IL NUOVO CIMENTO Vol. 28 C, N. 4-5 Luglio-Ottobre 2005
DOI 10.1393/ncc/i2005-10143-0

Optical Monitors and OT/GRB analyses(*)

R. Hudec([1]) and M. Křížek([2])

([1]) *Astronomical Institute, Academy of Sciences of the Czech Republic
CZ-251 65 Ondřejov, Czech Republic*

([2]) *Astronomical Institute, Faculty of Mathematics and Physics, Charles University
Prague, Czech Republic*

(ricevuto il 23 Maggio 2005; pubblicato online il 13 Ottobre 2005)

Summary. — The Optical Monitors, despite of lower detection limits, are still valuable for detection of prompt real-time and (hypothetical) pre-burst optical emission of gamma-ray bursts. We refer on the ongoing project at the Astronomical Institute in Ondřejov based on digitized data from the photographic EN network.

PACS 98.70.Rz – γ-ray surces; γ-ray bursts.
PACS 01.30.Cc – Conference proceedings.

1. – Introduction

The recent wide use of fast robotic follow-up systems together with improved satellite data distribution networks enables to achieve the early optical emission from the Gamma-Ray Bursts (GRBs), starting at times of only tens of seconds from the onset of the GRB. However, at the same time, the time 0 s after the GRB onset can be never achieved by alert systems, and the same is valid also for the pre-burst times: even the advanced and fast alert systems will never achieve coverage for times before the GRB triggers. On the contrary, both these time windows can be easily accessed by sky monitors. This is a not trivial contribution to optical GRB instrumentation and networks, since there are theoretical expectations that optical flashes may precede GRBs [1]. In fact, this may be the reason why only in a very few cases the prompt optical emission has been detected in the past, despite of many efforts in this direction [2-4]. It is possible that the prompt optical emission can be observed also in the case of orphan optical afterglows, *i.e.* case when the GRB is observable at lower energies but not in in gamma-rays [5, 6].

(*) Paper presented at the "4th Workshop on Gamma-Ray Burst in the Afterglow Era", Rome, October 18-22, 2004.

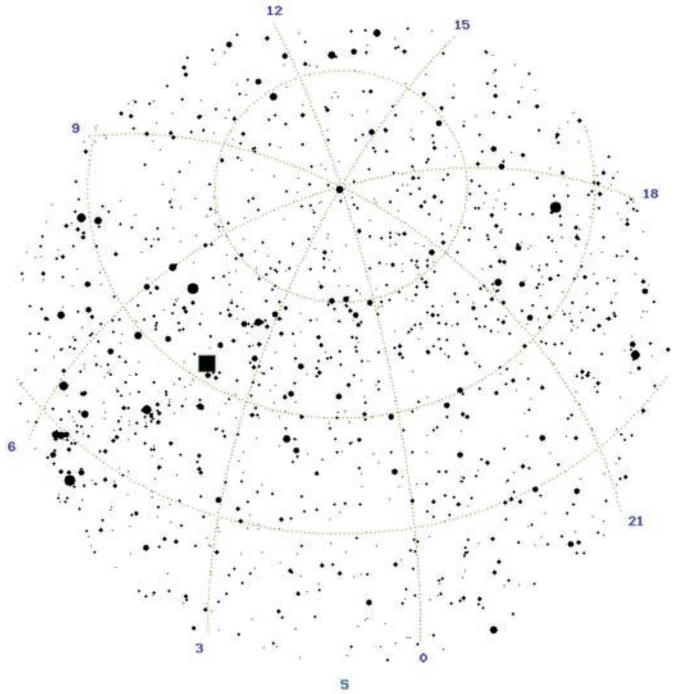

Fig. 1. – The computer-generated simulation of an all-sky image taken by an EN network guided camera (full image, 180 degrees diameter). The position of GRB031111B is indicated by a square.

2. – EN: Photographic all-sky monitoring

The European Fireball Network, EN, operates 11 stations in the Czech Republic, and hence represents an example of an extended system with a good sky coverage. The network provides simultaneous optical data for various projects (mainly meteor research and science), based on the complete sky monitoring (180 degrees diameter field of view). The cameras use the Fish-Eye Objective F-Distagon 3.5/30 lenses, while the planfilm FOMAPAN 400 ASA or 100 ASA (panchromatic emulsion) 90×120 mm, sky diameter 80 mm, serves as a detector. The typical exposure time amounts to 3 h for guided cameras, and the whole night for fixed cameras (2 stations are equipped with guided and 9 stations are equipped with fixed cameras). The sensitivity for brief 1 s triggers is 2-3 mag, and for stars up to mag 12. The response is limited to the red light above 400 nm (due to the use of massive fish-eye lenses). The preferences for the GRB/OT analyses can be summarized as follows. 1) Large sky coverage (full visible hemisphere), 2) large fraction of observation time: 2 400 to 6 000 sr.h for one station/year, 3) multiplicity of data to eliminate background triggers easily, and 4) Classification of detected triggers by parallax. The network will be operated as a fully remotely controlled network in a near future without any human assistance. The access to the plate data is facilitated by the new high-quality flatbed Heidelberg CCD film scanner with optical resolution of 3 000 dpi connected to a powerful computer/graphic station.

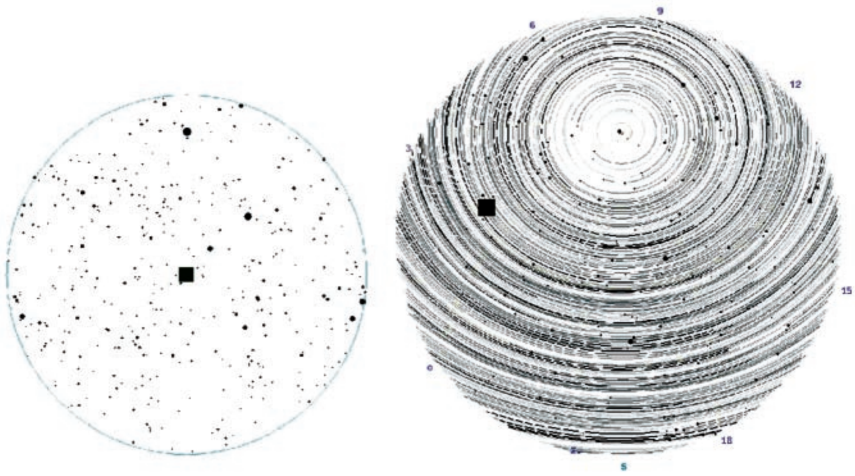

Fig. 2. – *Left*: the computer-generated simulation of an all-sky image taken by an EN network guided camera (small fraction around the GRB position, 3 degrees diameter). The position of GRB031111B is indicated by a square. *Right*: the computer-generated simulation of an all-sky image taken by an EN network non-guided (fixed) camera (full image, 180 degrees diameter). The position of GRB031111B is indicated by a square. In these images, the stars are represented by long trails, hence the simulation is essential to identify the right object position on the particular plate (which is a function of time).

3. – Summary of past GRB related results

No optical emission above mag 5 (1 s duration assumed) or mag 13 (full exposure time) or $Lg/Lo > 100$–300 has been detected for a few GRBs. The faintest limit (320) exists for GRB 830313 [7]. No optical emission above magnitudes 0–3 (1 s duration assumed) or 4–11 (full exposure time) or $Lg/Lo > 0.1$–10 has been detected for many (~ 140) GRBs. It should be however taken into account that a better statistics is required before drawing conclusions, as many GRBs have occurred under unfavorable observing conditions, resulting in degradation of the corresponding detection limits.

4. – The recent efforts

The recent efforts focus on computer-based correlation of plate databases and GRB catalogues to select all plates taken in the time period ± 3 days from the GRB trigger. Novel tools and programs have been developed to make these studies more effective and some of them are shown and are discussed in this paper. They are expected to make the plate related works and analyses, mostly laborious and time-consuming in the past, much more effective. Recently, for each GRB trigger the plates taken within 3 days from the GRB time are listed including their parameters, the computer-generated sky image analogous to the digitized plate is constructed, and the position and error box of corresponding GRB is indicated (both for pointed as well as for trailed plates). Examples are shown in this paper (figs. 1 and 2). This assumes the availability of the computer-readable observing logs (plate database) and related dedicated computer programs. Both is now available for the GRB analyses and other scientific analyses of the EN data. The selected plates relevant to particular GRBs will be then scanned by a plate scanner and further evaluated by both standard as well as specific procedures. The previous experience from the photographic emulsions analyses [8] is to be taken into account, especially regarding the plate defects and background phenomena [9, 10, 7]. The number of plates to be analysed is large: *e.g.*, for a sub-set of 182 well-localized GRBs for which pointed plates are available within ±3 d the total number of plates in this interval is 784 (but the number of positions to be investigated is 1050 since some plates correspond to more than one GRB), and for time window ±5 h from the GRB time, 34 plates are available for 23 triggers. For 8 GRBs, 12 plates taken right at the GRB time exist.

5. – Conclusion

The novel algorithms and software, together with advanced high-quality flatbed CCD plate scanners and powerful computers, allow for the first time the valuable scientific information recorded by photographic all-sky monitors to be fully and effectively extracted. The simultaneously and quasi-simultaneously exposed astronomical plates represent a suitable data source for searches for prompt optical emission of GRBs.

* * *

The study is supported by the Grant Agency of the Academy of Sciences of the Czech Republic, grant A3003206. We acknowledge the support provided by the colleagues from the Department of interplanetary matter of the Astronomical Institute in Ondrejov. Miss L. Šarounová has kindly developed computer programs for catalogue access and computer-generated images and simulations.

REFERENCES

[1] Paczynski B., astro-ph/108522 (2002).
[2] Akerlof C. *et al.*, *Nature*, **398** (1999) 400.
[3] Kehoe R., *AJ*, **577** (2002) 845.
[4] Boer M., *Baltic Astronomy*, **13** (2004) 241.
[5] Totani T. and Panaitescu A., *AJ*, **576** (2002) 120.
[6] Nakar E. *et al.*, *AJ*, **579** (2003) 699.
[7] Hudec R., *Astron. Astroph. Suppl.*, **97** (1993) 49.
[8] Hudec R., *Acta Historica Astronomiae*, **6** (1999) 28.
[9] Hudec R. and Wenzel W., *Astroph. Lett. Comm.*, **39** (1999) 249.
[10] Hudec R., *Astron. Astroph. Suppl.*, **138** (1999) 593.