Comparing the physical parameters of the intermediate and long GRB optical afterglows

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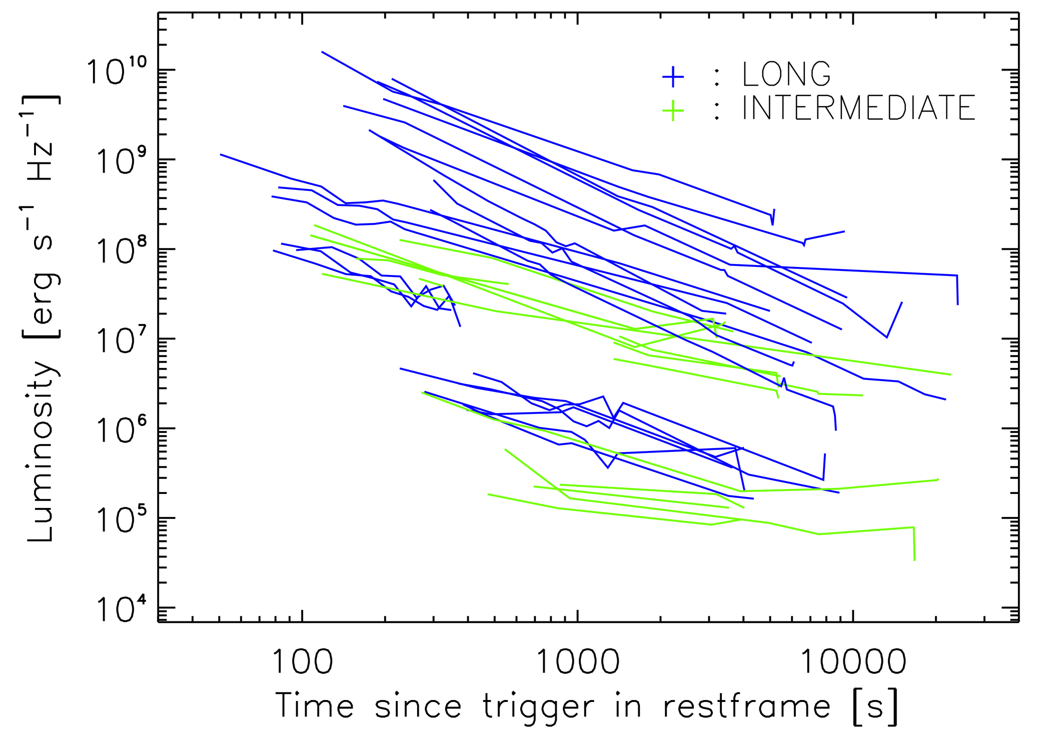
Data reduction - methods

We analyzed the UVOT data of 20 gamma-ray burst afterglows. The GRBs were taken from the sample used in [1]. This sample consists 46 intermediate and 331 long GRBs. From the former group 15 has UVOT detections and 9 is bright enough to construct the light curves. The long GRB afterglows were chosen so that the redshift distributions of the two groups are the same.
To determine the count rates we used the software Heasoft, version 6.11, with the CALDB version 20110731.
Since at some afterglows a color evolution can be observed, we do not normalized the count rates to the V filter, as it is a common practice in the literature. The count rates were first corrected for the Galactical extinction using the extinction maps constructed by Schlegel et al.([2]), then they were converted into AB fluxes. After that the lightcurves were fitted with a power-law function, and if a break was presented, than the two intervals were fitted separately.
Spectral energy distributions were constructed at arbitrarily chosen epochs, but if color evolution occured during the afterglow, the spectral slope was taken at the earliest epoch.
We also tried to determine the host extinction using the extinction curves described in [3], but probably because of the low number of the filters (just V,B and U) in most cases we got negative A_ν values.

Luminosity lightcurves

The flux lightcurves were converted into luminosity lightcurves through $L(\nu) = \frac{4\pi d_L^2}{(1+z)^{1-\beta_0}} F(\nu)$, where ν_0 is the central frequency of the photometric filter, d_L is the luminosity distance (with the following cosmological constants: $H_0 = 71$**km/s/Mpc**$, \Omega_M = 0.27, \Omega_\Lambda = 0.73$) and β_o is the unabsorbed spectral index.



On this figure the luminosity lightcurves can be seen. The blue lines indicate the V,B,U lightcurves of the long group, while the green lines mark the the same filters, but of the intermediate group.

It can be clearly observed that the sample is separating into two groups: the long (blue lines) GRB afterglows are brighter than the intermediate (green lines) GRB afterglows.

References

[1] P. Veres et al., A Distinct Peak-flux Distribution of the Third Class of Gamma-ray Bursts: A Possible Signature of X-ray Flashes?ApJ, 725, pp. 1955-1964, 2010
[2] D. J. Schlegel et al., Maps of Dust Infrared Emission for Use in Estimation of Reddening and Cosmic Microwave Background Radiation Foregrounds, ApJ, 500, Issue 2, 525, 1998
[3] Y. C. Pei, Interstellar dust from the Milky Way to the Magellanic Clouds, ApJ, Volume 395, p. 130-139, 1992
[4] A. de Ugarte Postigo et al., Searching for differences in Swift's intermediate GRBs, A&A, 525, A109, 2011

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ABSTRACT

We compared the physical parameters (e.g. temporal decay index, spectral index) of the intermediate and long GRB optical afterglows. The GRBs were chosen from the sample used in P. Veres et al., ApJ, 725, pp. 1955-1964, 2010. Both the long and intermediate afterglow data set consist the same number of afterglows, and the redshift distributions are the same as well. The afterglow data was taken from the Swift UVOT archive system, and the data reduction was carried out using the Heasoft, version 6.11.

Spectral slopes

In the table below the spectral slopes can be read. Most of them has an ordinary value, except in the cases of the GRB 080520 and GRB 080330, which are relatively high and low, respectively.

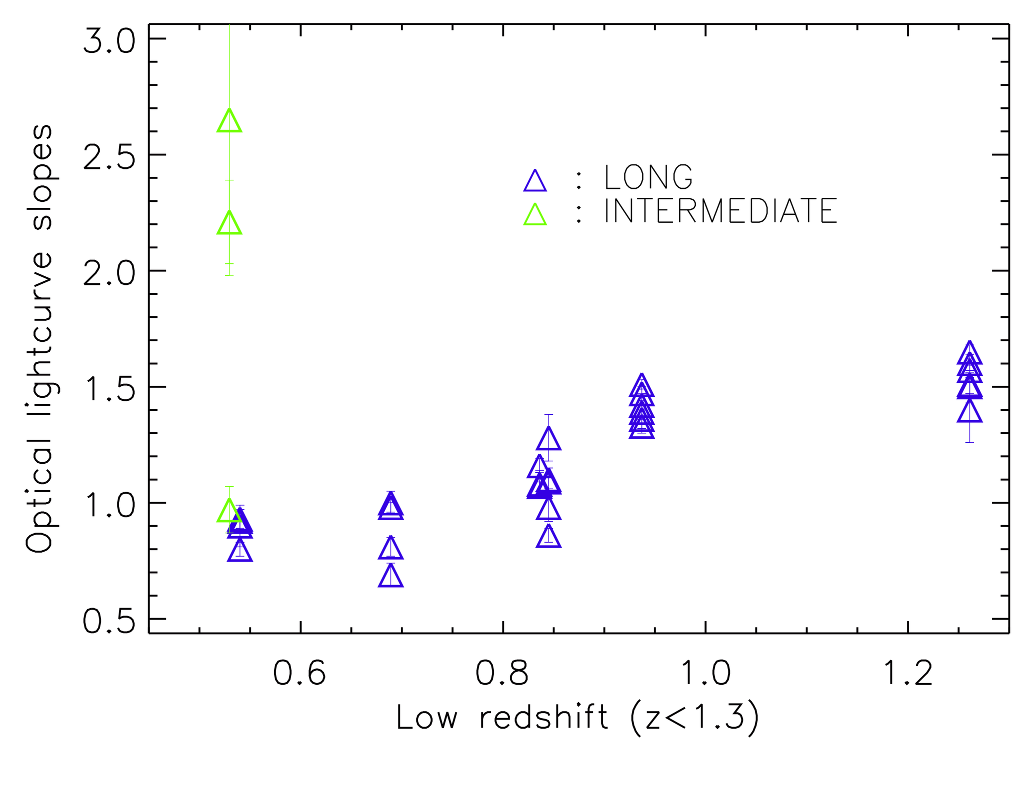
Long	β	β	Int.
060512	1.78	0.72	050801
070518	1.8	1.28	050922C
070810A	1.69	2.16	061007
080330	0.54	3.19	080721
080520	3.95	2.13	080916A
081007A	1.53	2.26	081203A
090426	1.9	1.89	090426

Lightcurve slopes

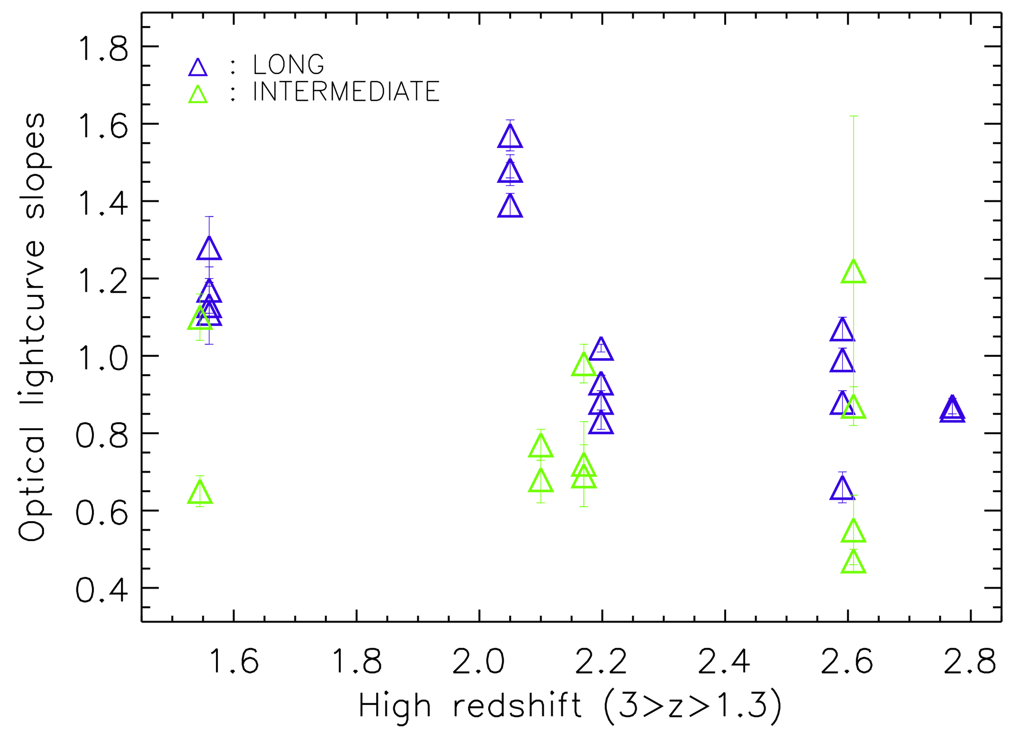
The table shows the average slopes of the functions fitted to the afterglows: the long ones are clustering around 1.1-1.2, while the intermediate ones lie on a wider range.

Filter	Long	Int.
$\overline{\alpha}_V$	1.10±0.02	0.87±0.02
$\overline{\alpha}_B$	1.11±0.02	0.69±0.05
$\overline{\alpha}_U$	1.12±0.02	0.62±0.16
$\overline{\alpha}_{W1}$	1.13±0.02	1.48±0.2
$\overline{\alpha}_{M2}$	1.50±0.07	2.21±0.18
$\overline{\alpha}_{W2}$	1.27±0.07	-

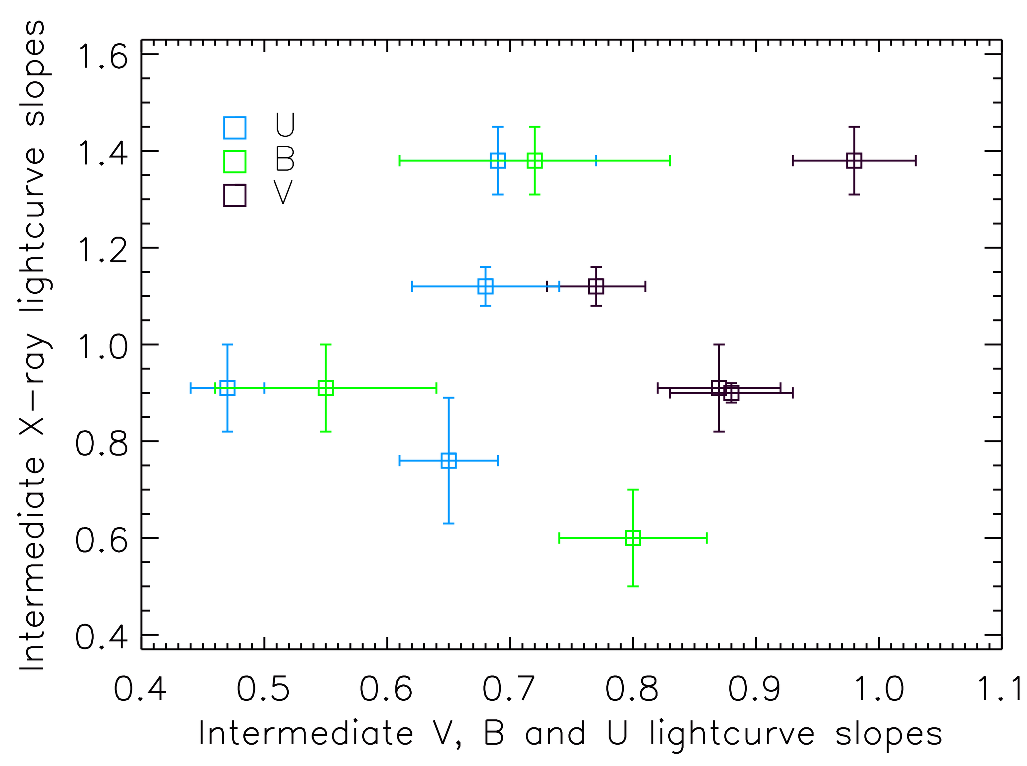
If we plot the optical lightcurve slopes of all filters against the redshift, a trend can be discovered. On the first figure the decay rates are plotted up to the median of the intermediate GRB redshifts, and it can be seen that there is a correlation between the redshift and decay slope of the long afterglows(blue triangles). Unfortunately, due to the low number of intermediate afterglows we can not test this correlation to the intermediate group.



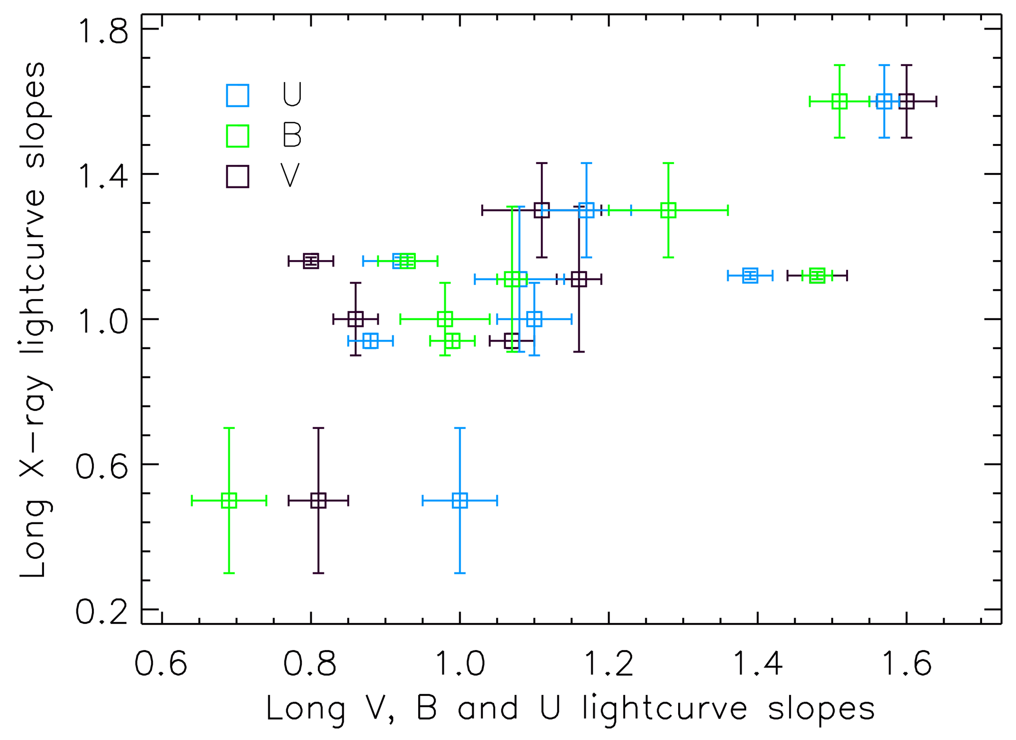
However, in the high (from median z up to z=2.8) redshift range there are more intermediate afterglows, but they do not show any connection to the redshift. In the cases of long GRB afterglows we can say that contrarily to the low redshift regime, the afterglows decay slowlier as the redshift becomes higher.



The next two figures show the V, B and U lightcurve slopes plotted against the X-ray slopes. On the first one the intermediate group's optical and X-ray slopes are compared. From the picture it is obvious that the optical decay indices are smaller than X-ray indices, i.e. the X-ray lightcurves decay faster than the optical afterglows.



In contrast to the previous result, the long optical and X-ray aftreglows have approximately the same decay indices.



Summary

Previous works(e.g. [4]) suggest that intermediate afterglows are dimmer than long afterglows. Although, the difference is observed mostly in the X-ray band, our results show, that this difference exists in the cases of optical afterglows as well. Also, we found that the X-ray decay rates are greater compared to the optical decay rates for the intermediate group, while for the long afterglows they are quite similar. Looking at the spectral and temporal indices, we can say, that regarding these afterglow parameters, the two group behave similarly.