Photospheric Emission in the Joint GBM and Konus Prompt Spectra of GRB 120323A

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Abstract

GRB 120323A is a very intense short gamma -ray burst (GRB) detected simultaneously during its prompt \(\gamma\)-ray emission phase with the Gamma-ray Burst Monitor (GBM) on board the Fermi Gamma-ray Space Telescope and the Konus experiment on board the Wind satellite. GBM and Konus operate in the keV–MeV regime; however, the GBM range is broader toward both the low and the high parts of the \(\gamma\)-ray spectrum. Analyses of such bright events provide a unique opportunity to check the consistency of the data analysis as well as cross-calibrate the two instruments. We performed time-integrated and coarse time-resolved spectral analysis of GRB 120323A prompt emission. We conclude that the analyses of GBM and Konus data are only consistent when using a double-hump spectral shape for both data sets; in contrast, the single hump of the empirical Band function, traditionally used to fit GRB prompt emission spectra, leads to significant discrepancies between GBM and Konus analysis results. Our two-hump model is a combination of a thermal-like and a non-thermal component. We interpret the first component as a natural manifestation of the jet photospheric emission.

Key words: acceleration of particles – gamma-ray burst: individual (GRB 120323A) – radiation mechanisms: non-thermal – radiation mechanisms: thermal

1. Introduction

Recent results on gamma-ray burst (GRB) prompt emission analysis revealed the existence of multiple simultaneous emission components (e.g., Guiriec et al. 2010, 2011, 2013, 2015a, 2015b, 2016a, 2016b). Using data collected with the Fermi Gamma-ray Space Telescope (hereafter, Fermi) for both short and long GRBs, Guiriec et al. (2015a) proposed a three-component model \((C_{\text{th1}} + C_{\text{th}} + C_{\text{th2}})\) that adequately describes their \(\gamma\)-ray prompt emission: two components with non-thermal shapes, \(C_{\text{th1}}\) and \(C_{\text{th2}}\), and a thermal-like component, \(C_{\text{th}}\). While \(C_{\text{th1}}\) and \(C_{\text{th2}}\) seem to be present in most GRBs, \(C_{\text{th2}}\) has only been detected in a few cases; it is not clear if this component is absent in most GRBs or if it is too weak to be detected. Reanalysis of GBM archival data collected with the Burst And Transient Source Experiment on board the Compton Gamma-Ray Observatory confirmed that \(C_{\text{th1}} + C_{\text{th}} + C_{\text{th2}}\) is a good model for \(\gamma\)-ray prompt emission (Guiriec et al. 2016a). Using optical, X- and \(\gamma\)-ray data collected with the three instruments on board Swift and Suzaku/Wide-band All-sky Monitor (WAM), Guiriec et al. (2016b) showed that \(C_{\text{th1}} + C_{\text{th}} + C_{\text{th2}}\) constitutes a unified model for the whole GRB broadband prompt emission, from the optical regime to higher energy \(\gamma\)-rays. Identification of the individual components of the prompt emission is a crucial step for disentangling the physical processes powering GRB jets.

Discovered in a long GRB (Guiriec et al. 2011), \(C_{\text{th}}\) has now been identified in an increasing number of both short and long GRBs. Although typically subdominant, compared to \(C_{\text{th1}}\), \(C_{\text{th}}\) is particularly intense in GRB 120323A, a short and bright GRB, which triggered both the Gamma-ray Burst Monitor (GBM) on board Fermi and the Konus instrument on board the Wind satellite. This burst provides, therefore, a unique opportunity to compare and contrast the analysis of the data collected with these two instruments, which operate in similar energy bands.

2. Observations

GRB 120323A triggered GBM (Gruber & Connaughton 2012) and Konus (Golenetskii et al. 2012a) on 2012 March 23 at 12:10:19.72 UT and 12:10:15.97 UT, respectively. This short and intense GRB has the highest peak flux among all short events observed with GBM thus far. While some emission can be observed up to several MeV with both GBM and Konus, this event is rather soft with the bulk of the emission below 100 keV. Despite an Autonomous Repointing Request (ARR) of the Fermi spacecraft triggered by the intensity of the event, the Fermi/Large Area Telescope (LAT) did not detect any significant emission even in the Low LAT Energy (LLE) data (20–100 MeV). Figure 1 shows the 2 ms time resolution light curves (LCs) of GRB 120323A as observed with GBM (left) and with Konus (right) in energy bands ranging from 8 keV to 1 MeV. Due to the 18 keV energy threshold of Konus, the energy band 8–20 keV is missing for this instrument. The LCs of the two instruments are very similar above 20 keV exhibiting a sharp increase at the trigger time, two peaks with a separation of about 0.1 s followed by a decaying tail with a small rebrightening from \(\sim 0.30\) to \(\sim 0.40\) s. The GBM LC below 20 keV exhibits one single peak with similar rising and decaying time up to 0.16 s followed by a decaying tail as observed in the other energy bands. The GBM and Konus \(T_{\text{90}}\) durations in the 50–300 keV energy range (Kouveliotou et al. 1993) reported for this event were \(0.448 \pm 0.090\) s (Gruber & Connaughton 2012) and \(\sim 0.5\) s (Golenetskii et al. 2012b), respectively.

For a catalog of short GRBs observed with Konus, see Svinkin et al. (2016).

Konus trigger time will be referred to as \(T_0\) later on.
The best location for this event was estimated with the Interplanetary Network (IPN) at R.A. \(=340^\circ.4\) and decl. \(=29^\circ.7\), inside an irregular error box with a minimal and maximal dimension of \(0^\circ.25\) and \(0^\circ.75\), respectively (Golenetskii et al. 2012a).

3. Data Analysis

For the analysis of GBM data, we use the same selection criteria (i.e., data file type, detectors, and energy selection) as described in Section 3 of Guiriec et al. (2013) as well as the same response files generated using the IPN location and the same background estimate. Konus data are extracted from detector S2 in two overlapping energy ranges covering from 20 keV to 16 MeV: 20 keV–1.6 MeV (i.e., high-gain PHA1) and 450 keV–16 MeV (i.e., low-gain PHA2). We exclude PHA1 data beyond 450 keV from the analysis to avoid duplication in the PHA1–PHA2 joint spectral fit process. No statistically significant emission is detected in Konus spectral channels beyond 7 MeV, which justifies the 7 MeV high-energy cut used later on in this article.

The background of PHA1 and PHA2 data for GRB 120323A is modeled as a constant using the total counts accumulated from \(T_0 + 25\) s to \(T_0 + 254\) s. Located at the L1 Lagrange point, Konus data are not affected by the same intense flux of charged particles captured in Earth’s magnetic field that strongly affect the GBM background (low Earth orbit). The Konus background is, therefore, usually more stable. However, the very short duration of GRB 120323A strongly reduces possible systematic effects in the background estimate used for the analysis of GBM data.

The full energy resolution of the Konus data is only available with a 64 ms time resolution. Therefore, this time resolution is the most constraining factor when defining time intervals for the joint GBM and Konus time-resolved spectral analysis. We extracted GBM spectral data in the same four time intervals as those imposed by the Konus time resolution in taking into account the light propagation time between the Fermi and Wind spacecraft. We performed a time-integrated spectral analysis of GRB 120323A over these four time intervals of Konus (later sp1–4) and a time-resolved spectral analysis of the first two: 0–64 ms (later sp1), corresponding mostly to the first peak of the LC observed above 20 keV, and 64–128 ms (later sp2), corresponding mostly to the second peak (see Figure 1). The last two intervals correspond to the decay phase of the burst; we did not perform spectral analysis in each of them individually because their signal is weak. The vertical dashed
red lines in Figure 1 indicate the three time intervals used in this analysis: sp1–4, sp1, and sp2.

We fitted the $C_{n\text{Th1}} + C_{\text{Th}}$ model (Guiriec et al. 2011, 2013, 2015a, 2015b, 2016a, 2016b)—where $C_{n\text{Th1}}$ is a nonthermal component that we approximate with a Band function or a power law with an exponential cutoff (CPL), and $C_{\text{Th}}$ is a thermal-like component that we approximate with 2 or a black body (BB)—to the data in each time interval using either Konus and GBM data separately or together in a joint fit. In this analysis, we only consider the best models reported in Guiriec et al. (2013) to compare Konus results to GBM ones. To perform the spectral analysis, we used the software package XSpec8 and the best-fit parameters as well as their corresponding uncertainties were estimated by minimizing PGSTAT (i.e., Poisson–Gaussian Statistic). This statistic is particularly interesting when fitting data in different statistical count regimes. The energy channels are grouped in order to have at least 1 count per energy bin as recommended for optimal usage of PGSTAT; the energy bins in the Konus data have typically more than 20 counts per bin.

While the two data sets of Konus are calibrated prior to the spectral analysis, no specific calibration is performed between the NaI and BGO detectors of GBM. Therefore, when fitting GBM data alone, we apply an effective area correction (EAC) factor between each NaI detector and BGO 0 (BGO 0 being the reference). This gives three additional free parameters to the fit of GBM data alone. When fitting simultaneously GBM and Konus data (later GBM + Konus), the EAC factors between BGO and NaI detectors are fixed to the values obtained from the best fit to the GBM data alone using the respective model. Therefore, GBM detectors are considered to be a single instrument, such as Konus. An EAC factor is then applied in between BGO 0 and Konus data to measure possible discrepancies in the flux estimates between the two instruments.

The analysis results are reported in Table 1, and Figures 2–5.

4. Results

4.1. Time-integrated Spectral Analysis

The Band function (Band et al. 1993) fits to the GBM and Konus data separately in time interval sp1–4 result in two dramatically different spectral shapes (see red and blue lines in Figure 2(a), and Table 1). While the $E_{\text{peak}}$ value measured by GBM is very low for such a bright and short GRB ($\sim$80 keV), the Konus measurement is quite typical ($\sim$300 keV). Also, the value of the spectral index $\alpha$ of the Band function estimated with Konus data ($\alpha \sim -1.50$) is significantly lower than the one measured with GBM data ($\alpha \sim -0.66$).

We investigated the possible impact of the difference in the energy ranges covered by the two instruments to explain the observed discrepancies. To do so, we fitted the GBM data over the same energy range as Konus (i.e., from 20 keV to 7 MeV). In reducing the GBM energy range, we obtain a higher value for $E_{\text{peak}}$ compared to the fit to GBM data over the whole energy range of the instrument, as well as lower values for $\alpha$ and $\beta$ (see green line in Figure 2(a) and Table 1). This fit result is intermediate between the fit of GBM data over its full energy range and the fit of Konus data. This is an indication that the extended energy range covered by GBM can strongly impact the fit results, and it may explain, at least in part, the discrepancies observed between the two instruments.9 We note that the high-energy power law of the Band function systematically overshoots the BGO data at the highest energies showing that the Band function alone is unable to adequately capture the spectral shape of the GBM data over its whole energy range (see Figure 3).

When fitting GBM and Konus data simultaneously, the resulting Band function is similar to the one obtained when fitting GBM data alone (see black line in Figure 2(a)); this is because GRB 120323A is much more intense in GBM than in Konus. While EAC factors of only a few percent are required between NaI and BGO detectors when fitting a Band function to the GBM data alone, 20%–30% correction is necessary to align the GBM and Konus fluxes (see Table 1).

Conversely to the results reported for the Band-only fits, the $C_{n\text{Th1}} + C_{\text{Th}}$ fits (with $C_{n\text{Th1}}$ being either Band or CPL, and $C_{\text{Th}}$ being BB) to the GBM and Konus data alone or together lead to consistent spectral shapes (see Table 1 and Figure 2(b)).

In the $C_{n\text{Th1}} + C_{\text{Th}}$ model, the shape of $C_{n\text{Th1}}$ is similar to the one obtained when fitting Band alone to the Konus data, and the shape of $C_{\text{Th}}$ mimics the Band function fit to the GBM (or GBM + Konus) data with $E_{\text{peak}}$ matching with the BB spectrum peak energy10 (see Figure 2(c)). We can also note that no correction is necessary between NaI and BGO data when fitting $C_{n\text{Th1}} + C_{\text{Th}}$ to the GBM data, and the correction between GBM and Konus is reduced by a few percent.

Moreover, the spectral shapes obtained with Band + BB and CPL + BB are identical (the parameter values and the fit statistics), so henceforth we will only consider CPL + BB when comparing models since it has one degree of freedom (later dof) less. The improvements in the PGSTAT values (later $\Delta$PGSTAT) between $C_{n\text{Th1}} + C_{\text{Th}}$ and Band fits are 52, 14, and 65 units for one additional dof. for GBM, Konus, and GBM + Konus data, respectively. In the three cases, this is a statistically significant improvement making $C_{n\text{Th1}} + C_{\text{Th}}$ the best model with the lower number of free parameters.

9 Because of the difference in the sensitivity, in the energy resolution, and in the observing conditions that impact the instrument response functions of the two instruments, we do not expect the GBM and Konus results to be exactly the same when using an incorrect model even over the same energy range.

10 The maximum of the BB spectrum peaks at $\sim$3 times the value of the temperature $kT$.8 http://heasarc.nasa.gov/docs/xanadu/xspec/
| Model       | Data Sets | Band or CPL | BB   | EAC   | pgstat| def  |
|-------------|-----------|-------------|------|-------|-------|------|
|            | Parameters | $E_{\text{peak}}$ | $\alpha$ | $\beta$ | KT   | N0/B0 | N1/B0 | N3/B0 | K/B0 |
| **sp1-4**   | GBM       | 196 ± 14    | −1.36 ± 0.03 | ...   | ...   | 0.79 ± 0.07 | 0.87 ± 0.07 | 0.83 ± 0.07 | ...   | 794/474 |
|            | (20 keV–7 MeV) | 231 ± 23    | −1.60 ± 0.04 | ...   | ...   | 0.85 ± 0.07 | 0.93 ± 0.07 | 0.90 ± 0.07 | ...   | 519/395 |
|            | Konus     | 316±53      | −1.51 ± 0.07 | ...   | ...   | ...   | ...   | ...   | ...   | 49/43   |
|            | GBM + Konus | 216 ± 11    | −1.40 ± 0.03 | ...   | ...   | 0.79(1x) | 0.87(1x) | 0.83(1x) | 0.72 ± 0.03 | 883/522 |
| **Band**    | GBM       | 72 ± 6      | −0.66 ± 0.09 | −2.09 ± 0.04 | ...   | 0.85 ± 0.07 | 0.93 ± 0.08 | 0.90 ± 0.08 | ...   | 579/473 |
|            | (20 keV–7 MeV) | 108 ± 13    | −1.21 ± 0.12 | −2.20 ± 0.09 | ...   | 0.79 ± 0.08 | 0.86 ± 0.08 | 0.83 ± 0.08 | ...   | 484/394 |
|            | Konus     | 290±62 ±144 | −1.49±0.67 −2.78±0.69 | ...   | ...   | ...   | ...   | ...   | ...   | 46/42   |
|            | GBM + Konus | 78 ± 9      | −0.75 ± 0.05 | −2.09 ± 0.10 | ...   | 0.85(1x) | 0.93(1x) | 0.90(1x) | 0.75 ± 0.03 | 642/521 |
| **B + BB**  | GBM       | 326 ± 36    | −1.35 ± 0.05 | <−3.00 | 12.0 ± 0.8 | 0.90 ± 0.08 | 0.98 ± 0.08 | 0.95 ± 0.08 | ...   | 527/472 |
|            | (20 keV–7 MeV) | 325±44 ±139 | −1.49 ± 0.08 | <−3.00 | 13.2±1.7 ±1.2 | 0.88 ± 0.07 | 0.96 ± 0.07 | 0.92 ± 0.07 | ...   | 444/392 |
|            | Konus     | 386±102 ±102 | −1.46±0.15 −2.99±0.52 | 18.2±5.0 ±3.6 | ...   | ...   | ...   | ...   | 31/40   |
|            | GBM + Konus | 343 ± 30    | −1.37 ± 0.05 | <−3.91 | 12.4 ± 0.8 | 0.90(1x) | 0.98(1x) | 0.95(1x) | 0.79 ± 0.03 | 577/519 |
| **C + BB**  | GBM       | 326 ± 36    | −1.34 ± 0.05 | ...   | 12.0 ± 0.8 | 0.90 ± 0.08 | 0.98 ± 0.08 | 0.95 ± 0.08 | ...   | 527/472 |
|            | (20 keV–7 MeV) | 325±44 ±139 | −1.49 ± 0.08 | ...   | 13.2±1.7 ±1.2 | 0.88 ± 0.07 | 0.96 ± 0.07 | 0.92 ± 0.07 | ...   | 444/392 |
|            | Konus     | 404±106 ±106 | −1.48±0.14 −2.80±0.14 | 18.5±5.0 ±3.6 | ...   | ...   | ...   | ...   | 32/41   |
|            | GBM + Konus | 346 ± 30    | −1.37 ± 0.04 | ...   | 12.5 ± 0.8 | 0.90(1x) | 0.98(1x) | 0.95(1x) | 0.79 ± 0.03 | 577/520 |
| **sp1**     | GBM       | 146 ± 10    | −0.96 ± 0.07 | ...   | ...   | 0.77 ± 0.12 | 0.86 ± 0.13 | 0.83 ± 0.12 | ...   | 725/474 |
|            | Konus     | 249±54 ±84 | −1.44 ± 0.13 | ...   | ...   | ...   | ...   | ...   | ...   | 44/26   |
|            | GBM + Konus | 161 ± 9     | −1.06 ± 0.05 | ...   | ...   | 0.77(1x) | 0.86(1x) | 0.83(1x) | 0.73 ± 0.04 | 821/505 |
| **Band**    | GBM       | 70 ± 7      | +0.07 ± 0.06 | −2.21 ± 0.10 | ...   | 0.98 ± 0.14 | 1.08 ± 0.15 | 1.06 ± 0.15 | ...   | 489/473 |
|            | Konus     | 70 ± 10     | +0.58 ± 0.50 | −2.11 ± 0.12 | ...   | ...   | ...   | ...   | 15/25   |
|            | GBM + Konus | 69 ± 6      | +0.08 ± 0.17 | −2.19 ± 0.05 | ...   | 0.98(1x) | 1.08(1x) | 1.06(1x) | 0.87 ± 0.05 | 499/504 |
| **B + BB**  | GBM       | 366±52 ±88 | −1.18 ± 0.10 | <−3.00 | 15.3 ± 1.0 | 1.08 ± 0.12 | 1.20 ± 0.14 | 1.17 ± 0.14 | ...   | 489/471 |
|            | Konus     | 404±101 ±101 | −1.17 ± 0.28 −2.66 ± 0.89 | 17.3±1.3 | ...   | ...   | ...   | ...   | 15/23   |
|            | GBM + Konus | 385±59 ±84 | −1.20 ± 0.08 | <−3.00 | 15.5 ± 0.9 | 1.08(1x) | 1.20(1x) | 1.17(1x) | 0.96 ± 0.05 | 506/502 |
| **C + BB**  | GBM       | 366±58 ±101 | −1.18 ± 0.10 | ...   | 15.3 ± 1.0 | 1.08 ± 0.14 | 1.19 ± 0.15 | 1.17 ± 0.15 | ...   | 489/472 |
|            | Konus     | 428±78 ±101 | −1.20±0.32 −2.66 ± 0.89 | 17.4±1.3 | ...   | ...   | ...   | ...   | 15/24   |
|            | GBM + Konus | 385±59 ±84 | −1.21 ± 0.09 | ...   | 15.5 ± 0.9 | 1.08(1x) | 1.19(1x) | 1.17(1x) | 0.96 ± 0.05 | 506/503 |
| **sp2**     | GBM       | 314±52 ±89 | −1.50 ± 0.04 | ...   | ...   | 0.77 ± 0.08 | 0.82 ± 0.09 | 0.80 ± 0.09 | ...   | 678/474 |
|            | Konus     | 482±83 ±101 | −1.52 ± 0.10 | ...   | ...   | ...   | ...   | ...   | 24/26   |
|            | GBM + Konus | 345±51 ±51 | −1.52 ± 0.03 | ...   | ...   | 0.77(1x) | 0.82(1x) | 0.80(1x) | 0.62 ± 0.04 | 710/505 |
| **Band**    | GBM (Option 1) | 48 ± 3      | −0.14 ± 0.30 | −1.96 ± 0.05 | ...   | 0.79 ± 0.10 | 0.83 ± 0.10 | 0.82 ± 0.10 | ...   | 607/473 |
| Model       | Data Sets | Band or CPL | BB     | EAC     | pgstat/dof |
|-------------|-----------|-------------|--------|---------|------------|
| (Option 2)  | 314\(\pm\)32 | -1.50 \(\pm\) 0.03 | -6.92  | ...     | 0.77 \(\pm\) 0.08 | 0.82 \(\pm\) 0.09 | 0.80 \(\pm\) 0.09 | ... | 678/473 |
| Konus       | 478\(\pm\)307 | -1.52 \(\pm\) 0.11 | -3.00  | ...     | ...        | ...        | ...        | ... | 24/25  |
| GBM + Konus | 48 \(\pm\) 3  | -0.17 \(\pm\) 0.10 | -1.93 \(\pm\) 0.20 | ...     | 0.79(\text{fix}) | 0.83(\text{fix}) | 0.82(\text{fix}) | 0.61 \(\pm\) 0.04 | 658/504 |
| ''          | 345\(\pm\)11 | -1.52 \(\pm\) 0.03 | -3.00  | ...     | 0.77(\text{fix}) | 0.82(\text{fix}) | 0.80(\text{fix}) | 0.62 \(\pm\) 0.04 | 709/504 |
| B + BB      | GBM       | 456\(\pm\)78  | -1.25 \(\pm\) 0.08 | -3.00  | 9.7 \(\pm\) 0.6  | 0.85 \(\pm\) 0.09 | 0.89 \(\pm\) 0.08 | 0.88 \(\pm\) 0.08 | ... | 507/471 |
| Konus       | 482\(\pm\)720 | -1.28 \(\pm\) 0.10 | -3.00  | ...     | 9.4\(\pm\)12 | ...        | ...        | ... | 21/23  |
| GBM + Konus | 469\(\pm\)47 | -1.26 \(\pm\) 0.08 | -3.00  | 9.7 \(\pm\) 0.6  | 0.85(\text{fix}) | 0.89(\text{fix}) | 0.88(\text{fix}) | 0.65 \(\pm\) 0.05 | 538/502 |
| C+BB        | GBM       | 456\(\pm\)78  | -1.25 \(\pm\) 0.08 | ...     | 9.7 \(\pm\) 0.6  | 0.85 \(\pm\) 0.09 | 0.89 \(\pm\) 0.08 | 0.88 \(\pm\) 0.08 | ... | 507/472 |
| Konus       | 484\(\pm\)343 | -1.28 \(\pm\) 0.19 | 9.4 \(\pm\) 2.0  | ...     | ...        | ...        | ...        | ... | 21/24  |
| GBM + Konus | 469\(\pm\)47 | -1.26 \(\pm\) 0.08 | ...     | 9.7 \(\pm\) 0.6  | 0.85(\text{fix}) | 0.89(\text{fix}) | 0.88(\text{fix}) | 0.65 \(\pm\) 0.04 | 538/503 |
much higher than the values of $E_{\text{peak}}$ and the values of $\alpha_{\text{nth1}}$ ($\alpha_{\text{nth1}} \sim -1.2$) are much lower than the values of $\alpha_{\text{band}}$ (>0).

Similarly, the high-energy spectral slope of $C_{\text{nth1}}$ is much steeper than the one resulting from the Band-only fit (i.e., $\beta$) and cannot be differentiated from an exponential cutoff based on our data sets. Therefore, CPL + BB is equivalent to Band + BB (for both the parameters of the components and the statistical results), and since CPL + BB has one free parameter less than Band + BB, we will consider this model for statistical comparison.

Figure 2(e) shows the very good consistency of the $C_{\text{nth1}} + C_{\text{th}}$ fits for the three data sets with the confidence region progressively decreasing from the Konus fit alone to the GBM fit alone to the GBM + Konus fit. A $C_{\text{th}}$ temperature of $\sim$16 keV is obtained with the three data sets. Once more, these results are consistent with the analysis presented in Guiriec et al. (2013).

For the three data sets (i.e., GBM, Konus, and GBM + Konus), the Band and $C_{\text{nth1}} + C_{\text{th}}$ (i.e., Band + BB or CPL + BB) fits result in similar PGSSTAT values. If the parameters of the Band function in the Band-only fits and of $C_{\text{nth1}}$ in $C_{\text{nth1}} + C_{\text{th}}$ were identical, it would indicate that the additional parameters introduced with $C_{\text{th}}$ are not required to improve the fits, and the intensity of this component should then be compatible with zero. Here, the shape of the Band functions and of $C_{\text{nth1}}$ + $C_{\text{th}}$ fits, respectively, are dramatically different, and in the $C_{\text{nth1}} + C_{\text{th}}$ scenario, $C_{\text{th}}$ is an intense component, which overpowers $C_{\text{nth1}}$ between 20 and 150 keV. From this result, we conclude that given the quality of our data sets, a spectral shape with two humps ($i.e., C_{\text{nth1}} + C_{\text{th}}$) describes the data in sp1 as well as a spectral shape with a single hump (i.e., Band). However, the positive values of the low-energy spectral indices in both scenarios require a thermal emission process. This is again in good agreement with the results reported in Guiriec et al. (2013). Indeed, the authors reported no statistically significant improvement of $C_{\text{nth1}} + C_{\text{th}}$ over Band in the first peak of the LC, but strong changes in the parameters of the Band function pointing to a thermal emission origin for the two scenarios.

When Band or $C_{\text{nth1}} + C_{\text{th}}$ are fitted to the GBM data of sp1, no EAC is required between NaI and BGO detectors.
within the $1\sigma$ uncertainties. Similarly, the $C_{\text{nTh1}} + C_{\text{Th}}$ fits to the GBM + Konus data do not require any correction between GBM and Konus. However, a flux correction $>12\%$ is required in the case of the Band-only fit. This shows once more that GBM and Konus data are fully consistent only when using $C_{\text{nTh1}} + C_{\text{Th}}$.

In time interval sp2, the $C_{\text{nTh1}} + C_{\text{Th}}$ fits to GBM, Konus, and GBM + Konus data give consistent results with a temperature of $\sim 10$ keV for the BB, $E_{\text{peak}}$ around 400–500 keV, $\alpha$ around $-1.2$ and a very steep slope for the high-energy PL making Band + BB similar to CPL + BB (see Table 1 and Figure 2(b)); this is in good agreement with the results reported in Guiriec et al. (2013). The spectral parameters obtained when fitting $C_{\text{nTh1}} + C_{\text{Th}}$ to the data in sp1 and sp2 are very similar. This is not the case when considering the Band-only fits for which the parameters are dramatically different between sp1 and sp2.

Interestingly, the minimization of a Band function alone to either GBM or GBM + Konus data converges toward two possible minima corresponding to dramatically different spectral parameters (see Table 1 and Figures 2(g) and 6): the solution called Option 1 has a lower PGSTAT value than the solution called Option 2. In Figure 6, we overplot in solid lines the $C_{\text{nTh1}} + C_{\text{Th}}$ best fit (red) to GBM + Konus data as
Figure 4. GBM, Konus, and GBM + Konus count data (left, center, and right columns, respectively) in time interval sp1 ($T_0$ to $T_0 + 0.064$ s) with the residuals resulting from the CPL, Band, B + BB, and C + BB fits (lines 1–5 from top to bottom, respectively). GBM energy channels have been grouped in larger energy bins for display purpose only; this grouping does not affect the fitting process that uses the best energy resolution of the instrument.
Figure 5. GBM, Konus, and GBM + Konus count data (left, center, and right columns, respectively) in time interval sp2 ($T_0 + 0.064$ s to $T_0 + 0.128$ s) with the residuals resulting from the CPL, Band, B + BB, and C + BB fits (lines 1–5 from top to bottom, respectively). GBM energy channels have been grouped in larger energy bins for display purpose only; this grouping does not affect the fitting process that uses the best energy resolution of the instrument.
Figure 6. Best C + BB fit (red line) and the two options for the Band function fits (solid blue and green lines for options 1 and 2, respectively) to GBM + Konus data in the time interval sp2. The dashed blue and green lines correspond to the BB and CPL components of the C + BB model, respectively.

well as the two options for the Band function (blue and green for options 1 and 2, respectively). The dashed blue and green lines correspond to the $C_{\text{Th}}$ and $C_{\text{Th1}}$ components of the $C_{\text{Th1}} + C_{\text{Th}}$ model, respectively. We note the strong similarities of the solid and dashed blue lines up to $\sim 35$ keV as well as the similarities of the solid and dashed green lines especially above $\sim 300$ keV. Therefore, Option 1 mimics clearly the low-energy hump of the $C_{\text{Th1}} + C_{\text{Th}}$ model (i.e., $C_{\text{Th}}$) while Option 2 mimics the high-energy hump of $C_{\text{Th1}} + C_{\text{Th}}$ (i.e., $C_{\text{Th1}}$).

A $\Delta$PGSTAT of 100, 3, and 120 is obtained between Band and $C_{\text{Th1}} + C_{\text{Th}}$ with GBM, Konus, and GBM + Konus data, respectively, showing that $C_{\text{Th1}} + C_{\text{Th}}$ is statistically significantly better than Band in the time interval sp2 only with GBM data. The limited improvement obtained with Konus can be explained by a weaker signal detected with Konus as well as with the Konus energy band pass starting at 20 keV, while the peak energy of the BB is at $\sim 30$ keV (see Figure 6). Once more, the results obtained in sp2 using GBM, Konus, and GBM + Konus data globally support those reported in Guiriec et al. (2013).

While a limited correction of order of a few percent may be needed to reconcile Na1 and BGO detector fluxes in sp2, a $\sim 30\%$ correction is needed in between GBM and Konus. In sp2, fluxes obtained with BGO seem to be systematically higher than those obtained with Na1 detectors and Konus. As in sp1, this correction factor required to renormalize the fluxes for the joint analysis in sp2 does not impact the very good consistency of the parameters resulting from the $C_{\text{Th1}} + C_{\text{Th}}$ fits when analyzing GBM and Konus data either separately or jointly.

5. Conclusion

Through the time-integrated and the coarse time-resolved spectral analysis of GRB 120323A using GBM and Konus data fitted either jointly or separately, we found consistency of the data sets from these two different instruments. However, although the spectral parameters are similar when fitting the data from one instrument or the other, a normalization correction factor, which can reach up to 30%, must be applied to calibrate the fluxes, with the Konus flux estimation being lower than GBM one. A few percent correction may also be applied in some cases to renormalize fluxes between Na1 and BGO detectors. BGO 0 seems to systematically predict higher fluxes than the selected sample of Na1 detectors and Konus. While the Band function fit to the data of GBM and Konus separately can lead to strong discrepancies in the resulting spectral parameters, $C_{\text{Th1}} + C_{\text{Th}}$ results in fits that are perfectly compatible for the two instruments.

Overall, the fits obtained in this analysis are very similar to those presented in Guiriec et al. (2013) who fitted coarse time intervals. Unfortunately, it is not possible to perform time-resolved spectral analysis of Konus data using the same fine time intervals as in Guiriec et al. (2013) due to the limited time resolution of Konus compared to GBM. Such fine time-resolved spectroscopy was crucial to track the evolution of the components with time, which is an important argument supporting the existence of these two components. Discontinuities were indeed found in the temporal evolution of the parameters of the Band function when Band-alone was fitted to high time resolution data. Such discontinuities are difficult to interpret on physical grounds. On the another hand, spectral fits using two humps (i.e., $C_{\text{Th1}} + C_{\text{Th}}$) did not show any discontinuities and the values of the parameters of $C_{\text{Th1}}$ were very compatible with synchrotron emission from electrons in the fast-cooling regime.

We observed similar results when comparing time intervals sp1 and sp2 in Section 4.2. However, with only two time intervals, this result does not appear to be as clear as in Guiriec et al. (2013).

Even with the coarse resolution of the Konus data, our results confirm the analysis performed in Guiriec et al. (2013), establishing two humps in the prompt emission spectra of GRB 120323A. We interpret this double-hump structure as resulting from two separate components (i.e., $C_{\text{Th1}} + C_{\text{Th}}$), one with a thermal-like shape, $C_{\text{Th}}$ (most-likely of photospheric origin), and the other one with a non-thermal shape, $C_{\text{Th1}}$ (possibly of synchrotron origin from electrons beyond the photosphere).

Our results show the importance of using the correct spectral model to intercalibrate data sets from different instruments. Despite the very good consistency of the spectral shapes resulting from the $C_{\text{Th1}} + C_{\text{Th}}$ fits to the GBM and Konus data, our results reveal flux normalization discrepancies between the two instruments. To efficiently intercalibrate Konus and GBM, we would need to analyze a larger data set of common events.

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