GAMMA-RAY BURST OPTICAL AFTERGLOW OBSERVATIONS AT NYRÖLÄ OBSERVATORY

Arto Oksanen
Harri Hyvönen
Marko Moilanen
Jyväskylän Sirius ry
Kyllikinkatu 1
FIN-40100 Jyväskylä
Finland

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Abstract

We present the results of observing five gamma-ray burst (GRB) localizations (GRB 000926, GRB 010119, GRB 010222, GRB 000324, and GRB 010412) at Nyrölä Observatory, Finland. Two optical afterglows were successfully detected. Also, the equipment and methods used for the observations are presented. Our example shows how dedicated amateur astronomers with modest equipment can make a significant contribution to GRB research.

1. Introduction

Nyrölä Observatory is an amateur observatory located in Finland. It is located in the countryside near the city of Jyväskylä and is operated by a 200-member astronomy club, "Jyväskylän Sirius." The equipment used in these observations consists of a 16-inch Meade LX200 telescope, a Santa Barbara Instrument Group ST7E CCD-imager, and photometric Johnson/Cousins *B*, *V*, and *R*c filters as shown in Figure 1.

Our three-person GRB Team has been involved with GRBs since 1999, when the observatory was joined to the GRB Coordinates Network, Circular Service (GCN) operated by NASA. The observatory computer is connected to the Internet and is receiving realtime socket alerts with only a few seconds' delay, and the observers are notified via text messages to mobile phones (GSM/SMS) and email. Five GRB fields have been imaged so far: two showing optical afterglows and three negative observations. The observers have also joined the AAVSO International Gamma-Ray Burst Network in 2000. There is more information about our GRB Team on the observatory web site http://nyrola.jklsirius.fi/grb/.

2. Observations

2.1. GRB000926

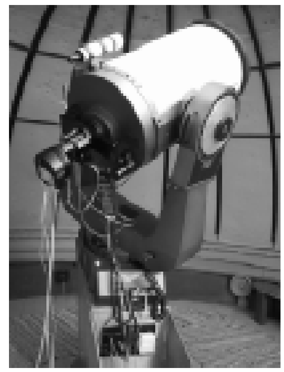

Figure 1. The 16-inch Meade LX200 telescope with SBIG ST7E CCD-imager of Nyrölä Observatory.

The first successful gamma-ray burst observation was of GRB 000926 on September 28, 1999, after several unsuccessful observing attempts. This afterglow was observed 43 hours after the satellite detection and after the optical transient coordinates were published on the GRB Coordinates Network (Fynbo 2000). The total exposure time was 4080 seconds, obtained by co-adding 17 unfiltered four-minute exposures. The limiting magnitude of the combined image was fainter than 20th magnitude and the optical transient was identified and measured by Hitoshi Yamaoka of Kyushu University, Japan (Kato 2000a, b). The final image is presented in Figure 2. This image demonstrated that the detection of 20-magnitude targets was possible with our equipment. This was also the first ever GRB optical transient observed by European amateur astronomers.

2.2. GRB010119

The second observation was of a short-hard burst GRB 010119. These bursts are more rare than the normal long-soft ones and they have never produced observed optical afterglows. The complete error box was observed by us 42 hours after the burst. This time the observation was made with a photometric *R*c filter. The upper-limit for an optical transient was determined at *R*c=19.5 magnitudes, using the dimmest stars visible in the image. No new objects were revealed by careful comparison to the digitized Palomar plates. The observation results were published by Henden (2001a). This observation is also included in a paper by K. Hurley *et al.* (2001).

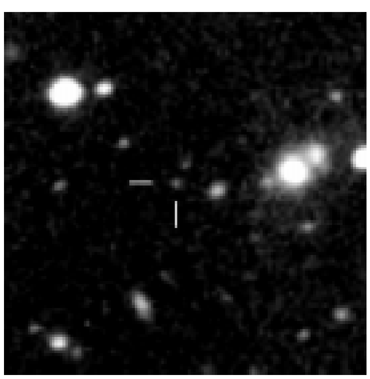

Figure 2. GRB 000926 optical afterglow imaged on September 28, 2000. North down, East left, field of view 2 arcminutes.

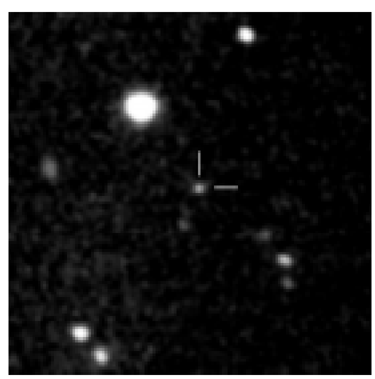

Figure 3. The optical counterpart of GRB 010222 imaged on February 22/23, 2001. North up, East left, field of view 2.5 arcminutes.

Table 1. All Nyrölä GRB optical transient observations.

Burst ID	*Delay (hrs)*	*Filter*	*Magnitude*
GRB000926	43	unfiltered	20 ± 0.2
GRB010119	42	*R*c	> 19.5
GRB010222	12.4	*B*	19.84 ± 0.31
	13.6	*R*c	19.57 ± 0.13
	14.6	*V*	19.70 ± 0.13
	15.8	*R*c	19.69 ± 0.15
	16.9	*V*	19.92 ± 0.14
	18.1	*R*c	19.92 ± 0.17
	20.1	*V*	20.29 ± 0.21
	20.6	*R*c	20.11 ± 0.31
GRB010324	10.9	unfiltered	> 18.8
GRB010412	29	*R*c	> 19.0

Magnitude reference is USNOA2.0 except for GRB 010222, for which Henden (2001c) sequence was used.

2.3. GRB010222

The very bright gamma-ray burst GRB 010222 was observed all night February 22/23, 2001, from 12 to 22 hours after the burst. The 12-hour delay in starting observations was caused by daylight and waiting for the burst localization to rise over the local horizon. Our observations were performed with photometric filters and the fading behavior of the optical afterglow was detected in *V* and *R* bands. The one-hour exposures were too short to show the optical transient well enough with *B* filter so that filter was left out from the initial plan to observe all night with all three filters. The composite (*BVR*) image of the afterglow is presented in Figure 3. The light curve is shown in Figure 4 and the individual observations are listed in Table 1. A GCN Circular was submitted by the observers (Oksanen 2001) after the careful calibration of all CCD frames.

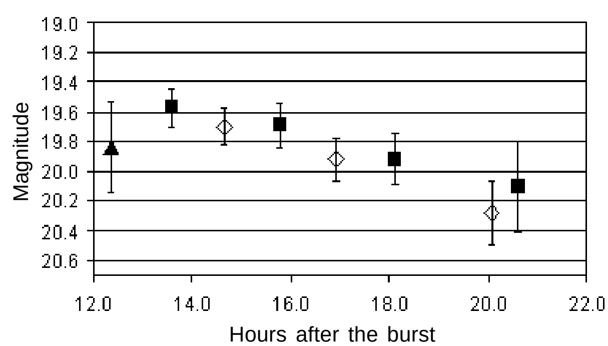

Figure 4. GRB 010222 optical observations from Nyrölä Observatory. The light curve shows fading of the optical transient in *V* and *R*c bands during the observing run. Symbols are: *B*—triangle; *V*—diamond; *R*c—square.

2.4. GRB 010324 and GRB 010412

The last two observations were both negative: GRB 010324 and GRB 010412. The upper limits for optical transients were CR (unfiltered; clear) = 18.8 and *R*c = 19.0 magnitudes, respectively. The GRB010324 field was imaged during a CCD Messier marathon just a few minutes after the alert was received from the GCN. The GRB 010324 error box was observed by several other observers of the AAVSO International GRB Network. The summary of the observations was published by Henden (2001b).

3. Conclusions

Dedicated amateurs can give significant help in GRB research with "off-the-shelf" equipment. Amateurs are often ready to observe these kinds of transient objects as they don't usually have pre-scheduled observations to do. The response time can be also very fast if the alerts are reaching the observer(s) already imaging other targets. By well-coordinated professional-amateur collaboration the amateur observations can be quickly forwarded by professional astronomers to the whole GRB community. The optical transients fade away very quickly, so the response time and the ability to image very dim objects are the key factors in successful GRB observations.

4. Acknowledgements

We want to thank Jyväskylän Sirius and the Jenny and Antti Wihuri Foundation for providing the observatory and its equipment, the Gamma-Ray Burst Coordinates Network, and especially Dr. Scott Barthelmy for accepting us amateurs in the network, the American Association of Variable Star Observers for coordinating amateur GRB observations, and Dr. Arne Henden for helping us with our observations and data reduction.

References

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