Illustration of the Emergence of Fundamental Forces

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Abstract: Here, within the Scale-Symmetric Theory (SST), we illustrate and describe briefly the emergence of fundamental forces.

1. Illustration

According to the Scale-Symmetric Theory (SST), fundamental forces emerged because of the phase transitions of the initial inflation field. Neutrinos and their gravitational fields were created during the inflation. At the end of inflation, because of the neutrino confinement and quantum entanglement, there appeared the still undiscovered neutrino-antineutrino pairs and next, due to the return shock wave in the Einstein spacetime (ES) (characteristic speed in ES is the speed of light in "vacuum" c) and the neutrino confinement and entanglement, the hadrons and charged leptons. Creation of the precursor/Protoworld of the early Universe was separated in time from the inflation – it was created in the centre of the two-component spacetime (spacetime consists of the SST non-gravitating superluminal Higgs field, which is the residual inflation field, plus the gravitating Einstein spacetime composed of the neutrino-antineutrino pairs). Neutrinos are the source of the gravitational force – their gravitational fields are the gradients in the SST Higgs field. Carriers of the electromagnetic force, weak force and strong force are the ES excited states created by hadrons and leptons.

1 (see Fig.1)

In paper [1], we present the initial conditions in the Scale-Symmetric Theory (7 parameters, 5 initial symmetries, and 4 initial formulae). Such initial conditions lead to 5 different levels of Nature and to the atom-like structure of baryons [2] which lead to the SM 19 initial parameters and to the 7 parameters beyond SM [3], [1].

The global left-handedness of the initial inflation field leads to the matter-antimatter asymmetry – such asymmetry is not associated with different behaviour of matter and antimatter [4].

Most fundamental is the fifth force associated with the non-gravitating tachyons the SST Higgs field consists of. This force follows from dynamic viscosity that results from smoothness of surfaces of the tachyons (it is very difficult to separate two sheets of glass) – it caused that there appeared stable structures composed of tachyons [1].

(2)

The phase transitions during the inflation lead to the neutrinos [5], [2] and their elementary gravitational fields [1], [2]. It means that gravitational force emerged during the SST inflation.

Neutrinos consist of the binary systems of closed strings built of tachyons (they are the superluminal entanglons responsible for quantum entanglement) – entanglons have unitary spin and internal helicity [2], [1].

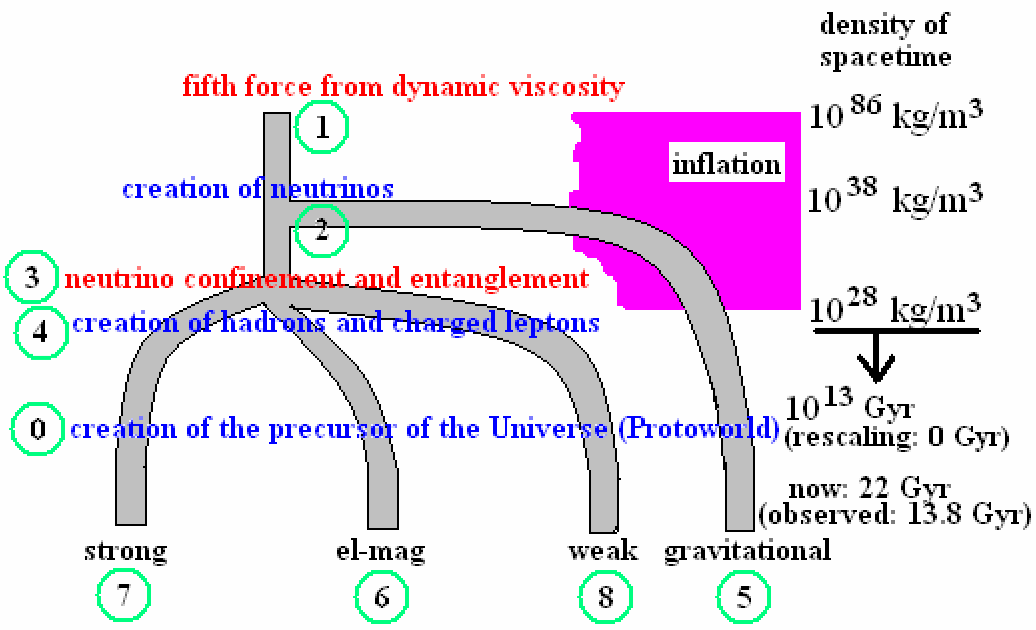

Fig.1
Illustration of the emergence of fundamental forces

(3)

Neutrino confinement and quantum entanglement [2] follow from exchanges of the superluminal entanglons the neutrinos consist of. There appeared the two-component spacetime [2].

(4)

Neutrino confinement, quantum entanglement, and the return shock wave created in ES because of the collapse of a layer close to the expanding boundary of ES, caused that at the end of the SST inflation there appeared hadrons and charged leptons [2].

In the Standard Model, particles acquire their gravitational mass due to non-symmetric ground-state/vacuum (the spontaneous symmetry breaking (SSB) is obtained for symmetrical Lagrangian) – but it is pure mathematics without some real physical phenomena. The SSB causes that a physical system in a symmetrical state ends up in an asymmetrical state – it can be, for example, due to the Mexican-hat-type potential.

In SST, Higgs mechanism is associated with the fifth force and internal helicities of the entanglons the neutrinos consist of. Internal helicities of the entanglons follow from the infinitesimal spins of the tachyons. In SST, SSB follows from internal helicity of bare fermions which causes that in spacetime appear jets – such jets cause that a little more fermions are moving in direction opposite to the jets. In a mirror image, there is transition to opposite internal helicity which changes direction of motion but we know that the mirror image cannot change direction of motion – it is the spontaneous symmetry breaking in SST [10]. The SST spontaneous symmetry breaking has nothing with the SST Higgs mechanism.

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The return shock wave in ES, which carried the hadrons and leptons, created the precursor of the early Universe (Protoworld) in the centre of the two-component spacetime [6]. Protoworld transformed into dark matter and forced the inflow of dark energy [6].

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The SST Higgs field is all the time the tachyonic field – it consists of the non-gravitating pieces of space (tachyons) carrying inertial-mass/physical-volume only. In SST, the massive Higgs boson (it is an ES condensate so it is not directly associated with Higgs mechanism), charged leptons, quarks, and gauge bosons (they as well are the ES condensates [8]) acquire their masses in the same way i.e. due to local changes in density of the gravitating Einstein spacetime – it is due to the neutrino quantum entanglement or/and confinement described within SST [2]). Only the neutrinos and binary systems of them acquire their gravitational masses because of the true, classical Higgs mechanism – it is due to the fifth force that follows from smoothness of the SST tachyons the whole Nature is built of and due to the internal helicities of entanglons. The entanglons transform the chaotic motions of tachyons in the SST Higgs field into the divergent motions. The collisions of the divergently moving tachyons with the tachyons moving chaotically produce gradient in the Higgs field – it is the gravitational field of a neutrino [1], [2].

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Electromagnetic force follows from emission and absorption of photons that can transform into electron-positron pairs [2]. We calculated from the SST initial conditions the electromagnetic gauge coupling $g'(Z) = 0.35706$ [3] and the fine-structure constant $\alpha_{em} = 1 / 137.0360$ [2].

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Mass of gluon loops decreases with increasing energy of interactions – it leads to the running strong coupling [2]. For energy scale equal to the mass of the Z boson, we obtained for the strong gauge coupling $g_S(Z) = 1.21529 \pm 0.00360$ and for the strong coupling constant $\alpha_S(Z) = 0.11753 \pm 0.00035$ [3] (formula for field strength is $\alpha_S(Z) = g_S(Z)^2/(4\pi)$) – the last value is consistent with experimental data [7] and with the value calculated within SST in a different way: $\alpha_S(Z) = 0.1176 \pm 0.0005$ [2].

According to SST, neutral pion consists of two spin-1 gluon loops. A simplest gluon loop consists of two spinning and rotating stable neutrinos [2]. It means that gluon loops have internal helicity.

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The ES condensates are the carriers of the weak interactions [2], [3], [8]. The origin of the weak interactions is very different from the electromagnetic interactions [3]. We showed many times that weak interactions associated with ES condensates lead to experimental data.

We calculated for energy scale equal to the mass of the Z boson the weak gauge coupling g = 0.65235 [3].

But there are many other evidences that weak force follows from exchanges of ES condensates. For example, mass of a circle-like ES slice, m_{slice}, with cross section equal to the maximum cross section of the Y condensate in centres of baryons is

$$m_{slice} = \rho_{surface}\, \pi\, r_{p,Y}^2 = [2m_{neutrino} / (3510.2\, r_{neutrino})^2]\, \pi\, r_{p,Y}^2 = 0.057866 \text{ eV}\ , \quad (1)$$

where $m_{neutrino} = 3.3349306 \cdot 10^{-67}$ kg is the particle mass of lightest neutrinos [2], [9], $3510.2 r_{neutrino} = 3.9260 \cdot 10^{-32}$ m is the mean distance between the ES components [2], whereas $r_{p,Y} = 0.8710945 \cdot 10^{-17}$ m is the radius of the Y condensate which is responsible for the nuclear weak interactions of baryons [2]. Such slice behaves as surface of electric charges [2] so it emits photons which energy is $\alpha_{em} m_{slice}$. It leads to conclusion that effective mass of the slice is

$$m_{slice,eff} = m_{slice}\,(1 - \alpha_{em}) = 0.057444 \text{ eV}\ . \quad (2)$$

This effective mass is very close to the lowest mass of the cosmological neutrinos $m_{\nu,cosmol}$ = 0.057452 eV (sum of masses of cosmological neutrinos with different flavours calculated within SST is 0.287 eV) [9]. It leads to conclusion that there was a resonance between $m_{slice,eff}$ and $m_{\nu,cosmol}$ and such resonance concerns the Y condensate.

In SST, the vacuum expectation value (VEV) is the sum of masses of gauge bosons: $VEV = W^+ + W^- + Z = 252.0$ GeV (here the symbols of particles denote their masses also). On the other hand, coupling constant is directly proportional to the product of mass of source and mass of carrier of interaction. Notice that there is satisfied following relation

$$e \cdot VEV = p \cdot \pi_{mean} = 0.1288 \text{ GeV}^2\ , \quad (3)$$

where $e = 0.5109989$ MeV, $p = 938.272$ MeV and $\pi_{mean} = (\pi^{+,-} + \pi^o) / 2$, where π^o = 134.9766 MeV and $\pi^{+,-}$ = 139.57013 MeV [7]. We can see that the strength of field defined by coupling constant for electron interacting via a carrier with a mass of the VEV is the same as for proton interacting via mean pion – it follows from the fact that the W and Z bosons, before their condensation, and pions are created in the same field (see the initial structure of the W and Z bosons [8] – there are pions).

2. Evolution of density and time

Within SST, we calculated speed of tachyons $v_t = 2.386343972 \cdot 10^{97}$ m/s, speed of entanglons $v_{cs} = 0.7269253 \cdot 10^{68}$ m/s, speed of neutrino-antineutrino pairs in ES $v_{ES} = c$ [2], initial radius of inflation field $R_{Initial\text{-}of\text{-}inflation\text{-}field} \approx 1.19 \cdot 10^{11}$ m and present-day radius of spacetime $R_{Cosmos} \approx 2.33 \cdot 10^{30}$ m [11].

The entanglons were produced already at the beginning of the SST inflation. They were frozen inside neutrinos when density of spacetime decreased from about 10^{86} kg/m^3 to about 10^{38} kg/m^3 (it is the density of neutrinos) [2]. It leads to conclusion that radius of spacetime increased $(10^{86}\text{ kg/m}^3 / 10^{38}\text{ kg/m}^3)^{1/3} = 10^{16}$ times i.e. from about 10^{11} m to 10^{27} m – it means that neutrinos were produced $(10^{27}\text{ m} - 10^{11}\text{ m}) / 10^{68}\text{ m/s} = 10^{-41}$ s after the beginning of the SST inflation. It reduced speed of expansion of spacetime to c. Then the distance about 10^{30} m – 10^{27} m was covered by the Einstein spacetime with the speed c – it lasted about (10^{30} m – 10^{27} m) / c = $3 \cdot 10^{21}$ s = 10^5 Gyr. Next, at the front of the expanding ES, the gravitational pressure exceeded the dynamic pressure so there was a collapse that created boundary of the ES [6], [11].

The collapse had created in ES the return shock wave that after about 10^{30} m / c = $3 \cdot 10^{21}$s = 10^5 Gyr produced the Protoworld in the centre of the ES [6].

The Universe is 21.6 Gyr old but time distance to most distant galaxies is 13.866 ± 0.096 Gyr [6].

Emphasize that tachyons cover the diameter of the spacetime during about $4.7 \cdot 10^{30}$ m / $2.4 \cdot 10^{97}$ m/s ≈ $2 \cdot 10^{-67}$ s whereas entanglons during about $4.7 \cdot 10^{30}$ m / $0.73 \cdot 10^{68}$ m/s ≈ $6 \cdot 10^{-38}$ s – both periods are many orders of magnitude shorter than the fastest Standard-Model interactions i.e. the nuclear strong interactions. Notice that there was produced as well the boundary for entanglons and free tachyons [6].

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