The Time and Mass versus Number of Bursts for Gamma-Ray Bursts

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Abstract: Here, using the Scale-Symmetric Theory (SST), we described the origin of the time and mass versus number of bursts for gamma-ray bursts (GRBs).

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].

In paper [3], we described 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.

In paper [5], we showed that the “hedgehog-like” mechanism in the neutron stars is responsible for the prompt emission of GRBs.

Here, using the Scale-Symmetric Theory (SST) [6], [7], we describe the graph of the time and mass versus number of bursts for the GRBs.

2. Time and mass versus number of bursts

According to SST [6], mass of neutron is $n = 939.54$ MeV while mass of proton is $p = 928.27$ MeV. In nucleons (baryons), there is core and relativistic charged pion with a mass of $W^{+,-} = 215.76$ MeV. The core consists of torus/electric-charge and central scalar condensate with a mass of $Y_{Baryon} = 424.12$ MeV. In the torus are created the neutral pions with a mass of $\pi^{o} = 134.98$ MeV. Spin and charge of such pion are equal to zero so it can collapse to scalar condensate $Y_{Pion(o)} = 134.98$ MeV. The condensate Y can decay to 4 muons $\mu^{+,-}$ ($\mu^{+,-} = 105.66$ MeV) or to the 8 muon-type condensates Y_{Muon} ($Y_{Muon} = 52.77$ MeV).

Masses of the condensates determine lifetimes of GRBs [3] and, because of the hedgehog mechanism [5], determine also masses of GRBs that are the no-neutron-star-remnant bursts – it is for Y_{Baryon}, $Y_{Pion(o)}$, and Y_{Muon}.

On the other hand, masses of neutron stars that relate to masses of charged particles evolve slower so their number is lower – it is for p, $W^{+,-}$, and $\mu^{+,-}$.

Assume that a denotes number of the ~30-second bursts, b denotes number of the ~0.3-second bursts, and c of the ~0.007-second Type-Ia supernovae in which the main very short burst (~0.007 s) overlaps with the afterglow so observation of the main burst is not possible. We assume that numbers of bursts in the Universe, a, b, c, are directly proportional to squared mass i.e. to radius of a torus.

Mass of the neutron, n, relates to mass of the neutron "black hole" (NBH) with a mass of $M_{NBH} = 24.81$ solar masses [7]. On the other hand, other masses of neutron stars are directly proportional to listed above masses. We assume that time-duration of a burst in which a big star collapses to NBH lasts 720 s.

Time-duration of bursts is directly proportional to four powers of mass of neutron star.

Calculate the main values for the graph of the time and masses versus number of bursts for GRBs. The foundations of calculations are as follows.

A) The neutron, n, relates to 24.81 solar masses and 720 s – mass of the neutron is close to mass of proton (it is electrically charged) so number of such bursts should be very low.

The foundations lead to:

B) The Y_{Baryon} relates to $M = 24.81 (Y_{Baryon} / n) = 11.20$ solar masses and $t = 720 (11.20 / 24.81)^4 = 30$ s. There is no neutron-star remnant as it is for the supernova SN 1987A. Number of such bursts is denoted by a.

C) The $W^{+,-}$ relates to $M = 24.81 (W^{+,-} / n) = 5.70$ solar masses and $t = 720 (5.70 / 24.81)^4 = 2.0$ s. Due to the charged $W^{+,-}$, number of such bursts should be much lower than the a. The $t = 2.0$ s separates the short-duration GRBs from the long-duration GRBs.

D) The $Y_{Pion(o)}$ relates to $M = 24.81 (Y_{Pion(o)} / n) = 3.56$ solar masses and $t = 720 (3.56 / 24.81)^4 = 0.3$ s. There should be no neutron-star remnant. Number of such bursts is denoted by b.

E) The $\mu^{+,-}$ relates to $M = 24.81 (\mu^{+,-} / n) = 2.79$ solar masses and $t = 720 (2.79 / 24.81)^4 = 0.12$ s. Due to the electrically charged $\mu^{+,-}$, number of such bursts should be lower than the b.

F) The Y_{Muon} relates to $M = 24.81 (Y_{Muon} / n) = 1.39$ solar masses and $t = 720 (1.39 / 24.81)^4 = 0.007$ s. There should be no neutron-star remnant. It is for the Type Ia supernovae but the main very short burst (~0.007 s) overlaps with the afterglow so observation of the main burst is not possible. Number of such bursts is denoted by c.

G) The ratio a/b should be $a/b = (11.20 / 3.56)^{1/2} \approx \pi^{1/2} = 1.77$.

H) The ratio a/c should be $a/c = (11.20 / 1.39)^{1/2} \approx 2.84$.

When we assume that $a = 70$ then the ratios are $a : b : c = 70 : 40 : 25$.

All obtained here results within the coherent model are consistent with observational facts [4].

In Fig.1 are collected results obtained in this paper.

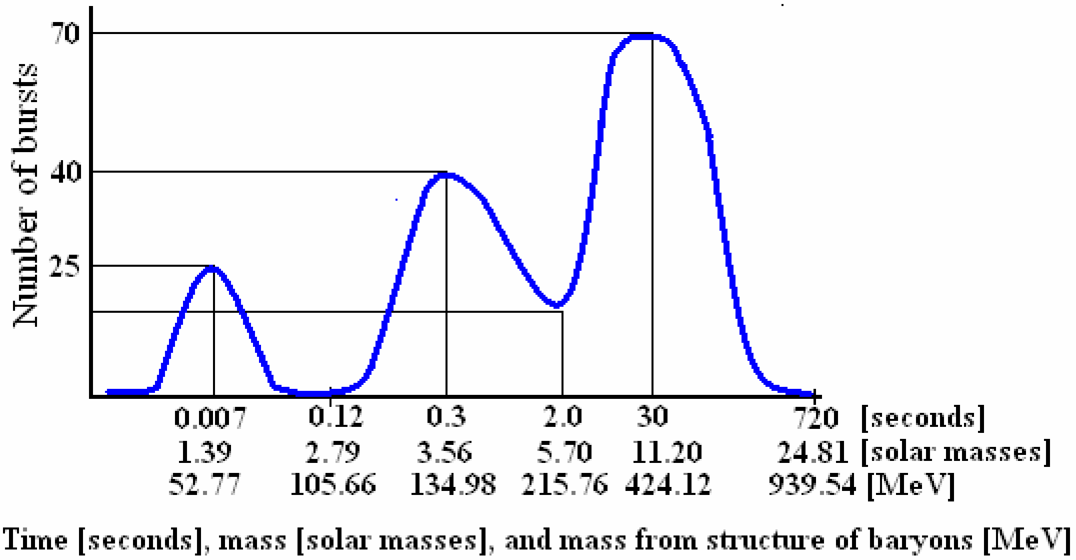

Fig.1 Time and masses versus number of bursts.

Summary

Here, using the Scale-Symmetric Theory (SST), we described the graph of the time and masses versus number of bursts for the GRBs. Presented here theory is consistent with observational data.

References

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