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The Optical Transient Search in the Bamberg Plate Archive

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Abstract. A substantial fraction of gamma-ray bursts is related to objects emitting temporarily optical light, i.e. optical afterglows and optical transients. So far, these phenomena (optical transients) were detected only 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 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 project (Jugend Forscht).

Keywords: Gamma-Ray Bursts, Optical Transients, Astronomical Photographic Plate Archives

PACS: 97.30, 97.80, 95.55

INTRODUCTION

A substantial fraction of gamma-ray bursts is related to objects emitting temporarily optical light, optical afterglows (OA) and optical Transients (OT). So far, these phenomena (OTs) were detected only after related gamma-ray satellite detection. However, these objects should be detectable in various historical and recent optical surveys, including photographic sky patrol. In addition to these triggers, one can also expect to detect in optical surveys the yet hypothetical orphan afterglows which are observed in optical light but are not detected in gamma-rays due to different opening jet angles (e.g. Hudec 2001). Here we report on a study based on blink-comparison of Bamberg Observatory Southern Sky Patrol Plates performed within a German high school student project (Jugend Forscht).

THE PLATE COLLECTION AT DR. REMEIS-STERNWARTE, BAMBERG

The Bamberg Observatory (Bavaria, Germany) dates back to 1899. The Observatory belongs to the University Erlangen-Nürnberg 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 data for these studies. The Bamberg plate archive contains 40 000 plates from Northern (18 000) and Southern (22 000) Surveys; 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 (Fig. 1). The northern patrol was performed in Bamberg directly. The archive is located nowadays in a separate building on the Observatory campus.

The instrumentation available at the Bamberg Observatory includes an Epson Expression 1640 XL flatbed scanner for plate digitization, as well as a Zeiss blinkmicroscope (Fig. 2). The Zeiss Blinkmicroscope was used in the past for very extended searches for new variable stars. The measurement principle is based on blink comparison of the left and the right plates. About 1700 new variable stars were detected this way at the Bamberg

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Observatory. The machine is still operational at the Bamberg Observatory and it was used in our work in re-detection of the objects on the plates.

FIGURE 1. (Left) The array of sky patrol photographic cameras operated in South Africa Boyden Observatory by the Bamberg Observatory.

FIGURE 2. (Right) The Bamberg Blinkmicroscope and Southern Sky Patrol Plates

THE BLINK PLATE COMPARISON

The blinkmicroscope analyses of numerous pairs of selected high-quality sky patrol plates were conducted in the past by Prof. W. Strohmeier, former Director of the Bamberg Observatory, and his collaborators. They have investigated more than 2500 southern sky survey plate pairs where one plate pair represented about 5 hours of work at blinkmicroscope. Each plate represents 13×13 square degrees, about 1 hr exposure, and has a limiting magnitude of about 15 (for southern plates) i.e. enough to detect bright OTs and OAs of GRBs. In addition to that, numerous (almost 1 000) northern sky survey plates were investigated in a similar way. Taking into account the large field of view (FOV) of the used plates (the northern plates are 35×35 degrees), it is one of major sky survey programmes in the past.

FIGURE 3. Left: Example of an OT candidate re-investigated on the basis of old records (left plate with OT candidate, right plate with nothing at this position) – photograph taken through the blinkmicroscope oculars

FIGURE 4. Right: Example of measurement log for blinkcomparison of two plates. Despite the fact that the measurement was performed about 40 years ago, we were able to re-discover the object on the relevant plates easily.

PRELIMINARY RESULTS

The original records of the whole project (southern sky patrol plates) led to the detection of a total of 8040 variable objects. From this amount 2766 were identified (some twice – the total number of these objects is 1700) as Bamberg Variable Stars, 4791 as others known variable stars, 45 as Planets, 8 as asteroids, 82 as plate faults, 56 as known objects of other types, and 292 remained not-classified (Fig. 3, 4).

In our recent study, we have focussed on objects not-classified with emphasis on possible OT candidates. We have identified in total 189 suspicious objects (possible OT candidates) found in 6 measurement logs, corresponding to total of 5004 fully investigated southern sky patrol plates. We have searched for objects who were detected only on one from several (or many) plates. 86 from these were found by us to represent reasonable OT candidates (not emulsion defects, visible only once, no GCVS object at the position, see Figs 3-5).

We note that analogous study by Bedient 2003 has indicated that from 24 OT candidates identified by Ross (1929) 6 represent asteroid miss-classified 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 datasets analysed involved total of 5004 southern sky patrol plates (always blinked as a pair of plates, i.e. 2500 blink comparisons), each plate representing 13×13 square = 169 square degrees and 60 min exposure. This represents in total 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 despite the statistical expectation to have a real GRB OT candidate in our sample is low, it is not negligible.

OUTLOOK AND FURTHER PLANS

In a near future we plan a further detailed analysis of selected OT candidates by computers (scanned data) to confirm their reality (Fig. 6). We will also continue classification of all OT candidates including comparison with astronomical databases (Simbad, variable stars, asteroids etc). The goal is the possible detection of OTs related to historical GRBs including orphan afterglows. For the best candidates we plan to study their relevant positions for possible host galaxies.

CONCLUSION

Numerous (86) OT candidates (objects visible only once, not obvious plate defects) were detected in a very extended photographic southern sky monitoring program 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 detailed OT classification.

The first part of this study won the 2nd place/award in the Jugend Forscht (Youth Research) high school competition in Oberfranken/Bavaria in 2009. Fabian and Pedro are (now) 16 years old students. The project was proposed by Rene Hudec and supervised by Rene Hudec and Uli Heber.

FIGURE 5. Example of an OT candidate found by blinkcomparison of two plates. Left: typical plate with no object at the position, right the OT candidate indicated by an arrow. This object was originally mis-classified as possible emulsion defect, however the recent study with advanced software confirms the image is star-like.

FIGURE 6. Example of advanced methods used to verify the found images. The detailed study of OT profile and of normal stars profiles may easily recognize and exclude emulsion defects.

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