Photometry of Some Recent Gamma-ray Bursts

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Abstract. We present the results of the optical, X-ray and gamma-ray analysis of some recent GRBs. The data were obtained by the automated P60 telescope and the Swift telescope (UVOT, XRT and BAT). We present some example fits for the lightcurves. The data reduction and the investigations were made by the Konkoly Observatory HEART group (http://www.konkoly.hu/HEART/index.html).

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1. PHOTOMETRIC DATA REDUCTION

The UVOT photometry was done using NASA’s HEASOFT software package. This package provides a complete assistance for doing photometry for measurements done by various telescopes (e.g. Swift, CGRO, INTEGRAL).

For photometry, contrary to the suggestions of the software manual, we explored various aperture sizes between 1" and 10" (instead of keeping 5" at all times) to get the most usable data. Then we chose those aperture sizes, which provided the most accurate results. For a given filter band we used the best aperture size, meaning that in some cases when obtaining photometry for a given GRB we used various apertures depending on the filter band.

All UVOT magnitudes are in the Standard UVOT Photometric System [2]. Magnitudes obtained by ground based telescopes were taken from GCNs (in detail see at references [7]). When converting magnitudes to fluxes, we used the methods described in [3, 4, 5]. Magnitudes are not corrected for galactic extinction. X-ray data is taken from the XRT observations available from [6]. According to our results we suggest 19 magnitude as acceptable faintest limit in the UVOT photometry system.

We used the mpfit package [1] for fitting broken power-law functions to the lightcurves with the $F_\nu \propto t^\alpha$ convention.

2. INDIVIDUAL AFTERGLOWS

GRB 080721: The afterglow was detected by several telescopes, but due to the lack of ground based observations we could not fit the data at the late times. However, the UVOT magnitudes show a lightcurve flattening about 6 ks. After this time the UVOT slope in "WHITE" filter is $-0.70 \pm 0.18$, which is inconsistent with the one inferred from filter R, $\alpha_R \sim -0.95$ (from 10.6 to 26.19 hours after the trigger), unless there was an additional steepening in the lightcurve. The redshift was inferred from the Lyman-\(\alpha\) absorption line and it is $z = 2.602$, while other lines (O I, Si II, C II, Si IV, C IV, Fe II and Al II) suggest $z = 2.591$.

GRB 081203A: The $\alpha$ index in the R band disagrees with those in the GCNs ($\alpha_{R,I} = -0.66$ between 6 and 12 ks), but after this time the results were similar. The redshift based on the Lyman-\(\alpha\) line is about 2.1.

GRB 090102: This is a well studied GRB [see GCN Circular: 8761, 8763, 8764, 8771, 8772, 8773, 8778, 8780]. Its redshift is 1.547. The observations have already begun 43 seconds after the BAT trigger and the TAROT magnitudes even show the brightening interval of the lightcurve. Furthermore, in the UVOT’s V and UVW1 band there is an additional rebrightening around 800 s, which can be also seen in the X-ray band, but unfortunately, this part is lacking in ground based observations. The lightcurve has a flattening around 1 ks. The redshift of this burst is $z = 1.547$.

GRB 090313: The afterglow brightened during the first 1.3 ks, then faded until $\sim 10$ ks. Starting this time the plateau phase appeared, which lasted at least until $\sim 19$ hours after the trigger. Then the average slope for g, r, i, z
bands changed to $\alpha = -1.77$. The redshift is $z = 3.375$.

**GRB 090618**: This burst was very luminous with a bright afterglow. The KAIT observations show an initial decline until 92 s then a rise at 120 s. After that time the lightcurve showed two breaks: the first occurred around 600 s, the second at 14.6 hours after the trigger. However, in the UVOT observations we found a third break (from $\alpha = -0.64$ to $\alpha = -1.07$), which is in between the previous two, at $\sim 8000$ s, but ground based telescopes did not report about such an event. This break explains why after the (8000 s) epoch the UVOT slopes did not match to the slopes reported in GCNs (between 600 s and 14.6 hours $\alpha = -0.76$). From RTT images I. Khamitov et al. determined that 7.68, 8.64 and 9.58 days after the burst the afterglow had a constant 22.3 ± 0.01 magnitude. The redshift is $z = 0.54$.

**GRB 090812**: Measurements from the RAPTOR telescope system shows the lightcurve rising up to $\sim 70$ s, which is followed by a steady decay. The redshift is 2.452.

### 3. Conclusion

In this work we aimed to produce photometric data with the highest possible accuracy. Our sample consisted of relatively bright and well observed bursts in order to achieve a reliable data set with our reduction method. We excluded those large error measurements which we had to disregard during our fitting procedure. According to our results we suggest 19 magnitude as the faintest limit when using the UVOT system.
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7. GCN Circulars:
   GRB080721: 7998, 7999, 7990
   GRB081203A: 8596, 8604, 8615, 8617, 8618, 8619, 8629, 8632, 8645, 8695
   GRB090102: 8761, 8763, 8764, 8771, 8772, 8773, 8778, 8780
   GRB090313: 8983, 8985, 8989, 8992, 8995, 8997, 8999, 9001, 9002, 9606, 9008
   GRB090618: 9513, 9517, 9520, 9522, 9529, 9531, 9536, 9539, 9541, 9542, 9548, 9563, 9575, 9576, 9597, 9613
   GRB090812: 9769, 9770, 9773, 9778, 9779
|                | GRB080721 | GRB081203A | GRB090102 | GRB090313 | GRB090618 | GRB090812 |
|----------------|-----------|------------|-----------|-----------|-----------|-----------|
| **V**          | -1.09 ± 0.07* | -1.54 ± 0.03 | -         | -         | -0.62 ± 0.04 & -1.06 ± 0.10 | -         |
| **B**          | -1.38 ± 0.20 | -1.45 ± 0.02 | -         | -         | -0.60 ± 0.04 | -         |
| **U**          | -1.34 ± 0.23 | -1.33 ± 0.01 | -         | -         | -0.70 ± 0.01* & -1.04 ± 0.05 | -0.49 ± 0.10† |
| **UVW1**       | -         | -1.61 ± 0.09 | -         | -         | -0.68 ± 0.03* & -1.15 ± 0.06 | -         |
| **UVM2**       | -         | -         | -         | -         | -0.72 ± 0.04* | -         |
| **UVW2**       | -         | -         | -         | -         | -0.55 ± 0.06 & -1.03 ± 0.04 | -         |
| **WHITE**      | -1.25 ± 0.01* & -0.70 ± 0.18 | -         | -1.35 ± 0.14† | -         | -0.73 ± 0.01 & -1.07 ± 0.03 | -         |
| **R**          | ~ -0.95* | -1.73 ± 0.01†* | -1.60 ± 0.02* | ~ -0.9* | -1.61 ± 0.01 | -0.69 ± 0.01* | -1.27 ± 0.01* |
| **I**          | -         | -1.75 ± 0.03†* | -         | -         | -         | -         |
| **J**          | -         | -         | -         | -0.76 ± 0.01 | -0.83 ± 0.04 | -         |
| **H**          | -         | -         | -         | -         | -0.86 ± 0.04 | -         |
| **K**          | -         | -         | -         | -0.55 ± 0.03 | -         | -         |
| **g'**         | -         | -2.27 ± 0.37 | ~ -0.9* | -         | -         | -1.98 ± 0.12 |
| **r'**         | -         | -         | -1.00 ± 0.24 | -         | -0.77 ± 0.03 | -1.24 ± 0.01 |
| **i'**         | -         | -         | ~ -0.9* | -         | -0.73 ± 0.02 | -1.21 ± 0.02* |
| **z'**         | -         | -         | -         | -         | -0.70 ± 0.04* | -         |