

# The Dark-Matter Mechanism Leads to the Standard Ruler in Cosmology

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**Abstract:** It is assumed that the not numerous pairs of galaxies separated by about 150 Mpc appeared due to the baryon acoustic oscillations (BAO). We can use this distance as the standard ruler in cosmology. On the other hand, the Scale-Symmetric Theory (SST) shows that the four succeeding phase transitions of the modified Higgs field lead to the cosmic object/Protoworld which was created after the inflation but before the expansion of the Universe. The Protoworld appeared due to fluctuations in the Einstein spacetime - at first there was produced a vortex with left internal helicity. Due to the quantum entanglement, the internal structure of the Protoworld leaked to the Einstein spacetime. It caused that in the Einstein spacetime, already before the expansion of the Universe, there appeared virtual structures and flows which mimicked the structure and characteristic motions in the Protoworld. Such ordered motions in the Einstein spacetime decrease local pressure so there appears the attraction and quantum entanglement between the virtual structures and visible matter. Most important for creation of the cosmological rulers were the virtual cosmological loops produced by the Protoworld in its  $d = 1$  state which is an analog to the  $d = 1$  state in baryons. Calculated here the radius of such cosmological loops is 151.13 Mpc and such is the true origin of the standard ruler in cosmology. Obtained theoretical result is consistent with observational facts.

## 1. Introduction and calculations

There is a small excess in number of pairs of galaxies separated by  $\sim 500$  million light-years ( $\sim 153.3$  Mpc). It is often referred to as the baryon acoustic oscillations (BAO). On basis of this phenomenon we can investigate some properties of the dark matter.

There is assumed existence in the very early Universe some regions filled with dark matter, baryons and photons. The heat of matter-photon interactions caused that there appeared dynamic pressure. The counteracting gravity and pressure created oscillations. The wave traveled outwards with the sound speed equal to 57% of the speed of light. Photons providing pressure decoupled at recombination and it fixed radius of the shell of baryonic matter. This radius is referred to as the sound horizon. The gas in the shell and dark matter in the original centre started the galaxies formation. The preferred separation was  $\sim 150$  Mpc [1], [2], [3].

The analysis of the WMAP data (CMB) yielded  $146.8 \pm 1.8$  Mpc for the sound horizon at the photon decoupling epoch and  $153.3 \pm 2.0$  Mpc at the end of the baryon drag epoch [4].

The standard ruler can be used to measure the geometry of the Universe via measurement of both the angular diameter distance  $D_A(z)$  and the expansion rate  $H(z)$ .

Here I will prove that the origin of the cosmological ruler is different.

The General Relativity leads to the non-gravitating Higgs field composed of tachyons [5A]. On the other hand, the Scale-Symmetric Theory (SST) shows that the succeeding phase transitions of such Higgs field lead to the different scales of sizes [5A]. Due to the saturation of interactions via the Higgs field and due to the law of conservation of the half-integral spin that is obligatory for all scales, there consequently appear the superluminal binary systems of closed strings (entanglons) responsible for the quantum entanglement, stable neutrinos and luminal neutrino-antineutrino pairs which are the components of the luminal Einstein spacetime (it is the Planck scale), cores of baryons, and the cosmic structures (protoworlds) that evolution leads to the dark matter, dark energy and expanding universes [5A], [5B]. The SST shows that the beginning of the expansion of the Universe (the “soft” big bang) was separated in time from the inflation (the big bang).

Due to the symmetrical decays of bosons on the equator of the core of baryons, there appears the atom-like structure of baryons described by the Titius-Bode orbits for the nuclear strong interactions [5A].

The three last scales are partially dual i.e., for example, there is an analogy between the strong-weak interactions concerning the core-of-baryon scale (the torus in the core of baryons behaves as the modified black hole in respect of the strong interactions whereas the condensate in its centre behaves as the modified black hole in respect of the weak interactions) and strong gravitational interactions concerning the cosmological scale [5A], [5B].

The gluons and photons are the rotational energies of the Einstein-spacetime components. Outside the strong fields, the gluons behave as photons [5A]. This and the entanglement cause that the virtual structure of proton leaks from protons [5C]. This means that in the Einstein spacetime appear virtual structures which mimic the shapes and internal motions in proton. Since the succeeding phase transitions concern the virtual structures as well so in the Einstein spacetime are virtual structures which mimic the motions in the Protoworld. The virtual cosmic structures were produced by Protoworld and some of them are stable so they are in the Einstein spacetime even in absence of the Protoworld. The core of the Protoworld transformed into the dark matter i.e. into the additional Einstein-spacetime components entangled with hadrons and charged leptons. The dynamic pressure created by the inflows of the dark matter and dark energy into the very early Universe started the expansion of the Universe [5B].

The Protoworld appeared due to fluctuations in the Einstein spacetime - at first there was produced a vortex with left internal helicity. Due to the quantum entanglement, the internal structure of the Protoworld leaked to the Einstein spacetime.

**Emphasize what is the big difference between the dark energy and dark matter.** In the dark energy, the Einstein-spacetime components are “free” (they interact gravitationally only) so their motions are chaotic. It causes that dark energy increases the dynamic pressure of the Einstein spacetime. On the other hand, in the dark matter, the Einstein-spacetime components are entangled so their motions are ordered. It causes that in regions in which appear the ordered motions, the local pressure in the Einstein spacetime is lowered. Just there appear the pressure holes. For example, a virtual loop composed of entangled Einstein-spacetime components produces a lowered-pressure loop. It means that to increase the lowered pressure (the Universe tries to equalize the pressure) such loop attracts the Einstein-spacetime components and visible matter. In absence of visible matter, in the Einstein spacetime there are produced the “islands” with higher mass density – the “islands” are the components of the dark matter. When there is more and more visible matter then instead the dark-matter islands

there are produced visible-matter islands. In the limit, due to the evolution of the Universe, some of dark-matter islands will be replaced for the visible-matter islands. The visible-matter islands are entangled with the virtual dynamic structures in the Einstein spacetime so there appears the advection which, for example, leads to the dark-matter orbital motions of stars [6]. Here, the advection is the transport mechanism of the mass of gas and dust by the entangled luminal Einstein-spacetime components because of the characteristic motions in the virtual structures.

The virtual loops, which lead to the cosmological rulers, are the analogs to the loops which appear in the  $d = I$  state in nucleons. Radius of the  $d = I$  shell is  $A + B = 1.19928$  fm, where  $A = 0.6974425$  fm is the external radius of the core of baryons [5A]. On the  $d = I$  shell, outside the core of baryons, is the relativistic pion. Emphasize that the loops emitted from the  $d = I$  state of nucleons lead to the black body spectrum of the Universe [5B].

The external radius of the core of the Protoworld was  $A_{Protoworld} = 2.71199 \cdot 10^{24}$  m = 286.66 million light-years [5B]. The dense nuclear matter in the  $d = I$  state of the Protoworld, produced in this state the virtual cosmological loops. Such loops were emitted and their radius is

$$R_{ruler-in-cosmology} = A_{Protoworld} (A + B) / A = 492.93 \text{ million ly} = 151.13 \text{ Mpc}. \quad (1)$$

Here [7], the mean value for sound horizon obtained on the basis of their fiducial cosmology and on the basis of definition of the sound horizon in  $C_{AMB}$  is 151.24 Mpc – it means that the obtained here theoretical result is very close to this result.

The virtual cosmological loops with a radius of 151.13 Mpc were the seeds for the ruler in cosmology. At first, they produced the lowered-pressure loops. Next, they attracted the protogalaxies the very early Universe consisted of [5B].

The spin speeds of the virtual loops are equal to the speed of light in ‘vacuum’  $c$ . But when on a cosmological loop appears very dense nuclear matter then spin speed of the virtual loop can be reduced to the spin speed of the nuclear matter. Since the resultant speed of the Einstein-spacetime components must be equal to the  $c$  so there appear the radial speeds of the entangled Einstein-spacetime components. The theory of baryons shows that spin speed of the nuclear matter in the  $d = I$  state is  $v_{spin} = 0.762594c$  [5A]. Applying the Pythagorean equation, we obtain that the radial speeds are  $v_{radial} = (c^2 - v_{spin}^2)^{1/2} \approx 0.647c$ . This value is close to the sound speed applied in the mainstream cosmology:  $\sim 57\%$ .

### 3. Summary

It is assumed that the not numerous pairs of galaxies separated by about 150 Mpc appeared due to baryon acoustic oscillations (BAO). We can use this distance as the standard ruler in cosmology.

On the other hand, the Scale-Symmetric Theory shows that the four succeeding phase transitions of the superluminal non-gravitating Higgs field (the inflation field) lead to the cosmic object/Protoworld which was created after the inflation but before the expansion of the Universe. The Protoworld appeared due to fluctuations in the Einstein spacetime – at first there was produced a vortex with left internal helicity. Due to the quantum entanglement, the internal structure of the Protoworld leaked to the Einstein spacetime. It caused that in the Einstein spacetime, already before the expansion of the Universe, there appeared virtual structures and flows which mimicked the structure and characteristic motions in the Protoworld. Such ordered motions in the Einstein spacetime decrease local pressure so there appears the attraction and quantum entanglement between the virtual structures and visible

matter. Most important for creation of the cosmological rulers were the virtual cosmological loops produced by the Protoworld in its  $d = I$  state which is an analog to the  $d = I$  state in baryons. Calculated here the radius of such cosmological loops is 151.13 Mpc and such is the true origin of the standard ruler in cosmology.

Obtained theoretical result is consistent with observational facts.

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