The Origin and Nature of Extreme-Energy Cosmic Rays

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Abstract: Here, applying the lacking part of ultimate theory, i.e. the Scale-Symmetric Theory, the origin and nature of the extreme-energy cosmic rays exceeding the GZK limit have to be explained. It follows from the four-particle symmetry and the phenomena which take place in collapsing to neutron star a big star. There are produced the binary systems of discs composed of the W or Z bosons. They decay to two tagged photons moving in opposite directions. There also are possible the other channels of decay so the decays to two tagged photons are very rare. The discs have strictly determined mass so the photons have strictly determined energy. The obtained results are consistent with the energy of the Oh-My-God particle seen in the detector operated by the University of Utah. The lowest mass/energy of such discs/photons should be detected in CERN. Here as well is explained why the energy distribution of cosmic rays should peak at approximately 0.32 GeV.

1. Introduction and motivation

The General Relativity leads to the non-gravitating Higgs field composed of tachyons [1A]. 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 [1A]. 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 [1A], [1B]. The non-gravitating tachyons have infinitesimal spin so all listed structures have internal helicity (helicities) which distinguishes particles from their antiparticles [1A]. SST shows that a fundamental theory should start from infinite nothingness and pieces of space [1A]. Sizes of pieces of space depend on their velocities [1A]. The inflation field started as the liquid-like field composed of non-gravitating pieces of space [1A]. Cosmoses composed of universes are created because of collisions of big pieces of space [1A], [1B]. During the inflation, the liquid-like inflation field (the non-gravitating superluminal Higgs field) transformed partially into the luminal Einstein spacetime [1A]. In our Cosmos, the two-component spacetime is

surrounded by timeless wall – it causes that the fundamental constants are invariant [1A], [1B].

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 [1A].

The dark matter consists of the additional Einstein-spacetime components entangled with baryonic matter and other visible matter [1B]. The dark matter appeared due to the evolution of the core of the Protoworld that appeared after the inflation (the big bang) but before the observed expansion of our Universe (the "soft" big bang).

Inside the core of the Protoworld was created the very early Universe composed of protogalaxies. It was the double-loop [1B].

Due to the quantum entanglement and the four-particle symmetry that follows from the fact that there are the two species of stable neutrinos i.e. the electron- and muon-neutrinos (the third unstable "neutrino" (in assumption the tau-neutrino) consists of three different stable neutrinos), the protogalaxies were grouped in bigger structures. The quantum entanglement leads to following formula which describes the number of binary systems of protogalaxies found in the very early structures of the Universe

$$D = 4^d, \tag{1}$$

where $d = 0, 1, 2, 4, 8, 16$ for a flattened-spheroid-like/disc-like structures, and $d = 3, 6, 12$ for a chain-like structures [1B]. Formula (1) concerns particles as well [1A], [1D].

Each protogalaxy consisted of 4^{16} modified neutron black holes (MNBHs have not a central singularity but there is a circle with spin speed equal to the speed of light in "vacuum" c. The inflows of the dark matter and dark energy (it consists of free additional neutrino-antineutrino pairs that interact gravitationally only) caused the exit of the MNBHs from their black-hole state.

We can replace the structures composed of the MNBHs for the W or Z bosons produced in collisions of nucleons – such collisions are very effective in production of structures defined by formula (1) in collapsing to neutron star a big star. There appear the binary systems of the W-discs or Z-discs. Such binary systems can decay to two tagged photons moving in opposite directions. But there as well are possible the other channels of decay so the decays to two photons are very rare.

The maximum number of the modified neutron black holes in the early Universe (the double-loop) was $2{\cdot}2{\cdot}4^{32}$ so the total mass of the Universe, without the dark matter and dark energy, is about $3.6{\cdot}10^{51}$ kg [1B]). The upper limit for number of MNBHs in one loop is $2{\cdot}4^{32}$ [1A]. Mass/energy U of some analog to one loop in the early Universe composed of W or Z bosons is (mass of W boson is $W \approx 80.4$ GeV $= 0.804{\cdot}10^{11}$ eV whereas of Z boson is $Z \approx 91.2$ GeV $= 0.912{\cdot}10^{11}$ eV)

$$U(W) = 2{\cdot}4^{32}\, W \approx 3{\cdot}10^{30} \text{ eV} \approx 3{\cdot}10^{21} \text{ GeV}, \tag{2a}$$

$$U(Z) = 2{\cdot}4^{32}\, Z \approx 3.4{\cdot}10^{30} \text{ eV} \approx 3.4{\cdot}10^{21} \text{ GeV}, \tag{2b}$$

These energies are greater than the Planck energy $\sim 1.2{\cdot}10^{19}$ GeV ($1\text{MeV} \approx 1.783{\cdot}10^{-30}$ kg).

It suggests that most important are the analogs to the protogalaxies i.e. the discs composed of 4^{16} W or Z bosons. Calculate the upper limits for energy of the extreme W-discs/photons and Z-discs/photons

$$E_{max}(W) = 4^{16} W \approx 3.45 \cdot 10^{20} \text{ eV}, \tag{3a}$$

$$E_{max}(Z) = 4^{16} Z \approx 3.92 \cdot 10^{20} \text{ eV}. \tag{3b}$$

The University of Utah operates a cosmic ray detector called the Fly's Eye II. On October 15, 1991, this detector detected the Oh-My-God particle – the estimated energy is approximately $(3.2 \pm 0.9) \cdot 10^{20}$ eV [2], [3]. We can see that both theoretical results (formulae (3a) and (3b)) are consistent with observational fact.

Calculate mass/energy of all discs/cosmic-rays that follow from formula (1):
4^1: for W-disc is 321.6 GeV; for Z-disc is 364.8 GeV (it should be detected in CERN),
4^2: for W-disc is 1.29 TeV; for Z-disc is 1.46 TeV,
4^4: for W-disc is $2.06 \cdot 10^{13}$ eV; for Z-disc is $2.33 \cdot 10^{13}$ eV,
4^8: for W-disc is $5.27 \cdot 10^{15}$ eV; for Z-disc is $5.98 \cdot 10^{15}$ eV,
4^{16}: for W-disc is $3.45 \cdot 10^{20}$ eV; for Z-disc is $3.92 \cdot 10^{20}$ eV (it is the Oh-My-God particle).

The energy distribution of cosmic rays should peak at about 0.32 GeV. SST shows that there is the atom-like structure of baryons [1A]. Mass of the electric charge inside the core of proton is 318.3 MeV ≈ 0.32 GeV so the annihilating core-anticore pairs can produce tagged photons each of energy about 0.32 GeV [1A]. Of course, on the other hand, there is the three-valence-quarks mainstream model of nucleons but within this model we cannot since 1964 calculate the exact masses and spins of protons and neutrons.

One of the phenomena in which are produced the X-rays and gamma-rays concerns the two succeeding transitions of photons via the weak condensates inside the bare protons [4] and bare electrons [5].

2. Summary

Here, applying the Scale-Symmetric Theory, the origin and nature of the extreme-energy cosmic rays exceeding the GZK limit have to be explained. It follows from the four-particle symmetry and the phenomena which take place in collapsing to neutron star a big star. There are produced the binary systems of discs composed of the W or Z bosons. They decay to two tagged photons moving in opposite directions. Since there as well are possible the other channels of decay so the decays to two tagged photons are very rare. The discs have strictly determined mass so the photons have strictly determined energy. The obtained results for most energetic photons ($3.45 \cdot 10^{20}$ eV for W-disc and $3.92 \cdot 10^{20}$ eV for Z-disc) are consistent with the energy of the Oh-My-God particle seen in the detector operated by the University of Utah.

The mass of the electric charge inside proton causes that the energy distribution of cosmic rays peaks at about 0.32 GeV.

References

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