Wits Astronomical Plate Archive – preservation of a century of Southern Hemisphere astronomy at the Johannesburg Observatory

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Abstract. In the present digital age, there is a growing potential to preserve the heritage of photographic astronomical observations by digitizing glass plates, especially necessary since photographic emulsions deteriorate over time. The original exposure of a glass plate was often for a specific astronomical object. However, now using modern DSLR camera, computer and Internet technology and the large number of standard stars on record, it has been possible to calibrate in the region of 60 000 stars, on average, on a single plate. This, in addition to the long time covered by the data and the accessibility of the data when posted on the Internet.

1. Introduction

The plates were held in the CSIR Archive in Pretoria without being accessed for about 30 years after the Johannesburg Observatory was closed in the late 1970's. In 2009 an astronomer at the South African Astronomical Observatory (SAAO) in Cape Town, Dr Ian Glass, on a visit to the CSIR Archive, was informed of the situation and that the space occupied was needed for other purposes. Dr Glass circulated a notice to this effect to Jhb ASSA and others. As librarian of the Jhb ASSA library, I was aware of some printed, Southern Hemisphere star charts in the library. Previously Jhb ASSA had recorded the idea of locating the glass plate originals, digitizing them and posting them on the Internet. Some sampling and estimating in the CSIR Archive soon showed that the archive contained approximately 10 000 plates, many more than the set of 556 glass plate originals of the glossy paper prints that had had been made to cover the southern sky from -19 to -90 degrees of declination [1]. Many more than originally thought.The lack of access to the plates was not an indication that they were worthless, but an indication of how impractical it was to travel to far-off archives and manually search for the required plates decades after the plates were exposed and stored. Completion of the task took many years and in the pre-digital era, dispatch by post to other observatories was the most practical method of distribution. These charts served as useful finder charts amongst the few Southern Hemisphere astronomical observatories in the early years of the 20th century. There were no plate registers in the CSIR Archive for the Franklin-Adams star camera. This was a potential fatal flaw to the whole plate preservation project and a real world example of just one of the difficulties of accessing an astronomical glass plate archive.

2. **The DASCH project** (Digital Access to a Sky Century at Harvard) [2]
Alternative accommodation was deemed more urgent than digitizing and Internet posting, so after securing at least 6 months storage at the premises of an engineering company in Johannesburg to which I had an association, we moved plates and compartmentalized plate cabinets in October 2010. While moving plates, I met Dr Keith Snedegar, Professor of History, Utah Valley University, USA who was doing research at the CSIR archive on the lives of early South African astronomers. He was well acquainted with astronomical plate preservation in the USA and sent information to me on the DASCH project.

2.1. 2000 dots per inch scanning resolution

The most surprising thing to me about the DASCH project was the scanning density of at least 2000 dots per inch required for the data transfer from plate image to computer file. That is equivalent to a dot pitch of 13 microns on a flat-bed scanner. Not much room for velocity errors of the moving parts of the flat-bed scanner. In the early stages of the DASCH project, around 2005, numerous assessments of high-end (and high cost) scanners were published by others. The DASCH project team decided to modify a micro-densitometer to digitize whole plates pixel by pixel at a pitch of approximately 10 microns (2500 dpi). [3] A micro-densitometer is typically used to record the opacity of thin sections of geological and metallurgical samples. The Harvard College Observatory (HCO) plate collection consists of about half a million plates and the HCO team soon decided to build a mark 2 precision plate scanner that could scan 4 pixels at a time relying on the precise position control of the micro-densitometer, at a budget cost of $50 000 US. [4]. Clearly, the DASCH team did not wish to risk scanning 500 000 plates using flat-bed scanners with any uncertainty about their precise plate movement control. The DASCH project was an early development in the history of glass plate digitization, based on highly specialized equipment, and the software developed for the calibration of the digitized plates was not published. Apart from the cost of the digitizing method, this was a further barrier to the prospect of adopting a similar approach.

In 1980's correspondence, the CSIR archivist traced 4 of the 5 Franklin-Adams plate registers to the SAAO library in Cape Town. On a holiday visit to Cape Town shortly afterwards I was able to inspect the plate registers and collect some photocopies of pages. Location of these Franklin-Adams star camera plate registers removed a major concern about the viability of the plate preservation project.

The plates remained in two temporary storage sites until 2014 when Wits got to hear about the difficulty that Jhb ASSA was having with finding permanent storage for the plates. As developments occurred with the Square Kilometre Array project, Wits expanded into Astronomy and Astrophysics and the School of Physics took over the management of the Wits Planetarium on the Wits campus. A member of the Planetarium staff mentioned to his new management the difficulty that Jhb ASSA was having in securing permanent storage for the Franklin-Adams star camera plates.

3. **Wits Plate Archive**

Professor John Carter, Head of Wits School of Physics and Prof Sergio Colafrancesco, Professor of Radio Astronomy, promptly arranged to inspect the plates in temporary storage at the site of the former Johannesburg Observatory, and expressed support for the concept of safe storage and digitization of the plates. For the proposed Wits Plate Archive, Wits cleared a windowless, force ventilated space. It was also necessary to remove the plumbing, as century old plate emulsions and water leaks should not share the same room. The plates were moved to the Wits School of Physics in April 2015 (see Fig. 1) and there was an Inaugural Function later that year in November 2015 (see Fig. 2).

Figure 1. Wits Astronomical Plate Archive.

The jacketed plates, about half of them, were returned to their compartmentalized wooden cabinets. The remainder were still packed in plate number order with tissue paper separators in the same cardboard boxes used to hold them at the CSIR Archive. These boxes were the same boxes in which unexposed plates had been received. The only identification of the boxed plates was a plate serial number inscribed by hand on the emulsion side of each plate. The plate registers were laid out in ranges of declination angles typically 5° to 20° wide. For the boxed plates, it was very difficult to find the plate register information relating to a particular plate number. This would remain an unsolved problem while sampling and digitizing the jacketed plates because all plate data was written on the outside of the plate jackets.

4. Scanning the Jacketed Sample Plates

Professor Colafrancesco recommended the use of a DSLR (Digital Single Lens Reflex) camera and light table instead of a flat-bed scanner for digitizing astronomical plates. This approach avoided the precision drive required for the moving parts of a flat-bed scanner and captured many megabits of information in a fraction of a second. After this decision, work commenced on digitizing a $1/20^{th}$ (later reduced to $1/40^{th}$) sample of jacketed plates to give some idea of plate contents, and for practicing the digitizing method before digitizing the whole plate collection. To facilitate space navigation and support digital astronomy, there are now so many stable, standard stars on record that there are enough on-plate standard stars on any plate for calibrating the brightness of all other stars on the plate. This greatly simplifies the calibration process between the plate exposure conditions and the lighting conditions for the plate data capture. Digitizing the jacketed plate sample commenced with a borrowed 34-megapixel Canon 5D Mark IV DSLR camera mounted above a light table. The camera was connected to a Wi-Fi shutter release to keep the camera steady and a tablet computer for convenient display of the camera target view.

Figure 2. Wits Plate Archive Inaugural Function November 2015. Top left and right: Halley's Comet 1910. Middle left: Mrs Hillary Veale (far left) a Wits Alumna whose generous donation made the Plate Archive possible. Middle right: The Moon. Bottom left: original packing unexposed photographic plates. Bottom right: viewing plate examples on light table.

5. Progress in digitisation of Astronomical Photographic Plates

The Astro-Plate Proceedings, Prague (rev. 2), 2014 [5] covered a workshop that presented a wide range of 42 glass plate preservation topics, in a 137 page document, including:

- presentations on the use of DSLR cameras instead of flat-bed scanners for digitising astronomical photographic plates and
- the APPLAUSE Collaboration.

In particular, APPLAUSE is an acronym for "Archives of Photographic Plates for Astronomical USE" [6]. The APPLAUSE Collaboration is a group of German astronomical observatories that have digitised about

85 000 photographic plates using high-resolution flatbed scanners. Of further interest, the APPLAUSE Collaboration has also calibrated and stored online the digital files produced from the 85 000 glass plates using the open-source Python package called Pyplate. It appears that the Python programming only requires the calling of proven software modules to create the desired software pipelines, for example, photometric and astrometric information.

6. The importance of Astronomical Plate Registers

After the Franklin-Adams plate registers Volumes I to IV were formally transferred from the SAAO Library to the Wits School of Physics we could see that there were some loose pages and some of the paper pages were becoming brittle and easily torn due to a slight snag when turning a page. To protect against loss of the four irreplaceable registers, we decided to photograph all written pages at JPEG resolution to provide working copies and avoid wear and tear.

To avoid nuisance flash reflections, we found that best results were obtained with no flash, close to a window in indirect sunlight. Some 8 mm diameter, mild steel page flatteners were used and the work proceeded quicker than expected with two operators, one for the camera and one to move page flatteners and turn pages. Having copies made it possible to work at home with the photographed pages of the plate registers. An unexpected advantage of the on-screen register pages was that indistinct handwriting could be quickly resolved in most cases by zooming the text up to 500%

Plate register copies at home also helped us to confirm a disputed comet from 1971, observed in New Zealand. An American author of a book in preparation on disputed comets contacted us to ask if we could find a confirming plate in the Union Observatory (now Johannesburg Observatory) plate collection. We found a plate that matched the search criteria and sent a scanned copy to him. Later, we received a copy of Electronic Telegram No. 5239 from the Central Bureau for Astronomical Telegrams confirming recognition of Comet c/1971M1 (EDWARDS).

7. Accessing the Plate Register Data for the Boxed Plates

This was a long-term worry because we knew that the plate registers were arranged in divisions of declination angle, typically 5° to 20° and the plates were arranged in plate serial number order on the shelves. The only identification for any plate removed from a box is a number of up to 5 digits inscribed on the emulsion side of the plate. Some areas of sky are observed more frequently than others, so some sections of the registers fill up more quickly than others and entries sometimes continue to blank pages in the same register or even in the next register. Before computers could quickly and effortlessly sort lists of thousands of items, the register layout in declination order made sense for astronomers, and less so for archivists. An astronomer would have a better idea of relevant celestial co-ordinates and would have a better idea than an archivist of how to narrow down the search in the plate register.

The only way to connect 10 000 plate numbers ranging from 1 000 to the mid 20 thousands in the order of astronomical declination angle, is to work through the plate registers volume by volume and page by page noting plate, volume and page numbers. This handwritten information would then be recorded in a 10 000-line spreadsheet so that it could be sorted into plate number order. This would create the index connecting plate number to plate register entry and the official plate meta-data recorded in the plate registers.

Creating a 10 000 line spreadsheet sounds like a tall order, but some simplifications became apparent:

- Only **plate** and **page** numbers are required on every line.
- The **page** number requires a manual change about once every 30 **plate** numbers
- The thousand digit in the **plate** number requires a manual increment about once in every 900 **plate** numbers.

- Only the 3 least significant digits of each **plate** number must be entered manually. This greatly reduced short term memory errors like transposition of digits when entering longer strings of digits.

- In a **plate** number, the thousand digit repeats from the previous line and only needs to be increased manually when the last three digits reach 000.

- The spreadsheet multiplies the digits signifying thousands in the **plate** number by 1000, then adds the last 3 digits, streamlining data entry and reducing errors.

8. Summary and Outlook

The recent developments in cameras together with those in computers and the internet have had an enormous positive impact on the preservation and world-wide accessibility of the last century and a half of photographic astronomical observations which would have otherwise been lost. It is now possible to extract detailed information on many thousands of astronomical sources from a single plate previously unthinkable at the time of exposure. The Wits Plate Archive is taking the first steps to preserve more of the limited southern-hemisphere historical astronomical data accessible to present day astronomers. It was through the foresight of Prof Sergio Colafrancesco that the heritage of the Wits Plate Archive was preserved for future use but it is very sad to note that Sergio passed away a few years after the Inaugural function of the Wits Plate Archive. He is sorely missed.

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