RESEARCH ARTICLE

The Nature of Gamma-ray Bursts in the Framework of the Byuon Theory

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Abstrat: Two models of gamma-ray bursts using the theory of byuons (TB) are considered. This theory describes a "life" of special unobservable discrete objects from which the surrounding space and the world of ultimate particles are formed. Basic axioms and some conclusions of this theory are discussed. It is shown that basic problems with nature of gamma-rays bursts can be solved in the framework of this theory not only for bursts connected with supernova explosions but also for those without explosions.

Keywords: gamma-ray bursts; theory of byuons; new non-gauge force

1. Introduction

Gamma-ray bursts (GRBs) were detected for the first time in 1967 in the range 0.1-1 MeV[1] by US satellites Vela intended for monitoring of nuclear explosions in the atmosphere of the Earth. As was shown later these bursts had astrophysical origin and did not connect to any processes at the Earth. Three possible locations of GRBs were assumed: the solar system, our Galaxy and sources at cosmological distances (see, for example[2]). A lot of GRBs were detected by space apparatuses, basically using BeppoSAX, BATSE, HETE, Swift and Fermi. This gave the possibility to reveal a number of their peculiarities which could be summarized in the following way (see, for example[3]).

1) GRBs are flares of gamma-rays in the range of 30 keV–100 MeV. Their durations are in the interval from several milliseconds to thousands of seconds[4]. They are characterized by complex emission profiles and by variabilities with typical time of order of msec. The distribution of GRBs on durations is bimodal. There are short bursts with the characteristic time less than 1.5 sec and long ones with longer durations. The first group includes about 30% of all known bursts, and 70% of bursts belong to the second group. However the distribution of durations is quite wide and these two groups overlap. So, sometimes it is difficult to attribute a GRB to the certain group.
2) The BATSE fluxes of the weakest bursts are of order of 10-7 erg cm-2. Their spectra are non-thermal and variable. Bright flashes can give photons of 1 GeV and even higher.
3) The distribution of GRBs in the sky is isotropic but non-uniform. There is a deficiency of weak sources.
4) In many cases afterglows are observed in optical and X-ray diapasons. Sometimes variable radio emission has been detected[5].
5) For a number of GRBs "host" galaxies were observed. Their optical spectra gave the possibility to estimate their red shifts Z. The known values of Z are up to several units.
6) For GRB990123 (Z >1.61) the total energy is 3 × 1054 erg if the isotropic radiation is suggested. This value is very near the equivalent rest mass of the Sun M⊙ c2 = 2 × 1054 erg. In fact, emission of GRBs is collimated and their beam widths are from 20 to 200[6].

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2. The possible origin and emission mechanisms of GRBs

The detailed analysis of observable properties of GRBs shows almost certainly that they connect to extragalactic objects. The most probable sources of GRBs are supernova explosions in fields of an active star formation. Such processes can take place in galaxies at distances d more than 50 Mpc. Indeed, the nearest galaxy with the registered GRB (GRB980425) has $Z = 0.0085$, *i.e.* $d = 40$ Mpc. A supernova explosion can release huge energy which can be transformed to observed gamma-emission. Such processes are associated at this moment with long GRBs. Indeed, GRB980425 was followed by the SN 1998bv of less than one day. This confirms the connection of GRBs with collapses of massive stars.

As for short gamma-bursts it is assumed usually that they are connected to merging of neutron stars or a neutron star and a black hole as the result of the evolution of a close binary system. Owing to gravitational radiation stars in such system move helically, approach each other and merge into isolated black hole. In this model emitted energy must be lower than from long bursts and such sources may be seen only at smaller distances. It is unclear what collimation must be in short GRBs.

It is worth noting that there are not satisfactory explanations of all observational data up to now. Light curves of GRBs differ extremely from one source to another. The number of peaks, structures, durations and variabilities of individual features are unrepeatable, and this makes a very complicated picture of a typical GRB.

3. Afterglows

In a number of cases some emissions are registered in optical, X-ray and radio ranges after gamma-flashes. There is not the common point of view on the origin of gamma-radiation, but as for mechanisms of afterglows many investigators connect them with the interaction of shock waves formed during a supernova explosion with the surrounding medium.

4. Soft gamma-ray repeaters

The separate group of GRBs includes the so called soft gamma-ray repeaters (SGRs). They belong to our Galaxy and are identified with isolated neutron stars. The most popular model of these objects is the magnetar model suggesting the existence of neutron stars with super-strong magnetic fields (10^{14}–10^{15} G)[7]. However some alternative models were put forward, for example, the drift model[8] and the accretion one[9]. It must be held in any model that gamma-radiation in SGRs is caused by nuclear reactions near the star surface. These processes can provide energy up to 10^{46} erg. The most energetic SGRs can be seen in distant galaxies.

The decision of basic problems connected with nature of gamma-ray bursts energetics will be shown in this article using the theory of byuons (TB)-non-gauge theory of the formation of physical space and the world of ultimate particles on the basis of unobservable objects named "byuons"[10–12].

5. GRBs in the byuon theory

In this article, we present only the basic axioms and main results from TB. In TB, there is initially no physical space, no time, and no world of ultimate particles that constitute all physical bodies around us, but there is an object that is inherently unobservable, namely byuon $\Phi(i)$ with discrete states. It has an internal vector property expressed in the form

$$\Phi(i) = \begin{cases} A_g x i \\ -\sqrt{-A_g x i} \end{cases} \qquad (1),$$

where *x(i)* is the byuon length, real (positive or negative) quantity that depends on index $i = 1, 2, \ldots, k$.. Quantity A_g is an internal potential whose modulus is equal to the cosmological vector potential[10–12]. This potential is determined by the byuon's properties, so it is referred as internal one. By definition, quantity $\Phi(i)$ can be either real or purely

imaginary. All multitude of states $\Phi(i)$ relative to index i can form one-dimensional space R_1 in which the distances between byuon states are determined as the difference between their lengths (Archimedean metrics). Discrete time, time quantum τ_0, and space quantum X_0 in one-dimensional R_1 formed by byuon states ($\tau_o \approx 0.9 \times 10^{-43}$ c, $X_0 \approx 2.8 \times 10^{-33}$ cm) are introduced.

Statics. We believe that in the set $\{\Phi(i)\}$, there are meant no static states with time $t > \tau_0$.

Kinematics. Depending on whether the vector $\Phi(i)$ is real or imaginary, the length *x(i)* is positive or negative, decreases or increases in magnitude, free byuons (*i.e.* not interacting one with another) can be only in one of the four so called vacuum states (VS) II^+, I^+, I^-, II^-.

Let us introduce the following definitions:

1. A free byuon is in the state II^+ if its positive length discretely, in a quantum of time τ_0, increases by a quantum of distance $\tilde{x}_0$ with the speed of propagation (increase in length) $c = \frac{\tilde{x}_0 - 0}{\tau_0} = c_0$ (c_0 is the speed of light).

2. A free byuon is in the state I^+ if its positive length discretely, in a quantum of time τ_0, decreases by $\tilde{x}_0$. In this case, $c = \frac{0 - \tilde{x}_0}{\tau_0} = -c_0$.

3. A free byuon is in the state II^- if the modulus of its negative length grows by $\tilde{x}_0$ in time τ_0. In this case, $c = \frac{-\tilde{x}_0 - 0}{\tau_0} = -c_0$.

4. A free byuon is in the state I^- if the modulus of its negative length discretely, in time τ_0, decreases by $\tilde{x}_0$. In this case, $c = \frac{0 - (-\tilde{x}_0)}{\tau_0} = c_0$.

The byuon residence in one VS or another has a probabilistic character and is described by wave function, which corresponds to four VSes[10–12].

The byuon concept allows us to express fundamental physical constants and properties of the surrounding world based on the quantum characteristics of the byuon VS only: space quantum $X_0 \approx 2.8 \times 10^{-33}$ cm, $\tau_o \approx 0.9 \times 10^{-43}$ c, and modulus of cosmological vector potential $A_g \approx 1.95 \cdot 10^{11}$ G × cm.

The following basic hypothesis was introduced in[10–12]. Let us assume that observed three-dimensional space R_3 is formed as a result of minimizing the interaction potential energy of byuon VSs in R_1 formed by them. More exactly, space R_3 is fixed due to the dynamics of objects that appear due to the interaction between byuon VSes. Dynamic processes thus arise in space R_3 for objects with the minimum residual positive potential energy of interactions between byuon VSes, resulting in the wave properties of the elementary particles that arise. In other words, the theory allows us to find values of all other fundamental constants and the main properties of the surrounding world by establishing only three constants: A_g, τ_o, X_0.

Fundamental spatial scales are determined by the relations $x_0 = k\,\tilde{x}_0 \approx 10^{-17}$ cm, $ct^* = kN\,\tilde{x}_0 \approx 10^{-13}$ cm, $L = kNP\,\tilde{x}_0 \approx 10^{28}$ cm, where k, N, and P are calculated periods of interaction between byuon VSes. Speed of light $c_0 = X_0/\tau_0$. Note that the speed of light appears in the TB due to variations in them, and there are no velocities greater than the c_0 in the TB. Plank's constant $h = (([A_g x_o]_{II^+}[A_g x_o]_{I^-})/c_o)x_o/ct^*$ and elementary electric charge

$e_o^2 = (1/(4\sqrt{3}))A_g^2 x_o^2 (x_o/ct^*)^{3/2}$ are integrals of motion in the dynamics of byuon VSes.

The constants of all interactions are determined; *e.g.*, the vector constant of weak interactions is given by the expression $C_v = e_o A_g 2x_o^3$. The masses of all leptons, proton, and π^0 meson are calculated. The energy density in the Universe (~ 10^{-29} g/cm^3) is also found, the Maxwell equations are derived, the physics of dark matter and dark energy demonstrated, the magnitudes of the galactic and intergalactic magnetic fields are calculated, and so on.

The TB predicts the following new physical phenomena:

- new non-gauge force of nature,
- new quantum information channel in nature.

It is shown in[10–12] that if we direct the vector potential of some magnetic system opposite to the vector A_g then any substance will be thrown out the region of certain weakened summary potential A_Σ since the masses of particles are

proportional to the modulus of the vector A_g. Unfortunately, the processes of origin of the bulk mass of such particles as the electron and the proton can be influenced upon only with very small probability, about 10^{-44}, but the action on the formation of their geometric space, *i.e.* on the mass of the pair "neutrino-antineutrino" ($\nu_e \leftrightarrow \widetilde{\nu}_e$) equaled to $2m_{\nu_e} c_o^2$(the minimum energy of four-contact byuon interaction $\approx i33eV$), is possible with the probability 1[10–12].

A great number of experiments on investigating properties of new anisotropic interaction on installations of various physical nature by different groups of experimenters in a number of institutes, is described in[10–12]. Among those investigations are experiments with high-current magnets, with torsion and piezoresonance balances[13–16], with gravimeters and attached magnets[17], with a system of two quartz resonators[11], studies on changes in β-decay rate of radioactive elements[18,19] and on heat releases in plasma devices[20]. The results of investigations have shown that the new interaction rejects any substance from space regions in which the vector potential of some current system has a component directed opposite to the vector A_g. The force is maximum when the angle between the vectors A and A_g is equal to $130°–135°$. This corresponds to the action of the force along the generatrix of a cone with an opening of $90°–100°$ and an axis parallel to the vector A_g having the following coordinates in the second equatorial system: right ascension $\alpha \approx 293° \pm 10°$, declination $\delta = 36° \pm 10°$[20].

A new principle for the motion of space vehicles that was based on using physical space as a support medium was described for the first time in[10]. It was shown in[12,21,22] that any object reduces the magnitude of the modulus of A_Σ wherever it is located in physical space due to interaction between the potentials of the physical fields of elementary particles and A_Σ. This comprehensive reduction in A_Σ is called the information image (II) of the object and is characteristic of it only since it is codified by coefficients

i (i = 1, 2, 3..), in a complicated series of terms for varying A_Σ through the field potentials of the object. If the object returns to its own II as it moves, this place will push it due to the action of a new force associated with the reduction in A_Σ. A long-term experiment to investigate a new force for vehicle propulsion was carried out in Italy from January 26, 2013 to February 28, 2014 [12,22]. The maximum of the new force was equaled 0.5 N but $\alpha = 316° \pm 5°$.

TB determines the average density of substance in the Universe taking $i = NkP$ and, hence, its characteristic dimension $\widetilde{x}_0 NkP \approx 10^{28} cm$. Then the total energy in the Universe can be represented as

$$\frac{h}{\tau_0} NkP \qquad (2)$$

Its value is 5.4×10^{77} erg, and the corresponding equivalent mass $\approx 6 \times 10^{56}$ g. The uniformity of distribution of substance over the sphere with the radius $\widetilde{x}_0 NkP$ gives the density of substance in the Universe $\approx 10^{-29}$ gcm^{-3}, which is really observed[23].

On the short hard gamma ray bursts.

As was indicated in TB, any value of index i can be always re-denoted by j and then $j = 0, 1, 2$ corresponds to reference points (new beginnings). Re-denoting $i+1$ by ξ, $i+2$ by γ etc. leads, depending on reference points, to formation of three families of subspaces embedded in each other[10–12].

So, R_3 can be represented as $R_3 = R_{1,0} \times R_{1,1} \times R_{1,2}$ at any moment. The new Universe birth process can has a beginning in any time too if the values k, N and P are integer numbers.

But in this case we can't take in (2) the time of potential energy minimizing of byuon VSs interaction in R_1 equaled τ_o because we have ultimate particles with their potential physical fields and all known interactions in R_3 by this time. Therefore the time of the minimal act (minimum action $h/2$) in process of an object formation with $E>0$ from byuons will be from 10^{-22} s (the time of strong interaction[24]) till 10^{-17} s (electromagnetic interaction). Then we shall have from (2) an appearance of object with energy from 10^{50} *erg* till 10^{55} *erg*. We think it is the initial source for realization of a short hard gamma ray burst. The possibility of this event is very small (10^{-60}) because we must have k, N and P in the set of integer numbers. It isn't zero because the variation of physical field potentials in the Universe can create this situation. Using this process we can explain gamma ray bursts by the known physics. VS of byuon II^+ and I^- describes the photons in TB. They must have the energies in the range from 10^2 eV until 10^7 eV.

On the gamma ray bursts connected with supernovae (SN).

This correlation takes place in nature[6] but not every SN produces a gamma ray burst. It is the first problem. The second problem is huge energy of gamma ray bursts more than the values released during SN explosions.

Let us show a decision of these problems using TB and new non-gauge force of nature. The new force has nonlinear and nonlocal character as variation of summary potential A_Σ. The A_Σ contains potentials of all existent fields of all

possible sources (Earth, Sun, Galaxy, *etc.*), and the new force can be represented as a complex series in terms of changes in this summary potential A_Σ. The first term of the series is

$$F = 2Nm_v c^2 \lambda_1^2 \cdot \Delta A_\Sigma (\Delta A_\Sigma / \Delta X) \cdot \quad (3),$$

where N is the number of stable particles (electrons, protons, and neutrons) in the test body, ΔA_Σ is the difference in changes of the summary potential A_Σ at the location points of a test body and sensor element, $\Delta A_\Sigma/\Delta x$ is the gradient in space of the difference potentials ΔA_Σ; x is the general spatial coordinate (Δx can be the length of an arc of a circle, or the characteristic size of the test body, according to the specific experiments); $2m_v c^2 = 33$ eV; $1 = 10^{-6}$ $(\text{Tm})^{-1}$ is the first coefficient of the series[10–11].

It's shown in the experiments with space thruster model[12,21,22] that for a rest time t_r (~ time of II existence) in the process of a body revolution during less than 0.1 s the value of the new force decreases rapidly. TB explains this phenomenon in the following way. If $t_r < 0.1c$ then ultimate particles can't "remember" a value of summary potential A_Σ in the process of its internal physical space forming. It will not "feel" the difference potentials ΔA_Σ in the process of the body revolution in the space thruster model.

So, if matter in the process of the SN explosion moves from strong gravitation potential ($A_{\Sigma 1}$) toward weakening of gravitation potential ($A_{\Sigma 2} < A_{\Sigma 1}$) then we can have the situation shown in Figure 1 and the realization of the new force action for an acceleration of matter in the process of the SN explosion. The author of[25] have developed this mechanism for accelerating of cosmic rays (CRs) with the application of the new force theory too. It was shown that CR can reach energy exceeding the Greisen-Zatsepin-Kuzmin limit of 5×10^{19} eV.

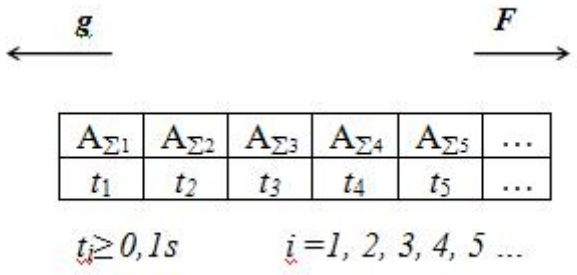

Figure 1. The diagram of the summary potential A_Σ change in the process when matter flies away from the SN explosion for the non-gauge force action realization.

g is the gravitation field action direction; F is the non-gauge force action direction; $A_{\Sigma i} < A_{\Sigma i+1}$.

It's shown in[18] that the value $(\Delta A_\Sigma/\Delta X)$ can be about 10^{15} G. If we take $\Delta A_\Sigma \approx 1.95 \cdot 10^{11}$ G×cm ($\Delta A_\Sigma \approx A_{\Sigma i+1} - A_{\Sigma i}$), $N \approx 10^{51}$ (for example, then summary mass for electrons will be about 10^{24} g) and the distance (L) of the new force action equaled with a radius of the Sun (7×10^{10} cm) then the work by the new force will be about 10^{54} erg. We can see that such values of energy are observed in the astrophysical investigations[6]. But this is the initial energy. So, the process of SN explosion can realize the gamma ray burst if the conditions shown in Figure 1 are satisfied.

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