*Paragraph 5.6 corrected in February 2018

# Foundations of the Scale-Symmetric Physics

## (Main Article No 1: Particle Physics)

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**Abstract:** Within the Standard Model (SM), among many other things, we cannot calculate precise mass and spin of proton or physical constants from some more fundamental initial conditions whereas within General Relativity (GR) we are unable, for example, to describe the exit of the Cosmos from a black-hole state. Moreover, the mentioned leading mainstream theories contain tens of free parameters. It suggests that SM and GR are the incomplete theories and it is the reason that they are very messy. It is not true that theoretical particle physics is very complicated - in reality, it is the very simple field of knowledge. Here we showed that the non-perturbative Scale-Symmetric Theory (SST) is the lacking part of Theory of Everything (ToE). General Relativity (GR) leads to the Higgs field composed of the non-gravitating tachyons. Due to the succeeding phase transitions of the superluminal Higgs field, there appear different scales - it is the foundations of the Scale-Symmetric Theory. Theories of three scales are dual i.e. ratios of physical quantities in these scales concerning the same mechanisms, have the same values. Due to the succeeding phase transitions, there appear the binary systems of superluminal closed strings (i.e. the entanglons that are responsible for the quantum entanglement), neutrinos and neutrino-antineutrino pairs the Einstein spacetime consists of, cores of baryons, and cores of cosmic structures (the cores of protoworlds) that evolution leads to dark matter, dark energy, and to the expanding universes. There appear three additional interactions i.e. viscosity of tachyons that follows from smoothness of their surfaces, superluminal linear quantum entanglement that follows from exchanges of the entanglons the neutrinos consist of, and volumetric confinement that is the result of production of a potential well near neutrinos and neutrino-antineutrino pairs and other cores (the Mexican-hat mechanism) - it follows from the ranges of the radiation energy of some analogs to the neutral pion. There appears the four-particle symmetry that solves many problems in particle physics and cosmology. Here as well we described the internal dynamics of baryons that leads to the atom-like structure of baryons and next to mesons and to the composite Higgs boson with a mass of 125 GeV. Among many other things, we described symmetries and laws of conservation that result from the initial parameters, we calculated the physical constants from initial conditions, coupling constants, running coupling for nuclear strong interactions and masses of quarks. Due to the superluminal Higgs field, the neutrinos acquire their gravitational mass. Theoretical results are much better than results obtained within SM. We apply 7 parameters only and very simple mathematics.

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## 1. Introduction

We know that the one-side open interval for speed $<0, c)$, where $c$ is the speed of light in "vacuum", is for the Principle-of-Equivalence particles (the PoE particles) i.e. for particles that gravitational mass is equal to inertial mass. There appear two questions:

*Can there be in existence a PoE particle with a mass not equal to zero moving with the speed $c$? What should be the structure of such particle and spacetime it could be possible? Are they the neutrinos and neutrino-antineutrino pairs?

*Can there be in existence superluminal objects i.e. objects moving with speed higher than the $c$, i.e. tachyons? What should be properties of tachyons?

Answers to these questions should follow from some extension of the mainstream theories, especially of the General Relativity (GR) because this theory starts from the PoE.

### 1.1 Non-gravitating tachyons

Our intuition tells us that superluminal can be only non-gravitating objects i.e. objects that carry inertial mass only i.e. objects that are internally structureless because such objects cannot emit any particles. Just tachyons must be bare i.e. cannot produce fields as the non-zero-mass PoE particles. The non-gravitating tachyons we can call the imaginary particles because they have broken contact with PoE matter i.e. they can interact only due to direct collisions. Such interactions follow from viscosity of tachyons – such viscosity results from smoothness of their surface.

We can obtain an extension of GR substituting the imaginary values instead the real values in the formula for the total energy

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

Substitute $ic$ instead the speed of light in "vacuum" $c$, $iv$ instead the kinetic speed $v$ and $im$ instead the PoE mass $M$, where $i = (-1)^{1/2}$ is the imaginary unit. Then, for non-gravitating objects, we can rewrite formula (1) as follows

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

We can see that now the non-gravitating objects must be superluminal ($v$ must be higher than the speed of light in "vacuum", $c$) i.e. they are the non-gravitating tachyons. Formula (2) leads to conclusion that the energy of the non-gravitating tachyons is real.

The gas composed of non-gravitating tachyons I refer to as the modified Higgs field. If $v$ is tens powers of ten higher than $c$ (kinetic speed is associated with time) then the modified Higgs field we can call as well the Newtonian spacetime – it is due to the fact that in the Newtonian gravity appears the absolute time. The modified Higgs field we will call the Higgs field because we will show that non-gravitating objects, due to their interaction with the Higgs field, acquire their gravitational mass (the Higgs mechanism).

If $v_{Tachyon} >> c$ then formula (2) leads to following formula for energy of a non-gravitating tachyon with inertial mass equal to $m_{T,inertial}$ and speed equal to $v_{Tachyon}$

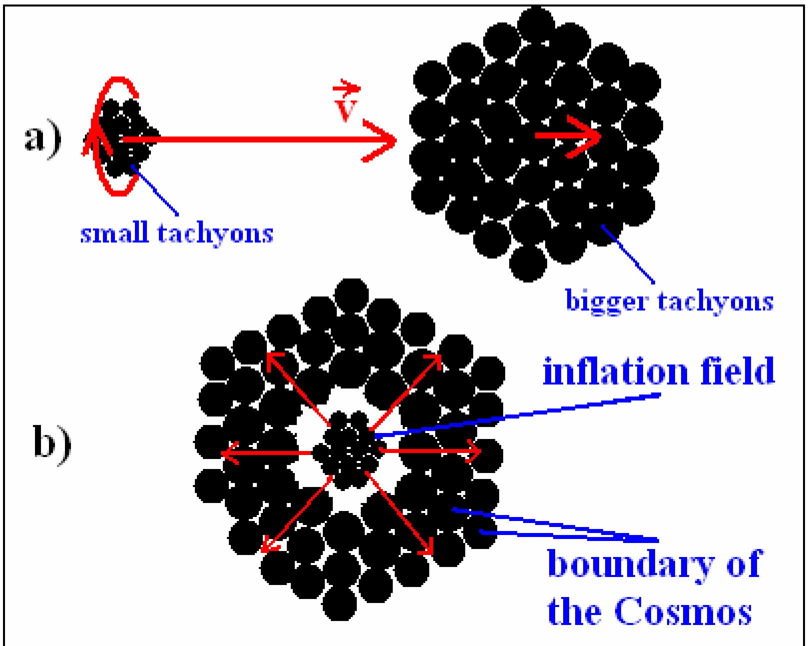
$$E_{Tachyon} = m_{T,inertial}\, c^3 / v_{Tachyon}. \tag{3}$$

How we should interpret this result? Why a faster tachyon has lower energy? It follows from the grinding of the non-gravitating tachyons because of their direct collisions. Greater mean speed of tachyons means that intensity of grinding is higher i.e. tachyons have smaller mean radius i.e. their inertial mass is smaller. We can assume that there is obligatory following formula $m_{T,inertial}\, v_{Tachyon}^{\,2} = F = const.$ (formula (3) shows that it is not formula for total energy) so inertial mass of a tachyon is inversely proportional to its squared speed. It leads to conclusion that we can rewrite formula (3) as follows

$$E_{Tachyon} = F\,(c / v_{Tachyon})^3, \tag{4}$$

where $F$ is a factor. Knowing that $F = m_{T,inertial}\, v_{Tachyon}^{\,2}$ and knowing the initial conditions for the inflation field that lead to a thousand theoretical results consistent or very close to experimental data (see Paragraph **3.1**), we can calculate the factor $F$

$$F = m_{T,inertial}\, v_{Tachyon}^{\,2} = 2.1370 \cdot 10^{88}\ \text{J}. \tag{5}$$




**a) Collision before the inflation,**
**b) the inflation.**

Tachyons, which are the internally structureless pieces of space, are moving in the infinite truly empty volume. They behave as vacuum cleaners i.e. due to their viscosity that follows from smoothness of their surfaces, they capture tachyons moving with very similar speed in the same direction (in a gas composed of chaotically moving tachyons, rate of such processes is infinitesimal). It causes that in the infinite volume can appear big pieces of space composed of tachyons. Big pieces of space moving with higher speed are composed of smaller tachyons. Due to collision of a big piece of space with a much bigger piece of space moving with much lower relative speed (so this speed we can neglect), there was created our Cosmos. Moreover, the much smaller big piece of space was rotating so we can say about the mean rotational speed of the tachyons on their equators. Probably, the external helicity of the smaller big piece of space was left-handed. The much smaller big piece of space was the initial state of the inflation field. The inflation took place inside the much bigger piece of space so the ordered linear motions of the tachyons had transformed into the chaotic motions. The boundary of our Cosmos consists of the bigger tachyons the much bigger piece of space consisted of – this boundary causes that the fundamental physical constants in our Cosmos are invariant.

The Scale-Symmetric Theory starts with three assumptions:

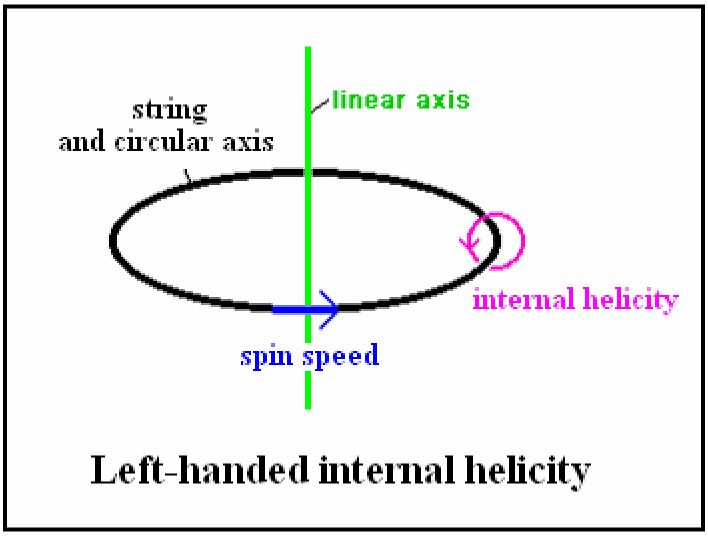
*That there exists the Higgs field composed of structureless non-gravitating tachyons that have a positive inertial mass only and have an infinitesimal spin in comparison with the reduced Planck constant, $\hbar$;

*That there are possible phase transitions of the Higgs field; and

*That among other stable objects arising due to the phase transitions of the Higgs field, the core of baryons arises. Due to the symmetrical decays of virtual bosons outside the core, the use of the Titius-Bode law for the strong interactions is obligatory. This will lead to an atom-like structure of baryons.

**1.2 The succeeding phase transitions of the superluminal Higgs field**

The tachyons have infinitesimal spin so a closed string/circle composed of tachyons should have internal helicity. This suggests that all the stable objects arising due to the succeeding phase transitions of the Higgs field should have internal helicity. Spheres cannot have internal helicity. Torus is the simplest object which can have an internal helicity.




Assume that a closed string is composed of $K^2$ adjoining tachyons (the square of the $K$ means that calculations are far simpler). The stable objects 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) – that saturates the interactions of stable objects via the Higgs field. The mass of the stable objects 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 neutrinos which consist of the binary closed strings (the binary closed strings are the superluminal entanglons responsible for the quantum entanglement), $d=4$ for the cores of baryons which consist of the neutrino-antineutrino pairs), and $d=8$ for cosmic objects which consist of the nucleons – they appeared after the inflation (it created the Cosmos) but before the ‘soft’ big bangs of the universes (in the Cosmos there are many universes). The cosmic objects defined by $d=8$ we will refer to as the protoworlds. The early Universe arose inside the Protoworld as the double cosmic loop. The evolution of the protoworlds leads to the dark matter, dark energy, and to the expanding universes.

Surface mass densities for all stable objects should have the same value. Furthermore, Nature immediately repairs any damages to stable objects – so they are the stable objects. We can see that the radii of the stable objects should be directly proportional to $K^{(d-1)}$.

The mean radii of the tori of stable objects are

$$r_d = r_1 K^{d-1}, \tag{6}$$

whereas the rest masses of the tori of the stable objects are

$$m_d = m_1 K^{2(d-1)}, \tag{7}$$

where $r_1$ and $m_1$ are for the closed string.

### 1.3 Program of the Scale-Symmetric Theory

In Table 1 we present the program of the SST. There are listed the dominating objects and characteristic features of the new fields appearing due to the succeeding phase transitions of the superluminal Higgs field.

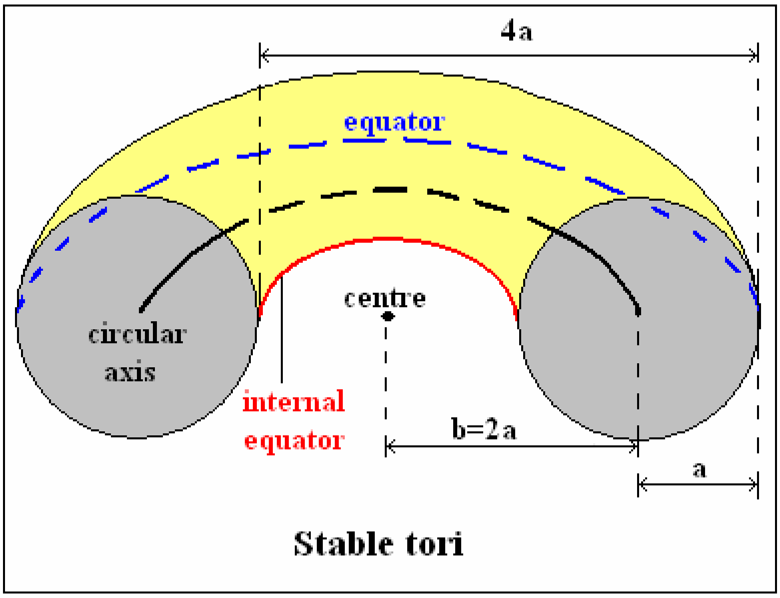
Table 1 *Program of the Scale-Symmetric Theory*

| Numeration of phase transitions | Objects dominating in field | Field | Characteristic features |
|---|---|---|---|
| 0 | Non-gravitating tachyons | Superluminal Higgs field | *The field directly associated with gravitational fields |
| 1 | Superluminal binary systems of closed strings (entanglons) | Finite field the neutrinos consist of | *Superluminal entanglons are directly responsible for quantum entanglement |
| 2 | Neutrino-antineutrino pairs | Einstein spacetime and fractal field | *Ground state of Einstein spacetime behaves classically whereas the excited states, due to entanglement, can behave in a quantum way<br>*Spin polarization of the pairs leads to SM or to fractal field<br>*Properties of electrons follow from structure of the Einstein spacetime<br>*Photons and gluons are the rotational energies of the pairs |
| 3 | Cores of baryons | Entangled and/or confined neutrino-antineutrino pairs (torus, condensate, loop) | *Phenomena that take place on surface of the core lead to the Titius-Bode law for the nuclear strong interactions i.e. lead to the atom-like structure of baryons |
| 4 | Protoworlds | Finite field composed of interacting nucleons the protoworlds consist of | *Evolution of protoworlds leads to the dark matter and dark energy and to the expanding universes |

**2. The internal dynamics of the baryons**

We know that following equation defines a torus:

$$(x^2 + y^2 + z^2 - a^2 - b^2)^2 = 4\, b^2 (a^2 - z^2). \qquad (8)$$



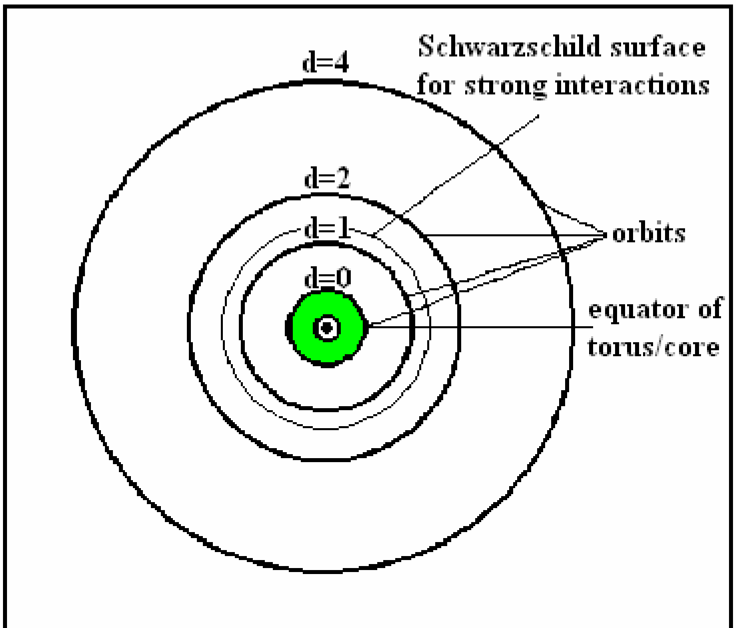

Physical tori are most stable when $b = 2a$ (see Fig. titled *"Stable tori"*). Therefore, the radius of the internal equator is equal to $a$. A most distant point of such torus (i.e. a point on the equator of torus) is in distance 3/2 of the mean radius resulting from formula (6). The radius of the equator we also refer to as external radius of torus. The stable objects that radii and masses of their tori are defined by formulae (6) and (7), have the natural speeds in the Higgs field, for example, the speed of the neutrino-antineutrino pairs is equal to the $c$. Spin speed on the equator of a torus in spacetime is practically equal to the natural speed of the components of the torus in the spacetime. This means that for $b = 2a$ the mean spin speed of whole torus is 2/3 of the natural speed of the components of a torus in spacetime. All components of a torus must have the same resultant speed in spacetimes. Because the mean spin speed is 2/3 of the natural speed in spacetime then there appear the radial speeds of the components of a torus. From the Pythagorean's theorem follows that the mean radial speed is $Z_1$=0.745355992 of the natural speed in the spacetimes. Due to the radial speeds of the components of a torus, the components are going through the circular axis of torus and through the centre. Notice that distance between the centre and circular axis is equal to diameter of the internal equator and equal to distance between the internal and external equators. Additional stabilization of the tori is due to the exchanged vortices produced by the components of the torus in the core of baryons – they cause that mean distance between the components of the torus is close to $2\pi R$, where $R$ is the equatorial radius of the stable neutrinos (electron- and muon-neutrinos are very stable whereas tau-neutrino, which consists of three different stable neutrinos, is unstable). Notice as well that the created negative pressures in the thickened beams of the Higgs field and Einstein spacetime when the beams are going through the surface of a torus stabilize the torus also.

The radial motions of the neutrino-antineutrino pairs in the core of baryons cause that in the centre of it is produced ball/condensate composed of confined pairs – it is the modified black hole with respect of the nuclear weak interactions. The term "modified black hole" means that there is not a singularity but there is a circle/equator on which the pairs have spin speed equal to the $c$. Due to the condensate/weak-black-hole, the mass of the central condensate and the mass of the torus are different.

On surface of the core of baryons, so on its equator as well, 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 there is produced a hole in the field surrounding the core. When the first part reaches the equator then the second one stops and decays to two identical parts – it takes place in distance $A + 2B$. Next decay takes place in distance $A + 4B$. A statistical distribution of the holes in the field in the plane of the equator (of the circular tunnels in field) is defined by following formula

$$R_d = A + dB, \tag{9}$$

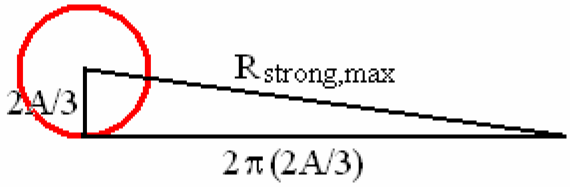
where $R_d$ denotes the radii of the circular tunnels, the $A$ denotes the external radius of the torus/core, $d = 0, 1, 2, 4$; the $B$ denotes the distance between the second tunnel ($d = 1$) and the first tunnel ($d = 0$). The first tunnel is in contact with the equator of the torus. Formula (9) is the Titius-Bode law for the nuclear strong interactions.



Cross-section of nucleon

On the circular axis of the torus in the core of baryons are produced virtual loops (we will call them the large loops) composed of the entangled rotating neutrino-antineutrino pairs. They have internal helicity – in baryons they have the left-handed internal helicity whereas in anti-baryons they are right-handed. The nuclear strong field of baryons consists of the open virtual loops that are the entangled gluons. Moreover, the cores of baryons as a whole are the modified black holes in respect of the nuclear strong interactions i.e. gluons on the equator have spin speed equal to the $c$. We can see that only the $d = 0$ and $d = 1$ states are placed under the Schwarzschild surface for the nuclear strong interactions.

The further calculations (see formula (25)) will show that the maximum range of the nuclear strong interactions is equal to $R_{strong,max} = 2.9582094$ fm (see Fig.) and that the $d = 4$ state defines the last orbit placed in the nuclear strong field.




**Maximum range of nuclear strong interactions:**
$R_{strong,max} = 2.9582094$ fm

In nucleons, in the $d = 1$ state, that is placed under the Schwarzschild surface, is relativistic pion that interacts with the core strongly – it is the reason that this pion cannot appear in decays of baryons but this pion can be exchanged for other relativistic pion.

The relativistic pion in the $d = 1$ state exchanges electric charge with the core. It causes that there are two different mass states in each nucleon.

We can see that statistical distribution of mass in nucleons and other baryons (in other baryons there are additional bosons in the $d$ states) is very complex. It causes that we never will able to describe internal structure of baryons via some equations. Moreover, we must apply other methods than the methods characteristic for the Standard Model. So how we can solve fruitfully the numerous unsolved basic problems in particle physics and cosmology?

It is obvious that we should start from the succeeding phase transitions of the superluminal Higgs field. The phase transitions cause that there appear new symmetries and forces that lead to correct statistical distributions of masses and their probabilities. Due to the superluminal gravity and superluminal quantum entanglement, there are the very quick step transitions between the different statistical distributions of mass. Moreover, probabilities can be different for different parts of the same mass state. We must decipher such distributions and find their probabilities – then we can apply following formula

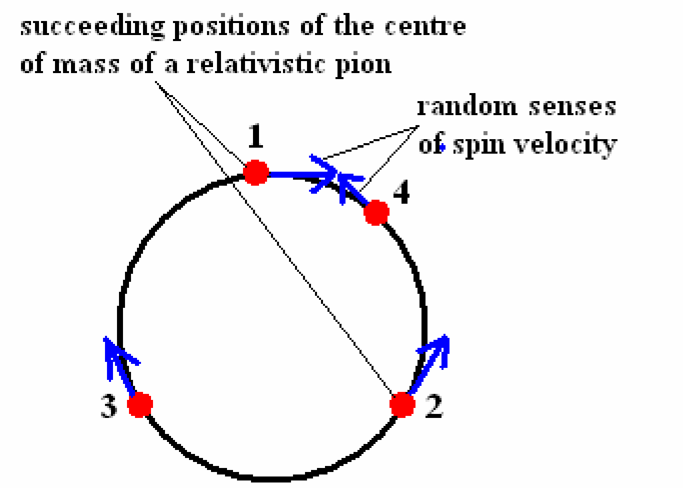
$$M_{Mean} = \Sigma_i \, a_i \, m_i \,, \tag{10}$$

where $a_i$ are the probabilities and $m_i$ are the masses of different states or masses of different parts of the same mass state. Similar formula can be applied to calculate a resultant spin.

The difference between the photons and gluons does not depend on their different structures. They both are the rotational energies of the neutrino-antineutrino pairs. The difference follows from their different interactions with fields having internal helicity (the nuclear strong fields have internal helicity; the three different helicities/colours of a carrier of gluon lead to eight different types of gluons) and having not (the gravitational fields and electromagnetic field have not internal helicity so there is only one type of photons). Emphasize once more that the rotating-spin neutrino-antineutrino pairs have three internal helicities (the three colours) but their internal structure is disclosed in the nuclear strong field only because this field, in contrary to the electromagnetic and gravitational fields, has internal helicity (it is due to the properties of the torus/charge in the core of baryons – the core of baryons produce the left-handed gluons whereas the core of anti-baryons produce right-handed gluons). It means that outside the nuclear strong fields the gluons behave as photons and vice versa.

In the Standard Model is assumed that many pions can simultaneously occupy the same state. Scale-Symmetric Theory shows that it is untrue in fields having internal helicity i.e. it does not concern the nuclear strong fields. A neutral pion consists of two large loops (in charged pions, among other particles, there are two large loops also – they can be virtual) both having left-handed internal helicity. Due to the internal helicity of the nuclear strong fields, the pions behave as the electron-electron pairs in the ground state in atoms i.e. the unitary angular momentums of the two large loops must be antiparallel. This means that the selection rules for the pions and loops created in baryons appears – they lead to the hyperons. There is the spin-1 signature of the Einstein spacetime so in the nuclear strong fields the spin-0 relativistic pions interact with the spin-1 gluons – to such bosons (more precisely: to a set of gluons interacting with relativistic pions) we can apply the Hund law. It leads to the spins of the hyperons consistent with experimental data.

Why all the $d$ states of the relativistic pions in baryons are the S states i.e. why all the azimuthal/secondary quantum numbers of the relativistic pions are $l = 0$? It results from the fact that a pion in defined $d$ state behaves as follows. Centre of mass of a pion disappears in one point of defined circular orbit/tunnel and appears in another one, and so on, but senses of the spin velocities of the pion change randomly – it causes that resultant angular momentum on the circular orbit is equal to zero (see Fig.).




S states (azimuthal number is $l = 0$) for circular orbits of quantum relativistic pions.

Only the large loops and relativistic charged pion in the $d = 1$ state have the unitary angular momentum. It leads to conclusion that only nucleons are the stable particles in relation to the nuclear strong interactions – other baryons are the unstable particles but there are two different possibilities:

*centre of mass of the relativistic pions is on the $d$ orbits and there are not loops overlapping with the orbits; such configuration leads to the hyperons which decay “slowly” due to the orbits/tunnels; masses of such pions will be denoted by $W_d$,

*besides the $W_d$ pions, there is one or more loops overlapping with the orbits/tunnels; the additional loops are in the short-lived resonance states; masses of such additional loops will be denoted by $S_d$.

SST shows as well that presented here the internal structure of baryons causes that there can be created particles, loops and condensates that mass is equal to the masses of quarks. Such objects appear as the object-antiobject pairs. But we must emphasize that the masses of quarks should not be among the initial conditions of SM.

Suppose that the neutrino-antineutrino pairs inside a condensate behave similarly to ionized gas in the stars. The theory of such stars says that the radiation pressure $p$ is directly in proportion to the four powers of absolute temperature $T$

$$p \sim T^4. \tag{11}$$

The analogous relation ties the total energy emitted by a black body with its temperature. Such theory also suggests that the absolute temperature of a star is directly in proportion to its mass. From it follows that total energy emitted by a star is directly proportional to the four powers of its mass. However, because the Heisenberg uncertainty principle results that the lifetime of a particle is inversely proportional to its energy we obtain that the lifetime of a condensate is inversely in proportion to the mass to the power of four

$$\tau_{Lifetime} \sim 1 / m^4. \tag{12}$$

The same relation concerns the loop/circular masses because they can collapse to condensate and vice versa.

SST shows that the formula for the coupling constants of the gravitational, weak and strong interactions is as follows:

$$\alpha_i = G_i M m / (c \hbar). \tag{13}$$

The energy of the interaction defines the formula

$$\Delta E_i = G_i M m / r, \tag{14}$$

then from (13) and (14) we obtain

$$\Delta E_i = \alpha_i c \hbar / r = m_i c^2. \tag{15}$$

From the uncertainty principle and formula (15) we obtain

$$\tau_{\mathrm{Lifetime}} \sim 1 / \alpha, \tag{16}$$

where $\alpha$ is the coupling constant.

To calculate lifetime of a particle we can apply formula (12) or formula (16).

## 3. Parameters in SST, fundamental physical constants, entanglons responsible for the quantum entanglement, neutrinos, electrons, pions, muons, and baryons

Here we described the origin of the fundamental physical constants and internal structure of fundamental particles.

### 3.1 The parameters in the Scale-Symmetric Theory (there do not appear free parameters)

Initial conditions contain the six parameters describing physical state of the Higgs field plus mass density of the Einstein spacetime. Mass density of the Einstein spacetime is the seventh parameter because it does not follow from the six parameters defining the Higgs field.

1. Mean size of tachyon is $2r_t = 0.9514211 \cdot 10^{-64}$ m
2. Mean linear speed of tachyon is $v_t = 2.386343972 \cdot 10^{97}$ m/s
3. Mean speed on equator of tachyon is $v_{st} = 1.725741 \cdot 10^{70}$ m/s
4. Mean inertial mass of tachyon is $m_t = 3.752673 \cdot 10^{-107}$ kg
5. Dynamic viscosity resulting from smoothness of surfaces of tachyons is $\eta = 1.87516465 \cdot 10^{138}$ kg/(m s)
6. Mean inertial mass density of the Higgs field is $\rho_N = 2.645834 \cdot 10^{-15}$ kg/m$^3$
7. Mean mass density of the Einstein spacetime is $\rho_E = 1.10220055 \cdot 10^{28}$ kg/m$^3$

The parameters in the Scale-Symmetric Theory.

Here we showed that the initial seven parameters lead to following set of new parameters applied in the GR and SM – obtained values are consistent or very, very close to experimental data [1]:

Gravitational constant: $G = 6.6740007 \cdot 10^{-11}$ m$^3$/(kg s$^2$)
Half-integral spin: $\hbar / 2 = (1.054571548 \cdot 10^{-34} / 2)$ Js
Speed of light in spacetimes: $c = 2.99792458 \cdot 10^{8}$ m/s
Electric charge of electron: $e = 1.60217642 \cdot 10^{-19}$ C
Mass of electron: $m_{electron} = 0.510998906$ MeV
Mass of free neutral pion: $m_{pion(o),free} = 134.97674$ MeV
Mass of charged pion: $m_{pion(+-)} = 139.57041$ MeV.

### 3.2 Fundamental symmetries and laws of conservation

The parameters in the Scale-Symmetric Theory lead to following fundamental symmetries and laws of conservation:

*__Internal helicity__: Since tachyons have the infinitesimal spin so objects composed of them must have internal helicity. Loops and tori are the simplest objects that can have internal helicity.

*__Symmetry concerning the saturation of fundamental interactions that follows from the viscosity of the tachyons the closed strings are built of__: Saturation of interactions of the closed strings (they consist of the non-gravitating tachyons) via the superluminal Higgs field forces that an object composed of $N$ tachyons interacts with $N$ such objects i.e. the next bigger object contains $N^2 + N$ tachyons. But the smallest object, i.e. the closed string, is built of $N \approx 0.624 \cdot 10^{20}$ tachyons (we will derive it from the initial parameters) so $N^2 >> N$ so we can assume that the succeeding bigger structures contain following number of tachyons: $N^d$, where $d = 0$ (free tachyons), $1$ (for closed string), $2, 4, 8, 16$.

*__Spin invariance__: The spin signature of Nature should be equal to the spin of the smallest loops (i.e. closed strings) – we will show that it is the half-integral spin. But due to the vortices produced in the superluminal Higgs field by the closed strings, there, during the inflation, appeared the binary systems of closed strings so spin signatures of Nature are both the half-integral for fermions and unitary for vectorial bosons.

*__Surface-density invariance__: Bigger tori consist of smaller tori. Tori surface density at all scales must be the same – then the immediate repair of surfaces of tori is possible.

*__The law of conservation of energy__: Number of tachyons and their mean energy are invariant so there is obligatory the law of conservation of energy. But due to the superluminal speeds of the components of the Higgs field that is directly associated with the gravitational fields, in gravity the law of conservation of energy is non-local.

*__Symmetrical decays of spin-0 bosons__: Such decays lead to the Titius-Bode law for interactions near to the modified black holes – such black holes do not contain a singularity but there is a circle on which the spin speed is equal to the speed of light in "vacuum" c, whereas the Schwarzschild radius is two times greater than the circle.

Of course, due to the succeeding phase transitions of the superluminal Higgs field, there appear more and more symmetries and laws of conservation.

### 3.3 Superluminal closed strings, half-integral spin, the four-particle symmetry, entanglons responsible for quantum entanglement and unitary spin

Since non-gravitating tachyons have linear and rotational energies the rotary vortices appear, i.e. the closed strings having internal helicity (see Fig. titled *"Left-handed internal helicity"*). A closed string is stable because of viscosity of the tachyons that follows from smoothness of their surface. Because of the shape of a closed string, the pressure is lowest on its internal equator (see Fig. titled *"Stable tori"*). This means that the vortices in the Higgs field around a closed string becomes detached from it on the internal equator. There appears a collimated jet in the Higgs field.

Closed strings were produced in regions with the tachyons packed to the maximum – such condition was satisfied at the beginning of the inflation. Such a state of the Higgs field behaves as incompressible liquid. The Reynolds number $N_R$ for maximum dense Higgs field is

$$N_R = \rho_t v_t (2\, r_t) / \eta = 1.0076047 \cdot 10^{-19}. \qquad (17)$$

In this definition the $\rho_t$ denotes the maximum density of the Newtonian spacetime – this is the mass density of a tachyon and is $\rho_t = 8.32192436 \cdot 10^{85}$ kg/m$^3$ (this value is close to value applied in the Loop Quantum Gravity: about $10^{85}$ kg/m$^3$ [2]). The $(2\, r_t)$ is the size of the element of a closed string or distance between the layers in the liquid.

Because $N_R = 0$ is for infinitely viscid fluid, the liquid behaves as a solid body and the radius of a vortex can be infinite. On the other hand, the radius of a vortex should be directly proportional to the size of the element of a vortex. We can define the radius of the spinning closed string, $r_1$, as follows

$$r_1 = (2\, r_t) / N_R = 0.94424045 \cdot 10^{-45} \text{ m}. \tag{18}$$

Only closed strings that have such a radius can arise in the Higgs field. The closed strings are inflexible. We can now calculate the number of tachyons $K^2$ a closed string consists of as follows:

$$K^2 = 2\, \pi\, r_1 / (2\, r_t) = (0.7896685548 \cdot 10^{10})^2. \tag{19}$$

The spin of each closed string is half-integral

$$Spin = K^2\, m_t\, v_t\, r_1 = \hbar / 2 = (1.054571548 \cdot 10^{-34}/2) \text{ Js}. \tag{20}$$

The first phase transition of the Higgs field leads to the closed strings with internal helicity. This suggests that all the stable objects arising due to the phase transitions of the Higgs field should have internal helicity. It follows from the fact that all objects are built of the tachyons that have infinitesimal spin which leads to the internal helicity. Just Nature copies the initial properties in bigger scales also. Spheres cannot have internal helicity. Torus is the simplest object, which can have an internal helicity.

The Higgs field as a whole should have the resultant internal helicity and spin equal to zero. It leads to the four-particle symmetry. To eliminate the turbulences in the initial state of the Higgs field, there appeared groups of four closed strings. The configuration in a group was as follows. There were two spin-1 binary systems with antiparallel spins and each binary system consisted of two spin-1/2 closed strings with overlapping directions of parallel spins and opposite internal helicities.

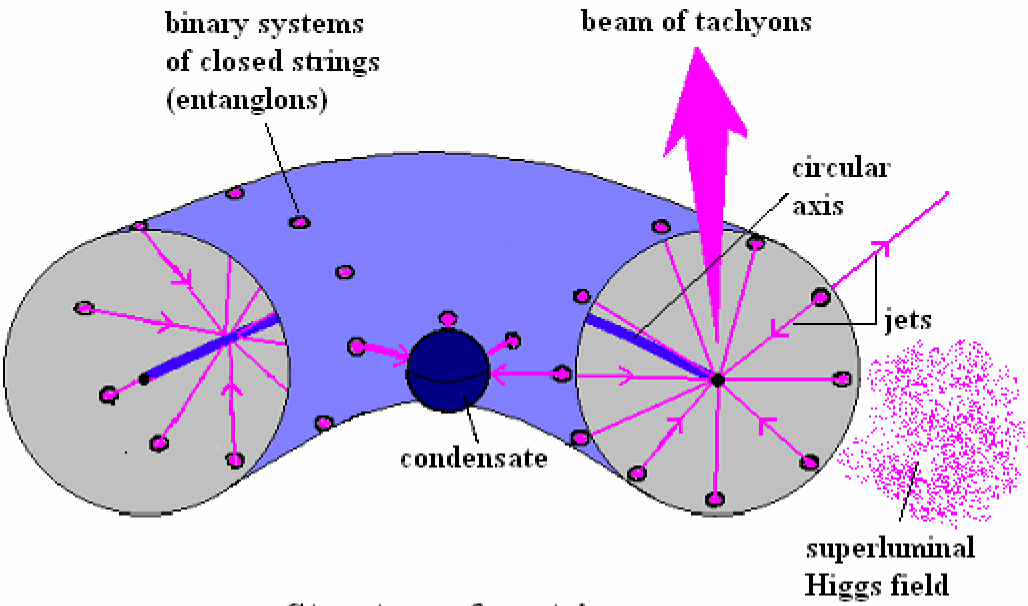
We can see that spin-signature of field composed of the binary closed strings is 1 – we will call them the entanglons responsible for the quantum entanglement. Each entanglon produces a pair of antiparallel jets in the Higgs field. Due to the opposite internal helicities of the closed strings in an entanglon, in the Higgs field between the closed strings arises area with lower pressure i.e. there appears an attraction between the two closed strings – it causes that the entanglons are the very stable objects.

### 3.4 Fundamental physical constants, neutrinos, electrons, pions, muons, and baryons

Neutrinos, electrons, cores of baryons, and the cores of protoworlds appear similar to, for example, the NGC 4261 galaxy i.e. there is a condensate in the centre of a torus. The surface of a torus looks similar to the Ketterle surface for a strongly interacting gas [3]. The tori consist of binary systems of smaller tori. The charges and spins of particles depend on the internal structure of the tori. The torus of the stable neutrinos consists of entanglons. The tori of the core of baryons and electrons (electron is only polarized in a specific way the Einstein spacetime) are composed of the neutrino-antineutrino pairs with unitary spin. The torus of the Protoworld (the Protoworld arose after the inflation) was composed of nucleons.

All spins are perpendicular to surface of the torus of a neutrino. There are four possibilities. On surface of the torus/weak-charge of a neutrino, the senses of all spins of the entanglons are towards the circular axis of the neutrino whereas in its weak anticharge all have opposite senses. The tori of neutrinos have also internal helicity – it results from the internal helicity of the more fundamental closed strings (their internal helicity follows from the infinitesimal spin of tachyons so the internal helicity is the fundamental feature of tori/charges). It leads to the four states of stable neutrinos (there are the two spin-orientations of the entanglons on surface of the torus and two different helicities of it). We can see that there are only two species of stable neutrinos (the electron- and muon-neutrinos and their antineutrinos) and the third unstable tau-neutrino composed of three different entangled stable neutrinos.

The exchanges of entanglons in a neutrino cause that their number density increases on the circular axis and in the centre of torus so there appear a loop inside the torus and a condensate in the centre of torus (inertial-mass density in these two regions is higher). The torus of the core of baryons consists of the neutrino-antineutrino pairs whereas the torus of Protoworld consists of nucleons so analogical phenomena take place in these objects as well.




Structure of neutrino

The neutrinos composed of the entanglons (entanglons are built of the non-gravitating tachyons) acquire their gravitational mass because of the interactions with the superluminal Higgs field (they follow from the viscosity of tachyons and internal helicities of entanglons). Just neutrinos transform the chaotic motions of tachyons in the superluminal Higgs field into the divergent motions of them. The collisions of the divergently moving tachyons with the chaotically moving tachyons produce gradient in the superluminal Higgs field – it is the gravitational field of a stable neutrino. Stable neutrinos carry the smallest gravitational mass. Because in spacetime (the Higgs field plus the Einstein spacetime) there are not free entanglons so the Einstein formula $E = mc^2$ is not valid for neutrinos – their speed is equal to the $c$ (it does not concern the weak decays inside the nuclear strong fields) but their mass is invariant.

Inside the tori are produced loops. From the Uncertainty Principle, for loop having angular momentum equal to 1, we obtain that mass of a loop $m_{loop,d}$ is $X_o$ times smaller than the mass of torus calculated from (7)

$$X_o = m_d / m_{loop,d} = 3\,\pi\, m_d v_d r_d / \hbar = 3\,\pi / 2 = 4.71238898. \tag{21}$$

For example, the large loops produced inside the torus in the core of baryons, which are responsible for the strong interactions, have mass $m_{LL} = 67.5444107$ MeV.

Due to the succeeding phase transitions of the superluminal Higgs field, Nature equips the closed strings, neutrinos, cores of baryons and cores of protoworlds with the same half-integral spin. Because all fundamental tori/charges have the same spin then from following formula

$$m\, v\, r = \hbar / 2, \tag{22}$$

we can calculate the natural speeds of the listed fundamental objects in the spacetime (it is the superluminal Higgs field plus the Einstein spacetime). The spin speed of a fundamental object, which is a component of a torus on its equator, is equal to the natural speed of the component in the spacetime. The neutrino-antineutrino pairs on equator of the core of baryons are moving with speed equal to the $c$ (i.e. with speed $3/2$ of the spin speed resulting from (22)) and it is the natural speed of the neutrino-antineutrino pairs in the spacetime

$$c = 3\,\hbar / (4\, m_4 r_4) = 3\,\hbar / (4\, m_t r_1 K^{11}) = 299792458 \text{ m/s}, \tag{23}$$

where mass of the torus in the core of baryons is (see formula (7))

$$X = m_4 = 318.295537 \text{ MeV} \tag{24}$$

whereas the radius of equator of the torus in the core of baryons is

$$A = 3\, r_4 / 2 = 0.69744247 \text{ fm}. \tag{25}$$

In centre of the torus of the core of baryons is the condensate with a mass of $Y$ that is the modified black hole in respect of the nuclear weak interactions. Calculated further the ratio of mass of the condensate and the torus, $X$, is (see formulae (72) and (73))

$$Z_2 = Y / X = 1.3324865 \tag{26}$$

times greater than mass of the torus calculated from formula (7). The same value is obligatory for neutrinos and protoworlds.

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

$$G = g\, \rho_N = 6.6740007 \cdot 10^{-11} \text{ m}^3/(\text{kg s}^2), \tag{27}$$

where the $g$ has the same value for all interactions and is equal to

$$g = v_{st}^4 / \eta^2 = 25{,}224.563 \text{ m}^6/(\text{kg}^2 \text{ s}^2). \tag{28}$$

The further calculations show that due to the weak binding energy, mass of the core of baryons (it is 727.440 MeV (see formula (56)) is 14.980 MeV (see explanation below formula (73)) smaller than the sum $X + Y$. This leads to conclusion that the masses of neutrinos, cores of baryons and cores of protoworlds are about

$$Z_3 = 2.2854236 \tag{29}$$

times greater than the mass of tori calculated from (7). For example, the mass of neutrino is $m_{neutrino} = 3.3349306 \cdot 10^{-67}$ kg. Present-day detectors cannot measure mass with such accuracy. Moreover, the resultant weak charge of the neutrino-antineutrino pairs is equal to zero so their detection is much more difficult than the neutrinos. We can detect only their rotational energies i.e. energies of the photons.

The number of the neutrino-antineutrino pairs, $Z_4$, on the torus in the core of a baryon is

$$Z_4 = m_4 / (2\, m_{neutrino}) = 8.50712236 \cdot 10^{38}. \tag{30}$$

Mean distance, $L_1$, of the neutrino-antineutrino pairs on the torus in the core of a baryon is

$$L_1 = (8\, \pi^2 A^2 / (9\, Z_4))^{1/2} = 7.08256654 \cdot 10^{-35} \text{ m}. \tag{31}$$

Mean distance, $L_2$, of the neutrino-antineutrino pairs in the Einstein spacetime is

$$L_2 = (2\, m_{neutrino} / \rho_E)^{1/3} = 3.92601594 \cdot 10^{-32} \text{ m}. \tag{32}$$

The ratio, $Z_5$, of the mean distances is

$$Z_5 = L_2 / L_1 = 554.321081. \tag{33}$$

The Compton length, $\lambda\!\!\!^{-}_{bare\text{-}electron}$, of the bare electron is

$$\lambda\!\!\!^{-}_{bare(electron)} = A\, Z_5 = 3.8660707 \cdot 10^{-13} \text{ m}. \tag{34}$$

The bare mass of electron is

$$m_{bare(electron)} = \hbar / (c\, \lambda\!\!\!^{-}_{bare(electron)}) = 0.510407011 \text{ MeV}. \tag{35}$$

The further calculations show that $m_{electron} = 1.0011596521735\, m_{bare(electron)}$ (see formula (97)) so we obtain following mass of electron $m_{electron} = 0.510998906$ MeV (for 1MeV = $1.78266168115 \cdot 10^{-30}$ kg).

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

$$k\, e^2 / (\hbar\, c) = G_{em}\, m_{electron}^{\;\;2} / (\hbar\, c), \tag{36}$$

where $k = c^2 / 10^7$ whereas $G_{em} = G\, \rho_E / \rho_N = 2.78025274 \cdot 10^{32}$ m$^3$/(kg s$^2$).

From formula (36), we can calculate the electric charge, $e$, of electron

$$e = m_{electron} (G\, \rho_E\, 10^7 / \rho_N)^{1/2} / c = 1.60217642 \cdot 10^{-19} \text{ C}, \tag{37}$$

and next the fine-structure constant, $\alpha_{em}$,

$$\alpha_{em} = e^2\, c / (10^7\, \hbar) = 1/137.036001. \tag{38}$$

The ratio of the binding energy of two large loops, $\Delta E_{LL}$, resulting from creations of the electron-positron pairs, to the mass of large loop, $m_{LL}$, is (energy is inversely proportional to a length; there is involved the core of baryons with the radius $A$ and the bare electron with the radius $\lambda\!\!\!^{-}_{bare(electron)}$)

$$\Delta E_{LL} / m_{LL} = A / \lambda\!\!\!^{-}_{bare(electron)}. \tag{39}$$

From this formula we obtain $\Delta E_{LL} = 0.1218507$ MeV.

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

$$\Delta E_{pion(o)} = \Delta E_{LL} (1 + \alpha_{em}) = 0.12273989 \text{ MeV}. \tag{40}$$

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

$$m_{pion(o)} = 2\, m_{LL} - \Delta E_{pion(o)} = 134.96608 \text{ MeV}. \tag{41}$$

The core of baryons produces the large loops with left-handed internal helicity whereas core of anti-baryons right-handed. Neutral pion produced by baryons is built of two left-handed large loops. Such binary system is stable when pressure between the loops is lowered. To create such pressure, the angular momentums of the loops must be antiparallel – then local helicities are opposite and because of creation of vortices in spacetime and the narrowing between the loops there is created the lowered pressure. Moreover, on the circular axis of the torus in the core of baryons there can appear only spin-0 and uncharged objects (it concerns objects interacting due to the nuclear strong interactions) because only then spin and charge of the torus is conserved. It leads to conclusion that there already appear the neutral pions and pairs of charged pions with resultant charge equal to zero. Due to the same reason, the electron-positron pairs are the spin-1 objects – it follows from the fact that internal helicities of the electron and positron are opposite so spins must be parallel. It causes that the electron-positron pairs have the same spin-signature as the Einstein spacetime.

The further calculations show that virtual boson with a mass of about 540 MeV has range equal to $A$ which is the equatorial radius of the core of baryons (see explanation below formula (54)). This mass is equivalent to mass of 8 virtual large loops. On the circular axis of the core is created the ninth virtual large loop so near the core of baryons can appear at the same time 9 virtual open large loops. They can produce nine virtual electron-positron pairs. Since with the rest mass of electron at the same time is associated one virtual bare electron-positron pair (the further calculations show that such assumption leads to the magnetic moment of electron consistent with experimental data: see formulae (88)–(97)) then the nine virtual electron-positron pairs force production of relativistic electron having mass

$$Z_6 = 9 \cdot 1.0011596521735 = 9.01043687 \tag{42}$$

times greater than the rest mass of electron. To produce spin-0 object, such electron must interact with electron antineutrino. Sometimes negatively charged pion decays to neutral pion, electron and electron antineutrino so mass of the charged pion is

$$m_{pion(+-)} = m_{pion(o)} + m_{electron} Z_6 = 139.57041 \text{ MeV}. \tag{43}$$

Outside the nuclear strong field, the radiation mass of the neutral pion disappears so the measured mass of the free neutral pion is

$$m_{pion(o),free} = m_{pion(+-)} - 9\, m_{bare(electron)} = 134.97674 \text{ MeV}. \tag{44}$$

The $\alpha$-order correction for the radiation energy, $m_{em} c^2$, created in the interactions of the virtual or real electron-positron pairs (it is a virtual or real photon emitted by an electrically charged particle) is

$$m_{em} c^2 = k\, e^2 / \lambda_C, \tag{45}$$

where $k = c^2 / 10^7$, the $\lambda_C$ is the Compton wavelength of a particle.

The Compton wavelength of electrically charged particle is

$$\lambda_C = 2\, \pi\, \hbar / (c\, m_{bare}). \tag{46}$$

Then from (45) and (46) we obtain

$$m_{em} = C\, m_{bare}, \tag{47}$$

where $C = e^2\, c / (2\, \pi\, 10^7\, \hbar) = 0.00116141$ and $m_{bare} = m / (1 + C)$.

The simplest neutral pion consists of four rotating-spin neutrinos. The charged pion more often than not, decays into a muon and a neutrino. We can assume that mass of a <u>bound</u> muon is equal to mass of a charged pion minus the one quarter of the mass of a neutral pion

$$m_{muon} = m_{pion(+-)} - m_{pion(o)} / 4 = 105.82889 \text{ MeV}. \tag{48}$$

It is obvious that there must be a reason that the mass of the muon is so and not another. In electron, both the circular mass and the mass of the condensate in its centre are the same 0.2552035 MeV. On the other hand, in the core of baryons, the mass of the torus and the condensate are not the same. The further calculations will show that contrary to the bare electron, the condensate in the core of baryons with a mass of $Y = 424.1244$ MeV is the modified black hole in respect of the nuclear weak interactions (see formula (72)). It is easy to notice that this mass is the sum of the mass of the torus, $X = 318.2955$ MeV, and the mass of a <u>bound</u> muon

$$Y = X + m_{muon} = 424.1244 \text{ MeV}. \qquad (49)$$

The further very precise calculations lead to $Y = 424.124493$ MeV (see explanations concerning formulae (72) and (73)).

Due to the nuclear strong interactions, in the decays of particles most often appear the neutral and charged pions. The charged pions decay to muon and muon-neutrino. We can assume that the bound neutral pion gains the mass at the cost of the mass of the bound muon. Moreover, there is emitted the radiation mass of charged pion (see formula 47). It leads to conclusion that mass of free muon is

$$m_{muon,free} = m_{muon} - (m_{pion(o),free} - m_{pion(o)}) - C\, m_{pion(+-)} / (1 + C) =$$

$$= 105.656314 \text{ MeV}. \qquad (50)$$

**3.5 Structure of baryons at low energy**

Hyperons arise very quickly because of strong interactions. They decay slowly due to the $d$ tunnels/orbits (in the tunnels, the bosons interact with the Einstein spacetime because of the nuclear weak interactions).

The relativistic pions in the tunnels "circulate" the torus (they are the $S$ states i.e. $l = 0$). Such pions we refer to as $W_d$ pions because they are associated with strong-**W**eak interactions. The pions behave in a similar way both in nucleons and in hyperons. Their mass is denoted by $m_{W(+-o),d}$.

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 nucleon, should have unitary angular momentum because this state is the ground state for $W_d$ pions:

$$m_{W(+-),d=1} (A + B)\, v_{d=1} = \hbar, \qquad (51)$$

where $v_{d=1}$ denotes the speed of the $W_d$ pion in the $d = 1$ state.

We can calculate the relativistic mass of the $W_d$ pions using Einstein's formula

$$m_{W(+-o),d} = m_{pion(+-o)} / (1 - v_d^2 / c^2)^{1/2}. \qquad (52)$$

We know that the square of the speed is inversely proportional to the radius $R_d$ (for $d = 1$ is $v^2_{d=1} = c^2 A / (A + B)$) so from (28) and (30) we have:

$$m_{W(+-o),d} = m_{pion(+-o)} (1 + A / (d\, B))^{1/2}. \qquad (53)$$

Since we know the $A$ then from formulae (51)–(53) we can obtain the $B = 0.5018395$ fm. We see that the $d = 1$ state is lying under the Schwarzschild surface for the nuclear strong interactions. We showed that range of the nuclear strong interactions cannot be greater than $R_{strong,max} = 2.9582094$ fm. It leads to conclusion that the radius of the last orbit for the strong interactions is $A + 4B = 2.7048$ fm. We will prove that the second solution $B' = 0.9692860$ fm is not valid.

Creation of a resonance is possible when loops overlap with tunnels. Such bosons I call $S_d$ bosons because they are associated with the nuclear **S**trong interactions. Their masses are denoted by $m_{S(+-o),d}$. The spin speeds of $S_d$ bosons (they are equal to the $c$) differ from the speeds calculated on the basis of the Titius-Bode law for strong interactions – this is the reason why the lifetimes of resonances are short.

The mass of the core of resting baryons is denoted by $m_{H(+-0)}$. The maximum mass of a virtual $S_d$ boson cannot be greater than the mass of the core so we assume that the mass of the $S_d$ 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, from (9) we obtain:

$$m_{H(+-0)} A = m_{S(+-o),d} (A + d B). \tag{54}$$

There is some probability that virtual $S_d$ boson arising in the $d = 0$ tunnel decays to two parts. One part covers the distance $A$ whereas the remainder covers the distance $4B$. The large loops arise as binary systems (i.e. as the neutral pions). The part covering the distance $A$ consists of four virtual neutral pions (i.e. of the eight large loops). Then the sum of the mass of the four neutral pions (539.87 MeV) and the mass of the remainder (187.57 MeV) is equal to the mass of the core of baryons and is equal to the mass of $S_d$ boson in the $d = 0$ state (727.44 MeV).

Denote the mass of the remainder (it is the $S_d$ boson) by $m_{S(+-),d=4}$, then:

$$m_{S(+-),d=4} = m_{H(+-)} - 4\, m_{pion(o)}. \tag{55}$$

Since there is the positron→core-of-proton transition, we should increase the mass of core by the electromagnetic energy emitted due to this transition. From this condition and using formulae (54) and (55) we have

$$m_{H(+-)} = m_{pion(o)} (A / B + 4) + \alpha_{em}\, m_{bare(electron)} = 727.440123 \text{ MeV}. \tag{56}$$

There is some analog to the energy appearing during this transition. The further calculations show that the weak energy of the large loop is $\alpha_{w(proton)}\, m_{LL} = 1.265$ MeV (see (73)) and such energy is needed in the proton→<u>bound</u>-neutron transition (see formulae (62) and (63a)).

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 distance of masses between the charged and neutral cores) and the carrier of an electric charge interacting with the charged pion (this is the electron). Assume that:

$$(m_{H(+-)} - m_{H(o)}) / m_{H(+-)} = m_{electron} / m_{pion(+-)}. \tag{57}$$

Formula (57) leads to the distance of mass between the charged and neutral core equal to 2.663 MeV. Similar value we obtain for electron (plus electron antineutrino) placed on the circular axis of the core (i.e. the centre of the condensate in electron is placed on this axis). Then the electromagnetic binding energy is $3\, k\, e^2 / (2\, A\, c^2) = 3.097$ MeV. If we subtract the mass of electron we obtain $E_{b1} = 2.586$ MeV. The weak binding energy of the $E_{b1}$ interacting with the core of baryon is $E_{b2} = 3\, G_w\, E_{b1}\, m_{H(+)} / (2\, A\, c^2) = 0.0831$ MeV . It leads to the distance of masses between the charged and neutral core equal to $E_{b1} + E_{b2} =$ 2.669 MeV.

The results obtained from formulae (53)–(57), with the value $A / B = 1.389772$, are collected in Table 2 (the masses are provided in MeV).

Table 2 *Relativistic masses*

| **d** | $\mathbf{m_{S(+-)}}$ | $\mathbf{m_{S(o)}}$ | $\mathbf{m_{W(+-)}}$ | $\mathbf{m_{W(o)}}$ |
|---|---|---|---|---|
| 0 | 727.440123 | 724.776800 | | |
| 1 | 423.043 | 421.494 | 215.760 | 208.643 |
| 2 | 298.243 | 297.151 | 181.704 | 175.709 |
| 4 | 187.573 | 186.886 | 162.013 | 156.668 |

We showed that there is obligatory the four-particle symmetry. The mass of group of four virtual remainders is smaller than the mass of the virtual field of nucleon (the upper limit for such mass is $2M$, where $M$ is the mass of bare particle). This leads to conclusion that the symmetrical decays of the group of the four remainders 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 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 identical particles, and so on. In place of the decay, a "hole" appears in the Einstein spacetime. A set of such holes is some "tunnel". The $d = 4$ orbit is the last orbit for strong interactions because on this orbit the remainder decays into photons so strong interactions disappear. We see that there is not in existence a boson having range equal to the $B'$ so this solution is not realized by Nature.

There is a probability that the $y$ proton is composed of $H^+$ and $W_{(o),d=1}$ and a probability that $1–y$ is composed of $H^o$ and $W_{(+),d=1}$. From the Heisenberg uncertainty principle follows that 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 $W_d$ pions so from this condition and (53) we have

$$y = m_{pion(+-)} / (m_{pion(+-)} + m_{pion(o)}) = 0.5083856, \tag{58}$$

$$1- y = m_{pion(o)} / (m_{pion(+-)} + m_{pion(o)}) = 0.4916144. \tag{59}$$

There is a probability that the $x$ neutron is composed of $H^+$ and $W_{(-),d=1}$ and a probability that $1–x$ is composed of $H^o$, resting neutral pion and $Z^o$. The mass of the last particle is $m_{Z(o)} = m_{W(o),d=1} - m_{pion(o)}$ (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 resting neutral pion is greater than the mass of $Z^o$ (so the neutral pion lives shorter) then

$$x = m_{pion(o)} / m_{W(-),d=1} = 0.6255371, \tag{60}$$

$$1- x = 0.3744629. \tag{61}$$

The mass of the baryons is equal to the sum of the mass of the components because the binding energy associated with the strong interactions cannot abandon the strong field.

The mass of the proton is

$$m_{proton} = (m_{H(+)} + m_{W(o),d=1})\, y + (m_{H(o)} + m_{W(+),d=1})\, (1- y) = 938.2725 \text{ MeV}. \quad (62)$$

The mass of the bound neutron is

$$m_{neutron} = (m_{H(+)} + m_{W(-),d=1})\, x + (m_{H(o)} + m_{pion(o)} + m_{Z(o)})(1- x) = \\ = 939.5378 \text{ MeV}. \quad (63a)$$

In the beta decay of a neutron there appears additional weak mass that results from the weak interactions of proton with electron: $\alpha'_{w(electron\text{-}proton)}\, m_{neutron}$ (see formula (86)). But this nuclear weak energy transforms in the decay into electromagnetic energy so it increases $\alpha_{w(proton)} / \alpha_{em} = 2.56571$ times (see formulae (73) and (38)). It leads to the mass of the free neutron

$$m_{neutron,free} = m_{neutron} + (\alpha_{w(proton)} / \alpha_{em})\, \alpha'_{w(electron\text{-}proton)}\, m_{neutron} = \\ = 939.5648 \text{ MeV}. \quad (63b)$$

The proton magnetic moment in the nuclear magneton is

$$\mu_{proton} / \mu_o = m_{proton}\, y / m_{H(+)} + m_{proton}\, (1-y) / m_{W(+),d=1} = +2.79360. \quad (64)$$

The neutron magnetic moment in the nuclear magneton is

$$\mu_{neutron} / \mu_o = m_{proton}\, x / m_{H(+)} - m_{proton}\, x / m_{W(-),d=1} = -1.91343. \quad (65)$$

The mean square charge for the proton is

$$<Q_{proton}^2> = e^2\, [y^2 + (1-y)^2] / 2 = 0.25e^2 \text{ (quark model gives } 0.33e^2) \quad (66)$$

The mean square charge for the neutron is

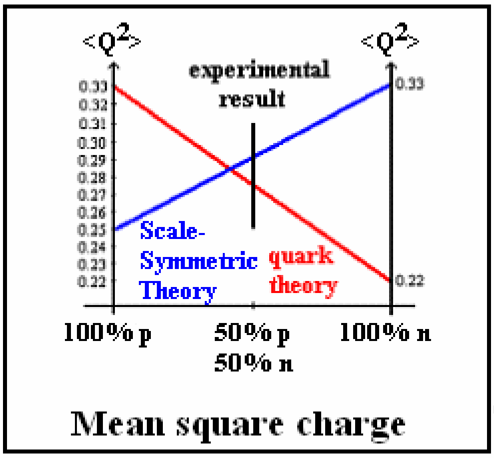
$$<Q_{neutron}^2> = e^2\, [x^2 + (-x)^2] / (2\, x + 3\, (1-x)) = \\ = 0.33e^2 \text{ (quark model gives } 0.22e^2), \quad (67)$$

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

The mean square charge for the nucleon is

$$<Q^2> = [<Q_{proton}^2> + <Q_{neutron}^2>] / 2 = 0.29e^2 \text{ (quark model gives } 0.28e^2). \quad (68)$$

Inside baryons are produced particles carrying the fractional electric charges so arithmetic mean of both results should lie inside the interval determined by the experiment (the experimental values of the $<Q^2>$ are $(0.25, 0.31)e^2$). We see that it is true. But there is the place for the masses of quarks too – it is described in paper titled *“Reformulated Quantum Chromodynamics”*.




Notice that the ratio of the mass distance between the charged and neutral pions to the mass of an electron is equal to the ratio of the masses of a charged core of baryons $H^+$ and $Z^+$, where $m_{Z(+)} = m_{W(+),d=1} - m_{pion(o)}$. This should have some deeper meaning. Assume that the increase in the mass of electrons and $Z^+$ boson are realized in the $d = 0$ state because this tunnel has some width resulting from the diameter of the condensate of the virtual $H^+$ created on the equator of the torus of the core of baryons. The width of the $d = 1$ tunnel means that the mentioned particles in this tunnel do not move with a speed equal to the $c$. The relativistic masses of the $W_d$ pions can be calculated using Einstein's formula (52). Definition of the coupling constant for the strong-weak interactions $\alpha_{sw}$ (the core of baryons is the modified black hole with respect to the strong interactions i.e. on the equator of torus the spin speed is equal to the $c$) leads to following formula

$$\alpha_{sw} = G_{sw} M\, m / (c\, s_d) = m\, v_d^2\, r_d / (c\, s_d) = v_d / c, \qquad (69)$$

where $G_{sw}$ denotes the strong-weak constant, $s_d$ is the angular momentum of particle in the $d$ state whereas $v_d$ is the speed in the $d$ tunnel. In the Einstein spacetime can appear particles or binary systems of particles having spin equal to 1 because such spin have the components of the Einstein spacetime i.e. the neutrino-antineutrino pairs. For example, for the large loop responsible for the strong interactions is $s_d = \hbar$ and $v_d = c$ – it leads to $\alpha_{sw(large\text{-}loop)} = 1$.

From formulae (52) and (69) we obtain

$$\alpha_{sw(Z(+),d=0)} = v_{d=0} / c = (1 - (m_{Z(+)} / m_{H(+)})^2)^{1/2} = 0.993812976. \qquad (70)$$

The $r_{p(proton)}$ denotes the radius of the condensate of a proton and the range of the weak interactions of the condensate of a proton. The condensate appears due to the confinement of the neutrino-antineutrino pairs the condensate consists of. The range of the confinement of a neutrino pair is 3510.1831 times bigger than the external radius of the torus of neutrino (see Chapter *"Interactions"*) so this radius is much smaller than the radius of the condensate of a proton. Because $v^2 = G_{sw}\, m_{H(+)} / r$ and because the particle $Z_{(+-o),d=0}$ is in distance $r = r_{p(proton)} + A$ from the centre of torus then from formula (70) we obtain

$$A / (r_{p(proton)} + A) = (v_{d=0} / c)^2 = 1 - (m_{Z(+)} / m_{H(+)})^2. \qquad (71)$$

Then $r_{p(proton)} = 0.8710945 \cdot 10^{-17}$ m.

We calculated the mass of the torus in the core of baryons: $X = m_{c(proton)} = 318.295537$ MeV. We showed that mass of the condensate in centre of the torus should be equal to the sum of the mass of the torus and the mass of bound muon (see formula (49)). The explanation below formula (73) leads to the very precise value $Y = 424.124493$ MeV.

Since on the equator of the condensate the spin speed of the binary systems of neutrinos must be equal to the $c$ then we can calculate the constant for the weak interactions

$$G_w = c^2 r_p / Y = 1.0354864 \cdot 10^{27}\ \mathrm{m^3 s^{-2} kg^{-1}}. \tag{72}$$

The coupling constant for weak interactions of protons, $\alpha_{w(proton)}$, can be calculated using the formula-definition

$$\alpha_{w(proton)} = G_w Y^2 / (c\, \hbar) = 0.0187228615. \tag{73}$$

$Y$ is both the mass of the source and the carrier of weak interactions.

The distance of mass between $X + Y$ and $H^+$ is equal to the binding energy resulting from the weak interactions of the condensate of the core of baryons with the virtual large loops arising at a distance of $2A/3$ from the condensate and with the virtual particles arising on the surface of the torus. There are exchanged the weak masses i.e. the volumes filled with a little compressed Einstein spacetime. There arises the virtual $H^{+,-}$ particles and the particles having masses equal to the distance of masses between charged and neutral pions. They arise as virtual pairs so the axes of these dipoles converge on the circular axis of the torus so they are also at a distance of $2A/3$ from the condensate. Binding energy is equal to the sum of the mass of these three virtual particles ($M = 727.440 + 67.544 + 4.604 = 799.59$ MeV) multiplied by the mass of the $Y$ condensate and the $G_w$ and divided by $2A/3$. This leads to 14.980 MeV and to the mass of the charged core of baryons that is equal to 727.440123 MeV and this result is consistent with the original mass of the $H^+$.

## 4. New electroweak theory, structure of muon and magnetic moment of electron and muon

The external radius of the torus of an electron is equal to the Compton wavelength for the bare electron which is $r_{z(electron)} = 3.8660707 \cdot 10^{-13}$ m (see formula (34)).

From (72) for a condensate with a mass $M_p$ we have

$$G_w M_p = r_p c^2, \tag{74}$$

where $r_p$ denotes the range of weak interactions.

Since

$$\alpha_w = G_w M_p m_p / (c\, \hbar), \tag{75}$$

where $m_p$ denotes a mass interacting weakly with the $M_p$, so

$$\alpha_w = m_p r_p c / \hbar. \tag{76}$$

To calculate the radius of the condensate of an electron, $r_{p(electron)}$, we should divide the mass of condensate of it by the mass of $Y$ and extract the cube root of the obtained result and next multiply it by the radius of the condensate of a proton. The radius $r_{p(electron)}$ is

$$r_{p(electron)} = 0.7354103 \cdot 10^{-18} \text{ m}. \quad (77)$$

Mass of the condensate of electron is the half of bare mass of electron (see formula (35)).

The density of the Einstein spacetime inside the condensate of an electron is the same as the condensate of a proton. This means that the speed on the equator of the condensate of an electron cannot be the $c$. By using the formula

$$c^2 = G_w M / r_{p(electron)}, \quad (78)$$

we can calculate the virtual or real energy/mass $E$ of two neutrinos which should be absorbed by the condensate of electron (the two neutrinos means that the structure is stable)

$$M = E + m_{p(electron)} = 35.806163 \text{ MeV}. \quad (79a)$$

$$E = 2\, E_{neutrino} = 35.550959 \text{ MeV}. \quad (79b)$$

$$E_{neutrino} = 17.775480 \text{ MeV}. \quad (79c)$$

A muon is an electron-like particle i.e. the condensate of a muon is equal to the circular mass of it i.e. about

$$(m_{muon,free} - m_{radiation(muon)}) / 2 = 52.828155 - m_{radiation(muon)} / 2 \text{ [MeV]}. \quad (80)$$

The condensate of a muon consists of three particles: two rotating-spin neutrinos and the condensate of the contracted electron. An additional mass of the contracted electron is outside the circle having the spin speed equal to the $c$. If we assume that the all three particles have the same mass/energy, then to obtain the mass of free muon, the weak binding energy of the condensate of a muon, $E_{weak\text{-}binding\text{-}muon}$, should be

$$E_{weak\text{-}binding\text{-}muon} = 3\, E_{neutrino} - m_{muon,free} / 2 + m_{radiation(muon)}/2 =$$
$$= 0.498281845 + m_{radiation(muon)}/2 \text{ [MeV]}. \quad (81a)$$

The total radiation mass of a muon is

$$E_{radiation\text{-}total} = E_{binding} =$$
$$= 0.498281845 + m_{radiation(muon)}/2 + (m_{pion(o),free} - m_{pion(o)}) \approx$$
$$\approx 0.508942 + m_{radiation(muon)}/2 \text{ [MeV]}. \quad (81b)$$

In a next Chapter we will use this energy to calculate the magnetic moment of muon. The $m_{radiation(muon)}/2$ we can calculate using the iteration.

The weak binding energy lost by a free muon increases additionally the mass of the virtual field – it causes that the ratio of the mass of muon to its bare mass is greater than for electron and such conclusion is consistent with experimental data. We can see that muon is an electron-like particle but there is some difference. The difference is much bigger for the tau lepton because there dominates the mass of the condensate of the tau-lepton.

From (76) we obtain following value for the coupling constant for the electron-muon transformation

$$\alpha_{w(electron\text{-}muon)} = 9.511082\cdot 10^{-7}. \qquad (82)$$

Applying formula (73) we obtain

$$X_w = \alpha_{w(proton)} / \alpha_{w(electron\text{-}muon)} = (M / m_{p(electron)})^2 = 19{,}685.3. \qquad (83)$$

Because the state of an electron describes the wave function filling the entire Universe and because the torus of an electron is a part of the Einstein spacetime, we must take into account the matter in our Universe. Dark matter is a field composed of entangled neutrino-antineutrino pairs entangled with ordinary matter also which appeared due to a phase transition of the core of the Protoworld. The mass of the dark matter is so many times greater than the baryonic mass of our Universe and how many times greater the bare mass of the proton (it is the core of the proton) is than the mass of the neutral pion created on the circular axis of the torus of the proton – see paper titled *"New Cosmology"*. The ratio of these values is about 5.389 and relates to an electron-positron pair. But the ratio of the mass of the core of baryons and the large loop is $\beta = 10.769805$ (it relates to single electron). The ratio of the mass of the core of baryons and large loop to mass of the large loop is $\beta + 1$. In understanding that the $Y$ is the carrier of the weak interactions of electrons, for the coupling constant of the weak electron-proton interactions we obtain:

$$\alpha'_{w(electron\text{-}proton)} \approx G_w (Y - g_w)\, m_{p(electron)} / (c\, \hbar) = 1.119\cdot 10^{-5}, \qquad (84)$$

where $g_w$ is the weak binding energy of the $Y$ and $m_{p(electron)}$ i.e.

$$g_w = G_w\, Y\, m_{p(electron)} / r_{p(electron)} = 3.0229 \text{ MeV}. \qquad (85)$$

There can be virtual or real mass of $Y$. The real mass $Y$ appears when the electron transforms into an antiproton. A value close to the $\beta + 1$, we obtain for the ratio of the mass $Y$–$g_w$ to the mass $M = 35.806163$ MeV. The exact value for the coupling constant of the weak interactions of an electron with proton is

$$\alpha'_{w(electron\text{-}proton)} = (\beta + 1)\, \alpha_{w(electron\text{-}muon)} = 1.11943581\cdot 10^{-5}. \qquad (86)$$

The mass of a resting electron is equal to the mass of a bare electron and the electromagnetic and weak masses resulting from the interaction of the components of virtual electron-positron pairs (it is the radiation mass of pairs) plus the weak mass resulting from the interaction of the condensate with the radiation mass of the virtual pairs. Virtual pairs behave as if they were in a distance equal to $2r_{z(torus)}/3$ from the condensate. We neglect the positron-electron electromagnetic interactions because the pairs are electrically neutral.

The formula for the coupling constants of the gravitational, weak and strong interactions is as follows:

$$\alpha_i = G_i\, M\, m / (c\, \hbar). \qquad (87)$$

The energy of the interaction defines the formula

$$\Delta E_i = G_i M m / r, \tag{88}$$

then from (87) and (88) we obtain

$$\Delta E_i = \alpha_i c \hbar / r = m_i c^2. \tag{89}$$

On the other hand the Compton wavelength of the bare particle is equal to the external radius of a torus and is defined by the formula

$$\lambda\!\!\!{}^{-} = r_{z(torus)} = \hbar / (m_{bare} c), \tag{90}$$

then from (89) and (90) we obtain

$$m_i = \alpha_i m_{bare} / (r / r_{z(torus)}). \tag{91}$$

Most often the condensate of an electron appears near the condensate of a nucleon because there is a higher mass density of the Einstein spacetime. Rewrite value from formula (86)

$$\alpha'_{w(electron\text{-}proton)} = 1.11943581 \cdot 10^{-5}. \tag{92}$$

As a result, we can introduce the symbol

$$\gamma = \alpha_{em} / (\alpha'_{w(electron\text{-}proton)} + \alpha_{em}), \tag{93}$$

where $\gamma$ 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.

Since the distance between the constituents of a virtual pair is equal to the length of the equator of a torus (because such is the length of the virtual photons) so the ratio of the radiation mass (created by the virtual pairs) to the bare mass of electron is

$$\delta = \gamma \alpha_{em} / 2\pi + (1 - \gamma) \alpha'_{w(electron\text{-}proton)} / 2\pi = 0.00115963354. \tag{94}$$

The ratio of the total mass of an electron to its bare mass, which is equal to the ratio of the magnetic moment of the bare electron to the Bohr magneton for the electron, without the correction concerning the virtual field, is

$$\varepsilon = 1 + \delta + \delta \alpha'_{w(electron\text{-}proton)} / (2 / 3). \tag{95}$$

Due to the virtual pairs annihilations, in the Einstein spacetime are produced holes decreasing mass density of the radiation field. Since for virtual electron the product $m_{bare(electron)} \alpha'_{w(electron\text{-}proton)}$ is about $7.2 \cdot 10^{-7}$ times smaller than the $m_{p(proton)} \alpha_{w(proton)}$ for proton so we obtain that the final result is lower than it follows from (95) by the value

$$\Delta\varepsilon_{electron} = (\varepsilon - 1) \cdot 7.2 \cdot 10^{-7} = 8.344077 \cdot 10^{-10}. \qquad (96)$$

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

$$\varepsilon' = \varepsilon - \Delta\varepsilon_{electron} = 1.0011596521735. \qquad (97)$$

The muon magnetic moment in the muon magneton should be the same as for electron because the muon is the electron-type particle. There is a little difference due to the binding energy emitted by muon (see formula (81b))

$$E_{binding} \approx 0.508942 + m_{radiation(muon)}/2 \text{ [MeV]}. \qquad (98)$$

This binding energy means that the mean mass of the virtual field composed of the virtual electron-positron pairs has mass $E_{binding} + m_{bare(muon)}$.

We can introduce the following symbol

$$\phi = 1 + E_{binding} / m_{bare(muon)}. \qquad (99)$$

The iteration leads to $\phi = 1.00540622$.

The ratio of the radiation mass resulting from the interactions of the virtual pairs to the bare mass of the muon is

$$\varphi = \phi\, \delta, \qquad (100)$$

where $\delta = 0.00115963354$ (see formula (94)).

The mass of muon in its bare mass, which is equal to the muon magnetic moment in the muon magneton, without the correction concerning the virtual field, is

$$\psi = 1 + \varphi\, [1 + \alpha'_{w(electron\text{-}proton)} / (2 / 3)]. \qquad (101)$$

From it, applying iteration, for $m_{muon} = 105.656314$ MeV, we obtain that the muon magnetic moment in the muon magneton is

$$\psi' = \psi - \Delta\psi = 1.00116592234 - 8.344077 \cdot 10^{-10} \text{ (see (96))} = 1.001165921508. \qquad (102)$$

This result is consistent with experimental result [1]. A greater mass of the muon leads to the smaller anomalous magnetic moment. For example, for 105.65837 MeV we obtain 1.0011659101.

## 5. Interactions

In Table 3 we summarized the properties of the different interactions. There are the seven different interactions: viscosity of non-gravitating tachyons, entanglement and confinement of neutrinos and neutrino-antineutrino pairs, gravity and the three Standard-Model interactions i.e. electromagnetism and the nuclear strong and weak interactions.

Table 3 *Interactions*

| Name of source | States | Exchanged objects | Name of interaction |
|---|---|---|---|
| Tachyons | 1 | | Viscosity of surface<br>Range ≈ $0.5 \cdot 10^{-64}$ m |
| Closed string | 2 | | Tachyon jet (line of gravitational field)<br>Range ≈ $2 \cdot 10^{36}$ m |
| Neutrino | 4 | Divergently moving tachyon jets; they produce a gradient in the superluminal Higgs field<br><br>The superluminal binary systems of closed strings (entanglons) or groups of them a neutrino consists of<br><br>A potential well produced by neutrino-antineutrino pair or neutrino (the Mexican-hat mechanism) **-** it follows from the range of the radiation energy of some analog to neutral pion | Gravitational<br>Range ≈ $2 \cdot 10^{36}$ m<br><br>Entanglement<br>Range: arbitrary<br><br>Confinement<br>Range ≈<br>≈ 3510.1831R(neutrino) |
| Core of baryon | 2 | Polarized field composed of virtual electron-positron pairs created by virtual photons<br><br>Virtual condensates with a mass of 424.1 MeV<br><br>Single large loops (in mesons) or binary systems of large loops (baryons) produced on the circular axis; mass of large loop is 67.544 MeV but depends on velocity of baryons so there appears the running coupling that value decreases with increasing velocity; large loops are built of rotating-spin neutrino pairs (gluons); outside nuclear strong fields gluons behave as photons and vice versa | Electromagnetic<br>Range ≈ $2 \cdot 10^{36}$ m<br><br>Weak: Range for proton ≈<br>≈ $0.871 \cdot 10^{-17}$ m,<br>Range for electron ≈<br>≈ $0.735 \cdot 10^{-18}$ m<br><br>Strong<br>Range ≈ $2.9582 \cdot 10^{-15}$ m |
| Protoworld | 2 | Divergently moving tachyon jets | Gravitational |

Table 4 *Phase spaces (degrees of freedom)*

| Stable object | Co-ordinates and quantities needed to describe position, shape and motions |
|---|---|
| Tachyon | **6** (5 + time) |
| Closed string<br>A pair/entanglon | **10** (9 + time) |
| Neutrino<br>Neutrino-antineutrino pair | **26** [9(large torus) + 7(small tori on the surface of the large torus) + 9(small tori on the surface of the condensate) + time] |
| Core of baryons<br>Electron | **58** (9 + 23 + 25 + time) |
| Core of Protoworld | **122** (9 + 55 + 57 + time) |

For stable objects we have $N = (d - 1) \cdot 8 + 2$, where $N$ denotes the numbers of needed co-ordinates and quantities (they are the degrees of freedom) whereas $d = 0, 1, 2, 4, 8, 16$. Then for the $N$ we obtain -6 (the superluminal Higgs field is the imaginary spacetime), 2 (for rotating spin), 10, 26, 58 and 122. For example, to describe the position, shape and motions of a closed string we need three coordinates, two radii, one spin speed, one angular speed associated with the internal helicity and the time associated with the linear speed. To describe the rotation of the spin we additionally need two angular speeds. This means that the phase space of a closed string or entanglon has ten elements. We can see that we can replace the higher spatial dimensions (i.e. the more than three) for the additional degrees of freedom.

### 5.1 Range of the confinement

Calculate the factor, $F_C$, for the range of the confinement for a neutrino-antineutrino pair, $R_{Confinement}$

$$R_{Confinement} = F_C\, r_d\,, \tag{103}$$

where $r_d$ follows from formula (6).

For the side of a cube occupied by one neutrino-antineutrino pair in the condensate of the core of baryons, $L_{Y+E}$, we obtain (we must take into account the pairs in the Einstein spacetime also)

$$L_{Y+E} = (2\, m_{neutrino} / (\rho_Y + \rho_E))^{1/3} = 3.9259835 \cdot 10^{-32}\ \mathrm{m}, \tag{104a}$$

$$L_{Y+E} = 3510.1831\, r_{neutrino}. \tag{104b}$$

where $\rho_Y = 2.730724 \cdot 10^{23}\ \mathrm{kg/m^3}$ is the density of the condensate and $\rho_E$ is the density of the Einstein spacetime. We can see that $R_{Confinement} = L_{Y+E}$ (it is the range of confinement) and $F_C = 3510.1831$. But it does not explain the origin of the confinement.

The scales concerning the neutrinos, cores of baryons, and cores of protoworlds are dual – it suggests that we can find the factor $F_C$ for nuclear plasma composed of the baryonic core-anticore pairs and this value, due to the duality, should be valid for the condensate $Y$ composed of the neutrino-antineutrino pairs.

Calculate radiation mass of a bound neutral pion (formula (47); the mass of bound neutral pion is the bare mass) decreased by its weak mass (the weak mass of the radiation mass interacts with $Y$): $M_{Radiation} = m_{pion(o)}\, C\, (1 - \alpha_{w(proton)})$. We proved that range of 4 bound neutral pions is equal to $A$ (see explanation below formula (54)). It leads to conclusion that range of the radiation mass, $R_R$ , is

$$R_R = 4\, m_{pion(o)}\, A / M_{Radiation} = 4 / \{C\, (1 - \alpha_{w(proton)})\}\, A. \tag{105a}$$

This value concerns a single core of baryons so there should appear some correction for a core-anticore pair. In a pair of aligned spins of cores, the size of it along the direction of spin is: $L = 2\,\pi\, A / 3 + 2\, A / 3 = 2\, A\, (\pi + 1) / 3$. Radius of the size is two times smaller i.e. $R = L / 2 = A\, (\pi + 1) / 3$. We can see that the increase in the radius $A$ is $\Delta A = L / 2 - A = A\, (\pi - 2) / 3$. In the nuclear plasma, there appear the segments composed of the core-anticore pairs with aligned spins (the Titius-Bode orbits for the nuclear strong interactions are destroyed). It leads to conclusion that in very good approximation the mean distance between the pairs is $R_{R,mean} = R_R + \Delta A$ and it is the range of confinement of the pairs

$$R_{R,mean} = [4 / \{C\, (1 - \alpha_{w(proton)})\} + (\pi - 2) / 3]\, A = 3510.1845\, A. \tag{105b}$$

The factor 3510.1844 is very close to $F_C$ so probability that presented here mechanism responsible for the confinement is correct is very high.

From formula (104a) follows that for the ground state of the Einstein spacetime is $F_{CE}$ = 3510.2121. We can see that the difference $\Delta F = F_{CE} - F_C = 0.029$ is very small in comparison with $F_C$ so it should be very easy to produce condensates in the Einstein spacetime.

Notice that the density of the condensate $Y$ of baryons is $f$ = 40,362.942 times lower than the density of the Einstein spacetime. It leads to conclusion that the mean distance between the neutrino-antineutrino pairs, $L_{Y+E}$, in the $Y$ condensate is:

$L_{Y+E} = F_{CE}\, \{f / (f + 1)\}^{1/3}\, r_{neutrino} = 3510.1831\, r_{neutrino}$ as it should be.

**5.2 Homogeneous description of all interactions**

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

$$\alpha_i = G_i\, M_i\, m_i / (c\, \hbar), \tag{106}$$

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

We know that the neutral pion is a binary system of large loops composed of the rotating-spin neutrino-antineutrino pairs. This means that inside the neutral pion the pairs are exchanged whereas between the neutral pions the large loops are exchanged. We can neglect the mass of the neutrino-antineutrino pairs in comparison to the mass of the neutral pion. On the other hand, from (69) it follows that coupling constant for the large loop is unitary because its spin speed is equal to the $c$. For strongly interacting neutral pion is

$$\alpha_S^{\pi\pi\gamma} = G_S\, (2\, m_{pion(0)})\, (m_{pion(0)} / 2) / (c\, \hbar) = v / c = 1, \tag{107}$$

where $v$ denotes the spin speed of the large loop. Then the constant of the strong interactions is $G_S = 5.46147 \cdot 10^{29}\ m^3 s^{-2} kg^{-1}$.

Coupling constant for strongly interacting proton, for low energies, is

$$\alpha_S^{pp\pi} = G_S\, (2\, m_{proton} + m_{pion(0)} / 2)\, m_{pion(0)} / (c\, \hbar) = 14.4038. \tag{108}$$

In a relativistic version, the $G_S$ is invariant. When we accelerate a baryon, then there decreases the spin speed of large loop so its energy decreases as well

$$E_{Loop}\, 2\, \pi\, r_{Loop} / v_{Spin\text{-}speed\text{-}of\text{-}loop} = \hbar. \tag{109}$$

This means that the mass of the carrier decreases whereas when nucleons collide, the number of the sources increases. These conditions lead to the conclusion that the value of the running coupling decreases when energy increases (see Paragraph titled "*Running couplings*").

The other constants of interactions for low energies i.e. the gravitational constant $G$, electromagnetic constant for electrons $G_{em}$ and weak constant $G_w$, we calculated before – see respectively formulae (27), (36) and (72).

### 5.3 Running couplings

We can calculate the coupling constants from the formula (106). Using the formulae (27) and (28) we know that the constants of interactions depend linearly on the mass densities of appropriate fields.

#### 5.3.1 Strong and strong-weak interactions of colliding nucleons

The formula (108) defines coupling constant for two strongly interacting non-relativistic protons. The scale in this theory is as follows. At high energy collisions of nucleons the Titius-Bode orbits for nuclear strong interactions are destroyed i.e. the strong field is destroyed. This means that colliding nucleons interact due to the weak masses of the large loops responsible for strong interactions. The strong-weak interactions of the colliding nucleons depend on the properties of the pions. The nuclear weak mass of virtual pions is $f_W = 2\ \alpha_{w(proton)} = 1 / 26.7053 = 0.0374457$ times smaller than rest mass of the large loop and this value is the scale/factor for the running coupling of the strong-weak interactions for colliding nucleons. This means that the running constant of the strong-weak interactions for colliding nucleons $\alpha_{sw}$ defines the following formula

$$\alpha_{sw} = f_W\ \alpha_s. \qquad (110)$$

When the energy of a proton increases then, due to the uncertainty principle, the mass of components of field decreases (see formula (109)). We can calculate the mass of the carrier $m_{sw}$ using the following formula

$$m_{sw} = m_{pion(o)}\beta, \qquad (111)$$

where

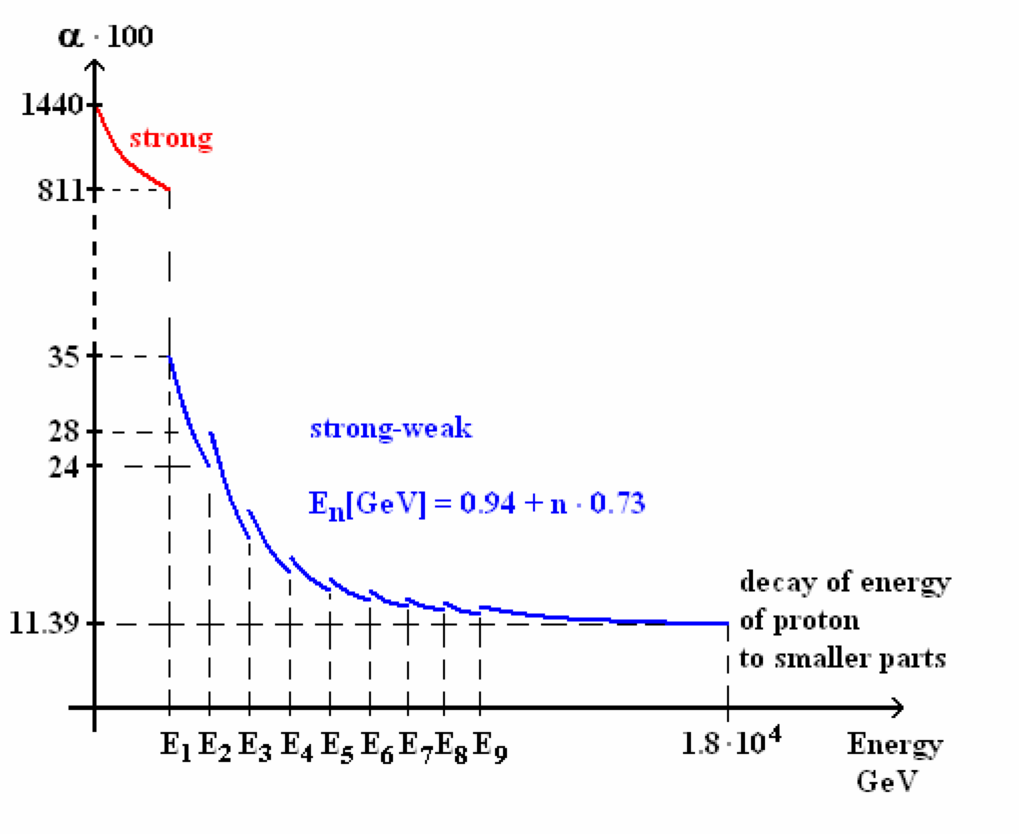
$$\beta = (1 - v^2 / c^2)^{1/2}, \qquad (112)$$

where $v$ denotes the relativistic speed of the nucleon. When energy of collision is $E = nm_{proton}$ then $\beta = 1 / n$.

When the energy of colliding protons increases, more sources interacting strongly appear. The sources are in contact because there is a liquid-like substance composed of the cores of baryons. There is the destruction of the atom-like structure of baryons. This means that a colliding nucleon and the new sources behave as one source. Strong-weak interactions are associated with the torus (the mass of the torus is $X = 318.3$ MeV whereas the mass of the core is $m_{H(+)} = 727.44$ MeV) then the mass of the source, $M_{sw}$, for colliding proton is

$$M_{sw} = 2\ m_{proton} + m_{pion(o)}\beta / 2 + X\ \backslash integer\text{-}of \backslash\{(n - 1)\ m_{proton} / m_{H(+)}\}. \qquad (113)$$

The torus-antitorus pairs are produced from energy $(n - 1)m_{proton}$, where $n = 1 / \beta$, but number of the tori is not proportional to number of protons but to the ratio $m_{proton} / m_{H(+)}$ i.e. their number is greater than $(n - 1)$.




**Strong and strong-weak interactions of nucleons**

This means that there are separated fragments of the curve representing the running coupling for the strong-weak interactions of colliding nucleons. When we neglect the \integer-of\ in the formula (113) then from (106), (108) and the formulae (110)-(113), we obtain the following function for strong-weak running-coupling

$$\alpha_{sw} = a_u \beta^2 + b_u \beta + c_u, \tag{114}$$

$a_u = 0.0187229 = \alpha_{w(proton)}$,
$b_u = 0.4067$,
$c_u = 0.1139$.

This curve starts from 1.67 GeV and leads through the upper limits of the sectors representing the successive 'jumps' of the running coupling. The 'jumps' appear for the following energies

$$E_n[GeV] = m_{proton} + n \cdot m_{H(+)}, \tag{115}$$

where $n = 2, 3, 4, 5, \ldots$ For the $n = 1$ we observe the drop in value of the running constant from 8.113 to 0.349. The widths of the 'jumps' can be calculated using the following formula

$$\Delta\alpha_{sw} = f_W\, G_s\, \Delta M\, m\, /\, (c\, \hbar) = d_j\, \beta, \tag{116}$$

where $d_j = 0.0883096$ whereas $\Delta M = X$ and $m = m_{pion(o)}\, \beta$ and should be expressed in kilograms.

For the curve leading through the lower limits of the sectors representing the successive 'jumps' we obtain

$$\alpha_{sw} = a_l\, \beta^2 + b_l\, \beta + c_l, \tag{117}$$

$a_l = 0.01872,$
$b_l = 0.3184,$
$c_l = c_u = 0.1139.$

We can see that there is an asymptote for $\alpha_{sw} = 0.1139$ (when we take into account the parton shower then the result is different). This means that there is asymptotic packing of the cores of baryons, not an asymptotic freedom of the quarks and gluons. The asymptotic freedom leads for high energies to gas-like plasma whereas the asymptotic packing leads to liquid-like plasma and is consistent with experimental data. It suggests that baryons do not consist of single quarks but SST shows that there appear the pairs which components carry the masses of quarks (see paper *"Reformulated Quantum Chromodynamics")*. This asymptotic packing suggests that baryons have a massive core. A closer experiment should show the internal structure of the curve for running coupling of the strong-weak interactions for colliding nucleons.

The internal structure of the core of baryons should be overcome when the surface of the condensate attains the torus i.e. when the radius of the condensate increases $A/(3r_{p(prpton)}) = 26.688$ times. It is when the mass of the proton increases $\{A/(3r_{p(prpton)})\}^3 = 1.9009 \cdot 10^4$ times i.e. for energy about 18 TeV. Above this energy, the proton loses the surplus energy. The mass of the Einstein spacetime overlapping with the non-relativistic condensate in the centre of the core of baryons is in approximation 17.12 TeV so probably there is in existence a boson carrying such a mass.

Define energy of collision per nucleon as $E_N[GeV] = nm_N = m_N / \beta$ i.e. $\beta = m_N / E_N$, where $m_N = 0.939$ GeV.

We can rewrite formulae (114) and (117) as follows

$$\alpha_{sw} = \alpha_{sw,central\text{-}value} \pm \Delta\alpha_{sw}, \tag{118}$$

$$\alpha_{sw} = \{\alpha_{w(proton)}\beta + b\, \beta + c\} \pm (b - b_l)\, \beta, \tag{119}$$

$\alpha_{w(proton)} = 0.0187229,$
$b = 0.36255,$
$c = 0.1139,$
$b - b_l = 0.04415.$

Within the Standard Model the parton shower (PS) is not good understood so the phenomena associated with the PS can change the experimental data concerning the running coupling for the strong interactions.

In the Scale-Symmetric Theory, PS is produced due to the weak decays of condensates composed of the carriers of gluons and photons i.e. of the neutrino-antineutrino pairs.

In the collisions of nucleons there are produced the $Z$ bosons and their weak decays into parton shower weakens the weak interactions of the colliding nucleons. It is due to the holes produced in the Einstein spacetime in the places of decays of the $Z$ bosons. Energy $E$ of a condensate composed of weakly interacting partons is directly proportional to volume i.e. $E \sim r^3$, where $r$ is the radius of the condensate. On the other hand, the coupling constant for weak interactions is directly proportional to the radius of a condensate $\alpha_{W,proton,Z\text{-}production} \sim r$ (see formula (76)). Since for $E = 0$ is $\alpha_{W,proton,Z\text{-}production} = \alpha_{W,proton} = 0.0187229$ whereas for $E = M_Z = 91.2$ GeV is $\alpha_{W,proton,Z\text{-}production} = 0$ so we obtain following formula

$$\alpha_{W,proton,Z\text{-}production} = \alpha_{W,proton} [1 - (E / M_Z)^{1/3}]. \qquad (120)$$

We can assume that the phenomena leading to the parton-shower production that lead to formula (120) are not eliminated in the Standard Model from the phenomena responsible for the strong interactions. It follows from the fact that such phenomena are not good understood within the Standard Model so generally they are neglected.

It leads to following formula that ties the experimental data for the “strong” running coupling $\alpha_{S,experiment}$ (in reality, it is the sum of coupling constants for strong and weak interactions) with the running coupling $\alpha_{sw}$

$$\alpha_{SST} = \alpha_{S,experiment} = \alpha_{sw} + \alpha_{W,proton}[1 - (E / M_Z)^{1/3}]. \qquad (121)$$

Calculate a few results that follow from formula (121) – they are collected in Table 5. We can see that they are consistent with experimental data [4]. The “strong” coupling $\alpha_{ET}(E=Q)$ is a function of the momentum transfer $Q$ $[GeV]$.

Table 5

| ***Q [GeV]*** | $\boldsymbol{\alpha_{SST}(E=Q)}$ |
|---|---|
| 2,000 | 0.080 |
| 1,000 | 0.091 |
| 91.2 | 0.1176 ± 0.0005 |
| 50 | 0.1241 ± 0.0008 |
| 20 | 0.1316 ± 0.0021 |
| 10 | 0.1579 ± 0.0041 |
| 5 | 0.1943 ± 0.0083 |
| 1 | 0.4854 ± 0.0415 |

**5.3.2 Electromagnetic interactions**

In the collisions of baryons there are created in the $d = 1$ state the relativistic electron-positron pairs – their mass is about 9 times greater than the resting ones. With increasing energy of collision, number density of the relativistic pairs increases so the fine-structure constant increases as well.

**5.3.3 Gravitational interactions**

Gravitational fields are the gradients produced in the superluminal Higgs field by neutrinos. The total cross section of all tachyons in volume of a rectangular prism $1\text{m}\cdot 1\text{m}\cdot 2\cdot 10^{36}\text{m}$ is

$1 m^2$ so all divergently moving tachyons are scattered. It leads to conclusion that range of the gravitational interactions is about $2 \cdot 10^{36}$ m.

### 5.4 Frequency of the radiation emitted by the hydrogen atom under a change of the mutual orientation of the electron and proton spin in the ground state

The parallel polarisation of two vortices increases the binding energy of a system

$$E_{par} = E + \Delta E_i, \tag{122}$$

whereas the antiparallel polarisation decreases the binding energy

$$E_{ant} = E - \Delta E_i. \tag{123}$$

Since $\Delta E_i = \alpha_i c \hbar / r$ (see formula (89)) the change of the mutual orientation of spins causes emitted energy to be

$$E_i = 2 \alpha_i c \hbar / r = h \nu, \tag{124}$$

and therefore

$$\nu = \alpha_i c / (\pi r), \tag{125}$$

where $\nu$ denotes the frequency.

SST shows that spins are associated with spinning so there are vortices. Spins of electron and of the core of proton can be parallel or antiparallel. Binding energy of the parallel state is higher. But there is non-zero probability for the antiparallel state. The returns to the parallel states cause emission of energy $E = h\nu$. What phenomena are responsible for value of frequency of emitted energy?

Most important is creation of a real electron-positron pair by the charge of the core of proton. Then, the bare electron-positron pair of the real pair and the virtual electron-positron pair associated with the real electron on the first Bohr orbit (the radius of the first Bohr orbit is $r_1 = 0.5291772 \cdot 10^{-10}$ m) continually change places whereas the radiation energy of the real electron interacts with the torus/charge of the core of proton i.e. it is in the $d = 0$ state. Applying formula (70), we obtain that the radiation energy increases $f_R = 9.00361443$ times. We can see that in the proton there is the electroweak interaction (such interaction is described by the product $\alpha_{w(proton)}\alpha_{em}$) and involved mass is equal to:

$M_p = Y + 2 m_{electron} + f_R (m_{electron} - m_{bare(electron)})$.

On the other hand, the involved mass in the real electron on the first Bohr orbit is equal to:

$M_e = 2 m_{bare(electron)}$.

The ratio of the involved masses is

$$F_H = M_e / M_p = 2.40105763365 \cdot 10^{-3}. \tag{126}$$

Formula (73) shows that coupling constant is directly proportional to squared mass of a condensate so we obtain

$$\alpha_i / (\alpha_{w(proton)} \alpha_{em}) = F_H^2. \tag{127}$$

Because, then applying formulae (125)-(127) we obtain

$$\nu = 1420.4057494 \text{ MHz}. \qquad (128)$$

This value is very, very close to experimental result.

**5.5 Lamb-Retherford shift**

The Lamb shift is associated with the two different states of pions in the $d = 1$ state in proton. We can calculate the Lamb shift using following formula

$$\Delta E_i = \alpha_i c \hbar / r = m_i c^2. \qquad (129)$$

The Compton wavelength of the bare particle is equal to the external radius of the torus and is defined by the following formula

$$\lambdabar = r_{z(torus)} = \hbar / (m_{bare} c). \qquad (130)$$

Using formulae (129) and (130) we can obtain

$$m_i = \alpha_i m_{bare} / (r / r_{z(torus)}). \qquad (131)$$

Applying the aforementioned three formulae, we obtain

$$\nu_L = \alpha_i c / (2 \pi \cdot 4 r_1). \qquad (132)$$

The coupling constant we can write in following form

$$\alpha_i = \alpha_{w(proton)} M_R m / Y^2 = 1058.05 \text{ MHz}. \qquad (133)$$

where $\alpha_{w(proton)} = 0.0187229$ denotes the coupling constant for the weak interactions of the proton, $m = 0.000591895$ MeV denotes the radiation mass of the electron, $Y = 424.1245$ MeV denotes the condensate of the proton whereas the $M_R$ is the distance of the masses between the relativistic charged $W_d$ pion in the $d = 1$ state and the charged pion in the rest i.e. $M_R = 215.760 - 139.5704 = 76.1899$ MeV.

We can calculate this shift by analysing the condition that the increase in the force acting on the proton which must be equal to the increase in the force acting on the electron. The force is directly in proportion to the energy of interaction falling to the given segment. The energy of the interaction is directly in proportion to the coupling constant of the interaction responsible for the change of the value of the force. The Lamb shift is caused by the weak interaction of the mass equal to the distance of the mass between the relativistic and the rest mass of the charged $W_d$ pion in the $d = 1$ state with the radiation mass of the electron. The increase to the radius of the orbit of the electron is as many times smaller than the external radius of the torus of proton hand equivalent to how many times smaller the sum of the coupling constants for the electron is than the coupling constant of the weak interactions for the proton

$$dr / A = (\alpha'_{w(electron\text{-}proton)} + \alpha_{em}) / \alpha_{w(proton)}. \qquad (134)$$

From this $dr = 2.722496 \cdot 10^{-16}$m.
For the second shell of the atom of hydrogen the frequency associated with such a shift is

$$\nu_L = R\, c\, [1 / 4 - 1 / (4 + dr / r_1)] = 1057.84 \text{ MHz}, \qquad (135)$$

where $R = 10{,}973{,}731.6 \text{ m}^{-1}$.

**5.6 Lifetimes**

Lifetimes we can calculate applying formulae (12) and (16).
Lifetime of the neutron is calculated in paper [7].

Muons are created as quadrupoles from the $Y$ condensates. It causes that they conserve electric charge and the half-integral spin of the core of baryons. They become free in distance $2\pi A$ i.e. in distance equal to circumference of a gluon/photon loop created on the equator of the core of baryons. A relativistic muon reaches such places after $T_o = 2\pi A/c = 1.4617314 \cdot 10^{-23}$ s. But the weak interactions of the muon increase its lifetime. There is the transition from the nuclear weak interactions (involved mass is $m_{w,1} = \alpha_{w(proton)}\, m_{muon}$) to weak interaction of electron (involved mass is $m_{w,2} = \alpha_{w(electron-muon)}\, m_{muon}$). Such transition increases lifetime. Since $\alpha_{w(proton)} / \alpha_{w(electron-muon)} = X_w = 19{,}685.3$ (formula (83)) so the lifetime of muon is

$$t_{w(muon)} = (2\pi A/c)\, X_w^{\,4} = 2.195006 \cdot 10^{-6} \text{ s}. \qquad (136)$$

The weak interactions are responsible for the decay of the hyperons and because of these interactions they behave as a nucleon, whereas the muon behaves as an electron, so the lifetimes of the hyperons should be close to

$$t_{w(hyperons)} = t_{w(muon)} / (\alpha_{w(proton)} / \alpha_{w(electron-muon)}) = 1.11505 \cdot 10^{-10} \text{ s}. \qquad (137)$$

The radiation mass of the tau is equal to the mass of $W^+_{d=1}$ (see a further formula for mass of tau). The tau decays because of the transition from the nuclear weak interactions of the large loops in $W^+_{d=1}$ to the nuclear strong interactions i.e. mass increases from

$$m_{w,3} = \alpha_{w(proton)}\, W^+_{d=1}, \qquad (138)$$

to

$$m_{S,4} = \alpha_S\, W^+_{d=1}, \qquad (139)$$

where $\alpha_S = 1$. It leads to conclusion that lifetime of tau is shorter than of muon

$$t_{w(tau)} = t_{w(muon)}\, [\alpha_{w(proton)}\, W^+_{d=1} / (\alpha_S\, W^+_{d=1})]^4 = t_{w(muon)}\, \alpha_{w(proton)}^{\;4} = = 2.6973 \cdot 10^{-13} \text{ s}. \qquad (140)$$

The lifetime of the charm hyperon $\Lambda^+_c(2260)$ is:

$$t_{w(\Lambda(2260))} = t_{w(hyperons)}\, (m_{p(proton)} / m_{p(\Lambda(2260))})^4 = 6.5 \cdot 10^{-13} \text{ s}, \qquad (141)$$

where $m_{p(\Lambda(2260))} = m_{\Lambda(2260)} - m_{\Lambda(1115)} + Y = 1573$ MeV.

The lifetime of the large loop created on the circular axis of the torus of the nucleon can be calculated using the uncertainty principle $E_{LL} \cdot t_{LL} = \hbar$, where $m_{LL} = 67.5444119$ MeV. The neutral pion decays in respect of the weak interaction. The weak mass of virtual particles produced by the large loop we can calculate using the formula $m_{LL(weak)} = m_{LL} \cdot \alpha_{w(proton)} = 1.26462$ MeV. This is the distance of masses between a neutron and a proton. Consequently the lifetime of the neutral pion is:

$$t_{pion(o)} = t_{LL} (m_{LL} / m_{LL(weak)})^4 = 0.793 \cdot 10^{-16} \text{ s.} \tag{142}$$

The charged pion decays because of the electromagnetic interaction of the weak mass, therefore:

$$t_{pion(+-)} = t_{pion(o)} (1 / \alpha_{em})^4 = 2.78 \cdot 10^{-8} \text{ s.} \tag{143}$$

**5.7 Coupling constant for confinement and quantum entanglement**

The coupling constant for all types of interactions (so for confinement and quantum entanglement as well) is defined within SST as follows

$$\alpha_i = G_i M_i m_i / (v \hbar), \tag{144}$$

where $M_i$ defines the sum of the mass of the sources of interaction being in touch plus the mass of the component of the field, $m_i$ defines the mass of the carrier of interactions whereas $v$ is the speed of exchanged particle.

On the other hand, the constants of interactions, $G_i = g \rho_i$, are directly proportional to the inertial mass densities of fields carrying the interactions, $\rho_i$, whereas $g = 25{,}224.563$ m/(kg$^2$ s$^2$) (see formulae (27) and (28)).

In a condensate, a carrier of gluon occupies a cube with a side about $L_{Y+E} \approx 3.926 \cdot 10^{-32}$ m. (Paragraph **5.1**). The non-gravitational energy frozen inside one carrier of gluon (i.e. in a neutrino-antineutrino pair) is $E_g \approx 2 \cdot 1.96 \cdot 10^{52}$ kg (Table 7). It leads to the mean density of the field responsible for the confinement, $\rho_C$,

$$\rho_C = E_g / L_{Y+E}^3 = 6.480515 \cdot 10^{146} \text{ kg/m}^3. \tag{145}$$

The carriers of gluons consist of the superluminal binary systems of closed strings (entanglons) which are responsible for the confinement and quantum entanglement. The non-gravitational energy of entanglon is $E_E \approx 4.68 \cdot 10^{-87}$ kg (Table 7) whereas its superluminal speed is $v = v_E \approx 0.727 \cdot 10^{68}$ m/s (Table 7). Gravitational mass of the carrier of gluon is $M_i = M_g \approx 6.67 \cdot 10^{-67}$ kg (mass of the component of field, i.e. mass of entanglon we can neglect). But the confinement is the volumetric interaction associated with the radiation mass of some analog to the neutral pion composed of entanglons so the mass of the carrier of interactions is the mass $m_i = m_R \approx 0.15382\, M_g / 727.44$ (Paragraph **5.1**). It leads to the coupling constant for the confinement, $\alpha_C$,

$$\alpha_C = g\, \rho_C\, 2\, M_g\, m_R / (v_E \hbar) = 4.011765 \cdot 10^{-19}. \tag{146}$$

The calculated coupling constant, which follows from the confinement, is very small so the Type Higgs-boson condensates are very unstable.

On the surface of the torus in the core of baryons, a carrier of gluon occupies a rectangular prism in which two sides are equal to $L_{E,1} \approx 2 \pi r_{neutrino} \approx 7.03 \cdot 10^{-35}$ m whereas the third side is $L_{E,2} \approx 2 r_{neutrino} (\pi + 1) / 3 \approx 3.09 \cdot 10^{-35}$ m (Paragraph **5.1**). It leads to the mean density of the field responsible for the shortest-distance quantum entanglement, $\rho_E$,

$$\rho_E = E_g / (L_{E,1}^2 L_{E,2}) \approx 2.6 \cdot 10^{155} \text{ kg/m}^3. \tag{147}$$

For the quantum entanglement are responsible the exchanges of single superluminal entanglons (it is the directional interaction) so the non-gravitational energy of the carrier of interactions is the energy $m_i = M_E = E_E (v_E / c)^2 \approx 2.75 \cdot 10^{32}$ kg. It leads to the coupling constant for the quantum entanglement, $\alpha_E$,

$$\alpha_E = g \rho_E 2 M_g M_E / (v_E \hbar) \approx 3.1 \cdot 10^{92}. \tag{148}$$

The coupling constant which follows from the quantum entanglement is very big so the torus inside the core of baryons is practically indestructible.

## 6. Leptons

Multiplying the Compton length of an electron by $2\pi$, we can calculate the state-lifetime. Slowly moving electrons have state-lifetime about $10^{-20}$ s. This means that within one second an electron appears in $10^{20}$ places of the Einstein spacetime. This leads to the wave function. An electron, when going through a set of slits (an electron only appears whereas the wave function is ongoing), appears many times in each slit. We cannot say for certain that an electron is going through only one slit.

### 6.1 The mass of tau lepton

A tau lepton consists of an electron and massive particle, created inside a baryon, which interact with the condensate of the electron.

The charged $W_d$ pion in the $d = 1$ state is responsible for the properties of the proton. What should be the mass of a lepton in order to the mass of such pion was the radiation mass of the lepton for the strong-weak interactions in the $d = 1$ state? Applying formula (91) we obtain

$$\alpha_{swW(+-),d=1} m_{tau,d=1} / m_{W(+-),d=1} = \alpha_{em} m_{electron} / m_{em(electron)}, \tag{149}$$

where $\alpha_{swW(+-),d=1} = 0.762594$.

The calculated mass of tau lepton is

$$m_{tau} = 1782.5 \text{ MeV}. \tag{150}$$

### 6.2 The behaviour of the electron-positron pairs

An electron-positron pair appears as the spin-1 binary loop (such spin-signature has the Einstein spacetime) with parallel spins and opposite internal helicities of the spin-1/2 constituent loops. Radius of the binary loop is equal to the reduced Compton length for the bare electron. Such binary loop is unstable and transforms into two tori representing the charges of the electron and positron – they are only the polarised Einstein spacetime so it is very difficult to detect them. Due to the dynamics similar to proton (see Paragraph **2.**) there appears the spin-1/2 circular mass and the central condensate – their masses are the same. The two masses of electron follow from rotation of the neutrino-antineutrino pairs so it is as well very difficult to detect them. Outside the torus there is created virtual electron-positron pair that interacts due to the weak interactions with the condensate. Due to the superluminal quantum entanglement, the virtual pair disappears in one place and appears in another one, and so on – it creates the radiation field. Such model leads to magnetic moment consistent with experimental result. Moreover, due to the quantum entanglement, electron (or electron-positron pair) disappears in one place and appears in another one, and so on – it leads to the wave function. The equatorial radius of the torus of the bare electron is 554.321 times greater than that of the core of baryons.

### 6.3 Properties of fundamental particles

The neutrinos interact with the condensate of electron. They are all fermions so their physical states should be different. Neutrinos and electrons can differ by internal helicity (which dominates inside the muon) and, if not by it, by the sign of the electric charge and the weak charge (it is for the third neutrino inside charged pion). The possible bound states are as follows

$\mu^-_R \equiv e^-_R\, \nu_{e(anti)L+}\, \nu_{\mu L-}$,

$\mu^+_L \equiv e^+_L\, \nu_{eR-}\, \nu_{\mu\,(anti)R+}$,

$\pi^-_R \equiv e^-_R\, \nu_{e(anti)L}\, L_L\, L_{LA} \rightarrow \mu^-_R\, \nu_{\mu\,(anti)R+}$,

where $L_{LA}$ denotes the large loop with the left helicity and antiparallel spin.

$\pi^+_L \equiv e^+_L\, \nu_{eR-}\, L_R\, L_{RA}$.

Table 6 *New symbols*

| Particle | Internal helicity | Electric charge | Weak charge | New symbol |
|---|---|---|---|---|
| $\nu_{e(anti)}$ | L (left) | | + | $\nu_{e(anti)L+}$ |
| $\nu_e$ | R (right) | | – | $\nu_{eR-}$ |
| $\nu_{\mu\,(anti)}$ | R | | + | $\nu_{\mu\,(anti)R+}$ |
| $\nu_\mu$ | L | | – | $\nu_{\mu L-}$ |
| $e^-$ | R | – | | $e^-_R$ |
| $e^+$ | L | + | | $e^+_L$ |
| $p^+$ | L | + | | $p^+_L$ |
| $p^-$ | R | – | | $p^-_R$ |
| n | L[1)] | | + | $n_L$ |
| $n_{(anti)}$ | R[1)] | | – | $n_{(anti)R}$ |
| $\mu^-$ | R[1)] | – | | $\mu^-_R$ |
| $\mu^+$ | L[1)] | + | | $\mu^+_L$ |
| $\pi^-$ | R[1)] | – | + | $\pi^-_R$ |
| $\pi^+$ | L[1)] | + | – | $\pi^+_L$ |

[1)] The resultant internal helicity is the same as the internal helicity of the torus having greatest mass.

There are in existence the following 8 states of the rotating-spin neutrino-antineutrino pairs

$\gamma_{L1} \equiv (\nu_{eR-}\, \nu_{e(anti)L+})_L$,

$\gamma_{L2} \equiv (\nu_{\mu L-}\, \nu_{\mu\,(anti)R+})_L$,

$\gamma_{L3} \equiv (\nu_{eR-}\, \nu_{\mu\,(anti)R+})_L$,

$\gamma_{L4} \equiv (\nu_{\mu L-}\, \nu_{e(anti)L+})_L$,

$\gamma_{R1} \equiv (\nu_{eR-}\, \nu_{e(anti)L+})_R$,

$\gamma_{R2} \equiv (\nu_{\mu L-}\ \nu_{\mu\,(anti)R+})_R$,
$\gamma_{R3} \equiv (\nu_{eR-}\ \nu_{\mu\,(anti)R+})_R$,
$\gamma_{R4} \equiv (\nu_{\mu L-}\ \nu_{e(anti)L+})_R$.

In fields with internal helicity, they behave as gluons (8 different types) whereas in field without internal helicity, they behave as photons (1 type only).

The kaon is a binary system and each component of this binary system consists of two large loops (created on the circular axis of the nucleon), an electron and a neutrino

$K^o \equiv L_L L_{LA} e^-_R\ \nu_{e(anti)L+} + L_L L_{LA} e^+_L\ \nu_{eR-}$,
$K^o_{(anti)} \equiv L_R L_{RA} e^-_R\ \nu_{e(anti)L+} + L_R L_{RA} e^+_L\ \nu_{eR-}$.
The mixture of $K^o$ and $K^o_{(anti)}$ is: $L_L L_{LA} L_R L_{RA}\ e^-_R\ \nu_{e(anti)L+}\ e^+_L\ \nu_{eR-}$.

## 7. Selected mesons

Mesons, meanwhile, are binary systems of gluon loops that are created inside and outside the torus of baryons. They can also be mesonic nuclei that are composed of the other mesons and the large loops, or they can be binary systems of mesonic nuclei and/or other binary systems.

### 7.1 Masses of the lightest mesonic nuclei

We can build three of the smallest unstable neutral objects containing the carriers of strong interactions i.e. the pions (134.96608 MeV, 139.57040 MeV) and bound large loops (134.96608/2 MeV). Each of those objects must contain the large loop because only then can it interact strongly.

The letter **a** denotes the mass of the object built of a neutral pion and one large loop

**a** = $m_{(neutral\ pion,\ loop)}$ = 202.45 MeV.

The parity of this object is equal to $P = +1$ because both the pion and the large loop have a negative parity so as a result the product has a positive value.

The letter **b** denotes the mass of the two neutral pions and one large loop

**b =** $m_{(2\ neutral\ pions,\ loop)}$ = 337.42 MeV,

where **b'** denotes the mass of the two charged pions and one large loop

**b'** = $m_{(2\ charged\ pions,\ loop)}$ = 346.62 MeV.

The parity of these objects is equal to $P = -1$.

In particles built of objects **a, b,** and **b'**, the spins are oriented in accordance with the Hund law (the sign "+" denotes spin oriented up, the sign "–" denotes spin oriented down, and the word "and" separates succeeding shells)

For example, +- and +- +++--- and +- +++--- +++++----- and etc.

Because electrically neutral mesonic nuclei may consist of three different types of objects whereas only one of them contains the charged pions the charged pions should, therefore, be two times less than the neutral pions. It is also obvious that there should be some analogy for mesonic and atomic nuclei. I will demonstrate this for the Ypsilon meson and the Gallion. The Gal is composed of 31 protons and has an atomic mass equal to 69.72. To try to build a meson having a mesonic mass equal to 69.5 we can use the following equation:

$^{69.5}Ypsilon$ = 8a + 14b + 9b' = 9463 MeV (vector).

Such a mesonic nucleus contains 18 charged pions, 36 neutral pions and contains 31 objects.

The mass of lightest mesonic nuclei is as follows. The Eta meson is an analog to the Helion-4. Since the Eta meson contains three pions there are two possibilities. Such a mesonic nucleus should contain one charged pion but such objects are not electrically neutral. This means that the Eta meson should contain two charged pions or zero

$^4Eta$ = **a** + **b’** = 549.073 MeV (pseudoscalar),
$^4Eta(minimal)$ = **a** + **b** = 539.864 MeV (pseudoscalar).

The Eta’ meson is an analog to Lithion-7

*Eta’* = **3a** + **b’** = 953.971 MeV (pseudoscalar).

We see that there is in existence the following mesonic nuclei (**a** + **b’**) and (**3a** + **b’**) **–** which suggests that there should also be (**2a** + **b’**). However, an atomic nucleus does not exist which has an atomic mass equal to 5.5. Such a mesonic nucleus can, however, exist in a bound state, for example inside a binary system of mesons

*X’* = **2a** + **b’** = 751.522 MeV (vector).

### 7.2 The mass of kaons

To calculate the mass of the particle created in the $d = 0$ state in a nucleon for which the ratio of its mass to the distance of mass between the charged and neutral pions is equal to $\alpha_{sw(d=0)} / \alpha_{w(proton)}$ we can use the following:

$$(m_{pion(+-)} - m_{pion(o)}) (\alpha_{sw(d=0)} / \alpha_{w(proton)}) = 244.398 \text{ MeV}. \tag{151}$$

This mass interacts with the condensate of the particle which has a mass equal to $(m_{pion(+-)} - m_{pion(o)})$. Therefore, the total mass equals 249.003 MeV. Two such particles create the binary system having mass equal to 497.76 MeV (the components are in a distance equal to the Compton wavelength for the muon so we must subtract the radiation energy from both components: see formula (47) for muon) which is the mass of neutral $K^o$ kaon. This kaon can emit one particle having a mass equal to $(m_{pion(+-)} - m_{pion(o)})$. The particle created as a result of this is in a charged state. If we add the radiation mass of the entire particle (the components are not at a distance equal to the Compton wavelength of the muon because there is only one charged muon: see formula (47) for neutral kaon minus $(m_{pion(+-)} - m_{pion(o)})$ ) we obtain the mass of $K^+$ kaon that is equal to 493.73 MeV.

Due to the strong interactions, the neutral kaon decays into two pions (the coupling constant is equal to 1) or due to the weak interactions to three pions. The condensate of the proton is about $\pi$ times greater than the rest mass of the neutral pion so the coupling constant of the weak interactions of two pions is $\pi^2$ times smaller than for the proton. This means that the $K^o{}_L$ kaons should live approximately 527 times longer than the $K^o{}_S$.

Earlier we calculated the lifetimes of pions.

### 7.3 The mass of $W^{+-}$ and $Z^o$ bosons

There are in existence the $W^{+-}$ and $Z$ bosons but they are not responsible for weak interactions at low energy. Calculate the mass of particles for which the ratio of their mass to the distance of mass between the different states of known particles is equal to $X_w = \alpha_{w(proton)}/\alpha_{w(electron\text{-}muon)}$ (see formula (83)).

For the kaons we obtain (it is created as a condensate in nuclear plasma so there is the spin-1 $X^+X^-$ structure; the spin-0 $[2(e^+ e^-)]$ structure is electrically neutral)

$$[(K^o - K^+)\, X_w + X^-] + (K^o + X^+) \rightarrow W^+ + 2(e^+ e^-)\,. \qquad (152)$$

Applying formula (152) and the Scale-Symmetric-Theory (SST) results, we obtain mass of $W^+$ boson equal to $m_{W.} = 80.385$ GeV.

For the pions we have (it is created as a condensate in nuclear plasma so there is $X^+X^-$)

$$[(\pi^+ - \pi^o)\, X_w + X^-] + (\pi^- + X^+) \rightarrow Z + \pi^o\,. \qquad (153)$$

Applying formula (153) and the SST results, we obtain mass of $Z$ boson equal to $m_{Z.} =$ 91.205 GeV.

**7.4 D and B mesons**

The neutral kaon is a binary system of two objects. If we divide the mass of the neutral kaon by the mass of the neutral pion, we obtain the factor $F_x = 3.68804$ for binary systems built of two mesonic nuclei or one mesonic nucleus and a binary system or two binary systems.

The mean mass of the binary system built up of two kaons is

$$D(charm, 1865) = [(\pi^o(134.966) + \pi^{+-}(139.570)) / 2]\, F_x^{\,2} = 1867 \text{ MeV}, \qquad (154a)$$

$$D(strange) = m(Eta(minimal, 539.864))\, F_x = 1991 \text{ MeV}, \qquad (154b)$$

$$K^*(892) = m(244.398)\, F_x = 901 \text{ MeV}, \qquad (154c)$$

$$B = [m(Eta(minimal, 539.864) + m(K^*, 892)]\, F_x = 5281 \text{ MeV}, \qquad (154d)$$

$$B(strange) = [m(Eta', 953.971) + m(K^o, 497.760)]\, F_x = 5354 \text{ MeV}, \qquad (154e)$$

$$B(charm) = [m(X', 751.522) + m(Eta', 953.971)]\, F_x = 6290 \text{ MeV}. \qquad (154f)$$

Why binary systems live longer than the lightest mesonic nuclei? It is because there changes nature of interactions. In binary systems, the weak interaction dominates so they behave in a similar way to a muon. Their lifetime is inversely proportional to four powers of mass. The mass of the $B(charm)$ meson is $N_y = 6290 / 105.66 = 59.53$ times greater than mass of muon. Therefore, the lifetime of the $B(charm)$ meson can be calculated using the following formula (the theoretical lifetime of muon is $t_{w(muon)} = 2.4 \cdot 10^{-6}$ s)

$$t_{w(B(charm))} = t_{w(muon)} / N_y^{\,4} = 1.9 \cdot 10^{-13} \text{ s}.$$

**8. Hyperons**

The $d = 2$ state is the ground state outside the Schwarzschild surface for the strong interactions and is responsible for the structure of hyperons. During the transition of the $W_d$

pion from the $d = 2$ state into $d = 4$, in the $d = 2$ state vector bosons occur as a result of decay of the $W_d$ pions into two large loops. Each loop has a mean energy equal to the $E$

$$E = (m_{W(-),d=2} + m_{W(o),d=2} - m_{W(-),d=4} - m_{W(o),d=4}) / 2 = 19.367 \text{ MeV}. \qquad (155)$$

The vector bosons interact with the $W_d$ pions in the $d = 2$ state. The mean relativistic energy, $E_W$, of these bosons is

$$E_W = E\,(A / (2\,B) + 1)^{1/2} = 25.213 \text{ MeV}. \qquad (156)$$

Groups of the vector bosons can contain $d$ loops. Then in the $d = 2$ state there may occur particles that have mass which can be calculated using the following formula

$$M_{(+-o),k,d=2} = m_{W(+-o),d=2} + \sum_{d=0,1,2,4}^{d<2^k} d E_W, \qquad (157)$$

where $k = 0, 1, 2, 3$; the $k$ and $d$ determine the quantum state of the particle having a mass $M_{(+-o),k,d}$.

The mass of a hyperon is equal to the sum of the mass of a nucleon and of the masses calculated from (157). We obtain extremely good conformity with the experimental data assuming that hyperons contain the following particles (the values of the mass are in MeV)

$$m_\Lambda = m_{neutron} + M_{(o),k=0,d=2} = 1115.3, \qquad (158a)$$
$$m_{\Sigma(+)} = m_{proton} + M_{(o),k=2,d=2} = 1189.6, \qquad (158b)$$
$$m_{\Sigma(o)} = m_{neutron} + M_{(o),k=2,d=2} = 1190.9, \qquad (158c)$$
$$m_{\Sigma(-)} = m_{neutron} + M_{(-),k=2,d=2} = 1196.9, \qquad (158d)$$
$$m_{\Xi(o)} = m_\Lambda + M_{(o),k=1,d=2} = 1316.2, \qquad (158e)$$
$$m_{\Xi(-)} = m_\Lambda + M_{(-),k=1,d=2} = 1322.2, \qquad (158f)$$
$$m_{\Omega(-)} = m_{\Xi(-o)} + M_{(o-),k=3,d=2} = 1674.4. \qquad (158g)$$

Using the formulae (157)-(158) we can summarise that for the given hyperon the following selection rules are satisfied:

a) each addend in the sum in (157) contains $d$ vectorial bosons,
b) for the $d = 2$ state the sum of the values of the $k$ numbers is equal to one of the $d$ numbers,
c) the sum of the following three numbers i.e. of the sum of the values of the $k$ numbers in the $d = 2$ state plus the number of particles denoted by $M_{(+-o),k,d=2}$ plus one nucleon is equal to one of the $d$ numbers,
d) there cannot be two or more objects in the nucleon or hyperon having the mass $M_{(+-o),k,d}$ for which the numbers $k$ and $d$ have the same values,
e) there cannot be vector bosons in the $d = 1$ state because this state lies under the Schwarzschild surface and transitions from the $d = 1$ state to the $d = 2$ or $d = 4$ states are forbidden, so in the $d = 1$ state there can only be one $W_d$ pion,

f) the mean charge of the torus of the nucleon is positive so if the relativistic pions are not charged positively then electric repulsion does not take place – there is, however, one exception to this rule: in the $d = 1$ state there can be a positively charged pion because during that time the torus of the proton is uncharged,
g) to eliminate electric repulsion between pions in the $d = 2$ state there cannot be two or more pions charged negatively,
h) there cannot be a negatively charged $W_d$ pion which does not interact with the vector boson in the $d = 2$ state in the proton because this particle and the $W_d$ pion in the $d = 1$ state would annihilate,
i) there cannot be a neutral pion in the $d = 2$ state in the proton because the exchange of the charged positively pion in the $d = 1$ state and of the neutral pion in the $d = 2$ state takes place. This means that the proton transforms itself into the neutron. Following such an exchange the positively charged pion in the $d = 2$ state is removed from the neutron because of the positively charged torus. Such a situation does not take place in the hyperon lambda $\Lambda = n\,W_{(o),d=2}$.

Using these rules we can conclude that the structure of hyperons strongly depends on the $d$ numbers associated with the Titius-Bode law for strong interactions (i.e. with symmetrical decays) and on the interactions of electric charges.

The above selection rules lead to the conclusion that there are in existence only two nucleons and seven hyperons.

The spins of the vector bosons are oriented in accordance with the Hund law. The angular momentums and the spins of the objects having the mass $M_{(+-o),k,d}$ are oriented in such a way that the total angular momentum of the hyperon has minimal value. All of the relativistic pions, which appear in the tunnels of nucleon, are in the $S$ ($l = 0$) state. This means that hyperons $\Lambda$, $\Sigma$, and $\Xi$ have half-integral spin, whereas $\Omega$ has a spin equal to $3/2$.

The strangeness of the hyperon is equal to the number of particles having the masses $M_{(+-o),k,d=2}$ taken with the sign "–".

Notice also that the percentages for the main channels of the decay of $\Lambda$ and $\Sigma^+$ hyperons are close to the $x$, $1-x$, $y$, $1-y$ probabilities. This suggests that in a hyperon, before it decays, the $W_{(o),d=2}$ pion transits to the $d = 1$ state and during its decay the pion appears which was in the $d = 1$ state.

## 9. Selected resonances

The distance of mass between the resonances, and between the mass of the resonances and the hyperons or nucleons, are close to the mass of the $S_d$ bosons.

The lightest resonance $\Delta(1236)$ consists of the nucleon and the $S_d$ boson in the $d = 2$ state, i.e. the $\Delta(1236)$ consists of $S_{(+-o),d=2}\{2-\}$ and of a proton or neutron $\{1/2+\}$. Mean mass calculated of all charge states i.e. $++$, $+$, $o$, $-$, equals 1236.8 MeV (the number before the signs "+" and "–" denotes the approximate value of angular momentum, whereas the "+" and "–" denotes the orientations of the angular momentum respectively "up" and "down").

The parity of the $S_{(o),d}$ pions is assumed to be negative, and the parity of the lambda hyperon is assumed to be positive. For selected resonances we have

$$m_{N(2650)} = 3m_{S(o),d=1}\{2+2+2-\} + 1m_{S(o),d=2}\{2+\} + 1m_{S(o),d=4}\{1+\} + 1m_{proton}\{1/2+\}$$
$$(or\ 1m_{neutron}\{1/2+\}) = 2688\ \text{MeV}\ (J^P = 11/2^-), \quad (159a)$$

$$m_{\Lambda(1520)} = 1m_{S(o),d=1}\{2-\} + m_{\Lambda(1115)}\{1/2+\} = 1537 \text{ MeV } (J^P = 3/2^-), \quad (159b)$$

$$m_{\Lambda(2100)} = 2m_{S(o),d=1}\{2+2+\} + 1m_{S(o),d=4}\{1-\} + m_{\Lambda(1115)}\{1/2+\} = $$
$$= 2145 \text{ MeV } (J^P = 7/2^-), \quad (159c)$$

$$m_{\Lambda(2350)} = 2m_{S(o),d=1}\{2+2+\} + 2m_{S(o),d=4}\{1+1-\} + m_{\Lambda(1115)}\{1/2+\} =$$
$$= 2332 \text{ MeV } (J^P = 9/2^+), \quad (159d)$$

$$m_{\Sigma(1765)} = 3m_{S(o),d=4}\{1\text{-}1\text{-}1\text{-}\} + m_{\Sigma(1192.5)}(\text{mean value})\,\{1/2+\} =$$
$$= 1753 \text{ MeV } (J^P = 5/2^-), \quad (159e)$$

$$m_{\Sigma(1915)} = 4m_{S(o),d=4}\{1+1+1+1-\} + m_{\Sigma(1192.5)}\{1/2+\}=$$
$$= 1940 \text{ MeV } (J^P = 5/2^+). \quad (159f)$$

**10. Mass of the composite Higgs boson**

Higgs bosons are produced in nuclear plasma i.e. in a liquid composed of the cores packed to maximum (i.e. the Titius-Bode orbits are destroyed. It leads to conclusion that the mass of the Higgs boson follows from structure of the core of baryons.

Notice that there appears the electromagnetic binding energy equal to $E_{em} = 3.0969530$ MeV (see explanation below formula (57) – it can be a condensate. On the other hand, the mass density of the underlying Einstein spacetime is $f = 40{,}362.942$ times higher (see Paragraph "*Range of confinement*"). Calculate the mass of the underlying Einstein spacetime which is the composite-Higgs-boson mass – it consists of the confined neutrino-antineutrino pairs

$$M_{Higgs\text{-}boson} = f\ E_{em} = 125.002 \text{ GeV}. \quad (160)$$

Emphasize that the neutrinos all PoE particles consist of, acquire their masses due to the superluminal Higgs field. The composite Higgs boson has nothing with the Higgs mechanism.

**11. Masses of quarks**

Within the 3-valence-quarks model of baryons we cannot calculate the precise mass and spin of proton whereas it is possible within the Scale-Symmetric Theory. It suggests that the quark theory is not important at low energy. But, of course, the masses of quarks should follow from presented here the atom-like structure of baryons and it is. Most important are the masses of the quark-antiquark pairs.

Mass of the up quark (2.23 MeV) is equal to the half of the distance of masses between the two states of proton.

Mass of the down quark (4.89 MeV) is equal to the half of the distance of masses between the two states of neutron.

Mass of the strange quark (87.85 MeV) should be associated with the mass of the relativistic neutral $W_d$ pion in the $d = 2$ state (this state is responsible for the masses of strange hyperons). Its mass is 175.709 MeV (see Table 2) so mass of the strange quark is equal to the half of this mass.

To calculate masses of the three heaviest quarks we must derive some formula.

Quark is a loop or a condensate of it. A loop has 10 degrees of freedom (see Table 4). A hypervolume of the phase space and its total mass (the mass is in proportion to the hypervolume), i.e. the mass of the quark-antiquark pairs created in collisions, must be in proportion to the radius of a gluon loop to the power of 10.

On the equator of the torus, there arise the gluon condensates which masses are the same as the calculated within the atom-like structure of baryons. Range of a condensate is $r_{range}$. Then, there is created a loop with radius $r_{loop} = r_{range} + A$. Mass of such a loop we can calculate from following formula

$$M_{Loop}\,[\mathrm{GeV}] = a\,(r_{Loop}\,[\mathrm{fm}])^{10} = a\,(r_{range}\,[\mathrm{fm}] + A\,[\mathrm{fm}])^{10}, \qquad (161)$$

where $a$ is a factor whereas $A = 0.6974425$ fm is the radius of the equator of the torus in the core. For $M = 0.72744$ GeV we should obtain $r_{loop} = A$ so then $a = 26.7124$ GeV/fm$^{10}$.

Knowing that range of mass equal to $m_{S(+,-),d=4} = 187.573$ MeV is $4B = 2.00736$ fm, we can calculate range for a gluon condensate from formula

$$r_{range}\,[\mathrm{fm}] = m_{S(+,-),d=4}\,[\mathrm{MeV}]\;4B\,[\mathrm{fm}]\,/\,m_{condensate}\,[\mathrm{MeV}] =$$

$$= b\,/\,m_{condensate}\,[\mathrm{MeV}], \qquad (162)$$

where $m_{condensate}$ is the mass of a gluon condensate whereas $b = 376.527$ fm·MeV.

We can rewrite formula (161) as follows

$$M_{Loop}\,[\mathrm{GeV}] = a\,(b\,/\,m_{condensate}\,[\mathrm{MeV}] + A\,[\mathrm{fm}])^{10}. \qquad (163)$$

Mass of gluon condensate equal to mass of the *Y(1S, 9460 MeV)* leads to the mass of the charm quark (1267 MeV).

A loop overlapping with the $d = 0$ orbit is 727.44 MeV. Calculate mass of a condensate that is equal to 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 $m_{condensate} = 2821.1$ MeV. Applying formula (163) we obtain mass of the bottom quark (4190 MeV). This mass is associated with the last orbit in the baryons so it is the reason that the calculations within the Standard Model of the running coupling for the strong interactions via the bottom quark are simplest.

Mass of gluon condensate equal to sum of masses of the torus inside the core of baryons ($X = 318.2955$ MeV) and the condensate ($Y = 424.1245$ MeV), i.e. $m_{condensate} = 742.42$ MeV, leads to the mass of the top quark (171.9 GeV).

## 12. Larger structures

The saturation of interactions via the Higgs field described in Paragraph **1.2** and the four-particle symmetry described in Paragraph **3.2**, lead to the larger structures.

For the single objects such as, for example, fermions, and for the binary systems, as for example, the neutrino-antineutrino pairs or binary systems of massive galaxies, there is obligatory following formula for number of constituents, $N$, in bigger composite structures

$$N = 4^d, \tag{164}$$

where $d = 0, 1, 2, 4, 8, 16, 32, \ldots$ For example, an object containing $4$ elements can simultaneously interact with $4 - 1 = 3$ objects, each containing $4$ elements i.e. the smaller object contains $4$ elements whereas the bigger one contains $16 = 4^2$ elements.

Such structures follow from the quantum entanglement i.e. results from the exchanges of the superluminal entanglons.

There is the upper limit for the larger structures.

We know that from energy equal to the rest mass of a nucleon can be produced at the very most six neutral pions. We showed that simplest neutral pion consists of two simplest closed gluons i.e. of four rotating neutrinos. We showed as well that each nucleon has two different mass states. Moreover, we showed that the closed gluons behave in the nuclear strong fields as electrons in atoms. These remarks lead to following formula for upper limit for number of neutrinos in a neutral pion

$$N_{maximum} = 2 \cdot 4^{32}. \tag{165}$$

The same concerns the binary systems. We can see that simplest composite objects can contain $4$ or $8$ constituents.

In next paper titled "New Cosmology" we will show that each initial super-photons produced at the beginning of the expansion of the Universe decayed to the $2 \cdot 4^{16}$ photon galaxies. It leads to $391$ million photons in cubic meter in our Universe.

## 13. The properties of Einstein spacetime lead to relativistic mass and to the correct interpretation of the formula E = m c²; what can be maximum energy of virtual particles produced by a bare particle?

It is not true that pure energy, i.e. rotational energy of something or kinetic energy of something can transform into inertial or gravitational mass. The pure energy always concerns masses.

Pure energy (it does not gravitate), $E$, which is associated with mass, can create a vortex. Such ordered motions decrease local pressure in the Einstein spacetime composed of the neutrino-antineutrino pairs. It causes that additional neutrino-antineutrino pairs inflow into the vortex – it increases the mass density of the vortex and it leads to the "created" mass. The "created" mass is equal to the pure energy $E$. We can see that if not the Einstein spacetime, the formula $E = m c^2$ would be invalid.

In the two-component spacetime there are not free entanglons – it causes that mass of the neutrinos (neutrinos are built of entanglons) is invariant.

Because the mean spin velocity of the proton, $v_{spin}$, is perpendicular to the relativistic velocity of the proton, $v_{relativistic}$, then for the neutrino-antineutrino pairs placed on the equator of the torus of the core of baryons is

$$n\, v_{spin}^2 + n\, v_{relativistic}^2 = n\, c^2, \tag{166}$$

where letter $n$ denotes the number of neutrino-antineutrino pairs within a relativistic proton.

Because it is obligatory that the law of conservation of spin exists then for neutrino-antineutrino pairs placed on the equator (similarly for all other pairs) we have:

$$N_n\, c = n\, v_{spin}, \tag{167}$$

where $N_n$ denotes the number of neutrino-antineutrino pairs in a resting proton. The size of the torus also cannot change because the spin and charge are continuously not changing.

Transformations of a very simple nature lead to following formula:

$$n = N_n / (1 - v^2 / c^2)^{1/2}. \tag{168}$$

Since the relativistic mass is directly proportional to the n whereas the rest mass to $N_n$, we subsequently obtained the very well known Einstein formula.

This means that a relativistic proton is built up of more binary systems of neutrinos i.e. the thickness of the surface of torus is greater – next are created layers built up of the same number of neutrino-antineutrino pairs because the number of lines of electric forces, created by the torus, cannot change over time. As the condensate must be about $4/3$ greater than the mass of torus this mass also increases when we accelerate a proton.

Emphasize that in a particle there is the non-gravitating energy, $E$, and the particle has the bare mass, $M$, equal to the $E$ so sum of absolute values of energies of virtual particles created outside the bare particle cannot be greater than $E + M = 2E$.

**14. The Ultimate Equation**

We can write the ultimate equation which ties the properties of the pieces of space i.e. tachyons with the all masses/sources responsible for the all types of interactions.

The ultimate equation looks as follows

$$4\pi m_{tachyon}\rho/3\eta = (2m_{closed\text{-}string}/\hbar)^2(2m_{neutrino}/\rho_E)^{1/3}(m_{bare(electron)}/2)c(X/H^+)^{1/2}. \tag{169}$$

The $4\pi/3$ on the left side of the ultimate equation shows that the tachyons are the balls. The mean mass of tachyons is the mean mass of the source of the fundamental interaction that follows from the direct collisions of tachyons and their viscosity which results from smoothness of their surface. The $\rho$ is the mass density of the pieces of space i.e. the tachyons (it is not the inertial mass density of the Higgs field). The $\eta$ is the dynamic viscosity of the pieces of space i.e. of the tachyons.

The two masses of the closed strings (the entanglon; their total spin is $2 \cdot \hbar/2 = \hbar$) on the right side of the ultimate equation are the carriers of the entanglement. The two masses of neutrinos, i.e. the neutrino-antineutrino pair, are the source of the gravitational field, linear quantum entanglement and volumetric confinement. The mass of single neutrino is the smallest gravitational mass. In the equation, the smallest gravitational mass is multiplied by 2 that points that the non-rotating-spin neutrino-antineutrino pairs are the components of the ground state of the Einstein spacetime (the $\rho_E$ in the denominator is the mass density of Einstein spacetime). The half of the mass of the bare electron is the mass of the electric charge i.e. the mass of the source of the electromagnetic interaction. The $c$ is the speed of photons and gluons. The $X$ is the mass of the torus/charge inside the core of baryons in which the large loops arise – they are responsible for the nuclear strong interactions. The $H^+ = X + Y - binding\text{-}energy$, where the $Y$ is the source of the nuclear weak interactions in the baryons at low energy.

To give possibility for a quick verification of correctness of the ultimate equation, we write once more the needed values:

$m_{tachyon}$ = $3.752673 \cdot 10^{-107}$ kg,
$\eta$ = $1.87516465 \cdot 10^{138}$ kg/(m s),
$\rho$ = $8.3219243620109 \cdot 10^{85}$ kg/m$^3$,
$m_{closed\text{-}string}$ = $2.3400784191307 \cdot 10^{-87}$ kg,
$\hbar$ = $1.0545715483339 \cdot 10^{-34}$ J s,
$m_{neutrino}$ = $3.3349306182144 \cdot 10^{-67}$ kg,
$\rho_E$ = $1.10220055 \cdot 10^{28}$ kg/m$^3$,
$c$ = $2.9979245801192 \cdot 10^{8}$ m/s,
$m_{bare(electron)}$ = $9.0988302032434 \cdot 10^{-31}$ kg,
$X$ = 318.29553671300 MeV,
$H^+$ = 727.44012298929 MeV.

The left and right side of the ultimate equation is $6.9761159243710 \cdot 10^{-159}$ kg s/m$^2$.

**How can we verify the Scale-Symmetric Theory?** My theory identifies where mainstream theories should be inconsistent with experimental data:

1. There should be the upper limit for energy of relativistic proton about 18 TeV. This follows from the internal structure of the core of baryons.
2. There should be weak signal of existence of a condensate with a mass of 17.1 TeV. This follows from the internal structure of the Einstein spacetime and the core of baryons.
3. There should be in existence the neutrino-antineutrino pairs which cannot annihilate.
4. There should not be in existence gravitons and gravitational waves.

**Turning points in the formulation of the Scale-Symmetric Theory**

At the beginning, I noticed that the following formula describes how to calculate the mass of a hyperon:

$m$ [MeV] $= 939 + 176\,n + 26\,d$, where $n = 0, 1, 2, 3$ and $d = 0, 1, 3, 7$.

For a nucleon it is $n = 0$ and $d = 0$ which gives 939 MeV. For lambda $n = 1$ and $d = 0$ which gives 1115 MeV. For sigma $n = 1$ and $d = 3$ which gives 1193 MeV. For ksi $n = 2$ and $d = 1$ which gives 1317 MeV. For omega $n = 3$ and $d = 7$ which gives 1649 MeV. I later noticed that the distances of the mass between the resonances and distances of the mass between the resonances and hyperons is approximately 200 MeV, 300 MeV, 400 MeV, and 700 MeV. This was in 1976.

In 1985, I grasped that in order to obtain positive theoretical results for hadrons, we should assume that outside the core of a nucleon is in force the Titius-Bode law for nuclear strong interactions. On orbits are relativistic pions. The year 1997 was the most productive for me because I described the phase transitions of the superluminal Higgs field, the four-particle symmetry also leading to the distribution of galaxies that is visible today, and I also described the fundamental phenomena associated with new cosmology of the Universe. In this eventful year, I practically formulated new particle physics and new cosmology.

First publication: "*General Theory of Singularities*",
Szczecin: Tajgeta, ISBN 83-901005-1-7 (1997);
Available in Polish National Library: Signature: NR_BBN: PB 9041/2000 or in Jagiellonian Library: Signature: B 250180 [5], [6].

The first publication contains the foundations of the Scale-Symmetric Theory i.e. the phase transitions of the inflation/Higgs field and the atom-like structure of baryons.

**15. Summary**

The Scale-Symmetric Theory is the non-perturbative theory – it is the lacking part and foundations of the theory of everything and is free from singularities and infinities.

Some extension of the General Relativity leads to the Higgs field composed of non-gravitating tachyons. The succeeding phase transitions of the superluminal Higgs field lead to the physical constants, to an atom-like structure of baryons, to structures and masses of baryons, mesons and leptons, to carriers of photons and gluons, and to new cosmology. Most important is the fact that SST leads to structures of bare particles. The succeeding phase transitions lead to different scales (theories of three last scales are dual), for example, during the inflation there appeared the superluminal entanglons responsible for the quantum entanglement and the Einstein spacetime composed of the neutrino-antineutrino pairs.

Neutrinos are the smallest and lightest Principle-of-Equivalence particles. They acquire their gravitational mass due to their interactions with the superluminal Higgs field – it causes that the $G$ has the same value for all masses.

There are the two long-distance interactions i.e. gravitation and electromagnetism. Gravitational fields are the gradients in the Higgs field produced by neutrinos and neutrino-antineutrino pairs the Einstein spacetime consists of. This suggests that there are two parallel spacetimes. To explain the inflation, long-distance entanglement, cohesion of wave function and constancy of the speed of light, we need the fundamental spacetime composed of tachyons and the superluminal entanglons. On the other hand, the quantum particles need the Einstein spacetime.

We cannot unify the Gravity and Standard Model within the same methods because gravitational fields are directly associated with the superluminal Higgs field whereas the Standard-Model interactions are associated directly with fields composed of the neutrino-antineutrino pairs and neutrinos.

SST is very simple because it is based on only seven parameters and three formulae – two formulae are associated with the phase transitions and one formula is associated with the Titius-Bode law for the nuclear strong interactions. SST does not contain free parameters and leads to theoretical results consistent or very, very close to experimental data.

Due to the succeeding phase transitions, there appeared the seven types of interactions: the viscosity that follows from smoothness of surface of the tachyons, directional entanglement and volumetric confinement associated with internal structure of neutrinos, gravity associated with the superluminal Higgs field and the three Standard-Model interactions associated with the fields composed of the neutrino-antineutrino pairs. The volumetric confinement of the neutrino-antineutrino pairs and neutrinos (the Mexican-hat mechanism) results from the range of the radiation mass of some analog to the neutral pion. Constants of interactions are directly in proportion to the mass densities of the fields carrying the interactions. The factor of proportionality has the same value for all interactions. The changing running coupling for strong-weak interactions follows from the invariance of spin and the Uncertainty Principle for the virtual large loops responsible for the nuclear strong interactions.

Our Cosmos composed of universes was created due to collision of big pieces of space built of the internally structureless and non-gravitating tachyons.

The properties of the two-component spacetime lead to the relativistic mass.

The four-particle symmetry solves many problems associated with particle physics and cosmology.

The atom-like structure of baryons leads to the mass of the composite Higgs boson (125 GeV) and to the masses of quarks.

There is also the ultimate equation that combines the masses of sources of all types of interactions.

## 16. Tables

Table 7 *Theoretical results*

| **Physical quantity** | **Theoretical value*** |
|---|---|
| Gravitational constant | 6.6740007 E-11 $m^3/(kg\ s^2)$ |
| Half-integral spin | (1.054571548 E-34)/2 Js |
| Speed of light | 2.99792458 E+8 m/s |
| Electric charge | 1.60217642 E-19 C |
| Mass of electron | 0.510998906 MeV |
| Fine-structure constant for low energies | 1/137.036001 |
| Mass of bound neutral pion | 134.96608 MeV |
| Mass of free neutral pion | 134.97674 MeV |
| Mass of charged pion | 139.57041 MeV |
| Radius of closed string | 0.94424045 E-45 m |
| Linear speed of closed string | 0.7269253 E+68 m/s |
| Mass of closed string | 2.3400784 E-87 kg |
| External radius of neutrino | 1.1184555 E-35 m |
| Mass of neutrino | 3.3349306 E-67 kg |
| Mass of core of Protoworld and superluminal energy frozen inside stable neutrino | 1.96076 E+52 kg |
| External radius of core of Protoworld | 287 million light-years |
| Baryonic mass of the Universe | 3.6382 E+51 kg |
| Radius of the early Universe loop | 191 million light-years |
| External radius of torus of nucleon | 0.697442473 fm |
| Constant K | 0.7896685548 E+10 |
| Binding energy of two large loops | 0.12273989 MeV |
| Mass of large loop | 67.5444107 MeV |
| Mass of torus of core of baryons | 318.295537 MeV |
| Mass of condensate of the nucleon | 424.124493 MeV |
| Range of weak interactions of the proton | 8.710945 E-18 m |
| Weak binding energy of core of baryons | 14.980 MeV |
| Mass of charged core of baryons | 727.440123 MeV |
| Ratio of mass of core of baryons to mass of large loop | 10.769805 |
| Mass of bound muon | 105.82889 MeV |
| Mass of free muon | 105.656314 MeV |
| The A/B in the Titius-Bode law for strong interactions | 1.38977193 |
| Mass of proton | 938.2725 MeV |
| Mass of bound neutron | 939.5378 MeV |
| Mass of free neutron | 939.5648 MeV |
| Proton magnetic moment in nuclear magneton | +2.79360 |
| Neutron magnetic moment in nuclear magneton | –1.91343 |
| Radius of last tunnel for strong interactions | 2.7048 fm |
| Mean square charge for nucleon | 0.29 |

*E-15=$10^{-15}$

Table 8 *Theoretical results*

| Physical quantity | Theoretical value |
|---|---|
| Mean square charge for proton | 0.25 |
| Mean square charge for neutron | 0.33 |
| External radius of torus of electron | 386.607 fm |
| Range of weak interactions of electron | 0.7354103 E-18 m |
| Weak constant | 1.0354864 E+27 $m^3/(kg\ s^2)$ |
| Electromagnetic constant for electrons | 2.7802527 E+32 $m^3/(kg\ s^2)$ |
| Coupling constant for weak interactions of the proton | 0.0187228615 |
| Coupling constant for the electron-proton weak interaction | 1.11943581 E-5 |
| Coupling constant for the electron-muon weak interaction | 0.9511082 E-6 |
| Coupling constant for strong-weak interactions inside the baryons | d=0: 0.993813<br>d=1: 0.762594<br>d=2: 0.640304 |
| Ratio of the hidden energy to mass of the neutrino | 0.59 E+119 |
| Mass of the composite “Higgs boson” | 125.002 GeV |
| Range of confinement | 3510.1831 $r_{neutrino}$ |
| Coupling constant for confinement | ~ 4.0 E-19 |
| Coupling constant for entanglement | ~ 3.1 E+92 |

Table 9 *Theoretical results*

| Physical quantity | Theoretical value |
|---|---|
| Lifetime of the proton | Stable |
| Lifetime of the muon | 2.195006 E-6 s |
| Lifetime of the tau | 2.6973 E-13 s |
| Lifetime of the hyperon | 1.11505 E-10 s |
| Lifetime of the charm baryon $\lambda_c^+(2260)$ | 6.5 E-13 s |
| Lifetime of the neutral pion | 0.79 E-16 s |
| Lifetime of the charged pion | 2.8 E-8 s |
| Coupling constant for strong interactions of the non-relativistic protons | 14.4038 |
| Coupling constant for strong interactions of the pions | 1 |

*2.2 E+133=$2.2 \cdot 10^{133}$

Table 10 *Values of the G(i)*

| Interaction | Relative value of the $G_i$ |
|---|---|
| Strong | 1 (for $G_S=5.46147 \cdot 10^{29}\ m^3s^{-2}kg^{-1}$) |
| Weak | $1.9 \cdot 10^{-3}$ |
| Electromagnetic interaction of electrons | $5.1 \cdot 10^2$ (it is not a mistake) |
| Gravitational | $1.2 \cdot 10^{-40}$ |

Table 11 *New electroweak theory*

| Physical quantity | Theoretical value |
|---|---|
| Electron magnetic moment in the Bohr magneton | 1.0011596521735 |
| Muon magnetic moment in the muon magneton | 1.001165921508 |
| Frequency of the radiation emitted by the hydrogen atom under a change in spin orientation | 1420.4057494 MHz |
| Lamb-Retherford Shift | 1057.84 MHz<br>1058.05 MHz |

Table 12 *Mesons*

| Physical quantity | Theoretical value |
|---|---|
| Mass of the $K^{+,-}$ kaon | 493.733693 MeV |
| Mass of the $K^o$ kaon | 497.759913 MeV |
| Lifetime of $K_L^0$/lifetime $K_S^0$ | 527 |
| Mass of K*(892) | 901 MeV |
| Mass of Eta | 549.073 MeV |
| Mass of Eta' | 953.971 MeV |
| Mass of Ypsilon | 9463 MeV |
| Mass of $Z^0$ | 91.205 GeV |
| Mass of $W^{+,-}$ | 80.385 GeV |
| Mass of D(charm) | 1867 MeV |
| Mass of D(strange) | 1991 MeV |
| Mass of B | 5281 MeV |
| Mass of B(strange) | 5354 MeV |
| Mass of B(charm) | 6290 MeV |
| Lifetime of B(charm) | $1.9 \cdot 10^{-13}$ s |

Table 13 *Hyperons and resonances*

| Particle | Theoretical value Mass | Theoretical value | | |
|---|---|---|---|---|
| | | J | P | S |
| Hyperon $\Lambda$ | 1115.3 MeV | 1/2 | +1* | -1 |
| Hyperon $\Sigma^+$ | 1189.6 MeV | 1/2 | +1 | -1 |
| Hyperon $\Sigma^o$ | 1190.9 MeV | 1/2 | +1 | -1 |
| Hyperon $\Sigma^-$ | 1196.9 MeV | 1/2 | +1 | -1 |
| Hyperon $\Xi^o$ | 1316.2 MeV | 1/2 | +1 | -2 |
| Hyperon $\Xi^-$ | 1322.2 MeV | 1/2 | +1 | -2 |
| Hyperon $\Omega^-$ | 1674.4 MeV | 3/2 | +1 | -3 |
| Tau lepton | 1782.5 MeV | 1/2 | | |
| Resonance $\Delta$(1232) | 1236.8 MeV | 3/2 | +1 | |
| Resonance N(2650) | 2688 MeV | 11/2 | -1 | |
| Resonance $\Lambda$(1520) | 1537 MeV | 3/2 | -1 | |
| Resonance $\Lambda$(2100) | 2145 MeV | 7/2 | -1 | |
| Resonance $\Lambda$(2350) | 2332 MeV | 9/2 | +1 | |
| Resonance $\Sigma$(1765) | 1753 MeV | 5/2 | -1 | |

*Assumed positive parity

Table 14 *Masses of quarks*

| **Physical quantity** | **Theoretical value** |
|---|---|
| Mass of up quark | 2.23 MeV |
| Mass of down quark | 4.89 MeV |
| Mass of strange quark | 87.85 MeV |
| Mass of charm quark | 1267 MeV |
| Mass of bottom quark | 4190 MeV |
| Mass of top quark | 171.9 GeV |

**References**

[1] K. A. Olive *et al.* (Particle Data Group), Chin. Phys. C, **38**, 090001 (2014) and 2015 update
[2] http://thewire.in/2015/10/29/good-scientists-solve-problems-but-great-scientists-know-whats-worth-solving-14279/
[3] M W Zwierlein, J R Abo-Shaeer, A Schirotzek, C H Schunck, and W Ketterle; *Vortices and superfluidity in a strongly interacting Fermi gas*; Nature **435**, 1047-1051 (2005).
[4] http://arxiv.org/pdf/1312.5694.pdf .
[5] Sylwester Kornowski (1997). “General Theory of Singularities”
Editor: Szczecin: Tajgeta (1997), ISBN 83-901005-1-7
Avaliable in Polish National Library: Signature: NR_BBN: PB 9041/2000 (1997)
or ISBN 83-901005-8-4, NR_BBN: PB 4736/98 (1998)
http://katalogi.bn.org.pl/iii/encore/search/C_Ssylwester%20kornowski_Orightresult_U?lang=pol&suite=cobalt
[6] Sylwester Kornowski (1997). “General Theory of Singularities”
Editor: Szczecin: Tajgeta (1997), ISBN 83-901005-1-7
Avaliable in Jagiellonian Library: Signature: B 250180 (1997)
or ISBN 83-901005-8-4, B 184997 (1998)
https://chamo.bj.uj.edu.pl/uj/search/query?term_1=sylwester+kornowski&theme=system
[7] Sylwester Kornowski (15 February 2018). “Lifetime of the Neutron”
http://vixra.org/abs/1802.0178