Fine-Structure Constant at High Energy and Cooper Pairs

Sylwester Kornowski

Abstract: The exchanged Higgs bosons could reduce distances between the spacetime components to zero but their very high stability (it is due to the tremendous non-gravitating energy frozen inside them) counteracts such destructive processes so spacetime can not be destroyed even at very high energy. Here we show that the produced electron-positron pairs polarize spacetime inside the uncharged scalar in centre of baryons - it is due to a contraction of the distances between the gravitating spacetime components. At energy equal to mass of the W boson, we obtain that the fine-structure constant is about 1/128 instead the 1/137.036 at energy close to zero. We show also that due to emission of virtual pairs with defined masses, we should observe increases in effective ranges of bare neutrinos, electrons or atomic nuclei. We calculated that maximum distance between electrons in Cooper pairs should be 1161 nm.

1. Introduction

The Scale-Symmetric Theory (SST) shows that due to the SST inflation, from the spacetime components were created the 4 stable and 3 meta-stable manifolds [1], [2]. The stable manifolds are: the binary systems of closed strings (entanglons) which are responsible for the quantum entanglement, the neutrinos, cores of baryons, and Protoworld which transformed into our Universe [1], [3]. The two-component spacetime consists of the Higgs field (Hf) composed of the non-gravitating tachyons and of the Einstein spacetime (Es) composed of the very stable neutrino-antineutrino pairs [1]. Each Es component or neutrino produce the elementary gradients in Hf – the gradients are the elementary gravitational fields carried by the Es components and by neutrinos. On the other hand, the Es is associated with the Standard-Model (SM) particles and SM interactions (there is the superluminal quantum entanglement as well) [1]. The densities of the Hf and Es are the initial parameters in SST [1]. Within SST we calculated that the mean side of a cube occupied by each Es component is $L_o = 3510.2121 r_{neutrino}$, where $r_{neutrino}$ is the equatorial radius of lightest neutrino (there is torus with central scalar) [1].

Within SST we calculated the fine-structure constant at $Q = 0$: $\alpha_{EM,E=0} = 1 / 137.036$ [1].

The baryons have the atom-like structure [1]. Mass of the central scalar in the core of baryons is $Y = 424.12$ MeV and its radius is $R_{C,proton} = 0.871095 \cdot 10^{-17}$ m whereas mass of the central scalar in the electron is $M_{C,electron} = 0.2552035$ MeV and its radius is $R_{C,electron} = 0.73541 \cdot 10^{-18}$ m [1]. The equatorial radius of the torus in the core of baryons is $A = 0.6974425$ fm whereas of the torus in the bare electron is $R_{e,torus} = 386.61$ fm (the electron torus is only the polarized Es so it is very difficult to detect it) [1]. Mass of the proton torus/electric-charge is X = 318.2955 MeV [1]. Outside the core of baryons are 4 shells. In nucleons, in the $d = 1$ state is relativistic pion – mass of charged one is $W_{pion(+,-),d=1}$ = 215.760 MeV [1]. Pions in baryons are created inside the torus in the core as a binary systems of large loops – mass of one large loop is m_{LL} = 67.54441 MeV [1]. The radius of such loop is $R_{LL} = 2\,A / 3$ [1].

2. Effective ranges of neutrinos, electrons and baryons

Mass/energy of a string or a loop (they can be virtual objects) is inversely proportional to its length. Assume that the m_{LL} loop shrinks to a string with length equal to its radius (its mass increases 2π times) and next appears on the equator of the torus (its mass decreases 1.5 times). The final mass, M_{final}, is

$$M_{final} = 4\,\pi\,m_{LL} / 3 = 282.92936 \text{ MeV}. \tag{1}$$

Its range is $2\pi A$.

It leads to conclusion that a bare electron (its mass is $m_{e,bare}$ = 0.510407 MeV [1]), created as a component of a bare electron-positron pair on the equator of the torus, has range, $R_{electron,bare,A} = R_{EM,baryons}$

$$R_{electron,bare,A} = R_{EM,baryons} = 2\pi\,A\,M_{final} / m_{e,bare} = 3482.9021\,A. \tag{2}$$

The $R_{EM,baryons}$ = 3482.9021A is a characteristic range for all baryons interacting electromagnetically – there, for example, in very low temperature can be created proton-proton pairs interacting electromagnetically (they are an analogue to the Cooper electron pairs).

A bare electron, created inside an atomic nucleus as a component of a bare electron-positron pair on the equator of the electron torus, has range

$$R_{electron,bare,R(e)} = R_{electron,bare,A}\,R_{e,torus} / A = 1.3465 \bullet 10^{-9}\text{ m}. \tag{3}$$

This value is only a little higher than $5^2\,r_B$, where r_B is the Bohr radius – it means that we should observe a difference between electrons inside the sphere with a radius defined by formula (3) and electrons outside it. But emphasize that the bare electron-positron pairs are created not only by nucleons but also by the electrons outside the atomic nuclei.

Notice that both the lightest neutrinos and cores of baryons have the same shape (torus + central scalar) so they are the dual manifolds [1], [2]. It leads to conclusion that there is an effective range of lightest neutrino

$$R_{neutrino,effective} = 3482.9021\,r_{neutrino}\,, \tag{4}$$

where $r_{neutrino}$ is the equatorial radius of the lightest neutrino [1].

3. Fine-structure constant at high energy

In paper [1], we calculated that the Es components inside the scalar Y occupy cubes with a mean side equal to $R_{Es,Y} = 3510.1831 r_{neutrino}$. We claim that it is due to the creations of the bare electron-positron pairs i.e. it corresponds to mass $M_{pair,[e(+)e(-)]bare}$ = 1.020814 MeV. It means that a change in range $\Delta R = L_o - R_{Es,Y}$ = (3510.2121 – 3510.1831) $r_{neutrino}$ =

$0.0290 r_{neutrino}$ is due to production of virtual objects with a mass of $M_{pair,[e(+)e(-)]bare}$ = 1.020814 MeV. What mass should have a virtual particle to shrink the Es to zero? We have

$$M_{spacetime,r=0} = M_{pair,[e(+)e(-)]bare} \, L_o / \Delta R = 123.561 \text{ GeV} . \quad (5)$$

We can see that this mass is close to the mass of the Higgs boson. Moreover, we can see that described here creations concern leptons (the bare electron-positron pairs). On the other hand, the ATLAS measurements with high mass resolution channels show that there are two different masses of Higgs boson – mass of it from the $H \rightarrow ZZ(*) \rightarrow 4l$ lepton channel is [4]

$$m_H = 123.5 \pm 0.8 \text{ (stat)} \pm 0.3 \text{ (sys) GeV} . \quad (6)$$

There is very high coincidence between the SST theory [5] and experimental data [4] concerning the mass of Higgs boson.

The exchanged Higgs bosons could reduce distances between the Es components to zero but their very high stability (it is due to the tremendous non-gravitating energy frozen inside them) [1] counteracts such destructive processes so spacetime can not be destroyed even at very high energy.

Notice that the electromagnetic interactions of nucleons at energy close to zero is due to exchanges of the open large loops with a virtual energy of m_{LL} = 67.54441 MeV. Such energy leads to following range

$$R_{EM,Q=0} = L_o - \Delta R \, m_{LL} / M_{pair,[e(+)e(-)]bare} = 3508.2933 \, r_{neutrino} . \quad (7)$$

The shrinking of Es is due to the electromagnetic interactions of proton so the fine-structure constant at $Q = 0$ we can calculate from following formula

$$R_{EM,Q=0} = R_{EM,baryons} (1 + \alpha_{EM,Q=0}) . \quad (8)$$

From this formula we obtain $\alpha_{EM,Q=0} = 1 / 137.17$ which is very close to $1 / 137.036$.

Within SST, we described the four-object symmetry – number of entangled objects in a system is quantized [6], [1]

$$N_d = 2 \cdot 4^d \text{ (for binary systems)}, \quad (9)$$

where d = 0, 1, 2, 4, 8,… = 0, 2^n, where n = 0, 1, 2, 3, 4, 5,… Inside the scalar Y are created the spin-1 bare electron-positron pairs. But to conserve the spin-1/2 and electric charge of the core of baryons, created objects must be the electrically neutral scalars. It means that single pairs cannot be created. From formula (9) follows that the next simplest uncharged object/scalar contains 4 bare electron-positron pairs: $N_{d=1} = 2 \cdot 4^1 = 8$ bare electrons. But the needed transition from the weak interactions of electrons to the nuclear weak interactions (the scalar Y is responsible for the nuclear weak interactions [1]) causes that the involved energy is X_W = 19685.3 times higher [1]. But such uncharged scalar with energy $E^o_W = 8 \, m_{e,bare} \, X_W$ = 80.380 GeV must be electrically charged to interact electromagnetically so it needs to capture the spin-1 electron—electron-antineutrino pair (or positron—electron-neutrino). As a result we obtain the W^- boson (or W^+ boson) with a mass of 80.3805 GeV. But we motivated that single charged vectors cannot be created inside the core of baryons so in the collisions of two nucleons there is created the W^+W^- pair but it is created in one of the two nucleons i.e. the involved energy is $Q = m_W \approx 80.4$ GeV per nucleon.

The fine-structure constant is measured at high energy equal to mass of the W bosons. But in reality, at first, the W^+W^- pair decays to the bare electron-positron pairs which, next, polarize the scalar Y. It means that we can calculate the fine-structure constant at $Q^2 = m_W^2 = (80.4 \text{ GeV})^2$ from following formula

$$R_{Es,Y} = R_{EM,baryons} (1 + \alpha_{EM,Q=m(W)}) . \quad (10)$$

From this formula we obtain $\alpha_{EM,Q=m(W)} = 1 / 127.67 \approx 1 / 128$ – this value is consistent with the experimental data [7].

4. Maximum distance between electrons in Cooper pairs

The mean separation at which pair correlation becomes effective is between 100 and 1000 nm [8]. We can see that maximum distance is about 1000 nm.

We claim that attraction between Cooper electrons is due to the exchanged phonons with energy equal to the radiation mass of electron ($E_{phonon} = m_{electron} - m_{e,bare} = 0.0005919$ MeV [1]) which are created on the equator of bare electrons. Maximum range of such phonons we can calculate by using some analog to formula (3)

$$R_{phonon,maximum} = R_{electron,bare,R(e)}\, m_{e,bare} / E_{phonon} =$$

$$= [R_{electron,bare,A}\, R_{e,torus} / A]\, m_{e,bare} / E_{phonon} = 1161 \text{ nm}. \quad (11)$$

5. Summary

Applying very simple calculations within SST, we obtained perfect results consistent with experimental data. We showed that the Einstein spacetime should be destroyed due to production of the Higgs boson but the stability of neutrinos described within SST counteracts such destruction. We calculated as well the fine-structure constant at energy $Q^2 = m_W^2$ (~1/128) and the maximum distance between electrons in Cooper pairs (1161 nm) – both results are consistent with experimental data. It suggests that the scale-symmetric theory of the manifolds (torus + central scalar) is correct.

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