The Origin and the Spectra of the Gamma-Ray Bursts

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Abstract: Here, applying the Scale-Symmetric Theory (SST), we described the origin and the spectra of the gamma-ray bursts (the exploding objects/progenitors we will call the GRBs). The GRBs explode due to the inflows of the dark energy into the associations of neutron black holes that are the constituents of the black holes in centres of galaxies. The GRBs should be placed near the Schwarzschild surface in the plane of the accretion discs. The bursts should be correlated with an increase in activity of the central-black-hole jet and accretion disc because it causes more dense flows of the dark energy. Such flows cause that the neutron black holes swell so their associations can transform into iron object. The increase in gravitational energy of the iron object is compensated by the decrease of the gravitational energy of the black holes as a whole, i.e. the central black holes become the more compact objects. A half of radiation energy is absorbed by the central black hole so the escaping energy looks as an analog to the Hawking radiation. The bursts are volumetric, not directional. Calculated here the typical emitted energy is equivalent to 1.9 solar masses. Most important are the fusions of nucleons mostly into iron-56 via helium-4, the beta decays of neutrons, and emission of photons with energy about 188 MeV that follows from the atom-like structure of baryons. According to SST, the radius of the observed Universe increased 46.55 times so the spectra of most distant GRBs (SST shows that galaxies with redshift higher than 0.6 all are in time distance about 13 – 13.8 Gyr) should peak near 17 keV, 150 keV, 190 keV, and 4 MeV. The spectra of GBRs placed, for example, in distance 1.2 Gyr should peak near 190 keV, 1.7 MeV, 2.2 MeV, and 46 MeV. But there can be other lower peaks as well. Most important are two results i.e. the released typical energy 1.9 solar masses and the peak for 150 keV or 190 keV for very distant GRBs because number density of photons emitted during the iron production from nucleons via helium-4 should be highest and because abundance of the gamma-ray bursts should be highest for the distant Universe.

1. Introduction

Here, applying the Scale-Symmetric Theory (SST), we described the origin and the spectra of the gamma-ray bursts (the exploding objects/progenitors we will call the GRBs).

The SST shows that the succeeding phase transitions of the superluminal non-gravitating Higgs field during its inflation (the initial big bang) lead to the different scales of sizes/energies [1A]. Due to a few new symmetries, there consequently appear the superluminal binary systems of closed strings (entanglons) responsible for the quantum entanglement (it is the quantum-entanglement scale), stable neutrinos and luminal neutrino-antineutrino pairs which are the components of the luminal gravitating Einstein spacetime (it is the Planck scale), cores of baryons (it is the electric-charge scale), and the cosmic-structures/protoworlds (it is the cosmological scale) that evolution leads to the dark-matter structures (they are the loops and filaments composed of entangled non-rotating-spin neutrino-antineutrino pairs), dark energy (it consists of the additional non-rotating-spin neutrino-antineutrino pairs interacting gravitationally only) and expanding universes (the "soft" big bangs due to the inflows of the dark energy into protoworlds) [1A], [1B]. The electric-charge scale leads to the atom-like structure of baryons [1A].

Among a thousand of calculated quantities within SST, which are consistent with experimental data, we calculated quantities that we use in this paper, i.e. the ratio of the present-day and initial sizes of the Universe $F = 72.56$ but size of the observed Universe increased $f = F \cdot 0.6415 = 46.55$ times [1B], the maximum radiation energy in the beta decay of neutron $E_{Beta} = 0.781$ MeV [1A], the binding energy per nucleon in helium-4 and iron-56: $\Delta E_{He\text{-}4} = 7.07$ MeV and $\Delta E_{Fe\text{-}56} = 8.79$ MeV [2], mass of the boson responsible for creation of the Titius-Bode states $m_{TB} = 750.28$ MeV that decays to two or four gluons (according to SST, outside the nuclear strong fields, the gluons become photons [1A]) so $E_\gamma = m_{TB} / 4 = 187.57$ MeV [1A], mass of neutron $m_{Neutron} = 939.5648$ MeV [1A], mass of proton $m_{Proton} = 938.2725$ MeV [1A], mass of electron $m_{Electron} = 0.5109989$ MeV [1A], and the characteristic mass of neutron black hole $M_{NBH} = 24.81$ solar masses [1B], [2].

We as well described the four-neutrino/four-particle symmetry – number of entangled objects in a system is quantized [1B]

$$D_n = 4^d \text{ (for single objects)}, \tag{1a}$$

or

$$D_n = 2 \cdot 4^d \text{ (for binary systems)}, \tag{1b}$$

where $d = 0, 1, 2, 4, 8, \ldots = 0, 2^n$, where $n = 0, 1, 2, 3, 4, 5, \ldots$ Most important are objects containing four (it is due to the four-object symmetry [1B]) binary systems i.e. $D_{Typical} = 2 \cdot 4^1 = 8$ constituents [3]. This means that according to SST, the black holes in centres of galaxies, first of all, consist of associations built of 8 neutron black holes i.e. their mass is $M_{8\text{-}NBH} = D_{Typical} M_{NBH} \approx 198.48$ solar masses.

2. Motivation and calculations

The GRBs explode due to the inflows of the dark energy into the associations of neutron black holes (NBHs) that are the constituents of the black holes in centres of galaxies [4]. The GRBs should be placed near the Schwarzschild surface of the central black hole in the plane of its accretion discs because the rotation of the neutron black holes causes that the dark energy and Einstein spacetime inspiral through the accretion discs towards the central black hole and next they flow out along the jet [4].

The bursts should be correlated with an increase in activity of the central-black-hole jet and accretion disc because it causes more dense flows of the dark energy and Einstein spacetime i.e. higher activity acts as a catalyst. Why? According to SST, the inspiralling nuclear plasma in accretion disc, due to the much higher density of the tori/charges in the cores of baryons than the mean of the Einstein spacetime (plus dark energy), additionally increases density of the flows of the dark energy and Einstein spacetime.

Such flows increase the dynamic pressure inside the neutron black holes so they swell – it causes that some associations of NBHs can transform into iron objects i.e. into less compact object so its gravitational energy increases.

The increase in gravitational energy of the iron object is compensated by the decrease of the gravitational energy of the central black hole as a whole so after the transition, the central black hole is a more compact object.

Due to the place of the bursts (near the event horizon), a half of radiation energy is absorbed by the central black hole so the escaping energy looks as an analog to the Hawking radiation.

The bursts are volumetric, not directional.

Calculate emitted energy by the typical association of the NBHs.

Most important phenomena that take place during transition of an association of NBHs into iron object are as follows: the fusions of nucleons mostly into iron-56 via helium-4, the beta decays of neutrons, and emission of photons with energy 187.57 MeV that follows from the atom-like structure of baryons [1A]. In the first process, about $X = \Delta E_{Fe\text{-}56} / m_{Neutron} = 0.0093554$ of mass of an association of the NBHs is emitted as radiation. For the typical association, the emitted radiation energy, $E_{Radiation}$, is

$$E_{Radiation} = X M_{8\text{-}NBH} \approx 1.86 \text{ solar masses.} \tag{2}$$

This result is consistent with experimental data. According to SST, the NBHs are the very cold objects i.e. neutrons have the rest mass only and binding energy is frozen inside the NBHs so they behave as a crystal composed of free neutrons [1B].

According to SST, the radius of the observed Universe (according to SST, the time distance to most distant observed objects is 13.866 ± 0.096 Gyr) increased $f = 46.55$ times [1B] so lengths of emitted photons by the most distant visible objects decreased f times. It leads to conclusion that the spectra of most distant visible GRBs (SST shows that galaxies with redshift higher than 0.6 all are in time distance about 13 – 13.8 Gyr) should peak near following energies

$$E_{n,peaks} = E_{n,0} / f, \tag{3}$$

where $n = 1, 2, 3, 4$, the $E_{1,0} = m_{Neutron} - m_{Proton} - m_{Electron} = 0.7813$ MeV is the maximum radiation energy that can appear in the beta decay of neutron, $E_{2,0} = \Delta E_{He\text{-}4} = 7.07$ MeV, $E_{3,0} = \Delta E_{Fe\text{-}56} = 8.79$ MeV, and $E_{4,0} = m_{TB} / 4 = 187.57$ MeV. Formula (3) leads to following series for most distant GRBs: $E_{1,peaks} \approx 17$ keV, $E_{2,peaks} \approx 150$ keV, $E_{3,peaks} \approx 190$ keV, and $E_{4,peaks} \approx 4.0$ MeV.

For time distance 1.2 Gyr, size of the Universe increased $f^* = f \cdot 1.2 / 13.8 = 4.05$ times. It leads to conclusion that the spectra of GRBs placed in time distance 1.2 Gyr should peak near following energies

$$E^*_{n,peaks} = E_{n,0} / f^*, \tag{4}$$

Formula (4) leads to following series: $E^*_{1,peaks} \approx 190$ keV, $E^*_{2,peaks} \approx 1.7$ MeV, $E^*_{3,peaks} \approx 2.2$ MeV, and $E^*_{4,peaks} \approx 46$ MeV. These results are consistent with observational data for GW150914 [5].

Most important are two results i.e. the released typical energy 1.9 solar masses and the peak for 150 keV or 190 keV for very distant GRBs because number density of photons emitted during the iron production from nucleons via helium-4 should be highest and because abundance of the gamma-ray bursts should be highest for the distant Universe.

There should be short- and long-duration bursts – it follows from rate of changes in the dynamical pressure inside the progenitors of the bursts caused by the flows of the dark energy and by the flows in the Einstein spacetime near and inside the central black holes in galaxies. The rates should be different for different galaxies.

References

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