Neutron Decay Time through the Holographic Principle

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Abstract- It is applied the Holographic Principle as a means to estimate the neutron decay time. A stationary condition for a free energy is also considered. The spherical surface at the boundary of this universe having the radius of the neutron is tiled with unit cells of area equal the Planck length times a length related to the weak interaction. It is also considered an energy difference tied to the electromagnetic interaction.

1 – Introduction

Neutron decay is usually studied by applying the tools of field theory to a process involving the weak interaction [1,2]. In this way, the neutron decays in a proton plus an electron and the electron- anti- neutrino. This reaction is mediated by the W^- - boson. A close examination reveals that, indeed we have a transmutation of a down into an up quark, with the emission of an electron and its anti-neutino. In previous papers [3,4] we have treated neutron decay first by considering weak interaction but in an alternative way to that which is usual in the literature [3], and second by defining a two-time least action principle [4], where a transverse time coincides with the Planck length divide by the light speed in vacuum. In the present work we intend to estimate the neutron decay time through the holographic principle (HP).

2 – The Holographic Principle

Recently the Holographic Principle (HP) [5,6,7] has been proposed as a means to explain that the quantity of information contained in a space-volume in the presence of a gravitational field is encoded in the surface area of its event horizon. The aim of the present note is to use HP in order to calculate the neutron decay time.

Here we quote two postulates of HP as stated by McMahon [7], but adapted to the present calculations. They are

. The total information content in a volume of space is equivalent to a theory that lives only on the surface area that encloses the region.

. The boundary of a region of this volume contains at most a single degree of freedom per unit-cell area.

3 – The neutron decay time

In order to evaluate the neutron decay time using the HP, we are going to look at the stationary condition for the free energy F. We write

$$\Delta F = \Delta U - T\Delta S = 0. \qquad (1)$$

To estimate ΔU, we consider that the transmutation of a neutron in a proton brings with it a certain amount of electrostatic energy given by

$$\Delta U = [h/(2R)]\,(\alpha c). \qquad (2)$$

In (2), $h/(2R)$ is a characteristic momentum of the system, being R: - the nucleon radius, and αc is the Bohr velocity. Next we define ΔS, using the HP, we have

$$\Delta S = \pi R^2/(L_{Pl}\, L_{SF}). \qquad (3)$$

The area of the unit cell was taken as the product of the Planck length (L_{Pl}) times the second Fermi length (L_{SF}). The second Fermi length was discussed in a previous paper [8], where a Fermi scale related to the weak interaction was defined in analogy with the Planck units. This Fermi scale has been introduced before by Roberto Onofrio [9], which conjectured that weak interactions could be a manifestation of the gravity at a short-distance. Besides this we can write

$$h\upsilon = h/\tau = T \ (k_B = 1). \qquad (4)$$

Inserting information of (2), (3), and (4) into (1) and solving for τ, we obtain the neutron time decay

$$\tau = (2\pi R^3)/(L_{SF} L_{Pl} \alpha c). \qquad (5)$$

As a means to evaluate numerically (5), we consider that

$$L_{PL} = 1.62 \times 10^{-35} \text{ m}; \quad L_{SF} = 1.07 \times 10^{-19} \text{ m}; \quad R = 0.84 \times 10^{-15} \text{ m}. \qquad (6)$$

In (6), the value of R is obtained from reference [10], and L_{SF} is quoted from reference [8]. Inserting numbers in (5) we get

$$\tau = 981 \text{ s}. \qquad (7)$$

This value for the neutron decay time must be compared with: - 1316 s; 914 s; 963 s; these three values evaluated through different approximations in reference [1]. It also must be compared with the experimental neutron lifetime of 898 ± 16 s, as quoted in [1].

References

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