear area \( 2R_\mu \) of the fundamental space-like structure with the center in “point” of \( \beta^+ \)-decay during time where \( R_\mu \) is the Bohr radius of N-th positronium state

\[
r_N = \frac{2\hbar^2 N^2}{e^2 m_e} \approx 5.57 \cdot 10^4 \text{cm} \equiv R_\mu
\]

and

\[
\tau_\mu = \frac{R_\mu}{c} \approx 2 \cdot 10^{-6} \text{s.} \tag{5}
\]
If we “occupy” each cell with a natural structural unit of the stable matter “electron(e)/proton(p)” for \( M_\mu > 0 \) and “electron hole (\( \bar{e} \))/proton hole (\( \bar{p} \))” for \( M_\mu < 0 \), then we shall receive the fundamental mass

\[
M_\mu = N^3 \cdot (m_p + m_e) = \frac{2^{9/2}}{3\pi^{1/2}} \cdot (m_p + m_e) \cong 2.179 \cdot 10^{-5}\text{g}. \tag{6}
\]

Comparison of the received value \( M_\mu \) with Planck mass obviously

\[
\pm M_{Pl} = \pm \sqrt{\hbar c/G} \cong 2.177 \cdot 10^{-5}\text{g}.
\]

At a conclusion (6) canonical values of positronium binding energy and the size are accepted (Bohr’s atom, Schrodinger equation). The account of the radiation corrections improves the accuracy of the representation of Planck mass (and gravitational constant \( G \)) through a constant of thin structure \( \alpha \).

Thus, identifying the received value of two-digit fundamental mass \( M_\mu \) with Planck mass (with accuracy \( \sim 0.1\% \)) on the basis of experiment [10-12] and additional realization of supersymmetry, when observable there is a shift (non-locality), and superpartners are latent from supervision in the ‘mirror Universe’, we are postulate ‘additional \( Gh/c\)-physics’.

### III. ON THE SUPPRESSION MACROSCOPIC QUANTUM EFFECT BY ELECTRIC FIELD

Since second half of the 1970th the experimental program has been proved which result became an establishment of “isotope anomaly” lifetime spectra of the positrons annihilation from \( \beta^+ \)-decay \(^{22}\text{Na} \) in a gaseous neon (\( \gamma_n-\gamma_a \)-delayed coincidence; \( \gamma_n^- \) is the nuclear gamma-quant, \( \gamma_a^- \) one of annihilation gamma-quanta) [10]. A growth of the intensity long-living orthopositronium components of annihilation lifetime spectra was observed (the factor 1.85\pm0.1) during a reduction of the contents of an isotope \(^{22}\text{Ne} \) from 8.86\% (in neon of natural isotope composition) up to 4.91\%. The standard estimation of the effect from isotopic shift of a threshold of the positronium formation in these conditions gives a vanishingly small value \( \sim 10^{-6} \).

Full degeneration of the ground states para- and ortho-superspetronium in \( N=2 \) supersymmetric QED (\( N=2 \) SQED) [30], as a manifestation of \( \sigma\)-Ps oscillation in the ‘mirror Universe’ (with conservation of \( CP \)-parity, see [11, 12]), it is based phenomenology of the \( \sigma\)-Ps ‘isotope anomaly’, and old calculations \( \sigma\)-Ps annihilation on a single-quantum and the neutral spin 1 boson \( U \) supersymmetric theory [17] have allowed to receive a realistic estimation of the contribution of an additional annihilation mode \( ^T\text{Ps}\backslash ^{\bar{T}\text{Ps}}(^8\text{Ps}) \sim 2 \cdot 10^{-3} \) (\( \”\lambda_T\)-anomaly”). This result can be interpreted as a consequence of the topological quantum transition in \( \beta^+ \)-decay (see [11, 12]). Thus, in works [11, 12] the substantiation and the quantitative description of the observable macroscopical quantum effects in final state of \( \beta^+ \)-decay of the nuclei such as \(^{22}\text{Na}, \, ^{68}\text{Ga} \) (\( \triangle J^\pi = 1^+ \)) is received. In the previous part (II) the conceptual foundations examined statement of a question are stated.

In article [31] (see section I) the critical analysis of the conclusions of the work [1] is carried out. It has been shown, that a technique of the new experiment of Michigan group,
in which the electric field is used, is qualitatively distinct from the techniques of the works [5, 6]. A theoretical base of the critical analysis [31] (in section I) of Michigan group conclusions [1] from the positions of the quantum theory of field (QTF) is:

- hypothesis about additional realization of a supersymmetry ("additional \(G\bar{c}/c\)-physics);
- antipodal symmetry of an energy (mass) and action in the "mirror Universe" in relation to the real observer (A.D. Linde [32]). For a consideration of vacuum reconstruction in the limited "volume" of space-time in \(\beta^+\)-decay the final state from the positions of the GR concepts are incorporated (see section II):
  - spontaneously broken full relativity (A.F. Andreev, 1982);
  - vacuum-like state of matter (VSM, E.B. Gliner, 1965) and
  - discrete, scalar C-field with the negative density of the energy (mass), compensating VSM (F. Hoyle & J.V. Narlikar, 1964).

For an explanation of the orthopositronium anomalies [5,6,10] the model of a long-range for a baryon charge is offered, as ‘...a qualitatively allocated state of the environment is the special phase, basically capable to exchange energy, pulse, baryon charge, etc. with the other phases of the environment’ [33]. The limit sized VSM (we shall name it “an atom of the long-range”) has the discrete, crystal-like structure with the common number of the cubic cells ("units") \(M_{Pl}/(m_p + m_e) \approx 1.302 \cdot 10^{19}\) (\(M_{Pl}\) is Planck mass, \(m_p\) – proton mass, \(m_e\) – electron mass). In an initial state (trivial topology) all types of the charges in "units" VSM are compensated by the charges of an opposite sign on the C-field (the "mirror Universe"). In final state of the \(\beta^+\)-decay in a gravitational field in the \(\alpha\)-Ps self-annihilation time occurs decompensation of a baryon charge, as the VSM (a positive mass \(M_{Pl}\)) falls in a gravitational field, and the "mirror Universe" with the negative mass \(-|M_{Pl}|\) goes opposite. A conformity of the structures of an usual substance ("atom"/ "nucleus of atom") and VSM takes place: in "an atom of the long-range" (2\(R_\mu\) \(\sim 1.2\) km) are allocated a "nucleus of atom of long-range", containing \(\pi = 5.2780 \cdot 10^4\) cells-"units" (2\(r_\pi\) \(\sim 2.6\) cm; \(r_\pi\) – radius of "nucleus"), with which \(\alpha\)-Ps interact [11,12].

In the "additional \(G\bar{c}/c\)-physics" observable there is a space "shift" in the constitution of the VSM's discrete structure (supersymmetry is restored). In a Standard Model supersymmetry is broken, space shift is not examined as an observable and it is supposed, that the mechanism of the supersymmetry breaking will be established as a result of the supervision of superpartners.

Sequence of the "shifts" in a process of the oscillations \(TPs\backslash TPs'(SPs')\) forms a Hamiltonian cycle (in the language of the graph theory), connecting a "nucleus of an atom of the long-range" and lifetime of \(\alpha\)-Ps: "wandering" \(\alpha\)-Ps at its oscillations to the ‘mirror Universe’ till the annihilation moment can be presented as a way with an steps length on all "units" (without recurrences) in a “nucleus of an atom of the long-range”. It assumes calculation of the shares \((l_a, l_b, l_c)\) each of the possible steps in total length of the way \(L\)

\[
L = \pi \cdot \Delta \cdot \left( \frac{l_a}{l_a + l_b + l_c} + \frac{l_b}{l_a + l_b + l_c} + \frac{l_c}{l_a + l_b + l_c} \right).
\]

In a spatial cubic lattice, alongside with steps on the edges of a cube \((a = 1)\) still two type steps are possible: on a small diagonal (on the verge of a cube) \(b = \sqrt{2}\) and on the big diagonal (between as much as possible removed tops of a cube) \(c = \sqrt{3}\). It is equivalent to appearing
of two allocated speeds \(c/\sqrt{2}\) and \(c/\sqrt{3}\) along with the light velocity. It is interesting, that it is recently marked peculiarity of speeds \(c/\sqrt{2}\) and \(c/\sqrt{3}\) in GR [34]. It is possible to make the following estimations for minimal (a) and maximal (c) distances between units. For “a nucleus of an atom of the long-range” the prospective length Hamiltonian cycle gives an estimation of the orthopositronium lifetime:

from below

\[
\frac{\pi \cdot \Delta \cdot a}{c} \approx \frac{52780 \cdot 5.5 \cdot 10^{-2} \text{cm}}{3 \cdot 10^{16} \text{cm/s}} \approx 96.9 \cdot 10^{-9} \text{s}
\]

and from above

\[
\frac{\pi \cdot \Delta \cdot c}{c} \approx \frac{52780 \cdot 5.5 \cdot 10^{-2} \cdot \sqrt{3} \text{cm}}{3 \cdot 10^{16} \text{cm/s}} \approx 167.8 \cdot 10^{-9} \text{s}
\]

\(96.9 \text{ ns} < < 1/\lambda_T \approx 142 \text{ ns} < < 167.8 \text{ ns.}

These estimations are the additional argument of the allocation of “a nucleus of an atom of the long-range” in structure “an atom of the long-range”.

The description of an additional mode (\(\sim 0.2\%\)) \(\alpha\)-Ps annihilation [12] means realization, along with standard QED – one of the fundamental theories in a structure of the “cube of the physical theories” (M.P.Bronshtein, 1934/A.L. Zelmanov, 1967), describing dynamics of 99.8% \(\alpha\)-Ps, – and a new physdics. The new physics (“additional -physics”) corresponds to “top” \((0, \hbar, G)\) of the “cube of the physical theories”, representing ‘...non-relativistic quantum gravitation (NQG), < ...> concerning which it is not clear, whether there are objects, which it describes...’ [35]. By A.L. Zelmanov identified all tops of “cube”, except of this.

The analysis with the account for “an additional \(G\hbar/c\)-physics” shows, that the decision of the orthopositronium problem can be received as a result of the comparative measurements which are not demanding changes of a technique of work [1]. It is necessary to compare with the other things being equal, the results of two measurements, when:

- the vector of an intensity of an electric field \(\mathbf{E}\) is directed parallel to a gravity \(\mathbf{P}\) (the perpendicularly to flatness of a porous film in which it is formed Ps; though in the published work of Michigan group are not present the information of the mutual orientation of the vectors \(\mathbf{E}\) and \(\mathbf{P}\), but the standards of an illustration of a scientific texts allow to assume according to Fig. 1 of [1], that this variant of experiment is already realized, in which the additional supersymmetric mode with the contribution \(\sim 2 \cdot 10^{-3}\) is suppressed) and

- the vector of an intensity of an electric field \(\mathbf{E}\) is directed perpendicularly to a gravity \(\mathbf{P}\) and to flatness of a porous film. Let’s calculate intensity \(\mathbf{E}\) of the electric field necessary for a deviation of a beam of positrons with energy 700 eV on a porous film. In non-relativistic approximation the positron trajectory is determined by expression (see, for example, [36])

\[
x = \frac{m_e \cdot |e| \cdot \mathbf{E}}{2p_y^2} \cdot y^2 + \frac{p_x}{p_y} \cdot y .
\]

Let’s choose an axis \(x||\mathbf{E}\) (projection of a positron pulse \(p_x = 0\)). Then in view of geometry of the measuring cavity used in work [1] we receive an intensity of an electric field \(E_{\text{exp}} < 4 \cdot 10^3 \text{V/cm.}

Opposite charged matrixes – cubic lattices of “particles” in a structure of a macroscopical quantum structure VSM and “holes” in a structure “mirror Universe” (accordingly, positive
and negative mass) – are accelerated by an electric field in one direction. Action of an electric field is shown in “units” which represent “points” of a crossing of the observable Universe (VSM) and C-fields (“mirror Universe”). Gravitation, on the contrary, moved apart these matrixes in a vertical direction. This counteraction is shown on a Fig.: electric force (2eE on “unit”) operates on an electric dipole under a angle \((180^\circ - \alpha)\) in relation to a gravity \(\mathbf{P}\), counteracting decompensation of a baryon charge.

![Fig. Direction of electric force relation to gravity](image)

In order to opposite sign baryon charges (and connected with these electric charges) did not compensate each other in each “unit”, they should moved apart (on a vertical) on the distance equal to the baryon size (“proton” in a structure VSM). The characteristic size of a proton is determined by its Compton’s length

\[
\lambda_p = \frac{\hbar}{m_p \cdot c} \approx 2 \cdot 10^{-14}\text{cm}.
\]

Hence, for the decompensation at would be an actions of an effective (critical) acceleration of the mass \(\gamma_{cr}\) during lifetime \(\alpha\)-Ps \((\tau_T \cong 1.42 \cdot 10^{-7}\text{s})\), enough

\[
\frac{2\gamma_{cr} \cdot \tau_T^2}{2} \cong 2 \cdot 10^{-14}\text{cm}, \quad \gamma_{cr} = \frac{2 \cdot 10^{-14}}{\tau_T^2} \cong 1\text{cm/s}^2.
\]

Other estimation \(\gamma_{cr}\), reflecting an exchange interaction of a baryon charges of nucleus of atoms of a matter with a baryon charge in “unit”, accounts the radius of an action of a nuclear forces \(r_b = (2 \div 3) \cdot 10^{-13}\text{cm}\)

\[
\gamma_{cr} = \frac{(2 \div 3) \cdot 10^{-13}}{\tau_T^2} \cong 10\text{cm/s}^2.
\]

The distinction between the resulting estimations on the order on an end result will not be reflected, because the acceleration of a gravity \(g \gg \gamma_{cr}\). It is necessary to take into account, that there are under an action of a gravitational field all “atom of the long-range” \((M_{Pl})\), i.e. \(\sim 10^{19}\) of its “units”, and the external electric field operates only in a volume of the measuring chamber \(V_{exp} = (1.5 \text{ cm})^3 \cong 3.4 \text{ cm}^3\) [1]. In this volume getting in a sphere of a “nucleus of an atom of the long-range”, contains \(n = V_{exp}/\Delta^3 = 3.4 \text{ cm}^3/(5.5 \cdot 10^{-2}\text{cm})^3 \cong 1.7 \cdot 10^4\) “units”. Let’s notice, that all volume of the measuring chamber is included to the structure of a “nucleus of an atom of the long-range”, as \(\pi(5.2780 \cdot 10^4) > n(1.7 \cdot 10^4)\). Therefore, operating with the force, braking falling VSM, an electric field creates the braking equal

\[
\frac{2n \cdot eE \cdot \cos \alpha}{m_{eff}},
\]
where $m_{\text{eff}}$ is an effective mass.

There is a question how to determine $m_{\text{eff}}$? As at the “top” NQG are simultaneously realized both “classics” and “quanta” then the mass applies for the role of this size is only

$$m_S = e/\sqrt{G} \sim 10^{-6} g,$$

for the first time considered by G.J. Stoney (1881) long before opening a constant of Planck (see [37]). An expression for $m_S$ has been received by an equating of the potentials Coulomb and Newton, a in spirit of a counteraction of an electric force and gravitation examined here:

$$\frac{e^2}{r} = G \cdot \frac{m_S^2}{r}.$$ 

Let’s, in passing notice, that the squares of the charges – an electric and “gravitational” – mean, as well as for Planck mass, an opportunity of their treatment as a plus- and minus-particles. Now there is all for the quantitative formulation of a condition of a suppression by an electric field of the additional $\alpha$-Ps self-annihilation mode:

$$M_{\text{Pl}} \left( g - \frac{2n \cdot eE \cdot \cos \alpha}{m_{\text{eff}}} \right) < M_{\text{Pl}} \cdot \gamma_{\text{cr}}$$

also we receive criterion of the suppression

$$E > \left( \frac{g - \gamma_{\text{cr}} \cdot m_{\text{eff}}}{2n \cdot e \cdot \cos \alpha} \right) = \frac{g - \gamma_{\text{cr}}}{2\pi \cdot \sqrt{G} \cdot \cos \alpha},$$

as $m_{\text{eff}} \equiv m_S$, $n \to \pi$. At $\alpha \cong 0$ ($E$ in anti-parallel $P$) the intensity of an external electric field should exceed critical value $E_{\text{cr}} \sim 10^4$ V/cm. The intensity of an electric field in the experiment [1] $E_{\text{exp}}$ satisfies to the criterion of the suppression of an additional supersymmetric mode of the $\alpha$-Ps annihilation $E_{\text{exp}} \sim E_{\text{cr}}$.

In the conditions when $E$ is perpendicular to $P$ ($\alpha \approx 90^\circ$, $\cos \alpha \approx 0$, $E_{\text{exp}} < < E_{\text{cr}}$), the additional supersymmetric mode with the contribution $\sim 2 \cdot 10^{-3}$ should be restored.

Addition at a proof-reading

The opportunity to check up the assumption of a conditions of a measurements in work [1] (see above) under the dissertation of R.S. Vallery “RESOLUTION OF THE ORTHOPOSITRONIUM LIFETIME PUZZLE” (University of Michigan, 2004) has appeared. A comparison of the diagram (Fig.1 in [1]) with photos of the installation and the measuring chamber (Fig. 4.6 and Fig. 4.15 in the dissertation) leaves no doubt that the measurements were carried out in conditions, when an electric field $E$ is in a parallel to gravity $P$.

Any of the methods and tests for a substantiation and exceptions of the regular mistakes submitted in the dissertation in details, does not contradict alternative interpretation of the result, received in a vacuum experiment with an electric field [1] discussed here. Additional annihilation mode with the contribution $(0.19 \pm 0.02)\%$ in the experiments in a magnetic field with buffer gases [5] and with the contribution $(0.14 \pm 0.023)\%$ in vacuum experiment without an electric field [6], it is caused by non-local interaction $\alpha$-Ps with VSM and the C-field (the “mirror Universe”). In the new vacuum experiment the additional mode is suppressed by action of an electric field to the macroscopical quantum structure “VSM +
C-field”. It can be restored by “neutralization” of an action of an electric field at \( \alpha \approx 90^0 \) the all intensities \( E \sim 10^4 \)V/cm. This alternative interpretation of the all results of Michigan group, received for two decades, cannot exclude even measurement of a kinetic energy \( \alpha \)-Ps according to a time of the flight, because the small share \( \alpha \)-Ps (\( \leq 0.2\% \)) represents a component (the “phase”) cooperating with a macroscopical quantum state ("VSM + C-field") in a final state of the \( \beta^+ \)-decay and dropping out of the standard kinetics laws (see section I). The situation with \( \alpha \)-Ps is in this respect similar to two-component structure of a superfluid state of the liquid helium. The tests, used in the dissertation, cannot allocate the small, but very important contribution from the basic point of view of this “phase” of \( \alpha \)-Ps. The choice for the benefit of one of alternatives without basic change of a technique can be made only on the basis of comparative measurements of the \( \alpha \)-Ps self-annihilation decay rate at \( E \) parallel and \( E \) perpendicular to gravity \( P \) under other identical conditions.

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† Year ago has died Dr. Sci. (Phys.&Math.) Boris Aleksandrovich Kotov (1938 – 2010). This work and the forthcoming experimental check of the ideas, which are put in its basis, all this – last scientific problem which interested B.A. till final days. The basic feature of B.A.Kotov’s person – Physicist-Constructor-Manager – was the feeling new. But novelty should be well proved by previous experience of a science and practice. From the end of 1980th, being already the Head of the Research-and-Production Association “Electron Integral Systems” (Saint-Petersburg), B.A. has constantly supported these researches.

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