

The Optical Transient Search in the Bamberg Southern Sky Survey: Preliminary Results

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Abstract

A large fraction of gamma-ray bursts temporarily emit optical light, i.e. optical afterglows and optical transients. So far, optical transients have only been detected after related gamma-ray satellite detection. However, taking into account their optical magnitudes at maximum light, these objects should be detectable in various historical and recent optical surveys, including the photographic sky patrol. Here we report on an extended study based on blink-comparison of 5004 Bamberg Observatory Southern Sky Patrol Plates performed within a student high school project (Jugend Forscht).

Keywords: gamma-ray, bursts-optical, transients-sky, surveys-photographic, sky plate archives.

1 Introduction

It is known that a substantial fraction of gamma-ray bursts (GRBs) temporarily emit (typically for minutes to weeks) optical light, namely optical afterglows (OA) and optical transients (OT). So far, these phenomena have only been detected after related gamma-ray satellite detection. However, these objects should be detectable in various historical and recent optical surveys, including the photographic sky patrol, as they may be brighter than the limits of these surveys. In addition to these triggers, one can also expect to detect in optical surveys the as yet hypothetical orphan afterglows which may be observed in optical light but are not in gamma-rays due to different opening jet angles (e.g. Hudec 2001).

In this paper, we report on the preliminary results of a study based on an extended blink-comparison of the Bamberg Observatory Southern Sky Patrol Plates performed within a German high school student project (Jugend Forscht). The Bamberg Observatory (Bavaria, Germany) dates back to 1899. The Observatory has belonged to Erlangen-Nürnberg University since 1962. The Observatory was deeply involved in variable star research in the past. The Bamberg Observatory photographic sky surveys (Hudec, 1999) were used to deliver obser-

vation data for these studies. The Bamberg plate archive contains 40 000 plates from Northern Surveys (18 000) and Southern Surveys (22 000); the relevant time periods are 1928–1939 (North) and 1963–1976 (South). The southern patrol was taken from the Boyden Observatory observing station in South Africa for variable star research (Figure 1). The northern patrol was performed in Bamberg directly. The work in variable star research in Bamberg in the past focused mostly on discoveries and on classifying new variable stars.

The archive is nowadays located in a separate building on the Observatory campus. The instrumentation available at the Bamberg Observatory for astronomical plate analyses includes an Epson Expression 1640 XL flatbed scanner for plate digitization, two plate microscopes, as well as a Zeiss blinkmicroscope (Figure 2). The Zeiss blinkmicroscope was used in the past for very extended and long-term searches for new variable stars. The measurement principle is based on blink comparison of the left and right plates (taken at various time epochs). About 1700 new variable stars have been detected this way at the Bamberg Observatory (designed as Bamberg Variables, BV). The machine is still operational at the Bamberg Observatory, and it was used in our work for re-detection of the objects on the plates.



Fig. 1: (Left) The cluster of sky patrol photographic cameras operated in the Boyden Observatory, South Africa, by the Bamberg Observatory. (Right) The Bamberg Zeiss blinkmicroscope and the Southern Sky Patrol Plates

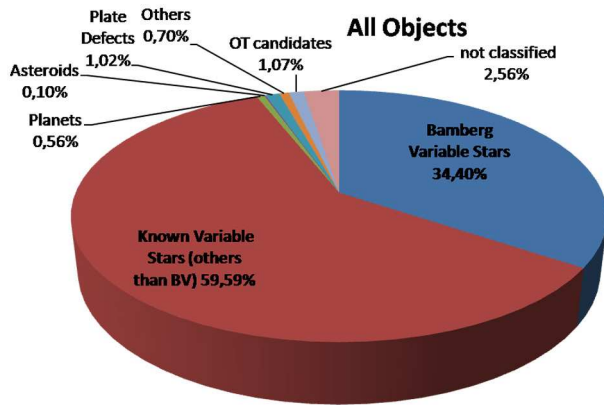


Fig. 2: Overall statistics of all 6 measurement books that have been investigated

2 The method

The search for new and variable objects was based on the blinkmicroscope method. Blinkmicroscope analyses of numerous pairs of selected high-quality sky patrol plates were conducted in the past under the direction of Prof. W. Strohmeier, former Director of the Bamberg Observatory, and his collaborators, mainly R. Knigge and H. Abt. They investigated more than 2500 southern sky survey plate pairs, where one plate pair represented about 5 hours of work at the blinkmicroscope. Each plate represents 13×13 square degrees, about 1 hr exposure time, and has a limiting magnitude of about 15 (for southern plates) i.e. enough to detect brighter OTs and OAs of GRBs. In addition, numerous (almost 1000) northern sky survey plates were investigated in a similar way (though they have not yet been included in our study). Due to the large field of view (FOV) of the plates (the northern plates are 35×35 degrees), it is one of major sky survey programmes in the past.

We have re-analysed the OT candidates recorded in 6 measurement books for southern sky surveys, with emphasis on a detailed investigation of non-classified objects suspected to occur only once (i.e.

visible only on one plate and below the limit of other plates).

3 Preliminary results and discussion

The original records of the whole project (southern sky patrol plates) led to the detection of a total of 8040 variable objects. Out of these, 2766 were identified as Bamberg Variable Stars (some twice — the total number of these objects is 1700). 4791 were identified as other known variable stars, 45 as Planets, 8 as asteroids, 82 as plate faults, 56 as known objects of other types, and 292 remained non-classified (see also Figure 2).

In our recent study, we focused on objects not previously classified, with emphasis on possible OT candidates. We have identified a total of 189 suspicious objects (possible OT candidates according to notes in the measurement logs) found in 6 measurement logs, corresponding to a total of 5004 fully investigated southern sky patrol plates. We have searched for objects which were detected only on one of several (or many) plates. We found that 86 of these are reasonable OT candidates (not emulsion defects, visible only once, no GCVS object at the position).

We note that an analogous study by Bedient (2003) indicated that out of 24 OT candidates identified by Ross (1929) 6 are asteroids misclassified as suspected variable stars. Hence one may expect that a similar fraction of these OT candidates may be asteroid images. The relevant identification study of our sample for asteroids is in progress.

The analysed datasets involved a total of 5004 southern sky patrol plates (always blinked as a pair of plates, i.e. 2502 blink comparisons), each plate representing 13×13 square = 169 square degrees and 60 min exposure time. This represents a total of 845 676 square degrees (i.e. 21.14 full sky spheres) monitored for 60 minutes, i.e. almost a full day and full sky sphere coverage. It is obvious that although the statistical expectation that there will be a real

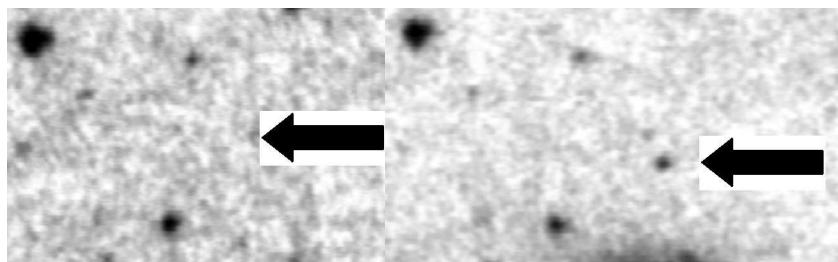


Fig. 3: Example of an OT candidate found by blink-comparison of two plates. Left: a typical plate with no object at the position, right: the OT candidate indicated by an arrow. This object was originally misclassified as a possible emulsion defect, but the recent study with advanced software confirms that the image is star-like

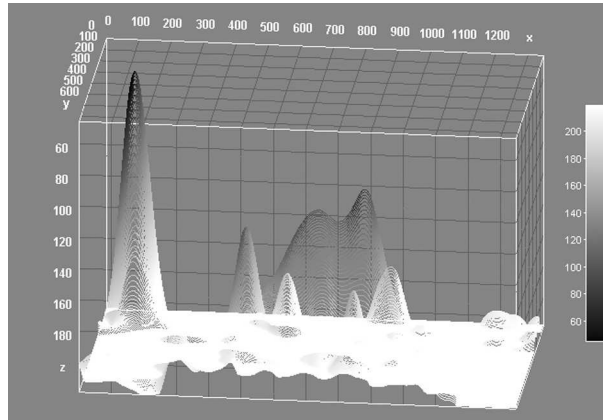


Fig. 4: An example of advanced methods used to verify the images that were found. A detailed study of the OT profile and of normal stars profiles (as 3D plots) can easily recognize and exclude emulsion defects

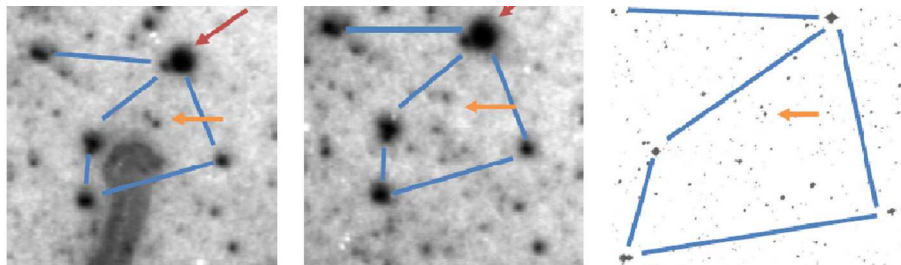


Fig. 5: The method used to identify new (unknown) variable stars among the OT sample. Left: the two Bamberg southern sky survey plates where the object is visible on the left plate and invisible on the right plate. The DSS image used for comparison is on the right and shows a star at the OT position

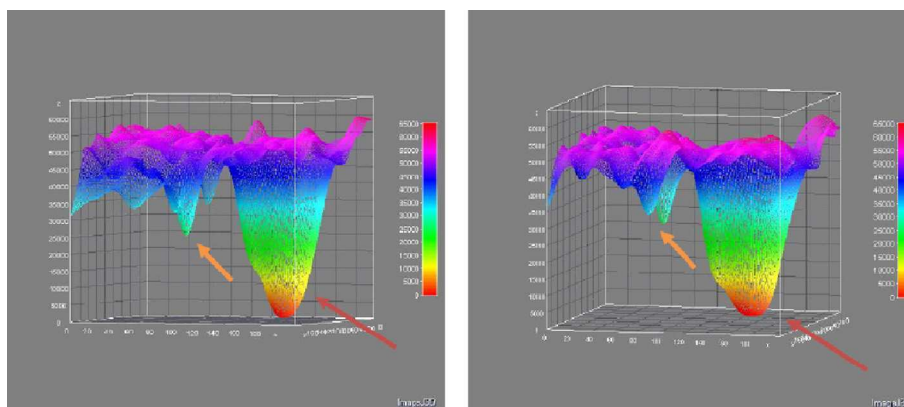


Fig. 6: 3D analyses used to analyse the profiles of the OT candidates. The image on the left corresponds to the image on the left in Figure 4. The image on the right to the image in the middle in Figure 5

GRB OT candidate in our sample is low, it is not negligible. The estimated observed GRB rate by GRBM is about 1.3/day (Guidorzi, 2011). However the intrinsic GRB rate is higher, as the estimated rate is influenced by instrument sensitivity, and one can expect there was at least one GRB inside the investigated plate sample.

In the near future we plan a further detailed analysis of selected OT candidates, using computers (scanned data) to confirm their reality (Figures 4–6).

We will also continue classifying all OT candidates, including a comparison with astronomical databases (Simbad, variable stars, asteroids, etc). The goal is to attempt to detect OTs related to historical GRBs, including orphan afterglows. We plan to study the relevant positions of the best candidates, for possible host galaxies. We note that the OT candidates noticed by past Bamberg investigators are almost free from emulsion defects, as the Bamberg astronomers were very experienced with that work.

4 Conclusion

Numerous (86) OT candidates (objects visible only once, not obvious plate defects) were detected in a very extended photographic southern sky monitoring program directed by Prof. W. Strohmeier (former Bamberg Observatory Director) and his collaborators at the Bamberg Observatory and were re-analysed by us. Their positions were given in measurement logs. We have re-analysed these logs and re-detected and investigated relevant OT candidates. The study continues with a detailed OT classification. The candidate objects were scanned and investigated by advanced computer programs.

This study won 2nd place/award in the Jugend Forscht (Youth Research) high school competition in Oberfranken/Bavaria in 2011. Fabian and Pedro are (now) 16-year-old students. The project was proposed by Rene Hudec and supervised by Rene Hudec and Uli Heber.

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