

On the Possibility of Nuclear Synthesis During Orthopositronium Formation by β^+ -Decay Positrons in Deuterium

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Observations of the “isotopic anomaly” of positron (^{22}Na) annihilation lifetime spectra in samples of gaseous neon of various isotopic abundance, the independent observations of the orthopositronium lifetime anomaly, and comparison of unique experimental data on the positron’s annihilation lifetime spectra in condensed deuterium (D_2) and protium (H_2), suggest a hypothesis on synthesis of ^4He during the orthopositronium formation in deuterium. The decisive experiment is offered.

1 Introduction

When a muon replaces an electron in a two-centre “molecular ion” of light nuclei (e.g. $[\text{d}\mu^-\text{d}]^+$, where d is the deuteron), the structure of the ion is changed in a qualitative way — it is converted into a one-centre “compound ion” [$^4\text{He}\mu^-$]⁺ owing to a two order increase in lepton mass. Energy is then released as a result of fragmentation* and the liberation of a muon (μ catalysis).

There is the possibility that conversions of this sort occur in processes involving light diatomic molecules (in particular, D_2) as they interact with positrons in the process of production of orthopositronium [o-Ps, $^3\text{Ps} \equiv {}^3(\text{e}^+\text{e}^-)_1$]. This suggestion is based primarily on the results of independent measurements which have established lifetime anomalies in o-Ps annihilation (deviations from QED), on the “isotopic anomaly” [1] and the “ λ_{T} -anomaly” [2, 3].

“Positronium, the bound state of the electron and positron, is a purely leptonic state — it is effectively free of hadronic and weak-interaction effects” [2], and its annihilation is calculated with high precision in QED. Observation of the “isotopic anomaly” [1] was the basis for careful study this assertion. This relationship sets up a new perspective which merits further studies.

In this connexion there is special interest in the results on lifetime annihilation spectra of positrons (orthopositronium) in liquid and solid deuterium [4] and comparison of these results with corresponding results on protium [5]. In particular, Liu and Roberts [4] have measured the short-lived components in the time-resolved spectra: $\tau_1 = 0.83 \pm 0.03$ ns (liquid D_2 , 20.4 K) and $\tau_1 = 0.74 \pm 0.03$ ns (solid D_2 , 13 K). However, there are no data on a long-lived component (o-Ps). The results for H_2 are $\tau_1 = 0.92 \pm 0.04$ ns (20.4 K) and $\tau_1 = 0.80 \pm 0.03$ ns (13 K). In contrast with the D_2 case, data were reported on o-Ps ($\tau_2 = 28.6 \pm 2.3$ ns at 20.4 K and 14.6 ± 1.2 ns at 13 K [5]).

Clearly, o-Ps is formed in condensed deuterium in the

*In the neutron channel ^3He (0.82 MeV) + n (2.45 MeV), or in the tritium channel, T (1.01 MeV) + p (3.02 MeV).

same way as in condensed protium. We are thus led to ask whether o-Ps is indeed absent from the time-resolved annihilation spectra in condensed deuterium. The single corresponding study [4] has failed to answer this question unambiguously.

2 Background of the hypothesis and the first attempt of its verification (a cumulative method of identification of products of nuclear synthesis)

If this difference between the time-resolved positron annihilation spectra in the condensed states of H_2 and D_2 is confirmed, then the absence of the o-Ps-component in liquid and solid deuterium could be explained on the basis that it is quenched by radiolysis products with net charge and spin, in a “blast hole” of charged products of nuclear synthesis which carry off a total energy of a few MeV per event. These products of radiolysis suppress the long-living component of the lifetime spectra (*quenching* of o-Ps [6]).

For an explanation and quantitative description of the orthopositronium anomalies [1–3] the hypothesis of representation of the β^+ -decay of the nuclei ^{22}Na , ^{68}Ga , etc. ($\Delta J^\pi = 1^+$) as a *topological quantum transition* in a limited (macroscopic) “volume” of space-time is justified. The limited “volume” (“*defect*”) of space-time, i.e. *vacuum-like state of matter* with positive Planckian mass $+M_{Pl}$, is the *long-range atom* having a full number of sites $N^{(3)} = 1.302 \times 10^{19}$. All its charges (baryon charge among them) are compensated for by a discrete scalar *C-field* (the “mirror Universe” with negative Planckian mass $-M_{Pl}$). A “defect” of space-time becomes some “background” where orthopositronium is within of macroscopic “*long-range atom nucleus*” with the number of sites $\bar{n} = 5.2780 \times 10^4$ in oscillation [7–12].

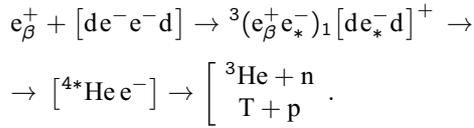
“Let there be a certain probability for disturbances in vacuum to alter its topology. If we now visualize some sort of ‘handedness’ such that at the entrance the particle is right-handed, and at the exit it is left-handed, then we have a certain probability for a right-left particle transition, which

means that the particles have a rest mass" [13].

The aforementioned oscillations between the observable Universe and the "mirror Universe" are responsible for an additional mode of the orthopositronium annihilations

$$o\text{-Ps} \setminus o\text{-Ps}'(p\text{-Ps}') \rightarrow \gamma^\circ \setminus 2\gamma',$$

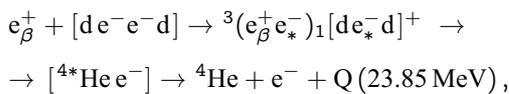
where γ° is a notoph, a massless particle with zero helicity, in addition to the properties to the photon (helicity ± 1); in interactions the notoph, as well as the photon, transfers spin 1 [14]. These oscillations can also cause an additional mass for electrons e_*^- that can result in nuclear synthesis during o-Ps formation by



Thus, the orthopositronium anomalies (as manifestation of its connexion with the "mirror Universe") permit the formulation of a hypothesis about effective o-Ps topological mass ($\sim 200 m_e$) and, accordingly, a two-way connexion of an electron in $[de_*^-d]^+$ (owing to an exchange interaction at the moment of o-Ps formation), along with an experimental programme for studying this hypothesis [15].

Amongst the products of reaction we focus on ${}^3\text{He}$, since (on the one hand) it is formed directly in the neutron channel, and (on the other) it accumulates, because of the decay $T \rightarrow {}^3\text{He} + e^- + \bar{\nu}$ from the tritium channel. The accumulation method with exposition time $t_{exp} \sim 0.32$ years and a high-sensitivity *magnetic resonant mass-spectrometer* for the analysis, ${}^3\text{He}$ and ${}^4\text{He}$ have established a *negative result* concerning the products of fragmentation of a compound ion $[{}^4\text{He}e^-]^+$ not only by the neutron channel, but also by the tritium channel [15].

However these results do not rule out the overall hypothesis which we consider: there is a possibility that nuclear synthesis involving o-Ps is cut off in the stage of formation of the "compound ion" $[{}^4\text{He}e^-]^+$, with subsequent relaxation of nuclear excitation energy (23.85 MeV) as kinetic energy of an " α -particle", as the "long-range atom" through an "atomic nucleus" can relinquish its non-recoil energy. Now there are no data on quantum energy excitation structure of the "nucleus" and "long-range atom" as a whole. Because of the disproportionately large mass of an "atom" (M_{Pl}) in comparison with the mass of an " α -particle", the latter can practically carry away all energy of excitation and formation in a final state, after delay and recombination, as follows,



but part of energy can be transferred to the "lattice" of the *vacuum-like state of matter*.

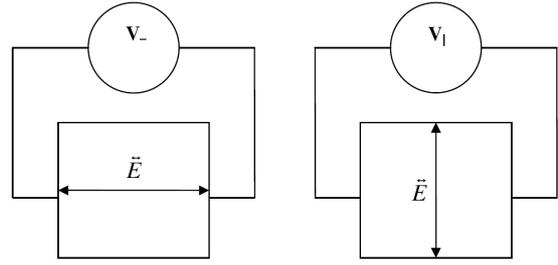


Fig. 1: V_- and $V_|$ are electric breakdown thresholds of the gas when the dc electric field is oriented horizontally and vertically respectively. A decrease in the electric breakdown threshold of deuterium (D_2) is anticipated for perpendicular orientation of electric field to gravity, under other identical conditions ($V_- < V_|$). For H_2 the electric breakdown thresholds in these measurements cannot significantly differ ($V_- \equiv V_|$). (A conventional criterion: $\vec{E} > 6.7 \text{ kV/cm}$ [16].)

3 The electric field opens an opportunity of direct check of a hypothesis

The latest work of the Michigan group has created a new situation for the hypothesis adduced herein. It is necessary to emphasize that the result of the last set of Michigan measurements, after introduction of a dc electric field up to $\sim 7 \text{ kV/cm}$ in a measuring cell [16], we treat as the first observation of a connexion between gravitation and electricity [11, 12]. The introduction of an electric field in the final Michigan experiment can have other (additional) consequences to those given by authors for o-Ps thermalization [16]. According to the hypothesis, manifestation of the "isotopic anomaly" [1] and the λ_T -anomaly [2, 3] as *macroscopic quantum effects* is the generalized "displacement currents" in the final state of the topological quantum transition of nuclei ${}^{22}\text{Na}$, ${}^{68}\text{Ga}$, etc. The electric field probably counteracts the generalized displacement currents and has led to suppression of macroscopic quantum effects [10, 12]. The Michigan experiment [16] was set up in such a way that an electric field introduced into the experiment (it accelerates the particle beam before the target) merely suppressed the anomaly, despite the fact that the electric field helps achieve complete thermalization of orthopositronium in the measurement cell. Consequently, the anomaly, present but suppressed by the field, merely became obscured in the given experiment.

In work [12] the analysis of the mechanism of suppression of macroscopic quantum effects by an electric field is presented, from which it follows that comparative measurements of a threshold of electric breakdown in a cell with a source of positrons (${}^{22}\text{Na}$) alternately filled by dense gases (D_2 , H_2), and (for each gas) with change of orientation of an electric field (parallel and perpendicular to gravity) can be a more sensitive tool for identification of *macroscopic quantum effects* in comparison with the accumulation method [15]. At sufficiently high pressures of D_2 the activity of a

source of stationary concentrations of positrons of the radio-lysis products in a field $\vec{E} > 6.7$ kV/cm, the background level created by cosmic and other casual sources of radiations can be repeatedly exceeded. In these conditions the threshold of electric breakdown of a gas oriented parallel to gravity (V_{\parallel}) will be higher than the electric breakdown threshold of gas oriented perpendicular to gravity (V_{\perp}), under other identical conditions ($V_{\parallel} > V_{\perp}$).

The experiment suggested herein, with introduction of an electric field $\vec{E} > 7$ kV/cm into a measuring cell, provided that a field $\vec{E} > 6.7$ kV/cm is still under the electric breakdown threshold of the gas (see Fig. 1), is the *decisive experiment*.

Dedication

This paper is dedicated to the memory of our long-time co-author Dr. Boris Aleksandrovich Kotov (October 8, 1938 — April 10, 2005).

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References

1. Levin B.M., Kochenda L.M., Markov A.A. and Shantarovich V.P. Time spectra of annihilation of positrons (^{22}Na) in gaseous neon of various isotopic compositions. *Sov. J. Nucl. Phys.*, 1987, v. 45 (6), 1119.
2. Westbrook C.I., Gidley D.W., Conti R.S. and Rich A. New Precision Measurement of the orthopositronium decay rate: a discrepancy with theory. *Phys. Rev. Lett.*, 1987, v. 58 (13), 1328; Precision measurement of the orthopositronium decay rate using the gas technique. *Phys. Rev. A*, v. 40 (10), 5489.
3. Nico J.S., Gidley D.W., Rich A. and Zitzewitz P.W. Precision measurement of the orthopositronium decay rate using the vacuum technique. *Phys. Rev. Lett.*, 1990, v. 65 (11), 1344.
4. Liu D.C. and Roberts W.K. Positron annihilation in condensed gases. *Phys. Rev.*, 1963, v. 130 (6), 2322.
5. Liu D.C. and Roberts W.K. Free-positron annihilation mean life in diatomic and rare gases in liquid and solid states. *Phys. Rev.*, 1963, v. 132 (4), 1633.
6. Goldanskii V.I. Physical chemistry of the positron and positronium. In: *Atomic Energy Review*, v. VI, No. 1, IAEA, Vienna, 1968.
7. Holdom B. Two U(1)'s and ϵ charge shifts. *Phys. Lett. B*, 1986, v. 166 (2), 196.
8. Glashow S.L. Positronium versus the mirror Universe. *Phys. Lett. B*, 1986, v. 167 (1), 35.
9. Levin B.M. On the kinematics of one-photon annihilation of orthopositronium. *Phys. At. Nucl.*, 1995, v. 58, 332.
10. Levin B.M. Orthopositronium: annihilation of positron in gaseous neon. arXiv: quant-ph/0303166.
11. Levin B.M. and Sokolov V.I. On an additional realization of supersymmetry in orthopositronium lifetime anomalies. arXiv: quant-ph/0702063.
12. Kotov B.A., Levin B.M. and Sokolov V.I. Orthopositronium: on the possible relation of gravity to electricity. Preprint-1784, A. F. Ioffe Physical Technical Institute of the Russian Academy of Sciences. St Petersburg, 2005; arXiv: quant-ph/0604171.
13. Zeldovich Y.B. Gravity, charges, cosmology and coherence. *Physics-Uspeski*, 1977, v. 123, 502.
14. Ogievetskii V.I. and Polubarinov I.V. Notoph and its possible interactions. *Sov. J. Nucl. Phys.*, 1966, v. 4 (1), 216.
15. Kotov B.A. and Levin B.M. Orthopositronium, mirror Universe and cold fusion. Preprint LSFF/91-01, January 5, 1991; Levin B.M., Sokolov V.I., Khabarin L.V. and V.S.Yudenich. Comparative measurements of the isotopic composition of trace amounts of helium in deuterium after bombardment with positrons from ^{22}Na decay. *Sov. J. Nucl. Phys.*, 1992, v. 55 (10), 1452; Levin B.M., Borissova L.B. and Rabounski D.D. Orthopositronium and space-time effects. Moscow-St.Petersburg, Lomonosov Workshop, 1999, p.59.
16. Vallery R.S., Gidley D.W. and Zitzewitz P.W. Resolution of orthopositronium-lifetime puzzle. *Phys. Rev. Lett.*, 2003, v. 90 (20), 203402.