SCAN–IT

The IAU Working Group for the

Preservation and Digitization of Photographic Plates

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Message from the Chair: The Time Has Come...

Elizabeth Griffin (Elizabeth.Griffin@nrc.gc.ca), PDPP Chair

Dear PDPP Member and SCAN-IT Reader,

Time for what?? Time to translate all our noble words into actions.

It is now 15 years – almost a tenured research-career half-life – since IAU Resolution C13 drew attention to the "large amount of spectroscopic data ... collected on photographic plates" and recommended establishing an agreed means to archive and distribute those, plus electronically-observed, data. We accordingly created the Working Group for Spectroscopic Data Archives (SDAWG), making one of its objectives the safeguarding of historic photographic spectra. Out of that aim grew the plan to set up a spectroscopic scanning laboratory in order to digitize spectra selected according to (a) type (all coudé plates), (b) object (those of known variability) and (c) demand (i.e. what astronomers want to see soon). The project as first announced to a meeting (actually of the AAVSO in Sion) in 1998 was labelled the Virtual Observatory, and its Website coined that term as its own. Within 2 years, unfortunately, others with more clout had taken up the name for themselves, so in deference to greater might we have re-named ours the Spectroscopic Virtual Observatory (SVO). But it is still a protégé of the SDAWG.

However, that is about to change. The SDAWG feels it has fulfilled its mandate to "encourage the creation and maintenance of archives of spectroscopic data" as far as it reasonably can for the present, but notices that the true barrier to more widespread and more *effective* archiving of spectra is the software needed to establish accurate pipeline reduction procedures. The SDAWG is therefore turning its attention to that scene instead – with doubtless some changes in personnel (I for one will no longer be the Chair). And it will not want to have the SVO tagging along.

Meanwhile, the PDPP was created in 2000 as a direct result of the debâcle at the Manchester GA over the successful passage of Resolution B3 on "Safeguarding the Information in Photographic Observations". The wording of the Resolution was simple and direct: it recommended the transfer of historic observations onto modern media by digital techniques. Had the IAU Executive Committee not taken inexplicable exception to such a harmless and commonsense Resolution and tried to kill it off through a debate, most of the IAU would probably have remained unaware of what we are trying to do; but by voting *en bloc* against it and challenging the floor (which included great figures like former IAU President Jean-Claude Pecker) they were beaten at their own game and our Resolution became, for a while, one of the hottest topics in astronomy politics. Wishing to focus that energy into productive channels, I thereupon requested to form a new Task Force to enact the Resolution. Thus the PDPP came into being; it is broader than the SVO but at present has not attempted action so has therefore been somewhat complementary to it.

Now is the time to unhook the SVO from the SDAWG and hand it over to the PDPP. The PDPP has hosted discussions about plate preservation, but individual groups are tackling plate digitization too. Now is the time for the PDPP also to shoulder some responsibility about digitizing plates *and their associated logs.*

Membership of PDPP is growing. This issue of SCAN-IT contains articles by newcomers reporting on digitizing projects that are entirely their own initiative – whether from a graduate student in Virginia or Mexico or staff at an Observatory in Venezuela or Estonia, these reports are saying that people want to get archives digitized, and that they will use whatever equipment their budgets and time-scales can support. Yet there are also many gaps; observatories in France, Japan, Australia, South Africa, the US, Canada... whose current focus is sufficiently far from historical observations are storing plates that probably never will get digitized unless by some central organization. We have identified PARI as an ideal scanning location and long-term plate repository for the US; in Europe it was agreed by the Royal Observatory of Belgium (Brussels) to seek ways of setting up a pan-European plate-storage and scanning facility there, and a pilot project has since been funded; but we are still leaving it very much to the enthusiast and the individual to get things moving. Given the nature and pressure of competition for research funding, anyone hoping to win resources to digitize material whose foreseen use can only be judged by hindsight is starting with a serious handicap. But supposing the whole of the PDPP movement, implying endorsement by all observatories concerned, were to design a suite of projects and submit applications to appropriate sources for funds, would that not be a better way to channel our energy on behalf of the astronomical community?

This is one of the matters to be debated in Prague – you will find a notice about the meeting on page 4. It is not solely a question of politics, i.e. where and when to submit a proposal, but also one of science: what sort of scanner is "best", which of the commercial ones are above reproach and in which situations can they be used? Is it possible to clone the Harvard Scanner (see page 5)? Can more projects use the D4A Digitizer (see page 11) currently under construction in Brussels?

Just as urgently: can we not get those log-books digitized? No library worth its salt nowadays would countenance "only" a manual card-index or a hand-written list of holdings! Every museum has some sort of accessible and searchable catalogue of what it contains. Yet astronomers guard treasures that are not only valuable for their own (historic and cultural) sakes but have immense potential for the science that they can reveal, whether crucial timings of past stellar variability, hitherto unknown observations of (e.g.) near-earth objects or evidence of what the concentration of the earth's ozone layer used to be at times and places where no other monitoring was carried out. These are all cast-iron reasons why we need to be able to access and share information of what has been observed, where, and when. The task of manually keying-in the log-book information is not rocket science, but a straightforward clerical job requiring just a small amount of supervision. Is it 'too basic' for modern astronomy to fund? If so, let's ask Library and cultural sources to help us pay to get the job done. It would create an interesting contribution to Public Education and Outreach; a few years ago when the SVO was given coverage by local newspapers, journalists took far more interest in it than astronomers did.

Spread the word, and encourage the pooling of ideas and results. Together we can tackle this matter. If man can recover fantastically close-up digital images of the planets in the solar system, surely we can manage, between us, to generate digital images of the glass plates that we hold in our hand?

IAU General Assembly: PDPP Task Force meeting

The PDPP Task Force invites you to its meeting on Thursday August 17, 2:00–5:30 pm. I hope as many as possible of those of you attending the GA will be free to take part in the meeting.

1. Business

(a) Summary report on the triennium
(b) Election of new officers
(c) Newsletter (SCAN-IT)
(d) Absorbing the WG AC/CdC (Astrographic Catalogue/Carte du Ciel) from Commission 8 (Astrometry), proposed unanimously by the AC/CdC WG
(e) Future meetings?

2. Plate Scanning

We have been talking for several years about how we support efforts to digitize archives of plates in order to rescue, preserve and share what may be unique and unrepeatable information. But who is actually going to do that unless we do it ourselves? The enlarged Task Force represents most of the astronomers in the world who are keen to see such a proposal completed, so it is little use our making grand statements of hope but expecting some other organization to provide the impetus – WE have got to provide that impetus. It is therefore time to draw up an appropriate plan of action.

In order for the plan to be comprehensive and coherent, its elements need to be thought through carefully, and appropriate commitments made. A crucial factor is the selection of appropriate scanning equipment. The meeting should debate these issues thoroughly.

Input is invited, and strongly encouraged. Rather than a formal programme with invited contributions, I suggest that you contact me if you would like to make a contribution of (say) 5–10 minutes, and that will be guaranteed. Contributions can include reports of success with whatever type of scanner, progress reports, problems and obstacles met, or ideas and suggestions.

3. Log-book Catalogues

Preparing a digital catalogue of a plate archive is an essential element of any programme that is making a digital archive of the images themselves, and can be undertaken as a separate, preliminary project. Could library and heritage organizations be sources of funds?

4. Connecting plate archives with other VO projects

Please suggest any other matters which the meeting should learn about or discuss.

Looking forward to seeing you in Prague!

Elizabeth Griffin (PDPP Chair)

Digital Access to a Sky Century at Harvard (DASCH) Project Update

Bob Simcoe (rsimcoe@charter.net), Ed Los, Josh Grindlay, Alison Doane, Doug Mink, Silas Laycock, George Champine, and Alan Siliski
Harvard College Observatory, Center for Astrophysics, USA

This year we are happy to report that we have an operating digitizer that appears to meet the design goals that we set out to achieve several years ago. We have digitized 8 × 10 inch (203 × 254 mm) and 14 × 17 inch (356 × 432 mm) plates in 16 seconds and 40 seconds respectively. We still have a way to go to fine tune the machine, learn fast and efficient plate cleaning techniques, and get all of the post-processing software operating fast enough to keep up with the digitizer and with less human intervention.

We expect to present more details of the design and what we have learned at the SPIE conference in August 2006, so this is only a summary of the progress we have made.

Shortly after the last report (see SCAN-IT 3) the project team was augmented when E.L. joined (as a volunteer) to write the software needed for the digitizer. The first thing we thus accomplished was to get the camera, which was not a commercially available device, functional with the video capture card from Coreco (now Dalsa). When we received the telecentric lens from Sill Optics we were able to start determining how much illumination was necessary to achieve the exposure times we wanted. Our first attempts at lighting systems proved inadequate. We were fortunate, though, to find an LED array from Lumina that could provide the light we needed and that would allow us to stay within the tight physical constraints we had set. After much experimentation, we settled on a set of 4 red (618 nm) LED area arrays, each containing 117 LED die in a one inch (25.4mm) square area. The arrays are arranged electrically as two parallel sets of two arrays in series. Each series set is pulsed with a 14 volt, 5 amp constant current source. The four arrays are driven with a 120-Watt pulse that we can program anywhere between 1 μ sec and 50 msecs.

A tough requirement for the lighting system was that it fit within a hollow U-channel of aluminum 3.0 ins. wide and only 0.5 in. deep. This size was chosen so that the device holding the plate can move around the light without the table's center of gravity getting too high.

With the basic table on order, we needed something to set it on. After investigating various options, we contracted with Aerotech to provide a vibration isolating and leveling stand that floats the table on compressed air. To keep the center of gravity of the table below the air chambers on the stand, and to get as much leverage as possible for the air system, we designed a set of aluminum extensions to the front and back sides of the granite table. To get the support table into the building, we split the stand support structure into two pieces. We also found a self-contained air compressor/dryer system that was quiet enough to operate in the same room as the digitizer and run both the table and the isolation stand.

In May 2005 E.L. and R.J.S. went to Aerotech to observe the testing and calibration of the table. This testing showed that the table would move a 50 lb (23 kg) load 25 mm and settle to within 0.2 μm in less than 300 ms. The table, which uses Zerodur glass scales for position feedback, was calibrated with a laser interferometer and with correction tables was able to achieve an accuracy of 0.2 μm over the entire surface. Ed had the scan pattern software ready to run, and we were able to run our scan patterns on the table while at Aerotech.

In June the table was delivered and successfully brought in through the four-foot (1.2m) square window that was the only access point into the bottom floor of the Harvard Plate stacks. The plate holding design was also conceptually completed in June, when the students at Worcester Poly (WPI) finished their school year. However, we had to finish much of the detailed design of the table over the summer, and manufactured the bulk of the components for it from August through October.

Much design work and machining was done to minimize the weight of the table. A 3-D model in Autodesk Inventor^{tm} was constructed for the entire system. The camera vendor and Aerotech had models of the camera and the table. By designing the table in Inventor^{tm}, we could keep track of the weight of each piece. We machined out many areas to lighten each piece to meet our overall weight target. The final weight came in at 46.5 lbs (21 kg).

We also built a model of the room and the window which everything would have to come through. This insured that the system could be brought into the room and assembled, and would fit between the steel supports of the plate stack area.

The tray was designed to be easily reconfigurable for different size plates. Two sizes have been fabricated, one to hold 14 $\times$ 17 inch (356 $\times$ 432 mm) plates and one to hold two 8 $\times$ 10 inch (203 $\times$ 254 mm) plates. Other sizes can be accommodated in the future as needed.

Digitizing is done with emulsion up and the plate supported from behind, with 3 layers of flash opal glass laminated together to keep the plate flat and to diffuse the LED light. The support glass along with the plate is lifted pneumatically against the top surface. This clamps the plate at its edges, and the pressure keeps all of the moving parts of the tray firmly in place during the acceleration and deceleration of the table.

Before the table fabrication was completed, we were able to do a lot of testing of the camera, lens, and lighting system. We observed that as the exposure times or light intensity levels increased the black levels in the center of large black areas also increased. Experiments with black optical flock paper showed that we could significantly reduce the scatter from the anodized aluminum extension tube that spaced the double telecentric lens system on the camera side. We also noticed that there was scatter from the ground edges of the lenses.

By constructing an artificial star system with a single mode fiber optic fiber of $\sim$7 μm diameter illuminated with a computer controlled LED, we were able to use the X–Y table to test the distortion of the lens. In general the lens was very good, but there was some distortion that was clearly in the lens system, since it rotated with the lens and did not change with various tilting experiments with the lens body and CCD. We have now moved to doing this kind of testing with a multi-mode fiber-optic fiber of 62.5 μm diameter. We can centroid the larger diameter (the single mode fiber diameter was less than a pixel), which gives more consistent positional data since we can accurately interpolate below the pixel level.

The distortion and the internal scattering in the lens led us to return it to the manufacturer to have them blacken the lens edges, line the interior areas of the lens mount with flock paper, and to remount the lenses in a newly designed housing which promised to control lens spacing and tilt better. We have received the lens back and current testing indicates that the lens is quite good (less than .01% distortion) over a 40–45mm image diameter, but that the distortion starts to increase beyond that.

Since the CCD diagonal is 61 mm, the four corner areas (beyond a 45 mm inscribed circle) of the chip can see distortion as much as a pixel. Because of this, we decided to step the plate a distance of one quadrant of the CCD in the X direction. Two exposures, one with the top quadrant of the chip and one the bottom quadrant of the chip, are averaged to reduce the distortions that the lens introduces at the far corners of the CCD.

When we had the key parts of the machine in hand, we were able to run a scan pattern on a plate, digitizing multiple frames and putting them together in a mosaic. Visually observable effects in the mosaic led us to investigate more carefully the flat-fielding of the light source as it interacted with the diffusing glass and the sides of the light source. We ultimately identified a number of problems that needed to be dealt with. The CCD camera electronics had a loop control system to force all quadrants of the CCD amplifiers to have a dark ADU reading of 50 counts. This creates non-linear behavior at the dark end of the conversion scale. The amplifiers have gain settings that are calibrated to give a 2000 ADU reading at a specific light level. The offset must be carefully calculated by projecting from the known linear portions of the curve, being careful to not use parts of the curve distorted by the dark current control loop.

We noticed that flat fielding with a clear glass plate worked better than flat fielding with no plate in place. Having the glass in the optical path made a difference. Even when we had taken all of these things into account in the flat-fielding computations, there remained a noticeable tiling effect in the mosaics. The four quadrants of the chip would have slightly different average white background levels.

While it is not clear that this tiling effect would matter much in photometric or astrometric measurements, it is very distracting aesthetically and for archival reasons we wanted to understand the causes of it and eliminate it as much as possible. Even an average white level difference of 5 ADU from quadrant to quadrant is very obvious to the eye on a good display.

We came to realize that although the CCD amplifiers meet their specified linearity accuracy of 0.3%, the residual non-linearities when multiplied in the flat-field algorithms are enough to create the obvious tiling effect in the final mosaic. Correction of this problem requires supplementing flat-frames with a linearity measurement sequence to remove nonlinearities of each quadrant as well as the bias offset and gain differences from the raw ADU counts for each pixel. Dark current is not a significant issue for these short exposures. Because of non-uniform illumination, the optical variations in the supporting opal glass, and shadowing effects near the edge of the light, a flat field frame is necessary for every scan position. These flat-field scans require a clear glass plate of a similar thickness (two clear glasses for repaired plate scans) to duplicate the optical path of the system with a photographic plate. The flat-field frame is an average of the two median values of four rotated and/or flipped clear plate scans. This effectively removes dust and blemishes on the clear plates from the flat-fields.

We customize exposure times for each plate such that the average white level equals an ADU count of 2710 at the plate center. That also helps keep the non-linear effects of the system similar for all of the plates.

Despite all of the efforts to eliminate this tiling effect, there are still some plates that show some light tiling. This may be caused by the non-linear behavior of the amplifiers drifting with time and/or temperature, large variations in darkness of the emulsion, variations in the thickness of the glass plate, and too many pixels in saturation.

The Newton ring patterns that formed between two flat glass plates are also a problem when flat fielding. We had considered this a potential problem from the start of the project. The opal glass we used to support the plates seemed to have a rough enough surface to prevent rings from forming. However, when we got the opal glass support pieces from the supplier they had some deep scratches so we had to send back to get them polished out. In the interest of time we started to scan with these newly polished glasses knowing that they might show Newton ring effects, particularly on the edges of the plates where the clamping occurs. Experience showed us that many plates had enough surface irregularities to prevent the rings from appearing. But on some plates the effect was quite pronounced. We are now sending the support plates back to the supplier to get a satin etch to prevent the rings from occurring.

Another interesting effect that showed up in the mosaic was a small mirror image, a few pixels wide, around the edge of the plates. We believed that these images were due to reflections from the vertical edge of the lens holder, which even though they were anodized black could act as mirrors at the high angles of incidence. We have now covered the vertical edge of the holder with optical flock paper, which did get rid of that artifact.

We did experiments to see if heating effects in the LED made a difference in the light level when the exposure times were long and the plates were large. We found a small effect, on the order of 0.3% difference. While this was not bad, we decided to add a liquid cooled heat sink to keep the LED temperature as uniform as possible and to remove that as a potential source of error.

The scanner software consists of image acquisition, pipeline processing to add co-ordinate (WCS) and photometry information and web access. E.L. is responsible for the image acquisition software described here. D.M. and S.L. are responsible for pipeline processing and web access, both of which will be described in a future report.

The image acquisition program controls the plate loading mechanism, the linear positioning stage and the camera. The software is essentially complete under the Windows XP operating system, and is now being ported to Linux for long-term maintainability. In addition to the basic plate scanning function, the software supports test modes of operation to determine linear stage accuracy, lens distortion, CCD amplifier linearity and best focus.

The linear stage has demonstrated the ability to move the width of the CCD field in under 410 ms with a drift of less than 0.5 μm during the expected exposure time of 8 to 50 ms. However, with the hardware in place, the table has some low frequency oscillations that persist for a few hundred milliseconds after a move has completed. Since it is hard to guarantee that the software can recognize the table in position signal and then generate the signal to trigger the camera with well understood timing relationships, we have delayed the camera trigger signal by 250 ms, which allows the table to settle more reliably.

The software was built with an option for half-width moves which was initially intended to allow compensating for bad pixels. The CCD quality appears to be good enough to make overlapping exposures and the use of bad pixel masks unnecessary, but we are now using the half step option to minimize lens distortion problems.

The focusing procedure takes advantage of the grain noise and selects the peak overall standard deviation of the ADU counts for best focus.This algorithm works on a set of 512 pixels taken along an X-shaped pair of diagonals of the CCD. This point of maximum range between black and white levels is the point where the individual grain particles of the emulsion are fully resolved. The focal point is not expected to change significantly during a scan because the device that supports the plate can be adjusted to be parallel to the granite.

The digitizer can generate the 60 exposures necessary for a 203×254 mm plate in about 30 seconds and the 160 exposures necessary for a 356×432 mm plate in 80 seconds. The resulting exposures are FITS files with project-specific keywords indicating the exposure time, associated flat fields, dark fields, linearity sequences and linear stage position. Because on-line catalog information is already available for 76,000 plates, the digitizer will include all of this catalog information and a preliminary WCS in every exposure. Because FITS files do not follow little-endian byte ordering and Windows raster scan conventions, some scan patterns require the writing of the data as a raw byte array for performance. A post-processing program then converts these raw files to standard FITS format files.

The mosaic tool combines the individual exposure tiles, individual flat field scans, and CCD linearity results into full plate images. Options are available to control the binning of the images and to correct for rotation and magnification of the camera assembly with respect to the linear stage. Because the largest mosaics are 2.3GB, the mosaic tool operates in a raster-scan mode to minimize use of CPU memory. If corrections for rotation and magnification are unnecessary because the hardware is aligned well, then the tool requires approximately 380 seconds under Linux to create a 2.3GB mosaic. These full-size mosaics are necessary for photometry calibration, but final web-access utilities will provide smaller plate extracts and binned mosaics. For our pilot runs we are generating two mosaics, an un-binned mosaic and a 16 by 16 binned mosaic. The binned mosaic is used as a thumbnail for viewing and is used by the WCS software to get a first cut at locating the center of the plate.

Two of us (AS and GC) joined the program in the fall of 2005, adding experience in optical systems and archival photography, respectively. We took on the task of investigating the requirements we would need to meet to photograph the log books so that the photographs would be adequate for data entry. We had decided that rather than continuing to do data entry from the handwritten index cards it would be better to go back to the original logbook data. Photographing the handwritten logbook pages with a 3 megapixel camera proved sufficient and that doing some post-processing to make the JPEG photos more readable would provide us with a database that we could send off site to be converted into an electronically searchable format. We have also created a database of log books and their characteristics. We started photographing the log books, and have completed about 20% to date. This database will be associated with the digitized plate data and the digitized catalog information to allow electronic and visual data for each plate's logbook entry to be available to researchers.

In order to capture the data that are written on the plate jackets, we obtained a Nikon D200 10 megapixel SLR camera. This camera can take pictures under computer control and we are using it to take a JPEG picture of the plate jacket, and in cases where there is written information on the back side of the plate itself we will take a back-lit picture of the plate before cleaning these markings off.

We have made great progress this year and have achieved the goal of an operating digitizer that can be used to digitize the Harvard plate stack collection. We still have to gain experience using the machine. We also are investigating cleaning and handling procedures, post processing and electronic storage pipelines and the operating stability of the system, to be sure that we can balance all parts of the digitizing process to achieve our desired throughput. A few pilot runs have indicated that we should be able to achieve our goal throughput of 400 8×10 inch plates per day.

We should note that the DASCH project is being accomplished with funding from the National Science Foundation (NSF). However, much of the work has been accomplished by volunteers from the Amateur Telescope Makers of Boston (ATMoB). The ATMoB has had a close and long association with the professional astronomy community in Boston. The first two and last two authors listed on the report are volunteers from the club.

The NSF funding was to build the digitizer and to do some pilot runs to show the feasibility of digitizing the collection. We are well on the way to accomplishing that goal. Now we need to find funding to digitize the collection, store it online, and provide long term maintenance of the digitized data and the original plates.

We would like to see a worldwide collaboration that would provide multiple locations where all of the digitized plate data, which we and others are generating, could be stored and made available over high-speed links to the researchers in a local region. This geographic dispersion would provide redundancy and assure access to, and long term survival of, the database.

The D4A Digitizer

J.-P. De Cuyper (Jean-Pierre.DeCuyper@oma.be), Royal Observatory of Belgium,
L. Winter (Hamburg), N. Zacharias (USNO)

The D4A (Digital Access to Aerial- and Astro-photographic Archives) project aims to acquire the necessary know-how, hardware and software to digitize the astro-photographic collections of the Royal Observatory of Belgium (ROB) and the aerial-photographic collections of the National Geographic Institute and the Royal Museum of Central Africa in collaboration with AGFA-Gevaert, a world-leader in photographic matters. The final design of the "D4A Digitiser" that is being built by the ROB in Brussels is presented. A geometric benchmark testing of different commercial flatbed scanners is given and the results are compared with the requirements needed for the astrometric and photometric data extraction from the digitised images.

The design and construction of the D4A Digitiser, as described in J.-P. DeCuyper, L. Winter & J. Vanommeslaeghe 2004 and in J.-P. De Cuyper &L. Winter 2005, is progressing towards completion. The XY-table will be an adapted Aerotech ABL3600 open frame air bearing system. The mechanical subsystem, designed and build to our specifications by Aerotech, Pittsburgh, includes: an automatic plate holder assembly and a plate change robot with plate tray magazine and turntable for the photographic glass plates and film sheets and an automatic film roll transport system. These custom made devices are necessary for a rapid change of the photographs to be digitised without manual intervention. The heart of the optical system is an air-cooled BCi4,12bit CMOS camera from C-Cam Vector International, mounted on a Schneider Xenoplan telecentric 1:1 objective. The back light illumination system consists of very bright LEDs (lifetime > 50000 hrs), that are computer controlled by a precision power supply, developed at the ROB, for adjusting the exposure of each individual sub-image of the photographic plate. The D4A Digitiser will be located in a temperature ($18 \pm 0.1^\circ$ C) and humidity (RH 50 $\pm 1\%$) stabilised clean room build by Becker Reinraumtechnik; the final accuracy of the XY-table will be better than 0.1μm. This corresponds to the required sub-micron accuracy (Zacharias et al., 2004).

The D4A Digitiser is intended to digitise photographs on glass plates and film sheets or rolls up to 350mm $\times$ 350mm in size. Special software is needed for handling the 25 GByte/hr data rate with online processing and storage of all images. The goal is to provide astrometrically and photometrically calibrated digital images with overlaid, identified stars. The extracted information and the metadata will be stored in a database. The digital images will be compressed lossless in order to reduce the storage size and time.

Commercial flatbed scanners

The geometric and radiometric accuracy of several commercial flatbed scanners was studied. Scans were made at their optical resolution of a very precise geometric grid, made by BV Maskshop in Germany, consisting of chrome dots with diameters ranging from 50μm to 300μm, placed at 0.5mm from each other on a glass plate. Figure 1 shows the radiometric quality and sharpness of the obtained digitised images of a 2mm $\times$ 2mm part of the grid (containing dots with diameters of 50μm, 100μm, 180μm and 200μm for the center one). As a comparison, the results on the purpose-built StarScan machine from USNO in Washington, DC (Winter, L. & Holdenried, E. 2001) are given. Of the tested commercial scanners, only the AgfaXY-15

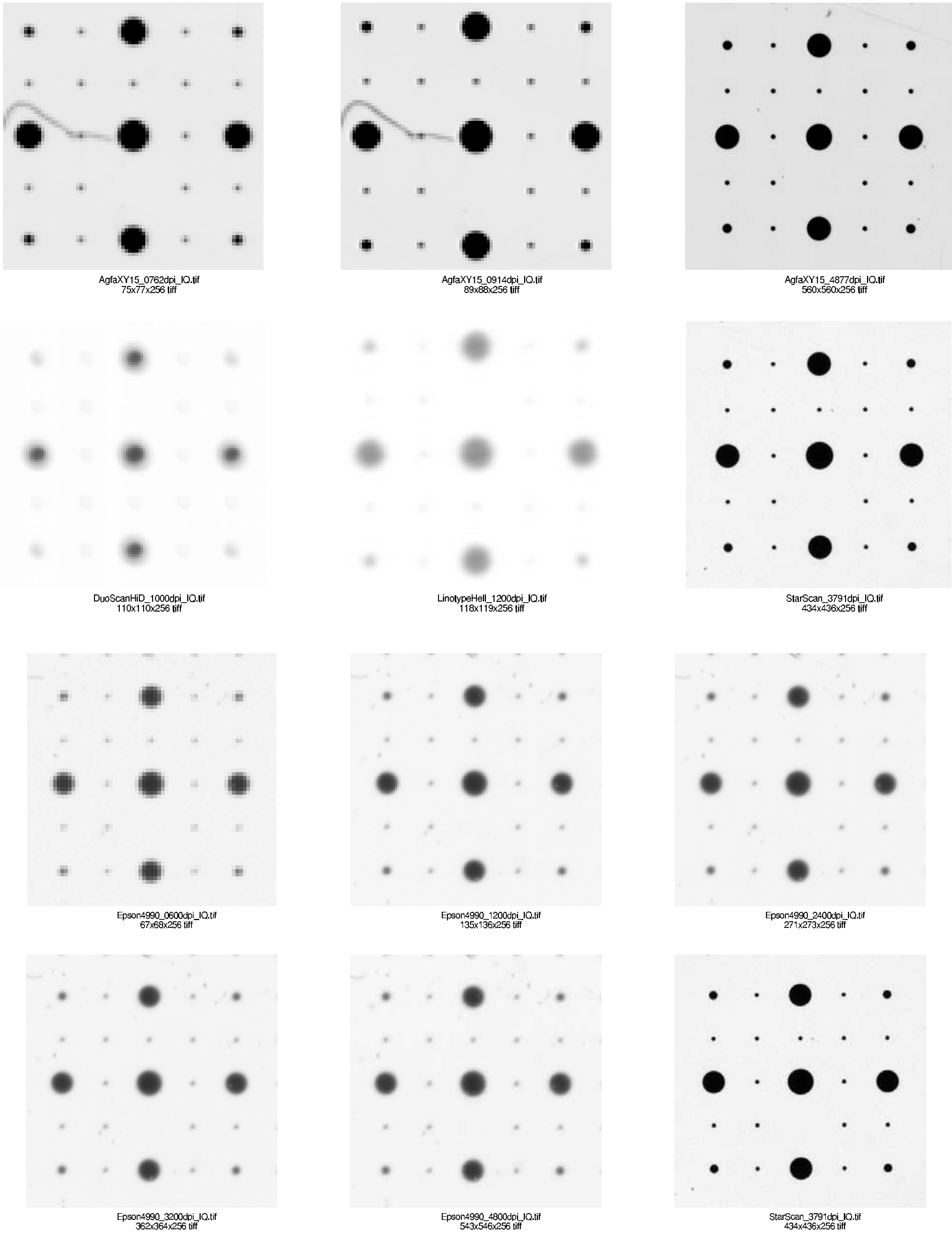

Figure 1: Digitised images of black chrome dots on a glass plate obtained with the tested commercial flatbed scanners. The StarScan result is included for comparison. (In case the wording is not legible, we list here their identities and scanning densities, in rows beginning at top left: Agfa-XY15, 762 dpi; Agfa-XY15, 914 dpi; Agfa-XY15, 4877 dpi; DuoScan-HiD, 1000 dpi; Linotype-Hell, 1200 dpi; StarScan, 3971 dpi; Epson-4990, 600 dpi; Epson-4990, 1200 dpi; Epson-4990, 2400 dpi; Epson-4990, 3200 dpi; Epson-4990, 4800 dpi; StarScan, 3791 dpi.)

reproduces well the radiometric density of the complete black dots. On the AGFA DuoScan HiD and the Linotype Hell the 50μm dots are completely filtered away by the noise suppression software of the scanner. Also the Epson 4990 does not reproduce the radiometric density even of the largest (200μm) dots. On all the digital images obtained with the tested commercial flatbed scanners at their optical resolution(s) the diameters of the dots were altered by the noise suppression ("image sharpening") software of the scanner. The local and global geometric errors of these commercial flatbed scanners are of the order of sub-millimeters to millimeters. Other tests revealed that position errors (dX, dY) at the different X and Y positions over the whole gridplate were up to a factor of a thousand larger on the commercial scanners compared to those of the StarScan machine, which vary only very smoothly over the plate and are in the required range for obtaining the needed sub-micron star position accuracy. All these results will shortly be published in detail.

Acknowledgments

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>>*Note from the Editor*

In an informal message, Lars Winter (USNO and Hamburg) has also described the results of the above tests that were carried out on commercial scanners and StarScan. Since he introduced points not explicitly included in the previous article, we include those here (with permission).

Lars pointed out that, according to previous tests, commercial scanners can have errors up to 0.1mm at the edge of a 240 mm $\times$ 240 mm field. It now turns out that even the "best" commercial scanners have unrecoverable errors of some μm attributable to their construction.

He also explained that it was quite simple to use the centre dots on the calibration plate as an indicator of image quality: the higher the contrast of a dot, the better the quality of the reproduced image and thus the smaller the FWHM of the scanner's PSF. He discovered that, in order to sharpen images, some scanners use software which cannot be switched off by the user! Those scanners also leave artifacts in the images, and should therefore not be used for scientific work. For photometric comparisons, he reported that he used an AGFA step-wedge; it showed that at least the photometric properties are acceptable for most of the scanners.

Lars added that he is hoping for a breakthrough with D4A compared even to StarScan. A recent calibration of the latter indicated that StarScan errors may be as low as 0.2 μm, which is near the stated goal; 103a-G plates generally have geometric errors of about 0.6 μm, but they can be less than 0.3 μm for Technical Pan.

Status of StarScan Operations, USNO/Washington

Norbert Zacharias (nz@usno.navy.mil), US Naval Observatory, Washington DC

The StarScan plate measuring machine at the US Naval Observatory, Washington, DC, is used mainly for astrometry. Its current program is supporting the derivation of proper motions for the final release of the USNO CCD Astrograph Catalog (UCAC).

During the last six months calibration tests have been performed on StarScan; the machine has also been upgraded with a larger CCD camera. A paper is in preparation describing the calibration effort and the measuring program in more detail. This article is a first look at preliminary results.

Dot Calibration Plate

Jean-Pierre De Cuyper (Royal Observatory of Belgium) kindly lent us the special ∼250 mm-square calibration plate described on page 11; its absolute geometry is believed to have a precision of the order of a few 0.1 μm. The deposits of round metal dots in the regular grid resemble star images at high contrast. The calibration plate was measured as if it were an astronomical photographic plate, and 2-D Gaussian models were fitted to each measured dot.

The calibration plate was measured on StarScan several times and with up to 4 different orientations, to provide an external reference for the geometry of StarScan's (X,Y) table coordinates over an area of 220 mm × 220 mm. In order to avoid errors in converting pixel coordinates at arbitrary locations on StarScan's imaging CCD, a step size of 5 mm was adopted for the dot plate measures and only the corresponding "central dot" of each CCD frame was used for the subsequent reductions. The centroids of all those dots fell within about ±10 pixels of the same location on the CCD, and the standard StarScan pipeline was then used for reductions.

Figure 1 shows the vector plot of position differences, in the sense (StarScan – nominal dot location), after using an 8-parameter transformation model to allow for zero-point offset, scale, orientation, and tilt. The largest vectors are about 2 μm long and a regular pattern is seen. Some of those systematic errors were known before and can be corrected with a parabolic model.

Similar results were obtained for the other 3 orientations: 90°, 180° and 270° rotation with respect to the original measures of Figure 1. The resulting patterns are not identical but are very similar, leading to the conclusion that most of the error budget is coming from the raw StarScan (X,Y) table coordinates, if left uncorrected. However, the fact that the plots for the different orientations look different on the few 0.1 μm level shows that StarScan actually can "see" errors in the geometry of the grid.

Figure 2 shows the repeatability of the StarScan measures: the dot plate was measured (in the same orientation) twice on different days. The RMS scatter of StarScan's repeatability is better than 0.2 μm per coordinate. Even grainy emulsions like the Kodak 103a series contain astrometrically useful information at the 0.7μm level (at least), as studies from the Hamburg observatory and Yale University groups have shown, while fine-grain emulsions like Technical Pan can go at least a factor of 2 smaller than that. More details will be presented at the upcoming IAU meeting.

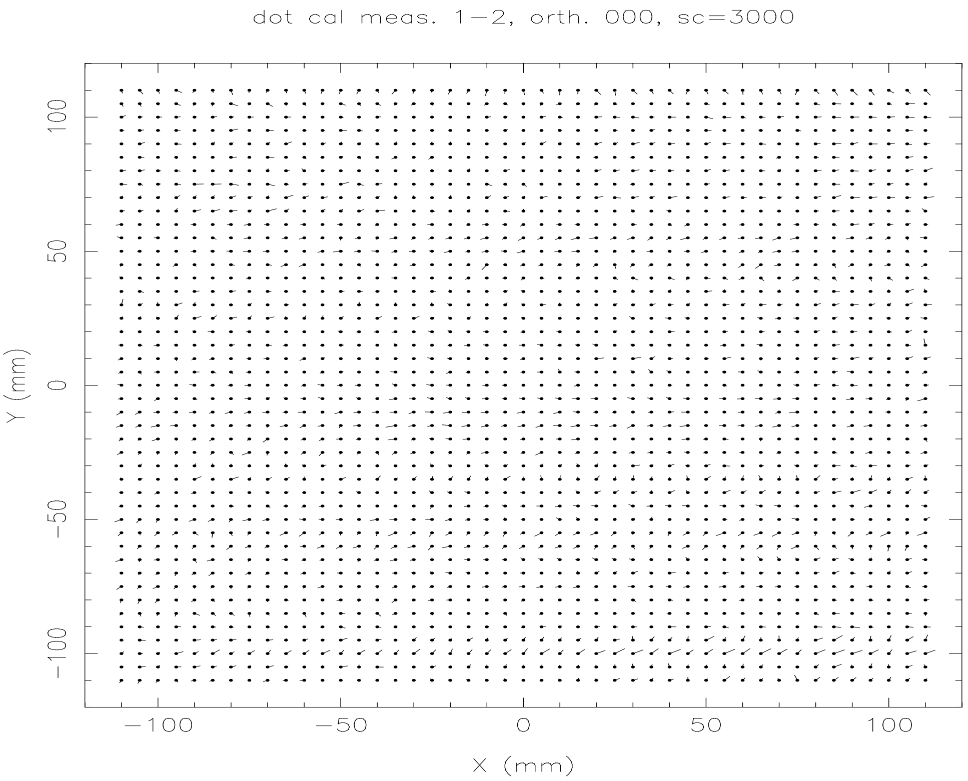

Figure 1: Vector plot of position differences, StarScan *minus* Nominal.

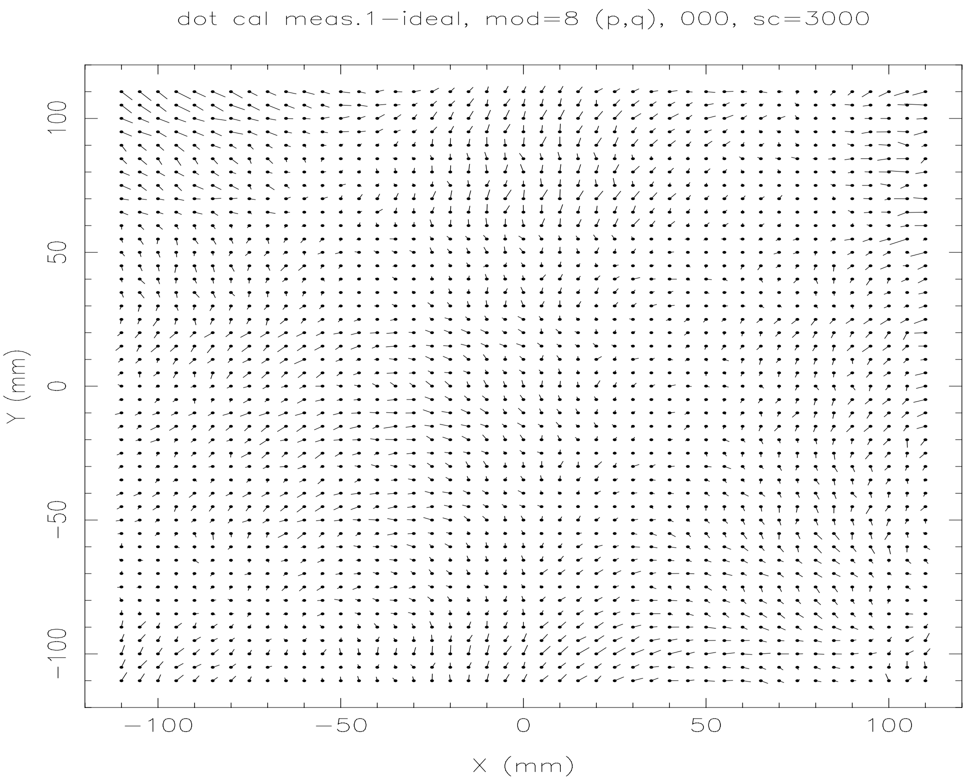

Figure 2: Repeatability of the ScarScan measurements.

2. Upgrade of StarScan

In spring 2006, the 1300 × 1000 pixel Pulnix CCD camera on StarScan was replaced by a 2k × 2k Kodak chip QImaging camera with slightly larger pixel size (7.4 μm compared to 6.7 μm). The intention was to capture a significantly larger plate area at each "footprint" step of StarScan measures and thus enhance the throughput. The camera was carefully selected in order to minimize changes in the existing system. Unfortunately the upgrade did not go smoothly, and even a change of operating system became necessary. After significant effort by our contractors Ellis Holdenried (USNO, retired) and Lars Winter (Hamburg), a new working system was set up with a factor of 2 throughput improvement. Details are to be published.

Acknowledgements

Many thanks are due to Ellis Holdenried and Lars Winter, who made the StarScan upgrade possible. I am also grateful to Jean-Pierre De Cuyper for lending us the dot calibration plate, to Gary Wycoff for leading the measure program with data handling, and to Brian Mason and Bill Hartkopf for participating in the StarScan operations.

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FITS Files Available for Digitized Ca II K Mt. Wilson Spectroheliograms

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70 years of digital Ca II K spectroheliograms from Mount Wilson are now available online as FITS files. The digitized Ca II K images from the Mount Wilson photographic archive form a database of 39,261 FITS files spanning the time period of August 10, 1915 to July 7, 1985. These files have standard FITS headers providing original logbook and digital reduction information. The main FITS file access page, with links to detailed descriptive resources, is at:
http://www.astro.ucla.edu/SolarData/MW_SPADP/

Data files can also be retrieved through the Virtual Solar Observatory:
http://vso.nascom.nasa.gov/cgi/search

The current images are not calibrated for a photographic density/incident intensity conversion curve and have been binned 3 by 3 to less than full scanned resolution. The images are stored in the observed co-ordinate system, which depends on an arbitrary and variable coelostat mirror setup. Some images include roll-angle information.

Feel free to use the database, but if your work results in a publication please include the statement: "This publication has made use of data from the Mount Wilson Solar Photographic Archive Digitization Project supported by NSF grant No. 0236682."

Please also inform me by e-mail of papers in preparation or in press. Evidence of interest in this data may make it possible to consider the digitization of the Balmer Hα images that are not part of the current project.

The above announcement appeared in the March 17, 2006 issue of SolarNews

Digitizing Old Photographic Plates and Data Archiving at Tartu Observatory

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There are two kind of astronomical plates at Tartu Observatory: (a) direct-image plates obtained at Old Tartu Observatory, and (b) spectroscopic plates.

The direct-plate archive consists of more than 4000 plates spanning the interval 1950 to 1987. Most of these images were obtained with the Petzval astrograph of Old Tartu Observatory. The plate sizes are about 120 $\times$ 90 mm and the photographed objects are asteroids, comets and variable stars in several areas of the Northern Sky.

We started the plate digitizing project in 2004. For the years 2005 and 2006, we received a small grant for this project.

First, we purchased an Epson Expression 10000XL Pro flatbed scanner and a computer with DVD writer for controlling the scanner and saving preliminary data. The next step was testing the scanner and choosing the most suitable scanning parameters. We decided to carry out plate scanning with the resolution of 1600 DPI in 16 bit mode. In this case, every plate includes about 65-70 MB of information. All TIFF files are written to DVD. The capacity of each DVD is about 60–65 plates.

A small *C* program was written for converting TIFF files to FITS files. All images are also converted to JPEG (8 bit) format. Using SExtractor and WCSTools, we are supplying the FITS file for each plate with World Coordinates. This work is now under development.

We created an on-line database (based on MySQL^{tm} database) which includes all the available information for every plate, i.e. plate number, scanned file name, date of observation, observer, exposure time, emulsion type, object(s), sky coordinates, information about weather and some comments. During a scan all these parameters are entered into the database.

The spectroscopic plate collection consists of more than 2500 plates covering the period from 1976 to 1994. All spectroscopic plates were obtained with the 1.5-m telescope using the Cassegrain spectrographs UAGS and ASP-32. Most of them were originally scanned with the PDS-1010 densitometer or a home-built densitometer and processed, but for several reasons many of those digital data are not currently available. Therefore, we also plan to scan all spectroscopic plates using the above technique. A printed version of the spectroscopic plate catalogue for internal use was prepared in 1999 (K. Annuk and T. Nugis, *Catalogue of photographic spectra obtained with the 1.5-m telescope of Tartu Observatory*). Very soon it will be available through our webpage (http://www.aai.ee).

Astrometric Scans Using a Flatbed Scanner at the University of Virginia

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Our group at UVa is working on the determination of absolute proper motions of a sample of dwarf spheroidal galaxies (dSphs), globular clusters (GCs), and open clusters (OCs). We have a unique and valuable set of hundreds of archived photographic plates that includes data on many dSphs and GCs/OCs taken with the Palomar 200-inch telescope (and others) as far back as the 1950s. Our work combines photographic data with recent Hubble Space Telescope (HST) observations to derive absolute proper motions of the Milky Way satellites in the sample. We employ the same techniques as Dinescu *et al.* (2004), who combined HST data of the Fornax dSph with archived ground-based photographic images, providing a much longer time baseline and larger areal coverage (plus more background QSOs and galaxies for reference) than is achieved by Piatek *et al.* (2002) using multiple epochs of HST data alone.

Scanner Characterization

To digitize the photographic plates, we've been working with an Epson Expression 10000XL digital flatbed scanner, which has both the size (up to 18 $\times$ 24 inches) and resolution (2400 dpi, or 10.583 μm/pixel) to perform the task at hand. We have been investigating the astrometric stability of scans from this device, and have found that while it holds the promise of rapid digitization (a few minutes per large format plate) of photographic images with $\sim$1.0 μm accuracy, the device introduces systematic errors that need to be accounted for. Fortunately, these systematic errors appear to be periodic and readily determinable, and it appears likely that they can be mapped and removed. Two different effects are seen: (a) along the scanner arm (the 1-D CCD array), large-scale (linear) distortions are introduced due to deviations of the array elements from their prescribed separation, while (b) perpendicular to the scanner arm (along the scan direction), comparison of repeated measurements of stellar positions from the same plate reveals small-scale (less than 2 μm), roughly sinusoidal variations, which are probably attributable to tolerances in the mechanical sweeping mechanism for the scanner arm.

To calibrate the systematic positional errors we have obtained a precisely ruled glass calibration plate with appropriate periodic fiducials. By stacking the calibration plate with the target photographic plate when scanning, the fiducial references are imprinted on the scan, and allow us to correct for the large-scale errors introduced by the scanner. Multiple scans are performed for each plate, in different orientations, the combination of which allows us to remove smaller-scale distortions as well. At $\sim$10 minutes per scan, making multiple high-resolution scans per plate is still much more efficient than a single PDS scan, which typically takes $\sim$24 hours.

Characterizing the scanner's astrometric stability and repeatability will continue, followed by examination of its photometric properties. Once the scan behavior is well understood, we will complete the proper motion work for all available targets. Our scanning techniques also lay the groundwork for digitizing the $\sim$150,000 plates in the Leander McCormick Observatory archive.

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Piatek S. *et al.*, 2002, *AJ*, **124**, 3198

Digitization of the Tonantzintla Sky Survey

Progress Report

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Abstract

In recent years, INAOE has been working towards digitizing the information stored on photographic plates exposed at Tonantzintla, with the goal of creating a hybrid image database in order to re-use its collection of photographic plates. The design of the database has now been completed, and a second version of the system has been implemented.

Introduction

INAOE has an extensive collection of plates taken with the Tonantzintla Schmidt Camera over a period of 50 years. The observations, which commenced at the Astrophysics National Observatory at Tonantzintla in 1942, were discontinued in 1992 because of light pollution from nearby cities. There are altogether 15456 plates, of which there are 4484 spectra and 10972 direct plates; 2540 of the latter bear images in three colours (Tepanecatl & Gonzlez 2002). Different types of emulsion were used, but most are Kodak 103a. The most important studies accomplished to date with the plates involve spectroscopy of interstellar clouds, blue giants at different galactic latitudes, red stars, early-type stars with Hα in emission, blue galaxies (Chavira 1989), high-luminosity stars, blue stars at the north and south Galactic poles, and Wolf-Rayet stars. From those studies, a catalogue of nebula was created (as reported in Tonantzintla & Tacubaya Observatory Bulletins 1954–1972). It is important to mention that all these studies were accomplished through detailed *visual* inspection of each plate.

The Tonantzintla Schmidt Camera has the following features: a focal length of 231.4 cm, a focal ratio of 3.2, a plate scale of 95 $''$/mm, a corrector plate of 66.4 cm, a mirror of 76.20 cm and an objective prism. There is also an objective prism of $3^\circ.96$, with a dispersion of 1533 Å/mm between Hβ and Hγ, 954 Å/mm between Hγ and Hδ and 626 Å/mm between Hδ and Hϵ (Haro 1956). The plates measure 8×8 inches and show a 5×5 degree square of the sky. Between them the observations cover a region of the sky from 90° N to 65° S (Diaz-Hernandez 2005).

Plate Digitization

The plates are being digitized with a high-resolution Epson Expression 1680 Professional Firewire scanner, which generates a 300Mb image for each plate. Each image is 11500×11500 pixels, and has a resolution of 1600 dpi. With that resolution we can obtain a pixel size of 16μm in transparency (positive) mode. The data are recorded with a dynamic range of 16 bits. First a digital image is obtained in TIFF format; the system analyzes that image and extracts information about each astronomical object. In a subsequent process, each image is converted to FITS format. The digital images are converted from TIFF into a JPEG format for rapid recovery.

To date we have digitized a set of 1000 plates. To store, process and analyse the digital images it was necessary to create a hybrid text and image database; it complies with astronomical standards and is compatible with other similar astronomical systems. The information included in our database is comprised of two main types: (1) metadata specific to each plate (e.g. date of observation, emulsion, target (or central) object, telescope coordinates (RA and Dec.), type of plate (direct or spectrogram), UT, local time and the observer's name and (2) information about the digitized image: characteristics such as pixel size, file size, and available format. That information is associated both with each digital image and with each stellar object identified and/or known by plate. The two types of information must be correctly related in order to obtain the correct data from several objects on the same plate.

Astronomical Database

The analysis and design of our system was developed using UML, a modelling language that assists the systematic development of a software system by providing diagrams that organize the knowledge so as to represent the relationship between the different components of the system. We later programmed the system in an Object Oriented (OO) language.

Once the database requirements were defined, we identified the 'user' cases so as to generate the system architecture. In our design there are three user cases, defined as the actual users: administrator, contributor user and normal user. Eight table-descriptors capture the attributes that define the full database.

The tables contain coordinates, magnitudes, colours, and several other computed image parameters that are used for indexing. In the object data table we used some parameters to store each of the objects in our catalogue, the most important being object identifier, Right Ascension, Declination, Galactic longitude and Galactic latitude.

At present all queries are processed centrally using a database management system, but in the near future we are planning to implement a federated database.

One final point: for its user interface, the software has a graphics interface that permits both the execution and the visualization of the queries which the user wants to perform. The interface can also display images in different formats such as FITS, TIFF and JPEG.

At the present stage of development, the principal retrieval data are positional information related to some star or galaxy. A search can be a complex query on position, colour and other parts of attribute-space, and constitutes the basis for a more complex search. We still have to implement our own parallel query optimizer and run-time system. Let us suppose that interesting objects with unique properties are found in a particular area of sky; the intention is to generalize those properties, and to search for similar objects over the entire sky. In the near future we plan to implement complex searches on our data, and to carry out high-dimensional queries which involve a metric distance not only on the sky but also in colour-space.

Implementation

We have now implemented the system to take into account the information described above. The first version used MySQL, but although the system began by working well, with increasing user number and data size it started to get unstable. Consequently, for the second version of the system we change the DB manager to PostgreSQL. The latter offers a wider data manager capacity and stability.

The PostgreSQL system which we have now implemented actually performs queries of different complexity. To date we have digitized more than 1000 plates, and have begun the identification of stellar objects in the regions covered. The digitized images are stored on a server.

Our system complies with the accepted standards for information handling and retrieval of astronomical systems such as ALADIN and SIMBAD. The development of this work gives us the capability to understand database design methodology and its correct application. We also have the capability to create tools to reduce, calibrate, and classify stellar spectra, so it will be possible to develop automatic stellar extraction and calibration.

Spectrophotometry and Photometry

We are developing an image analysis software to perform spectrophotometry on each plate. The first step in this process is the selection of spectra. In that stage, the background level (i.e. where there is no spectrum) is subtracted from each image, having first derived a mean sky level in order to reduce the sky noise. After thus 'cleaning' the image we can select regions; for that process we applied segmentation techniques and morphological operators such as area, length, eccentricity, width, etc. To determine the correct morphological operators it is necessary to apply some characteristics related to the emulsion (e.g. sensitivity versus wavelength, the characteristic curve, fog level and grain size), the plate glass density and the noise of the detector by which the image was obtained. At the end of that step, we then have morphological characteristics for each spectrum.

The second step is the analysis of the spectral shape. The software identifies the Balmer lines and other features in each spectrum, taking as a reference the emulsion cut-off. The emulsion cut-off is derived from the analysis of a continuum fit, by means of a continuum curve for each spectrum. The spectra that fulfill the conditions for the first step are analyzed with the purpose of deriving their continuum shape. One approach for identifying all objects of a given type is to determine the continuum shape of a particular spectrum and to look for objects with large residuals compared to the selected continuum profile. For curve fitting we are using a 5th-order polynomial for each spectrum. To improve the efficiency of the selection procedure we have analyzed the shapes of one-dimensional spectra: each spectrum is characterized by a slope derived from one residual previously fixed by statistical tests on the entire sample. The variations in the slopes give the distribution and peculiarities of the spectra.

The final step is wavelength fitting. For each spectrum we first derive the the plate scale from the positions of identified stars on the plate (Nandy 1979; Hantzios et al. 1994), and then apply the dispersion curve. To calculate the dispersion curve is necessary to measure the positions of spectral features. To measure those positions we first identify the main spectral lines in stars of different spectral type (A–M) by visual inspection, and then measure those lines for each spectrum. The dispersion curve can then be derived from those measured positions. The results of this wavelength fitting are now in preparation using the approach explained above.

As already mentioned, to date we have carried out spectrophotometry on our digitized images; we can select spectra from an image, and perform the wavelength calibration using the dispersion curve of the objective prism. We can thus obtain spectra adjusted in wavelength.

At present we are working on the photometry aspect, in order to obtain an intensity curve that takes in account the visual intensities of some identified stars in the image and compares them with measurements of the same stars in published catalogues. This curve will help us make intensity adjustments for each image.

This project opens the possibility to discover objects that have not previously been catalogued, as (for example) was achieved by the research done on the UK Survey and Hamburg ESO Survey (Beers & Christlieb 2005). Through this approach we are renewing the use of valuable astronomical material so as to make it accessible for studies of any topical interest.

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Reduction of the San Fernando Zone CdC Plates
A CIDA-ROA Collaboration

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J.L. Muiños, M. Vallejo, and F. Belizón, ROA

The Astrographic Catalog (AC) and the Carte du Ciel (CdC) were the most important projects in astronomy at the end of the 19th and the beginning of the 20th centuries, but the scientific objectives were never fully completed. To those ends a collaboration has been established between the Centro de Investigaciones de Astronomía of Venezuela (CIDA) and the Real Instituto y Observatorio de la Armada de San Fernando, Spain (ROA). The project uses a commercial flatbed scanner to digitize the plates, and the recent epoch Carlsberg (CAMC) and San Juan-ROA (CMASF) Meridian Catalogues in order to determine stellar proper motions.

ROA and CIDA have been working together since 1998 to digitize and reduce the collection of plates of the CdC San Fernando Zone. The plate collection constitutes an important legacy of ROA, and cannot therefore be removed physically from the Institute, so additional effort is required to establish an adequate digitizing process.

The project was first attempted with the CIDA PDS, using acetate copies of the plates that were generated through collaboration with the Instituto Hidrográfico de la Armada (Spain). The Yale and CIDA PDSs were both used. However, after considerable progress, the project was stopped on account of random errors stemming from the semi-contact technique and drying process used in making the copies.

The possibility of using a flatbed scanner to digitize the acetate copies was then investigated by testing a 1000 $\times$ 2000 ppp high-resolution scanner (AGFA DuoScan model F32) of the

Departamento de Tratamiento de Imagenes of Zaragoza University (Spain). The partial results are described in Vicente & Abad (2002), and are summarized below:

- the possibility to transport the scanner to ROA in order to use the original plates,
- the residual mean errors, after correction for distortion, are low, and are similar to those of traditional visual measuring machines (3–5 μm),
- the high speed of digitizing,
- the low cost of the machine.

A similar flatbed one-pass commercial scanner (AGFA DuoScan model F40) was then purchased by CIDA for use at ROA. Its principal characteristics include an optical resolution of 1200 $\times$ 2400 ppp, a dynamic range of 3.0, and 16-bit resolution. It uses a tri-linear CCD with 10600 elements. An important technical specification of this particular F40 model is a built-in scanning bed for transparencies. It has the advantage that images scanned from it are captured directly, and not through a glass platen as is the case for opaque material.

The 2520 AC/CdC plates of the San Fernando Zone have now been digitized with it; the data are recorded on CD-roms at ROA. Two scientific projects have been born of this collaboration, and are summarised below. The first investigates the use of a commercial scanner for digitizing plates with an astrometric objective: a catalogue was derived from the reduction of 420 CdC plates, and proper motions were derived and added to it using data from the second USNO CCD Astrograph Catalog, UCAC2 (Zacharias et al., 2004), thereby contributing information about the kinematics and dynamics our Galaxy, down to the CdC plate limit. The second project involves the reduction of plates and the subsequent creation of a complete catalogue, including the CAMC and CMASF data, to get proper motions. This project is the culmination of a major long-period observing programme at ROA. Both projects, especially the second one, were listed in Annex I of the CIDA-ROA agreement signed in January 2000.

The First Project

This project corresponds to Belén Vicente's PhD dissertation at Zaragoza University. From that dissertation (still in progress) we can extract some significant facts:

1. The most important characteristics of the plates that complicate the determination of precise astrometry include:
   - merging of triple-exposures images on the odd-numbered declination plates,
   - blending of some star images with the réseau grid lines,
   - false detections due to plate flaws, spurious dust and other blemishes that have accumulated during storage, and,
   - effects caused by optical aberrations.

   The measuring process uses the software package SExtractor (Bertin & Arnouts 1996) as an initial procedure for detecting possible stellar images. Data from the UCAC2 catalogue then confirmed which images were stellar, and a bivariant gaussian-fitting method developed at Yale for use with their PDS machine (Lee & van Altena, 1983) was applied.

The detection and removal of the réseau grid lines was performed by using the x and y marginal distributions of the list of possible stellar images obtained by SExtractor. A method to calculate the offsets of each triple exposure and relate them to a center-of-light system has also been developed. Both procedures are explained by Vicente (2004).

2. As regards distortion, the scanner introduces significant systematic errors that differ in magnitude and degree of stability in the two axes. An X-axis pattern, constant from scan to scan, depends on the metric defined by the solid-state detector, while a Y-axis pattern that changes from scan to scan is caused by random slippage as the carriage moves. By scanning each plate in two orientations rotated through 90° it is possible to detect and separate the errors.

   The Y-axis distortion appears as 1-dimensional pattern when transforming the double (X,Y) coordinate system obtained per plate into a double system defined by the X-axis through the use of a cubic polynomial fitting (See Figure 1. The pattern is obtained making use of "Weighted Sliding Polynomial" technique (Stock & Abad 1988). The X-axis distortion is quantified by an external comparisons, e.g. with original measurements of the AC plates.

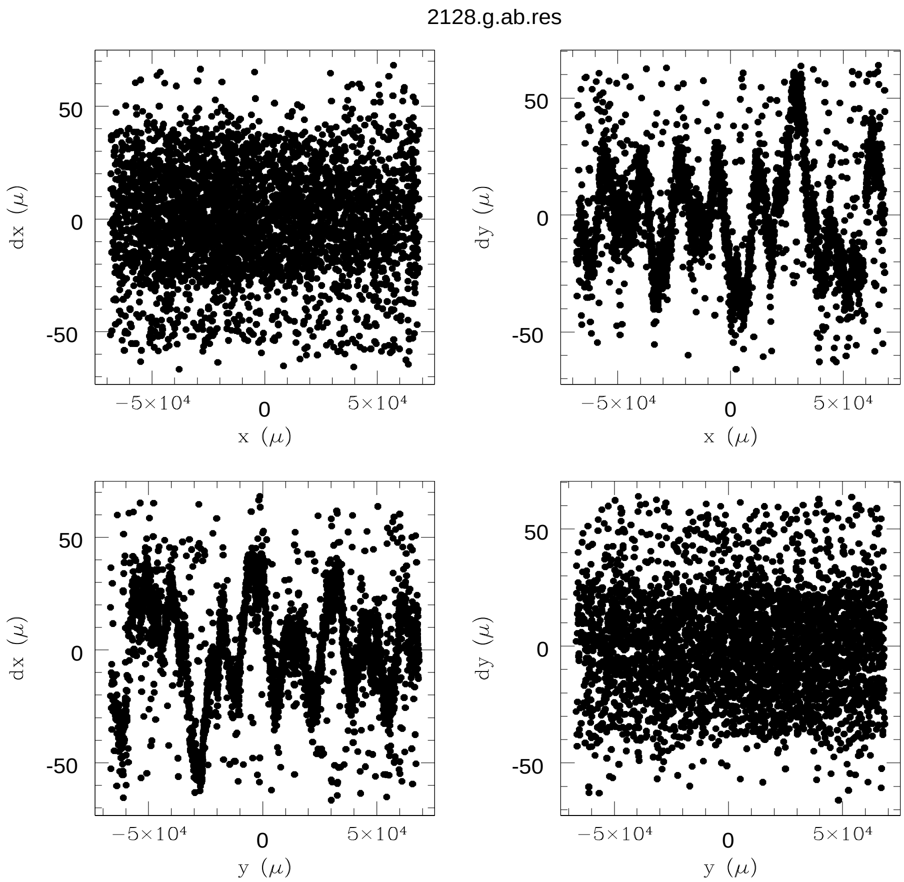

Figure 1: Residuals after a cubic transformation has improved the alignment of the coordinates from two scans, rotated by 90°, of the same plate. The 1-dimensional function characterizing the scanner's Y-axis measuring error is very well defined.

Table 1: Provisional results for different steps of the process

Step	R.M.S. in X (μm)	R.M.S. in Y (μm)
Initial, uncorrected	31.2	32.9
1-D function, corrected	18.2	23.0
Correction with cubic pattern	4.5	4.3
Internal accuracy of individual measurements		
Single-image plates	3.2	3.9
Triple-image plates	5.5	5.1

Table 2: Provisional mean errors, in R.A. (sec.) and Dec. ($''$), for the CdC plate reductions, grouped by magnitude, for stars between 5–6 hours R.A. in the *Tycho Catalogue*

V (mag)	errors in R.A.	errors in Dec.	No. of stars
7	0.019	0.54	22
8	0.024	0.51	431
9	0.023	0.40	1710
10	0.019	0.32	5269
11	0.018	0.28	10865
12	0.019	0.30	4352
13	0.021	0.32	101
14	0.026	0.15	2
total	0.019	0.31	22753

3. Plate reductions have followed methods by Stock (1981) and Abad et al. (1998).

4. A complete explanation of the steps and results will be published soon in a journal.

5. Proper motion is an essential tool for studying the structure and kinematics of the Galaxy. However, catalogues containing proper motions of faint stars measured across wide-interval epochs are limited. The partial catalogue obtained from the 420 CdC plates down to $V = 15$, covers -10 to $+60°$ galactic latitude, and will provide an excellent basis for studies of the kinematics of different components of the disk and halo of our Galaxy.

The Second Project

The compiled CdC astrometric catalogue is an institutional project linking the beginnings of photographic astronomy with current meridian astrometry at ROA. The latter includes the CAMC and the CMASF meridian telescopes, both run by ROA.

The area covered by CdC plates is included in the CAMC and CMASF surveys, though the plates have a brighter magnitude limit than the Meridian observations. The Meridian Catalogues constitute an excellent recent epoch for the determinations of proper motions.

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Seen in the Literature

1. New Light on the Peculiar Star HD 108 (*IBVS No. 5693, April 2006*)
Nazé Y., Barbieri C., Segafredo A., Rauw G., De Becker M.

This *Bulletin* details fascinating changes in the profiles of H and He I lines in this object, which is a very rare breed of O-type spectrum variable. By including photographic spectra observed at Asiago, but only recently accessible digitally, the base-line of the changes has been extended back another 30 years and long-term trends can at last be distinguished.

2. The Bordeaux CdC2000 Catalogue (*2005, A&A,* **449**, *435*)
Rapaport M., Ducourant C., Le Campion J.F. & Fresneau A.

The PM2000 Bordeaux Proper Motion Catalogue (*2005, A&A,* **448**, *1235*)
Ducourant C., et al.

A major step towards the preservation and exploitation of ancient *Carte du Ciel* plates has surely been performed in Bordeaux with the publication of the *CdC2000* (Rapaport et al. 2005) and the *PM2000* (Ducourant et al. 2005) catalogues. The *CdC2000* gives positions at mean epoch 1900 of the entire zone of the Bordeaux *Carte du Ciel* (1/20 of the sky); the plates were scanned with the APM at Cambridge, UK, and reduced with Tycho2. The *PM2000* catalogue is a comparison of the *CdC2000* catalogue with modern re-observations of the Bordeaux *Carte du Ciel* zone using the CCD meridian circle of Bordeaux (plus other intermediate sources of positions) to derive 2.7 million proper motions with precisions between 0.002 and 0.006 ″/year.

(*We need to build a database of similar references in the literature to studies in which access to relatively historic photographic material has proved important, often essential.* **Make your own lists, and send them to the SCAN-IT Editors from time to time!** *Such lists are the stuff that turn the heads of funding organizations – Ed.*)

Plates Rule!

Colin Aspin (caa@gemini.edu),
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One of my main areas of research is the study of young, eruptive variable stars. These objects are younger than a few million years and have been found to increase in brightness in the optical and near-IR by up to 6 magnitudes on time-scales of a few weeks to a few months. They were first studied in the 1960s, 70s, and 80s by George Herbig, who determined that they are young pre-main sequence objects and that the brightness increase was probably the result of an extreme burst of accretion. He categorized the objects into two classes: FUORS (after the prototype FU Orionis) and EXORS (after the prototype EX Lupi). FUORS were observed to brighten and stay bright for long periods with perhaps a slow decline back to quiescence. FU Ori itself erupted in the 1960s and is still in an elevated state. EXORS were seen to be more highly variable, and an outburst typically lasted a shorter time, perhaps weeks or a few months. They were also seen to be repetitive. FUOR and EXOR events are clearly an important phase of young star's evolution, and may be periods when a considerable amount of mass is accumulated by the young star. It is still unclear, however, if FUORS and EXORS are related but with different 'flavors' of the same physical process(es) or if, as some have suggested, they are the result of totally different events. Herbig himself has suggested that FUOR events could occur in rapidly rotating young stars, or are perhaps the result of binary interactions. Whatever the cause, the result is that these objects flare by many magnitudes, making them possibly visible on photographic plates in archives around the world.

In late 2003, an amateur astronomer, Jay McNeil from Kentucky, discovered a nebula in Orion that he had never seen before. He contacted Brian Skiff at Lowell Observatory who passed his query onto Bo Reipurth, of the University of Hawaii, and myself. This nebula, now named McNeil's Nebula, was being illuminated by a young star that had brightened by approximately 5 magnitudes.

The star was designated V1647 Orionis, and has been the subject of intense study by many professionals world-wide. The eruption lasted until March 2006, by which time the star had faded and the nebula had disappeared. One aspect of this eruption that interested me was the fact that the nebula was seen, faintly, on a plate of M78 taken in 1966 and shown in the book "The Messier Album" by Mallas & Kreimer, published in 1970. Since I had been studying McNeil's Nebula intensely at the Gemini Observatory telescopes throughout the eruption, I decided to try and find other plates taken around 1966. I used the Sofia Plate Archive Database and, with the help of Milcho Tsvetkov, found that there were numerous plates of M78 in the Asiago Observatory plate collection, as well as in the Harvard College Observatory collection. With the help of staff at Padova University in Italy, including Professor Cesare Barbieri, over 400 plates were inspected and 19 were found to show the nebula. The plates were mostly blue-sensitive and had a limit of around 19th magnitude – ideal for this study. The Harvard plates were not as sensitive but did cover a much longer time period: way back to 1898! After much scanning and calibrating, we concluded that most of the features of the 1966 eruption were very similar to the 2003 eruption and that no other eruption was detected during the previous century. A paper was submitted to the *Astronomical Journal* and has now been accepted for publication.

Subsequent to that study, I have been in contact with numerous other plate archives in an attempt to find plates of this region. The archives include the Lowell Observatory, Palomar Observatory, Sternberg Institute in Moscow, the UK Schmidt Telescope Unit at the Royal Observatory, Edinburgh, and the Vatican Observatory. I am indebted to Brian Skiff, Nikolai Samus, Jean Mueller, Alessandro Omizzolo, and Sue Tritton, respectively, for their assistance. We hope both to constrain better the time-scales associated with the 1966–1967 outburst, and to determine from these archival data if other outbursts occurred.

For the study of eruptive variables like V1647 Ori, plate archives are an invaluable resource. If only they were all digitized and accessible on-line!

Someday, I sincerely hope.

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Film for Long-term Archives of Astronomical Images

M. Schots, Business manager, specialty products, Agfa-Gevaert NV

Challenges of long-term archiving

The glass carrier of a photographic plate is free from distortion and is in many ways a perfect tool for image measurements. However, in historical collections, deterioration of the emulsion through improper processing or storage conditions or unprofessional handling triggers the need for full lossless conversion of each collection onto a long-term medium. Long-term storage implies storage media that do not suffer from deterioration in time (when used and stored in an appropriate way) and requires a medium that is "un-coded". Un-coded media do not need external decoders like software in order to read them. External decoders may become unavailable or may not be supported when they are no longer the latest technology. In addition, problems can be expected when a multitude of decoders are used, so that not every bit of stored information can be easily read.

Properties of film

Film images are physically high quality. They can be scanned and fed into any modern data communication set-up. The scanner type or software used does not affect the archived image – the only concern is that the scanner chosen should be suitable for the job.

However, films don't last for ever. They can get burned or eaten by acids or bacteria, so an archive needs to respect storage rules and shelter the contents from calamities. Silver-based images (black and white films) hold well in time as silver is very resistant to hostile environments provided that the processing has been carried out following the rules of good practice. Poor fixing or washing may cause deterioration of the film image over long periods.

Often the major problem for archived films is the quality of the transparent film carrier. Old films on celluloid disintegrate in today's archives and images are lost just because the substrate deteriorates. Modern films have a polyester base, a sturdy and stable polymer with enormous life expectancy.

Digitizing and archiving original images in one operation

Although the quality of stored images in archives is an important issue for coming generations, budgets for archive conversion – just copying images – are difficult to find. It is probably easier to find budgets for digitizing in order to increase the accessibility of a collection via digital media or the internet.

The "smart way" is to copy film and glass originals onto a high-resolution film. The copy-image is kept on roll, then an automatic scanner can scan and advance the film without any operator intervention. This operation can happen overnight or as a "background" task, and the use of a intermediate copy film may save a lot of costs compared to specific scanning. The archive is thus backed-up for another century, and digital files are also created. If a grey-wedge is imaged together with the contact copy image at every stage of the conversion process, the digital image can display the original image contrast and greyscale distribution using a simple conversion table in software.

Modern astronomical archives are tasked to improve the access to their image database. By using the internet for access and distribution, one can easily allow access to low-resolution "thumbnails", together with a adequate metadata, though accessing digital files for scientific use will still need a separate procedure – not making use of the internet as it is today.

Whether the conversion is finally performed in a smart or less smart way is only a matter of operational procedure, quality and cost. The most important is to keep the image content secure at conversion and after conversion and in a long-term archive so as to provide tools for future scientists.

Selecting a conversion technique needs professional consideration, and only the system offering the best guarantees should be preferred above economic arguments, or above systems allowing faster digital conversion but which may endanger the image content.

Observatory Plate Collections - 1

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(One of the tasks associated with preserving astronomical plates is assessing the status of the various collections. Below are contributions concerning five observatory collections. We are hoping you will send information about other collections, so that we can compile a full list of reports for publication in a future SCAN-IT *Newsletter. Another pressing issue is identifying the rightful owners of "borrowed" plates, and whether (and if so, how) to return them. – Ed.)*

The University of Michigan plate collection

The astronomy program of the University of Michigan (USA) had a significant library of astronomical plates. The collection had two major components: spectrograms exposed in the period 1911–1973 and direct plates exposed with the Curtis Schmidt telescope from 1950 until the telescope was transferred to Cerro Tololo in 1967. Lack of space and staff led the University Michigan to dispose of the collection.

The collection of spectrograms numbers over 20,000. Publ. Univ. Michigan (1912), **1**, 37 contains a description of the original spectrograph. Subsequent papers in the series describe the spectroscopy of specific objects, provide further details about the spectra, show representative examples, and give lists of plate numbers for objects. One learns that:

- A prism spectrograph was used on the 37.5-inch (95-cm) reflector.
- Observations began in May 1911 and continued until at least 1973.
- The stated useful spectral range was $\lambda\,3700$–6000 Å, but most measured lines were in the $\lambda\,3750$–5040 Å range. There was, however, some use of Hα.
- The original prism was of Jena O:102 glass that gave dispersions and resolutions, of, respectively: 26.7 Å/mm and R = 27,000 at $\lambda\,4000$ Å; 62.5 Å/mm and R = 11,000 at $\lambda\,5000$ Å; and 133 Å/mm and R = 5,400 at $\lambda\,6000$ Å.
- The original prism was replaced in 1914 May 20 (1938, Publ. Univ. Michigan, 7, 57) with a flint glass prism of better transmission but slightly lower dispersion: 40Å/mm at Hγ compared to the former 37Å/mm.

In the *Observatory Reports* for the University of Michigan, published in the *Astronomical Journal*, there are references to two other spectrographs:

- A "two-prism spectrograph" with (at least) two cameras: a six-inch camera with a dispersion of 76Å/mm and a 12-inch one with a dispersion of 38 Å/mm (1964, *AJ*, **69**, 689; 1969, *BAAS*, **1**, 65; 1971, *BAAS*, **3**, 131; 1972, *BAAS*, **4**, 119).
- An "ultraviolet quartz spectrograph" with f/1 and f/2 cameras that gave dispersions of 300 Å/mm and 150 Å/mm at the Balmer limit (1958, *AJ*, **63**, 366).

It is not known if any of the plates in the library were obtained with these instruments.

The Michigan spectrograms have been placed on long term loan in the North American Astronomical Plate Center at the Pisgah Astronomical Research Institute (PARI) in Rosman, North Carolina, U.S.A. A preliminary catalogue of the plates, developed by Thurburn Barker, is available on the PARI web site (http://www.pari.edu/library/astronomical-plate-center/ and go to annarborspectrographindex).

Contact Michael Castelaz (mcastelaz@pari.edu) at PARI to request a quick-look scan of a particular plate or to arrange to visit PARI to access the plates.

A total of 6835 direct plates was exposed with the Curtis Schmidt in Ann Arbor from February 2, 1950 to October 21, 1966, when the telescope was transferred to Cerro Tololo. The number of plates was approximately evenly divided between direct images and objective prism spectra. Unfortunately, almost all of those early plates have been discarded. Only two are known still to exist, although it is possible that others are in the possession of early observers with the instrument. Anyone holding such plates is urged to contact Wayne Osborn, who has the plate catalogue. An additional 34,000 plates were obtained with this same telescope at CTIO from 1967 until it was decommissioned in 1994 (see below).

The Cerro Tololo plate collection

A large number of plates, both direct and spectroscopic, were exposed at the Cerro Tololo Inter-American Observatory (CTIO) Chile, using a variety of telescopes and instruments. Two of the most important collections are the 6900 plates obtained with the 4-m telescope from 1974–1998 and the 34,000 direct and objective prism plates taken with the Curtis Schmidt telescope from 1967–1994.

Typical direct exposures with the 4-m were obtained at the f/2.7 prime focus. They have a plate scale of 19 Å/mm and cover a field a little less than a degree in diameter (representative photographs from 4-m plates can be found in 1988, *PASP*, **100**, 346 and 1980, *AJ*, **85**, 423. The Curtis telescope is a 0.6/0.9-m f/3.5 Schmidt with a scale of 97 Å/mm, and the plates typically cover a 5 $\times$ 5 degree field. Catalogues of the 4-m and Curtis Schmidt plates are available at the CTIO web site (http://www.ctio.noao.edu/telescopes/4m/base4m.html)

As CTIO had no policy to maintain its own plate collection, most of the plates exposed there were taken home by the researcher/observer or shipped to the center coordinating a specific project (e.g. N. Houk's two-dimensional reclassification of HD stars). As a result, some plates are currently at CTIO but the majority are scattered throughout the world. Many are in the hands of astronomers who have retired or are nearing retiring age and are wondering what should be done with the plates still in their possession.

CTIO does not want its plates returned to Chile. They have agreed that those astronomers wishing to dispose of unwanted CTIO plates can deposit them at PARI in Rosman, North Carolina, USA. About 3000 plates have so far been received.

Astronomers holding CTIO plates that they would like to deposit at PARI are asked to contact either Wayne Osborn or Michael Castelaz. Castelaz can be contacted about the plates now at PARI (an on-line catalogue is being developed). Osborn and Castelaz are also interested in hearing from astronomers who have CTIO plates that they still wish to retain so that records can be compiled of where all the plates are.

Photographic Plate Archive of the Kyiv University Astronomical Observatory

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Astronomical Observatory of the Kyiv Taras Shevchenko University

The Astronomical Observatory of the Kyiv Taras Shevchenko University began cataloguing its photographic plate archive only recently. The observations were begun in 1892 with the installation the Merc-Repsold astrograph (D=20 cm, F=43 cm), but at first were not regular. Direct plates were later received from many other instruments.

Our collection totals about 13,000 direct images on glass and film in various formats. Among them are images of comets dating back to 1898, the Moon in different libration (from 1907), star fields (from 1909), the planets and eclipses (both from 1912), asteroids (from 1938), and transits of Mercury and Venus across the disk of the Sun. To the collection has since been added various images of meteorite trails (from 1958), photoheliograms (starting in 1940), spectrograms of photosphere of the Sun in white light (1954) [see page 16 for Mt. Wilson spectroheliograms. -Ed.] and echelle spectrograms (1978). In addition the collection contains 600 hours of videos of star fields made during observations of the maxima of meteor showers. Journals of observations showing sketches of sun-spots (dating from 1923) and magnetic fields (from 1981–1988) have also been archived.

The KAO scanner (Microtek SkanMaker-4) has an optical resolution of 600 × 1200 dpi and a 36-bit colour capture. Careful examination of the astrometric quality of the processed images from the direct plates that we have scanned has revealed errors of runs, with a periodic dependence on plate coordinates. The problem appears to arise from a design flaw in the scanner, associated with a lack of synchronicity between the scanning movement and the charge transfer process in the CCD receiver. Generally, the errors are worst in the direction of travel, and are less serious in an orthogonal direction. Regular scale errors have also been detected.

In order to minimize the effect of these linear scanning errors we are proposing to scan by turning the plate through 90 degrees and incorporating the scale changes in the data processing by masking the image into zones.

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From the Institute of Astrophysics, Tajikistan

A heart-rending plea was received from N. Minikulov (*mnasredin@mail.ru*) on New Year's Day for assistance in preserving the photographic-plate archive of the above Institute. Dr. Minikulov described the archive as containing more than 70,000 plates from 1930–1985, but that each year the storage conditions get only worse. It is now critically important to digitize the plates as soon as possible in order to make the information accessible to astronomers worldwide.

News from l'Observatoire de Haute-Provence

E. Griffin/S. Ilovaisky (*ilovaisky@obs-hp.fr*)

Haute-Provence Observatory, situated in the region known as the "low Alpes" in S.E. France, is the oldest of France's currently operational observatories, its first observations dating back about three-quarters of a century. For several decades it supported programmes involving photography, both direct and spectroscopic, though it is mainly through the latter that its largest plate archive was built up; the relative proximity of Marseille, its modest elevation of only ~670m and characteristic inland seeing (plus the economic stringencies of the war years) discouraged the development of large-telescope projects but favoured the pursuit of spectroscopy, objective-prism observations, and innovative ideas in both science and technology. Its spectroscopic archive is therefore a fairly substantial one. But – the familiar story – when photographic spectroscopy ceased, it was closed and left in a state of some disorganization.

Our man-on-the-spot is Sergio Ilovaisky, who may already be familiar to some of you through htttp://www.obs-hp.fr/www/archive/archive.html, the OHP digital archive of spectra observed with ELODIE (the spectrograph used to search for exosolar planets). Recent changes at OHP, along with the retirement of people who had prior use of key laboratory space, are now presenting an opportunity to preserve and sort the photographic material, too, into an organization that will endure.

Sergio writes: "First, we are planning serious steps to preserve our plate archives. At the very least this calls for refurbishing the OHP plate-stacks room, including a new air-conditioning system, putting the entire plate collection in order (spectroscopic, objective-prism and direct plates), and in the process indexing the entire contents into a searchable database. I am now recovering all the original observing books, presently scattered throughout the different domes, as they will all be needed in the indexing process.

"I have also established contact with people from Marseille and Nice Observatories who are also concerned about the same matter, and I am joining them in a proposal for funding a comprehensive campaign to preserve what we can, including material from Marseille Observatory (the latter is scheduled to move to a new building next year). At the same time, we also plan to save our historical photo collection."

Sergio goes on to speak of the new echelle spectrograph SOPHIE, at the 1.93-m telescope. His new will feature will be complete pipeline processing and automatic data archiving. That will be a very considerable advance even on ELODIE; even though the data from the latter were fully digital, there had been no thought-through means of archiving the data into a scientifically useful tool and it was a considerable effort to create one retroactively. As he explains:

"The instrument, which is briefly described at http://www.obs-hp.fr/www/guide/sophie/, will feature automated reduction software which will produce fully reduced spectra (and radial velocities) on the fly. The raw data and the data products will be stored in a RAID array and automatically indexed into a database system so that easy access via a Web browser will be possible (as in the ELODIE Archive http://atlas.obs-hp.fr/elodie/) when the data become public after a year."

I would like to congratulate Sergio for the initiative in setting these projects in motion, and – in your name – offer him the support of the PDPP.

Report on AC/CdC WG Activities and Recommendations to be Presented at the XXVI IAU GA

Beatrice Bucciarelli (bucciarelli@to.astro.it)

(*As you will have gathered, this IAU WG is to merge with the PDPP at the next General Assembly, making PDPP a slightly larger organization. The following Report was prepared by Dr. Bucciarelli for the triennial report of the parent Commission (20), and in the circumstances it seemed appropriate to reproduce it here, with permission – Ed.*)

Since the last IAU GA, various efforts have been undertaken to digitize parts of the AC/CdC collections pertaining to the different zones, with the twofold intent of exploiting the scientific potential of these plates and making the digitized images available to the community.

• The AC/CdC plates of the Cordoba zone have been digitized with a commercial scanner (UMAX Astra1220P) at low resolution for identification and quick-and-raw measurements (Calderon et al., 2004, *Astrophysics and Space Science*, **290**, 345); positional accuracy is 1", photometric accuracy not yet determined. The digitized plates are available to the community; digitization of selected images at high resolution can be made available upon request.

• The *Real Instituto y Observatorio de la Armada en San Fernando* (ROA, Spain) has completed the scan of its collection of AC/CdC plates (Dec. zone –3° to –9°) with a precision Agfa DuoScan flatbed scanner. Each plate has been digitized in two positions (rotated by 90° with respect to each other) in order to detect possible systematic trends in the measured coordinates. The two images of every plate have been recorded in FITS format on CD-ROM. Copies of these CD-ROMs may be requested from the ROA.

• Busto Fierro and Calderon (2003, *Revista Mexicana de Astronomia y Astrofisica*, **39**, 303) have developed a method for the measurement and reduction of AC/CdC plates using a CCD camera + photographic objective, which has been tested on a plate of the Cordoba zone. Their results indicate an astrometric error of $0''.2 - 0''.25$ for stars covered by the Tycho-2 catalog, but possibly worse for fainter stars.

• Lamareille et al. (2003, A&A, **402**, 395) investigated the use of a commercial scanner to digitize CdC plates of the Toulouse collection for stellar photometry. The tested scanner is an AGFA SNAPSCAN 1236S with resolution 600 × 600 dpi. Having calibrated the density-to-intensity transformation with the use of about 100 standard stars per plate, the reported photometric accuracies are of the order of $0^m.2$ to $0^m.4$, depending on the location of the target star on the plate.

• Ducourant et al. (2006, A&A, **448**, 1235) have published the PM2000, a catalog of proper motions for 2,670,974 stars, complete to $V = 15^m.4$. The proper motions were derived from the reduction of 512 CdC plates of the Bordeaux zone scanned at the APM in Cambridge plus modern-epoch observations with the Bordeaux CCD meridian circle. Reported errors are from $0''.0015$ to $0''.006$/yr, depending on magnitude.

• Fresneau et al. (2003, AJ, **125**, 1519; 2005, AJ, **130**, 2701) have selected, measured (with the APM machine in Cambridge) and analyzed a set of 650 CdC astrographic plates of the former Sydney Observatory along the 4th galactic quadrant. When compared to the GSC 1.2, stars with total annual p.m. larger than $0''.015$ can be considered as 'high' p.m. stars and their distances are derived in order to investigate the differential rotation in the galactic plane up to 500 pc from the Sun. The use of the first Epoch positions provided by these plates in the framework of the Virtual Observatory is currently being investigated in order to provide a 'hands-on' experiment when scanning the legacy of the CdC programme in the far southern hemisphere at Macquarie University with a fast scanner.

Summary and Conclusions

Various experiments have definitely demonstrated that the 1-μm accuracy ($0''.06$) for the definition of stellar images on CdC plates, as was speculated back in 1999, cannot now be claimed.

More realistically, a 2–3 μm accuracy is achievable, getting worse towards the survey magnitude limit, with an average magnitude error of $0^m.3$. These are levels of accuracy that can be obtained with precision measuring machines like APM or MAMA, and are intrinsic to the images themselves. That level of astrometric accuracy corresponds to a $0''.2 - 0''.3$ error in position at Epoch 1900, and if the latter is used as first Epoch for proper motion determinations in combination with modern-epoch observations, an error at the level of $0''.002 - 0''.005$/yr can be produced, so we will be able to detect stellar motions larger than $0''.01$/yr. At a distance of 500 pc from the Sun, that corresponds to 25–60 km/s tangential velocity. Therefore, the AC/CdC heritage collection can be regarded as a highly valuable first-epoch material, e.g., for the realization of a Tycho-2 extension to fainter magnitudes ($V \sim 15^m$ photographic), especially in selected areas where radial velocity data are available, for the exploration of stellar kinematics beyond our solar neighborhood. It is therefore essential that the scanners used to digitize these plates can do so without loss of information.

More generally, the Cart du Ciel plate material deserves to be salvaged and digitally recorded to the best accuracy for those astrophysical investigations which can exploit this unique, 100 year-old picture of the sky. In this respect, the scientific interest of such collection is potentially equivalent to that of all the other world-wide astronomical plate archives. For this reason, I think that the goals and objectives of this WG and the PDPP are shared, and therefore, in the best interest of both groups, just one WG/TF dealing with the preservation and digitization of this heritage from the past should be retained.

Finally, I want to point out a sensible question not yet clearly answered, which would be decisive for a realistic estimation of project resources and timelines, namely, the level of accuracies achievable from the fits images of AC/CdC plates scanned with commercial scanners. This issue is equally relevant to all astronomical plate collections.

In Memoriam

Willem Wamsteker

The whole community was shocked to learn of Willem's untimely passing last November, within days of his 64th birthday. This space is a deserved but totally inadequate tribute to the essential rôle he played in salvaging the information on historic plates.

It was Willem who wrote the 1991 IAU Resolution that eventually turned world attention to the plight of astronomical plates, and Willem who fought for resources to create a "final archive" of *IUE* spectra – a facility that has enabled *IUE* data to be re-used 5 times over (thereby effectively extending the scientific life of the satellite from 15 to 75 years), and proving through action the importance of on-line data archives.

In 1991 Willem was a space scientist, the Director of the IUE-VILSPA Tracking station in Madrid, but his vision was broad enough to encompass such terrestrial matters as historic plates that were inaccessible unless digitized. It was his encouragement and example that fuelled the progress of the IAU Spectroscopic Data Archiving WG, and his personal generosity that offered abundant support and encouragement at all stages.

Willem was an initiator *par excellence*. His ideal was to get a good idea growing, but to let it be nurtured to maturation under the more focussed attention of other specialists. He had friends and contacts everywhere.

May he rest in peace, knowing that this idea of his is also very much alive and kicking and developing very healthily!