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US Astronomical Photographic Data Archives: Hidden Treasures and Importance for High-Energy Astrophysics

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Abstract

We report here on an ongoing investigation of US astronomical plate archives and tests of the suitability of transportable scanning devices for in situ digitization of archival astronomical plates, with emphasis on application in high-energy astrophysics.

Keywords: Astronomical Data Archives: astronomical photographic archives – spectroscopy: low-dispersion spectra – data mining.

1 Introduction

There are numerous important astronomical plate archives in the USA, including plate collections that are little known to the community and that have been little investigated in the past. Within the framework of a Czech-US collaborative project (MSMT KONTAKT AMVIS ME09027), we have recently analyzed some of them, obtaining test scans with the use of a portable digitizing device. Digitization is a necessary step for an extended evaluation of the plate data using dedicated programs and powerful computers. Several recently found large US negative archives are expected to play important role in high-energy astronomy.

Motivation for including this subject into Multi–frequency studies of high energy sources is as follows. Numerous HE/VHE/UHE sources are also emitters of optical light, many of them are variable. The astronomical plate archives represent the only method how to study the behavior of the objects over very long (100 years or even more) time intervals (Hudec, 1999 and 2012). In addition, huge monitoring times allows to detect and to study rare events such as flares. The databases allow to study prominent spectra and/or spectral changes as well (Hudec et al., 2012).

2 The Plate Archives

The US astronomical archival plate collections that we recently visited and investigated include those housed in the following 16 institutions: Carnegie Observatories Pasadena, CA, Lick Observatory, CA Yerkes Observatory, WI, Mt Palomar Observatory, CA, PARI, Rosman, NC (which has a collection of plates from many observatories), KPNO Tucson, AZ, CFHT Waimea, HI, IfA Manoa, HI, USNO Flagstaff, AZ, USNO Washington, DC, Steward Observatory Tucson, AZ, NMSU, Las Cruces, NM, Rosemary Hill Observatory, University of Florida, Gainesville, FL And Leander McCormick Observatory, University of Virginia, Charlottesville, VA, Smithsonial Archives Washington, DC, and Hazy Space Center, Dulles, VA. Our estimate is that there are more than 2 million astronomical archival plates and/or negatives in these archives. There are however many US plate collections not included in our study (Robbins and Osborn, 2009). We performed a quality check and analyzed these plate archives with emphasis on their scientific, historical and cultural value, which we have found to be enormous. In addition to that, collaboration with several German Institutes with astronomical plate archives started, with emphasis on digitization and investigation of relevant photographic collections.

3 Transportable Digitizing Device

Most of the plate archives that we visited have no plate scanners and lack modern instrumentation in general. As our study includes plate digitization, it was necessary to find a solution. Since we were going to travel from Europe to the US by air, the obvious option was a transportable digitization device based on a digital camera with a high-quality lens and a stable tripod. This solution has the following advantages over other techniques: the device is easily transportable, and offers much faster scanning and higher repeatability than commercial flatbed scanners, because there are no moving scanner parts. The equipment that we used was as follows: Camera: 21 MPx Canon EOS 5D Mark II, Lenses: Canon EF 24-70 f/2.8 L USM and Canon 70-200mm F4, a stable tripod, and a Fomei LP-310 professional photographic light table. In last project year, a better custom-made light table based on highly homogeneous LED illumination was used, and also a further improved camera (39 Mpx) and lenses. The recorded images are then corrected for lens image distortions and for other effects, in order to store research-grade digital images. The achieved pixel size depends on the size of the plate, and fine pixel sizes of order of 25–30 microns or less can be typically obtained for small and medium sized plates (up to 16 cm x 16 cm or 18 cm x 24 cm) while for larger plates larger pixel sizes will be obtained (or, alternatively, the large plate may be covered by several shots to achieve smaller pixel sizes). Examples of digitized 16 cm x 16 cm plates are illustrated in Figs. 1 and 2 with relevant field recognition and star identification.

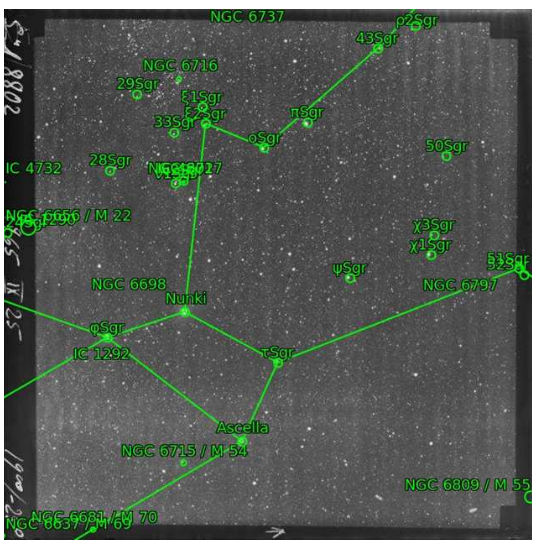

Figure 1: Example of digitized Bamberg southern sky patrol plate processed by astrometry.net tools: field recognition

4 General Picture

After visiting the US plate collections mentioned above, we offer a (subjective) list of the major problems found in these archives: (i) The list of US plate collections provided by Dr. Wayne Osborn (Robbins and Osborn, 2009) was found to be incomplete. We have found valuable plate collections with plates from important telescopes that are not listed, e.g. the two Hawaii plate collections in Manoa (Institute of Astronomy) and in Waimea (Canada-France Hawaii Telescope CFHT). Some plate archives have been completely hidden, as their home institutes were in some extreme cases not even aware that they have plate stacks. (ii) In numerous collections, only a very rough estimate of the number of plates can be given, as no exact information about the total number of plates, etc., is available. Usually, the real number of plates is higher than the previously available estimate. In general, it is very difficult to give the exact number of plates, due to lack of observation logs and inadequate organization of the plate archives. (iii) In many cases, there is no contact person responsible for the plate archive, and it is difficult to make contact. In some places, it is even difficult to get access. This situation very has a serious adverse effect on efforts to exploit these plate collections for scientific purposes. (iv) For some archives, no information is available, not even an approximate number of plates. In many archives, no plate logs are available; they have either been removed or are lost. The only available information is what is written on the plates or on the envelopes (in some cases, there is not even adequate information on the envelope). We guess that there were originally observation logs, but that these were later separated from the plates and archived in a different location. Example: Carnegie Observatories Pasadena (nearly 0.5 million plates), where the logs are probably located in the attic above the library, with difficult access. (v) Damaged plates in some archives (mostly due to a partly-released or even complete released emulsion layer), probably due to improper storage (or changes in humidity/temperature over time). We point out however that even these plates can be restored using suitable chemical methods and procedures. (vi) Lack of electronic records - no lists of plates, the only information is on the plates and/or plate envelopes (vii) Many of the archives that we visited suffer from inadequate funding, lack of devices, e.g. no scanners. (viii) We have revealed that many plates have been removed from their home: these plates are usually scattered in private homes and offices, or are being kept by observers (often abroad). Numerous plates taken at US observatories have been found in European plate archives. Nevertheless, we found highly valuable plates almost everywhere, and the quality of the plates (and hence their scientific potential) is mostly high or even very high, in comparison with the plates in European archives. This is true both for direct images and for spectral images (taken with an objective prism). In addition to stellar images, some of the archives that we visited also include extensive collections of solar images (e.g. Carnegie Observatories in Pasadena) and/or planetary images (unique collection in Las Cruces). The storage conditions were found to vary from archive to archive, from proper temperature and humidity conditions, to less proper conditions. The main degradation sources found in the plate collections were high levels of humidity and probably also temperature variation, resulting in partial or complete release of the emulsion layer. The scientific use of the plate archives is negatively impacted by poor access to the plates at some places, and also by the fact that the plates have in most cases not yet been cataloged.

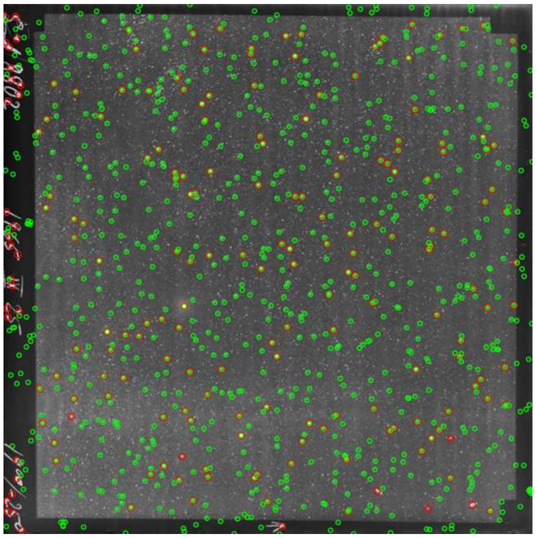

Figure 2: Example of digitized Bamberg southern sky patrol plate processed by astrometry.net tools: star identification/astrometry

5 Two Recently Found Large US Archives with Possible Major Impact on HEA

The two following databases found within our project are expected to play an especially important role in high-energy astronomy.

Baker Super Schmidt camera domed films with 55 degrees diameter FOV, limiting magnitude up to 15, dense sampling 20 min, ∼ 110 000 negatives (Fig. 5), ∼ 10 years coverage. The essential part of the archive is located at PARI (Pisgah Astronomical Research Institute) in NC.

Baker-Nunn camera networks negatives FOV 30 x 5 degrees, limiting magnitude up to 16, very dense sampling ∼ few sec, more than 1 mil negatives, ∼20 years coverage (Figs. 3 and 4). The part of the archive (21 boxes with ∼ 2000 film rolls) is located at Smithsonian Institution Archive in Washington, D.C.

These data are suitable for wide-field studies, Optical Transient (OT) searches, and fast variability studies. There are up to 100 000 stars per 1 full frame. These data represent direct images suitable for photometry. However, one Baker Nunn Kwajalein Slit-less Spectrograph Camera for U.S. Air Force was designed to provide unique low–dispersive spectra. This Baker Nunn Missal Reentry Tracking Camera consisted of a three-element 20-inch entrance aperture corrector lens system. Mounted on top of the corrector lens assembly was a multi-set of triangular prisms converting the incoming sky image into a spectrum image.

Figure 3: Dismantling of the USAF Baker–Nunn camera at the Evergreen Aviation & Space Museum, McMinnville, Oregon, United States

Figure 4: Example of digitized film from SAO Baker–Nunn camera

The corrected spectral image is then projected down to a 31-inch f/1 spherical primary mirror. The focusing converging image was then reflected back up to a 4-inch x 6-inch x 0.6-inch thick mosaic of fiber-optics making film supporting focusing plate. The resulting database is expected to has applications in astronomy as well.

6 Summary

16 US astronomical plate archives were visited within the AMVIS Czech-US collaborative project. The quality of the plates and their scientific, historical and cultural value were investigated for possible inclusion in the US astronomical plate repository at PARI, NC. Some of these archives (e.g. Baker Super Schmidt, Baker–Nunn, CFHT Waimea, IfA Manoa) were un-

known to the astronomical community before our study, and the two first mentioned are expected to play important role in high–energy astronomy because of their very wide–field and very fine time resolution.

Selected plates were digitized using a transportable scanning device. All the archives that we visited have plates that are scientifically valuable, and in many cases unique. The plates are however mostly hidden from the astronomical community, and the plates have not yet been catalogued.

The total number of plates is higher than expected - in many of the locations, the actual number of plates is unknown. As no catalogs exist, the real number of plates is very difficult to estimate, but for sure the places that we visited have more than 2 million photographic plates and/or negatives in their collections. We plan to continue these efforts, now with emphasis on German astronomical plate collections.

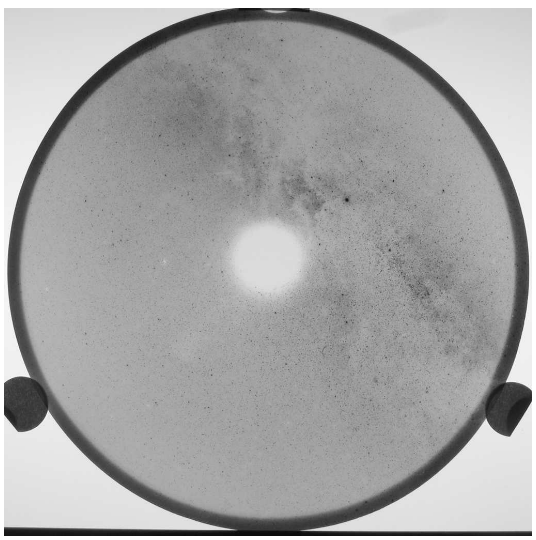

Figure 5: Example of digitized film from SAO Baker Super Schmidt camera

We plan to continue data mining and plate digitization in astronomical photographic plate/negative archives is as follows. (i) Digitize the plate archives using a fast and transportable scanning device, as described above. This scanning method is fast and inexpensive. These are important considerations, as the archives are scattered and there are very large numbers of plates. (ii) Create electronic catalogs. (iii) Include these catalogs into search programs like WFPD, operated by our Bulgarian colleagues (e.g. Tsvetkov et al., 2005, and Tsvetkov, 2009).

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References

[1] Hudec, R. et al., Acta Polytechnica, IBWS2011 Proceedings, 1(52), 2012.

[2] Hudec, R. Astrophysics with Astronomical Plate Archives, in Exploring the Cosmic Frontier: Astrophysical Instruments for the 21st Century. ESO Astrophysics Symposia, European Southern Observatory series. Edited by Andrei P. Lobanov, J. Anton Zensus, Catherine Cesarsky and Phillip J. Diamond. Series editor: Bruno Leibundgut, ESO. ISBN 978-3-540-39755-7. Published by Springer-Verlag, Berlin and Heidelberg, Germany, 2007, p.79

[3] Hudec, R., An introduction to the world's large plate archives, Acta Historica Astronomiae, vol. 6, p. 28-40, 1999.

[4] Robbins, L.; Osborn, W., Preserving Astronomy's Photographic Legacy: Current State and the Future of North American Astronomical Plates. ASP Conference Series, Vol. 410, Appendix B and C. Edited by Wayne Osborn and Lee Robbins. San Francisco: Astronomical Society of the Pacific, 2009.