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# Bursts from Soft Gamma-Ray Repeaters triggered by HETE-2(*)

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**Summary.** — HETE-2 triggered 166 events from SGR1900+14 and SGR1806−20 in summer periods from June 18 2001 to September 8 2004. Among these events, 6 events were localized to SGR1900+14 and 53 events to SGR1806−20. We performed the energy spectral analyses of bursts from SGR1900+14 and SGR1806−20 using the data of the WXM and FREGATE onboard HETE-2. We find that the energy spectra of SGR1900+14 and SGR1806−20 are well described by a sum of two blackbody models with temperatures of ∼4 keV and ∼11 keV.

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## 1. – Introduction

Spectra of bursts from Soft Gamma-Ray Repeaters (SGRs) were believed to be represented by Optically Thin Thermal Bremsstrahlung (OTTB) in earlier days. Recently Olive *et al.* (2004) [1] report that the spectra of a long burst from SGR1900+14 detected by High Energy Transient Explorer 2 (HETE-2) are not described by OTTB especially in low-energy part below 15 keV. Their analyses show that a sum of two blackbody models gives better fits. Similar results are reported for SGR1900+14 by Feroci *et al.* (2004) [2] based on *BeppoSAX* data. Fenimore *et al.* (1994) [3] also report that burst spectra from

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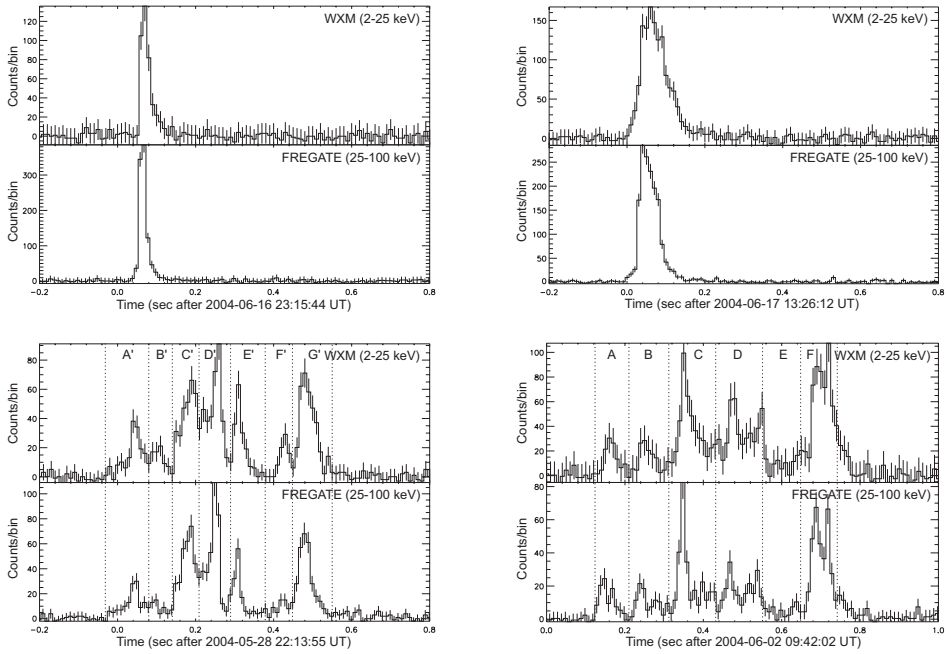


Fig. 1. – The examples of a light curve for SGR1806−20 with the error bar which is evaluated using 68% confidence level. The upper panels represent the single spike events, while the lower panels represent the multiple spike events. The horizontal axis is a time, the vertical axis of the first panel is a counts per bin in 2–25 keV and that of the second panel is a counts per bin in 25–100 keV.

SGR1806−20 are not reproduced by "traditional" models such as OTTB. We have investigated burst spectra from SGR1806−20 assuming several models including a sum of two blackbody models.

## 2. – Observations and data analysis

HETE-2 is a small satellite for researching cosmic high-energy transient phenomena [4]. The scientific instruments onboard HETE-2 always point the anti-solar direction and therefore the galactic center region comes in their field of view every summer seasons. We analyze data of the Wide-Field X-Ray Monitor (WXM) [5] and the French Gamma-Ray Telescope (FREGATE) [6] for this study. HETE-2 triggered 166 events for the period from 18 June 2001 to 8 September 2004, of which 6 events were localized to SGR1900+14 and 53 events to SGR1806−20. Other 107 events are out of WXM field of view or too weak to be localized.

We looked at all events available. Some events lack sufficient statistics or the burst data from FREGATE. We used 19 single spike events and two multiple spike events, H3259 and H3303 ([1]), for SGR1806−20. In the case of SGR1900+14, we took all 6 events for spectral analyses. Examples of light curves are shown in fig. 1. We carried out time-resolved spectral analyses for multiple spike events as shown in fig. 1.

([1]) H3259 indicates a burst on 22:13:55, May 28, 2004 UT, and H3303 indicates a burst on 09:42:02, June 2, 2004 UT.

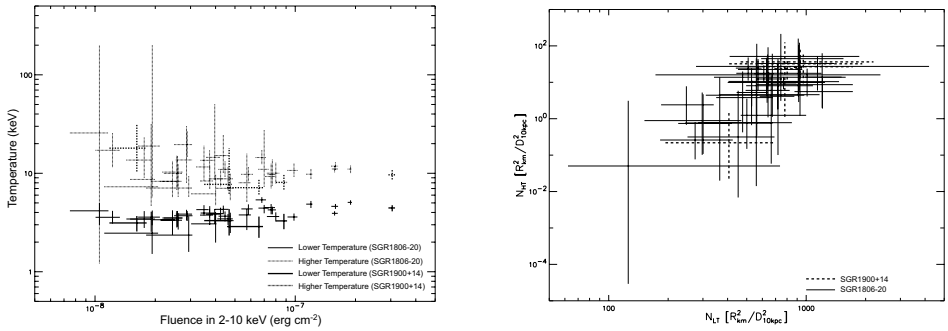


Fig. 2. – The left figure shows the relationship between a fluence in 2–10 keV and a temperature (lower and higher). In the left figure, the dotted lines represent the higher temperature, while the solid lines represent the lower temperature. The right figure shows the relationship between $N_{\rm LT}$ and $N_{\rm HT}$. In the right figure, the dotted lines represent the normalizations of SGR1900+14 and the solid lines represent the normalizations of SGR1806−20.

**2˙1.** *Spectral Analysis with Sum of Two Blackbody Models.* – We tried following functional form for all events; power law model (PL), cutoff power law model (CPL), single blackbody model (BB), sum of two blackbody models (two-BB), disk blackbody (disk-BB) model and OTTB. In all fits we adopted an interstellar absorption $N_{\rm H} = 2.2 \times 10^{22}\,{\rm cm}^{-2}$ for SGR1900+14 [7] and $N_{\rm H} = 6.5 \times 10^{22}\,{\rm cm}^{-2}$ for SGR1806−20 [8,9].

Two-BB gave acceptable fits for all events except for a long burst from SGR1900+14 on 03:34:06, July 2, 2001 UT ([2]) and best reduced $\chi^2$ values ranging from 0.39 to 0.97 for almost all events. The left panel in fig. 2 shows the relationship between a fluence in 2–10 keV and temperatures (lower and higher). The lower and higher temperatures are lying around 4 keV and 11 keV, respectively. They do not depend on either the magnitude of burst, the event morphology (*i.e.* single spike or multiple spike) or the source (*i.e.* SGR1900+14 or SGR1806−20). The right panel in fig. 2 shows the relationship between the normalization for the lower temperature ($N_{\rm LT}$) and the normalization for the higher temperature ($N_{\rm HT}$). It seems that the variation of $N_{\rm LT}$ correlates with that of $N_{\rm HT}$.

**2˙2.** *Spectral Evolution (Softening Trend).* – We investigated the spectral evolution in one spike using time resolved hardness ratios ($R = (N_{\rm X} - N_\gamma)(N_{\rm X} + N_\gamma)$), where $N_{\rm X}$ and $N_\gamma$ show counts per bin in 2–25 keV and in 25–100 keV, respectively. The examples of the hardness ratio for H3348 and H3351 ([3]) represented in fig. 3. There seems a softening trend over one spike.

## 3. – Conclusion

Two-BB is the most favorable model to represent the spectra of bursts from SGR1900+14 and SGR1806−20. The temperature are lying around 4 keV and 11 keV. These temperatures for SGR1900+14 are consistent with previous studies [1, 2]. The most im-

([2]) This event gives a large $\chi^2_{\rm r}$ of 1.30 which is caused by an uncertain systematic error for a high counting rate of FREGATE (∼50000 counts per second). The systematic error for this effect is not consider in this analysis.

([3]) H3348 indicates a burst on 23:15:44, June 16, 2004 UT, and H3351 indicates a burst on 13:26:12, June 17, 2004 UT.

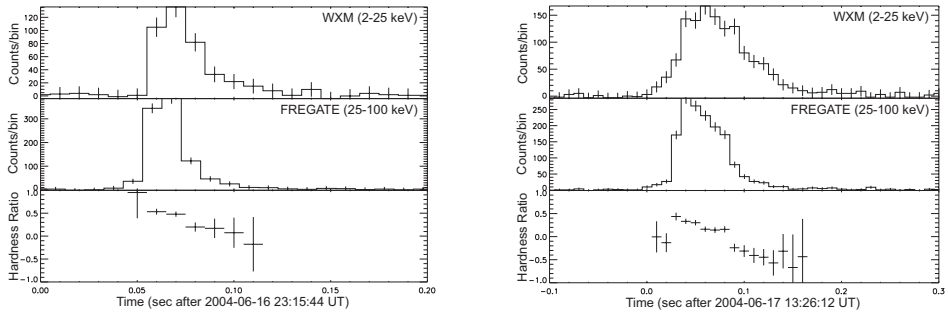


Fig. 3. – The examples of a spectral evolution. The horizontal axis shows a time. The vertical axis of the first panel is a counts per bin in 2–25 keV, that of the second panel is a counts per bin in 25–100 keV and that of the third panel is a hardness ratio.

portant result in our studies is that we can adopt two-BB not only for SGR1900+14 but also for SGR1806−20 and their temperatures are lying around 4 keV and 11 keV. There is no apparent clustering nor deviation of parameter by either event morphology (*i.e.* single spike or multiple spike) or the source (*i.e.* SGR1900+14 or SGR1806−20). The variation of $N_{\rm LT}$ seems to correlate with that of $N_{\rm HT}$. These results might imply that some common mechanism and/or radiative transfer are responsible for very similar spectra irrespective of brightness, event morphology or sources.

It was reported that the spectral evolution is weak in earlier days [3, 10]. Recent studies suggest softening seem in some events [11-13]. Our results indicate that there seems a spectral softening trend over one spike.

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