The Scale-Symmetric Theory as the Lacking Part of the Theory of Everything

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Abstract: Here we present the new structure of the Theory of Everything (ToE or SQUARE Theory). The time problem that concerns the General Relativity (GR) and Quantum Mechanics (QM) (contrary to QM, in GR is not a distinguished physical time) suggests that the irreversible separation of GR and QM during the inflation is the good idea - just there was created the two-component spacetime with very different properties of the two components. One component is directly associated with gravitational fields whereas the second with the Standard-Model interactions and particles. It causes that unification of GR and QM within the same methods is impossible. The separation of GR and QM follows from the succeeding phase transitions of the superluminal Higgs field that existence results from the extended GR (the phase transitions are described within the unique Scale-Symmetric Theory (SST)). The SST shows that both theories, i.e. GR and QM, start from correct but incomplete sets of initial conditions. It causes that, generally, they lead to experimental data so both are the correct theories but due to the incompleteness, there appear as well the not numerous incorrect solutions i.e. solutions that cannot be realized by Nature. The Scale-Symmetric Theory limits the GR and QM in such a way that there do not appear infinities, indeterminate mathematical forms, approximations, mathematical tricks and free parameters. Nature on lower and lower levels should be simpler and simpler, not more and more complex as it is in the not unique Loop Quantum Gravity or the not unique string/M-theory. We do not need new differential equations to solve the tremendous number of unsolved basic problems - we need a very simple theory that limits the GR and QM and describes the scales below the Planck scale and solves all problems above this scale and SST is such a theory. In the RHIC experiment we can test the SST.

1. Introduction

Scientists try to formulate a single theory to describe all phenomena within the same methods. It is assumed that quantum gravity could be a Theory of Everything (ToE). But the problem of time (the classical-quantum duality of a distinguished physical time to describe as everything evolves) shows that a coherent unification of General Relativity (GR) and Quantum Mechanics (QM) (or its extension i.e. Quantum Field Theory (QFT)) within the same methods (so within the same definition of time) is impossible. So scientists assumed that one of the two leading mainstream theories, i.e. GR or QM, must be incorrect. But we know that both theories lead to experimental and observational facts so are correct. It suggests that during the inflation (the correct theory of inflation is described within the Scale-Symmetric Theory (SST), [1]) the GR and QM were irreversibly separated and it is the main reason that they are incompatible. But their incompleteness causes that together with the correct solutions

there appear as well the not numerous solutions that Nature cannot realize as, for example, the time loops in GR or the many-worlds interpretation of QM.

Nature on its lower and lower levels should be simpler and simpler, not more and more complex as it is in the theories of quantum gravity i.e. in the not unique Loop Quantum Gravity (LQG) within which we try to unify GR and QM without additional assumptions (there appears the time problem), or in the not unique string/M-theory starting from additional assumptions i.e. extra dimensions and supersymmetry. Both these theories are very complicated and the non-unique theories so today they are the useless theories.

To obtain the Planck length/scale (about 10^{-35} m), we use the gravitational constant, G, speed of light in "vacuum", c, and reduced Planck constant, ħ. The used physical constants suggest that the Planck length is the lower limit for both GR and QM but for LQG and string/M-theory as well. On the other hand, within GR we obtain formula for the total energy of particles that inertial mass is equal to their gravitational mass (the Principle-of-Equivalence objects). Assume that the gravitational fields consist of non-gravitating objects i.e. imaginary objects. Substitute ic instead the speed of light in "vacuum" c, iv instead the kinetic speed v and im instead the gravitational mass M, where i = sqrt(–1) is the imaginary unit. Then the formula for the total energy of a gas composed of the non-gravitating objects is

$$E = m c^2 / (v^2 / c^2 - 1)^{1/2}. \quad (1)$$

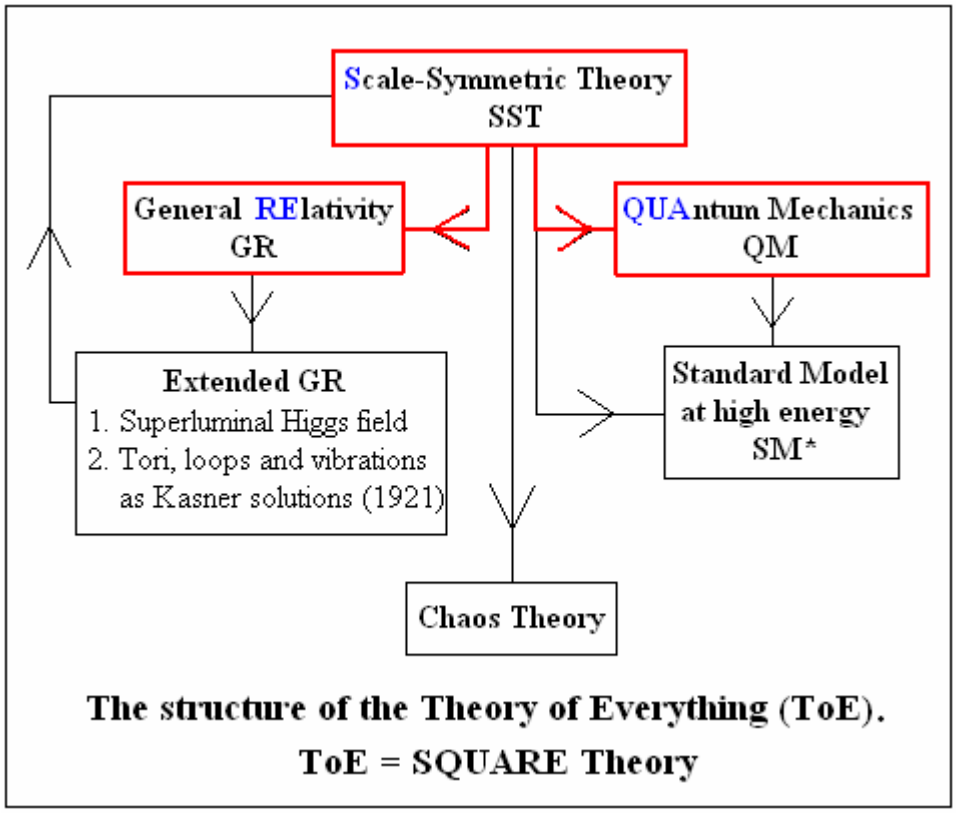
We can see that now the non-gravitating objects must be superluminal (v must be higher than the speed of light in "vacuum", c,) i.e. they are the non-gravitating tachyons. The gas composed of non-gravitating tachyons I refer to as the modified Higgs field. It is the Higgs field which causes that non-gravitating objects, due to the interaction with the Higgs field, acquire their gravitational mass (the Higgs mechanism). In formula (1) appears the speed of light in "vacuum", c, as well and it is a threshold speed. It leads to conclusion that sizes of the tachyons are smaller than the Planck length. Just the theory of tachyonic/Higgs field is beyond GR but results from GR so we can call such theory of Higgs field the extended-GR.

The GR concerns the non-gravitating objects also so we can apply to the superluminal Higgs field the Kasner solutions (1921). Beside the superluminal Higgs field, in the extended-GR there appear also the new interpretations of the Kasner solutions: the (2/3, 2/3, –1/3) Kasner solution represents tori or loops whereas the (0, 0, 1) solution represents vibrations [1]. Due to the quantum entanglement, such structures, i.e. tori, loops and vibrations, appear also in higher scales of Nature i.e. concern the gravitating objects also. Such structures appear in SST, GR, QM and Chaos Theory (the structure of proton leads to the Feigenbaum constant $\delta = 4.6692016\ldots$) [1].

The extended-GR is the starting point of the Scale-Symmetric Theory. We can see that existence of superluminal Higgs field follows from extended-GR. Next, the three new symmetries (i.e. the saturation of interactions, four-particle symmetry, and spin-1/2 phase transitions) lead to the succeeding phase transitions of the non-gravitating tachyonic Higgs field. There appear bigger and bigger objects/scales for which the simplest non-trivial compactification has 26 degrees of freedom (there do not appear extra dimensions but extra degrees of freedom) and consists of torus/charge, loop/radion, and ball/condensate(dilaton), [2]. Such foundations of the SST lead to the atom-like structure of baryons, physical constants and a thousand of fundamental theoretical results consistent with experimental data. The SST leads as well to the masses of quarks and shows that the Quantum Chromodynamics (QCD) is correct only at high energies because then the produced quark-antiquark pairs dominate – at low energy, in proton, there are dense fields composed of entangled and/or confined Einstein-spacetime components i.e. dense fields composed of the carriers of gluons.

Due to the succeeding phase transitions of the superluminal Higgs field, there appear following scales: the superluminal quantum-entanglement scale (it is smaller than the Planck length/scale), the luminal Planck scale associated with the Einstein spacetime, the baryonic scale, and the cosmological scale which leads to dark matter and dark energy as well.

The SST leads to the initial conditions applied in GR and QM and shows that during the inflation these two theories were irreversibly separated so their unification within the same methods is impossible. Just there appeared the two-component spacetime with very different properties of the components i.e. the superluminal Higgs field associated directly with gravitational fields, and the luminal Einstein spacetime and superluminal quantum entanglement both directly associated with the Standard-Model interactions and particles.



The structure of the Theory of Everything (ToE).
ToE = SQUARE Theory

Many scientists believe that up to about 10^{-43} seconds after the big bang, the gravity and the SM forces were a single fundamental force. SST shows that it is untrue. Of course, the Planck-scale objects, the cores of baryons and the cores of the cosmological objects are the self-similar objects, [2], but the charges and spins are defined by the tori of the 26-degrees-of-freedom compactified objects, the strong interactions are defined by the loops/radions, whereas weak interactions are defined by the balls/condensates(dilatons). It leads to conclusion that the SM interactions are associated with the core of baryons (i.e. with the same entity) but each interaction is associated with different part of the entity and with different phenomena so the unification proposed by the string/M-theory cannot be realized by Nature. We can unify the SM interactions only via the phase transitions described within the SST. And only such unification can be called the Grand Unified Theory (GUT). GUTs are QFTs which involve the mathematically incoherent renormalization so GUTs are only effective field theories. On the other hand, in SST the bare particles are not the mathematical points so the renormalization does not appear.

SST shows that the inflationary force is the fundamental force that follows from the dynamic viscosity of the tachyons and this force acts during the direct collisions of tachyons

so this force was very important at the beginning of the inflation when the superluminal Higgs field had behaved as a liquid-like field, and later when there appeared the tachyonic condensates [3]. This force is as well very important all the time because due to this force the Einstein-spacetime components and neutrinos produce the gravitational fields.

In LQG and SST, space itself is discrete i.e. there is a minimum distance possible to travel through it. In SST it is size of a tachyon (about 10^{-64} m) whereas in LQG it is the Planck length. Within LQG we cannot prove that at the Planck scale spacetime has a continuum limit. On the other hand, within SST it is possible. Just during the shortest SM interactions (about 10^{-25} s), due to the superluminal speed of the tachyons the gravitational fields consist of, the tachyons are tremendous number of times in each point of spacetime (about 10^{35} times) i.e. for the interacting SM particles the gravitational fields look as very smooth fields. We can see that even during the Planck time (about 10^{-43} s) the tachyons are about 10^{17} times in each point of spacetime.

In SST, which is the realistic/unique string theory, contrary to the non-unique string/M-theory, the massless luminal gravitons do not appear. The gravitational energy is emitted via the flows in the Einstein spacetime composed of the sources of gravitational fields (i.e. via flows of the neutrino-antineutrino pairs and free neutrinos) that carry gravitational mass and the associated gravitational fields i.e. that carry the gravitational energy [4].

Can we create an experiment to test the proposed Scale-Symmetric Theory? Yes. In the Relativistic Heavy Ion Collider (RHIC) the spin structure of the proton is explored. The results suggest that instead the single quarks there are dense gluon fields – it is consistent with SST. Some further investigations should show that spin of proton is associated with the torus in the core of proton – it will be the ultimate evidence that SST is the correct theory and is the lacking part of ToE. The external radius of the torus is about 0.7 fm. Presented within SST the structure of proton at low energy leads to precise mass, spin and the electron and muon radii of proton [1], [5].

2. Definitions

$$\textit{Complete theory = unique theory} \tag{2}$$

Any change in initial conditions of a complete theory causes that it does not lead to experimental data. The Scale-Symmetric Theory is the complete/unique theory.

$$\textit{Incomplete theory is a theory that starts from correct but incomplete initial conditions.} \tag{3}$$

Generally, incomplete theories lead to experimental data but due to the incompleteness, there together with solutions that can be realized by Nature we obtain as well not numerous solutions that cannot be realized by Nature as, for example, the time loops in GR or the many-worlds interpretation of QM. The GR and QM are the incomplete theories.

The unique SST leads to the initial conditions the GR and QM start from and shows that the sets of initial conditions are incomplete i.e. the SST can point the solutions that cannot be realized by Nature. The SST as well removes the infinities, indeterminate mathematical forms, approximations, mathematical tricks and free parameters from the incomplete theories.

$$\textit{Incorrect theory is a theory that starts from a set of initial conditions containing one or more incorrect conditions} \tag{4}$$

The string/M-theory is the incorrect theory because the assumed internal structure of the strings (the extra dimensions) cannot be realized by Nature.

The SST is the realistic/unique string theory.

3. The time problem

In GR, there is not a distinguished global/absolute physical time to describe how everything evolves (the Hamiltonian is a constraint that must vanish). The SST shows that there are the local units of time defined by mean time between collisions of the non-gravitating tachyons the gravitational fields consist of i.e. the superluminal Higgs field consists of. The lack of a distinguished physical time in GR follows from the curvature of the gravitational fields produced by the Principle-of-Equivalence particles the luminal Einstein spacetime consists of (they are the dominating neutrino-antineutrino pairs and the free neutrinos). All gravitational masses consist of entangled or/and confined Einstein-spacetime components and neutrinos. The mean inertial-mass density of the non-gravitating gravitational fields associated directly with the Higgs field is about $2.65 \cdot 10^{-15}$ kg/m^3.

The Scale-Symmetric theory shows that the Einstein-spacetime components are the luminal but non-relativistic objects i.e. their mass does not depend on their velocities and their interactions (i.e. the gravitation, the entanglement and/or confinement) do not change gravitational mass of a system. Gravitational energy is emitted via emission of sources of gravitational energy, i.e. via emission of gravitational masses, which carry the associated gravitational energy – they are the flows in the Einstein spacetime and they are not the luminal gravitational waves incorrectly predicted by GR.

On the other hand, in QM there is in existence a distinguished global/absolute physical time to describe how quantum systems evolve (the Hamiltonian generates the time evolution of quantum states). The Scale-Symmetric Theory shows that it follows from the fact that the electromagnetic, weak, and strong interactions (i.e. the Standard Model interactions) are associated directly with the luminal Einstein spacetime which properties are very different from the properties of the superluminal Higgs field associated with gravity. Densities of the electromagnetic, weak, and strong fields are very low in comparison with the mean density of the very ordered ground state of the Einstein spacetime that is about $1.10 \cdot 10^{28}$ kg/m^3. Some physical analog is as follows. The densities of the listed three fields can be represented by amplitude of waves on surface of a very deep ocean whereas the depth of the ocean represents the density of the Einstein spacetime. We can see that spacetime associated with QM plus the SM fields, is practically flat (i.e. the sum of angles in each triangle is 180^o). We can see that all the local units of time defined by mean time between collisions of the luminal Einstein-spacetime components have practically the same value in whole Universe and it is the unit of time of the distinguished global/absolute physical time in QM.

Of course, we can define the local units of time in a different way, for example, as the periods of rotation of particles. Contrary to the periods of rotation of the Einstein-spacetime components, the period of rotation of tachyons cannot change. Notice as well that such definitions are not associated directly with GR and QM. Just the times associated with GR and QM are the “thermal” times associated with the chaotic motions and collisions of, respectively, tachyons and neutrino-antineutrino pairs. We need the inverted commas (“thermal”) because both times concern the absolute-zero state of the spacetime.

We can see that the problem of time is a conceptual conflict between GR and QM. This conflict suggests that unification of GR and QM within the same methods is impossible. It caused that there appeared an incorrect conclusion that one of the leading mainstream theories must be incorrect. The Scale-Symmetric theory shows that, generally, both theories, i.e. GR and QM, are correct (the Quantum Chromodynamics is correct only at high energy because then the quark-antiquark pairs dominate; at low energy there dominate the dense fields

composed of the entangled and/or confined Einstein-spacetime components which are the carriers of gluons), but due to the irreversible phase transitions during the inflation, the GR and QM were irreversibly separated – just there appeared the two very different spacetimes i.e. the superluminal Higgs field associated with gravitational fields and the luminal Einstein spacetime and superluminal entanglement associated with the Standard-Model interactions.

4. Curvature and flatness of the two-component spacetime and the Universe

We can see that the densities of the superluminal non-gravitating gravitational fields, i.e. of the curved part of the two-component spacetime, are about $2.65 \cdot 10^{-15}$ kg/m^3 whereas of the practically flat part of the two-component spacetime, i.e. of the luminal Einstein spacetime, is much, much higher i.e. about $4 \cdot 10^{42}$ times higher. It leads to conclusion that the two-component spacetime, as a whole, is flat whereas the very weak gravitational fields (in comparison with the Standard-Model fields) produce the curved part of the two-component spacetime.

The differences in the densities cause that even near the black holes the two-component spacetime as a whole is flat.

5. Summary

Here I present the new structure of the Theory of Everything (ToE or SQUARE Theory). We motivated that the ToE consists of thee theories i.e. of the theory of **S**cales (SST) as the foundations, and of the **QUA**ntum mechanics and theory of **RE**lativity that follow from SST. The first letters shows that we can call the ToE the SQUARE theory. In 1958, Wolfgang Pauli made use of the word "SQUARE" as a joke. In history of civilisation, ToE appeared many times. The present dream began in 1958. On the radio interview, Heisenberg said that they, i.e. Pauli and himself, were able to explain the masses of various particles. Pauli comment was rapid. In his letter, he drew a blank SQUARE and put down the comment "This is to show the world, that I can paint like Titian. Only technical details are missing".

The Scale-Symmetric Theory (SST) is the lacking part of ToE.

The extended General Relativity (extended-GR) leads to the superluminal Higgs field which is the starting point of the SST. Due to the three new symmetries, there appear the succeeding phase transitions of the superluminal Higgs field – they are the foundations of SST.

The GR concerns the non-gravitating objects also so we can apply to the superluminal Higgs field the Kasner solutions (1921). Beside the superluminal Higgs field, in the extended-GR there appear also the new interpretations of the Kasner solutions – they represent tori, loops and vibrations. Due to the quantum entanglement, such structures appear also in higher scales of Nature i.e. concern the gravitating objects also. Such structures appear in SST, GR, QM and Chaos Theory.

The time problem suggests that one of the leading mainstream theories, i.e. General Relativity (GR) or Quantum Mechanics (QM), is incorrect i.e. cannot be realized by Nature. But we know that both theories lead to experimental data so the conclusion is wrong.

SST shows that during the inflation described within SST, the GR and QM were irreversibly separated and both are the correct but incomplete theories. The same concerns the not unique Loop Quantum Gravity (LQG) whereas the not unique string/M-theory is the incorrect theory because there appear the initial conditions that cannot be realized by Nature. At the end of the inflation there appeared the two-component spacetime with very different properties of the components. The superluminal non-gravitating Higgs field is directly associated with gravitational fields whereas the luminal Einstein spacetime and the superluminal quantum entanglement are directly associated with the Standard-Model fields.

We can test the SST – in the RHIC experiment, the spin structure of the proton is explored. The results suggest that instead the single quarks there are dense gluon fields – it is consistent

with SST. Some further investigations should show that spin of proton is associated with the torus in the core of proton – it will be the ultimate evidence that SST is the correct theory and that SST is the lacking part of ToE. The external radius of the torus is about 0.7 fm. Presented within SST the structure of proton at low energy leads to precise mass, spin and the electron and muon radius of proton.

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