The Non-Perturbative Quantum Electrodynamics

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Abstract: Here, within the Scale-Symmetric Physics, the non-perturbative quantum electrodynamics of electron is presented. We calculated the lower and upper limits for the fine structure constant (1/137.035999053(11194)). The error is equal to the value of the coupling constant for the electron-proton weak interactions. The obtained results are very close to the experimental values which follow from the experimental values of the electron charge and reduced Planck constant (1/137.35999053(12095)). As expected, the error is a little higher than the theoretical value. There appeared papers in which theoretical and experimental values of the fine structure constant have much higher accuracy than the quantities which appear in its definition. In this paper is proven that the higher accuracies are groundless. Using the combined value of the fine structure constant (the experimental central value plus the theoretical limits), 1/137.035999053(11194), we obtain a theoretical value of the electron anomaly 0.001159652191(95). The weak interactions cause that this value cannot have higher accuracy. Within the Scale-Symmetric Physics are calculated physical constants and other quantities which appear in definitions, from the fundamental initial conditions. The initial parameters lead to 1/137.036001 and 0.001159652174. We can see that both results are consistent with the determinations. Emphasize that today the mainstream QED contains the 12,672 diagrams (number of terms is tremendous) whereas presented here non-perturbative QED contains only one diagram with six terms. The difference follows from an improperly understood weak interactions and production of virtual pairs in the Einstein spacetime. To calculate all needed quantities we do not need supercomputers, we used the Microsoft Office Excel with 13 decimal places.

1. Introduction

The Scale-Symmetric Everlasting Theory (S-SET), [1], describes the succeeding phase transitions of the modified Higgs field. During the inflation there appeared the Einstein spacetime composed of luminal components. The phenomena in the Einstein spacetime lead to the electromagnetic, weak and strong interactions.

In the luminal Einstein spacetime can appear the fermion-antifermion pairs. They are built of entangled and/or confined Einstein-spacetime components. At first there appears a loop with unitary spin. In reality, the loop is a binary system of two entangled loops with parallel half-integral spins and opposite internal helicity. Protons are left-handed (antiprotons are right-handed) whereas electrons right-handed (positrons are left-handed). The binary system is unstable and transforms into torus-antitorus pair and in centre of each torus (it is the electric charge with half-integral spin) there appears a condensate responsible for weak interactions. Contrary to electron, outside the core of proton is relativistic pion.

Radius of the initial loop, which transforms into the electron-positron pair, is the reduced Compton length of the bare electron $\lambda_{bare(electron)} = \hbar/(m_{bare(electron)}c) = 3.8660707 \cdot 10^{-13}$ m ([1]: formula (17)) where $m_{bare(electron)} = 0.510407011$ MeV ([1]: formula (18)). Mass of the torus/electric-charge is the same as the condensate i.e. both have mass $m_{bare(electron)}/2$. It is very difficult to detect the internal structure of an electron because it consists only of rotating and non-rotating Einstein-spacetime components. The coupling constant of the weak interactions of electron is $\alpha'_{w(electron-proton)} = 1.11943581 \cdot 10^{-5}$ ([1]: formula (58)). The fine structure constant calculated within S-SET is $\alpha_{em} = 1/137.036001$ ([1]: formula (21)).

In this paper appears as well the mass of the condensate in proton $Y = m_{p(proton)} = 424.1245$ MeV which is responsible for the weak interactions ([1]: the explanation below formulae (49)-(51)) . The coupling constant of the weak interactions of proton is $\alpha_{w(proton)} = 0.0187228615$ ([1]: formula (51)).

Define the symbol γ as follows

$$\gamma = \alpha_{em} / (\alpha'_{w(electron-proton)} + \alpha_{em}), \tag{1}$$

where γ denotes the mass fraction in the bare mass of the electron that can interact electromagnetically, whereas $1-\gamma$ denotes the mass fraction in the bare mass of the electron that can interact weakly. The electromagnetic mass of the torus/electric-charge of electron is equal to mass of the condensate/weak-mass.

Since the distance between the constituents of a virtual pair is equal to the length of the equator of a torus (because such is the length of the virtual photons) so there appears the factor $1/(2\pi)$. The ratio of the radiation mass (created by the virtual pairs) to the bare mass of electron is ([1]: formula (66))

$$\delta = \gamma\, \alpha_{em} / (2\pi) + (1 - \gamma)\, \alpha'_{w(electron-proton)} / (2\pi) = 0.00115963354. \tag{2}$$

Due to the virtual-pair annihilations, in the Einstein spacetime are produced the mass ‘holes’ (m < 0) decreasing mass density of the radiation field [2]. Notice as well that S-SET shows that to create an electron-positron pair, at first there appears the loop composed of the entangled and rotating Einstein-spacetime components. Denote the rotational energy of one loop in a binary system of loops by E. The ordered motions of the Einstein-spacetime components in the loop decrease the local dynamic pressure so there appear inflows of additional Einstein-spacetime components into the loop. Mass M of the additional components is M = E so the total energy of the loop is M + E = 2E. Sum of absolute masses of created virtual particles cannot be greater than 2E so near a real electron there simultaneously is created only one virtual bare electron-positron pair [1]. It leads to conclusion that there is only one diagram describing the electromagnetic and weak interactions of the real electron with one virtual pair. Polarization of the virtual pair causes that its axis always cross the circle inside the torus/electric-charge. Radius of the circle is $2\lambda_{bare(electron)}/3$ so there appears the factor $2/3$ [1], (see formula (3) in this paper).

The ratio of the total mass of an electron to its bare mass, which is equal to the ratio of the magnetic moment of the bare electron to the Bohr magneton for the electron, describes the formula

$$\varepsilon = 1 + \delta + \delta\, \alpha'_{w(electron-proton)} / (2 / 3). \tag{3}$$

Electrons are entangled with atomic nuclei even when atoms are ionized. Due to the weak interactions of electrons with protons, there are produced virtual objects. Their annihilations decrease local dynamic pressure in the Einstein spacetime i.e. there are produced the mass 'holes' ($m < 0$) [2]. Such phenomena decrease the mass of real electron. Notice that the weak mass of virtual pair is equal to mass of bare electron $2m_{W(electron)} = m_{bare(electron)}$. The change in mass is (the hadronic contributions to the electron anomaly appear as well in the mainstream QED)

$$(m_{bare(electron)} - \Delta m_{electron})/m_{bare(electron)} = \\ =(m_{p(proton)}\alpha_{w(proton)} - m_{bare(electron)}\alpha'_{w(electron-proton)})/(m_{p(proton)}\alpha_{w(proton)}). \tag{4}$$

From formula (4) we obtain

$$R = \Delta m_{electron} / m_{bare(electron)} = \\ = m_{bare(electron)}\alpha'_{w(electron-proton)} / (m_{p(proton)}\alpha_{w(proton)}) = 7.1953 \cdot 10^{-7}. \tag{5}$$

The R concerns the terms containing coupling constants

$$\Delta\varepsilon_{electron} = (\varepsilon - 1)\, R = 8.344077 \cdot 10^{-10}. \tag{6}$$

Then we obtain following value ([1]: formula (69))

$$\varepsilon' = \varepsilon - \Delta\varepsilon_{electron} = 1.0011596521735 \tag{7}$$

Within the non-perturbative S-SET, we calculated as well the other important quantities [1] (see Table 1 in this paper).

Table 1 *The non-perturbative QED*

Physical quantity	**Theoretical value**
Electron magnetic moment in the Bohr magneton	1.0011596521735
Muon magnetic moment in the muon magneton	1.001165921508
Frequency of the radiation emitted by the hydrogen atom under a change of the mutual orientation of the electron and proton spin in the ground state	1420.4076 MHz
Lamb-Retherford Shift	1057.84 MHz 1058.05 MHz

In the S-SET, the coupling constants are defined as follows ([1]: formula (76))

$$\alpha_i = G_i\, M_i\, m_i / (c\, \hbar), \tag{8}$$

where M_i defines the sum of the mass of the sources of interaction being in touch plus the mass of the component of the field whereas m_i defines the mass of the carrier of interactions.

We can see that coupling constants are directly proportional to masses of carriers of interactions

$$\alpha_i \sim m_i \, . \tag{9}$$

For example, neutron decays due to the weak interactions whereas the virtual electron-positron pairs are responsible for the electromagnetic interactions. It leads to following formula for pairs

$$\alpha_{w,nucleon} / \alpha_{em} = 2\,(m_{neutron} - m_{proton}) / (2\, m_{bare(elektron)}) \approx 2.53. \tag{10}$$

On the other hand, within the S-SET we obtain

$$\alpha_{w(proton)} / \alpha_{em} \approx 2.5657. \tag{11}$$

Notice also that weak mass of electromagnetic mass of a particle carrying mass M is

$$m = \alpha'_{w(electron\text{-}proton)}\, \alpha_{em}\, M. \tag{12}$$

2. Calculations

The fine structure constant is defined as follows (the International System) ([1]: formula (21))

$$\alpha_{em} = e^2 c / (10^7 \hbar). \tag{13}$$

The CODATA gives [3]:
- The reduced Planck constant is $\hbar = 1.054571726(47) \cdot 10^{-34}$ Js
- The speed of light in spacetime is (the definition) $c = 2.99792458 \cdot 10^8$ m/s
- The electric charge of electron is $e = 1.602176565(35) \cdot 10^{-19}$ C

Using formula (13), calculate the central value and upper and lower limits for the fine structure constant in such a way that in the numerator we put the maximum values whereas in denominator the minimum values and, next, the vice versa

$$\alpha_{em,exp.} = 1 / 137.035999053(12095). \tag{14}$$

A real electron interacts with one virtual electron-positron pair electromagnetically and weakly. It causes that there are the quantized smallest portions of energy ± m (formula (12)). Their creations and annihilations cause that in the field appear fluctuations. A quantum mass M we can define as follows

$$M \rightarrow M \pm m. \tag{15}$$

Applying formula (12) we obtain the error in measurement of the fine structure constant

$$\alpha_{em,theory}^{-1} \rightarrow \alpha_{em,central\text{-}value,exp.}^{-1} \pm \alpha'_{w(electron\text{-}proton)}. \tag{16}$$

We can rewrite formula (16) as follows

$$\alpha_{em,theory} = 1 / 137.035999053(11194). \qquad (17)$$

As expected, the error in the experimental value (formula (14)), (±0.000012095), is a little higher than the theoretical value, (±0.000011194). Just such error cannot be lower than it follows from the theoretical value. But the experimental and theoretical errors are very close so an improvement in accuracy of the experimental data concerning the reduced Planck constant and electric charge of electron is practically impossible. There appeared papers in which theoretical and experimental values of the fine structure constant have much higher accuracy than the quantities which appear in its definition. We can see that in this paper is proven that the higher accuracies are groundless. It follows from the fact that experimentalists neglect the fluctuations in the Einstein spacetime. The weak interactions cause that the error in the fine structure constant cannot be lower than ±0.000011194. Just the Einstein-spacetime components interact weakly as well (and gravitationally), [1], so there appear the fluctuations which we can see in the CMB as well.

Using the combined value of the fine structure constant (the experimental central value plus-minus the theoretical limits), 1/137.035999053(11194), and applying the non-perturbative QED described in this paper we obtain a theoretical value of the electron anomaly

$$a_e = 0.001159652191(95). \qquad (18)$$

The weak interactions cause that this value cannot have higher accuracy.

Within the Scale-Symmetric Physics are calculated physical constants and other quantities which appear in definitions, from the fundamental initial conditions. The initial parameters lead to 1/137.036001 and 0.001159652174. We can see that both results are consistent with the determinations.

Emphasize that today the mainstream QED contains the 12,672 diagrams (number of terms is tremendous), [4], whereas presented here non-perturbative QED contains only one diagram with six terms. The difference results from an improperly understood weak interactions and production of virtual pairs in the Einstein spacetime.

To calculate all needed quantities we do not need supercomputers, we used the Microsoft Office Excel with 13 decimal places.

3. Summary

An improperly understood the weak interactions and the mechanism of production of virtual particles (a virtual electron-positron pair looks as a real pair but there arises as well a mass “hole” in field or Einstein spacetime) causes that mainstream QED is very complicated. Presented here the non-perturbative QED gives the correct values and correct errors for the fine structure constant and electron anomaly. Due to the fluctuations in fields, which follow from the weak interactions, there is the minimum error and no improvement in experiment can reduce such error.

References

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[4] Tatsumi Aoyama, *et al.* (18 August 2012). "Tenth-Order QED Contribution to the Electron g – 2 and an Improved Value of the Fine Structure Constant" arXiv:1205.5368v2 [hep-ph].