Cosmic Neutrino Background

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Abstract: Here, within the Scale-Symmetric Theory (SST), we calculated temperature and energy density in radiation of the cosmic neutrino background. Presented here model leads to N(effective) equal to 3.4065 and this result is consistent with the Planck-spacecraft 2013 results and is close to the central value: 3.36. Calculated here the today temperature of the cosmic neutrino background is 2.008 K - we can compare it with the Cosmological-Standard-Model value that is 1.945 K.

1. Introduction

The Planck 2013 results concerning the Cosmic Neutrino Background (CνB) show that the central value for $N_{eff,Planck}$ is 3.36 (it is assumed that N_{eff} defines the effective number of species of neutrinos) [1]. The assumption that the future observational data will confirm that this central value is in approximation a correct result, leads to conclusion that we must formulate new model of CνB. The effective energy density of neutrinos, ρ_{ν}, is defined within the Cosmological Standard Model (CSM) as follows: $\rho_{\nu} = (7 / 8) N_{eff} (4 / 11)^{4/3} \rho_{\gamma}$, where ρ_{γ} is the effective energy density of photons concerning the Cosmic Microwave Background (CMB).

In this paper we show that the Scale-Symmetric Theory (SST), [2], leads to $N_{eff,SST} = 3.4065$. On the other hand, the Standard Model leads to $N_{eff,SM} = 3.046$, [3], that differs very much from the Planck central value.

The General Relativity leads to the non-gravitating Higgs field composed of tachyons [2A]. On the other hand, the Scale-Symmetric Theory, [2], shows that the succeeding phase transitions of such Higgs field lead to the different scales of sizes [2A]. 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 (the 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 (the protoworlds) that evolution leads to the dark matter, dark energy and expanding universes (it was due to the Protoworld→neutrino transition) [2A], [2B]. The non-gravitating tachyons have infinitesimal spin so all listed structures have internal helicity (helicities) which

distinguish particles from their antiparticles [2A]. The inflation field started as the liquid-like field composed of non-gravitating pieces of space. Cosmoses composed of universes are created because of collisions of big pieces of space. During the inflation, the liquid-like inflation field transformed partially into the luminal Einstein spacetime. In our Cosmos, the two-component spacetime is surrounded by timeless wall – it causes that the fundamental constants are invariant [2A], [2B].

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 [2A].

In CSM, the temperature of CνB is estimated on assumption that the inflation and the observed expansion of the Universe were not separated in time and that the number of neutrino species is $N_{\nu,SM} = 3$. The SST shows that the first assumption is incorrect whereas there are two species of stable neutrinos (the electron-neutrino and muon-neutrino and their antiparticles) and one species of unstable "neutrino" composed of three different stable neutrinos (the tau "neutrino") [2A].

Photons and gluons are the rotational energies of the Einstein-spacetime components i.e. of the neutrino-antineutrino pairs. When a pair rotates then there are three different helicities/colours that lead to 8 different gluons but only to 1 photon. The difference between the gluons and photons follow from different interactions of their carriers with the nuclear strong fields (such fields have internal helicity) and with the gravitational and electromagnetic fields (these fields have not internal helicity).

2. The temperature of the CνB and radiation energy density

SST shows that there are not in existence black holes with central singularity but there are in existence the modified black holes (such as, for example, the modified neutron black holes (MNBHs)) in which there is an orbit with the spin speed equal to the speed of light in "vacuum" c. The cosmic black holes are the associations of the MNBHs [2B].

The very early Universe was the double cosmic loop composed of the MNBHs [2B]. Due to the inflows of the dark matter and dark energy they consist of the neutrino-antineutrino pairs also [2B]) there dominated the beta decays so the primordial plasma consisted of 5 different particles carrying different masses: neutrons, protons, electrons, photons, and electron-antineutrinos.

The cosmological formula for the total number of degrees of freedom g_i is in the Scale-Symmetric Theory as follows

$$g_i = 2\,(N_{bosons} + N_{fermions}), \tag{1}$$

where N is the number of particle species whereas the factor 2 follows from the fact that we sum over species and spin states. SST shows that all stable neutrinos have the same mass and suggests that the degrees of freedom concern particles carrying different masses.

Decoupling of the electron-antineutrinos took place already during the initial beta decays so the temperature of neutrinos is defined by the initial degrees of freedom. There was one massless boson (photon) and 4 fermions (neutron, proton, electron, and electron-antineutrino) so $g_i = 10$.

When during the expansion of the Universe density of matter and energy decreased sufficiently then there was the decoupling of the photons produced because of the beta decays, nuclear transformations and because of the electron captures by the atomic nuclei. Such processes increased temperature of the decoupled photons. But the annihilation of the real and virtual electron-positron pairs caused that there were produced the clouds composed of the

photons and electrons. We can see that there was one massless boson (photon) and one fermion (electron) so $g_i = 4$.

We know that in local thermal equilibrium, the entropy S is directly proportional to the g_i and to the three powers of temperature

$$S \sim g_i T^3. \tag{2}$$

Using the entropy conservation law ($S = const.$) we obtain $T_i / T = T_{i(before)} / T_{after} = (g_{i(after)} / g_{i(before)})^{1/3}$, where $T_i \leq T$ whereas $g_{i(after)} < g_{i(before)}$. This leads to conclusion that the ratio of the today temperature of the electron-antineutrinos T_ν (it is the today temperature of the CνB) to the today temperature of the photons T_γ is $T_\nu / T_\gamma = (4 / 10)^{1/3}$ i.e. since $T_\gamma = 2.725$ K so $T_\nu = 2.008$ K.

For defined redshift, the radiation energy density ρ_r of the Universe we can write as follows (the radiation energy is directly proportional to four powers of its temperature so there appears the factor $(T_i / T)^4$ also)

$$\rho_r = C_1 [1 + (7 / 8) N (4 / 10)^{4/3}], \tag{3}$$

where C_1 is a constant. Due to the different statistics for fermions and bosons there appears the factor $7/8$ for the neutrinos whereas for photons the factor is unitary. The first term in the square bracket is due to the CMB whereas the second due to the CνB.

What is the physical meaning of the symbol N? In Cosmological Standard Model it is assumed that N defines number of neutrino species. Due to the neutrino "oscillations", the CSM gives $N = 3.046$ [3]. But SST shows that these two assumptions are incorrect. In reality, the stable neutrino-antineutrino pairs do not annihilate and due to the tremendous superluminal energy (not mass) frozen inside them, they are indestructible and they cannot oscillate. In reality, the observed neutrino "oscillations" are the exchanges of free neutrinos for neutrinos in the neutrino-antineutrino pairs or decays of the unstable tau "neutrinos". SST shows that the neutrinos are entangled with their sources i.e. protons and electrons and that the N denotes number of entangled fermions i.e. in SST $N = 3$.

Compare the effective energy density of neutrinos, ρ_ν, defined within the Cosmological Standard Model (CSM), i.e. $\rho_\nu = (7 / 8) N_{eff} (4 / 11)^{4/3} \rho_\gamma$, with the expression obtained within the Scale-Symmetric Theory (formula (3)): $\rho_\nu = (7 / 8) N (4 / 10)^{4/3} \rho_\gamma$, where $N = 3$ does not define the species of neutrinos but number of entangled particles (neutrino plus proton plus electron)

$$N_{eff} = N_{eff,SST} = N (11 / 10)^{4/3} = 3.4065. \tag{4}$$

3. Summary

Here, within the Scale-Symmetric Theory (SST), we calculated temperature and energy density in radiation of the cosmic neutrino background. Presented here model leads to $N_{effective}$ equal to 3.4065 and this result is consistent with the Planck-spacecraft 2013 results and is close to the central value: 3.36. Calculated here the today temperature of the cosmic neutrino background is 2.008 K – we can compare it with the Cosmological-Standard-Model value that is 1.945 K.

SST shows that there are the three species of neutrinos but only two species of neutrinos are the stable neutrinos. We showed that the $N = 3$ does not concern the species of neutrinos but the number of entangled fermions and we showed that instead the CSM factor $4/11$ we should apply the factor $4/10$.

References

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[2] Sylwester Kornowski (2015). *Scale-Symmetric Theory*
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[2B]: http://vixra.org/abs/1511.0223 (Cosmology)
[2C]: http://vixra.org/abs/1511.0284 (Chaos Theory)
[2D]: http://vixra.org/abs/1512.0020 (Reformulated QCD)

[3] Mangano, Gianpiero, *et al.*, (2005). „Relic neutrino decoupling including flavor oscillations"
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