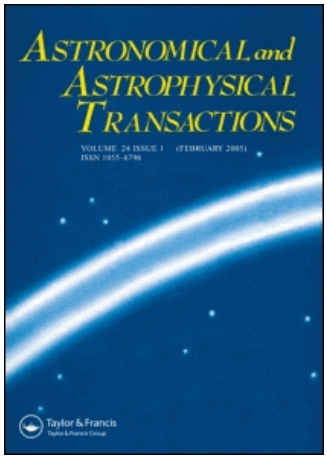

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

Some evidences in favour of the existence of a local galactic population of GRBs

B. V. Komberg [a]; V. G. Kurt [a]; Ya. Yu. Tikhomirova [ab]
[a] Astro Space Center of Lebedev Physical Institute, Moscow, Russia
[b] Moscow State University, Russia

Online Publication Date: 01 August 1999
To cite this Article: Komberg, B. V., Kurt, V. G. and Tikhomirova, Ya. Yu. (1999) 'Some evidences in favour of the existence of a local galactic population of GRBs', Astronomical & Astrophysical Transactions, 18:1, 173 - 178
To link to this article: DOI: 10.1080/10556799908203053
URL: http://dx.doi.org/10.1080/10556799908203053

Astronomical and Astrophysical Transactions, 1999, Vol. 18, pp. 173–178
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SOME EVIDENCES IN FAVOUR OF THE EXISTENCE OF A LOCAL GALACTIC POPULATION OF GRBs

B. V. KOMBERG[1], V. G. KURT[2], and Ya. Yu. TIKHOMIROVA[3]

[1,2] *Astro Space Center of Lebedev Physical Institute, Profsouznaya 84/32, 117810 Moscow, Russia,*

[3] *Moscow State University, Russia; Astro Space Center of Lebedev Physical Institute, Profsouznaya 84/32, 117810 Moscow, Russia*

(Received November 8, 1996)

The observed statistical properties of GRBs including isotropy in spatial distribution and the behaviour of the log N–log S diagram indicate that either GRBs appear in the local vicinity of the Sun (less than a few hundred parsecs) or they appear on distances of over hundreds of kiloparsecs. Accepting the hypothesis of the local ($r < 300$ pc) origin of GRBs it would give a reason to try to find the influence of local galactic structures like the local (Orion) arm, the Gould belt or separate stellar-dust complexes on the spatial distribution and other properties of GRBs. Using the 3rd BATSE catalogue we found the excesses of numbers of GRBs in two directions coincided with the directions of the local (Orion) arm stretch. In addition, log N–log S towards the arm shows an excess of bright bursts in comparison with that for the longitude range where the arm is hardly felt. To explain these facts we should assume the existence of at least two GRBs populations, one of which (poor but brighter or nearer) is associated with the local (Orion) arm.

KEY WORDS Gamma ray Bursts, spatial distribution, galactic origin

The observed statistical properties of GRBs including isotropy in spatial distribution and the behaviour of the log N–log S diagram indicate that either GRBs appear in the local vicinity of the Sun (less than a few hundred parsecs) or they appear at distances of over hundreds of kiloparsecs (indicating a halo or cosmological origin). If there exists a local galactic population of GRBs then some anisotropy of the properties of GRBs should exist due to the influence of local galactic structures like the local (Orion) arm, the Gould belt or separate stellar-dust complexes.

It is clear from Figure 1 that the Sun is situated on the edge of the local (Orion) arm. Therefore, if there exists a nearby population of GRBs associated with the Orion arm then there should be sensible directions corresponding to stretches and the spatial properties of GRBs should differ towards the arm – Δl_1 from 60° to 245° – and in the direction where the arm should be hardly felt – Δl_2 from 245° to

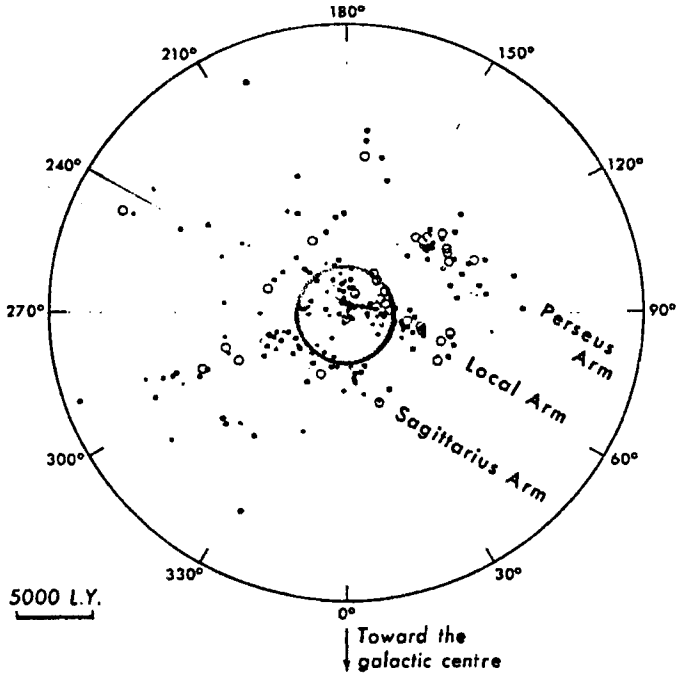

Figure 1 A modern diagram of the spiral structure in the vicinity of the Sun as indicated by optical spiral tracers (taken from Weaver, 1975). The Sun is in the centre. The spiral structure is shown in the projection to the galactic plane. The small circle indicates the solar vicinity within $r < 1$ kpc. It is seen that the Sun is situated on the edge of the local (Orion) arm.

360° and from 0° to 60°. This problem has already been discussed by Mitrofanov and Pozanenko (1990) based on 74 GRBs.

The distribution of 1122 GRBs constructed from the 3BATSE catalogue over galactic longitude (Figure 2) revealed strong scattering from the mean and the presence of peaks and ravines on the 2–3σ level in Figure 2(a) and over the 3σ level in Figure 2(b). The most important fact we found is that the excesses towards $l_1 - [85; 95]$ and $l_2 - [235; 245]$ coincided with the directions of the local (Orion) arm stretch.

In addition, the log N–log S diagrams constructed from the 3BATSE catalogue for Δl_1 and Δl_2 (Figure 3) are found to be essentially different. log N–log S towards the arm shows the excess of bright bursts in comparison with that for the longitude the range where the arm is hardly felt. It is seen that all the GRBs with fluxes log $S > -3.8$ ergs cm^{-2} are concentrated in Δl_1. It is possible that this excess of bright bursts associates exactly with the influence of the local arm.

To explain these facts we should assume the existence of at least two GRBs populations, one of which (poor but brighter or nearer) is associated with the local Orion arm.

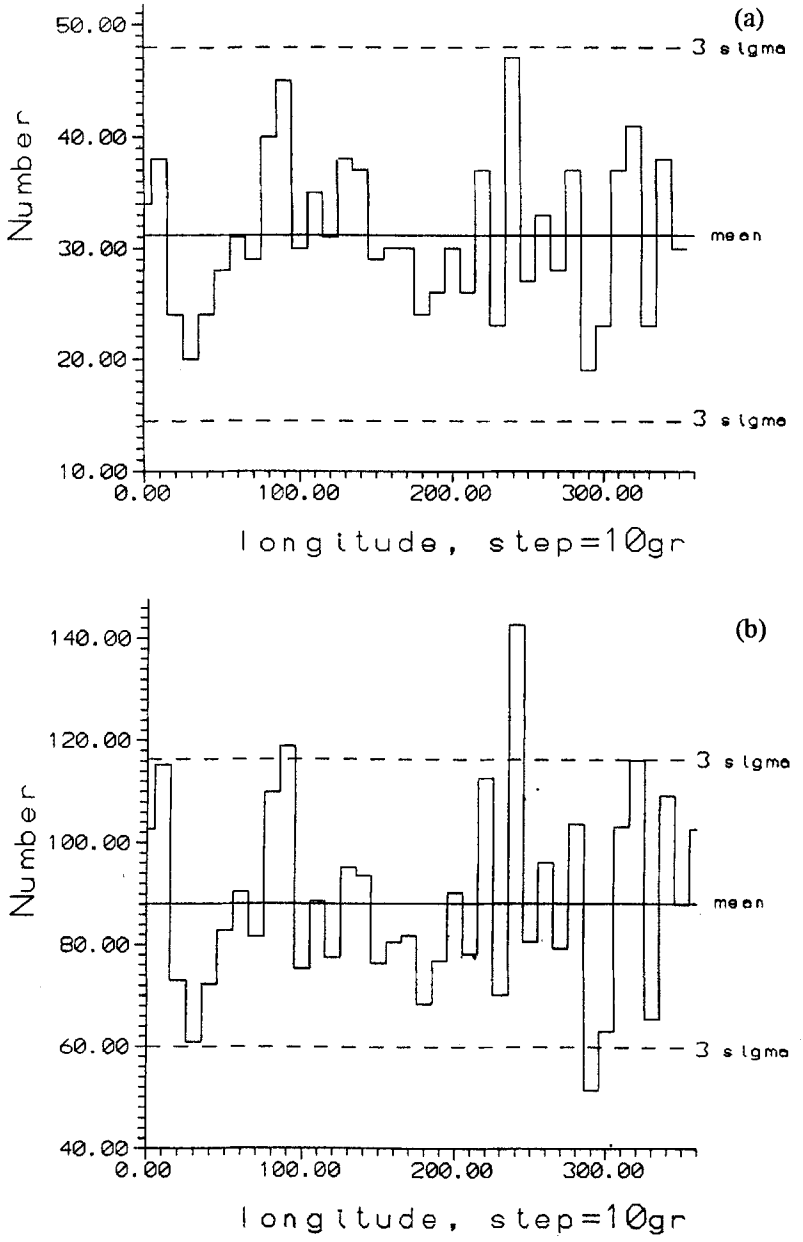

Figure 2 The distribution of 1122 GRBs from the 3BATSE catalogue over galactic longitude with a step of 10°: (*a*) without taking into account the BATSE sky exposure; (*b*) with taking into account the BATSE sky exposure. The number of GRBs in each longitude interval is corrected according to 100% sky exposure. The horizontal solid line shows the expected mean value for uniform distribution, the dashed lines show the 3σ level. Both diagrams reveal strong scattering from the mean and the presence of excesses of GRBs towards l_1 – [85; 95] and l_2 – [235; 245] coincided with the directions of the local (Orion) arm stretch.

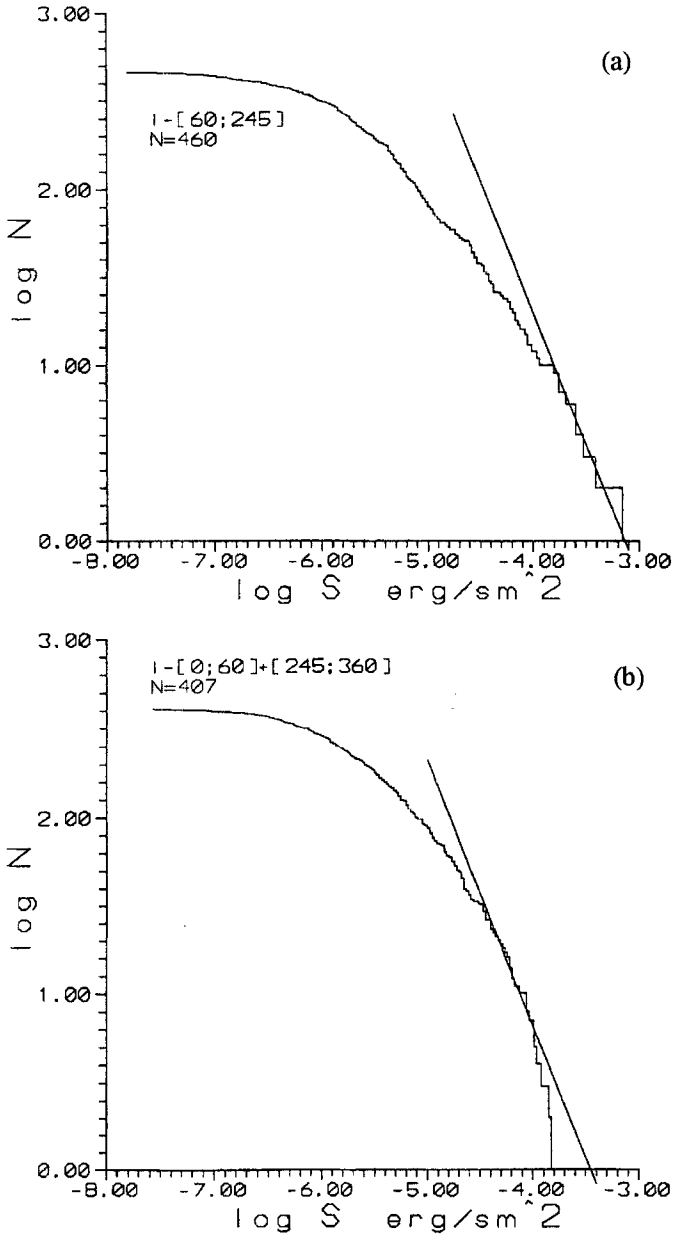

Figure 3 The log N–log S diagrams for GRBs: (*a*) for bursts from the 3BATSE catalogue with the galactic longitude from 60° to 245° (Δl_1) (towards the Orion arm); (*b*) for bursts from the 3BATSE catalogue with the galactic longitude from 245° to 360° and from 0° to 60° (Δl_2) (in the direction where the Orion arm is hardly felt) and the line with slope (–3/2) for comparison. The log N–log S diagrams constructed for Δl_1 and Δl_2 are essentially different. log N–log S towards the arm shows an excess of bright bursts in comparison with that for the longitude range where the arm is hardly felt.

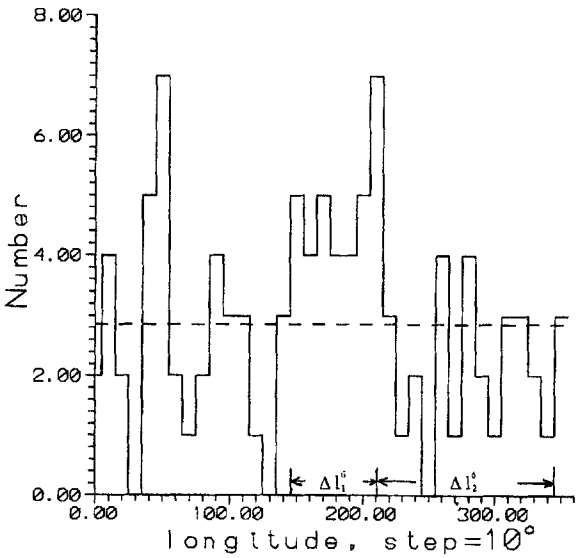

Figure 4 The distribution of 232 flare stars from the solar vicinity ($r < 25$ pc) (Hershberg *et al.*, 1997) over galactic longitude with a step of 10°. The horizontal line shows the expected mean value for the uniform distribution. Two ranges were selected: $\Delta l'_1$ from 145° to 210° with a surplus number of stars, and $\Delta l'_2$ from 210° to 345° with a deficit of stars.

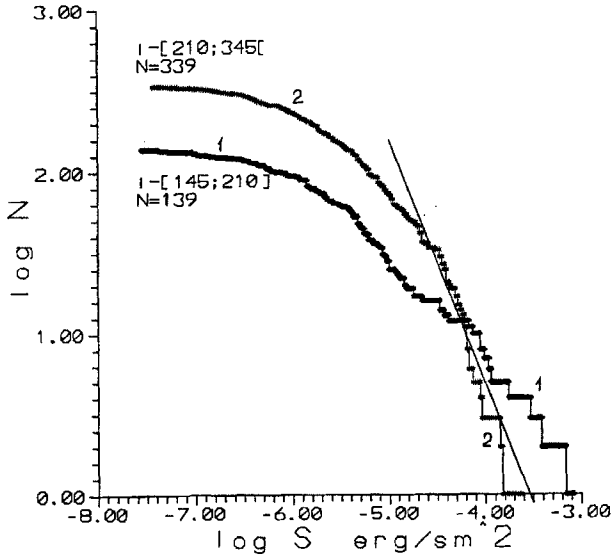

Figure 5 The log N–log S diagrams for $\Delta l'_1$ and $\Delta l'_2$ (Figure 4) for GRBs from the 3BATSE catalogue: *1*, for bursts with galactic longitudes from $\Delta l'_1$ (a surplus number of flare stars); *2*, for bursts with galactic longitudes from $\Delta l'_2$ (a surplus number of flare stars) and a line with slope (−3/2) for comparison. In the longitude range where there is an excess of flare stars the log N–log S diagram for GRBs shows an excess of bright bursts.

We should mention that to verify the possible relation of this population with flare stars the distribution over galactic longitudes, like that in Figure 1, for 232 flare stars [15] has been constructed (Figure 4). Two longitude ranges were selected on the diagram; one of them has a clear excess of stars in comparison to the other. For each of these ranges there were also constructed log N–log S diagrams for 3BATSE GRBs (Figure 5). It is surprising that the picture was the same as the log N–log S diagrams towards the arm and in the direction where the arm is hardly felt: in the longitude range where there is an excess of flare stars the log N–log S diagram for GRBs shows an excess of bright bursts.

Finally, it should be emphasized that due to large errors in the localization of GRBs in BATSE (3–5° on average) and due to possible statistical fluctuations one may consider each of these results sceptically but their agreement concerning the presence of the arm gives us a clear indication of the existence of a local population of GRBs close to the Sun associated with the local arm which gives a contribution to the observable properties of GRBs.

Acknowledgments

We would like to thank Dr. D. A. Kompaneets, I. M. Golynskaya and A. V. Berezin for their help during the work on this article.

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