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Global characteristics of X-ray flashes and X-ray rich GRBs observed by HETE-2(*)

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Summary. — We describe and discuss the global properties of 45 gamma-ray bursts (GRBs) observed by HETE-2 during the first three years of its mission, forcing on the properties of X-Ray Flashes (XRFs) and X-ray-rich GRBs (XRRs). We find that: 1) the numbers of XRFs, XRRs, and GRBs are comparable, 2) the durations of XRFs and XRRs are similar to those of GRBs, and 3) the spectral properties of XRFs and XRRs are similar to those of GRBs, expect that the values of the peak energy E_{peak} of the burst spectrum is νF_ν, the peak flux F, and the fluence S of XRFs are much smaller —and those of XRRs are smaller— than those of GRBs. These results provide strong evidence that all three kinds of bursts arise from the same phenomenon.

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1. – Introduction

Gamma-ray bursts (GRBs) whose energy fluence in X-ray energy band S_X (2–30 keV) is larger than their energy fluence in the gamma-ray S_γ (30–400 keV) have received increasing attention. These events are so-called X-ray flashes (XRFs) and X-ray–rich GRBs (XRR) depending on their hardness, and are studied in details by *Ginga* [1] and *Beppo*SAX [2] satellite. Understanding the relationship between XRFs, XRRs, and GRBs(1) may provide a deeper knowledge of the prompt emission of GRBs.

In this paper, we investigate the global properties of 45 GRBs localized by HETE-2 between the beginning of the mission and 2003 September. The time-averaged spectral analysis is performed to all of them using both WXM (2–25 keV) and FREGATE (7–400 keV) data. Three spectral models: the simple power law model, the power law times exponential cutoff model, and the Band function [3] are tested for the fitting.

2. – Distribution of the fluence ratio S_X/S_γ

Figure 1 shows the distribution of XRFs, XRRs, and GRBs in the [S(2–30 keV), S(30–400 keV)]-plane. The three GRB classes seems to form a single broad distribution. The numbers of XRFs, XRRs, and GRBs, are 16, 19, and 10, respectively. The numbers of three kinds of bursts are roughly equal.

3. – Distribution of duration and low energy photon index α

The distributions of the burst duration and the low energy photon index are shown in fig. 2. There is no evidence for any difference in the distribution of the duration between the three kinds of GRBs. Although the energy bands in which durations are calculated are different for HETE-2 and BATSE, we also found no difference in the distribution of durations of the BATSE long GRBs [4]. This result is consistent with the *Beppo*SAX WFC/CGRO BATSE sample of XRFs [5].

(1) Throughout this paper, we define "X-ray–rich" GRBs (XRRs) and "X-ray flashes" (XRFs) as those events for which $\log[S_X(2\text{–}30\,\mathrm{keV})/S_\gamma(30\text{–}400\,\mathrm{keV})] > -0.5$ and 0.0, respectively.

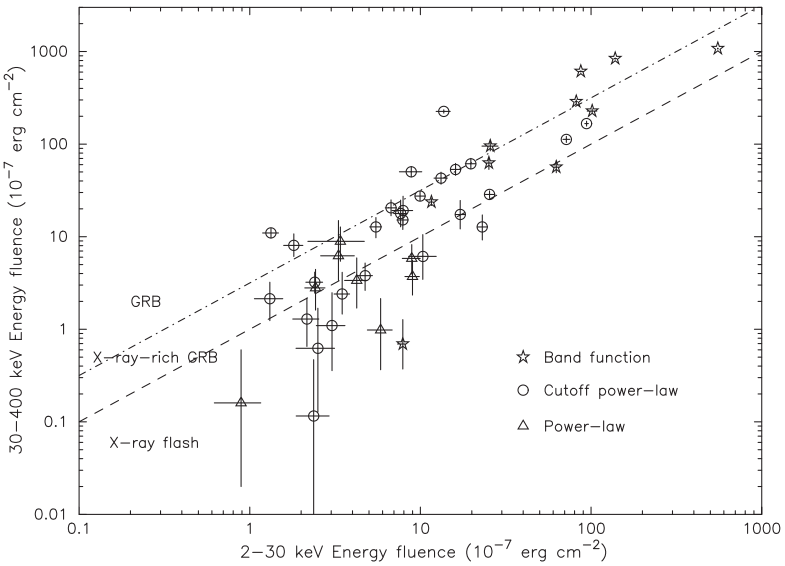

Fig. 1. – Distribution of 45 bursts in the [S(2–30 keV), S(30–400 keV)]-plane. The dashed line corresponds to the boundary between XRFs and XRRs. The dash-dotted line corresponds to the boundary between XRRs and GRBs.

Our sample suffers from small number of statistics, however, there are no significant difference between the distribution of α. This result is also consistent with the WFC/BATSE sample [5].

4. – Distribution of E_{peak}

Distributions of E_{peak} for each GRB class are shown in fig. 3. The E_{peak} values of HETE-2 burst sample extends to much lower energies than that of the BATSE sample of the time-resolved spectra of bright bursts [6]. Note that the clear separation between XRFs and XRRs around 30 keV is due to the fact that we are classifying the GRBs for 30 keV as a boundary.

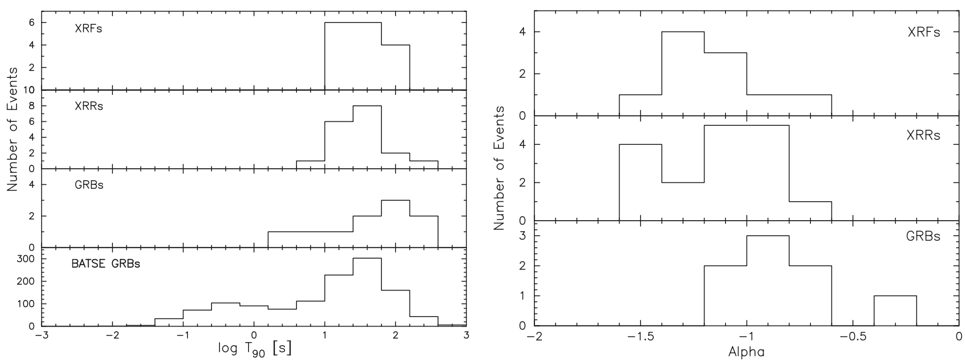

Fig. 2. – Left: Comparison between T_{90} measurement of burst duration in the 2–25 keV energy band for the three kinds of bursts seen by HETE-2 and in the 50–300 keV energy band for BATSE GRBs. Right: Distribution of the low-energy photon index α for each of three kinds of bursts.

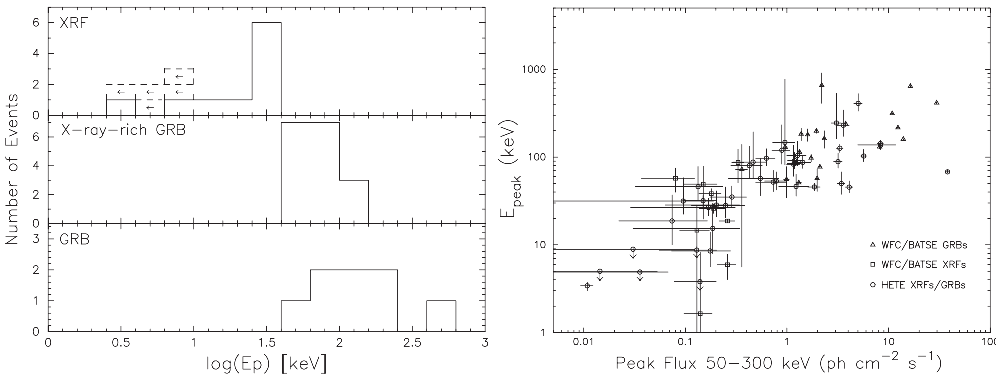

Fig. 3. – Left: Distribution of $E_{\rm peak}$ for each of three kinds of bursts. The events labeled with left-pointing arrows are the 99.7% upper limits for $E_{\rm peak}$ derived using the *constrainted* Band function [7]. Right: Distribution of HETE-2 bursts (circles), WFC/BATSE GRBs (triangles), and WFC/BATSE XRFs (squares).

5. – $E_{\rm peak}$ *vs.* 50–300 keV **peak photon flux**

The distribution of the HETE sample is consistent with the distribution of the BATSE/WFC sample [5] in the $E_{\rm peak}$ and the 50–300 keV peak flux plane. Moreover, the distribution of the HETE bursts extends down to fainter photon peak fluxes.

6. – Conclusion

We have studied the global properties of 45 GRBs observed by HETE-2 during the first three years of its mission, focusing on the properties of XRFs and XRRs. We find that: 1) the numbers of XRFs, XRRs, and GRBs are comparable, 2) the durations are similar to those of GRBs, 3) the spectral properties of XRFs and XRRs are similar to those of GRBs, except that $E_{\rm peak}$, the peak flux, and the fluence of XRFs are much smaller than those of GRBs. These results provide strong evidence that all three kinds of bursts arise from the same phenomenon.

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