Utilizing Astronomy's Photographic Heritage: Progress, Problems and Challenges

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Abstract

This paper critically examines the use in modern research of astronomy's rich store of over one hundred years of photographic observations. The necessary steps to permit such use are summarized, and a few success stories mentioned. The problems that presently cause limited use of -- and little interest in -- this material by most researchers are discussed. Opinions are offered on how to best meet the challenge of ensuring that the photographic material becomes recognized as an important observational resource.

Keywords: Photographic astronomical observations

Introduction

Photographic astronomical observations became practical with the invention of the dry gelatin plate technique in 1871; they have been routinely carried out since the 1880s [1]. It is estimated that some four million of these photographic records still exist [2, 3]. Most are located in the files of present or former observatories, but there is an increasing trend toward combining collections in specialized centers. Examples are the Astronomical Photographic Data Archive (APDA) at PARI in North America [4], the Uccle Direct Astronomical Plate Archive Centre (UDPAC) in Western Europe [5], and the Zo-Se plate archive in China [6].

It is well known that the photographic material represents a unique and irreproducible source of astronomical data [7, 8, 9]. It has particular value for research on long-term variability and as a complement to the synoptic surveys now being initiated (e.g., LSST, GAIA). It also provides the only data available for historic events such as, for example, the past outbursts of novae and passages of non-periodic comets. Nevertheless, presently relatively little use is made of this large observational data set. This paper explores the reasons for this and offers some opinions on what might be done to make the photographic data an integral part of modern astronomical research.

Using the Photographic Material

There are two basic approaches to utilizing photographic data sets for science. The first, approach is the survey of a given region of the sky. As many plates of the selected sky region as are available are digitized, and then all objects detected on the plates (above a certain threshold) are compared seeking changes in brightness (or possibly position). This approach has the most potential for scientific return but requires a large investment of both time and funds. The DASCH project at Harvard College Observatory is the archetype for photographic surveys of the time domain [10].

This project will eventually provide time coverage of 100 years (1890 - 1990) for the entire sky with a typical cadence of two weeks. About 60,000 of Harvard's collection of 450,000 direct plates have so far been digitized, with the resulting data being released as given fields are completed. Although less than 15% of the plates have been scanned, the scientific value of this project has already been demonstrated: discoveries of a new class of K giant variables and of new symbiotic novae, to mention two examples. A second survey worth noting is the digitization of plates from Italian observatories which produced the Asiago Photographic Archive (http://dipastro.pd.astro.it/asiago/). This survey has also yielded valuable scientific results, particularly on symbiotic stars and novae (see, for example, [11]).

The second, and most utilized, approach for scientific use of the archival photographic material is the targeted approach: study of one particular object. The most common case is the study of photometric variability. For this, the object's brightness is determined - often by simple eye estimate - on as many plates as can be accessed. A good example of scientific results from a targeted study is the discovery from archival data that the recurrent nova T Pyx shows a steady secular decline in brightness underlying its periodic outbursts [12]. The targeted approach is also that usually employed for scientific study of spectra, but in some cases the targets are not a particular astronomical object but a specific spectral feature (e.g., Hα or Ca II lines).

Increasing the Usage

There is tremendous potential for astronomical discoveries in the archival photographic records. Their scientific value has been demonstrated many times, some examples of which have just been mentioned. It is therefore surprising that relatively little use is made of these data in comparison to other archival data sets. An ADS search for papers published in the five most-read astronomical journals - A&A, ApJ, AJ, MNRAS, PASP - in the past five years (2009 - 2013) yielded only thirty-three papers that utilized unpublished photographic material *for scientific investigations* (papers that describe plate archives, digitization projects, scanner tests and the like were not counted).[1] While some papers certainly have been overlooked, this number can compared to the over 8400 articles in these journals in 2013 alone! Table 1 gives some basic statistics for the 33 papers. One notes (1) the wide variety in the types of objects that were the subject of the study, (2) that in several cases the only photographic data used came from the well-known digitized sky surveys that are on-line and (3) projects that employed direct plates dominate; papers utilizing archival photographic spectra, both slit and objective prism, are few.

The limited use can be attributed to three main factors. The majority of today's astronomers were trained in the CCD era and are not aware that this rich resource exists. Of those that are aware of its existence, many think the old photographic data is not trustworthy (in some cases this had led to plates being discarded). In fact, results from such observations can be just as reliable as those from modern detectors *but only if care is taken to ensure high quality measurement*; on the other hand, careless plate measurement, such as digitization with an unreliable flatbed scanner, can introduce errors that compromise the science as well as tarnish the reputation of photographic data [14, 15, 16, 17]. Finally,

[1] A similar compilation for 2000 - 2008 [13] lists 57 papers, which gives an average of only six papers per year in these journals over the past fourteen years See http://atlas.obs-hp.fr/pdpp/publications/ for more details.

Table 1. Properties of research papers in 2009 - 2013 that utilized photographic plate

Type of plates used	Direct plates of star fields = 30, slit spectra = 2, solar patrol plates = 1
Approach used	Survey approach = 6, targeted approach = 27
Purpose	Photometry = 23, astrometry = 3, spectroscopy = 2, morphology =1, search and discovery = 4
Subject	Star (usually a variable) = 17, nova = 7, extragalactic object = 5, stellar cluster = 2, sun = 1, planetary satellites = 1
Source of plate material	1 plate archive = 13, 2 archives = 6, more than 2 archives = 5, DASCH survey = 4, other survey = 1, on-line digital sky surveys = 4

there is the difficulty in locating and accessing the data desired. The reduced data (magnitudes, calibrated spectra) are usually not available on-line nor are the original images that could be down-loaded and measured, as is often the case with CCD observations. Use of photographic records often requires a visit the plate archive and physically handling each plate of interest. This final factor is, however, gradually being addressed by plate digitization programs.

Perhaps more surprising than the low usage of the photographic material is the limited interest in these data by the astronomical community given its known scientific value. This is reflected by the lack of support - by both research groups and funding agencies - for projects intended to make photographic records more accessible; many such projects have been curtailed or eliminated for financial reasons. One can ask what needs to be done to make the photographic observations become recognized as an integral part of modern astronomical research data.[2] Below are four possibilities for discussion.

First, it is common for investigators using photographic data to utilize plates from only one archive. The norm in modern astronomical research is the collaborative effort, usually involving investigators from several institutions. Utilizing plates from several collections would improve the historical data, particularly time coverage in variability studies. I can cite studies where relevant plates in our Yerkes plate collection were not utilized. The use of an institution's plates greatly helps it in justifying the importance of its plate collection and in seeking funding. Shouldn't researchers be encouraged to broaden their nets when using photographic data?

Second, effective use of the targeted approach in using plates, as well to a certain extent of the survey approach, requires catalogs so those plates of interest can be located. There is a critical need for internet-searchable catalogs of the plates held in plate collections. The useful Wide Field Plate Database (http://www.skyarchive.org; [18]) lists where plate collections are located, but the catalogs listing the individual plates are not easily located, if they even exist. I would argue producing detailed catalogs of plates in collections should be a higher priority at this time than digitizing small sets of plates. If a researcher knows the identities of relevant plates, he or she can probably arrange for

[2] This would no doubt occur if paper referees would question, when relevant, whether the authors have examined the historical record in the same was as they often ask them if pertinent theoretical predictions or observations in other wavelength regions were considered.

digitization. Further, these plate catalogs need not only to be on-line, the links must be easily accessible and discoverable. The wide-spread use of the digital sky surveys, 2MASS and Sloan data and the like reflects their well-known and easily-used internet links. Shouldn't the creation of a prominent web page with links to all the existing on-line plate catalogs be a high priority?

Third, more communication and collaborative efforts are needed between the groups involved in cataloguing and digitizing plates. The DASCH project likely will eventually produce the fundamental database for time domain investigations involving the last century. But to optimize the database the Harvard plates need to be supplemented with plates from other collections. The Harvard plates have gaps in their time coverage, most notably the infamous Menzel gap of 1954 - 1965 which resulted from the 1950's decision by then Observatory Director D. Menzel to discarded some plates to create more office space and to suspend Harvard's long-running photographic sky patrol for budgetary reasons. There are several plate collections that can help fill this lack of coverage for the northern sky (e.g., Sonneberg's), but identifying southern-sky plates taken in this period is more challenging and should be a priority. Shouldn't the plate archive community start work now to identify and ensure preserving of those plates that can eventually be used to address this shortcoming of the Harvard data?

Finally, there is presently the tendency for those involved in plate cataloging and digitizing efforts to work fairly independently. At times, groups may even be competing for support. Shouldn't this work be conducted in the modern way - a coordinated, international team approach rather than the independent individual efforts most common at present?

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