Foundations of the Scale-Symmetric Physics

(Main Article No 2: Cosmology)

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Abstract: A collision of two very big pieces of space leads to the initial conditions for the inflation field and next to the succeeding phase transitions of the superluminal inflation field (i.e. of the superluminal Higgs field composed of the non-gravitating tachyons) so there appear different scales. Due to the inflation, there appear two boundaries of our Cosmos that cause that the basic physical constants are invariant. The fourth phase transition of the Higgs field, described within the Scale-Symmetric Theory, leads to the cosmological structure (Protoworld) which appeared in our Cosmos after the inflation. Evolution of the Protoworld leads to the dark matter, dark energy, and expanding Universe – the three components of the Universe consist of the components of the Einstein spacetime that appeared during the inflation (the components are the neutrino-antineutrino pairs). The first phase transition leads to the superluminal spin-1 entanglons responsible for the quantum entanglement, the second phase transition leads to the Einstein spacetime, whereas the third to the cores of baryons and electrons. The dark matter is entangled with the expanding baryonic matter (it is the long-distance directional quantum entanglement), the dark energy consists of free neutrino-antineutrino pairs whereas in hadrons and electron-like leptons, the neutrino-antineutrino pairs are confined (it is the volumetric confinement) and/or entangled (it is the short-distance directional entanglement). For both the confinement and quantum entanglement are responsible the entanglons the neutrinos consist of. The Universe was created inside the core of Protoworld (it looks similar to creation of neutral pion in the core of baryons). Gravitational mass of the core of Protoworld is equal to the superluminal non-gravitating energy frozen inside each stable neutrino (stable are only the electron- and muon-neutrinos). The Protoworld-neutrino transition caused that entanglons responsible for quantum entanglement of the dark-matter (DM) loops the Protoworld consisted of, are frozen in the new neutrino so the DM loops are entangled only with the baryonic matter. The inflows of the dark matter and dark energy into the baryonic matter caused the exit of the Universe from its black-hole state. To describe correctly dynamics of the expanding Universe, we must know that the speed of light in "vacuum" c, is the speed in relation to source or in relation to a last-interaction object/detector - it follows from the quantum entanglement of light with a last-interaction object that fixes the speed c. The inflows of the dark matter fix the radial speed of the front of expanding baryonic matter - in our Universe it is equal to 0.6415c. It causes that the relative speed of light emitted by most distant galaxies in relation to galaxies placed close to the centre of the expanding Universe is 0.3585c. Such cosmological dynamics shows that the Universe is 21.614 Gyr old but we can see only the last period 13.866 +- 0.096 Gyr of evolution of the galaxies. Moreover, the last period is the time distance, not the spatial distance that is equal to about 4.971 Gyr only. Among many other things, we calculated the abundances of the dark matter, dark energy and the baryonic matter, Hubble constant, number of CMB photons, we described the origin of the large-scale structure of the Universe, the anisotropy power for the CMB radiation, and the standard ruler in cosmology, we calculated as well the ratio of B-modes to E-modes and abundance of helium and hydrogen.

Contents

1. Introduction (the inflation field)

According to the Scale-Symmetric Theory (SST), [1], our Cosmos was created due to a collision of very big pieces of space composed of non-gravitating tachyons. The smaller big piece of space was the expanding inflation field (the superluminal Higgs field) inside the bigger one, whereas the bigger one transformed into the boundary of the superluminal Higgs field. During the inflation, the superluminal field transformed partially into the Einstein spacetime composed of the neutrino-antineutrino pairs. The neutrinos acquire their gravitational mass (only two from the three different neutrinos, i.e. the electron- and muon-neutrinos, are stable) due to their interactions with the SST Higgs field.

Emphasize that all not calculated here but used theoretical results and used arguments without sufficient explanations follow from paper [1].

2. Two boundaries of the Cosmos

All needed here values are calculated within SST [1].

We can calculate radius of the Einstein spacetime from the condition that gravitational pressure inserted on a single neutrino on surface of the spacetime cannot be higher than the dynamic pressure inside it.

The gravitational force acts on area that is the cross-section of the neutrino but due to the confinement, the radius of neutrino is enlarged $x = 3{,}510.1831$ times i.e. the effective radius R is $R = x\, r_{neutrino}$, where $r_{neutrino} = 1.1184555 \cdot 10^{-35}$ m. The gravitational pressure, p_{gr}, is

$$p_{gr} = F_{gr} / S_R = (G\, M_{Cosmos}\, m_{neutrino} / R^2{}_{Cosmos}) / (\pi R^2) = \\ = 4\, G\, \pi\, \rho_E\, R_{Cosmos}\, m_{neutrino} / (3\pi R^2), \tag{1}$$

where $\rho_E = 1.10220055 \cdot 10^{28}$ kg/m^3 is the mass density of the Einstein spacetime and $m_{neutrino} = 3.3349306 \cdot 10^{-67}$ kg is the gravitational mass of stable neutrino.

On the other hand, the dynamic pressure of the Einstein spacetime, p_{dynE}, is

$$p_{dynE} = \rho_E\, c^2 / 2. \tag{2}$$

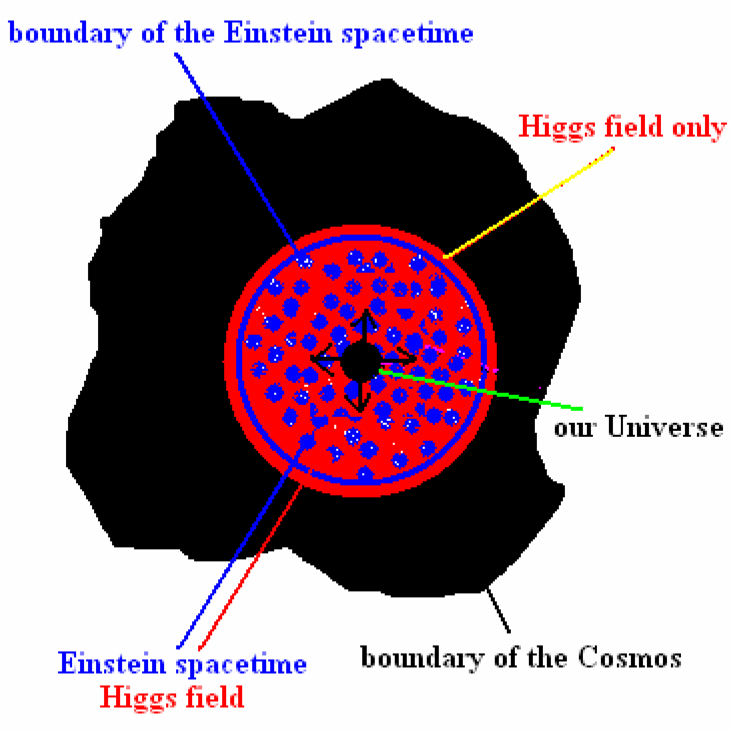
From equality of the pressures we obtain

$$R_{Cosmos} = 3\, x^2\, r_{neutrino}{}^2\, c^2 / (8\, G\, m_{neutrino}) \approx 2.334 \cdot 10^{30} \text{ m}. \tag{3}$$

Total mass of the Einstein spacetime of the Cosmos is $M_{Cosmos} \approx 5.870 \cdot 10^{119}$ kg.

We can as well calculate the initial radius of the inflation field i.e. of the densest Higgs field in which the tachyons are packed to maximum. SST shows that we can neglect the present-day density of the Higgs field in relation to the Einstein spacetime. Knowing inertial-mass density of a tachyon, $\rho_t = 8.32192436 \cdot 10^{85}$ kg/m^3, and the mass of the inner Cosmos, we obtain that initial radius of the inflation field was $R_{Initial\text{-}of\text{-}inflation\text{-}field} \approx 1.19 \cdot 10^{11}$ m – this radius is close to the radius of the orbit of the Venus.

We can assume that due to the superluminal radial speed during the inflation, the initial radius of the sphere filled with the Einstein spacetime and the superluminal Higgs field was greater than the calculated radius of the Einstein spacetime. But then the radial speed was quickly dampened by the gravitational pressure – it caused that the regions of the Einstein spacetime with gravitational pressure higher than the dynamic pressure collapsed to an inner boundary. Mean distances between the neutrino-antineutrino pairs in the inner boundary should be close to the range of the shortest-distance quantum entanglement i.e. density of the inner boundary should be about ten powers of ten higher than density of the Einstein spacetime. Very high dynamic pressure of the Einstein spacetime causes that the Cosmos and our Universe are flat.



Present-day structure of the Cosmos.

3. Dynamics of the vortices in the Einstein spacetime (ES), the matter-antimatter asymmetry, the modified black holes, creation and the large-scale structure of the very early Universe

The initial inflation field had left-handed external helicity which is responsible for the matter-antimatter asymmetry. Because of tremendous non-gravitating energy frozen inside neutrinos, such asymmetry can not concern the Einstein spacetime. The asymmetry appeared simultaneously with the ES boundary. Nucleons, contrary to antinucleons, have left-handed internal helicity so there appeared a surplus of baryons over antibaryons. Simultaneously with the ES boundary there appeared a return shock wave which created in the centre of the Cosmos the Protoworld with the very early Universe inside it. The Protoworld is the result of the fourth phase transition of the SST Higgs field [1].

The core of Protoworld looked similar to the core of baryons [1] – there was a torus and central condensate both composed of a dark matter (DM) particle. Such DM particles as well were created simultaneously with the ES boundary.

The DM particle is a torus composed of identical DM loops which are entangled. Its shape and size are the same as the torus in the core of baryons but the arrangement of the ES components (electric lines of forces are the circles which overlap with the DM loops so the DM torus is electrically neutral) and mass of such torus are different. One loop of the entanglon [1] consists of K^2 tachyons ($K = 0.78966855 \cdot 10^{10}$ [1]) so we can assume that one DM loop consists of K^2 neutrinos and that the DM torus consists of K^2 such loops. Then mass of the DM torus is $M_{DM,torus} = K^4 m_{neutrino} = 727.43$ MeV. The core of Protoworld was built of binary systems of the DM tori. Range of the DM tori is $2\pi A$, where $A = 0.6974425$ fm [1]. Radius of one DM loop, $R_{DM,loop}$, was

$$R_{DM,loop} = K^2 2\pi (r_{neutrino} / 3) / (2\pi) = K^2 r_{neutrino} / 3 = A / 3 . \quad (4)$$

The surplus of baryons caused that inside the torus of the Protoworld there were produced two loops composed of the modified neutron black holes (MNBHs) – it is an analog to the neutral pion produced inside the torus in the core of baryons [1]. There are not in existence black holes with central singularities – it follows from the fact that practically the cores of baryons are indestructible because of very big coupling constant for the shortest-distance entanglement ($3.1 \cdot 10^{92}$), which is responsible for stability of the torus in the core of baryons. On the other hand, the modified black holes have a circle on which spin speed is equal to the speed of light in “vacuum” c, whereas the Schwarzschild radius of an abstract surface is two times greater than the radius of the circle.

Calculate mass and radius of the modified neutron black hole.

Surface density of the torus inside the core of a neutron is about 300,000 times higher than on a plain in the Einstein spacetime. It means that both the rotating MNBH and the Einstein spacetime inside it have the same angular momentum i.e. the rotating MNBH is in the rest in relation to the spacetime i.e. the MNBH is a regular sphere and all neutrons have the rest mass only. Assume that neutrons occupy cubes in such a way that the diagonal of a mesh of the lattice is equal to the radius of the last Titius-Bode orbit for the nuclear strong interactions i.e. the lattice constant is $a_L = (A + 4B) / 2^{1/2}$, where $A = 0.6974425$ fm is the equatorial radius of the core of baryons, whereas $B = 0.5018395$ fm determines the Titius-Bode radii for the nuclear strong interactions.

The radius of the MNBH is r_{NBH} and the mass m_{NBH} that satisfies the following formula:

$$r_{MNBH} = G m_{MNBH} / c^2. \quad (5)$$

If N_1 denotes the number of neutrons in such modified neutron black hole then

$$4 \pi r_{MNBH}^3 / 3 = N_1 a_L^3, \quad (6)$$

and

$$m_{MNBH} = N_1 m_{neutron}. \quad (7)$$

Solving the set of formulae (5)-(7) we get

$N_1 = 2.946 \cdot 10^{58}$,

$m_{MNBH} = 4.935 \cdot 10^{31}$ kg i.e. about 24.81 solar masses,

$r_{MNBH} = 3.664 \cdot 10^4$ m i.e. 36.64 km.

The mass density of the modified neutron black hole, ρ_{MNBH}, is

$$\rho_{MNBH} = m_{neutron} / [(A + 4B) / 2^{1/2}]^3 = 2.394 \cdot 10^{17} \text{ kg/m}^3. \quad (8)$$

More massive MBHs consist of the MNBHs.

Due to the succeeding phase transitions of the superluminal Higgs field, the nucleons are a miniature of the Protoworld and their structures are dual i.e. the ratios of quantities describing analogous phenomena for both the nucleons and protoworlds have the same values. We can see that cosmology follows from particle physics and vice versa. The structure of the nucleons and the above remarks show that the Protoworld consisted of a cosmic torus and central condensate both composed of DM tori and there was a ring of matter in the $d = 1$ state (it was not a baryonic matter because density in this state was too low to create it: there were created first of all the electron-positron pairs) that is an analog to the relativistic pion in the $d = 1$ state in nucleons (it is the S state i.e. the azimuthal quantum number is equal to zero).

Lines of gravitational forces produced by the cosmic torus crossed the circular axis inside the cosmic torus. It caused that on the circular axis had accumulated baryonic matter. Finally, there appeared some analog to the neutral pion – the neutral pions in nucleons are produced on the circular axis inside the torus in the core of baryons and neutral pion is the double loop with antiparallel spins of the two loops and both loops are left-handed. It leads to conclusion that the very early Universe was a double loop composed of MNBHs. Moreover, due to the four-object symmetry described within SST, the MNBHs were grouped in larger structures so there appeared the protogalaxies and bigger structures composed of the protogalaxies already before the exit of the very early Universe from its black-hole state.

According to the four-object symmetry that follows from the superluminal quantum entanglement, maximum number of entangled MNBHs in each cosmic loop can be $2{\cdot}4^{32}$ (there were $2{\cdot}4^{16} \approx 0.86{\cdot}10^{10}$ protogalaxies each containing such number of MNBHs). Knowing the mass of MNBH, we can calculate the baryonic mass of the very early Universe (for two loops) $M_{B\text{-}Universe} \approx 3.6414{\cdot}10^{51}$ kg.

Precise baryonic mass of the Protoworld and the Universe we can calculate from the succeeding phase transitions.

Mass of the core of the Protoworld is $M_{P,core} = 1.96076{\cdot}10^{52}$ kg.

Mass of the core of baryons is $H^+ = 727.44012$ MeV, whereas mass of neutral pion calculated within SST is $m_{pion(o),SST} = 134.97674$ MeV – this value is very close to the experimental result $m_{pion(o)} = 134.9766$ MeV that is used in this paper. It leads to following baryonic mass of the Universe

$$M_{B,Universe} = M_{P,core}\, m_{pion(o)} / H^+ = 3.6382{\cdot}10^{51}\ \text{kg} \qquad (9)$$

The equatorial radius of the cosmic torus was $R_{P,Core} = 286.7$ million light-years, whereas the radius of the double loop, i.e. of the very early Universe, was equal to $R_{Initial,Universe} = 191.1$ million light-years.

The four-object symmetry that results from the long-distance superluminal quantum entanglement, leads to following formula for number of protogalaxies in the cosmic structures

$$N = 4^d, \qquad (10)$$

where $d = 0, 1, 2, 4, 8, 16$ is for a flattened spheroid-like structures, and $d = 3, 6, 12$ for a chain-like structures.

The cosmic structures composed of the binary systems of protogalaxies we will refer to as follows:

$d = 0$ is for single object (i.e. a binary system),

$d = 1$ is for group,
$d = 2$ is for supergroup,
$d = 4$ is for cluster,
$d = 8$ is for supercluster,
$d = 16$ is for megacluster (the early Universe was the binary system of megaclusters composed of the binary systems of protogalaxies),
$d = 3$ is for chain,
$d = 6$ is for superchain,
$d = 12$ is for megachain.

Generally, the radial velocities of the cosmic structures are the same as the local velocities of the expanding dark matter and dark energy so the structures have the rest mass only.

4. Dynamics of the Protoworld, the dark matter and dark energy, and the exit of the Universe from the black-hole state

Because a neutrino is built of the superluminal closed strings (they are the entanglons responsible for the quantum entanglement) moving with a speed $v_{entanglon} / c = 2.4248 \cdot 10^{59}$ times higher than the c, the non-gravitating energy (not gravitating mass) frozen inside a neutrino (so not measured by an external observer) is equal to

$$E_{neutrino,frozen} = m_{neutrino} (2.4248 \cdot 10^{59})^2 = 1.9608 \cdot 10^{52} \text{ kg}, \quad (11)$$

where $m_{neutrino} = 3.33493 \cdot 10^{-67}$ kg. This means that there is the possibility of the core-of-Protoworld→neutrino transition. Emphasize that the mass of the core of Protoworld was the dark matter. The transition looks as follows. The entanglons responsible for the quantum entanglement of the core of Protoworld were frozen inside the new neutrino – it caused that the core of the Protoworld decayed to the DM loops. Since the very early Universe was entangled with the core of the Protoworld so the DM loops were and are entangled with the baryonic mass of the Universe – it is the dark matter.

It is easy to calculate the present-day ratio of the dark matter to baryonic matter of the Universe

$$F = M_{P,core} / M_{B\text{-}Universe} = 5.389. \quad (12)$$

We can see that obtained theoretical results are consistent with the Planck results (CMB + lensing) at the $68\ \%$ limits [2].

SST shows that a bare object with a mass M can create virtual field that sum of absolute values of masses of all virtual particles (they have both positive and negative masses) is $2M$. After the core-of-Protoworld→neutrino transition, the virtual pairs annihilated to virtual photons that still are entangled with the dark matter – their ordered radial motions decreased dynamic pressure in the Einstein spacetime so there was the inflow of additional free neutrino-antineutrino pairs into the Universe – it is the dark energy.

From $M_{Dark\text{-}Matter} = M_{P,core} = 1.960762 \cdot 10^{52}$ kg we can calculate the mass of the $d = 1$ state. Mass of the relativistic charged pion in the $d = 1$ state in proton is $W_{Rel,pion(-)} = 215.760$ MeV. An cosmic analog to it, W_{CA}, has mass

$$W_{CA} = M_{Dark\text{-}Matter} W_{Rel,pion(-)} / H^{+} = 5.8157 \cdot 10^{51} \text{ kg}. \quad (13)$$

Due to the very strong gravitational interactions, the mass W_{CA} was destroyed to photons and neutrinos and today they are on the expanding front of the CMB.

Estimate abundance of matter and energy in the today Universe. We assume the same rate of expansion of all components. According to the SST, the sum of absolute masses of virtual particles is two times greater than mass of bare particle. The Protoworld had mass

$$M_{Bare\text{-}Protoworld} = M_{Dark\text{-}Matter} + W_{CA}. \tag{14}$$

This leads to conclusion that mass of the present-day dark energy is

$$E_{Dark\text{-}Energy} = 2\ M_{Bare\text{-}Protoworld} = 5.0853 \cdot 10^{52}\ \text{kg}. \tag{15}$$

The photons and neutrinos from decay of W_{CA} are today on the front of the expanding CMB so we can neglect them in the calculations concerning the today distribution. It leads to conclusion that today the total energy is

$$E_{T,today} = M_{B,Universe} + M_{Dark\text{-}Matter} + E_{Dark\text{-}Energy} = 7.4101 \cdot 10^{52}\ \text{kg}. \tag{16}$$

The today percentage of the baryonic matter is

$$\text{Baryonic matter (today)} = 100\%\ M_{B,Universe} / E_{T,today} \approx 4.91\ \%. \tag{17}$$

The today percentage of the dark matter is

$$\text{Dark matter (today)} = 100\%\ M_{Dark\text{-}Matter} / E_{T,today} \approx 26.46\ \%. \tag{18}$$

The today percentage of the dark energy is

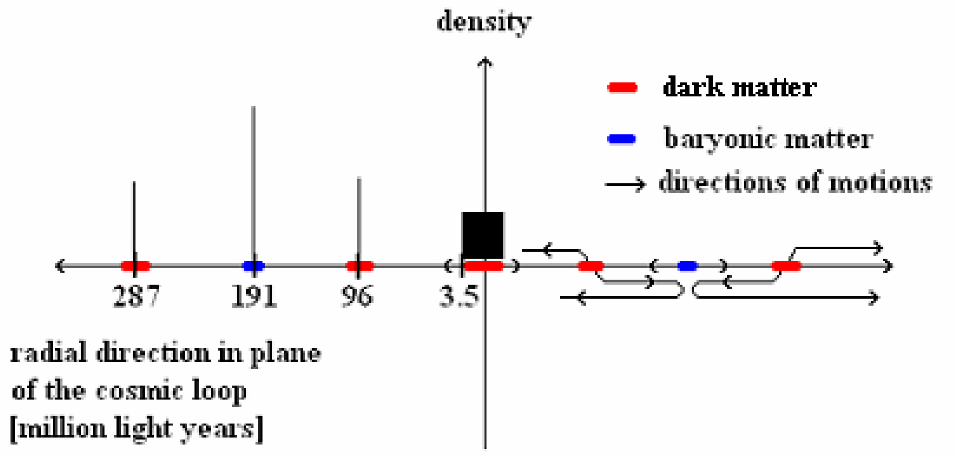
$$\text{Dark energy (today)} = 100\%\ E_{Dark\text{-}Energy} / E_{T,today} \approx 68.63\ \%. \tag{19}$$

The succeeding inflows of the dark matter and dark energy into the very early Universe caused the exit of it from the black-hole state.

The structure of the core of the Protoworld leads to conclusion that there were the four succeeding inflows of the dark matter and next the inflow of the dark energy into the early Universe. The inflows started the expansion of the Universe. We can see that today the Universe should be a little flattened sphere – the time distance between the equatorial radius and the polar radius should be 0.1911 Gyr i.e. the deviation from the mean radius is ±0.096 Gyr (a precise value is 0.09555 Gyr).

The largest peak/maximum is associated with the first inflow of dark matter to the early Universe. In nucleons, the spin speeds are tangent to the surface of the torus of a nucleon. The spin speeds of the binary systems of neutrinos in the torus of the nucleon are from $c/3$ to c and the average spin speed is equal to $2c/3$. This means that radial speeds must be on a scale from zero to $0.94281c$ with the average radial speed equal to $0.745356c$. A similar theory can be acknowledged by examining the cosmic torus after the transition. The maximum mass-density flow of the dark matter reached the early Universe after 0.09555 Gyr / $0.745356c$ = 128 million years.

Because the surface of an expanding cosmic loop was the closed pipe/chain, we can assume that on the surface were $N = 4^{12}$ binary systems of protogalaxies i.e. a megachain (see formula (10)). We can calculate the angular size of the structures using the formula $L = sqrt[(360^o)^2 / N]$, where N denotes the number of structures, whereas the multipole moment can be calculated using the formula $I = 180^o / L$.



Initial distribution and motions of matter and dark matter

On the surface of each of the two expanding cosmic loops was one megachain ($L = 360^o$, $I = 0.5$). There were 4^4 superclusters ($L = 22.5^o$, $I = 8$), 4^6 superchains ($L = 5.63^o$, $I = 32$), 4^8 clusters ($L = 1.41^o$, $I = 128$), 4^9 chains ($L = 0.703^o$, $I = 256$), 4^{10} supergroups ($L = 0.352^o$, $I = 512$), 4^{11} groups ($L = 0.176^o$, $I = 1024$) and 4^{12} single objects ($L = 0.088^o$, $I = 2048$).

Using the formula $t_{lifetime} = \lambda / c$, we can calculate the lifetime of a photon vortex which has a circumference equal to λ. At the beginning of the "soft" big bang (the inflation was the big bang whereas the beginning of the expansion of the early Universe we will call the "soft" big bang), the length of the photons coupling the structures was 2π times longer than the mean distance between the binary systems of protogalaxies in the double cosmic loop (the planes of rotation of the binary systems were perpendicular to the double cosmic loop). Because in a cosmic loop there were 4^{16} binary systems of protogalaxies then mean distance between the planes of rotation of the binary systems of protogalaxies was 0.28 light years. The circumference was 1.76 light years so the lifetime of such a photon galaxy/loop would be 1.76 years. Each of the two superphotons (a superphoton is a cosmic loop composed of entangled photon galaxies/loops that coupled the cosmic structures) consisted of $2 \cdot 4^{16}$ photon galaxies/loops so it decayed into photon galaxies/loops after 15.09 Gyr. The lifetime of a photon galaxy/loop is considerably longer than the age of the Universe today – photon galaxies will live approximately $3.9 \cdot 10^{12}$ years (and will decay into 256 fragments).

Due to the succeeding decays of the superphotons, the cosmic loops also decayed. The free binary systems of massive galaxies appeared after 7.54 Gyr. The free groups appeared after 1.89 Gyr, supergroups after 472 million years, chains after 118 million years, clusters after

1.84 million years, superclusters after 115 thousand years and the free megachains after 1.76 years.

We can see that the maximum mass-density flow of the dark matter reached the early Universe just after the decaying of the superphotons and double cosmic loop to the chains $L = 0.703^o$, $I = 256$ (118 million years since the transition). We can assume in approximation that the first maximum is for such a value of the multipole moment i.e. for about $I = 256$.

5. Duality of relativity

Due to the superluminal quantum entanglement, emitted photons are entangled with their source or with a last-interaction object (it can be a detector). The superluminal quantum entanglement fixes the speed of photons c in relation to source or a last-interaction object so it is not true that a photon has simultaneously the speed c in relation to all frames of reference but it is true that all detectors (they are the last-interaction objects) always measure the speed c – such is the correct interpretation of the Michelson-Morley experiment.

6. Dynamics of the Universe and the CMB

Our Universe arose and developed as the double cosmic loop inside the torus of the core of the Protoworld. The magnetic axes of the neutrons in the cosmic structures were tangent to the double cosmic loop. Magnetic polarisation dominated because the neutrons are electrically neutral. This means that the double cosmic loop was the magnetic loop. The cosmic structures in the expanding double cosmic loop were mostly moving in directions perpendicular to the cosmic loops. Due to the law of conservation of spin, the magnetic axes of the protogalaxies should be parallel to the direction of their acceleration i.e. they should be perpendicular to the double cosmic loop and next, in the expanding ball, there should dominate their polarization along the radial directions. This means that there were the 90^o turns of the magnetic axes of the protogalaxies.

6.1 Radial speed on the front of the baryonic and dark matter and dark energy

The front of the CMB had and has radial speed equal to the speed of light in "vacuum" c. But the front of expanding baryonic matter, dark matter and dark energy had and has a different radial speed. The mean spin speed of the core of the Protoworld and the double cosmic loop was $2c/3$ so their radial speed after the core-of-Protoworld→neutrino transition was $v_{Radial,initial} = 0.745356c$. But in the $d = 1$ state there was a cosmic analog to the relativistic charged pion in the neutron. It decayed to the cosmic analog to the resting charged pion (such cosmic analog decayed later to photons and neutrinos). The resultant maximum radial speed of the expanding baryonic matter, dark matter and dark energy, $v_{Radial,resultant}$, we can calculate from the law of conservation of momentum

$$v_{Radial,resultant} = v_{Radial,initial} (H^+ + m_{pion(o)}) / (H^+ + m_{pion(o)} + m_{pion(-)}) = 0.6415c \quad (20a)$$

$$v_{Radial,resultant} = F_C\, c = 0.6415\, c \quad (20b)$$

We can see that the dark matter and dark energy must have a spin speed also but directions of spin speeds of the neutrino-antineutrino pairs are arbitrary so we should not see a rotation of the expanding Universe.

The inflows produced also protuberances composed of the dark matter and baryonic matter. This caused that some of the most distant cosmic objects to have a redshift greater than the $z_{obs.} = F_C = 0.6415$. But with time such protuberances were dampened.

6.2 Radius of the Universe, Hubble constant, and number of CMB photons

Initially, the baryonic matter consisted of the neutrons placed in the MNBHs but due to the inflows of the dark matter and dark energy, it transformed into nuclear plasma (we neglect the mass of the modified black holes in centres of the galaxies). The lightest stable ions are the hydrogen and helium-4 ions. It is very reasonable to assume that initially there was the equivalence in number density of nucleons in the two different ions.

When mean distance between the nucleons in baryonic plasma increased to size of bare electrons, i.e. to $2\lambda_{C,bare}$ (from the Wien's law equation follows that then temperature was $3.748 \cdot 10^9$ K), there appeared gas containing 50% of ionized hydrogen and 50% of ionized helium by number of nucleons i.e. there was 75% of the protons and 25% of the neutrons. The released energy per each initial neutron was

$$L_0 = 0.75 \cdot (m_{neutron} - m_{proton} - m_{electron}) + 0.5 \cdot 7.07 \text{ MeV} = 4.121 \text{ MeV}. \quad (21)$$

This energy leads to the CMB and the front of it was expanding with the radial speed equal to c.

The energy of the CMB (without the ripples) is

$$E_{background} = M_{B,Universe}\, L_0\, c^2 / m_{neutron} = 1.4342 \cdot 10^{66} \text{ J}. \quad (22)$$

We know that today the density of the energy of the microwave background radiation is equal to $\rho_{background} = 4.005 \cdot 10^{-14}$ J/m^3. The formula is therefore

$$4 \pi R_{CMB}^3 / 3 = E_{background} / \rho_{background}, \quad (23)$$

which results that the mean radius of the sphere filled with CMB is

$$R_{CMB} = 2.04476 \cdot 10^{26} \text{ m, i.e. } 21.614 \text{ billion light-years}. \quad (24)$$

Precisely it is 21.614 ± 0.096 Gyr – it follows from the radius of the cosmic double loop. Volume of the CMB is

$$V_{CMB} = 3.5811 \cdot 10^{79} \text{ m}^3. \quad (25)$$

Radius of the sphere filled with the baryonic matter, dark matter and dark energy is about 0.6415 times smaller i.e. is

$$\mathrm{R}_{\text{Baryonic-Matter,Dark-Matter,Dark-Energy}} = 13.866 \pm 0.096 \text{ Gyr}. \quad (26)$$

It is consistent with the Planck data within the 68% limits [2].

Volume of such sphere is

$$V_{Matter\text{-}Energy} = 0.94551 \cdot 10^{79} \text{ m}^3. \quad (27)$$

Calculated density of baryonic matter is

$$\rho_B = (0.385 \pm 0.008) \cdot 10^{-27} \text{ kg/m}^3. \quad (28)$$

Due to the duality of relativity (Paragraph **5.**), the spatial distance differs from time distance when both are expressed in the same units. We assume that the Milky Way is close to the centre of the expanding Universe. Light emitted by most distant galaxies that we observe today was not sent at the beginning of the expansion of the Universe – at first, the most distant galaxies have gone some distance. Calculate this distance, i.e. spatial distance, applying following formula

$$X / v_{Radial,resultant} + X / (c - v_{Radial,resultant}) = R_{CMB} . \quad (29)$$

It gives $X \approx 4.971$ Gyr (here, we neglect the protuberances of the dark matter and dark energy). This spatial distance is equivalent to following time distance: $X / (c - v_{Radial,resultant})$ = 13.866 Gyr. We cannot see the initial period of evolution of the protogalaxies equal to: $X / v_{Radial,resultant} \approx 7.75$ Gyr.

Here [3] we can find a recapitulation concerning the ages of stars. There are cited the results obtained by Ludwig *et al.* (2009) [4] (see References: [91]). Ludwig *et al.* derived solar ages from 1.7 to 22.3 Gyr. The applied Th/Eu ratio is most credible. But the upper limit of the obtained interval is inconsistent with the age of the Universe (about 13.8 Gyr) calculated within the mainstream cosmology. On the other hand, the Ludwig upper limit is close to the age of the Universe obtained within SST: 21.614 ± 0.096 Gyr.

The Hubble constant H is defined as the ratio of the relative radial speed of light emitted by the most distant galaxies to their spatial distance so we obtain

$$H = (c - v_{Radial,resultant}) / X = 70.52 \text{ km}\cdot\text{s}^{-1}\cdot\text{Mpc}^{-1}. \quad (30)$$

Number of initial superphotons was equal to the number of protons when the CMB was released i.e. there was 75% of the protons. About 15.09 Gyr following the transition, $2 \cdot 4^{16}$ photon galaxies per each initial superphoton produced by each initial proton appeared. By knowing the mass of our Universe and by knowing the mass of neutron, we can calculate the initial number of neutrons. This is equal to $2.1722 \cdot 10^{78}$ so the total number of the CMB photons is

$$N_{CMB\text{-}photons} = 0.75 \cdot 2.1722 \cdot 10^{78} \cdot 2 \cdot 4^{16} = 1.3994 \cdot 10^{88} \text{ CMB photons.} \quad (31)$$

The volume of a sphere filled with CMB radiation is $V_{CMB} = 3.5811 \cdot 10^{79}$ m^3 (formula (25)). This leads to conclusion that in cubic centimetre there should be approximately 391 CMB photons.

6.3 The evolution of massive galaxies

More detailed description of evolution of massive galaxies is presented in a separated paper. Here we should emphasize that, generally, the binary systems of protogalaxies transformed into the spiral galaxies whereas the mergers of two structures each containing four binary systems transformed into the elliptical galaxies – such transformations are most probable. The dwarf galaxies appeared due to the mergers of the protogalaxies that led to their explosions. Due to the duality of relativity, we cannot see the initial period 7.75 Gyr of their evolution. It causes that in the most distant visible Universe we do not see an initial field composed of dwarf galaxies only – we should see tens of dwarf galaxies per each massive galaxy.

6.4 The CMB and the last-scattering cosmic spheres

Due to the very high initial temperature, the electrons were separated from protons whereas due to the rotations of the protogalaxies, there appeared vortices of electrons. There as well was the radial polarization of rotational and magnetic axes of the electron vortices. Generally, the maximum radial speed of the baryonic matter was and is $0.6415c$. But mass of the electrons is much lower than protons so maximum radial speed of the electron vortices was close to the speed of light c. Of course, it was possible only at the beginning of expansion of the Universe when temperature was very high and distances between the proton and electron vortices were not big (in the cosmic scale). We can see that above the expanding baryonic front there were concentric spheres composed of the electron vortices with radial speeds of the expanding spheres from $0.6415c$ to c. There were such spheres as well inside the baryonic matter and their radial speeds changed from zero to $0.6415c$. The concentric spheres were the last-scattering spheres for photons emitted by the protogalaxies. In such a way there appeared the set of CMBs – due to the duality of relativity, the relative radial speeds of photons scattered on different spheres of the electron vortices is different so all the time we can observe the CMB emitted at the beginning of expansion of the Universe. It does not concern the protogalaxies.

6.5 The standard ruler in cosmology

The radius of the $d = 1$ state in the Protoworld is 151.13 Mpc. There were produced cosmic loops overlapping with this state. Such loops were built of the entangled non-rotating-spin neutrino-antineutrino pairs – they are the dark-matter structures. Due to the confinement of the neutrinos, such loops, because of their nuclear weak interactions (via leptons), interact with the baryonic matter so there appear in different time distances baryonic loops with radius close to the 151.13 Mpc

$$R_{ruler\text{-}in\text{-}cosmology} = R_{P,Core}\,(A + B)\,/\,A = 492.93 \text{ million ly} = 151.13 \text{ Mpc}. \quad (32)$$

It causes that radius of such baryonic loops built of galaxies is the standard ruler in cosmology.

On the other hand, there is a small excess in number of pairs of galaxies separated by ~153.3 Mpc. It is often referred to as the baryon acoustic oscillations (BAO). On basis of this phenomenon we can investigate some properties of dark matter.

The analysis of the WMAP data (CMB) yielded 146.8 ± 1.8 Mpc for the sound horizon at the photon decoupling epoch and 153.3 ± 2.0 Mpc at the end of the baryon drag epoch [5].

We can see that the result obtained within SST is close to the observational data.

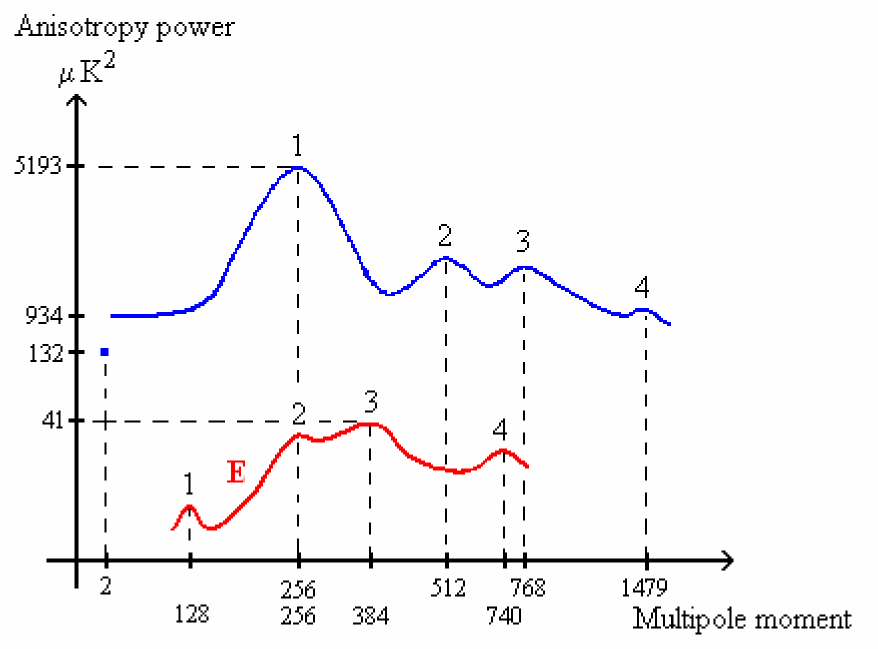
7. Anisotropy power and polarization of the CMB radiation

7.1 Anisotropy power

The anisotropy power of the quadrupole is associated with the dark matter produced during the core-of-Protoworld→neutrino transition. The megachain on the surface of the cosmic loop decayed into 16 parts each containing 16 superclusters ($L = 90^o$, $l = 2$). This is known as the quadrupole. In the dark matter, the virtual electron-positron pairs had appeared. The energy of the photons per neutron associated with the weak interactions of the radiation mass of the pairs with dark matter can be calculated using the formula

$$X_L = a\, m_{neutron}\, \alpha'_{weak(electron\text{-}proton)} = 12.197 \text{ eV/neutron}, \quad (33)$$

where a = 0.001159652, $m_{neutron}$ = 939.54·10^6 eV (it is the mass in the bound state), $\alpha'_{weak(electron\text{-}proton)}$ = 1.11944·10^{-5}.



CMB spectrum - theoretical results

This energy is inside the sphere filled with CMB (radius is 21.614 ± 0.096 Gyr) which meant that energy inside the sphere filled with baryons (radius is 13.866 ± 0.096 Gyr) is

$$Y_L = a_l^3 X_L = 3.22 \text{ eV/neutron}, \quad (34)$$

where a_l = 13.866 / 21.614 = 0.6415.

Because there are β_1 = 5.389 less nucleons in the Universe than were in the core of the Protoworld, released energy per nucleon in the Universe was, therefore,

$$Z_L = \beta_1 Y_L = 17.35 \text{ eV/nucleon}. \quad (35)$$

The released nuclear energy was L_0 = 4.121126 MeV/nucleon and today the temperature is T = 2.73 K. Therefore, the energy of Z_L leads to following temperature associated with the core-of-Protoworld→neutrino transition

$$T_L = T Z_L / L_0 = 1.15\cdot10^{-5} \text{ K}. \quad (36)$$

Because the anisotropy power is equal to T_L^2, the anisotropy power of the quadrupole is equal to 1.32·10^{-10} K^2 = 132 μK^2.

Our early Universe was a double loop composed of MNBHs, therefore, due to beta decays there appeared protons and electrons. Under the Schwarzschild surface appeared atomic nuclei and there were the electron-proton weak interactions. The circumference of the large loop in proton changes due to the weak electron-proton interactions. The coupling constant for strong interactions of the large loops is equal to 1 and such interactions led to the mean temperature of the Universe today of about 2.73 K. The coupling constant for the electron-proton weak interactions is $1.11944 \cdot 10^{-5}$, therefore, the mean amplitude of temperature fluctuations for the electron-proton weak interactions is $2.73\ \text{K} \cdot 1.11944 \cdot 10^{-5} = 30.56\ \mu\text{K}$ on an angular scale of about 11° on the sky. Today it is half an angular distance between the largest structures i.e. the megachains of the binary systems of massive galaxies. This leads to the mean anisotropy power equal to $934\ \mu\text{K}^2$. When the mass density of the Einstein spacetime increases (the additional mass is the dark matter) then additional particle-antiparticle pairs appear. This means that mass density and temperature fluctuations increase.

After the first inflow of dark matter into the early Universe (mass of this inflow is some analog to the mass of the torus in the core of nucleons: $X = 318.3$ MeV), the total mass of the early Universe increased $X / m_{pion(o)} = 2.358$ times. It also increased temperature fluctuations to $30.56\ \mu\text{K} \cdot 2.358 = 72.06\ \mu\text{K}$ and anisotropy power to $5193\ \mu\text{K}^2$ (we showed before that then the multipole moment was approximately $I = 256$). But we should emphasize that not whole dark matter concerning the cosmic torus was moving towards the cosmic double loop so the first maximum should be lower.

The second, third and fourth maximums are also associated with the inflows of the dark matter into the early Universe. The second maximum was produced by the central mass in the cosmic torus whereas the third and fourth by the opposite part of the big torus. The maximums of the mass density of the dark matter flows approached the centre of the expanding Universe (initially it was a double loop) after 256 million years (multipole moment $I \approx 512$), 384 million years (multipole moment $I \approx 768$) and 740 million years (multipole moment $I \approx 1479$).

7.2 Polarization

Due to the Thomson polarization theory, there appeared E photons. We can see that at first there appears anisotropy power maximum (i.e. maximum for density fluctuation of the dark matter and temperature fluctuation), followed by the maximum for density of ionized matter and then the maximum for the E polarization. The CMB polarization was highest when the produced velocity gradient was at its highest (i.e. the MNBHs swelled due to the inflows of the dark matter). The velocity gradient, i.e. the polarization spectrum, is out of phase with the density spectrum, i.e. with the temperature anisotropy. For the maximums of the E polarization, we should observe multipole moments equal to approximately $I \approx 128$, 256, 384, and 740. The most energetic early photons had energy of about 8.79 MeV – which is the binding energy of the nucleons inside iron. The characteristic energy for the beta decays is 0.7815 MeV. Furthermore, the maximum temperature fluctuations for the scalar E-mode polarization should be approximately $8.79 / 0.7815 = 11.25$ times lower than the maximum temperature fluctuations for the densest matter i.e. $72.06 / 11.25 = 6.4\ \mu\text{K}$. The maximum anisotropy power associated with the scalar E-mode polarization should be approximately $41\ \mu\text{K}^2$. This was for the multipole moment $I = 384$ because the density of ionized matter was at its lowest then. The obtained value is only a rough estimate.

8. The B-modes in the CMB

SST shows that range of bosons of energy about $E_{boson} = 0.7503$ GeV is about $B = 0.5018 \cdot 10^{-15}$ m. On the other hand, during the activation of the protogalaxies by the inflows of the dark matter and dark energy, instead the gravitational interactions between the Einstein-spacetime components there dominated the weak interactions of condensates. According to the SST, range of the confinement of the Einstein-spacetime components is about $R_C = 3.926 \cdot 10^{-32}$ m. Since energy is inversely proportional to range so energy E_C of the Einstein-spacetime components, during the period of the B-modes production, was

$$E_C = E_{boson}\, B / R_C = 0.959 \cdot 10^{16}\ \text{GeV}. \tag{37}$$

This energy is characteristic for the beginning of the expansion of the very early Universe.

SST shows that due to the Thomson polarization theory, the CMB should be polarized with amplitude of a few μK with upper limit for E-mode 6.4 μK. This E-mode is associated with energies produced in the beta decays of neutrons. The CMB polarization was highest when the produced velocity gradient was at its highest (i.e. the modified neutron black holes swelled due to the inflows of the dark matter and dark energy). The velocity gradient, i.e. the polarization spectrum, is out of phase with the density spectrum, i.e. with temperature anisotropy.

The electrons that appeared due to the beta decays, at very high energy produced condensates composed of the Einstein-spacetime components. Their gravitational mass Δm is the same as the condensate in centres of the electrons i.e. is equal to the half of the mass of bare electron $\Delta m = m_{bare(electron)} / 2 = 0.2552$ MeV. Such condensates are less unstable when the spins of the Einstein-spacetime components are polarized in a manner similar to magnetic domains. At very high densities, the resultant spins of the condensates rotated. Such curling and spreading condensates produced the B-modes.

SST shows that when the early Universe (the cosmic double loop) transformed into expanding ball, there was the radial polarization of the magnetic axes of the protogalaxies – it follows from the conservation of spins of nucleons. It leads to the E polarization perpendicular to the radial directions so we can see the maximum effect. There is some difference for the B-modes. The fine structure constant, which concerns the E-modes, is 1/137.036 i.e. about 10^{-2} whereas the coupling constants for the weak interactions of the electron condensates are much lower – for the weak electron-muon interactions is about 10^{-6} whereas for the weak electron-proton interactions is about 10^{-5}. It leads to conclusion that the orientation of the resultant spins of the condensates can be arbitrary. Since there are the three orthogonal/perpendicular directions so for the B-modes we can see the 2/3 of the maximum effect i.e. $2\Delta m/3$.

For multipole moment $I = 384$, the calculated temperature fluctuation which results from energy released in the beta decays, is for the E-modes 6.4 μK. This temperature fluctuation is associated with the energy $\Delta E = m_{neutron} - m_{proton} - m_{electron} \approx 0.7815$ MeV released by decaying neutrons in the activated protogalaxies.

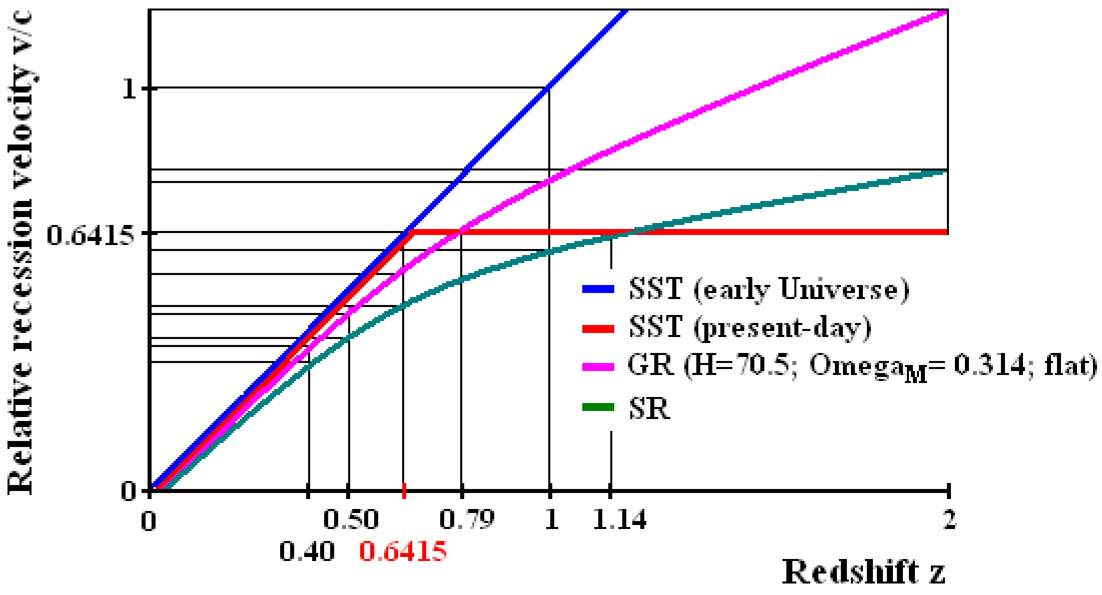
Calculate for the $I = 384$ the ratio r_A of amplitudes of the B-modes to the E-modes

$$r_A = 2\Delta m / (3\Delta E) \approx 0.22. \tag{38}$$

This result is very close to the central value in the BICEP data [6].

9. An illusion of acceleration in the expansion of the Universe

Due to the jets produced in spacetime by the neutron black holes the protogalaxies consisted of, there appeared cascades of protogalaxies or their groups increasing rapidly the distances between them. It caused that there appeared protogalaxies or groups of them with redshift higher than 1. With time, due to decays of the jets, such motions were decelerated.



Discrepancy between SST, GR and SR for recession velocity.

To calculate the relative recession velocities within General Relativity (GR), we used the cosmological calculator [7], whereas within SR we can use the relativistic redshift: $v_{Recession} / c = [(1 + z)^2 - 1] / [(1 + z)^2 + 1]$, where z is the observed redshift.

In the Figure, we can see that there is discrepancy between the SST curve describing the present-day Universe and the GR curve. We can see that for redshift about 0.40 up to 0.6415, the SST curve is above the GR curve and distance between them increases with increasing z. This means that the Type Ia supernovae are in reality at a greater distance from us than it follows from the GR formula and it is the reason why they are fainter than they should be. Emphasize once more that an illusion of acceleration in the expansion of the spacetime in the Universe follows from the duality of relativity that results from the quantum entanglement of photons with their sources or a last-interaction object that fixes the speed c. But emphasize also that the higher number density of dim massive galaxies for redshift z = 0.6415 causes that there appears gravitational attraction which accelerates galaxies with redshift lower than 0.6415 and decelerates galaxies with redshift higher than 0.6415.

10. Black body spectrum

How is the black body spectrum produced? Large loops are produced from energy released during nuclear transformations. The distance between the binary systems in the Einstein spacetime is 554.321 times greater than on the torus of the proton. The mean distance between the neutrino-antineutrino pairs on the torus is approximately 2π times greater than the external radius of the neutrino. From these conditions, we can calculate that approximately $7.5 \cdot 10^{16}$ neutrino-antineutrino pairs are on the large loop. This means that $2 \cdot 4^4 = 512$ such loops contain approximately $3.84 \cdot 10^{19}$ neutrino-antineutrino pairs. A superphoton consists of

$2 \cdot 4^{32} = 3.69 \cdot 10^{19}$ neutrino-antineutrino pairs. This means that inside the torus in the core of nucleons, superphotons can be created and SST shows that each such superphoton has energy equal to 67.5444 MeV. An equivalent of this amount of energy transits into the equator of the torus and then such superphoton has a length equal to $\lambda_T = 2\pi A$, where A denotes the external radius of the torus (the equator of the torus is the trap for the photons). This length is associated with the internal temperature of a nucleon/black-body via the Wien's law equation $\lambda_T[m] \cdot T[K] = 0.002898$. This means that temperature on the equators of nucleons is $6.6 \cdot 10^{11}$ K. When the energy of such a set of superphotons is 208.644 MeV (it is the relativistic mass of the neutral pion in the $d = 1$ state) then such a set transits to the $d = 1$ state and the length of such *superphoton* increases to $2\pi\ (A + B)$. Such photons are emitted because in the $d = 1$ state there can only be one portion having energy equal to 208.644 MeV. This means that the measured frequency of the photons related to the maximum of intensity is $A / (A + B) = 0.58154$ times lower than would result having used Wien's law equation. Using today's temperature of the Universe (2.725 K) we obtain $\lambda_T = 1.0635$ mm, $\lambda_\nu = 1.8287$ mm and $\nu = 163.94$ GHz.

Why is the length of the photons increased from $2\pi A \cdot 2/3 = 2.9214 \cdot 10^{-15}$ m to $1.8287 \cdot 10^{-3}$ m in present-day i.e. by approximately $6.26 \cdot 10^{11}$ times? The answer to this is for the following two reasons. The decay of each superphoton to the photon galaxies increased the length of the early photons $2 \cdot 4^{16} = 8.6 \cdot 10^{9}$ times. Initially, the superphotons overlapped with the cosmic loops so it had a radius of approximately 0.1911 Gyr. Today the elements of a superphoton interacting with the baryonic matter fill the sphere and its radius is approximately 13.866 Gyr i.e. the radius and the length of the early photons increased about 72.56 times. This means that the length of the early photons increased approximately $6.24 \cdot 10^{11}$ times. We see that this theoretical result is consistent with the observational fact discussed. Because of the broadening of the $d = 1$ state we observe a black body spectrum.

11. The hydrogen-to-helium-4 ratio in the expanding Universe

Due to evolution of the Universe, hydrogen transforms into helium whereas helium transforms into more massive atomic nuclei. It suggests that it can be that with time mass abundance of helium in relation to hydrogen can slowly decrease.

The Stefan-Boltzmann law is a function of total emitted energy of a black body j^* proportional to its thermodynamic temperature T

$$j^* = \sigma\, T^4. \tag{39}$$

Assume that due to the big stars, a change in abundance of helium-4 (He-4), $\Delta Y_{A,He\text{-}4}\ [\%]$, is directly proportional to the temperature T (higher temperature means higher changes in abundance) whereas that total emitted energy is directly proportional to age of the Universe, $\tau_{Universe}\ [Gyr]$. Then, we can rewrite formula (39) as follows

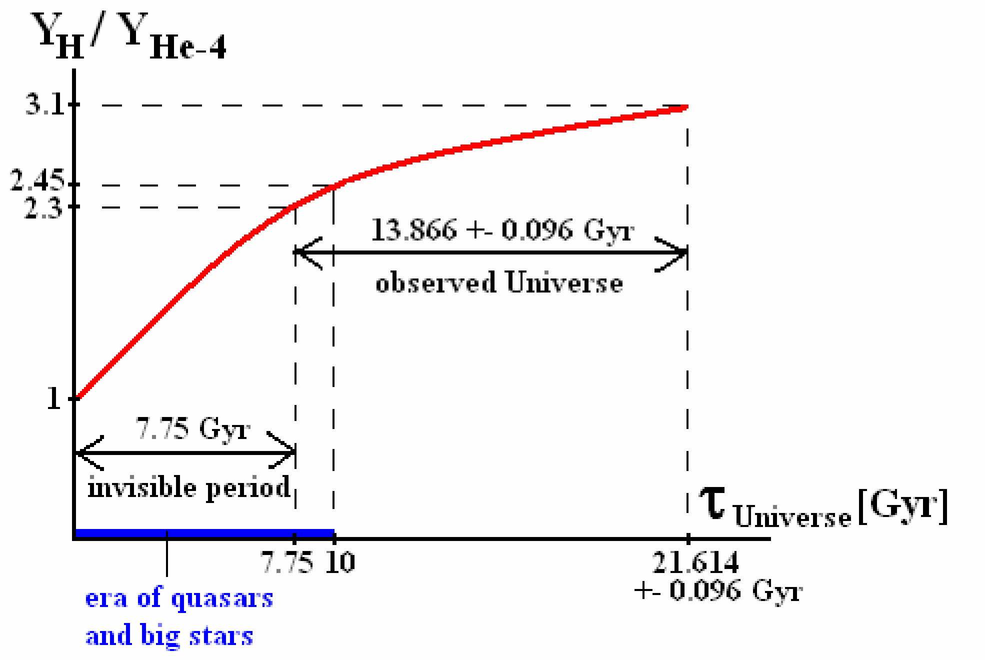
$$\Delta Y_{A,He\text{-}4}\ [\%] = f\ (\tau_{Universe}\ [Gyr])^{1/4}. \tag{40}$$

The resultant abundance of helium-4 is

$$Y_{He\text{-}4} = Y_{P,He\text{-}4} - \Delta Y_{A,He\text{-}4}\ [\%] = Y_{P,He\text{-}4} - f\ (\tau_{Universe}\ [Gyr])^{1/4}, \tag{41}$$

where $Y_{P,He\text{-}4}$ = 50% is the primordial mass abundance of helium. On the assumption that the today abundances of helium-4 and hydrogen are respectively 24.5% and 75.5%, we obtain that the factor f is equal to f = 11.8.

The era of quasars and big stars lasted about 10 Gyr i.e. $\tau_{Universe,Q}$ $[Gyr]$ = 10. Applying formula (41) we obtain that at the end of the era of quasars, i.e. in time distance from observer about 21.6 – 10 = 11.6 Gyr, abundance of helium-4 should be 29% whereas in most distant observed Universe (i.e. $\tau_{Universe,D}$ $[Gyr]$ = 7.75) should be 30.3%.



Hydrogen-to-helium-4 ratio in the expanding Universe

Above surfaces of the neutron stars and in the symmetrical decays of nuclei in the supernova explosions there appear protons so in such regions, with time, abundance of hydrogen increases. The production of neutron stars in the supernova explosions and the symmetrical decays of nuclei in the supernova explosions are cooling down the Universe whereas the transformations (in big stars) of helium-4 into iron are heating the Universe.

On assumption that there is some symmetry, for abundance of hydrogen we obtain

$$Y_H = Y_{P,H} + \Delta Y_{A,H}\ [\%] \quad = Y_{P,H} + f\ \ (\tau_{Universe}\ [Gyr])^{1/4}. \qquad (42)$$

Dividing formula (42) by (41) we obtain the hydrogen-to-helium-4 ratio. For the invisible primordial Universe we obtain about 1, for the most distant observed Universe is 2.3, for the end of the era of quasars and big stars is 2.45 whereas for the present-day Universe is about 3.1 (see Fig).

Rewrite formula (41) in such a way to obtain a dimensionless value of the factor f

$$Y^*_{He\text{-}4} = Y^*_{P,He\text{-}4} - f^*\ \ (\tau_{Universe}\ [Gyr]\ /\ \tau_{Universe\text{-}now}\ [Gyr]\ )^{1/4}, \qquad (43)$$

where $Y^*_{P,He\text{-}4} = 0.5$ whereas $\tau_{Universe\text{-}now}$ $[Gyr] = 21.614$ Gyr. The factor f^* should define the initial ratio of the number of alpha particles to number of protons i.e. value of f^* is close to 0.25 ($f^* \approx 0.25$). In such a no-free-parameter model, we obtain for the mass abundance of helium in the present-day Universe $Y^*_{He\text{-}4;now} = 0.25$ i.e. for H/He ratio is $Y^*_{H;now} / Y^*_{He\text{-}4;now} = 3.0$ whereas for most distant observed Universe we obtain following values $Y^*_{He\text{-}4;7.75\text{-}Gyr} = 0.307$ i.e. $Y^*_{H,now} / Y^*_{He\text{-}4,now} = 2.26$.

From formula (43) follows that the $16 \cdot 21.614$ Gyr ≈ 346 Gyr old Universe should be free from helium.

12. Summary

The Cosmos appeared due to the collision of two very big pieces of space composed of non-gravitating tachyons. The initial radius of the inflation field was close to the radius of the orbit of Venus. During the inflation, the inflation field, i.e. the superluminal Higgs field, partially transformed into the Einstein spacetime composed of the neutrino-antineutrino pairs. There appeared two boundaries one for the inflation field and second for the Einstein spacetime. Gravitational fields are directly associated with the superluminal, non-gravitating field whereas the three Standard-Model interactions are directly associated with the field composed of the neutrino-antineutrino pairs. It causes that we cannot unify gravity with electromagnetism and nuclear strong and weak interactions within the same methods. There are not in existence the gravitational waves composed of tachyons and gravitons.

Due to the initial left-handedness of the SST inflation field there is the matter-antimatter asymmetry whereas due to the return shock wave there was produced one Protoworld in the centre of the inner Cosmos.

The early Universe was created inside the cores of Protoworld similarly to neutral pions in baryons. The early Universe was the double loops composed of the MNBHs grouped in larger structures already before the expansion of the Universe.

Exit from the black-hole state of the early Universe follows from the core-of-protoworld→neutrino transition which transformed the core into the dark matter loops. The transition forced an inflow of additional free neutrino-antineutrino pairs into the early Universe (the dark energy).

The duality of relativity leads to an illusion of acceleration in expansion of the Universe.

The Universe is about 21.614 Gyr old but due to the duality of relativity that results from the quantum entanglement of photons with source or a last-interaction object, we can see only the last period 13.866 ± 0.096 Gyr. We can see the CMB due to the concentric spheres composed of the vortices of electrons moving with different radial speeds – there appeared a set of CMBs with different radial velocities in relation to Milky Way.

Calculated here the mean value of the Hubble constant is $70.52\ km \cdot s^{-1} \cdot Mps^{-1}$ whereas calculated number of CMB photons in a cubic centimetre is 391 millions.

The standard ruler in cosmology (151.13 Mpc) results from creation of the dark-matter loops by the Protoworld already before the expansion of the Universe. Their interactions with baryonic matter via leptons lead to the loops composed of galaxies with a radius of about 151.13 Mpc.

Anisotropy power in the CMB follows from the four succeeding inflows of the dark matter into the early Universe.

B-modes are not associated with gravitational waves but with behaviour of condensates composed of the confined neutrino-antineutrino pairs.

13. Tables

Table 1 *The Cosmos*

Cosmological quantity	Theoretical value*
Radius of the internal Cosmos ≈ ≈ radius of the Einstein spacetime	2.3 E+30
Mass of the internal Cosmos i.e. without the two boundaries	5.9 E+119
Inertial-mass density of the initial inflation field	8.32192436 E+85 kg/m^3
Inertial-mass density of the superluminal Higgs field (initial parameter)	2.645834 E–15 kg/m^3
Density of the Einstein spacetime (initial parameter)	1.10220055 E+28 kg/m^3

*2.3 E+30 = $2.3 \cdot 10^{30}$

Table 2 *The Protoworld and early Universe*

Cosmological quantity	Theoretical value*
Mass of the core of the Protoworld ≈ ≈ mass of the dark matter	1.960762 E+52 kg
Equatorial radius of the core of the Protoworld	0.28665 Gyr
Radius of the $d = 1$ state = = radius of the standard ruler in cosmology	151.13 Mpc
Baryonic mass of the early Universe	3.6382 E+51 kg
Radius of the early Universe	0.1911 Gyr

Table 3 *The Universe*

Cosmological quantity	Theoretical value*
Present-day abundance of baryonic matter	4.91 %
Present-day abundance of dark matter	26.46 %
Present-day abundance of dark energy	68.63 %
Radius of modified neutron black hole (MNBH)	3.664 E+4 m
Mass of MNBH	4.935 E+31 kg i.e. about 24.81 solar masses
Mass density of MNBH	2.394 E+17 kg/m^3
Radius of the sphere filled with CMB photons	21.614 Gyr
Radius of the sphere filled with baryons, dark matter and dark energy	13.866 ± 0.096 Gyr
Hubble constant	70.52 km$\cdot$s$^{-1}\cdot$Mps^{-1}
Number of binary systems of protogalaxies	$2 \cdot 4.295 \cdot 10^9$
Number of dwarf galaxies per one massive galaxy	A few tens per massive one i.e. about 10^{11} to 10^{12}

Table 4 *Structures of the Universe*

Structures of the Universe	Mass
Largest neutron star/black-hole	$4.9 \cdot 10^{31}$ kg
Massive galaxy	$2.1 \cdot 10^{41}$ kg
Group of binary systems of galaxies	$1.7 \cdot 10^{42}$ kg
Supergroup of binary systems of galaxies	$6.8 \cdot 10^{42}$ kg
Cluster of binary systems of galaxies	$1.1 \cdot 10^{44}$ kg
Supercluster of binary systems of galaxies	$2.8 \cdot 10^{46}$ kg
Chain of binary systems of galaxies	$2.7 \cdot 10^{43}$ kg
Superchain of binary systems of galaxies	$1.7 \cdot 10^{45}$ kg
Megachain of binary systems of galaxies	$7.1 \cdot 10^{48}$ kg

Table 5 *Theoretical results*

Cosmological quantity	Theoretical value
Abundance of H-1 and He-4 for the most distant visible Universe when we do not take into account the heavier elements	69.7% H and 30.3% He
λ_ν/λ_T for black body	1.7195
Number of CMB photons in a cubic metre	391 million
Anisotropy power for a quadrupole	132 μK^2
Anisotropy power for megachains	934 μK^2
Maximum anisotropy power for mass density fluctuations	5193 μK^2
Multipole moments for maximums of the anisotropy power associated with inflows of dark matter	256, 512, 768, 1479
Multipole moments for maximums of the E polarization spectrum	128, 256, 384, 740
Maximum anisotropy power for scalar E-mode polarisation	41 μK^2
Amplitude of the temperature fluctuations for the CMB on angular scale of 11 degrees	$1.11944 \cdot 10^{-5}$
Ratio of the B-modes to E-modes	~ 0.22

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