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AUTHOR(S): James C. Lochner

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PROPERTIES OF MULTIPLE EVENT GAMMA RAY BURSTS

James C. Lochner

Space Astronomy and Astrophysics Group, Los Alamos National Lab, NM 87545

ABSTRACT

We present results from a study of 37 multiple event gamma ray bursts found in the monitoring data of the PVO gamma ray burst detector. We define these bursts as those which have two or more distinct emission events separated by a return to the background intensity. Significant correlation exists between the duration of the first event and the duration of the second event, while some correlation exists between the hardness of the events and only weak correlation exists in the intensity of the events. Although the time profiles of events in a burst may be similar, as measured in the phase portrait, there is no general rule about the degree of similarity of the time profiles. Subdividing the data according to the recurrence time, we find a tendency for the strength of the correlation in the hardness to increase with decreasing separation between the events.

INTRODUCTION

Multiple event gamma ray bursts have long been recognized as a subset of classical gamma ray bursts.¹ In Figure 1a we show data from the PVO monitoring data for one such burst having 3 distinct events separated by quiescence. This burst was also observed by the International Sun-Earth Explorer and the Solar Maximum Mission.

We have studied the statistical properties of 37 multiple event bursts which appear in the PVO monitoring data. These 37 bursts contribute 56 event pairs, with 2 bursts contributing 2 pairs, 3 bursts contributing 3 pairs, and the event of July 9, 1980 contributing 6 pairs. (The March 5, 1979 event and the soft repeaters are purposely omitted from this study.) This collection is only a sample of multiple event bursts in the PVO data, and by no means represents a complete survey of these bursts in the data base. When possible, confirmation of these bursts have been obtained from burst detectors on other satellites, and times have been checked against solar activity reported in the Solar-Geophysical Data.

Through the study of these events, one would like to determine whether they are caused by a single event mechanism which is reset and goes off again, or whether a distinct mechanism is responsible for these multiple event sequences. If the former, then the degree of similarity of the events may indicate the coherence or stability of the burst process. Systematic dissimilarity would indicate an evolution of the process, while complete dissimilarity would indicate incoherence or randomness in the initial conditions of the process.

DEFINITIONS AND CORRELATIONS

We define an event as emission in the full PVO bandpass (0.1 - 2.0 MeV) which is 2σ above the background intensity. The duration of the event, τ , is the length of time this instantaneous intensity is above 2σ . The separation between

Figure 1. a) Time history of GB820301, according the monitoring data of PVO. The dashed line indicates the background intensity. b) The phase portrait for the 1st and 2nd events. With a delay η of 39 s, as shown, $R_s = 0.84$ and $S = 2.1 \times 10^{-6}$

events, Δt , is the time from the end of one event to the beginning of the next event, i.e., the time for which the intensity is below 2σ . The hardness, H , of the event is the ratio of total net counts in the 0.2 - 2 MeV band to the total net counts in the 0.1 - 0.2 MeV band. With these definitions, the typical duration of an event in our sample is 1 to 130 s, and the separation between events varies from one to a few hundred seconds.

To quantify the degree of similarity, we have computed correlations among various properties of the events, such as their intensity, duration, and hardness. We have also looked for relationships between these quantities and the separation between the events.

Figure 2. Comparisons of total intensity, hardness, and duration for the 1st and 2nd events. The respective correlation coefficients and their significances are given.

COMPARISON OF TIME PROFILES

The time profiles of the event pairs may best be compared through use of the phase portrait, an example of which is shown in Fig. 1b. The phase portrait depicts the autocorrelation function at delay η , but allows greater flexibility in the analysis. For example, the trace in the portrait can reveal similarities in scale invariant structure. Further, by eliminating points known to be in the background intensity, events with dissimilar lengths can be compared. The technique is limited by its demand for an adequate number of points in each event. The portrait of the first two events in GB820301 (Fig. 1b) is the most correlated case we have come across thus far. Of 11 event pairs we have analyzed in this manner, only 5 have $S \leq 0.05$. Thus, correlation in time profiles of the events is not a general property of these bursts.

SUMMARY

Our investigation into these multiple event bursts does not yet permit any firm conclusions. We only note that correlation coefficients and linear fits may not always do justice to determining the existence of potentially complex relationships. Further, the effects of the timing resolution and instrument sensitivity must be properly explored. Nonetheless, we recognize this class of bursts as worthy of investigation, so that theories may properly take account of them.

With these caveats, the fact that we have found some degree of correlation in each of the quantities we have described here indicates some relation between them. The differences in the strength of the correlation between τ_1 vs Δt and τ_2 vs Δt , and between the $R \leq 1$ and $R > 1$ subsets may indicate that a single mechanism is being reset after not expending all of its energy. The events appear not to be completely independent.

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