GRB without hard to soft evolution and high energy emission

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Abstract: Spectral properties of some GRB with presence of high energy component within RHESSI, HETE and SWIFT t90 intervals are discussed. In some cases the temporal profiles of GRB in low and high energy bands are similar but in some cases they are different and maxima are not coincided. We found the same type GRB in CGRO database too – for example, GRB930131. Moreover, for some GRB from CGRO and AVS-F database in which spectra contradict Band model high energy component are present the hard to soft spectral evolution is absent – for example, for GRB930506 (t90=22.144 ± 0.091) Epeak on burst begin less than Epeak during other burst parts - Epeak(1-3s)=540 ± 58 keV, Epeak(3-7s)=1064 ± 38 keV, Epeak(7-23s)=850 ± 32 keV. All GRB with such properties are long GRB for standard BATSE and other classifications including taking in account burst hardness ones. We suppose that such type GRB consist a new subgroup of long GRB.

Typical GRB spectra

The analysis of gamma-ray burst spectral evolution give some trends that may constrain the emission mechanisms. Earlier works on spectral evolution used GRB “hardness”, defined by the ratio between two detector channels or with more physical variables such as the spectral break or peak power energy Epeak [1], which is the maximum of E×F, where E is photon energy and F is the specific energy flux. Such hardness parameters were typically decreasing monotonically while the flux rises and falls [2] or its behavior corresponds to flux temporal profile one [3]. Moreover, for most part of GRB Epeak decay exponentially in bright, long, smooth BATSE GRB pulses as a function of photon fluence F [4]. Usually GRB spectra (both time resolved and time integrated) are well described by two component Band function [5]:

\[
f(E) = \begin{cases} 
\frac{A}{E_{100}^{\alpha}} \exp\left(\frac{-E}{E_{\text{break}}^{\alpha}}\right), & E < \frac{(\alpha-\beta)E_{\text{break}}}{2+\alpha} \\
\frac{A}{E_{100}^{\alpha}} \exp\left(\frac{-E}{E_{\text{peak}}^{\beta}}\right), & E \geq \frac{(\alpha-\beta)E_{\text{break}}}{2+\alpha}
\end{cases}
\]

where first component proportional to combination of power law with index \(\alpha\) and exponential cutoff defined by \(E_{\text{break}}=E_{\text{peak}}/(2+\alpha)\) and second component is proportional to power law with index \(\beta\). Typical spectral evolution during GRB is shown at Figure 1. Hard to soft and hardness-intensity correlations are presented for most part of GRB, power law indexes in Band model decrease to GRB end. The observed values and variability of all three parameters of Band function of typical GRB give the limitations on theoretical models of GRB sources. For example, many models of the spectral break require \(\alpha\) to stay...
constant (e.g., self-absorption) or to have negative values (e.g., fireball models). Studying GRB with atypical spectral features allows make some conclusions about GRB source models too.

**GRB with high energy tails**

GRB with presence of high energy component (more than some MeV) in spectra were found in 1991 by common analysis of CGRO data. There were 4 experiments onboard CGRO: BATSE, COMPTEL, OSSE and EGRET [6]. Each experiment consists of different type detectors, some of them functioned as temporal profile ones. Some tens GRB were detected simultaneously by all these detectors [7] and the widest energy range for gamma emission registration on satellite experiment for the same GRB is ~10 keV ÷ ~20 GeV. One typical example of GRB with high energy component in spectrum is GRB920622 [8] – see Figure 2. The common structure of these temporal profiles consistent in various energy bands: the same amount of global peaks on temporal profiles are presented and approximate ratio of relative peak intensity are the same too – first peak has lowest intensity, last peak has highest one. In some GRB spectra the new spectral components not corresponded to Band model was found [9] GRB 941017 is typical example of such burst (Figures 3a-c.). As for GRB920622 the common structure of these GRB temporal profiles are

![Figure 2: The GRB920622 (BATSE trigger #1663) temporal profiles on BATSE (a), COMPTEL (b) and EGRET (c) data.](image)

![Figure 3: The temporal profiles on BATSE (a) and EGRET (b,c) data and spectrum (d) of GRB941017 [4].](image)
in agreement in various energy bands too. Spectrum of this burst (see Figure 3d) contradicts to Band model in high energy region. Second components of Band model for GRB941017 spectra in various energy regions are shown as blue lines at Figure 3d. Approximations for high energy part of this burst spectra are shown as red ones. The difference between these two types of spectral shapes is well seen. One of the next steps of GRB high energy emission investigation by satellite data started with beginning function of Russian satellite CORO-

Table 1. GRB990123 and GRB930506 spectral properties evolution.

<table>
<thead>
<tr>
<th>GRB</th>
<th>t</th>
<th>α</th>
<th>β</th>
<th>E_{peak}, keV</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRB990123</td>
<td>0-33</td>
<td>-0.52±0.01</td>
<td>2.58±0.06</td>
<td>734±13</td>
</tr>
<tr>
<td>typical</td>
<td>33-66</td>
<td>-0.88±0.01</td>
<td>2.77±0.08</td>
<td>543±10</td>
</tr>
<tr>
<td>GRB930506</td>
<td>1-3</td>
<td>-1.06±0.04</td>
<td>-1.90±0.06</td>
<td>540±58</td>
</tr>
<tr>
<td></td>
<td>3-7</td>
<td>-0.89±0.01</td>
<td>-1.84±0.02</td>
<td>1064±38</td>
</tr>
<tr>
<td></td>
<td>7-23</td>
<td>-1.24±0.01</td>
<td>-1.87±0.01</td>
<td>850±32</td>
</tr>
</tbody>
</table>
ones in RHESSI energy band. The same is for some EGRET GRB, the summarized spectrum of this burst (see Figure 5) contradict Band model in high energy region too. Second component of Band model for it is shown as blue line at Figure 5 and approximation for high energy part of this burst spectra is shown as red one.

Than we analyze CGRO database and found that some GRB from CGRO database with high energy emission have temporal profiles with different time structure in BATSE and other experiments energy bands too. The typical example of such event is GRB930131 – see Figure 6. These GRB temporal profiles are quite different in BATSE and COMPTEL energy bands: there are two peaks in both ranges but relative intensities of these peaks maxima I1/I2 ~ 5 in low energy band (BATSE) and I1/I2 ~ 0.3 in high energy band (COMPTEL). It seems that these GRB constitute different GRB group taken in account that for some ones of this type GRB hard to soft evolution in spectrum is absent, including some CGRO GRB. During GRB930506 there is no monotonically decay for $E_{\text{peak}}$, $\alpha$ and $\beta$ (see Table 1). In GRB050525 spectra hard to soft evolution is subdelirium too. In spectra of all GRB without hard to soft evolution component which contradict to Band model in high energy region is presented.

**Conclusions**

So, some GRB with presence of high energy component (more than some MeV) within BATSE $t_{90}$ intervals were detected by other experiments onboard CGRO and later such component within RHESSI, HETE and SWIFT ones were detected by AVS-F apparatus onboard CORONAS-F satellite too. In some cases the temporal profiles of GRB in low and high energy bands are similar but in some cases they are different and their maxima are not coincided both in CGRO and CORONAS-F database (for example, GRB930131 and GRB 050525) Moreover, for some GRB in which spectra high energy component contradicted to Band model is presented the hard to soft spectral evolution is absent or subdelirium – for example, for GRB930506 from CGRO database and for GRB050525.

**References**