Cosmology in Crisis

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Abstract: The value of the Hubble constant depends strongly on the models we use and ranges from 40 to 100. Most often we get a value of about 70, but recent measurements (November 2019) suggest a value of 50-58, suggesting a possible crisis for cosmology. On the other hand, the Scale-Symmetric Theory leads to a result of 44-45 and shows that the erroneous assumption about invariance of speed of light in "vacuum" leads to a result of about 69-71. Here we also calculated the critical density from the properties of the initial inflation field and we described the origin of the baryon-antibaryon asymmetry.

1. Introduction

Within the Scale-Symmetric Theory (SST), we showed that the Universe is flat because density of the Einstein spacetime, $\rho_{ES} = 1.10220055 \cdot 10^{28}$ kg/m^3 [1], is much higher than the critical density, $\rho_{Critical,SST}$, calculated here (about 10^{55} times higher).

Critical density is the value at which the Universe is at balance, and expansion is stopped. In SST, such definition means that all matter of the Universe is evenly distributed in the inner Cosmos with a radius of ~$2 \cdot 10^{30}$ m [2].

From the Friedmann equation for the flat Universe we have

$$H_{o,SST}^2 = \{100\ h_{SST}\ [(km/s)/Mpc]\}^2 = 8\ \pi\ G\ \rho_{Critical,SST} / 3\ , \quad (1)$$

where $H_{o,SST}$ is the Hubble constant and h_{SST} is the Hubble parameter calculated within SST.

Knowing that (km/s)/Mpc = $3.2408 \cdot 10^{-20}$ [1/s], we have

$$(H_{o,SST} / 100)^2 = h_{SST}^2 = 0.53236 \cdot 10^{26}\ \rho_{Critical,SST}\ . \quad (2)$$

The value of H_o depends strongly on the models we use and ranges from 40 to 100. Most often we get a value of about 70, but recent measurements suggest a value of [3]

$$H_o = 54.4^{+3.3}_{-4.0}\ . \quad (3)$$

Such value was obtained in a ΛCDM + Ω_K model – PL18 power spectra provide such constraint at 68 % C.L. Is it evidence for a possible crisis for cosmology?

On the other hand, the SST leads here to a result of 44.0 while our earlier result is 45.2 [4]. We showed that the erroneous assumption about invariance of speed of light in “vacuum” leads to a result of about [4]

$$H_{o,SST}^* = H_{o,SST} / 0.6415 \tag{4}$$

so we obtain about 68.6-70.5.

Here we also calculated the critical density from the properties of the initial inflation field, we described the origin of the baryon-antibaryon asymmetry, **and we provide a physical and mathematical explanation for the anomalous lensing amplitude that results from the recent Planck Legacy 2018 (PL18) release – it leads to** $H_o = 54.4^{+3.3}_{-4.0}$.

2. Calculations

In SST, the baryon-antibaryon asymmetry follows from the left-handedness of the initial inflation field (it was composed of the non-gravitating tachyons). The excess of the baryon matter is directly proportional to the squared mean spin speed of the tachyons [1]. Such mean spin speed, we can calculate as the spin speed on equator of an abstract tachyon with a mass two times lower than the mean mass of the real tachyons. We have

$$4 \pi R_{Real\text{-}tachyons,mean}^3 / 3 = 2 \cdot 4 \pi R_{Abstract\text{-}tachyon,M/2}^3 / 3 , \tag{5}$$

i.e.

$$R_{Abstract\text{-}tachyon,M/2} = R_{Real\text{-}tachyons,mean} / 2^{1/3} \approx 0.7937 \, R_{Real\text{-}tachyons,mean} , \tag{6}$$

where $F = 1/2^{1/3} \approx 0.7937$ is a factor which define polarization of the tachyons.

Tachyons are the rigid objects so the spin speed on equator of the abstract tachyon is

$$v_{Tachyon\text{-}spin,abstract} = F \, v_{Tachyon\text{-}spin,real} , \tag{7}$$

where $v_{Tachyon\text{-}spin,real} = 1.725741 \cdot 10^{70}$ m/s is the mean spin speed on equators of the real tachyons [1].

We know that kinetic or rotational energy is directly proportional to squared speed. On the other hand, there is the energy-mass equivalence so density of a field is directly proportional to squared speed.

We assume that the Einstein spacetime does not violate the matter-antimatter asymmetry and its density is directly proportional to the squared mean linear speed of the real tachyons

$$\rho_{ES} \sim v_{Tachyon\text{-}linear,real}^2 , \tag{8}$$

where $v_{Tachyon\text{-}linear,real} = 2.386344 \cdot 10^{97}$ m/s [1].

On the other hand, we assume that the critical density of baryon matter (i.e. the mean density of the excess baryon matter evenly distributed in the inner Cosmos [2]) is directly proportional to the squared abstract spin speed

$$\rho_{Critical,SST} \sim v_{Tachyon\text{-}spin,abstract}^2 . \tag{9}$$

From (8) and (9) we have

$$\rho_{Critical,SST} = \rho_{Critical,BM} = \rho_{ES} (F\, v_{Tachyon\text{-}spin,real} / v_{Tachyon\text{-}linear,real})^2 =$$

$$= 3.631275 \cdot 10^{-27}\ kg/m^3\ . \qquad (10)$$

From (2) and (10) we have

$$H_{o,SST} = 44.0\ (km/s)/Mpc\ . \qquad (11)$$

Formulae (4) and (11) lead to

$$H_{o,SST}{}^* = 68.6\ (km/s)/Mpc\ . \qquad (12)$$

3. A strange coincidence

Notice that when we remove the factor $F \approx 0.7937$ from formula (10) then we obtain following value for the critical density

$$\rho_{Critical,SST,beginning} = \rho_{ES} (v_{Tachyon\text{-}spin,real} / v_{Tachyon\text{-}linear,real})^2 = 5.7643 \cdot 10^{-27}\ kg/m^3 \qquad (13)$$

so from (2) and (13) we obtain

$$H_{o,SST,beginning} = 55.40\ (km/s)/Mpc\ . \qquad (14)$$

This value is consistent with the result which follows from the recent Planck Legacy 2018 release [3].

What is the origin of such strange coincidence? We can see that the SST provides a mathematical explanation of it. But what is a physical explanation? SST shows that at the beginning of the expansion of the Universe there was a period of transition of the Universe from the highly polarized state to a thermal state – the process of thermalization erases local memory of the initial magnetic polarization [2]. It suggests that at the beginning of the expansion, most tachyons had angular momentums parallel or antiparallel to their directions of motions i.e. the mean spin speed was equal to the mean spin speed of the real tachyons $v_{Tachyon\text{-}spin,real}$.

4. Summary

The different values of the Hubble constant in SST and General Theory of Relativity (~45 and ~70 respectively) follow from the fact that the speed of light in "vacuum" c is in SST not an invariant. In reality, the c is the speed of photons in relation to objects with which the photons are entangled.

The recent measurements [3] lead to $H_o = 54.4^{+3.3}_{-4.0}$ which suggests a crisis in cosmology. Here we provide a mathematical and physical explanation of such result. We showed that such Hubble constant concerns the beginning of the expansion of the Universe and follows from a phase transition which erased local memory of the initial magnetic polarization. On the other hand, in paper [3], it is argued that such value of Hubble constant follows from the fact that our Universe is closed

$$-0.007 > \Omega_K > -0.095 \text{ at 99\% C.L.} \qquad (15)$$

According to SST, this conclusion is incorrect.

We have the three different states of the cosmological matter/energy: baryon matter (BM), dark matter (DM), and dark energy (DE).

Can we relate the different cosmological states of matter/energy to the values of Hubble constants, i.e. 44.0 or 45.2 (they relate to 68.6 or 70.5 in General Theory of Relativity (GR)) and 55.4? Yes, we can do it.

We claim that the distance between the critical densities that follows from the polarized state ($\rho_{Critical,SST,beginning} = \rho_{Polarized,Critical,BM+DM} = 5.7643 \cdot 10^{-27}$ kg/m^3 – it relates to $H_{o,SST,beginning} = H_{o,Polarized} = 55.40$ (km/s)/Mpc) and that results from the thermal state ($\rho_{Critical,SST} = \rho_{Thermal,Critical,BM} = 3.631275 \cdot 10^{-27}$ kg/m^3 – it relates to $H_{o,SST} = H_{o,Thermal} = 44.0$ (km/s)/Mpc (68.6 in GR)) is associated with dark matter so it has a magnetic nature: there are the magnetic tori with a mass of 727.43 MeV and the closed electric loops with much lower mass and both cannot interact electromagnetically [5].

From it follows that critical density of dark matter, $\rho_{Critical,DM}$, is

$$\rho_{Critical,DM} = \rho_{Polarized,Critical,BM+DM} - \rho_{Thermal,Critical,BM} = 2.1330 \cdot 10^{-27} \text{ kg/m}^3 . \quad (16)$$

From the Einstein formula $E = mc^2$ results that critical density of dark energy, $\rho_{Critical,DE}$, should be equal to the critical density for the polarized state

$$\rho_{Critical,DE} = \rho_{Polarized,Critical,BM+DM} = 5.7643 \cdot 10^{-27} \text{ kg/m}^3 . \quad (17)$$

On the other hand, the density of baryonic matter in the present-day Universe calculated within SST is [2]

$$\rho_{BM} = (0.385 \pm 0.008) \cdot 10^{-27} \text{ kg/m}^3 . \quad (18)$$

Notice that dark matter and dark energy interact very weakly with baryon matter so the densities of them in the present-day Universe should be close to their critical values. It means that from formulae (16), (17) and (18), we can calculate abundances of the three cosmological states in the present-day Universe. For the central value of ρ_{BM} we obtain: **~4.6% of baryonic matter, ~25.8% of dark matter, and ~69.6% of dark energy**.

According to SST, baryons and dark matter were created at the end of the SST inflation at the time when the boundary of the inner Cosmos was created – radius of the inner Cosmos is $2.3 \cdot 10^{30}$ m [2].

Notice that we have already calculated the abundances of the cosmological states in the present-day Universe using a different method – we obtained 4.91% of BM, 26.46% of DM and 68.63% of DE [2].

The two different methods used in the Scale-Symmetric Theory give the following average results:

~5% of baryonic matter,

~26% of dark matter,

~69% of dark energy.

We should also describe the second strange coincidence that concerns cosmology. Calculate the radius of a cosmological ball with critical density equal to the sum of critical densities of dark matter (see formula (16)) and dark energy (see formula (17)) in such a way to obtain the equatorial spin speed equal to the speed of light in “vacuum” c (such object behaves as a physical black hole so we will call it the Cosmological Black Hole (CBH))

$$c^2 = G\,M / R = 4\,\pi\,G\,R^2\,\rho_{\mathrm{Critical,DM+DE}} / 3\,. \tag{19}$$

From this formula we obtain R = 21.3 **Giga light-years**, which is close to the real age of the Universe calculated within the SST: 21.6 **Giga years** [2]. But emphasize that according to SST, the light travels the path from the farthest observed galaxies to us in about 13.8 **Giga years** [2]. Does this coincidence lead to a new cosmology?

According to SST, the baryonic matter is today distributed in volume with a radius of 13.8 **Giga light-years** so its mean density in our CBH is

$$\rho_{\mathrm{BM,mean}} \approx (13.8 / 21.3)^3\ 0.385{\cdot}10^{-27}\ \mathrm{kg/m^3} \approx 0.1{\cdot}10^{-27}\ \mathrm{kg/m^3}\,. \tag{20}$$

We can see that this value is ~20 times lower than the DM critical density and ~55 times lower than the DE critical density so in formula (19) we neglected it – inclusion of baryonic matter in the calculation leads to 21.2 **Giga light-years** instead of 21.3 **Giga light-years**.

It is obvious that due to creation of the Protoworld [2] in centre of our CBH, densities of baryonic matter, dark matter, and dark energy in the central region were different compared to regions near the CBH surface. Just in the central region was more the baryonic matter and dark matter while dark energy has been pushed out to even out the resultant density. The transition described in [2] caused the Protoworld to break up and the inflow of dark energy that forced the Universe to expand.

The existence of the cosmological black holes (CBHs) forces the following problems to be formulated.

A) Are there other CBHs in the inner Cosmos?

B) Critical densities of dark matter and dark energy in all CBHs should be similar because these forms of matter/energy interact very weakly with baryon matter.

C) If the cosmic evolution described in SST is correct, the CBHs in the central part of the inner Cosmos should have lower densities of the baryon matter and these densities should be higher in the CBHs closer to the boundary of the inner Cosmos. The mean density of the baryonic matter in the inner Cosmos should be equal to the critical density of the baryonic matter (see formula (10)). From formula (19) follows that radii of the CBHs with higher density of baryon matter are smaller.

D) Is evolution of the Universe in our CBH cyclic?

E) Can the CBHs near our CBH give high radial velocities to some clusters of galaxies in our CBH?

Notice that from formula (19) we have

$$R \sim \rho_{\mathrm{Critical}}^{-1/2}\,. \tag{21}$$

We calculated that a CBH free from baryonic matter has radius 21.3 **Giga light-years** so from (21) we have that a typical CBH, i.e. with the critical density equal to $\rho_{\mathrm{Critical,BM+DM+DE}} = 1.5286{\cdot}10^{-26}\ \mathrm{kg/m^3}$, has radius ~17.6 **Giga light-years**. The radii of the CBHs in the inner Cosmos are in the following range

$$R < 21.3\ \textbf{Giga light-years}\,. \tag{22}$$

According to SST, matter was created near the boundary of the inner Cosmos at the end of the inflation and there appeared a shock wave towards the centre of the inner Cosmos. It suggests that the critical baryon densities in CBHs decrease when their distance from the centre is smaller and smaller.

The very low critical density of baryonic matter in our CBH ($\sim 0.385 \cdot 10^{-27}$ kg/m^3) in comparison with the mean value in the inner Cosmos ($\sim 3.631 \cdot 10^{-27}$ kg/m^3) suggests that our CBH is placed near the centre of the inner Cosmos. We can assume that the solar system really has a special location in the inner Cosmos because it is close to its centre – we can call it our-CBH-centric theory.

Notice that according to SST, today the front of baryonic matter in our CBH is in distance about 13.8 **Giga light-years** from its centre and its radial speed is about 0.64c [2].

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