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Foundations of the Scale-Symmetric Theory and the Illusory Total Width of the Off-Shell Higgs Bosons

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Abstract

Here we present the foundations of the Scale-Symmetric Theory (SST), *i.e.* the fundamental phase transitions of the initial inflation field, the atom-like structure of baryons and different types of black holes. Within SST we show that the transition from the nuclear strong interactions in the off-shell Higgs boson production to the nuclear weak interactions causes that the real total width of the Higgs boson from the Higgs line shape (*i.e.* 3.3 GeV) decreases to 4.3 MeV that is the illusory total width. Moreover, there appear some glueballs/condensates with the energy 3.3 GeV that accompany the production of the off-shell Higgs bosons.

Keywords

Scale-Symmetric Theory, Black Holes, Higgs Boson

1. The Foundations of the Scale-Symmetric Theory (SST)

SST is the missing part of the theory of everything (ToE). SST is based on two pillars. The first pillar describes the four successive phase transitions of the initial inflation field composed of tachyons/pieces-of-space and it is the basis of the ToE. The second pillar is the atom-like structure of baryons, which is due to the electroweak and nuclear strong interactions.

In SST, the first two levels of Nature, *i.e.* the SST Higgs field and the carriers of quantum entanglement (entanglons), behave classically, so we apply the classical thermodynamics. Quantum gravity concerns the SST Higgs potential around the neutrinos, it is the third level of Nature. The Standard Model concerns the excited states of the SST absolute spacetime (SST-As) which is a part of the two-component spacetime (*i.e.* the SST Higgs field plus SST-As), it is the fourth level of Nature. The fifth level of Nature leads to new cosmology.

The SST spacetime

A unique theory of everything must be based on correct description of the internal structure of spacetime. SST starts from the simplest physical scenery. Just superluminal pieces of space without internal structure (the (SST) tachyons) are moving in truly empty volume and interact due to the simplest interaction, *i.e.* the viscid force that is a result of smoothness of surfaces of the tachyons. All physical objects, particles and fields consist of free tachyons (the SST Higgs field) and pairs of closed strings (entanglons) that are made of adjacent tachyons. The superluminal entanglons are responsible for the quantum entanglement, to determine their properties we apply the classical thermodynamics to the initial inflation field composed of tachyons packed to maximum.

To explain the matter-antimatter asymmetry we assume that the initial inflation field, before some collision, had the left-handed external helicity.

Generally, the superluminal entanglons are frozen inside the neutrinos and the neutrino-antineutrino pairs, so we have the two-component spacetime that is a mixture of locality (the neutrino-antineutrino pairs and neutrinos) and nonlocality (the tachyons and entanglons).

The entanglons and their associations (it is due to the direct interactions of the entanglons with the SST Higgs field) can be exchanged between neutrinos and their pairs, so the neutrinos and their pairs can be entangled or confined.

The ratio of the non-gravitating energy of the superluminal entanglons frozen inside a neutrino to its gravitating mass is $\sim 0.6 \times 10^{119}$, so it explains why the tremendous zero-point energy that results from the quantum field theory does not lead to a big cosmological constant.

Due to the left-handedness of the initial inflation field, the closed strings in entanglons have both the toroidal and poloidal velocities, so they have the internal helicity. Due to their tremendous internal energy, symmetry of Nature was not broken on such second level of Nature, *i.e.* of the field of entanglons, *i.e.* each entanglon contains both the internally left-handed closed string and right-handed closed string.

Due to the viscid interactions, the SST Higgs field interacts with the entanglons the neutrinos consist of. In such a way, the neutrinos acquire their gravitational mass, there is produced a gradient/gravitational-field in the SST Higgs field. The superluminal motions of tachyons cause that such a gradient is "attached" to neutrino that is moving with speed $c \approx 3 \times 10^8\ \mathrm{m} \cdot \mathrm{s}^{-1}$.

We will show that the excited states of the SST two-component spacetime have 32 = 26 + 6 degrees of freedom, where 26 concerns the SST absolute spacetime (SST-As) composed of the neutrino-antineutrino pairs while 6 concerns the SST Higgs field. Among the first 32 natural numbers there are 11 prime numbers, so it is a good assumption that theory of everything should start from 11 initial parameters to describe mathematically coherently whole Nature. The initial parameters were fixed during the initial cosmological collision of two giant pieces of space and the turbulent inflation of the initial inflation field inside the other giant piece of space, so a coherent mathematical description of such a phenomenon via some differential equation is practically impossible. We can only partially describe some phase transitions during such violent inflation, and it is done in SST. It is the reason that SST starts with the two-component spacetime and eleven parameters. Then SST is the mathematically coherent theory.

SST, SM, GR and gravitational waves

Let us emphasize that the number of initial parameters used jointly in the Standard Model (SM) and General Relativity (GR) (notice that applied physical and mathematical constants are also the parameters) significantly exceeds the number of parameters used in SST. SST describes definitely more structures and phenomena than all other basic theories combined, and contains definitely fewer parameters, so it is the superior theory.

In SST, the SM concerns the quantum phenomena in the SST absolute spacetime while the GR gravitational fields concern the gradients produced in the SST Higgs field by neutrinos. Emphasize that we cannot separate the gradients/gravitational-fields from neutrinos, *i.e.* we cannot separate gravitational fields from masses. It causes that the orthodox gravitational wave is a flow of a part of the absolute spacetime (*i.e.* it is a matter flows) that carries a gradient/gravitational-field, it is the reason that the gradients/gravitational-fields travel at the speed c.

We cannot unify the gravitational fields and the SM fields because physical properties of the two components of the SST two-component spacetime are very different. We can only partially unify them by the viscid interactions of the SST Higgs field with the entanglons the neutrinos consist of.

The SST initial parameters

The 11 parameters applied in SST are as follows.

*Mean radius of the tachyons

$$r_t = 4.757105905231615 \times 10^{-65}\ \mathrm{m}.$$

*Mean linear speed of tachyons

$$v_t = 2.38634397 \times 10^{97}\ \mathrm{m \cdot s^{-1}},$$

*Mean spin speed on equator of tachyons

$$v_{st} = 1.725740638 \times 10^{70}\ \mathrm{m \cdot s^{-1}},$$

*Mean inertial mass of tachyons

$$m_t = 3.7526736431501 \times 10^{-107}\ \mathrm{kg}.$$

*Dynamic viscosity resulting from smoothness of surfaces of tachyons

$$\eta_t = 1.87516465 \times 10^{138}\ \mathrm{kg \cdot m^{-1} \cdot s^{-2}},$$

*The present-day mean inertial mass density of the SST Higgs field

$$\rho_{Hf} = 2.645954 \times 10^{-15}\ \mathrm{kg \cdot m^{-3}}.$$

*Mean gravitational mass density of the SST absolute spacetime

$$\rho_{As} = 1.1022013011 \times 10^{28}\ \text{kg} \cdot \text{m}^{-3}.$$

*Mass of the lightest non-rotating-spin neutrino

$$m_{Neutrino} = 3.3349269504 \times 10^{-67}\ \text{kg}.$$

Mass of the local zero-energy field around a neutrino depends on frequency of its spin rotation so measured masses of neutrinos can be even tens of orders of magnitude higher than of the non-rotating-spin neutrinos.

*Elementary electric charge (it is defined in the SI; in the SST, it depends on the invariant number of lines of electric forces produced by the SST-As components the different tori/electric-charges or loops/electric-charges are built of)

$$e^{\pm} = 1.602176634 \times 10^{-19}\ \text{C}.$$

*Mass density of the absolute-spacetime condensates (it is due to the range of the SST volumetric Higgs potential for the SST-As components)

$$\rho_{Y} = 2.7306383581 \times 10^{23}\ \text{kg} \cdot \text{m}^{-3}.$$

*Mass of the electron

$$m_e = 0.510998946\ \text{MeV}.$$

The three fundamental equations

In SST is valid the saturation symmetry. It follows from collisions of the free and bound tachyons. Consider an object composed of four parts each composed of four elements. Then three elements of each part are exchanged between a part and the three other parts while the fourth element represents the part. We see that if a smaller object contains N elements then the next bigger one contains N^2 elements.

The initial inflation field had the left-handed external helicity, so during the inflation appeared objects that must have internal helicity. The tori and loops are the simplest objects that can have internal helicity.

Assume that the closed string is composed of K^2 adjoining tachyons (the square of the K means that calculations are far simpler). The saturation symmetry causes that the tori created during the succeeding phase transitions of the Higgs field should contain K^2, K^4, K^8, K^{16} tachyons (the K^{16} tachyons is the upper limit that follows from the size of our Cosmos). The mass of the tori are directly proportional to the number of closed strings. This means that the stable objects contain the following number of closed strings: K^0, K^2, K^6, K^{14}, and means that the mass of the stable objects are directly proportional to $K^{2(d-1)}$, where $d = 1$ for closed strings, $d = 2$ for the torus of the lightest neutrinos (it consists of the entanglons), $d = 4$ for the torus inside the core of baryons (it consists of the neutrino-antineutrino pairs), and $d = 8$ for a cosmological torus (in the core of the Protoworld) which consisted of the DM particles, their masses were the same as the core of baryons. The early Universe (its baryonic part) arose inside the Protoworld as the double cosmic loop composed of the neutron black holes (NBHs) grouped in protogalaxies. The evolution of the Protoworld leads to the dark matter, dark energy, and to the expanding Universe.

The radii of the tori are

$$r_d = r_1 K^{d-1}, \tag{1}$$

whereas the rest masses of the tori are

$$m_d = m_1 K^{2(d-1)}, \tag{2}$$

where r_1 and m_1 are for the closed string.

On equator of the core of baryons, there appear virtual bosons that to equalize their number density in spacetime are emitted. Assume that the radius of the equator of the core of baryons is A, and that the range of a virtual boson is B. At distance $A + B$ there is symmetrical decay of the virtual boson to two identical parts. One part is moving towards the equator whereas the second one is moving in the opposite direction. It means that in the place of decay, in the field surrounding the core, there is produced a "hole". When the first part reaches the equator then the second one stops and decays to two identical parts, it takes place in distance $A + 2B$. In the place of decay is created "hole" in the zero-energy field. The next decay takes place in distance $A + 4B$. A statistical distribution of the "holes" in the field (of the circular tunnels in the field) in the plane of the equator is defined by following formula

$$R_d = A + dB, \tag{3}$$

where R_d denotes the radii of the circular tunnels, the A denotes the external/equatorial radius of the torus/core, $d = 0,1,2,4$ are the Titius-Bode (TB) numbers, B denotes the distance between the second tunnel ($d = 1$) and the first tunnel ($d = 0$). The first tunnel is in contact with the equator of the torus. Formula (3) is the Titius-Bode (TB) law for the nuclear strong interactions.

The gluon loop which overlaps with the circular axis of the torus (Figure 1) in the core of baryons, we will call the fundamental gluon loop (FGL), from Figure 1 we have that its radius is $R_{FGL} = \frac{2A}{3}$.

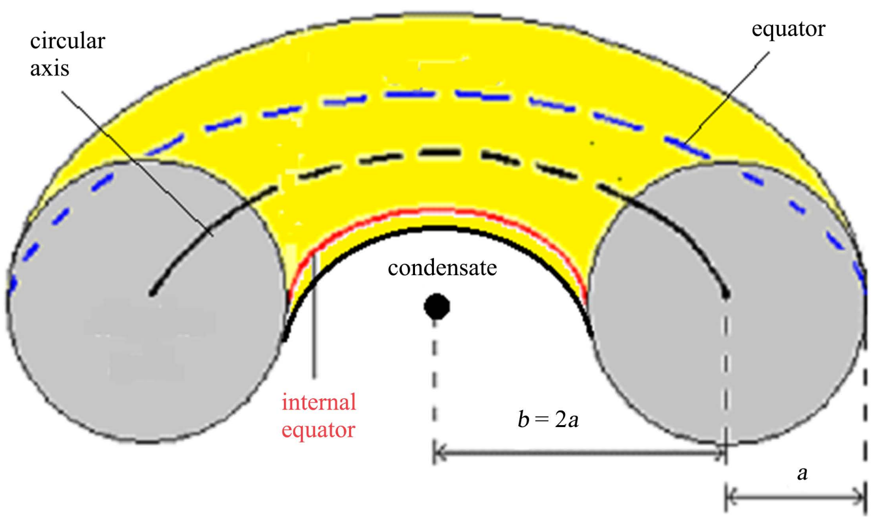

Figure 1. Stable cores of fermions.

The spin-$\frac{1}{2}$ tori are most stable when $b = 2a$ (see **Figure 1**) because then the distance between points in the same state on the torus in the plane of the equator is $4a = \lambda$, where λ is the classical radius of a fermion (it is the $\frac{4}{3}$ of the quantum radius). Then the maximal changes in amplitude of the standing wave coincide with the center of the condensate and a point on the circular axis of the torus, while its three nodes are placed on the torus. The spin speed on the equator is c so the mean spin speed of the torus is $\frac{2c}{3}$, it forces the radial and poloidal motions of the SST-As components so there appears the spin-0 condensate in the center of the torus. Mean radius of the tori is the $\frac{2}{3}$ of their equatorial radius.

Circumference and radius of FGL determine the maximum range of the nuclear strong interactions in baryons. We will show that the $d = 4$ in Formula (3) defines the radius of the last TB orbit.

Classical thermodynamics of the closed strings, phase transitions of inflation field, and physical constants

The definition of the Reynolds number N_R for the SST Higgs field with tachyons packed to maximum looks as follows

$$N_R = \frac{\rho_t v_t (2r_t)}{\eta_t} = 1.007604688 \times 10^{-19}. \quad (4)$$

where ρ_t is the inertial-mass density of single tachyon

$$\rho_t = \frac{m_t}{\frac{4\pi r_t^3}{3}} = 8.321923662 \times 10^{85}\ \text{kg} \cdot \text{m}^{-3}. \quad (5)$$

The radius of closed string which can be produced due to the value of the Reynolds number is (it consists of tachyons which are in direct contact)

$$r_1 = \frac{2r_t}{N_R} = 0.9442405262 \times 10^{-45}\ \text{m}. \quad (6)$$

We can calculate the number of tachyons, K^2, a closed string consists of

$$K^2 = \frac{2\pi r_1}{2r_t} = \left(0.7896685548 \times 10^{10}\right)^2. \quad (7)$$

The spin of each closed string is half-integral while of the entanglons is 1

$$\frac{h}{2\pi} = h = 2K^2 m_t v_t r_1 = 1.054571818 \times 10^{-34}\ \text{J} \cdot \text{s}. \quad (8)$$

The Planck constant, h, is

$$h = 4\pi K^2 m_t v_t r_1 = 6.6260701500004 \times 10^{-34}\ \text{J} \cdot \text{s}.$$

Due to the International System of Units (SI), since 2019, the Planck constant is not measured (it is defined as follows: $h = 6.62607015 \times 10^{-34}\ \text{J} \cdot \text{s}$). We can see that our calculated value of the h is consistent with the SI definition for the first

13 digits. Such high accuracy is enough to compare the SST results with experimental results.

We can express the h by only the initial parameters

$$h = \frac{16\pi^4}{9}\frac{\eta_t^2 r_t^5}{v_t m_t} = 6.626070150 \times 10^{-34}\ \text{J} \cdot \text{s} .$$

We see that the Planck constant depends on four initial parameters: $h = f\left(\eta_t, r_t, v_t, m_t\right)$. Why the spins of particles are the same in all inertial frames? It follows from the fact that the invariant viscosity of the tachyons, η_t, fixes their speed v_t in relation to an inertial frame with which a particle composed of tachyons interacts, there must be the quantum entanglement between the particle and the inertial frame.

Spins of all objects defined by Formulaes (1) and (2) are half-integral so from definition of spin

$$Spin = MvR \tag{9}$$

we can calculate the speed of light in "vacuum" c

$$c = \frac{3\hbar}{4m_4 r_4} = \frac{3\hbar}{4m_t r_1 K^{11}} = 299792458.000\ \text{m} \cdot \text{s}^{-1} . \tag{10}$$

Such high accuracy of the c is enough to compare the SST results with experimental results as well.

We can express the c by only the initial parameters

$$c = \frac{3v_t}{2}\left(\frac{3v_t m_t}{4\pi^2 \eta_t r_t^2}\right)^{\frac{9}{2}} = 299792458\ \text{m} \cdot \text{s}^{-1} .$$

We see that the speed of light in "vacuum" also depends on four initial parameters: $c = f\left(\eta_t, r_t, v_t, m_t\right)$. Why the c is the same in all inertial frames? It follows from the fact that the invariant viscosity of the tachyons, η_t, fixes their speed v_t in relation to an inertial frame with which a particle composed of tachyons interacts, there must be the quantum entanglement between a neutrino or photon or gluon and the inertial frame.

Mass of the superluminal closed string is

$$m_1 = m_t K^2 = 2.340078820 \times 10^{-87}\ \text{kg} . \tag{11}$$

Speed of the closed string is

$$v_1 = \frac{3\hbar}{4m_t r_1 K^5} = 0.7269252749 \times 10^{68}\ \text{m} \cdot \text{s}^{-1} . \tag{12}$$

We can calculate the factor which changes kg into MeV

$$F = \frac{10^6 e}{c^2} = 1.782661922 \times 10^{-30}\ \text{kg} \cdot \text{MeV}^{-1} . \tag{13}$$

Mass of the torus/electric-charge in the core of baryons is

$$X^{\pm} = \frac{m_4}{F} = \frac{m_1 K^6}{F} = 318.2955481\ \text{MeV} . \tag{14}$$

The ratio of the masses of the lightest neutrino, $m_{Neutrino}$, and its torus, m_2, and the ratio of the masses of the electrically charged core of baryons, $H^{\pm}$, and its torus, $X^{\pm}$, and the ratio of the masses of the core of the Protoworld, $M_{Pw,core}$, and its torus, $M_{Pw,torus}$, are the same so we have

$$H^{\pm} = \frac{X^{\pm} m_{Neutrino}}{m_2} = 727.4392245 \text{ MeV}, \tag{15}$$

where

$$m_2 = m_1 K^2 = 1.459217988 \times 10^{-67} \text{ kg}. \tag{16}$$

The equatorial radius of the lightest neutrinos is

$$r_{neutrino} = \frac{3 r_1 K}{2} = \frac{A}{K^2} = 1.118455577 \times 10^{-35} \text{ m}, \tag{17}$$

where A is the equatorial radius of the torus/electric-charge in the core of baryons

$$A = \frac{3 r_4}{2} = \frac{3 r_1 K^3}{2} = 0.6974425321 \text{ fm}. \tag{18}$$

By an analogy, the core of the cosmological Protoworld, *i.e.* the cosmological torus and its central condensate, should be built of the cores of baryons. But the cores of baryons are the SST black holes in respect of the nuclear strong interactions, so they capture relativistic pion which is in the $d = 1$ state, it is because such TB orbit is below the Schwarzschild surface for the nuclear strong interactions. Masses of nucleons do not satisfy the Formulaes (1) and (2). We need a stable particle with a mass equal to $H^{\pm}$. Consider a torus composed of K^2 entangled loops each composed of K^2 entangled lightest neutrinos with spins tangent to the loops, we will call such a torus and such a loop the dark-matter (DM) objects because due to the orientations of the spins of neutrinos, they cannot interact electromagnetically. Then the shortest-distance quantum entanglement causes that two nearest neutrinos in a loop are in distance equal to

$$L_{Neutrinos} = \frac{2\pi r_{neutrino}}{3}. \tag{19}$$

Such distance results from the geometry of the torus of lightest neutrino.

We assume that the distance between neutrinos in the nearest loops on the equator of the DM torus is also defined by the geometry of the torus of lightest neutrinos, so it is

$$L_{Neutrinos,loops} = 2\pi r_{neutrino}. \tag{20}$$

The above remarks lead to a conclusion that the radius of a single DM loop is

$$R_{DM-loop} = \frac{K^2 L_{Neutrinos}}{2\pi} = \frac{K^2 r_{neutrino}}{3} = \frac{r_1 K^3}{2} = \frac{A}{3}. \tag{21}$$

On the other hand, the equatorial radius of the DM torus is

$$R_{DM-torus} = \frac{K^2 L_{Neutrinos,loops}}{2\pi} = K^2 r_{neutrino} = \frac{3 r_1 K^3}{2} = A. \tag{22}$$

We see that sizes of the DM torus are the same as of the torus/electric-charge in the core of baryons.

Mass of the DM loop is

$$M_{DM-loop} = K^2 m_{Neutrino} = 2.079581830 \times 10^{-47}\ \text{kg}. \tag{23}$$

$$M_{DM-loop} = 10^6 K^2 m_{Neutrino} / F = 1.166559853 \times 10^{-11}\ \text{eV}. \tag{24}$$

Mass of the DM torus is

$$M_{DM-torus} = K^4 m_{Neutrino} / F = H^{\pm} = 727.4392245\ \text{MeV}. \tag{25}$$

Emphasize that the masses of the charged core of baryons and the DM torus are the same, both tori have the same sizes, but in center of the DM torus is no spacetime condensate, and contrary to the core of baryons, the DM torus does not interact electromagnetically.

Ratio of masses of the charged core of baryons, $H^{\pm}$, and the charged torus/electric-charge, $X^{\pm}$, is

$$F_{H/X} = H^{\pm} / X^{\pm} = 2.285420669. \tag{26}$$

The Protoworld was the stable cosmological object because its core, *i.e.* the cosmological torus and the central condensate both were built of the binary systems of the DM tori.

Mass of the core of the Protoworld was

$$H^{+}_{Protoworld} = F_{H/X} m_1 K^{14} = 1.960760088 \times 10^{52}\ \text{kg}. \tag{27}$$

The equatorial radius of the core of the Protoworld was

$$A_{Protoworld} = \frac{3r_8}{2} = \frac{3r_1 K^7}{2} = 2.711988265 \times 10^{24}\ \text{m},$$

$$A_{Protoworld} = 286.6635076\ \text{million light-years}\left[\text{Mly}\right]. \tag{28}$$

The internal helicity of the closed string resulting from the infinitesimal spin of the tachyons and their viscosity means that the entanglons a neutrino consists of transform the chaotic motions of tachyons into divergently moving tachyons. The direct collisions of divergently moving tachyons with tachyons the SST Higgs field consists of produce a gradient in this field. The gravitational constant, G, results from behavior of all closed strings a neutrino consists of. Constants of interactions are directly proportional to the mass densities of fields carrying the interactions then the G we can calculate from following formula

$$G = g\rho_{Hf} = 6.674297784 \times 10^{-11}\ \text{m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}, \tag{29}$$

where the g has the same value for all interactions and is equal to (it depends on the tachyon spin speed and the viscosity of tachyon, both quantities are the invariants)

$$g = \frac{v_{st}^4}{\eta_t^2} = 25224.54201\ \text{m}^6 \cdot \text{kg}^{-2} \cdot \text{s}^{-2}. \tag{30}$$

Notice that curvature of the SST Higgs field produced by the entanglons is residual and has not spherical symmetry so such curvature does not relate to the G.

Emphasize that the Planck scale, *i.e.* the Planck length, Planck time, Planck mass and Planck energy density, are defined by the basic physical constants $\hbar$, c and G that are calculated in SST with perfect accuracy. But the Planck quantities are defined for an abstract cube so to obtain the real values for the Planck quantities we must take into account the shape and size of the lightest neutrino because the $\hbar/2$, c and G concern such object, it is the lightest object for which the gravitational and inertial masses are the same.

Dynamics of the core of baryons

The virtual or real fundamental gluon loop (FGL) is created on the circular axis (**Figure 1**) of the torus/electric-charge in the core of baryons (they initially overlap) from the SST-As components. Masses of spinning virtual objects can be calculated from the definition

$$ET_{Period} = \hbar\,, \tag{31}$$

where $E = mc^2$.

Mass of the resting FGL is

$$m_{FGL} = \frac{3h}{4\pi AcF} = 67.54441313\ \text{MeV}\,. \tag{32}$$

The central condensate, Y, is created due to the transition of the FGL from its circumference to its radius so the mass increases 2π times (or in circumference-diameter transition of $2m_{FGL}$). In such a process is emitted energy/mass defined by the Stefan-Boltzmann law. From the Wien's displacement law follows that temperature is inversely proportional to radius so the emitted energy is directly proportional to $(2\pi)^{-4}$, so we have

$$Y = 2\pi m_{FGL}\left(1-(2\pi)^{-4}\right) = 424.1217628\ \text{MeV}\,. \tag{33}$$

The condensate Y is the SST black hole for the nuclear weak interactions so the spin speed on its surface is c.

The number of the neutrino-antineutrino pairs, N_{NA}, on the torus in the core of a baryon is

$$N_{NA} = \frac{X^{\pm}F}{2m_{Neutrino}} = 8.507133168\times10^{38}\,. \tag{34}$$

Mean distance, L_{NA}, of the neutrino-antineutrino pairs on the torus in the core of a baryon is

$$L_{NA} = \left(\frac{8\pi^2A^2}{9N_{NA}}\right)^{\frac{1}{2}} = 7.082562641\times10^{-35}\ \text{m}\,. \tag{35}$$

Notice that surface density of the torus in the core of baryons is about 300,000 times higher than in SST-As, it is very important in the theory of the neutron black holes.

Mean distance, L_{As}, of the neutrino-antineutrino pairs in the SST-As is

$$L_{As} = \left(\frac{2m_{Neutrino}}{\rho_{As}} \right)^{\frac{1}{3}} = 3.926013608 \times 10^{-32}\ \text{m} = 3510.209692 r_{neutrino}. \quad (36)$$

Structure of the bare electron and the electromagnetic interactions

The ratio, N^*, of the mean distances is

$$N^* = \frac{L_{As}}{L_{NA}} = 554.3210568. \quad (37)$$

It characterizes the projection of the proton electric charge on the SST absolute spacetime. We can say that it relates the effective distances between the As components on the torus/electric-charge of proton with distances between the As components in the SST absolute spacetime. But the real distances between the As components on the proton torus are $2\pi r_{neutrino}$. Effective distances are bigger because some of the As components change places to keep the torus stable. It leads to conclusion that the As components in the electron loop that represents the mass of the electric charge of the bare electron are in distances equal to $L_{e,bare} = 2\pi r_{neutrino} N^*$

$$L_{e,bare} = 2\pi r_{neutrino} N^* = 3482.901919 r_{neutrino}. \quad (38)$$

Due to the adaptation symmetry, the bare-electron loop consists of K^2 the SST-absolute-spacetime components. Then radius of such loop, $\lambda_{e,bare}$, is

$$\lambda_{e,bare} = \frac{K^2 L_{e,bare}}{2\pi} = 3.866070814 \times 10^{-13}\ \text{m}. \quad (39)$$

It is the Compton length, $\lambda_{e,bare}$, of the bare electron and we can calculate it also from following formula

$$\lambda_{e,bare} = AN^* = 3.866070814 \times 10^{-13}\ \text{m}. \quad (40)$$

It is very difficult to detect the bare-electron loop because distances of the As components in it are close to the distances in the absolute spacetime. Moreover, it is the quantum object so there is a distribution of it in whole spacetime.

The bare mass of electron is

$$m_{e,bare} = \frac{\hbar}{c\lambda_{e,bare}} = 9.098832150 \times 10^{-31}\ \text{kg}, \quad (41)$$

$$m_{e,bare} = \frac{\hbar}{c\lambda_{e,bare} F} = 0.5104070514\ \text{MeV}. \quad (42)$$

Spin of the bare-electron loop should be half-integral and it is (in our model of the electron, mass of the bare-electron loop is equal to mass of the central spacetime condensate)

$$\frac{m_{e,bare} F}{2} c\lambda_{e,bare} = \frac{\hbar}{2}. \quad (43)$$

On comparing the two definitions of the fine-structure constant for low energies, α_{em}, we arrive at the relation

$$\frac{ke^2}{\hbar c} = \frac{G_{em} m_e^2}{\hbar c}, \tag{44}$$

where $k = \frac{c^2 \mu_o}{4\pi}$ whereas the electromagnetic constant at low energy, G_{em}, is

$$G_{em} = G \frac{\rho_{As}}{\rho_{Hf}} = 2.780252303 \times 10^{32}\ \text{m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}. \tag{45}$$

Emphasize that since 2019 the magnetic constant (permeability in vacuum), μ_o, is the measured quantity.

From Formulaes (44) and (45), we can calculate the magnetic constant

$$\mu_o = \frac{4\pi G_{em} m_e^2 F^2}{c^2 e^2} = 1.256637062 \times 10^{-6}\ \text{H} \cdot \text{m}^{-1} = 4\pi (1.000000000538) \times 10^{-7}\ \text{H} \cdot \text{m}^{-1}. \tag{46}$$

The electric constant (vacuum permittivity) is

$$\varepsilon_o = \left(c^2 \mu_o\right)^{-1} = 8.854187813 \times 10^{-12}\ \text{F} \cdot \text{m}^{-1}. \tag{47}$$

The fine-structure constant at low energy

The fine-structure constant, α_{em}, is

$$\alpha_{em}^{-1} = \frac{2h}{e^2 c \mu_o} = 137.035999085. \tag{48}$$

Notice that the ratio of masses of the electron and bare electron is

$$F_{1+a} = \frac{m_e}{m_{e,bare}} = 1.0011596521793 \approx 1.00115965218. \tag{49}$$

We later will calculate the anomalous magnetic moment from our model of electron, *i.e.* there is only one virtual electron-positron pair outside the bare electron (it is the bare-electron loop, torus/electric-charge and the central space-time condensate).

We can assume that the ratio $\frac{L_{NA}}{2\pi r_{neutrino}} = 1.007840523$ defines the electro-magnetic coupling constant at high energy

$$\frac{L_{NA}}{2\pi r_{neutrino}} = 1 + \alpha_{em,high}, \tag{50}$$

so we have

$$\alpha_{em,high}^{-1} = 127.5425133. \tag{51}$$

This value corresponds to the minimum distance between the As components on the proton torus/electric-charge, *i.e.* to distance equal to $2\pi r_{neutrino}$.

Notice that there is satisfied following relation

$$\left(\frac{L_{As}}{L_{e,bare}}\right)^2 = \frac{X_{2\pi r}^{\pm}}{X^{\pm}} = 1.015742520, \tag{52}$$

where $X_{2\pi r}^{\pm}$ is an abstract mass of the torus/electric charge in which the As components occupy squares with the side equal to $2\pi r_{neutrino}$. For the torus $X_{2\pi r}^{\pm}$ we have

$$X_{2\pi r}^{\pm} = \frac{2}{9}\left(\frac{A}{r_{neutrino}}\right)^2 2\frac{m_{Neutrino}}{F} = 323.3063220 \text{ MeV}. \tag{53}$$

We see that because mass $M \sim L^{-2}$ so when L_{As} leads to $X^{\pm}$ then $L_{e,bare}$ leads to $X_{2\pi r}^{\pm}$.

***The other coupling constants and masses of pions**

The ratio of the binding energy of two FGLs, ΔE_{FGL} (it results from creations of the virtual electron-positron pairs), to the mass of FGL, m_{FGL}, is (energy is inversely proportional to a length, and m_{FGL} is associated with A while ΔE_{FGL} with $\lambda\!\!\!^{-}_{e,bare}$)

$$\frac{\Delta E_{FGL}}{m_{FGL}} = \frac{A}{\lambda\!\!\!^{-}_{e,bare}}. \tag{54}$$

From this formula we obtain $\Delta E_{FGL} = 0.1218507078 \text{ MeV}$.

During creation of the bound neutral pion from two fundamental gluon loops, due to the electromagnetic interactions, there is released additional energy equal to $\alpha_{em}\Delta E_{FGL}$. The total binding energy of the bound neutral pion is

$$\Delta E_{pion(o),bound} = \Delta E_{FGL}\left(1+\alpha_{em}\right) = 0.1227398954 \text{ MeV}. \tag{55}$$

The mass of bound neutral pion

This means that the mass of bound neutral pion (*i.e.* placed in nuclear strong field) is

$$\pi^{o}_{bound} = 2m_{FGL} - \Delta E_{pion(o),bound} = 134.9660864 \text{ MeV}. \tag{56}$$

Assume that the virtual Y spacetime condensates appear on the equator of the core of baryons in such a way that they are tangent to the equator. The spin speed on the equator is c so spin speed for the effective radius of the $d = 0$ state (the effective radius is $A + r_{C(p)}$, where $r_{C(p)}$ is the radius of the central spacetime condensate) is (radius is inversely proportional to squared spin speed)

$$\frac{A + r_{C(p)}}{A} = \left(\frac{c}{v_{d=0}}\right)^2. \tag{57}$$

The $r_{C(p)}$ we can calculate from following formula

$$\frac{4\pi r_{C(p)}^3}{3} = \frac{YF}{\rho_Y}, \tag{58}$$

so we have

$$r_{C(p)} = 0.8711018109 \times 10^{-17} \text{ m}. \tag{59}$$

From (57) we obtain

$$v_{d=0} = 0.9938129253c. \tag{60}$$

From the Einstein formula for relativistic mass we obtain that in the $d = 0$ state, the ratio of the relativistic mass and rest mass is

$$\frac{M_{Rel}}{M_o} = \left(1 - \frac{A}{A + r_{C(p)}}\right)^{-\frac{1}{2}} = 9.003577665. \quad (61)$$

The mass of charged pion

Assume that the charged pion, $\pi^{\pm}$, is created due to emission of the two bare electrons and two bare positrons (the 4-particle symmetry) by Y or by the precursor of Y, *i.e.* by $2\pi m_{FGL}$. Then one of the electrons appears in the $d^* = 0$ state (its radius is smaller than $r_{C(p)}$ because of the emission of the quadrupole) and is absorbed by the bound neutral pion. Mean mass of the spacetime condensate is

$$Y_{Mean} = \frac{\left(Y - 4m_{e,bare}\right) + \left(2\pi m_{FGL} - 4m_{e,bare}\right)}{2}. \quad (62)$$

From (58) we calculate the new radius of the spacetime condensate $r^*_{C(p)}$ and then from (61) we calculate the relativistic mass of the electron

$$m_{e,rel} = 9.010253908 m_e. \quad (63)$$

The mass of charged pion $\pi^{\pm}$ is

$$\pi^{\pm} = \pi^o_{bound} + m_{e,rel} = 139.5703166\ \text{MeV}. \quad (64)$$

Masses of bound charged pion and free charged pion are the same.

We very frequently will use the mass distance between the charged pion and the bound neutral pion

$$\Delta\pi = \pi^{\pm} - \pi^o_{bound} = 4.604230250\ \text{MeV}. \quad (65)$$

The Y is responsible for the nuclear weak interactions and it is the SST nuclear-weak black hole so we have

$$r_{C(p)} = \frac{G_w Y F}{c^2}. \quad (66)$$

From (66) we obtain value of the constant of the weak interactions, G_w, for baryons

$$G_w = \frac{r_{C(p)} c^2}{YF} = 1.035502479 \times 10^{27}\ \text{m}^3 \cdot \text{kg}^{-1} \cdot \text{s}^{-2}. \quad (67)$$

The invariant coupling constant for the nuclear weak interactions

The characteristic feature of the nuclear weak interactions is that Y is both the source and the carrier of interactions so from the definition of the coupling constants is

$$\alpha_{w(p)} = \frac{G_w (YF)^2}{c\hbar} = 0.01872289510, \quad (68)$$

where $\alpha_{w(p)}$ is the coupling constant for the nuclear weak interactions.

The invariant coupling constant for the weak interactions of electrons in absence of dark matter

Mass of the condensate in the center of electron is a half of its bare mass so it is $N_{Y/m(e)-bare}$ times lower than Y

$$N_{Y/m(e)-bare} = \frac{Y}{\frac{m_{e,bare}}{2}} = 1661.896173 . \quad (69)$$

The ratio, $N_{p/e}$, of the radii of the Y and the condensate in electron is

$$N_{p/e} = \frac{r_{C(p)}}{r_{C(e)}} = \left(\frac{Y}{\frac{m_{e,bare}}{2}} \right)^{\frac{1}{3}} = 11.84498811 . \quad (70)$$

Then

$$r_{C(e)} = 0.7354180540 \times 10^{-18} \text{ m} . \quad (71)$$

From Formulaes (67) and (68) results that the ratio of the coupling constants is directly proportional to both the ratio of masses of the condensates and the ratio of their radii, so the coupling constant of the weak interactions of the electron and positron is

$$\alpha_{w(e)} = \frac{\alpha_{w(p)}}{N_{Y/m(e)-bare} N_{p/e}} = 0.9511181887 \times 10^{-6} . \quad (72)$$

The invariant coupling constant for the weak interactions of electrons in presence of dark matter

Electron is a pure quantum particle because its torus/electric-charge and the bare-electron loop behave as a virtual particle. We cannot say it about the torus/electric-charge inside the core of baryons because its surface density is about 300,000 times higher than in the SST absolute spacetime. Such scenario causes that an electron disappears in one place and appears in another one, and so on. It causes that outside hadrons we must take into account the dark matter. From observational data we know that density of dark matter is about 5.4 times higher than the baryonic matter. On the other hand, in SST is assumed that the baryonic matter of our Universe appeared similarly to the two fundamental gluon loops (it leads to the bound neutral pion) in the core of baryons, there were two cosmological loops overlapping with the circular axis of the core of the Protoworld. Each loop was composed of the protogalaxies built of the neutron black holes (NBHs). These remarks lead to the ratio, ξ^*, of the total mass of dark matter, $M_{Pw,core}$, to the baryonic mass of the Universe, $M_{Baryonic}$

$$\xi^* = \frac{M_{Pw,core}}{M_{Baryonic}} = \frac{H^{\pm}}{2m_{FGL}} = 5.384895589 . \quad (73)$$

The Formula (73) concerns a binary system such as, for example, two gluon loops or the electron-positron pair. For a single electron is

$$\xi = 2\xi^* = \frac{H^{\pm}}{m_{FGL}} = 10.76979118 . \quad (74)$$

Coupling constants, α_i, are directly proportional to constants of interaction, G_i, and G_i are directly proportional to densities of fields, so for an electron in presence of dark matter we have

$$\alpha'_{w(e),DM} = \alpha_{w(e)} (1+\xi) = 1.119446247 \times 10^{-5} . \tag{75}$$

Constants of interactions, G_i, are directly proportional to the inertial mass densities of fields carrying the interactions. The following formula defines the coupling constants of all interactions

$$\alpha_i = \frac{G_i M_i m_i}{c\hbar} = \frac{v_{spin}^2 r m_i}{c\hbar} = \frac{v_{spin}}{c} , \tag{76}$$

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

The coupling constant for the nuclear strong interactions inside hadrons at low energy

The FGL is responsible for the nuclear strong interactions in hadrons. At low energy, the spin speed of the FGL is $v_{spin} = c$ so at low energy, the coupling constant for the nuclear strong interactions inside hadrons is

$$\alpha_s = 1 . \tag{77}$$

The mass of neutral pion (free)

The ratio of the densities of the absolute spacetime and the spacetime condensates is

$$f = \frac{\rho_{As}}{\rho_Y} = 40,364.23563 . \tag{78}$$

Calculate mass m_C that relates to ρ_Y when ρ_{As} relates to the strong-electroweak mass of FGL transiting to its radius

$$m_C = \frac{2\pi m_{FGL} \left(\alpha_s + \alpha_{w(p)} + \alpha_{em} \right)}{f} = 0.01078769103 \text{ MeV} . \tag{79}$$

Mass of the neutral pion is the sum of masses of the bound neutral pion and the m_C

$$\pi^o = \pi^o_{bound} + m_C = 134.9768740 \text{ MeV} . \tag{80}$$

Some resonances with energy close to m_C can be produced due to other paths of interactions, for example, due to the 4-particle symmetry and the transition from the nuclear weak interactions to the weak interactions of the electrons, the Y condensate can produce two the bound neutral pions (*i.e.* 4 FGLs) and a transition energy that is a binary system. Then the correction mass is

$$m_C^* = \frac{Y}{2} \frac{\alpha_{w(e)}}{\alpha_{w(p)}} = 0.01077264 \text{ MeV} , \text{ so } \pi^o = 134.9768590 \text{ MeV} .$$

$$\Delta\pi^* = \pi^{\pm} - \pi^o = 4.593442559 \text{ MeV} . \tag{81}$$

The ratio of the coupling constant for the nuclear weak interactions to the coupling constant for the weak interactions of electrons is

$$X_{w(p/e)} = \frac{\alpha_{w(p)}}{\alpha_{w(e)}} = 19685.14042\,. \tag{82}$$

The coupling constant for the nuclear strong interactions outside baryons at low energy

We know that the bound neutral pion is a binary system of FGLs composed of the rotating-spin-1 neutrino-antineutrino pairs (the SST-As components). This means that inside the bound neutral pion, the SST-As components are exchanged whereas between the bound neutral pions the FGLs are exchanged. We can neglect the mass of the SST-As components in comparison to the mass of the neutral pion. On the other hand, from (76) it follows that coupling constant for the FGL is unitary because its spin speed, v_{spin}, is equal to the *c*. For strongly interacting bound neutral pion is

$$\alpha_s^{\pi\pi,FGL} = \alpha_s = \frac{G_s\left(2\pi^o_{bound}\right)m_{FGL}F^2}{c\hbar} = \frac{v_{spin}}{c} = 1\,. \tag{83}$$

Then the constant of the strong interactions is $G_s = 5.456508113\times10^{29}\ \mathrm{m^3\cdot s^{-2}\cdot kg^{-1}}$.

Coupling constant for strongly interacting proton at low energies is

$$\alpha_s^{pp,\pi} = \frac{G_s\left(2p + m_{FGL}\right)\pi^o_{bound}F^2}{ch} = 14.39118713\,. \tag{84}$$

In (84), the FGL is exchanged between the cores of the protons so it is a part of the $2p$ system. On the other hand, the bound neutral pion is the exchanged peripheral object.

In a relativistic version, the G_s is invariant. When we accelerate a baryon, then there decreases the spin speed of FGL so its energy (so also of pions) decreases as well

$$\frac{E_{Loop}2\pi r_{loop}}{v_{spin}} = \hbar\,. \tag{85}$$

This condition leads to the conclusion that the value of the strong coupling decreases when energy increases, *i.e.* it is the running coupling constant for the nuclear strong interactions. But this is not the subject of consideration in this paper.

Energy frozen inside the SST-absolute-spacetime components

The SST-As consists of the non-rotating-spin-1 neutrino-antineutrino pairs. Gravitational energy of a single lightest neutrino is

$$E_G = m_{Neutrino}c^2\,. \tag{86}$$

On the other hand, the not observed non-gravitating superluminal energy of the entanglons the lightest neutrino consists of is

$$E_S = m_{Neutrino}v_1^2\,. \tag{87}$$

The ratio of these energies is

$$\frac{E_S}{E_G} = \left(\frac{v_1}{c}\right)^2 \approx 0.6 \times 10^{119} . \tag{88}$$

We see that inside the SST-As is frozen tremendous amount of unobserved energy about 0.6×10^{119} parts per 1 part of the observed gravitating energy.

The atom-like structure of baryons at low energy

Hyperons arise very quickly because of the nuclear strong interactions. Due to the electroweak interactions, they decay slowly on the TB orbits (in the "tunnels" in the SST-As).

The relativistic pions in the tunnels "circulate" the torus (they are the S states *i.e.* $l = 0$). Such pions we refer to as $W_{(+-o),d}$ pions because they are associated with the strong-electro Weak interactions.

The distance B we can calculate on the condition that the relativistic charged pion in the d = 1 state, which is responsible for the properties of nucleons, should have unitary angular momentum (this state is the ground state for the $W_{(+-o),d}$ pions)

$$W_{(+-),d=1} (A + B) v_{d=1} = \hbar , \tag{89}$$

where $v_{d=1}$ denotes the orbital speed of the $W_{(+-),d=1}$ pion in the d = 1 state.

We can calculate the relativistic mass of the $W_{(+-o),d}$ pions using Einstein's formula

$$W_{(+-o),d} = \pi^{\pm o}_{bound} \left(1 - \frac{v_d^2}{c^2}\right)^{-\frac{1}{2}} . \tag{90}$$

For the SST black holes, the square of the orbital speed is inversely proportional to the radius R_d and for A we have c^2 so we have

$$\left(\frac{v_{d=1}}{c}\right)^2 = \frac{A}{A + B} . \tag{91}$$

From (90) and (91) is

$$W_{(+-o),d} = \pi^{\pm o}_{bound} \left(1 + \frac{A}{dB}\right)^{\frac{1}{2}} . \tag{92}$$

The Formulaes (89)-(92) give two solutions for the B. The first solution is

$$B = 0.5018354435 \text{ fm} . \tag{93}$$

Then

$$\frac{A}{B} = 1.389783327 . \tag{94}$$

The second solution is $B^* = 0.9692940024 \text{ fm}$ but this solution is not realized by Nature. It follows from the fact that after creation of a baryon, inside the core dominates the nuclear weak interaction defined by $\alpha_{w(p)}$ while outside it there dominates the electroweak interaction defined by $\alpha_{em} + \alpha_{w(p)}$. There can be also the electroweak interactions of the virtual quark-antiquark pairs and of the virtual electron-positron pairs defined by $2\alpha_{w(e)}$. We know that coupling constant is directly proportional to exchanged mass while the mass is inversely proportional to its range so we have

$$\left(\frac{A}{B}\right)_{\alpha}=\frac{\alpha_{em}+\alpha_{w(p)}}{\alpha_{w(p)}}\approx 1.38976 . \tag{95}$$

This value is very close to (94).

The A/B^{*} differs very much from (95) so the value B^{*} is not realized in baryons.

Creation of a resonance is possible when gluon loops overlap with the tunnels. Such bosons we call $S_{(+-o),d}$ bosons because they are associated with the nuclear Strong interactions. The spin speeds of the $S_{(+-o),d}$ bosons (they are equal to the *c*) differ from the speeds calculated on the basis of the Titius-Bode law for the strong interactions.

The masses of the charged and neutral core of resting baryons are denoted by $H^{\pm o}$. The maximum mass of a virtual $S_{(+-o),d}$ boson cannot be greater than the mass of the core so we assume that the mass of the $S_{(+-o),d}$ boson, created in the $d = 0$ tunnel, is equal to the mass of the core. As we know, the ranges of virtual particles are inversely proportional to their mass. As a result, we obtain

$$H^{\pm o}A=S_{(+-o),d}\left(A+dB\right). \tag{96}$$

There is some probability that a virtual $S_{(+-o),d}$ boson arising in the $d = 0$ tunnel decays to two parts. One part covers the distance A whereas the remainder covers the distance $4B$.

Notice that there is

$$\frac{4\pi^{o}_{bound}}{H^{\pm}-4\pi^{o}_{bound}}=\frac{4B}{A}\approx 2.8781 , \tag{97}$$

so for the remainder we have

$$S_{(+-),d=4}=H^{\pm}-4\pi^{o}_{bound} . \tag{98}$$

The nucleons and pions are respectively the lightest baryons and mesons interacting strongly, so there should be some analogy between the carrier of the electric charge interacting with the core of baryons (it is the mass distance between the charged and neutral core) and the carrier of an electric charge interacting with the charged pion (this is the electron). It leads to following formula

$$\frac{H^{\pm}-H^{o}}{H^{\pm}}=\frac{m_e}{\pi^{\pm}} . \tag{99}$$

From (99) we obtain

$$H^{o}=724.7759027\text{ MeV} . \tag{100}$$

The mass distance $\Delta H=H^{\pm}-H^{o}$ is

$$\Delta H=H^{\pm}-H^{o}=2.663321873\text{ MeV} . \tag{101}$$

For electron (plus electron antineutrino) placed on the circular axis of the core (*i.e.* the center of the electron condensate is placed on this axis) we obtain that the electromagnetic binding energy is

$$\Delta E_{em} = \frac{3ke^2}{2Ac^2F} = 3.09695311\text{ MeV}. \quad (102)$$

The results are collected in **Table 1** (the masses are provided in MeV).

The binding energy of the core of baryons is

$$\Delta E_{core} = X^{\pm} + Y - H^{\pm} = 14.97808631\text{ MeV}. \quad (103)$$

There is the four-object symmetry so the symmetrical decays of a virtual boson with a mass four times higher than the remainder

$$M_{TB} = M_4 = 4S_{(+-),d=4} = 750.2957682\text{ MeV} \quad (104)$$

lead to the Titius-Bode law for the strong interactions. The group of four virtual remainders reaches the $d = 1$ state. There, it decays to two identical bosons. One of these components is moving towards the equator of the torus whereas the other one is moving in the opposite direction. When the first component reaches the equator of the torus, the other one is stopping and decays into two particles, and so on. In place of the decay, a "hole" appears in the SST absolute spacetime. A set of such holes is some "tunnel".

The $d = 4$ orbit is the last orbit for the strong interactions.

The probability of the occurrence in the proton of the state $H^+W_{(o),d=1}$ is y while the probability of the occurrence of $H^oW_{(+),d=1}$ is $1-y$. The probabilities y and $1-y$, which are associated with the lifetimes of protons in the above-mentioned states, are inversely proportional to the relativistic masses of the $W_{(+-o),d}$ pions so we have

$$y = \frac{\pi^{\pm}}{\pi^{\pm} + \pi^o_{bound}} = 0.5083854640, \quad (105)$$

$$1-y = \frac{\pi^o_{bound}}{\pi^{\pm} + \pi^o_{bound}} = 0.4916145360. \quad (106)$$

The probability of the occurrence in the neutron of the state $H^+W_{(-),d=1}$ is x while the probability of the occurrence of H^o, π^o_{bound} and Z^o is $1-x$, where $Z^o = W_{(o),d=1} - \pi^o_{bound}$ (the pion $W_{(o),d=1}$ decays because in this state both particles, *i.e.* the torus and the $W_{(o),d=1}$ pion, are electrically neutral). Since the $W_{(o),d=1}$ pion only occurs in the $d = 1$ state and because the mass of the resting bound neutral pion is greater than the mass of Z^o (so the neutral pion lives shorter) then

Table 1. Relativistic mass on the TB orbits.

d	$S_{(+-),d}$	$S_{(o),d}$	$W_{(+-),d}$	$W_{(o),d}$
0	$H^{\pm} = 727.439225$	$H^o = 724.775903$		
1	423.04375	421.49489	215.76069	208.64305
2	298.24411	297.15217	181.70381	175.70966
4	187.57394	186.88719	162.01257	156.66800

$$x = \frac{\pi^o_{bound}}{W_{(-),d=1}} = 0.6255360274\,, \tag{107}$$

$$1 - x = 0.3744639726\,. \tag{108}$$

The mean square charge for the proton is

$$\left\langle Q^2_{proton} \right\rangle = e^2 \frac{y^2 + (1-y)^2}{2} = 0.25e^2\,. \tag{109}$$

The mean square charge for the neutron is

$$\left\langle Q^2_{neutron} \right\rangle = e^2 \frac{x^2 + (-x)^2}{2x + 3(1-x)} = 0.33e^2\,, \tag{110}$$

where $2x + 3(1-x)$ defines the mean number of particles in the neutron.

The mean square charge for a nucleon is (it is consistent with experimental data)

$$\left\langle Q^2 \right\rangle = \frac{\left\langle Q^2_{proton} \right\rangle + \left\langle Q^2_{neutron} \right\rangle}{2} = 0.29e^2 \quad \text{(quark model gives } 0.28e^2\text{)}. \tag{111}$$

Masses of nucleons

The mass of a baryon is equal to the sum of the masses of the components because the binding energy associated with the strong interactions cannot abandon the strong field, it follows from the fact that the periods of changes in masses that result from the strong interactions are shorter than lifetimes of the baryons and from the fact that the $d = 0$ and $d = 1$ TB orbits are placed under the Schwarzschild surface for the strong interactions.

The mass of the proton is

$$p = \left(H^+ + W_{(o),d=1}\right) y + \left(H^o + W_{(+),d=1}\right)(1-y) = 938.272082 \text{ MeV}\,. \tag{112}$$

For the mass of the neutron we obtain

$$n^* = \left(H^+ + W_{(-),d=1}\right) x + \left(H^o + W_{(o),d=1}\right)(1-x) = 939.5372973 \text{ MeV}\,.$$

In the case of a slight difference between the theoretical and experimental result, as for the neutron, one should look for unique interactions of a given particle to obtain the correct value.

In nucleons, the state $H^+W_{(-),d=1}$ in the neutron is the only one state when both components are charged so we should add some electroweak mass. Notice that the $H^+W_{(-),d=1}$ dipole appears with probability $x = 0.6255360$, so the additional electroweak mass of the neutron is $n_{add} = E_{es} 2\alpha_{w(p)} x$, where the factor 2 is due to the dipole, and E_{es} is the electrostatic energy of the dipole $E_{es} = \frac{e^2}{4\pi\varepsilon_o (A+B)} = \frac{\alpha_{em} c\hbar}{A+B}$. We have $n_{add} = 0.02812465924 \text{ MeV}$. Our final mass of the free neutron is

$$n = n^* + n_{add} = 939.565422006 \text{ MeV}\,. \tag{113}$$

The SST mass distance between neutron and proton is

$$n - p = 1.2933399 \text{ MeV} .$$

Our theoretical masses of the nucleons and their mass distance are very close to experimental data. Particle Data Group gives (R. L. Workman *et al.*, Prog. Theor. Exp. Phys. 2022, 083C01 (2022) and 2023 update):

$$p(\text{experiment}) = 938.27208816(29) \text{ MeV} ,$$

$$n(\text{experiment}) = 939.5654205(5) \text{ MeV} ,$$

$$n - p(\text{experiment}) = 1.2933324(5) \text{ MeV} .$$

The origin of the SST volumetric Higgs potentials for the SST-absolute-spacetime components

To explain the origin of the SST volumetric Higgs potential we need quanta which ranges are equal to the ranges in Formula (114).

The side of a mean cube occupied by one SST-As component in the condensate Y is (we denote it by L_{Y+As}, it is the range of the volumetric confinement and it is the range of the volumetric Higgs potential)

$$L_{Y+As} = \left(\frac{2m_{Neutrino}}{\rho_Y + \rho_{As}} \right)^{\frac{1}{3}} = 3510.180704 r_{neutrino} . \tag{114}$$

Notice that our result does not explain the origin of the range of the volumetric Higgs potential/confinement.

The theories of the core of lightest neutrinos and core of baryons are similar so the ratios of similar quantities in both theories have the same values. Instead to consider neutrinos we are considering the core of baryons.

Calculate the binding energy of the $X^{\pm}$ and Y (*i.e.* of the core of baryons)

$$\Delta E_{core} = X^{\pm} + Y - H^{\pm} = 14.97808631 \text{ MeV} . \tag{115}$$

This binding energy lowers the zero-point of the zero-energy field.

But there can appear also following virtual processes that increase the binding energy. Calculate energy, ΔE_1, which relates to the energy emitted during the described earlier collapse of the FGL that transits from the effective radii of the central spacetime condensate, *i.e.* Y and $2\pi m_{FGL}$ (the radius is $r^*_{c(p)} = 0.8697952917 \times 10^{-17}$ m), to the equator of the core of baryons (the radius is A)

$$\Delta E_1 = \frac{2\pi m_{FGL}}{(2\pi)^4} \frac{r^*_{C(p)}}{A} = 0.003395927826 \text{ MeV} . \tag{116}$$

Such energy increases the energy defined by (115). Next the circular oscillations on edge of the total binding energy transform into diagonal oscillations. Then energy of emitted quanta is

$$\Delta E_{volumetric} = \frac{\Delta E_{core} + \Delta E_1}{\pi^4} = 0.1537996308 \text{ MeV} . \tag{117}$$

Internal structure of baryons shows that range of the quadrupole of the bound neutral pions is A so range of the $\Delta E_{volumetric}$ is

$$R_{volumetric} = \frac{4\pi^{o}_{bound} A}{\Delta E_{volumetric}} = 3510.17972A. \quad (118)$$

By an analogy, for the SST-As components is

$$R_{Higgs,volumetric} = 3510.17972 r_{neutrino}. \quad (119)$$

This result differs from the result in (114) only by 1 part in about 3.6 million parts so we can say that we showed the origin of the SST volumetric Higgs potential.

General remarks concerning different types of black holes (BHs)

If on equator of same BHs (it is the abstract circle with spin speed equal to *c*, *i.e.* $R_{BH,equator} = \frac{G_i M_{BH}}{c^2}$) can be realized transition of some virtual field from the nuclear weak interactions to electroweak interactions (*i.e.* $\alpha_{w(p)} \to \alpha_{w(p)} + \alpha_{em}$, see Formula (95)) then outside such BH appear the TB orbits defined by $R_{BH,d} = A_{BH} + dB_{BH}$, where $\frac{A_{BH}}{B_{BH}} = \frac{\alpha_{w(p)} + \alpha_{em}}{\alpha_{w(p)}} = 1.3898$, and $d = 0,1,2,4,\cdots$ are the TB numbers. It follows from the fact that on equator of such BHs there appear the virtual masses (positive and negative) that are absorbed by BH, so their range is A_{BH}. Due to the $\alpha_{w(p)} \to \alpha_{w(p)} + \alpha_{em}$ transition, the virtual positive mass increases 1.3898 times and is emitted from the equator, so its range is B_{BH}. The symmetrical decay in distance $A_{BH} + B_{BH}$ and the motions in opposite directions of the components of the decay cause that there appear a tunnel/orbit in the field with a radius $R_{BH,d=1} = A_{BH} + B_{BH}$. The next successive symmetrical decays create the next TB orbits, so we have $R_{BH,d} = A_{BH} + dB_{BH}$.

The TB orbits are created only when there is an equator with the spin speed equal to *c* because only then can be created the photon loops that interact electromagnetically.

The BHs with the TB orbits use the TB mechanism to evaporate. Why is it possible? Just Nature tries to equalize the mass density and there is the photon-loop/gluon-loop instability on the BH equator because the equator with the spin speed *c* is only the mathematical/abstract circle while the loops are the physical objects. It means that some part of the loops spinning with speed c is above the abstract equator, so there appear the radial speeds of the loops, *i.e.* their radius increases. We can say that a part of the loops on the BH equator exceeds the first cosmic velocity for black holes. Such photon loops with increasing radius, due to the electromagnetic interactions, can carry the charged baryons and charged leptons, so mass of a baryonic BH can decrease.

Moreover, the spin-1 FGLs, even though they are bosons (not fermions), behave as electrons in atoms, *i.e.* there is obligatory the Pauli exclusion principle and the Hund's rule for FGLs [2 + (2 + 6) + (2 + 6 + 10) + …], in such a way we can explain the mass spectrum of the X-particles (it contains the exotic X(3872)). The similarity in behavior of the electrons and FGLs follows from the fact that electrons in electromagnetic field behave as FGLs in nuclear strong field, it is the result of the internal helicity of both the FGLs and nuclear strong field.

The TB orbits for the nuclear strong interactions

The appearing TB orbits for the nuclear strong interactions are a result of two phenomena, *i.e.* the 4-particle symmetry and the symmetrical decays of neutral bosons.

The virtual charged energy equal to the mass of the charged core of baryons (~727.44 MeV) appears on the equator of the core of baryons and next decays to two parts, *i.e.* to the 4 virtual neutral bound pions with energy of ~539.86 MeV (it is due to the 4-particle symmetry) and the virtual charged remainder (~187.57 MeV). The virtual energy equal to ~539.86 MeV is absorbed by the core of baryons, so its range is A, while the virtual charged remainder is emitted and its range is $4B$ from the equator (range is inversely proportional to mass/energy). Due to the 4-particle symmetry, on the equator appears the virtual neutral energy M_{TB}, where $M_{TB} = 4 \times 187.57\ \text{MeV}$, in its symmetrical decays are created the TB orbits/"tunnels" for the nuclear strong interactions.

We see that the potential of the nuclear strong field outside the core of baryons is an analog to the gravitational potential in GR, so we can apply the relativistic formulae.

Emphasize also that the TB orbits are created also due to the $\alpha_{w(p)} \to \alpha_{w(p)} + \alpha_{em}$ transition, so there is a resonance between described two different phenomena.

The TB orbits around the Protoworld for the gravitational interactions

The cosmological-quantum-gravitational black hole

The TB orbits around the neutron black holes (NBH)

The core of the SST Protoworld is an analog to the charged core of baryons and was built of the dark-matter tori while the initial baryonic matter of the early Universe is an analog to the neutral pion created on the circular axis of the torus of a nucleon.

The virtual energy equal to the baryonic mass in the core of Protoworld ($M_{BM} = 0.363791 \times 10^{52}\ \text{kg}$) appears on the equator of the core of the Protoworld ($A_{Protoworld} = 2.71199 \times 10^{24}\ \text{m} = 286.66\ \text{Mly}$). Such a mass behaves as virtual gravitational black hole

$$\frac{GM_{BH}}{A_{Protoworld}} = \left(3.0 \times 10^{8}\ \text{m} \cdot \text{s}^{-1}\right)^{2} = c^{2}. \tag{120}$$

Such virtual mass is both absorbed by the core (so its range is $A_{Protoworld}$) and in such an object is a transition from the nuclear weak interactions to the electroweak interactions, so its mass increases $\frac{A_{BH}}{B_{BH}} = \frac{\alpha_{w(p)} + \alpha_{em}}{\alpha_{w(p)}} = 1.3898$ times, *i.e.* its range is $B_{Protoworld} = A_{Protoworld} \frac{B_{BH}}{A_{BH}} = 206.26\ \text{Mly}$. We see that radius of the $d = 1$ cosmological TB orbit was 492.92 Mly = 151.13 Mpc, it is the known standard ruler in cosmology.

The same mechanism of creation of the TB orbits concern the neutron black holes (NBH). On their equator are created the virtual masses equal to the quantized mass of NBH. In such virtual masses is the transition from the nuclear weak interactions to electroweak interactions, so its range is $R\frac{B_{BH}}{A_{BH}}$, where R is the equatorial radius of NBH. Next there are the symmetrical decays of such modified virtual field, so we obtain $R_d = A_{BH} + dB_{BH}$, where $d = 0,1,2,4,\cdots$ are the TB numbers.

The nuclear-strong black hole (Strong-BHs)

From experiments we know that the hyperons are created quickly due to the nuclear strong interactions and they decay slowly due to the weak interactions (Σ^o decays due to the electromagnetic interactions), so we are interested in the nuclear strong plus electroweak interactions. It means that on the circular axis in the core of baryons should be the virtual FGL and bare electron plus electron-antineutrino. It means that energy of the FGL is lowered because of the electromagnetic binding energy $\Delta E_{em} = 3.097\ \text{MeV}$ (see Formula (102)). The resultant energy appears on the equator of the core of baryons and then is emitted, so we have

$$\frac{G_s\left(m_{FGL} - \Delta E_{em}\right)F}{A} = \left(2.998\times10^8\ \text{m}\cdot\text{s}^{-1}\right)^2 = c^2, \tag{121}$$

i.e. the core of baryons, due to the lowered energy of the FGL, behaves as a nuclear-strong black hole. Notice also that the electron plus electron-antineutrino appear in the β-decays of the neutrons. Emphasize also that the energy ΔE_{em} leads to the mass of the Higgs boson.

The nuclear-weak/quantum black holes (Weak-BHs)

For the Y spacetime condensates we have

$$\frac{G_w YF}{r_{C(p)}} = c^2, \tag{122}$$

so they are the nuclear-weak black holes.

Associations of the Y spacetime condensates also can behave as the nuclear-weak black holes with the invariant coupling constant $\alpha_{w(p)} = 0.0187229$ for the nuclear weak interactions, *i.e.* there is a radius

$$R = \frac{G_w nYF}{c^2} \tag{123}$$

that defines the sphere filled with $n = 1,2,3,\cdots$ the Y spacetime condensates. It is easy to show that Formula (123) can be valid for $n \geq 1$.

In the interactions of the Weak-BHs there dominate the nuclear weak interactions, so on their equator appear the virtual spacetime condensates (*i.e.* with negative and positive masses) with a mass of $\alpha_{w(p)}M_{weakBH}$. Such masses are absorbed and emitted, so the emitted ones appear on the apparent-event Schwarzschild surface for the nuclear weak interactions. To conserve the momentums of the spacetime condensates, when their speed decreases below the *c*, their mass must increase via changes in their volume, *i.e.* then mass is inversely proportional to speed. In SST, the spin speed on the Schwarzschild surface is $\sqrt{2}$

times lower than on the equator, so mass increases $\sqrt{2}$ times to $\Gamma_{weak} = \sqrt{2}\alpha_{w(p)} M_{weakBH}$. They can be emitted or absorbed, it leads to the total width that follows from the line shape.

The BHs defined by (123) are built of the Y spacetime condensates, so due to their weak interactions they look as compact "dark stars". The Y spacetime condensates are held up by the SST quantum gravity that concerns the SST-absolute-spacetime components (the SST Higgs potential leads to the volumetric confinement).

Similar scenario is presented in [1] [2] but it is based on the solution of the black hole Schrödinger equation with the "gravitational fine structure constant", *i.e.* it concerns the gravitational BHs, not the weak-BHs.

Masses of the three heaviest quarks

Density of the spacetime condensates is invariant, so for a 3-D volume (3 degrees of freedom) we have

$$E \sim V \sim r^3. \tag{124}$$

By some analogy, for a hypervolume with N degrees of freedom we have

$$E \sim V \sim r^N. \tag{125}$$

The gluon loops have the 10 SST degrees of freedom: the three coordinates of its center, mean radius of the loop, its thickness, toroidal/spin speed, poloidal speed, linear speed (*i.e.* time), and two angles describing rotation of the spin of the loop.

Quark is a loop. Gluon loops and loops can collapse to a glueball. Particles can collapse to spacetime condensates.

On the equator of the torus, there arise some particles. Denote range of a particle by r_{range}. Then, there is created a loop with radius $r_{loop} = r_{range} + A$. Mass of such a loop we can calculate from following formula

$$M_{Loop,Glueball}[\text{GeV}] = a_q \left(r_{Loop}[\text{fm}]\right)^{10} = a_q \left(r_{range}[\text{fm}] + A[\text{fm}]\right)^{10}, \tag{126}$$

where a_q is a factor whereas $A = 0.6974425\ \text{fm}$ is the radius of the equator of the torus in the core of baryons. For $M_{Loop} = H^{\pm} = 0.7274392\ \text{GeV}$ we should obtain $r_{Loop} = A$, so we have $a_q = 26.71238\ \text{GeVfm}^{-10}$.

Knowing that range of a mass equal to $S_{(+-),d=4} = 187.5739\ \text{MeV}$ is $4B = 2.007342\ \text{fm}$, we can calculate range of a particle or spacetime condensate from formula

$$r_{range}[\text{fm}] = \frac{S_{(+-),d=4}[\text{MeV}]\,4B[\text{fm}]}{m_{Particle,Condensate}[\text{MeV}]} = \frac{b_q}{m_{Particle,Condensate}[\text{MeV}]}, \tag{127}$$

where $b_q = 376.5249\ \text{fm} \cdot \text{MeV}$.

We can rewrite Formula (126) as follows

$$M_{Quark,Glueball}[\text{GeV}] = a_q \left(\frac{b_q}{m_{Particle,Condensate}[\text{MeV}]} + A[\text{fm}]\right)^{10}, \tag{128}$$

or

$$M_{Quark,Glueball}[\text{GeV}] = \left(\frac{0.5229558}{m_{Particle,Condensate}[\text{GeV}]} + 0.9686785[\text{fm}]\right)^{10}. \quad (129)$$

Mass of the Upsilon ϒ(1S, 9460 MeV) leads to the mass of the charm quark ($M_{Quark-c} = 1267.15\ \text{MeV}$).

Mass of a loop overlapping with the d = 0 orbit is 727.4392 MeV. Calculate mass of a loop overlapping with the last orbit, d = 4, on assumption that linear density is the same as for the loop overlapping with the d = 0 state. We obtain $m_{Particle} = 2821.116\ \text{MeV}$. Applying Formula (129) we obtain mass of the bottom quark ($M_{Quark-b} = 4190.33\ \text{MeV}$).

The sum of masses of the torus inside the core of baryons ($X^{\pm}$ = 318.29555 MeV) and the condensate (Y = 424.12176 MeV), *i.e.* $m_{Particle} = 742.4173\ \text{MeV}$, leads to the mass of the top quark ($M_{Quark-t} = 171.85\ \text{GeV}$).

Mass of the Higgs boson

Mass of the region of the SST absolute spacetime, H_{Higgs}, which overlaps with the electromagnetic binding energy of the bare electron on the circular axis of the torus in the core of baryons, $\Delta E_{em} = 3.09695311\ \text{MeV}$, is

$$H_{Higgs} = f\Delta E_{em} = 125.00615\ \text{GeV}, \quad (130)$$

where $f = \frac{\rho_{As}}{\rho_Y} = 40364.2356$. It is the Higgs boson, it is the composite scalar particle composed of the confined SST-As components.

We predict existence of new Higgs boson: $C = fY = 17.12\ \text{TeV}$.

The mass of $W^{\pm}$ and Z bosons

Assume that due to the four-fermion symmetry, a spin-0 charge-0 quadrupole of bare electron-positron pairs ($8m_{e,bare}$) transits from the weak interactions of electrons to the nuclear weak interactions ($X_{w(p/e)} = 19685.1404$) and then to such an object is added the spin-1 virtual pair composed of electron (positron) and electron-antineutrino (electron-neutrino). Mass and spin of such a particle is equal to the mass and spin of the $W^{\pm}$ boson

$$W^{\pm} = 8m_{e,bare}X_{w(p/e)} + \left\{m_{e,bare} + \nu_{e(anti)}\right\}_{virtual} = 80.37948\ \text{GeV}. \quad (131)$$

By same analogy, assume that instead the expression $8m_{e,bare}$ in (131), there is the mass distance between the charged pion and the bound or free neutral pion which attaches its electromagnetic mass. Then for the spin-1 Z boson we have

$$Z = \left[\pi^{\pm} - \frac{\pi^{o}_{bound} + \pi^{o}}{2}\right](1+\alpha_{em})X_{w(p/e)} + \left\{m_{e,bare} + \nu_{e(anti)}\right\}_{virtual} \quad (132)$$
$$= 91.18936\ \text{GeV}.$$

The SST quantum gravity

The part of gravitational field carried by the spin-2 pairs of entanglons we can call the SST gravitons or gravitons (**Figure 2**). The torus of neutrinos consists of such carriers of gravitons, they are emitted and absorbed within the Higgs potential for the neutrinos and the SST-absolute-spacetime components, so the SST quantum gravity has range of the SST Higgs potential for the neutrinos ~4 × 10^{-32} m.

Magnetic moment of electron

In SST, the electron consists of the bare electron and only one the virtual e^+e^- pair, it leads to correct value for the magnetic moment of electron.

We can introduce the symbol

$$\gamma = \frac{\alpha_{em}}{\alpha'_{w(e),DM} + \alpha_{em}} = 0.998468305339348\,, \tag{133}$$

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. Whereas the electromagnetic mass of a bare electron is equal to its weak mass.

For photon loops, mass is inversely proportional to radius, and αM denotes a mass which is responsible for an interaction defined by the α coupling constant. Since the distance between the constituents of a virtual electron-positron pair (virtual dipole) is equal to the length of the equator of the electron torus (because such is the length of the virtual photons) so the ratio of the radiation mass (created by the virtual pair), Δm_{rad}^{**}, to the bare mass of electron is (it concerns only the virtual dipole)

$$\delta = \frac{\Delta m_{rad}^{**}}{m_{e,bare}} = \gamma \frac{\alpha_{em}}{2\pi} + (1-\gamma)\frac{\alpha'_{w(e),DM}}{2\pi} = 0.00115963353674058\,. \tag{134}$$

The virtual dipole is polarized in such a way that its electric line converges on the circular axis of the electron torus so the distance of such axis to the electron condensate is equal to $\frac{2}{3}$ of the equatorial radius of the electron torus, such a

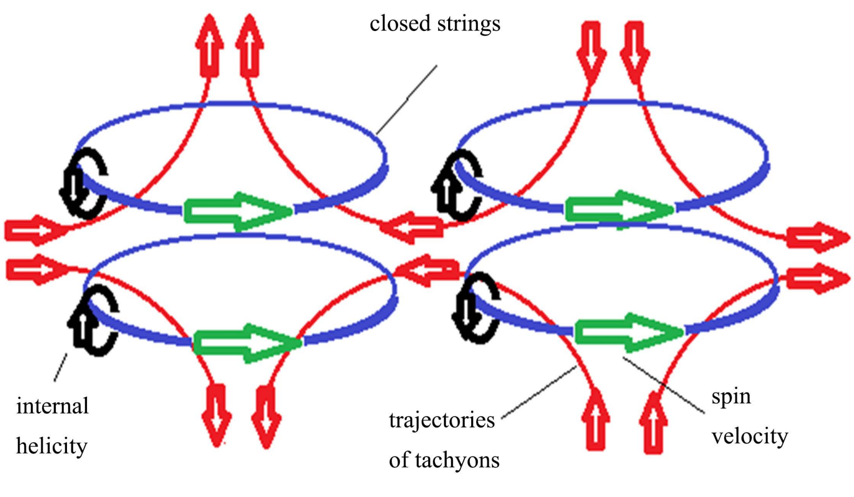

Figure 2. The spin-2 SST graviton.

factor must appear for the weak interactions of the virtual dipole with the real bare electron. 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 electron to the Bohr magneton for the electron, without the virtual-field correction described below, is (it concerns the virtual dipole and its weak interactions with the real bare electron (the Δm_{rad}^{**} is a part of the total radiation mass Δm_{rad}^{*})

$$\varepsilon = \frac{\Delta m_{rad}^{*} + m_{e,bare}}{m_{e,bare}} = \frac{m_{e}^{*}}{m_{e,bare}} = 1 + \delta + \delta \frac{\alpha'_{w(e),DM}}{\frac{2}{3}} = 1.00115965300895 \,. \quad (135)$$

Each real electron is entangled with proton and it is the virtual proton field that increases the density of the zero-energy field, so measured mass of electron is a little lower than it would be for a free electron (*i.e.* for electron not entangled with proton). There are the weak interactions of the Y with the two condensates in the virtual electron-positron pair (its total mass is equal to the bare mass of electron). It causes that we must subtract from ε following value

$$\Delta\varepsilon_{electron} = (\varepsilon - 1)\frac{\alpha'_{w(e),DM} m_{e,bare}}{\alpha_{w(p)} Y} = 8.34419428182199 \times 10^{-10} \,. \quad (136)$$

The final ratio of the magnetic moment of the electron to the Bohr magneton for the electron describes the formula

$$\varepsilon' = 1 + a_e = \frac{m_e}{m_{e,bare}} = \varepsilon - \Delta\varepsilon_{electron} = 1.00115965217453 \,. \quad (137)$$

4-closed-string symmetry (generally, the 4-object/particle/fermion symmetry)

It follows from the fact that internal helicity and spin of the inflation field was conserved. The tachyons rotate so the created closed strings have internal helicity and spin. To create an object with zero internal helicity and zero spin, the closed strings must be created as binary systems of binary systems. The constituents of the single binary systems have parallel spins and opposite internal helicities whereas the binary systems in a binary system have opposite spins. Such four-object symmetry can be adopted by other objects on higher levels of Nature.

2. Introduction

In Table 2, we present the ATLAS and CMS results for upper limits of the total width (in GeV) of the Higgs boson from the Higgs line shape (mass spectrum) in the $H \to \gamma\gamma$ channel 1 and $H \to ZZ* \to 4l$ channel 2 at 95% CL limit [3].

On the other hand, the measured total width of the off-shell Higgs bosons is [4]

$$\Gamma_{H,off-shell} = 4.6^{+2.6}_{-2.5} \text{ MeV} \,. \quad (138)$$

Table 2. Upper limits of the total width of H from line-shape [3].

	Channel 1	Channel 2
ATLAS	<5.0 (6.2)	<2.6 (6.2)
CMS	<2.4 (3.1)	<1.1 (1.6)

Why are the total width obtained from the mass spectrum (the upper limits) and the total width of the off-shell Higgs bosons so different, about three orders of magnitude?

In this paper, using the SST, we are trying to answer this important question.

We will use the two equations we obtained in SST.

3. The First Equation and the Full Width of the Spacetime Condensates

The first formula is for the total width of the spacetime condensates (due to their weak interactions that dominate) such as the Higgs boson H, $W^{\pm}$ bosons or Z bosons

$$\Gamma_{weak} = \sqrt{2}\alpha_{w(p)} M . \tag{139}$$

where $\alpha_{w(p)} = 0.0187229$ is the SST coupling constant for the nuclear weak interactions (see Paragraph "The nuclear-weak/quantum black holes (Weak-BHs)").

From (139), for the $W^{\pm}$ bosons we obtain $\Gamma_{weak,W\pm} = 2.1\,\text{GeV}$ (the experimental value is ~2.1 GeV [3]), for Z bosons is $\Gamma_{weak,Z} = 2.4\,\text{GeV}$ (the experimental value is ~2.5 GeV [3]), and for the Higgs boson we obtain $\Gamma_{weak,H} = 3.3\,\text{GeV}$ (it is consistent with the line-shape total width but it is inconsistent with the value for the off-shell Higgs bosons).

The consistency of the SST theoretical results and experimental results for $W^{\pm}$ bosons and Z bosons suggests that there is no reason to say that the SST result for the Higgs boson is wrong.

What is the origin of Formula (139)?

The cross sections as function of energy for the spacetime condensates have the approximate form of a Breit-Wigner line shape (see **Figure 3**).

According to SST, the spacetime condensates with masses equal or higher than $Y = 424.12\,\text{MeV}$ are the nuclear-weak black holes. Scalar Higgs bosons and the vector $W^{\pm}$ and Z bosons are such condensates. Orbital speed of virtual particles created on the Schwarzschild surface for the nuclear weak interactions that are the weak masses is $c/\sqrt{2}$, so their relativistic absolute masses are $\sqrt{2}$ times higher than their rest masses. Such virtual particles on the Schwarzschild surface can be emitted or absorbed by the spacetime condensates and their mean absolute mass is defined by Formula (139). Such is the origin in SST of the full width of the SST spacetime condensates.

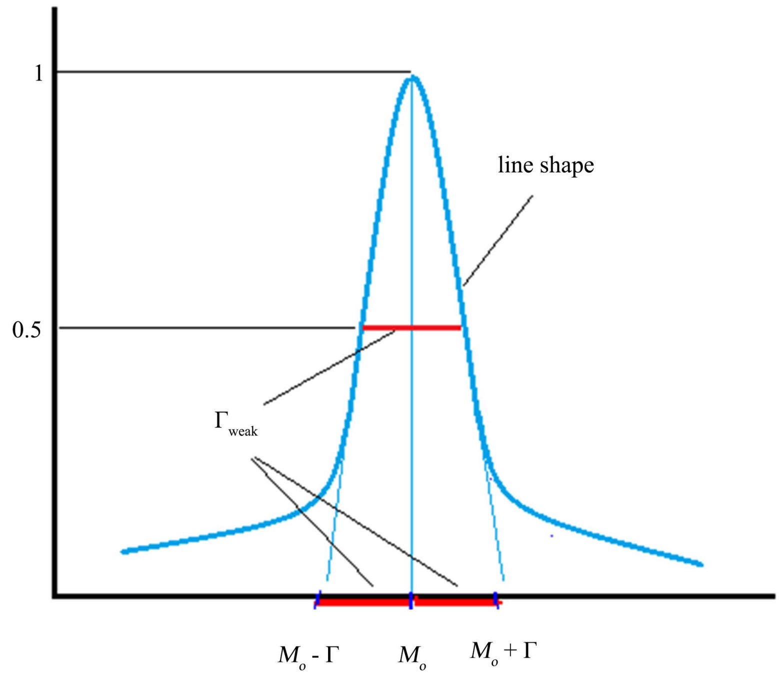

Figure 3. Breit-Wigner line shape.

4. The Second Formula

Within SST we derived following Formula (see (129))

$$M_{Quark,Glueball}[\text{GeV}] = \left(\frac{0.5229558}{m_{Particle,Condensate}[\text{GeV}]} + 0.9686785[\text{fm}] \right)^{10} . \quad (140)$$

Using this formula we calculated masses of the three heaviest quarks.

Formula (140) relates the masses of the created glueballs composed of the SST fundamental gluon loops (FGLs) that are responsible for the nuclear strong interactions (*i.e.* there are loops) or the masses of the quarks/loops with the scalar or vector spacetime condensates and other particles.

In Formula (140), there is the radius with the exponent 10 because within SST we showed that the loops and the glueballs composed of loops have 10 degrees of freedom.

5. Why the Standard Model Mimics the Scale-Symmetric Theory at Higher Energies?

We must answer this question to understand the problem.

SST shows that the electron consists of the real charged bare electron and only one the virtual bare electron-positron pair, *i.e.* the positive mass of the virtual pair is two times higher than the mass of the real bare electron. Such model leads to correct value for the magnetic moment of the electron. On the other hand, in nucleons is the real spin-1/2 charge $X^+ = 318.3\,\text{MeV}$ that is the source of the nuclear strong interactions and electromagnetic interactions, so by an analogy to the electron, there should be only one virtual X^+X^- pair with the virtual positive mass 2·318.3 MeV. It means that in such a system we have three charged spin-1/2 parts (two fermions and one antifermion) each with mass ~318 MeV as it is in the quark model of nucleons (each quark has relativistic mass about 300 MeV). In SST, we showed also that the fractional electric charges of quarks (+2*e*/3 and −1*e*/3), for a sample containing 50% protons and 50% neutrons, mimic the elementary charges of the SST nucleon components.

Moreover, the rest masses of the *u*-quark and *d*-quark are associated with the mass distances between both the charged and neutral core of baryons and between the relativistic pions in the $d = 1$ state.

SST shows that in the high-energy particle physics, most important are the peripheral processes concerning the last $d = 4$ orbit for the nuclear strong interactions and the dynamics of the core of baryons. The last orbit is associated with the production of the *b*-quarks (~4190 MeV) and with the virtual field composed of the relativistic charged pions with a mass of 162 MeV. On the other hand, from Formula (140) follows that the sum of masses of the two main parts of the baryonic core (742.42 MeV) leads to mass of the *t*-quark (~172 GeV).

It leads to a conclusion that the high-energy particle physics should be based on the quark-antiquark pairs of the two heaviest quarks (*b* and *t*) and on the virtual field composed of the 162-MeV relativistic pions, but emphasize that such peripheral virtual field is very important also at low energies.

Emphasize also that neutrinos acquire their masses due to their interactions with the SST Higgs field. It is not true that the Higgs boson relates directly to the SST Higgs field. The Higgs boson acquires its mass due to the volumetric confinement of the SST absolute-spacetime components, such interaction is not the fundamental interaction between the SST Higgs field and the components of the neutrinos.

SST shows that, unlike the SST Higgs field, Nature works fine without the Higgs boson, so there is no point in defending its Standard-Model properties at all costs.

Within SST we already calculated mass of the Higgs boson (see Formula (130))

$$m_{H,SST} = 125.006\ \text{GeV}\,. \tag{141}$$

Now the value of the Higgs mass from ATLAS is [5]

$$m_{H,ATLAS} = 124.99 \pm 0.18(stat) \pm 0.04(syst)\,\text{GeV}\,, \tag{142}$$

so the central value, *i.e.* 124.99 GeV, is much closer to the SST value.

But we can calculate also the second SST value for the Higgs boson. Assume that a mean nucleon $\frac{p+n}{2} = 938.919\ \text{MeV}$ emits the mean positive mass of virtual pion $\frac{\pi^{\pm} + \pi^{o}}{2} = 137.274\ \text{MeV}$, so mass of nucleon decreases to $M = 0.80165\ \text{GeV}$. Next such mass collapses to a scalar spacetime condensate. Then, applying Formula (140) for the mass 0.80165 GeV, we obtain the "second

Higgs mass" equal to

$$m_{H,SST,2} = 125.29\ \text{GeV}\ . \tag{143}$$

This value is consistent with the PDG value 125.25(17) GeV [3]. Notice that from Formula (140) results that it is not mass of the scalar spacetime condensate (Higgs boson) but the mass of the scalar glueball.

6. Calculations

Notice that Formula (140) is obligatory for following relationship (it is a resonance)

$$M_{Glueball}[\text{GeV}] = m_{Condensate}[\text{GeV}] = 3.3\ \text{GeV}\ , \tag{144}$$

i.e. is obligatory for the SST real total width of the Higgs bosons. It can additionally lead to wrong results for the off-shell Higgs bosons.

We know that the gluon fusion production process is the dominant production mode. For the $ZZ \to 4l$ and $ZZ \to 2l2\nu$ channels, there initially appear the glueballs that only then transform into the scalar spacetime condensates, see the collapse of the fundamental gluon loops (FGLs) described in SST (see Formula (33)). The gluon-gluon-fusion (ggF) Higgs-boson production is due to the nuclear strong interactions of the FGL pairs (neutral pions), so for the coupling constant we have

$$\alpha_s^{pp,\pi} = 14.391187\ . \tag{145}$$

Such glueballs, due to the nuclear weak interactions, can transform into the scalar spacetime condensates, so we have

$$\alpha_{w(p)} = 0.0187229\ . \tag{146}$$

The ratio of the strong coupling constant to the weak coupling constant is

$$f^* = \frac{\alpha_s^{pp,\pi}}{\alpha_{w(p)}} = 768.641\ , \tag{147}$$

and such number of times decrease both the real total width of the Higgs boson calculated within SST and the mass of the of-shell Higgs bosons

$$\Gamma_{weak,H,illusory} = \frac{\Gamma_{weak,H}}{f^*} = \frac{3.3\ \text{GeV}}{768.641} = 4.3\ \text{MeV}\ , \tag{148}$$

$$M_{H,new} = \frac{m_{H,SST}}{f^*} = \frac{125.006\ \text{GeV}}{768.641} = 162.6\ \text{MeV}\ . \tag{149}$$

The last mass is close to mass of the virtual relativistic pions in the peripheral dominating virtual field in baryons, so we have a resonance.

But emphasize that we cannot apply Formula (139) to the mass 162.6 MeV because it is lower than Y so it cannot be a spacetime-condensate (nuclear-weak) black hole for the nuclear weak interactions.

Such is the origin of the "total width" of the off-shell Higgs bosons.

Consider the "total width" of the Z boson for the off-shell measurements. From (147)-(149) we obtain

$$\Gamma_{weak,Z,illusory} = \frac{\Gamma_{weak,Z}}{f^*} = \frac{2.4\text{ GeV}}{768.641} = 3.1\text{ MeV}, \quad (150)$$

$$M_{Z,new} = \frac{m_{Z,SST}}{f^*} = \frac{91.1894\text{ GeV}}{768.641} = 118.6\text{ MeV}. \quad (151)$$

We can see that contrary to the 4.3 MeV for the Higgs boson, the 3.1 MeV signal for the Z boson should be much less clear because of lack of a resonance. Notice also that the 3.1 MeV is very close to the central value of the PDG result $\Gamma = 3.2^{+2.4}_{-1.7}$ MeV on the assumption that the on-shell and off-shell effective couplings are the same [3].

The CMS-Collaboration team obtained $\Gamma_H = 3.2^{+2.4}_{-1.7}$ MeV (at 95% CL.) using 140 fb^{-1} $4l$ on-shell plus 78 fb^{-1} $4l$ off-shell plus 138 fb^{-1} $2l2\nu$ off-shell [6], so the CMS central value (3.2 MeV) is very close to our value (3.1 MeV).

For $ZZ \to 2l2\nu$, the CMS team obtained $\Gamma_H = 3.1^{+3.4}_{-2.1}$ MeV at 68% CL [6]. The $2l2\nu$ analysis was based on the reconstruction of $Z \to ll$ decays with a second Z boson decaying to neutrinos that escaped detection.

Probably the differences in the ATLAS and CMS measurements were the cause of the different central values (*i.e.* 4.6 MeV and 3.2 MeV, respectively). Just in ATLAS dominated the production of the Higgs bosons while in CMS dominated the production of the Z bosons.

7. The Off-Shell Higgs Bosons Production and Detection

The Higgs bosons can be produced outside the peak 125 GeV, *i.e.* off-shell.

In the ATLAS experiment [4], there was an attempt to measure the total width of the Higgs boson in the off-shell production. Via Formula (148) we showed that it is untrue. The correct description of the Higgs boson production and detection is graphically presented in **Figure 4** and **Figure 5**.

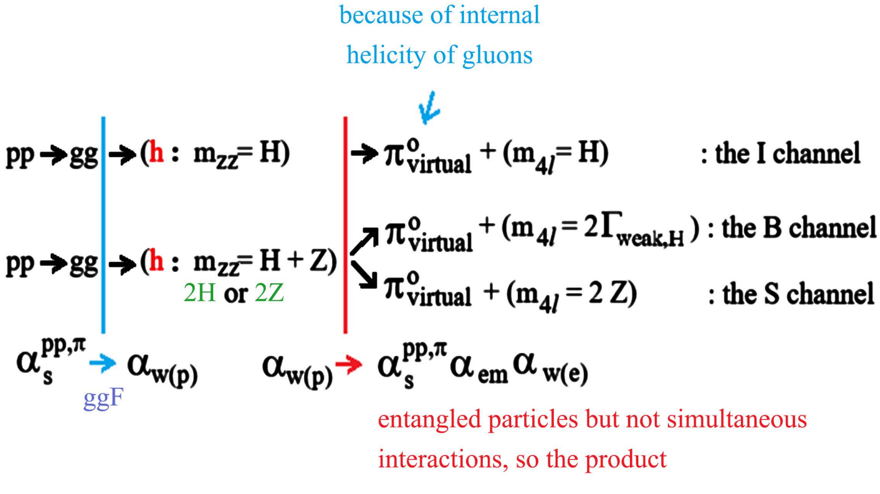

Figure 4. The threshold resonances.

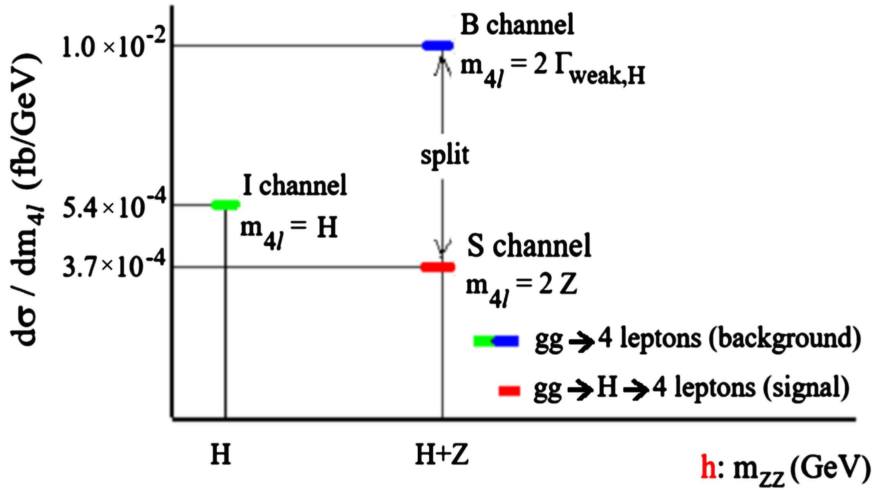

Figure 5. The split of the (2H + 2Z)/2 = H + Z state into the B and S channel.

According to SST, the core of protons is internally left-handed, so it produces the fundamental gluon loops (FGLs) with the left-handed internal helicity. On the other hand, the neutral pion consists of two FGLs, so the virtual neutral pion in the final state carries the internal helicities of the initial gluons which in the gluon-gluon fusion create the scalar-Higgs and vector-Z bosons. Just the internal helicity must be conserved. Coupling constant for such virtual neutral pion is $\alpha_s^{pp,\pi} = 14.391187$. On the other hand, the four leptons in the final state interact electroweakly: $\alpha_{em}^{-1} = 137.035999$ is the fine structure constant while $\alpha_{w(e)} = 0.951118 \times 10^{-6}$ is the coupling constant for the weak interactions of the charged leptons. The virtual neutral pion and the four leptons in the final state are entangled but their interactions are not simultaneous, so there appears the product of the three above coupling constants. According to SST, the Higgs boson and the Z and $W^{\pm}$ bosons interact due to the nuclear weak interactions ($\alpha_{w(p)} = 0.0187229$).

SST shows that the weak coupling constant of the spacetime condensates is directly proportional to their radius, so due to the described transition, there are produced spacetime condensates with following effective radius

$$R_{new} = r_{C(p)} \frac{\alpha_s^{pp,\pi} \alpha_{em} \alpha_{w(e)}}{\alpha_{w(p)}}, \tag{152}$$

where $r_{C(p)} = 0.8711018 \times 10^{-17}$ m is the radius of the scalar spacetime-condensate in the center of the proton.

The change in cross section is

$$\Delta\sigma = \pi R_{new}^2 - 0. \tag{153}$$

The change in mass is

$$\Delta m_{4l} = m_{4l} - 0. \tag{154}$$

So we have

$$\begin{aligned}\frac{\mathrm{d}\sigma}{\mathrm{d}m_{4l}} &= \frac{\pi R_{new}^2}{m_{4l}} = \pi\frac{\left(r_{C(p)} f^* \alpha_{em}\alpha_{w(e)}\right)^2}{m_{4l}} \\ &= \frac{\sigma_o \left(f^*\right)^2 \alpha_{em}^2 \alpha_{w(e)}^2}{m_{4l}} = \frac{6.7848\times 10^{-2}}{m_{4l}}\ \mathrm{fb}\cdot\mathrm{GeV}^{-1}\end{aligned} . \tag{155}$$

The factor $\left(f^*\right)^2 \approx 0.6\times 10^6$ in Formula (155) (see Formula (147)) causes that the increases in measured cross sections in the off-shell processes are enormous. There appear also the electroweak interactions of leptons ($\alpha_{em}^2\alpha_{w(e)}^2$).

For $m_{ZZ} = m_{4l} = H$ we obtain $\left(\frac{\mathrm{d}\sigma}{\mathrm{d}m_{4l}}\right)_H = 5.4\times 10^{-4}\ \mathrm{fb}\cdot\mathrm{GeV}^{-1}$ (it is for the initial (I) channel).

For $m_{ZZ} = H + Z$ and $m_{4l} = 2\Gamma_{weak,H}$ we obtain

$\left(\frac{\mathrm{d}\sigma}{\mathrm{d}m_{4l}}\right)_{H+Z} = 1.0\times 10^{-2}\ \mathrm{fb}\cdot\mathrm{GeV}^{-1}$ (it is for the background (B) channel).

For $m_{ZZ} = H + Z$ and $m_{4l} = 2Z$ we obtain

$\left(\frac{\mathrm{d}\sigma}{\mathrm{d}m_{4l}}\right)_{H+Z} = 3.7\times 10^{-4}\ \mathrm{fb}\cdot\mathrm{GeV}^{-1}$ (it is for the signal (S) channel).

We can see that there is the split of the $m_{ZZ} = H + Z$ state into the B and S states and that there dominates the B state.

Our results are consistent with the ATLAS and CMS simulations [4].

8. Internal Structure and Couplings of *H*, *W*±, *Z* and Heavier Spacetime Condensates and Their Production and Decays

The scalar or vector spacetime condensates that interact due to the nuclear weak interactions (the coupling constant is $\alpha_{w(p)}$) are the SST nuclear-weak black holes (WBHs) composed of the $Y = 424.12\ \mathrm{MeV}$ spacetime condensates which are the elementary WBHs (EWBHs). Such granular structure of the WBHs causes that for all of them the weak coupling constant is invariant and is equal to $\alpha_{w(p)}$. The EWBHs in a WBH are entangled because they exchange the virtual EWBHs. The EWBHs can exchange a single spin-1 electron-(electron-antineutrino) pair as it is in the $W^{\pm}$ or spin-1 electron-positron pair as it is in the Z, so there appear the electroweak interactions (the coupling constant is $\alpha_{em}\alpha_{w(e)}$). But the EWBHs can be produced in the gluon-gluon fusion because of the circle-diameter transitions of two FGLs, so there can appear the strong-electroweak interactions (the coupling constant is $\alpha_s^{pp,\pi}\alpha_{em}\alpha_{w(e)}$).

Radius, $R_{WBH,sphere}$, of the sphere of a WBH with a mass of M_{WBH} on which the virtual spacetime condensates are moving with the spin speed equal to c is

$$R_{WBH,sphere} = \frac{G_w M_{WBH}}{c^2}, \tag{156}$$

where $G_w = 1.03550248\times 10^{27}\ \mathrm{m}^3\cdot\mathrm{kg}^{-1}\cdot\mathrm{s}^{-2}$.

Emphasize that $R_{WBH,sphere}$ is not the radius, R_{WBH}, of the sphere filled with the EWBHs. Moreover, the effective radius (so cross section as well) depends on coupling constants as it is in Formula (152).

At high energies of the *pp* collisions, the gluon loops produced on the equator of the core of baryons have the range equal to $R = 2\pi A \approx 4.38\ \text{fm}$. The granular nuclear-weak black hole with such a radius ($R_{WBH,sphere} = 2\pi A$) has a mass of (see Formula (156))

$$M_{WBH} = \frac{2\pi A c^2}{G_w} \approx 213.36\ \text{GeV}. \tag{157}$$

It means that we have a resonance for the HV production, where V is close to the mean mass of the vector bosons: $\frac{W^{\pm} + Z}{2} \approx 86\ \text{GeV}$ (*i.e.* 125 GeV + 86 GeV = 211 GeV ≈ 213 GeV) but notice that the uncharged HZ state (~216 GeV) is preferred as it is in **Figure 5**.

On the other hand, for $R = 2\pi(A + B) \approx 7.535\ \text{fm}$ that is the circumference of the d = 1 state, we obtain 183 GeV ≈ 2(2Z), so the control region (CR) for the Higgs-boson off-shell production should be from 183 GeV (~2Z) up to 216 GeV (~HZ). The CR in the ATLAS experiment was from 180 GeV up to 220 GeV, so it is close to the SST resonance/split region.

Radius of the last orbit for the nuclear strong interactions is
$R = A + 4B = 2.7048\ \text{fm}$ that corresponds to energy equal to

$$M_{WBH} = \frac{(A + 4B)c^2}{G_w} \approx 131.69\ \text{GeV}. \tag{158}$$

We see that there is 131.7 GeV ≈ $H + 2\Gamma_{weak,H}$ = 131.6 GeV, so there appears the $2\Gamma_{weak,H}$ resonance for the HZ state as it is in **Figure 5**. We see that there dominate two resonances: for the A state (the equatorial effects leading to HZ) and for the $A + 4B$ state (the peripheral effects in background leading to $2\Gamma_{weak,H}$) as it should be at high energies.

Emphasize also that due to the four-particle/object symmetry, because of the gluon-gluon collapses/fusions in centers of the colliding protons, there are produced not only the Y spacetime condensates and the Higgs bosons, but also the virtual quadrupoles of the bound neutral pions, their quantized range is A, so the quantized range of the virtual single bound neutral pions is $4A \approx 2.79\ \text{fm}$, *i.e.* is peripheral. It means that at the peripheral distance, there appear the $H + 2\Gamma_{weak,H}$ (the H can decay to $4l$ or $2l2\nu$) and the virtual neutral pions, such is the origin of the $\alpha_s^{pp,\pi}\alpha_{em}\alpha_{w(e)}$ coupling constant. The $ggF \to \Gamma_{weak,H}$ (see also Formula (145)), due to the $\alpha_s^{pp,\pi} \to \alpha_{w(p)}$ transition, reduces mass of the $\Gamma_{weak,H}$ to $\Gamma_{weak,H,illusory} = 4.3\ \text{MeV}$. Such is the origin of the illusory total width of the Higgs boson.

Notice also that there can be created Higgs bosons with not quantized masses ($h = m_{ZZ}$, see the x-axis in **Figure 5**) but the lack of quantization causes that they very quickly decay to the Y spacetime condensates or, due to the four-object symmetry, they can decay to one or more groups of 4 fermions.

We see that we cannot explain fully the dynamics in the ATLAS experiment without the atom-like structure of baryons described in the Scale-Symmetric Theory. We showed that the peripheral interactions at high energies are very important.

The virtual pseudoscalar composed of the two spin-1 fundamental gluon loops causes that there appear the hypotheses with spin-2 or negative-parity of the Higgs boson.

SST shows that mass of the SST absolute spacetime overlapping with the Y spacetime condensate is ~17.12 TeV, so we predict that there is the third Higgs boson with such quantized mass (*i.e.* $C = fY = 17.12\ \text{TeV}$, where f = 40364.2356).

9. Off-Shell/On-Shell Couplings

The joint off-shell ($4l + 2l2\nu$ channel) and on-shell (only $4l$ channel) analysis in the ATLAS experiment leads to following two parameters [4]

$$R_{gg,ATLAS} = \frac{\kappa^2_{g,off-shell}}{\kappa^2_{g,on-shell}} = 137^{+0.92}_{-1.33}, \tag{159}$$

$$R_{VV,ATLAS} = \frac{\kappa^2_{V,off-shell}}{\kappa^2_{V,on-shell}} = 0.9^{+0.42}_{-0.35}, \tag{160}$$

On the other hand, we have

$$R_{gg,SST} = \frac{H(the\ ggF\ production)}{Z} = 1.37, \tag{161}$$

$$R_{VV,SST} = \frac{W^{\pm}(the\ EW \rightarrow W_{nuclear}\ production)}{Z} = 0.88 \approx 0.9. \tag{162}$$

We see that the central values in (159) and (160) are equal to our values in (161) and (162). In the definitions of such parameters, there appear the gluons and bosons and the on-shell and off-shell processes, so from the same values in (159) & (160) and (161) & (162) follows that in the ATLAS selected decays, there dominated the characteristic bosons.

We also have

$$\frac{\Gamma_{weak,H,illusory}}{\Gamma^{SM}_{H}} \approx 1.05. \tag{163}$$

10. Summary

Here we showed that the measured ATLAS total width of the off-shell Higgs bosons is a value that does not concern the Higgs bosons but the SST weak total width of the Higgs boson 3.3 GeV, and we see that the 4.3 MeV value appears because of the transition from the nuclear strong interactions to the nuclear weak interactions.

The main conclusion is as follows. Mean mass of the virtual spin-0 particles surrounding the Higgs boson is 3.3 GeV, so such mean mass has also the virtual gluon-gluon (gg) pairs. Transitions from the gluon-gluon pairs (the gluon-gluon fusion ggF) to electroweak (EW) condensates (such as for example the $W^{\pm}$ bosons) cause that there appear the spacetime condensates with a mass of $M_{Pretending-to-be} = \Gamma_{weak,H} \frac{\alpha_{w(p)}}{\alpha_s^{pp,\pi}} = 4.3\ \text{MeV}$ "pretending to be" the real total width of the Higgs boson that is 3.3 GeV. Notice also that $\alpha_{w(p)}$ (*i.e.* $W_{nuclear}$) $\gg \alpha_{em}\alpha_{w(p)}$ (*i.e.* $EW_{nuclear}$) $\gg \alpha_{em}\alpha_{w(e)}$ (*i.e.* $EW_{leptons}$), so the nuclear weak interactions overwhelmingly dominate over the electroweak interactions, so we have $EW \to W_{nuclear}$.

We showed here that in the off-shell processes, the interference effects between the background ($gg \to ZZ$) and signal processes ($gg \to h \to ZZ$) are via the virtual neutral pion (it is a pseudoscalar $J^P = 0^-$) that carries the initial internal helicity of the gluons. Such interference is large because $\frac{\alpha_s^{pp,\pi}}{\alpha_{w(p)}} \approx 769$.

The two different central values, *i.e.* the ATLAS 4.6 MeV (according to SST, it is for *H*) and the CMS 3.2 MeV (according to SST, it is for *Z*) {or our prediction for $W^{\pm}$ bosons equal to 2.7 MeV}, additionally validate our model.

We calculated here also the second value for mass of the Higgs boson: 125.29 GeV (the first SST value is 125.006 GeV).

The Scale-Symmetric Theory shows that the detected in 2012 Higgs boson is not the Standard-Model boson. Unlike the SST Higgs field, Nature works fine without the Higgs boson, so there is no point in defending its Standard-Model properties at all costs. The Standard-Model full width of the Higgs boson equal to 4.1 MeV is not realized by Nature, so we need new physics beyond the SM. We showed many times that the Scale-Symmetric Theory is the lacking part of the theory of everything.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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