The Hedgehog-Like Mechanism as the Origin of the Prompt Emission of Gamma-Ray Bursts

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Abstract: Here, using the Scale-Symmetric Theory (SST), we show that the hedgehog-like mechanism in the neutron stars is responsible for the prompt emission of GRBs. The half-jets/"hedgehog-needles" produced from the cores of baryons inside the created neutron stars act as "wave-guides" of the Einstein-spacetime scalar condensates which on surface of the neutron stars decay to gamma rays and energetic leptons. Most energetic particles are the result of annihilation of the half-jets.

1. Introduction

In paper [1], we explained the origin of the energies about 0.3 MeV and about 400 MeV which appear in the AstroMeV documents as the peaks in best-fit model for the time-integrated photon spectrum (3.3 s – 21.6 s) for Gamma-Ray Bursts (GRBs) [2].

On the other hand, in paper [3] we explained the origin of the curves for the rest frame peak energy versus the bolometric energy, and we showed that the long-duration GRBs (LGRBs) last at the average 97.4 times longer than the short-duration GRBs (SGRBs). It is consistent with observational data [4]: LGRBs last with an average time of about 30 seconds while SGRBs with an average duration of about 0.3 seconds i.e. the SGRBs last about 100 times shorter.

The mechanism responsible for the prompt emission of GRBs is still a debated issue [5]. Here, using the Scale-Symmetric Theory (SST) [6], [7], we show that the "hedgehog-like" mechanism in the neutron stars is responsible for the prompt emission of GRBs.

2. The mechanism and calculations

The transformation of the collapsing star into a neutron star (or even into the neutron "black hole" described within SST [7]) is accompanied by the creation of huge amounts of energy in the centre of the created neutron star. To ensure the stability of the created object, there must be a very efficient mechanism for transmitting this energy from the inside of the neutron star to its surface.

In the transverse directions of colliding nucleons, in the nuclear plasma (it consists of the cores of baryons), there are produced half-jets/"hedgehog-needles" composed of the cores of baryons. The half-integral spins of the cores are tangent to the half-jets.

The core-anticore pairs have unitary spin and distance between the cores/anticores is 2πA/3, where A = 0.69744 fm is the equatorial radius of the torus/electric-charge in the core of the baryons [6]. In centre of such torus is the Einstein-spacetime

condensate/scalar with a mass of Y = 424.12 MeV. Due to the SST nuclear weak interactions, due to the huge amounts of energy in the centre of the created neutron star, near the Y scalar condensates are produced other scalar condensates with different masses. Mean mass of such condensates determines lifetime of GRBs [3]. The tunnels inside the produced half-jets/"hedgehog-needles" which run from the centre of the neutron star to its surface (and often even further) are pipes through which excess energy in the form of scalar condensates is sent to the surface of the star and beyond. On the surface of the star, scalar condensates transform into energetic leptons and gamma rays. Such is the mechanism of the prompt emission of GRBs.

Correlated annihilation of a jet produces very energetic fermion moving in radial direction. Calculate maximum energy of a fermion, for example, of neutrino emitted by the biggest neutron star i.e. by the neutron "black hole" (NBH) with a mass of 24.81 solar masses and radius equal to $R_{NBH} = 3.664 \cdot 10^4$ m [7].

The half-jet consists of following number of cores of baryons

$$N = R_{NBH} / (2 \pi A / 3) = 2.5084 \cdot 10^{19} . \quad (1)$$

Mass of charged core of baryons is $H^{+,-} = 727.44$ MeV. So mass/energy of one half-jet (so of emitted neutrino as well) is

$$E_{Maximum} = N H^{+,-} = 3.2529 \cdot 10^{-8} \text{ kg} . \quad (2)$$

This mass/energy is close to the Planck mass/energy: $2.1765 \cdot 10^{-8}$ kg.

Mass of non-rotating-spin lightest neutrino is $M_{Neutrino} = 3.3349 \cdot 10^{-67}$ kg [6] so the geometric-mean energy of cosmic neutrinos calculated from CMB should be

$$M_{Neutrino,CMB} = (E_{Maximum} M_{Neutrino})^{1/2} = 1.0415 \cdot 10^{-37} \text{ kg} = 0.05849 \text{ eV} . \quad (3)$$

SST shows that mass of all species of cosmic neutrinos (calculated from CMB) should be $5M_{Neutrino,CMB} = 0.292$ eV [6] – it is consistent with value obtained from CMB: 0.320 ± 0.081 eV [8].

We already calculated the maximum mass/energy of the CMB neutrino from the assumption that the maximum spin speed of rotating neutrino is equal to the speed of light in "vacuum" [9] – we obtained $3.1451 \cdot 10^{-8}$ kg. It is incredible that the SST neutrinos and the SST NBHs lead to the same maximum mass/energy $\sim 3 \cdot 10^{-8}$ kg (see paper [9] and formula (2)) which is close to the Planck mass/energy $\sim 2 \cdot 10^{-8}$ kg.

Energies of particles produced by smaller and smaller neutron stars are lower and lower.

Summary

Here, using the Scale-Symmetric Theory (SST), we described the "hedgehog-like" mechanism in the neutron stars that is responsible for the prompt emission of GRBs.

References

[1] Sylwester Kornowski (16 October 2019). "A Counterpart of the Isotropic Gamma-Ray Bursts in the Centres of Created Baryons"
http://vixra.org/abs/1910.0285

[2] V. Tatischeff (2014). “AstroMeV project”
https://astromev.in2p3.fr/?q=aboutus/gamma-ray-bursts
[3] Sylwester Kornowski (20 October 2019). “The Origin of Gamma-Ray Bursts”
http://vixra.org/abs/1910.0387
[4] https://imagine.gsfc.nasa.gov/science/objects/bursts1.html
[5] M. G. Dainotti, et al. (Published 24 January 2018). “Review Article: Gamma-Ray Burst Prompt Correlations”
Advances in Astronomy
Volume 2018, Article ID 4969503
www.oa.uj.edu.pl/M.Tarnopolski/AdvAst.pdf
[6] Sylwester Kornowski (23 February 2018). “Foundations of the Scale-Symmetric Physics (Main Article No 1: Particle Physics)”
http://vixra.org/abs/1511.0188
[7] Sylwester Kornowski (14 February 2019). “Foundations of the Scale-Symmetric Physics (Main Article No 2: Cosmology)”
http://vixra.org/abs/1511.0223
[8] Richard A. Battye and Adam Moss (6 February 2014). “Evidence for Massive Neutrinos from Cosmic Microwave Background and Lensing Observations”
Phys. Rev. Lett. **112**, 051303
[9] Sylwester Kornowski (18 December 2016). “The PMNS Neutrino-Mixing Matrix in the Scale-Symmetric Theory”
http://vixra.org/abs/1608.0145