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A NEW PROOF OF THE COSMOLOGICAL ORIGIN OF GAMMA RAY BURSTS

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Concerning the distances of gamma ray bursts (GRB) there are two different points of view; they are either in the Galactic halo, or at cosmological distances. After the launch of the BATSE instrument on CGRO, several indications of indirect support for a cosmological origin were found (for survey see, e.g., Paczyński 1995). However, a direct proof of a cosmological origin would be the confirmation of the fact that the average duration of faint GRBs is longer than the duration of bright bursts due to the cosmological time dilatation.

Actually, Norris et al. (1995) and Fenimore et al. (1995) indicated that the brighter GRBs have in average shorter duration. Nevertheless, the situation remains still unclear (cf. Paczyński 1995). Recently we predicted (Mészáros et al. 1996) that - if the cosmological origin is correct - there should be a simple linear anticorrelation between $\ln T$ and $\ln F$ (T is the duration and F is the peak flux) of GRBs, if one considers only the bursts with the longest durations. The key ideas of this paper are the following.

Assume that the GBRs have the same intrinsic luminosity L_o (in units photons/s) and the same intrinsic duration T_o (in seconds). The assumption of constant luminosity is acceptable (Mészáros & Mészáros 1995; Horváth, Mészáros, & Mészáros 1996; Mészáros & Mészáros 1996). The assumption of standard duration is also acceptable, if one considers only GRBs with the longest durations (Kouveliotou et al. 1993). Therefore, we consider only GRBs with $T \gg T_o$, where $T_o \simeq (10-20)s$ is the intrinsic duration (Kouveliotou et al. 1993). Then we may approximately write

$$-\ln F = const_1 \ln T + const_2, \qquad (1)$$

where F is the observed peak flux of GBR in units photons/(cm^2 s). This means that in this case we should expect a direct linear anticorrelation between $\ln F$ and $\ln T$ (the use of logarithms is essential).

For comparison, we consider different $T_{cut} \gg T_o$; and consider the number N of GBRs with durations longer than T_{cut}. To determine the goodness of the anticorrelation we calculate the Student's t, and hence the probability P that for the number N of $\ln F - \ln T$ pairs one still has no anticorrelation (i.e. $(1-P)$ defines the probability of the existence of anticorrelation for the pairs $\ln F - \ln T$).

The results of this procedure are the following: for $T_{cut} = 70$ s (80 s; 90 s; 100 s) and $N = 21$ (20; 17; 14) one obtains $P = 0.07$ (0.08; 0.04; 0.03). We see that for the small number of GBRs with longest durations the expected linear anticorrelation between $\ln T$ and $\ln F$ is present with a (93-97) % probability.

REFERENCES

Fenimore, E.E., et al. 1995, ApJ, 448, L101

Horváth, I., Mészáros, P., & Mészáros, A. 1996, ApJ, 470, 56

Kouveliotou, C., et al. 1993, ApJ, 413, L101

Mészáros, P., & Mészáros, A. 1995, ApJ, 449, 9

Mészáros, A., & Mészáros, P. 1996, ApJ, 466, 29

Mészáros, A., Mészáros, P., Horváth, I. & Bagoly, Z. 1996, in preparation

Norris, J.P., et al. 1995, ApJ, 439, 542

Paczyński, B. 1995, PASP, 107, 1167