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. 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 as well. 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 smallest mass/energy of disc/photon 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 Scale-Symmetric Theory [1], [2] starts from the expansion of the cracked space (it is the inflation of the Higgs field; the big bang) which leads to the Einstein spacetime. There appear the four succeeding phase transitions of the Higgs field and the atom-like structure of baryons.

The dark matter consists of the additional Einstein-spacetime components entangled with matter. It appeared due to the evolution of the cosmic structure (it was the Protoworld that appeared due to the fourth phase transition of the Higgs field) which appeared after the inflation described within the Scale-Symmetric Theory but before the observed expansion of our Universe (the ‘soft’ big bang).

Inside the Protoworld was created the Double Cosmic Loop (the very early Universe) composed of protogalaxies. Due to the quantum entanglement and the four-particle symmetry that follows from the fact that there are the two species of neutrinos i.e. the electron- and muon-neutrinos (the third “neutrino”, in assumption the tau-neutrino, consists of three different 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. Formula (1) concerns particles as well [1].

Each protogalaxy consisted of 4^{16} neutron black holes. The inflows of the dark matter caused the exit of the black holes from their black-hole state.

We can replace the neutron black holes for the W or Z bosons produced in collisions of nucleons – such collisions are very effective 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 neutron black holes in the Double Cosmic Loop (the very early Universe) was $2\cdot 2\cdot 4^{32}$ so the total mass of the Universe, without the dark matter and dark energy, is about $3.6382\cdot 10^{51}$ kg [1]). Here [1], we can find the motivation why the number $2\cdot 4^{32}$ of the neutron black holes in one cosmic loop is the upper limit. Mass/energy U of some analog to the Cosmic Loop composed of W or Z bosons is (mass of W boson is W ≈ 80.4 GeV = $0.804\cdot 10^{11}$ eV whereas of Z boson Z ≈ 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 $1.2\cdot 10^{19}$ GeV (1MeV ≈ $1.783\cdot 10^{-30}$ 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 possible extreme-energy of 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 [3], [4]. We can see that both theoretical results (formulae (3a) and (3b)) are consistent with the observational fact.

Calculate mass/energy of all discs/cosmic-rays that follow from formula (1):
$\mathbf{4^1}$: for W-disc is 321.6 GeV; for Z-disc is 364.8 GeV (it should be detected in CERN),
$\mathbf{4^2}$: for W-disc is 1.29 TeV; for Z-disc is 1.46 TeV,
$\mathbf{4^4}$: for W-disc is $2.06\cdot 10^{13}$ eV; for Z-disc is $2.33\cdot 10^{13}$ eV,
$\mathbf{4^8}$: for W-disc is $5.27\cdot 10^{15}$ eV; for Z-disc is $5.98\cdot 10^{15}$ eV,
$\mathbf{4^{16}}$: 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. It follows from the fact that mass of the electric charge inside proton is 318.3 MeV [1]. There is the atom-like structure of baryons. Within the three-valence-quarks mainstream model of nucleons we cannot since 1964 calculate the exact masses, magnetic moments and spin of protons and neutrons. We can do it within the Scale-Symmetric Theory [1].

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 [5] and bare electrons [6].

2. Summary

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. 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 as well. 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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