Is the Electron Unstable?

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Abstract

The problem I shall address in this paper is concerned with the mean lifetimes of leptons. After proposing a formula for the lifetime of the tau particle and following two rules, I build a formula for the lifetime of the muon. Based on these two formulas and based on the same rules, I derived the formula for the mean lifetime of the electron. The formula I found through this extrapolation process indicates that the electron is unstable and that its mean lifetime is, approximately, $(\pi/2)\times 10^{90}$ *years, which is about* 10^{80} *times the age of the universe. Thus according to this formulation the lifetime of the electron is extraordinarily long but not infinite as previously thought.*

Keywords: *mean lifetime, fine-structure constant, tau particle, muon, electron, Planck's constant.*

1. Introduction

Both the proton and the electron have always been considered stable particles. However, if this analysis is correct, we can put the electron in the "bag" of unstable particles. Therefore, should the proton and the electron proved to indeed be unstable, the whole universe would have a finite lifetime.

Let us consider the decays caused by weak and strong forces. The Hyperphysics web page entitled *Decays Caused by Weak and Strong Forces* [1] quotes:

"The lifetime of a decay is proportional to the inverse square of the coupling constant between the initial and final products"

$$\textit{lifetime} \propto \frac{1}{\alpha^2} \tag{1}$$

I shall generalize this law by postulating that the lifetimes of the leptons are proportional to the inverse of the *n* power of the electromagnetic coupling constant; where *n* is an integer. Mathematically I postulate that

$$\textit{mean lepton lifetime} \propto \frac{1}{\alpha^n} \tag{2}$$

Based on this postulate I shall build the lifetime formulas starting from the third generation of matter, then the second generation and, lastly, the first generation. Thus, if this assumption is correct, we should get a very long mean lifetime for the electron.

2. Nomenclature

I shall use the following nomenclature for the constants and variables used in this paper

α = fine-structure constant (atomic structure constant)
c = speed of light in vacuum
h = Planck's constant
m_e = electron rest mass
τ_τ = tau particle mean lifetime
τ_μ = muon mean lifetime
τ_e = electron mean lifetime
a_τ = numerator of the first factor for the tau particle
a_μ = numerator of the first factor for the muon
a_e = numerator of the first factor for the electron
n_τ = main part of the exponent N_τ of the formula for the tau particle mean lifetime ($N_\tau = n_\tau + 1$). However N_τ is not used.
n_μ = main part of the exponent N_μ of the formula for the muon mean lifetime ($N_\mu = n_\mu + 1$). However N_μ is not used.
n_e = main part of the exponent N_e of the formula for the electron mean lifetime ($N_e = n_e + 1$). However N_e is not used.
F = total number of generations of matter or families (3)
f = family quantum number or generation quantum number (1 for generation 1, 2 for generation 2 and 3 for generation 3)

3. The Leptons Mean Lifetime Formulas

Leptons are divided into three generations: the lepton generation 1 comprises the electron and the electron neutrino, the lepton generation 2 comprises the muon and the muon neutrino and the lepton generation 3 comprises the tau particle and the tau neutrino. In this article I shall only deal with the electron, the muon and the tau particle. Starting from the tau particle and taking into consideration the generalized lifetime formula (2), I shall, firstly, build the formula for the mean lifetime of the tau particle, secondly, the formula for the mean lifetime of the muon and, lastly, the formula for the mean lifetime of the electron.

3.1 The Tau Particle Mean Lifetime Formula

The formula for the lifetime of the tau particle is

$$\tau_\tau = \frac{a_\tau}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha} \right)^{n_\tau + 1} \tag{3.1-1}$$

$$n_\tau = F \tag{3.1-2}$$

$$a_\tau = 1 \tag{3.1-3}$$

Where F is the total number of known families or generations of matter, which is 3, and a_τ is the numerator of the first factor, which is 1. Therefore we have

$$n_\tau = 3$$

The exponent for the tau particle lifetime formula is simply n_τ plus 1

$$n_\tau + 1 = 3 + 1 = 4 \tag{3.1-4}$$

Thus, the final formula for the tau particle is

$$\tau_\tau = \frac{1}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha} \right)^4 \tag{3.1-5}$$

It is worthy to observe that we have used the electron rest mass and not the tau particle mass.

3.2 The Muon Mean Lifetime Formula

The formula for the lifetime of the muon is

$$\tau_\mu = \frac{a_\mu}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha} \right)^{n_\mu + 1} \tag{3.2-1}$$

$$n_\mu = n_\tau (F + 1 - f) \tag{3.2-2}$$

Because the constant a_μ is equal to n_τ (the main part of the exponent of the tau particle – this is the rule!) we can write

$$\tau_\mu = \frac{n_\tau}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha} \right)^{n_\mu + 1} \tag{3.2-3}$$

Once again *F* is the total number of families or generations of matter, $F = 3$ and n_μ is main part of the exponent for the muon lifetime formula. Because the muon belongs to the second generation of matter, the family quantum number, f , is 2. Thus the value of n_μ turns out to be

$$n_\mu = 3(3 + 1 - 2) = 6$$

$$n_\mu + 1 = 6 + 1 = 7 \tag{3.2-4}$$

Thus the final formula for the muon is

$$\tau_\mu = \frac{3}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha} \right)^7 \tag{3.2-5}$$

3.3 The Electron Mean Lifetime Formula

The formula for the lifetime of the electron is

$$\tau_e = \frac{a_e}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha} \right)^{n_e+1} \tag{3.3-1}$$

$$n_e = n_\tau n_\mu (F + 1 - f) \tag{3.3-2}$$

Because the constant a_e is equal to $n_\tau n_\mu$ (the product of the main part of the exponent for the tau particle and the muon – this is the rule again!) we can write

$$\tau_e = \frac{n_\tau n_\mu}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha} \right)^{n_e+1} \tag{3.3-3}$$

Thus we can announce the two rules:

Factor Rule

The factor a_f for generation f, is the product of the main part of the exponents of the heavier generations. For the heaviest generation $a_f = 1$.

Thus, for the muon there is only one heavier generation: the generation that corresponds to the tau particle, as a consequence $a_\mu = n_\tau$. For the electron there are two heavier generations: one that corresponds to the tau particle and another one that corresponds to the muon, consequently $a_e = n_\tau n_\mu$.

Exponent Rule

It is easier to express this rule mathematically than in words. Thus we shall express it as follows

$N_\tau = 1(F + 1)$
$N_\mu = n_\tau (F + 1 - f) + 1$ (where f = 2)
$N_e = n_\tau n_\mu (F + 1 - f) + 1$ (where f = 1)

Here, as in the previous two formulas, F is the total number of generations of matter $F = 3$ and n_e is part of the exponent for the electron lifetime formula. Because the electron belongs to the first generation of matter, the family quantum number, f , is 1. Thus the value oft n_e can be computed as follows

$$n_e = 3 \times 6 \, (3 + 1 - 1) = 54$$

To get the complete exponent for the formula of the electron we simply add one

$$n_e + 1 = 55 \tag{3.3-4}$$

The numerator, a_e , of the factor that contains the number π^2 turns out to be

$$a_e = n_\tau n_\mu = 3 \times 6 = 18 \qquad (3.3\text{-}5)$$

Thus, the final formula for the electron lifetime is

$$\tau_e = \frac{18}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha}\right)^{55} \qquad (3.3\text{-}6)$$

4. Summary

The following table shows the mean lifetime formulas for the tree heaviest leptons.

Particle	f	Mean lifetime formula (algebraic factors and exponents)	Mean lifetime formula (numeric factors and exponents)	Predicted value of the mean lifetime
τ (tauon)	3	$\tau_\tau = \frac{a_\tau}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha}\right)^{n_\tau+1}$ $a_\tau = 1$ $n_\tau = F$ Then eliminating a_τ : $\tau_\tau = \frac{1}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha}\right)^{n_\tau+1}$	$\tau_\tau = \frac{1}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha}\right)^4$	$2.89 \times 10^{-13} \mu S$
μ (muon)	2	$\tau_\mu = \frac{a_\mu}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha}\right)^{n_\mu+1}$ $a_\mu = n_\tau$ $n_\mu = n_\tau (F + 1 - f)$ Then eliminating a_μ : $\tau_\mu = \frac{n_\tau}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha}\right)^{n_\mu+1}$	$\tau_\mu = \frac{3}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha}\right)^7$	$2.23 \mu S$
e (electron)	1	$\tau_e = \frac{a_e}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha}\right)^{n_e+1}$ $a_e = n_\tau n_\mu$ $n_e = n_\tau n_\mu (F + 1 - f)$ Then eliminating a_e : $\tau_e = \frac{n_\tau n_\mu}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha}\right)^{n_e+1}$	$\tau_e = \frac{18}{\pi^2} \frac{h}{m_e c^2} \left(\frac{1}{\alpha}\right)^{55}$	$4.96 \times 10^{97} S =$ 1.57×10^{90} *years* $=$ $\frac{\pi}{2} \times 10^{90}$ *years*

Table 1: Mean lifetime formulas for the tau particle, the muon and the electron. It is worthy to emphasize that the formulas were built from the tau particle (generation 3); this is from the "bottom up". Note that the quantum number f is different for each generation while F remains constant.

5. Conclusions

We can draw the following conclusions

1) The predicted lifetimes for both the tau particle and the muon are in excellent agreement with the observed values.

2) The predicted lifetime of the electron: $\frac{\pi}{2} \times 10^{90}$ years, is extraordinarily long but not infinite.

3) The Universe (as a Meta-transformation) could have a finite lifetime.

4) The decay products of the electron could comprise a negatively charge particle that I shall call "**electrino**". This hypothetical particle must be lighter than the electron. If the electrino exists, then there is either another generation of matter or this particle is sterile.

In summary, the tau particle turned out to be the lepton with the simplest lifetime formula and the electron the one with the most complex one. The formula for the electron is based on the other two formulas and this seems to indicate that there are only three generations of matter. It also suggests that a) the structure of the electron is, somehow, connected to the structures of the tauon and the muon and that b) the electron incorporates the parameters that make up the lifetime formulas of the other two heavy leptons. If this were the case, then we are before a new and mysterious quantum mechanical phenomenon for which we have no explanation.

REFERENCES

[1] C. R. Nave, *Decays Caused by Weak and Strong Forces*, retrieved 2011 from: http: //hyperphysics.phy-astr.gsu.edu/hbase/particles/weastr.html, (1990)