The Experiments Of The Bottle And The Beam For The Lifetime Of The Neutron: A Theoretical Approximation Derived From The Casimir Effect

Author : Angel Garcés Doz*

Abstract

The last neutron life-time experiments using the bottle method rule out possible experimental errors and possible sources of interference; mainly the interaction of the neutrons with the material of the walls of the bottle. Therefore, the discrepancy between the lifetimes of the neutron by experiments of the beam and the bottle require a theoretical explanation.The main and crucial difference between the beam and bottle experiments is the different topology of the experiments. While in the beam experiment the neutrons are not confined; in the experiment of the bottle a confinement takes place. In our theoretical approach we postulate the existence of a type of Casimir effect that due to the different geometry-topology of the experiments; it produces an induction-polarization of the vacuum by the confinement and the existence of the trapped neutrons; in such a way that there is an increase in the density of the quarks u, d, gluons and the virtual W and Z bosons. This density increase, mainly, of the neutral Z bosons; would be responsible for the increased probability of the decay of a neutron in a proton; and therefore of the shortening of the decay time of the neutron in the experiment of the bottle; of 877.7 seconds.

---

*Electronic address: angel1056510@gmail.com

I. INTRODUCTION

The experimental state of both methods can be summarized with the quote from an article published in quantamagazine (Neutron Lifetime Puzzle Deepens, but No Dark Matter Seen)

“Wen physicists strip neutrons from atomic nuclei, put them in a bottle, then count how many remain there after some time, they infer that neutrons radioactively decay in 14 minutes and 39 seconds, on average. But when other physicists generate beams of neutrons and tally the emerging protons — the particles that free neutrons decay into — they peg the average neutron lifetime at around 14 minutes and 48 seconds.

The discrepancy between the “bottle” and “beam” measurements has persisted since both methods of gauging the neutron’s longevity began yielding results in the 1990s. At first, all the measurements were so imprecise that nobody worried. Gradually, though, both methods have improved, and still they disagree. Now, researchers at Los Alamos National Laboratory in New Mexico have made the most precise bottle measurement of the neutron lifetime yet, using a new type of bottle that eliminates possible sources of error in earlier designs. The result, which will soon appear in the journal Science, reinforces the discrepancy with beam experiments and increases the chance that it reflects new physics rather than mere experimental error.

But what new physics? In January, two theoretical physicists put forward a thrilling hypothesis about the cause of the discrepancy. Bartosz Fornal and Benjamin Grinstein of the University of California, San Diego, argued that neutrons might sometimes decay into dark matter — the invisible particles that seem to make up six-sevenths of the matter in the universe based on their gravitational influence, while evading decades of experimental searches. If neutrons sometimes transmogrify into dark matter particles instead of protons, then they would disappear from bottles at a faster rate than protons appear in beams, exactly as observed.

Fornal and Grinstein determined that, in the simplest scenario, the hypothetical dark matter particle’s mass must fall between 937.9 and 938.8 mega-electron volts, and that a neutron decaying into such a particle would emit a gamma ray of a specific energy. “This is a very concrete signal that experimentalists can look for,” Fornal said in an interview.

The UCNtau experimental team in Los Alamos — named for ultracold neutrons and tau, the Greek symbol for the neutron lifetime — heard about Fornal and Grinstein's paper last month, just as they were gearing up for another experimental run. Almost immediately, Zhaowen Tang and Chris Morris, members of the collaboration, realized they could mount a germanium detector onto their bottle apparatus to measure gamma-ray emissions while neutrons decayed inside. "Zhaowen went off and built a stand, and we got together the parts for our detector and put them up next to the tank and started taking data," Morris said.

Data analysis was similarly quick. On Feb. 7, just one month after Fornal and Grinstein's hypothesis appeared, the UCNtau team reported the results of their experimental test on the physics preprint site arxiv.org: They claim to have ruled out the presence of the telltale gamma rays with 99 percent certainty. Commenting on the outcome, Fornal noted that the dark matter hypothesis is not entirely excluded: A second scenario exists in which the neutron decays into two dark matter particles, rather than one of them and a gamma ray. Without a clear experimental signature, this scenario will be far harder to test. (Fornal and Grinstein's paper, and the UCNtau team's, are now simultaneously under review for publication in Physical Review Letters.)

So there's no evidence of dark matter. Yet the neutron lifetime discrepancy is stronger than ever. And whether free neutrons live 14 minutes and 39 or 48 seconds, on average, actually matters."

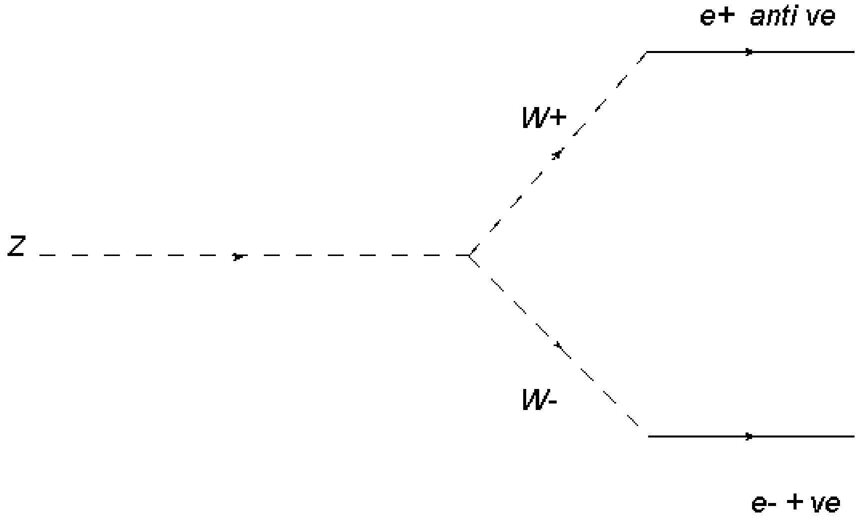
The theoretical approximation of the hypothesis of particles of dark matter does not explain the authentic origin: the difference topology of both experiments; that is: confinement or non-confinement. Therefore, we consider this explanation very implausible. In addition this hypothesis (dark matter) does not take into account that in this experiment of the bottle there is the detection of the protons converted by the decay of the confined neutrons; which further invalidates this hypothesis. The theory presented in this article is the simplest, and is based on physics already known, specifically in the Casimir effect. The novel part would be derived, perhaps, from the participation of quantum gravity by means of an Unruh type effect.

II. THEORETICAL HYPOTHESES

A. Induction of increase in the density of certain virtual particles by modifying the quantum vacuum by topological effect of confinement and the presence of neutrons.

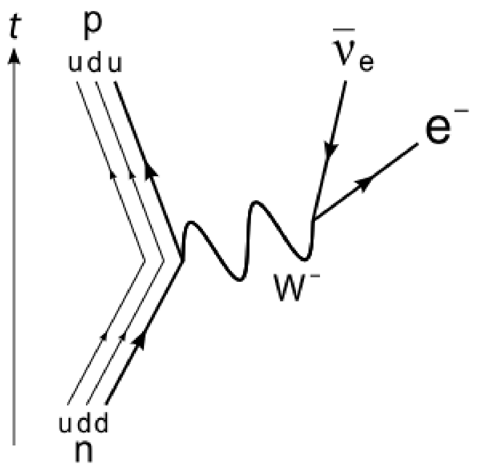
In this section the hypothesis is made that the existence of confined neutrons modifies the virtual vacuum in such a way that there is an increase in the probability of the decay of these neutrons confined by; Z bosons that decay in pairs of bosons W +, W-. And in turn these virtual bosons W +, W-, would decay as: $W^- \rightarrow e^- + \overline{\nu_e}$; $W^+ \rightarrow e^+ + \nu_e$

It starts from the principle of minimum energy states of the virtual vacuum induced by the confinement and presence of real neutrons. This implies that the preferred particles of this virtual vacuum are the quarks, u and d; by the decay of bosons Z and W



The previous Feynman diagram shows the final process by which the probability of neutron decay would be increased; and therefore the lifetime of the neutron would be reduced. The W + boson would be free and the W- would virtually interact with a real neutron; increasing the probability of decaying more quickly in a proton.

The diagram shown would be the end; existing intermediate diagrams produced by gluons, quark-antiquark pairs, lepton-antileptom pairs, etc. Ultimately it will show the possibility that the origin is a genuine effect of the repulsive acceleration of the quantum vacuum, by means of a virtual thermal effect; unruh effect type; which would produce virtual gravitons. This complementary hypothesis will be developed later.



The lifetime of the free neutron in the confinement of the bottle; would depend, then, essentially, on the mass difference between boson Z and neutron. And it would be deduced as a differential equation analogous to that of the average life time. In this case; applied to the ratio of the lifetimes of the free neutron in the bottle and in the beam.

1. Exponential decay

A quantity is subject to exponential decay if it decreases at a rate proportional to its current value. Symbolically, this process can be expressed by the following differential equation, where N is the quantity and λ (lambda) is a positive rate called the exponential decay constant:

$$\frac{dN}{dt} = -\lambda N$$

The solution to this equation (see derivation below) is:

$$N(t) = N_0 \exp -(\lambda t)$$

where N(t) is the quantity at time t, and N0 = N(0) is the initial quantity, i.e. the quantity at time t = 0.

2. Ratio between the lifetimes of the neutrons in the beam and in the bottle: exponential decay derived from the probability density function.

For the ratio of a single neutron in the bottle and in the beam; the number of neutrons will be 1; This is: N = 1.

And the differential equation analogous to exponential decay; in this case as a ratio between the lifetimes of a neutron in the bottle and in the beam; it will be:

$\frac{dt}{t} = -\lambda dN$

Solving the previous equation; and doing N = 1; is obtained:

$t_n(beam) = neutron\,lifetime\,beam = 886.9\,s$; $t_n(bottle) = neutron\,lifettime\,bottle = 877.7\,s$

$\ln\left(\frac{t_n(bottle)}{t_n(beam)}\right) = -\lambda$; $N = 1$; $\lambda = \frac{m_n}{m_Z - m_n}$; $m_n = neutron\,mass = 0.9395654133\,GeV$

$m_Z = boson\ Z\ mass = 91.1876\ GeV$; $\lambda = \frac{0.9395654133\,GeV}{91.1876\,GeV - 0.9395654133\,GeV}$ =0.0104109238234609

Finally, the equation between the neutron life time ratios of both experiments (bottle and beam) is:

$\frac{t_n(bottle)}{t_n(beam)} = \exp -\lambda = \exp -0.0104109238234609 \rightarrow t_n(bottle) = t_n(beam) \cdot \exp -0.0104109238234609$

$$t_n(bottle) = 877.714\,s = t_n(beam) = 886.9\,s \cdot \exp -0.0104109238234609 \ (1)$$

B. Possible origin of the phenomenon of hypothesis A; produced by the repulsive acceleration of the quantum vacuum, which originated virtual gravitons by the unruh effect.

As it has been demonstrated in several of our works; The repulsive acceleration of the quantum vacuum is a direct function of the Hubble constant and the speed of light in the vacuum.That is: $a_0 = H \cdot c \simeq 6.91151937 \cdot 10^{-10}\ m/s^2$

The associated resting mass; Due to the temperature of the unruh effect of this acceleration of the quantum vacuum, it is expressed by the following equation:

$$T = \frac{\hbar \cdot a_0}{2\pi \cdot c \cdot K_B} \ (2)$$

From the above equation an associated gravitational mass is derived, given by:

$$m_G = \frac{\hbar \cdot a_0}{2\pi \cdot c^3} = 4.3053427349 \cdot 10^{-70}\, Kg \; (3)$$

The entropy defined as the sum of probabilities becomes the number of microstates. In our case, this entropy is defined as the natural logarithm ratio of the mass of the Z boson and the gravitational mass (equation 3). This amount of microstates is, then, equivalent to density of particles (number of particles). Taking into account the probability of decay, or conversion, of the quarks u and d; and that is defined by the square of the cosine of the Cabiboo angle (13.04 degrees); It would have:

$$\ln\left(m_Z/m_G\right) = \int\limits_{m_G}^{m_Z} \frac{dm}{m}$$

Being the probability of transition of the quark d in the quark u: $p(d \rightarrow u) = \cos^2\theta_{c12} = \cos^2(13.04^{\circ})$

Multiplying the previous entropy by the probability of transition p (du); you get the number of particles. Bearing in mind that the origin are bosons; and applying the Bose-Einstein statistics; you would finally have the lambda factor of equation 1:

$$\lambda_1 = \frac{1}{\ln\left(m_Z/m_G\right) \cdot \cos^2\theta_{c12} - 1} = 0.0103716296127535$$

The lifetime of the neutrons in the experiment of the bottle is totally coincident with the result obtained by equation (1); this is:

$$t_n(bottle) = 886.9 \cdot \exp -\lambda_1 = 877.748\; s \; (4)$$

III. OTHER HEURISTIC EQUATIONS

1. Entropy: Planck mass neutron mass. Mass ratio quark u quark d.

$$\lambda = \frac{m_u/m_d}{\ln\left(m_{PK}/m_n\right)}$$

2. Entropy: Planck mass neutron mass. Energy ratio; boson W Higgs vacuum.

$$\lambda = \frac{m_W \cdot \sqrt{2}}{\ln\left(m_{PK}/m_n\right) \cdot V_H}$$

IV. CONCLUSIONS

The theoretical derivation of the neutron life time in the bottle; it has been well founded by the hypothesis A. Its mathematical basis is simple and totally in accordance with the function of probability density; from which the exponential law of decay is derived. The hypothesis B, as a primordial origin seems to be quite consistent, to our modest way of thinking. And finally, several simple heuristic relations that seem to confirm both hypothesis A, as well as B. It is quite possible that similar experiments to other particles such as pions (whose lifetime is relatively long), produce differences in lifetime experiments beam and bottles.

Acknowledgments

We thank God the Father, all Powerful, creator of all things. And to our Lord Jesus Christ, our Savior.

[1] Authors, R. W. Pattie Jr.1 , N. B. Callahan2 , C. Cude-Woods1,3, E. R. Adamek2 , L. J. Broussard4 , S. M. Clayton1 , S. A. Currie1 , E. B. Dees3 , X. Ding5 , E. M. Engel6 , D. E. Fellers1 , W. Fox2 , P. Geltenbort7 , K. P. Hickerson8 , M. A. Hoffbauer1 , A. T. Holley9 , A. Komives10, C.-Y. Liu2 , S. W. T. MacDonald1 , M. Makela1 , C. L. Morris1 , J. D. Ortiz1 , J. Ramsey1 , D. J. Salvat11, A. Saunders1 , S. J. Seestrom1†, E. I. Sharapov12, S. K. Sjue1 , Z. Tang1 , J. Vanderwerp2 , B. Vogelaar5 , P. L. Walstrom1 , Z. Wang1 , W. Wei1 , H. L. Weaver1 , J. W. Wexler3 , T. L. Womack1 , A. R. Young3 , and B. A. Zeck1,3, "Measurement of the neutron lifetime using an asymmetric magnetogravitational trap and in situ detection ", https://arxiv.org/ftp/arxiv/papers/1707/1707.01817.pdf

[2] Exponential decay, https://en.wikipedia.org/wiki/Exponential_decay

[3] Neutron, https://en.wikipedia.org/wiki/Neutron

[4] W and Z bosons, https://en.wikipedia.org/wiki/W_and_Z_bosons

[5] Angel Garcés Doz, http://vixra.org/author/angel_g_doz

[6] Unruh effect, https://en.wikipedia.org/wiki/Unruh_effect

[7] Cabibbo,Kobayashi,Maskawa matrix, https://en.wikipedia.org/wiki/Cabibbo–Kobayashi–Maskawa_matrix

[8] Bose–Einstein statistics,