A New Approach to the Beyond the Standard Model Analysis of the Inclusive Electron-Proton Scattering

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Abstract: There can be many scenarios to explain the deviation of the measured cross sections by HERA from the predicted cross sections within the Standard Model (SM) for the deep inelastic electron-proton scattering especially at higher energy transfer. Here we present new-physics scenario that follows from the atom-like structure of baryons, structure of bare electrons and electroweak theory described within the Scale-Symmetric Theory (SST). The ratio of cross sections for momentum transfer 100 GeV obtained within SST and SM is 0.977 - this result obtained within SST is consistent with the HERA data (the SM result is inconsistent with the HERA data). For momentum transfer about 265 GeV such ratio is 0.843 +- 0.002 - this result obtained within SST is inconsistent with theoretical result (about 0.9) that follows from the beyond the Standard Model (BSM) contributions to electron-quark scattering with the non-zero effective quark radius. It means that future more precise measurements for momentum transfer about 265 GeV should determine which theory (SST or BSM-theory) is correct. Applying the Kasner solution to the Einstein's field equations, we answered as well the question why many results obtained within the SST and Quantum Chromodynamics (they are the very different theories) are the same and why many SST results are the best ones.

1. Introduction

There can be many scenarios to explain the deviation of the measured cross sections by HERA from the predicted cross sections within the Standard Model (SM) for the deep inelastic electron-proton ($e^{\pm}p$) scattering especially at higher energy transfer. For example, we can explain it via effective quark radius within the quark form-factor model [1]. The resulting 95% C.L. upper limit on the effective quark radius is about $0.43 \cdot 10^{-16}$ cm [1]. Notice that according to the Standard Model, the bare quarks are the point-like particles so effective non-zero quark radius appears in the beyond the Standard Model (BSM) theories. If the expected deviations are small and we neglect radius of the bare electron $R_e \equiv 0$ (it is consistent with SM), the SM predictions for the cross sections are modified, approximately, to [2], [1]

$$d\sigma / d\sigma_{SM} = (1 - R_q^{\,2}\, Q^2 / 6)^2, \qquad (1)$$

where $R_q^{\,2}$ is the mean-square radius of the quark related to new BSM energy scales whereas Q^2 is the squared momentum transfer.

Here, to explain the deviation, we present the Scale-Symmetric Theory (SST) scenario that follows from the atom-like structure of baryons, from structure of bare electrons and electroweak interactions described within the Scale-Symmetric Theory. Here we argue that the Einstein-spacetime condensates in centres of electrons are scattered on the Einstein-spacetime condensates with a mass about 14.98 MeV which is the binding energy of torus/charge and central condensate in the core of baryons so inside core of protons as well [3A]. There is as well a second phenomenon that leads to condensates with a radius of $0.42674 \cdot 10^{-16}$ cm that is consistent with the upper limit for the effective quark radius assumed within the BSM analysis. But cross sections calculated from scattering of electrons on such condensates at higher energies (higher than 100 GeV) differ from cross sections obtained within the BSM analysis so future more precise experimental data will show which description, i.e. within SST or BSM, is realized by Nature.

Applying the Kasner solution to the Einstein's field equations, we answered as well the question why many results obtained within the SST and Quantum Chromodynamics (they are the very different theories) are the same and why many SST results are the best ones (http://vixra.org/author/sylwester_kornowski).

Within the Standard Model we still cannot calculate exact masses and spin of nucleons from the initial conditions (since 1964). On the other hand, within the Cosmological Standard Model we cannot define properties of the dark matter and dark energy and calculate their abundances from some initial conditions. We as well do not understand the origin of physical constants and applied in physics mathematical constants. It suggests that the two leading mainstream theories, i.e. the Quantum Physics and General Theory of Relativity, are the incomplete theories and that there should be a theory superior to these two theories. Such theory should lead to initial conditions applied in these two theories and should describe the lacking part of the Theory of Everything. We showed that the Scale-Symmetric Theory described in tens of papers is the lacking part.

The General Relativity leads to the non-gravitating Higgs field composed of tachyons [3A]. On the other hand, the Scale-Symmetric Theory shows that the succeeding phase transitions of such Higgs field lead to the different scales of sizes/energies [3A]. Due to the saturation of interactions via the Higgs field and due to the law of conservation of the half-integral spin that is obligatory for all scales, there consequently appear the superluminal binary systems of closed strings (entanglons) responsible for the quantum entanglement (it is the quantum-entanglement scale), stable neutrinos and luminal neutrino-antineutrino pairs which are the components of the Einstein spacetime (it is the Planck scale), cores of baryons (it is the electric-charges/condensates/loops/quantum-physics scale), and the cosmic structures (protoworlds; it is the cosmological scale) that evolution leads to the dark matter, dark energy and expanding universes (the "soft" big bangs) [3A], [3B]. The non-gravitating tachyons have infinitesimal spin so all listed structures have internal helicity (helicities) which distinguishes particles from their antiparticles [3A]. The inflation field started as the liquid-like field composed of non-gravitating pieces of space (tachyons) [3A]. Cosmoses composed of universes are created because of collisions of big pieces of space [3A], [3B]. During the inflation, the liquid-like inflation field (the non-gravitating superluminal Higgs field) transformed partially into the gravitating luminal Einstein spacetime (the big bang) [3A], [3B]. In our Cosmos, the two-component spacetime is surrounded by timeless wall – it causes that the fundamental constants are practically invariant [3A], [3B].

SST shows that to obtain results consistent with experimental data, the big piece of space that transformed into the inflation field had before the collision a rotational energy very low in comparison with kinetic energy [3A]. It leads to conclusion that there was low anisotropy of the inflation field i.e. of the expanding superluminal non-gravitating Higgs field. It means that to such field we can apply the Kasner metric, [4], that is a solution to the vacuum Einstein equations so the Ricci tensor always vanishes. The Kasner metric is for an anisotropic cosmos without matter so it is a vacuum solution for the Higgs field. The one of the two partially symmetrical Kasner solutions, i.e. $(2/3, 2/3 -1/3)$, we interpret as virtual Higgs cyclones with toroidal and poloidal motions. Such tori appear in the succeeding phase transitions of the Higgs field [3A]. The mentioned Kasner solution concerns as well structures composed of exchanged entanglons between the Einstein-spacetime components because entanglons are the Kasner particles as well [3A].

Due to the symmetrical decays of bosons on the equator of the core of baryons, there appears the atom-like structure of baryons described by the Titius-Bode orbits for the nuclear strong-weak interactions [3A].

Applying 7 parameters only and a few new symmetries, [3A], we calculated a thousand of basic physical (and mathematical) quantities (there are derived the physical and mathematical constants as well) which are consistent or very close to experimental data and observational facts. In SST there do not appear approximations, mathematical tricks, and free parameters which are characteristic for the mainstream particle physics and mainstream cosmology.

2. Why many results obtained within the SST and QCD are the same? Why very different inputs in these very different theories lead to the same output?

The Scale-Symmetric Theory shows that the two partially symmetrical Kasner solutions to the Einstein's field equations, i.e. $(0, 0, 1)$ and $(2/3, 2/3, -1/3)$, concern the Kasner particles/objects i.e. the tachyons and the structures composed of the exchanged entanglons (they do not carry the gravitational mass so to them we can apply the Kasner solutions) between the structures composed of the Einstein-spacetime components i.e. of the neutrino-antineutrino pairs [4], [3A].

Now we will show that there is the converted interpretation of the two partially symmetrical Kasner solutions in QCD and SST and that such conversion causes that the very different inputs in these very different theories leads to the same output i.e. to the same dependence on energy and momentum transfer.

The first Kasner solution $(0, 0, 1)$ we can interpret as an oscillation (then the 1 represents a characteristic frequency for a bare fermion or its characteristic radius) or as unitary charge (then the 1 represents the charge whereas the zeros represent the particle-antiparticle pairs). The second Kasner solution $(2/3, 2/3, -1/3)$ we can interpret as fractional charges of quarks or as three frequencies along three orthogonal directions that follow from shape of an entangled structure inside a bare fermion – it is a torus-like structure.

Charges, according to the Kaluza-Klein-theory interpretation within SST, are the loops, [5], which compactification leads to oscillators. On the other hand, according to SST, charges are tori which compactification leads to loops and next to oscillators. Sign of charge depends on internal helicity of loop/tori.

In QCD or in the beyond the Standard Model theory (BSM-theory [1]), the first Kasner solution defines characteristic radius of a baryon whereas the second one defines the charges of quarks. In SST, the first Kasner solution defines unitary charge and resultant charge of the quark-antiquark pairs whereas the second one defines mean radii (toroidal and poloidal) of the torus (the negative sign in front of the third component can define the left internal helicity of the torus of a fermion; the $(-2/3, -2/3, +1/3)$ is for antifermions, for example, for antiproton) [4].

We can see that due to the Kasner solutions, we can replace the three point-like fractional charges of valence quarks in baryons for unique torus carrying unitary charge. It follows from following relation

$$[\Sigma_n (q_n^2)]_{SM} = (q_o^2 = 1^2)_{SST} = 1. \quad (2)$$

Due to the Kasner solutions, for the contact interactions of the carriers of gluons and photons (i.e. of the neutrino-antineutrino pairs [3A]) with a torus/charge, when we neglect scales, there is satisfied following formula for, for example, proton and electron

$$[\Sigma_n (R_n)]_{SST} = (R_o = 1)_{SM} = 1. \quad (3)$$

In the BSM-thery, the quark radius is the free parameter whereas in SST free parameters do not appear. We can see that contrary to SST, the QCD is the incomplete theory so there are formulated the BSM-theories to explain experimental results that are inconsistent with SM. Emphasize that in SST there appear both the atom-like structure of baryons (and the structure of bare leptons) and the quark-antiquark pairs whereas in SM appear the quarks and their pairs only. Of course, in both theories appear the all other particles as well except the Kasner particles that appear in the SST only (i.e. the entanglons and tachyons). They are the reasons that, generally, SST leads to better results and this theory is much simpler. For example, contrary to SM, within SST we can calculate the exact mass and spin of proton.

3. The SST analysis

A coupling constant, α_i, we can define as follows

$$\alpha_i = f_i\, Q\, R / (c\, \hbar), \quad (4)$$

where f_i is a factor defining scale whereas Q denotes energy transfer on distance R.

On the other hand, $Q = h\nu = hc / \lambda_Q$ so we can rewrite formula (4) as follows

$$\alpha_i = 2\, \pi\, f_i\, R / \lambda_Q\, , \quad (5a)$$

$$\alpha_i \sim R / \lambda_Q\, . \quad (5b)$$

To show how the scales f_i act, consider a few processes at low energies for $R = \lambda_Q$. According to SST, the size of proton is $R_{proton} \approx 4\pi A/3 = 2.92144$ fm ($A = 0.6974425$ fm [3A]) whereas of the pure nuclear weak interactions is $R_W = 0.00871095$ fm [3A]. So for the pure nuclear weak interactions is $f_W = R_{proton} / R_{SW} = 0.002982$ i.e. we obtain $\alpha_{W(proton)} = 2\pi\, f_W = 0.01873$ (see formula (5a)) – this value is very close to the exact value obtained within SST: 0.0187229 [3A]. According to SST, the radius of the electric charge of the core of proton is $R_{e(proton)} = 2A/3 = 0.46496$ fm whereas of the electric charge of electron is $R_{e(electron)} = 386.61$ fm [3A]. So for the pure electromagnetic interactions of proton is $f_{EM} = R_{e(proton)} / R_{e(electron)} = 0.0012027$ i.e. $\alpha_{EM(proton)} = 2\pi\, f_{EM} = 1 / 132.3$ (see formula (5a)) – this value is very close to the exact value obtained within SST for electron: $1 / 137.036$ [3A]. The lower limit for range of the strong interactions is $R_{S(proton)} = 2A/3 = 0.46496$ fm whereas the upper limit is 2π times longer so for the strong interactions via the loops overlapping with the electric charge of the core of proton we obtain $f_{S,lower-limit} = 1 / 2\pi$ i.e. $\alpha_{S,lower-limit} = 1$ (emphasize that it is valid at low energies) [3A]. Notice that for the strong interactions of nucleons via pions, at low energies, we obtain that strong coupling constant is about 14.4 and decreases for higher energies [3A].

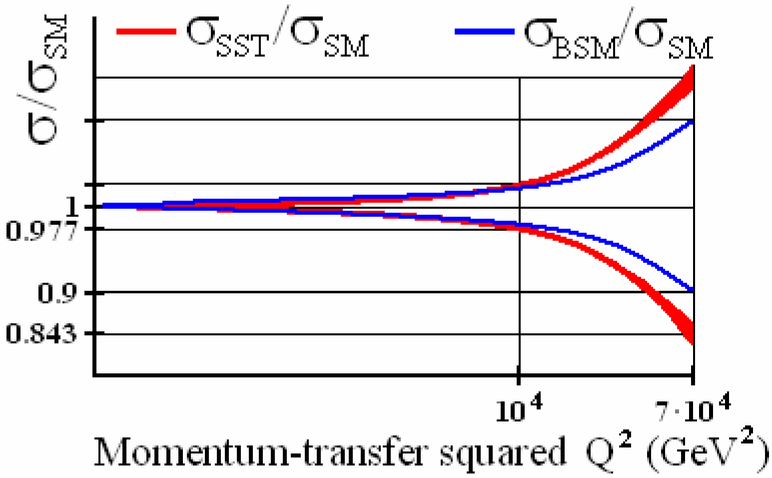
Mass density of all Einstein-spacetime condensates is invariant – it follows from the confinement which results from the Mexican-hat mechanism for the Einstein-spacetime components (i.e. for the neutrino-antineutrino pairs) [3A]. It means that mass of a condensate, M_C, is directly proportional to three powers of its radius $R_{C,M}$

$$R_{C,M} = F\, M_C^{\;1/3}. \tag{6}$$

SST shows that $F = 1.1594 \cdot 10^{-18}$ m MeV$^{-1/3}$ [3A]. For example, the condensate in the centre of the core of baryons with a mass of $Y = 424.12$ MeV has a radius of $R_{C,proton} = 0.871095 \cdot 10^{-17}$ m whereas the condensate with a mass of $M_{C,electron} = 0.25520$ MeV in the centre of the bare electron has a radius of $R_{C,electron} = 0.73541 \cdot 10^{-18}$ m [3A].

The scale f_i in the electron-proton scattering is equal to the ratio of the radii of the electron condensate and the proton condensate i.e. is $f_i = R_{C,electron} / R_{C,proton} = 0.084424$.

SST show that the deviation of cross sections from the cross sections predicted within SM for the deep inelastic $e^{\pm}p$ scattering follows from the scattering of the electron condensates on condensates carrying mass equal to the binding energy of the baryon condensate ($Y = 424.1245$ MeV) and the torus/charge in the core of baryons ($X = 318.2955$ MeV). Such binding energy follows from the nuclear weak interactions and is equal to $M_{C,YX\text{-}binding\text{-}energy} = 14.980$ MeV [3A] – radius of such a condensate is $R_{C,binding\text{-}energy} = 2.8581 \cdot 10^{-18}$ m [3A]. With increasing energy transfer between such condensates, there increases number density of produced core-anticore pairs. Production of the cores and anticores of baryons (they consist of condensate and torus/charge) cause that there are created the binding-energy condensates that scatter the electrons.



Ratio of cross sections

In the electroweak theory of hydrogen atom described within the Scale-Symmetric Theory, we showed that the first-order and second-order corrections are negative and directly proportional to, respectively, squared coupling constant divided by 2 and four powers of coupling constant divided by 8 [6].

Such SST conditions lead to following first-order deviation of the SST cross sections from the predicted cross sections within the Standard Model (SM) for the contact-interactions deep inelastic electron-proton ($e^{\pm}p$) scattering

$$d\sigma_{SST} / d\sigma_{SM} = \{1 - k\,[(R_{C,binding\text{-}energy} + R_{C,electron}) / \lambda_Q]^2\}^2, \tag{7}$$

where from formula (5a) and the condition $f_i = R_{C,electron} / R_{C,proton} = 0.084424$ and condition $d\sigma_{SST} / d\sigma_{SM} = (1 - \alpha^2 / 2)^2$, we obtain $k = 2\pi^2 f_i^2 = 0.14069$.

For $Q = 100$ GeV ($\lambda_Q = 1.2399 \cdot 10^{-17}$ m) we obtain $(d\sigma_{SST} / d\sigma_{SM})_{Q=100GeV} = 0.977$ whereas for $Q = 265$ GeV ($\lambda_Q = 4.6789 \cdot 10^{-18}$ m) we obtain $(d\sigma_{SST} / d\sigma_{SM})_{Q=265GeV} = 0.841$.

Production of the core-anticore pairs causes that besides the condensates carrying mass equal to 14.98 MeV there are created as well condensates that mass is equal to the nuclear weak mass of the mass distance between the charged core ($H^{+,-} = 727.4401$ MeV) and neutral core ($H^o = 724.7768$ MeV) of baryons [3A]. Such weak mass is

$$M_{C,H} = \alpha_{W(proton)}\,(H^{+,-} - H^o) = 0.0498647 \text{ MeV}, \tag{8}$$

where $\alpha_{W(proton)} = 0.0187229$ [3A]. Applying formula (6) we obtain for radius of such condensate $R_{C,H} = 0.42674 \cdot 10^{-18}$ m. This radius is consistent with the upper limit for the effective quark radius assumed within the BSM analysis to obtain results consistent with the HERA data. Notice that such value obtained within SST, contrary to the BSM analysis, is not a free parameter.

We can see that there at first are produced simultaneously the core-anticore pairs and the condensates with a mass of 14.98 MeV on which the electrons are scattered – it causes that the scale is $f_i = R_{C,electron} / R_{C,proton} = 0.084424$. Next there are produced the condensates with a mass of 0.0498647 MeV on which the electrons are scattered – it causes that the scale is different $f_j = R_{C,electron} / R_{C,binding\text{-}energy} = 0.25731$. For such scale we obtain $k^* = 2\pi^2 f_j^2 = 1.3069$.

Applying formula (7), replacing k by k^* and $R_{C,binding\text{-}energy}$ by $R_{C,H}$, for $Q = 100$ GeV ($\lambda_Q = 1.2399 \cdot 10^{-17}$ m) we obtain $(d\sigma_{SST} / d\sigma_{SM})^*_{Q=100GeV} = 0.977$ whereas for $Q = 265$ GeV ($\lambda_Q = 4.6789 \cdot 10^{-18}$ m) we obtain $(d\sigma_{SST} / d\sigma_{SM})^*_{Q=265GeV} = 0.845$.

We can see that described here within SST the two different scattering processes lead to following ratios of cross sections: for $Q = 100$ GeV is $(\sigma_{SST} / \sigma_{SM})_{Q=100GeV} = 0.977$ whereas for $Q = 265$ GeV we obtain $(\sigma_{SST} / \sigma_{SM})_{Q=265GeV} = 0.843 \pm 0.002$.

4. Summary

There can be many scenarios to explain the deviation of the measured cross sections by HERA from the predicted cross sections within the Standard Model (SM) for the deep inelastic electron-proton scattering especially at higher energy transfer.

Here, to explain the first-order deviation, we present the Scale-Symmetric Theory scenario that follows from the atom-like structure of baryons, from structure of bare electrons and electroweak interactions described within the Scale-Symmetric Theory. Here, the Einstein-spacetime condensates in centres of electrons are scattered on the Einstein-spacetime condensates with a mass about 14.98 MeV which is the weak binding energy of the central condensate and torus/charge in the core of baryons. There is as well a second phenomenon that leads to condensates with a radius of $0.42674 \cdot 10^{-16}$ cm (their mass is the nuclear weak mass of the mass distance between the charged core and neutral core of baryons) that is consistent with the upper limit for the effective quark radius assumed within the BSM analysis. But cross sections calculated from scattering of electrons on such condensates at higher energies (higher than 100 GeV) differ from cross sections obtained within the BSM analysis so future more precise experimental data will show which description, i.e. within SST or BSM, is realized by Nature.

The ratio of SST and SM cross sections for momentum transfer 100 GeV is 0.977 – this result obtained within SST is consistent with the HERA data. For momentum transfer about 265 GeV such ratio is 0.843 ± 0.002 – this result obtained within SST is inconsistent with theoretical result (about 0.9) that follows from the beyond the Standard Model (BSM) contributions to electron-quark scattering with the non-zero effective quark radius. It means that future more precise measurements for momentum transfer about 265 GeV should determine which theory (SST or BSM-theory) is correct.

Applying the Kasner solution to the Einstein's field equations, we answered as well the question why many results obtained within the SST and Quantum Chromodynamics (they are the very different theories) are the same and why many SST results are the best ones.

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