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The Mass of Lepton Tau

Sylwester Kornowski

Abstract: Here, using the atom-like structure of baryons described in the Scale-Symmetric Theory (SST), we calculated the mass of lepton tau (1776.947 MeV and 1776.944 MeV) in two different elegant ways.

1. Introduction

The successive phase transitions of the inflation field described within the Scale-Symmetric Theory (SST) lead to the atom-like structure of nucleons [1].

There is the spin-$1/2$ core of nucleons. It consists of the spin-$1/2$ electric-charge/torus X^+ and the spin-0 central condensate Y both composed of the Einstein-spacetime (Es) components – the Es components are the spin-1 neutrino-antineutrino pairs. The spin-1 large loops with a mass of $m_{LL} = 67.5445451$ MeV [2] and with a radius of $b = 2A/3$ (where $A = 0.697441139$ fm is the equatorial radius of the electric-charge/torus [2]) are produced inside the electric-charge/torus – the neutral pions are built of two such loops with antiparallel spins. In the $d = 1$ state (it is the S state i.e. the azimuthal quantum number is $l = 0$) there is a relativistic pion. Calculated within SST mass of the bare electron is $m_{bare(electron)} = 0.5104070$ MeV [1]. The calculated ratio of the sides of squares occupied by the neutrino-antineutrino pairs on the flat plane in the Einstein spacetime and on the electric-charge/torus X^+ inside the core of baryons is $Z_5 = 554.321081$ [1].

Within SST we calculated the coupling constants and the running coupling constant for the nuclear strong interactions [1], [2]. Here we will apply two of them i.e. the fine structure constant $\alpha_{em} = e^2 c/(10^7 \hbar) = 1/137.03599905$ and the coupling constant for the nuclear weak interactions $\alpha_{w(proton)} = Y \mathrm{F}\, c\, r_{p(proton)} / \hbar = 0.018723025693$, where $r_{p(proton)}$ is the radius of the condensate Y and $\mathrm{F} = e\ 10^6 / c^2 = 1.7826618449 \cdot 10^{-30}$ kg/MeV is the factor to convert MeV into kg [2].

2. Calculations

We know that ranges of particles/systems are inversely proportional to their mass. SST shows that range of the spin-1 large loop, R_{LL}, is equal to its circumference: $R_{LL} = 2\pi \cdot 2A/3$.

To conserve the spin and charge of the core of baryons, created system inside the core must have resultant spin/angular-momentum and charge both equal to zero. It means that inside the core can be created a system composed of the spin-1 large loop and the spin-1 pair of leptons (it can be the tau lepton plus bare electron) with antiparallel spins. Assume that the bound mass of the tau lepton, $m_{tau(bound)}$, we obtain when the range of the pair of leptons is

$R_{\tau(bound),e(bare)} = A/2\pi$ i.e. the radius A curls into a circle so its radius/length-of-wave decreases 2π times so mass increases 2π times.

The above remarks and the equivalence of the spins lead to following formula

$$m_{LL} R_{LL} c = (m_{tau(bound),1} + m_{bare(electron)}) R_{\tau(bound),e(bare)} c . \quad (1)$$

We can write formula (1) in a simpler way

$$m_{tau(bound),1} = 8 \pi^2 m_{LL} / 3 - m_{bare(electron)} = 1777.190 \text{ MeV} . \quad (2)$$

During the decays, the bound tau lepton interacts with the colliding nucleons electromagnetically and next weakly or vice versa – there is emitted the electroweak mass of the bound tau lepton: $\Delta E = \alpha_{em} \alpha_{w(proton)} m_{tau(bound)}$ (this energy is a part of the virtual field of colliding nucleons). This mean that mass of tau lepton is

$$m_{tau,1} = m_{tau(bound),1} - \Delta E = m_{tau(bound),1} (1 - \alpha_{em} \alpha_{w(proton)}) = 1776.947 \text{ MeV} . \quad (3)$$

The experimental result is 1776.86 ± 0.12 MeV [3].

The second solutions follows from the fact that in the bare electron, the distance between the entangled Einstein-spacetime components is $f_{Es,electron(bare)} = 2\pi Z_5 L_o$, where L_o is a distance close to the Planck length [1]. Let us calculate mass of the bound tau lepton on the assumption that the distances between the neutrino-antineutrino pairs in the lepton pair are $f_{Es,\tau(bound),e(bare)} = L_o$. We obtain following relation

$$(m_{tau(bound),2} + m_{bare(electron)}) / m_{bare(electron)} = 2\pi Z_5 . \quad (4)$$

From (4) results that mass of the bound tau lepton is

$$m_{tau(bound),2} = (2\pi Z_5 - 1) m_{bare(electron)} = 1777.187 \text{ MeV} . \quad (5)$$

From (3) and (5) we obtain

$$m_{tau,2} = m_{tau(bound),2} (1 - \alpha_{em} \alpha_{w(proton)}) = 1776.944 \text{ MeV} . \quad (6)$$

Summary

Emphasize that the two masses of the tau lepton calculated within the atom-like structure of baryons are consistent with experimental data – it suggests that we should verify the 3-valence-quarks model of nucleons.

References

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[2] Sylwester Kornowski (17 March 2018). "The Simplest and Accurate Theory of Proton and Neutron Based on Only Six Parameters that are Experimental Values" http://vixra.org/abs/1803.0250

[3] C. Patrignani et al. (Particle Data Group) Chin. Phys. C, **40**, 100001 (2016) and 2017 update