A Search for Short Time-Scale Optical Variability in the GRB 030329 Afterglow

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Abstract. We present a densely sampled *R*-band light curve of the optical afterglow of GRB 030329 obtained during the period 15.5–23 hours after the burst. This dataset allows us to search for short time-scale fluctuations that must be present at some level due to inhomogeneities in the circumburst medium and/or if the afterglow is intrinsically variable.

INTRODUCTION

The recent detection of early fluctuations about the mean power-law decay of GRB afterglows [1, 4] may provide important clues in our understanding of the afterglow evolution. However, since several interpretations have been put forth to explain the fluctuations (e.g. [2]), it is crucial to determine the mechanism ultimately responsible for the variability. Here we present an initial attempt to help constrain the microphysics of GRB afterglows using a rapid optical photometric sequence.

DISCUSSION

High-speed optical photometry of the GRB 030329 afterglow was obtained at the MDM 1.3 m telescope beginning on March 30 03:05 UT, 15.5 hours after the burst. The data consists of a 7.5–hour time series in the *R*-band with a time resolution of 90 s. Altogether, we obtained a total of 306 points. During this period, the magnitude of the optical afterglow declined from $R = 15.4$ to $R = 16.2$. Figure 1 shows a power-law decay slope $\alpha = -1.931 \pm 0.005$ fitted to the data, where the uncertainties are dominated by faint comparison stars and large airmasses at the beginning and the end of the run.

The computed residuals indicate that the average fluctuation about the power-law fit is smaller than 0.01 mag on time scales of minutes to hours. If the flux variability f_1/f_0 traces the density contrast n_1/n_0 as a function of $f_1/f_0 \propto (n_1/n_0)^{1/2}$ [3], this implies that the enhancements in the vicinity of the GRB are less than a factor of 1.03 in density. In other words, the circumburst medium was close to homogeneous between 1.4×10^{17} cm and 1.7×10^{17} cm from the burst site, assuming a spherical adiabatic blast wave expanding in a stellar wind. Unfortunately this fast sequence by itself cannot place strong limits on intrinsic afterglow variability, but it shows that the afterglow evolution can be highly uniform on short time-scales.

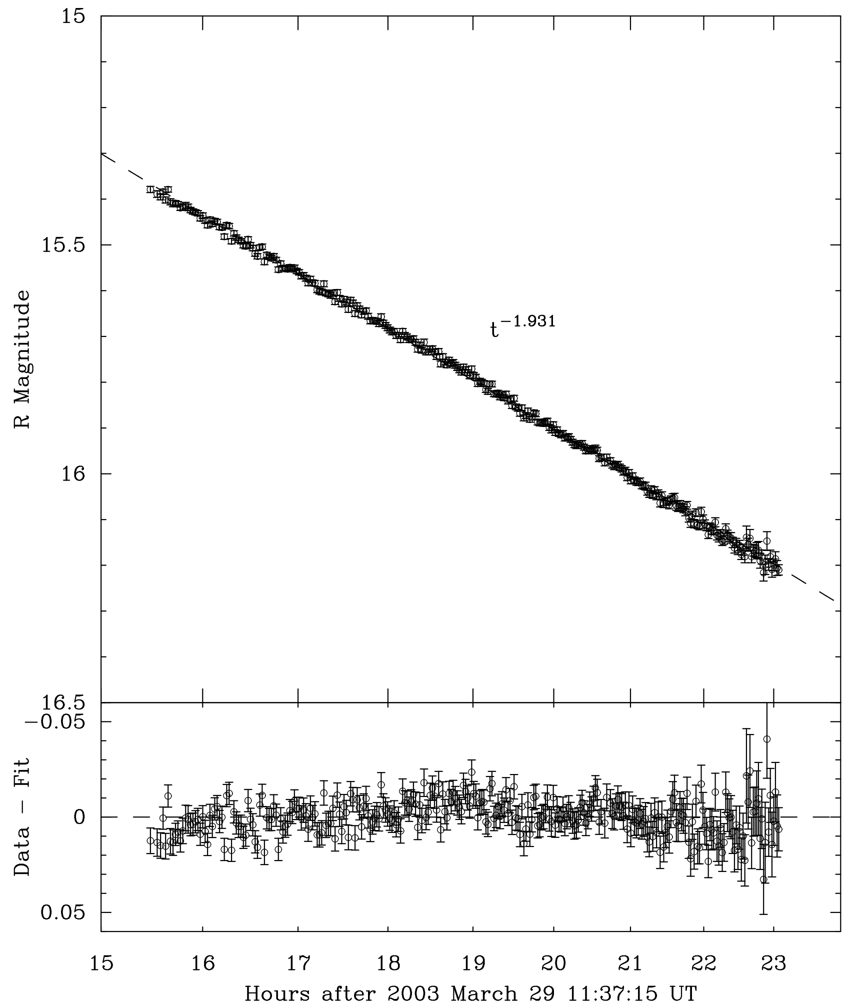

FIGURE 1. *Top*: *R*-band light curve of the GRB 030329 afterglow. *Bottom*: Difference between data and model.

CONCLUSIONS AND FUTURE WORK

We have shown preliminary results of a high-speed optical photometry program to access short time-scale fluctuations in GRB afterglows. A comprehensive effort to observe and model fluctuations at different time scales might hold the key to understanding the microphysics of GRB afterglows.

REFERENCES

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