Theory with a Finite Mass Gap

Sylwester Kornowski

Abstract: Here we present how neutrinos acquire their masses and how internal structure of the neutrinos leads to the volumetric quantum confinement described within the Neutrino Quantum Gravity (NQG). Such confinement is responsible for mass of the condensates/scalars that are made of the Einstein-spacetime components (they are the neutrino-antineutrino pairs). Mean distance between such pairs in the two-component spacetime is slightly larger than the range of NQG.

1. Introduction

Existence of a theory with a finite mass gap is one of the problems listed as the Millennium Prize Problems in mathematics.

The quanta in the Yang-Mills theory must be massless in order to maintain gauge invariance while confinement has not been theoretically proven so we have a big problem to describe the origin of masses of particles [1].

Here we show that neutrinos acquire their mass because of interactions of them with the Higgs field described within the Scale-Symmetric Theory (SST) [2].

SST shows that the Einstein spacetime consists of the neutrino-antineutrino pairs so the volumetric quantum confinement described within the Neutrino Quantum Gravity (NQG) [3], which is precisely formulated in this paper, leads to a finite mass gap for scalars such as, for example, the SST Higgs boson with a mass of 125.00 GeV [2]. We show that such scalars have a finite mass-gap with regard to the “vacuum” state. Described here confinement acts also in the presence of additional fermion particles.

The internal structure of fermions, due to the quantum entanglement described within SST [2], causes that after an interaction the states are rotated the same way as the states before the interaction – it is the well known a global symmetry. Just the fields inside the cores of neutrinos and baryons are perfectly localized. On the other hand, spins and charges of fermions or mass and isospin of pions are defined by internal structure of the cores of fermions.

SST shows also that the nuclear strong fields composed of gluons have internal helicity so such forces rotate.

2. Masses of neutrinos [2]

The internal helicity of closed string (it consists of the SST tachyons) resulting from the infinitesimal spin of the SST tachyons and their viscosity means that the entanglons (i.e. the binary systems of the closed strings) a neutrino consists of transform, outside the neutrino, the chaotic motions of tachyons into divergently moving tachyons. The direct collisions of divergently moving tachyons with tachyons the SST Higgs field consists of produce a gradient in this field. The gravitational constant, G, results from behaviour of all closed strings a neutrino consists of. Because the constants of interactions are directly proportional to the mass densities of fields carrying the interactions then the G we can calculate from following formula

$$G = g\, \rho_N = 6.6740007 \cdot 10^{-11}\ m^3/(kg\ s^2), \quad (1)$$

where the g has the same value for all interactions and is equal to

$$g = v_{st}^4 / \eta^2 = 25{,}224.563\ m^6/(kg^2\ s^2)\ , \quad (2)$$

where ρ_N is the inertial-mass density of the SST Higgs field, v_{st} is the spin speed on equator of the tachyons, and η is the dynamic viscosity between the closed strings a neutrino consists of and the tachyons the SST Higgs field consists of.

Emphasize that SST shows that our Cosmos (not the expanding Universe) has stable boundary so its total energy is conserved i.e. there is obligatory the global symmetry for the closed strings.

3. Masses of the scalar condensate in the centre of baryons

Consider a relativistic proton-antiproton pair which interacts electromagnetically with a pair composed of charged pions i.e. with $\pi^+\pi^-$ pair. To protect the pair of pions from a quick annihilation, it interacts with the spin-1 electron-positron pair. Next there is a transition from the electromagnetic interactions (of the proton-antiproton pair with the pair of charged pions) to the weak interactions (of the proton-antiproton pair with the electron-positron pair) in the presence of the dark matter (DM). Due to such transition, the mass of the carrier of interactions, i.e. the mass of $[(\pi^+ + e^-) + (\pi^- + e^+)]$, increases F/2 times, where $F = \alpha_{em}/\alpha'_{w(proton-electron)} = 651.87776$, $\alpha_{em} = 1/137.035999084(21)$ is the fine-structure constant for the electromagnetic interactions [4], and $\alpha'_{w(proton-electron)} = 1.1194358 \cdot 10^{-5}$ is the coupling constant for the weak interactions of protons with electrons in the presence of dark matter [2].

Why there is F/2 instead F? According to SST, coupling constant for weak interactions is directly proportional to the product of the mass of ES condensate responsible for the interaction and the sum of masses of exchanged condensates. For a pair, number of exchanged condensates is 2 so coupling constant is two times higher i.e. instead α_w is $2\alpha_w$ so instead F is F/2.

One of the two charged pions can be neutral. But initially all particles must be electrically charged because of the α_{em} in the nominator of the F. It leads to conclusion that initially the neutral pion must decay to muon and electron. For the $W^{+,-}$ boson we obtain following relation

$$\{[(\mu^- + e^+) + e^-] + (\pi^- + e^+)\}\ F / 2 \rightarrow W^- + 6(e^+ + e^-)\ , \quad (3)$$

where $\mu^{+,-} = 105.6583745(24)$ MeV, $\pi^{+,-} = 139.57061(24)$ MeV, and $e^{+,-} = 0.5109989461(31)$ MeV [5]. Contrary to [6], here we assumed that each charged single particle (i.e. μ^-, e^+, e^-, π^-, e^+, and W^-, i.e. there is the six single charged particles) creates one electron-positron pair.

Emphasize that spin of the $\mu^- e^+$ pair is zero whereas of the $e^+ e^-$ pair is unitary so of the W^- boson is unitary also.

From (3) we obtain mass of the W^- boson: $m_W = 80{,}423.185$ MeV.

We can calculate the approximate value of the fine structure constant at low energies for baryons applying following formula [3]

$$\alpha_{em} = (e^+ + e^-) / (\pi^+ + 2M_{electron,scalar}) = 1 / 137.066\,, \tag{4}$$

where $M_{electron,scalar} = e^{+,-}{}_{bare} / 2 = 0.2552035$ MeV is the mass of the Einstein-spacetime condensate/scalar in centre of the electron, and $e^{+,-}{}_{bare}$ is the bare mass of electron [2]. In [2], we calculated the fine structure constant with higher accuracy: $1/137.036$.

From (4) follows that a charged pion produced inside a baryon interacts electromagnetically via one virtual electron-positron pair.

By an analogy to (4), applying (3), we can calculate value of the fine structure constant at high energy [3]

$$\alpha_{em,high\text{-}energy} = (X^+ + X^-) / (W^+ + 2Y^*) = 1 / 127.66747\,, \tag{5}$$

where $X^{+,-} = 318.295537$ MeV is the mass of the torus/electric-charge in the core of baryons, and $Y^* = 424.39405$ MeV. Value of the Y^* we obtain from following mechanism. The large loop (in baryons its mass is $M_{LL} = 67.54441$ MeV) with circumference equal to $L_{LL} = 4\pi A/3$, where $A = 0.6974425$ fm is the equatorial radius of the core of baryons, transits to radius of the loop so mass of such scalar condensate increases 2π times: $Y^* = 2\pi M_{LL} = 424.39405$ MeV.

Due to the phase transitions of the initial inflation field, the neutrinos look as a miniature of the core of baryons (i.e. there is the torus/charge and central scalar condensate) and theories of both are similar i.e. we can apply the same mathematics [2].

The mean density for the quantum region of neutrinos is about 10^{28} kg/m^3 [3] so it is an analog to physics of the cores of baryons at very high energies. The same concerns the neutrino-antineutrino pairs the Einstein-spacetime consists of.

Within SST we calculated that the mean side of a cube occupied by each Einstein-spacetime component is $L_o = 3510.21208\, R_{neutrino}$, where $R_{neutrino}$ is the equatorial radius of neutrinos (there is torus with central scalar) – such a value follows from the density of the Einstein spacetime, $\rho_{ES} = 1.10220055 \cdot 10^{28}$ kg/m^3, which, in SST, is the initial parameter [2].

Electric charge of the electron is a torus with the equatorial radius equal to (see formula (34) in [2])

$$\lambda\!\!\!^{-}{}_{Compton,electron} = 3.8660707 \cdot 10^{-13}\ \text{m}\,. \tag{6}$$

It is very difficult to detect the torus/charge of electron because it is only the polarized Einstein spacetime so there are not some changes in density of the spacetime. The same concerns the loop inside the torus (it has mass) and the central condensate (it has mass too) because such masses follow from rotations of the neutrino-antineutrino pairs – such rotations decrease local pressure so mass density of spacetime inside such regions is slightly higher but such regions are very transparent for particles used to detect them.

The Compton length of electron is equal to the length of the equator of the electron torus

$$\lambda_{Compton,electron} = 2\,\pi\,\bar{\lambda}_{Compton,electron} = 2.4291239 \cdot 10^{-12}\ \mathrm{m}\,. \quad (7)$$

Due to the electromagnetic interactions at high energies, the Compton length of electron increases

$$\lambda^{*}_{Compton,electron} = 2\,\pi\,\bar{\lambda}_{Compton,electron}\,(1 + \alpha_{em,high\text{-}energy}) = 2.4481509 \cdot 10^{-12}\ \mathrm{m}\,. \quad (8)$$

This value is

$$F_{o,Baryon} = \lambda^{*}_{Compton,electron} / A = 3510.18308 \quad (9)$$

times larger than the equatorial radius of the core of baryons.

Due to the phase transitions of the inflation field, theory of the core of baryons and of the core of lightest neutrinos are similar [2] so we can apply similar scenarios. The cores of neutrinos emit objects composed of the entanglons/gravitons [2], [3]. It leads to conclusion that the range of the Neutrino Quantum Gravity is

$$L_{o,Neutrino} = 3510.18308\ R_{Neutrino}\,, \quad (10)$$

where $R_{Neutrino}$ is the equatorial radius of lightest neutrinos [2].

The range of NQG, $R_{NQG} = 3510.18308\ R_{Neutrino}$, defines the range of the volumetric quantum confinement of the neutrino-antineutrino pairs. It is slightly smaller than the mean value of side of a cube occupied by the neutrino-antineutrino pair in the Einstein-spacetime: $L_o = 3510.21208\ r_{neutrino}$ [2].

The Volumetric Quantum Confinement (VQC)) is responsible for creation of the scalar condensates such as the Higgs boson or the condensate in centre of the core of baryons or the condensates in centres of the charged leptons [2].

Notice that the density of the condensate $Y = 424.1245$ MeV of baryons is $f = 40{,}362.942$ times lower than the density of the Einstein spacetime. It leads to conclusion that the mean distance between the neutrino-antineutrino pairs in the Y condensate is:

$$L_{o,Neutrino} = F_{o,Baryon}\,\{f / (f + 1)\}^{1/3}\,R_{Neutrino} = 3510.1831\ R_{Neutrino} \quad (11)$$

as it should be.

Knowing radius of the Y condensate [2] and its density $\rho_Y = \rho_{ES}/f$ we can calculate the mass Y. Due to the NQG, mass density of all the pure scalar condensates created in the Einstein spacetime is the same.

4. Summary

We showed that the two-component spacetime cause that neutrinos acquire their mass. Such spacetime does not appear in the Standard Model.

In the Standard Model we completely neglect existence of the cores of fermions which are responsible for the volumetric quantum confinement that leads to masses of the scalars and to the strong field with internal helicity.

Just within the Standard Model we cannot solve the mass-gap problem.

We can test the Neutrino Quantum Gravity on nucleons because both theories are similar. But emphasize that mass density inside the core of neutrinos is about 20 orders of magnitude higher than in core of baryons so the similar processes near baryons are much weaker – they are much weaker than the strong interactions. Notice that at high energies we should observe some very weak attraction between nucleons on distances defined by formula (8) – it relates to the range of the much, much stronger confinement of neutrinos.

References

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