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POTSDAM LIBRARY OF ASTRONOMICAL PHOTOGRAPHIC PLATES*

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Abstract. We present the Potsdam photographic plate library at the Leibniz Institute for Astrophysics Potsdam. It includes plate archives, data from plate index catalogues and extracts from astronomical logbooks, as well as digitized plate images and interfaces for accessing all the available information. The plate index catalogues and the digitized images of the Potsdam astronomical photographic plates are prepared according to the standards of the Wide-Field Plate Database and German Astrophysical Virtual Observatory. The high-resolution digitization of the plates (in standardized FITS file format), the low-resolution plate previews (in TIFF and JPEG file format), as well as suitable digitization of the catalogues, logbooks, and relevant scientific research papers (in JPEG and TIFF) are made using commercial flatbed scanners.

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1. Introduction. The establishment of the Potsdam Library of Astronomical Photographic Plates responds to the need of easy access to various astronomical data in our digital data world. The photographic plates obtained in the Potsdam Observatory date from the first astronomical application of photography which happened more than 130 years ago. The plates store information on astronomical objects observed in the period before photography was replaced by charge-coupled devices (CCD) technology for astronomical observations. Photographic plates are considered scientific heritage with option of using the unique stored information for many astronomical tasks. The plates have to be handled carefully (better, the digital plate image should be handled instead) because of their composition: glass coated on one side by silver bromide dry emulsion. Another reason for the plate's need of appropriate storage and preparation for handling is the chemical and physical deterioration of the emulsion. The Potsdam Library of Astronomical Photographic Plates, as the other similar libraries at European astronomical observatories [1], offers appropriate long-term storage of the plates with building and environmental control; Potsdam plate collection inventory with preparation of web-based searchable catalogues; access to the information on plates and locations and contents of plate archives, including plate envelopes, observing logbooks, card catalogues or other paper files; easy and fast access to the plates; plate digitisation and curation. The team of the Potsdam Library of Astronomical Photographic Plates consists of astronomers, librarians, networking and information technology specialists.

The library has a connection to the Wide-Field Plate Database (WFPDB, [2]), where information on all 2.4 million known and stored wide-field ($> 1^\circ$) plates from 476 plate archives in professional astronomical observatories and institutions all over the world (in the Catalogue of Wide-Field Plate Archives, [3-4]) and online information on 563 612 plates (from 133 plate archives), i.e., 23% of all at the moment – September 2011 (in the Catalogue of Wide-Field Plate Indexes) – are collected.

2. Inventory of the Potsdam plate collection. The inventory of the wide-field plate collection of the Leibniz Institute for Astrophysics Potsdam (AIP) [5] shows that the collection consists of 9900 plates, obtained in the period 1879–1970 in the Astrophysical Observatory Potsdam (Telegrafenberg and Babelsberg). The collection has been assembled as a result of various observational programmes (Potsdam Survey of Northern BD Stars, Potsdam CdC Zone, Photographic Photometry, Kapteyn's Selected Areas (SA) Photometric Survey, Double Stars, Application of Objective Prisms, Dark Nebulae, Mira Type Stars, Open

Fig. 1. View of the shelf with the Kapteyn Selected Areas plates and available logbooks in the Potsdam Library of Astronomical Photographic Plates

Stellar Clusters, Eclipsing Binary Stars, Comets and Minor Planets) by historic names as O. Lohse, J. Scheiner, J. Hartmann, E. Hertzsprung, K. Schwarzschild, G. Eberhard, etc. The plate collection also reflects the history and development of the Potsdam Observatory, e.g., the observatory was the base for testing new astronomical emulsions, beginning with Schleussner's dry photographic plates, as well as AGFA plates up to 1960 and ORWO emulsions after 1960.

The plate collection contains one of the oldest archives of systematic wide-field photographic observations made in the frames of observational programmes for studies of planet surfaces, bright stars, some double stars, stellar clusters and nebulous objects started by Oswald Lohse (the stored part of the archives is since 1885, [6–7]).

The collection includes 977 Potsdam Carte du Ciel (CdC) plates – from the first photographic all-sky survey produced maps (CdC charts) to 15th magnitude and measured positions for stars to 12th magnitude (AC catalogue) – since the start of the project in 1887. The Potsdam CdC plates (with the WFPDB identifier POT032), taken in the zone between +31 to +39 degrees with the double Steinheil and Repsold refractor (known as "Himmelskarte" refractor) have good potential for seeing the astronomical objects of interest back in time starting since 1893 up to 1924.

The plates from the Kapteyn Selected Areas (SA) programme (part of them are presented in Fig. 1) were taken in SAs 68–91, as well as in the additional 10 Kapteyn-Pritchard areas (No. 1–10) and Kapteyn Special areas (No. 2, 3, 4, 5, 6, 7, 24, 25). The plates were taken with two telescopes: the 80 cm refractor (from 210 obtained plates in the period 1910–1933, 206 are available now) and 15 cm Zeiss Triplet (from 225 obtained plates in the period 1910–1926, 221 are available now) with the identifiers in WFPDB, respectively POT080 and POT015.

The collection of the Pleiades plates obtained in the period 1889–1928 is of great interest too. The plates have been found to be in a relatively good condition. Nevertheless there are some plates from Lohse's archives with emulsions completely detached (or having begun to detach) from the glass, some of the plates have yellow spots with different sizes or no images at all. The aging of the emulsion influences the image silver and as a result golden spots appear and the image information is destroyed, which makes urgent the digitization of the plates.

All Potsdam plates from Telegrafenberg and Babelsberg have been brought together to the institute's library and stored under special conditions assuring lack of humidity and mould, dust, strong illumination, sudden temperature changes, as well as control room access in order to avoid non-professional treatment of the plates. The replacement of the old time-damaged plate envelopes was done with the new envelopes for 16×16 cm and 20×20 cm plates of a special material, Tyvek 54 g, which is robust and does not produce dust.

3. Preparation of the web-based searchable catalogues. The Potsdam plate index catalogues, presenting descriptive plate data, are prepared according to the standards of the WFPDB (for more details see [8]). To this moment five Potsdam catalogues of plates have been included into the WFPDB (in chronological order POT050, POT025, POT032, POT080, POT015) with some references to the preview images of the plates, if available, which can be examined in detail by zooming the preview. Only for two archives logbooks were found and used for preparation of the respective catalogues, the rest of the catalogues were directly prepared using the notes on the plates. For the preparation of the computer-readable plate catalogues special software had to be written—for converting the employed local sidereal time to required universal time, for extracting metadata from graphic file formats, etc.

In the WFPDB Search Page the Potsdam plate catalogues can be found with the WFPDB observatory identifier POT, instrument aperture (e.g., 080 for the Great Refractor), and the original plate number (e.g., for the plate with

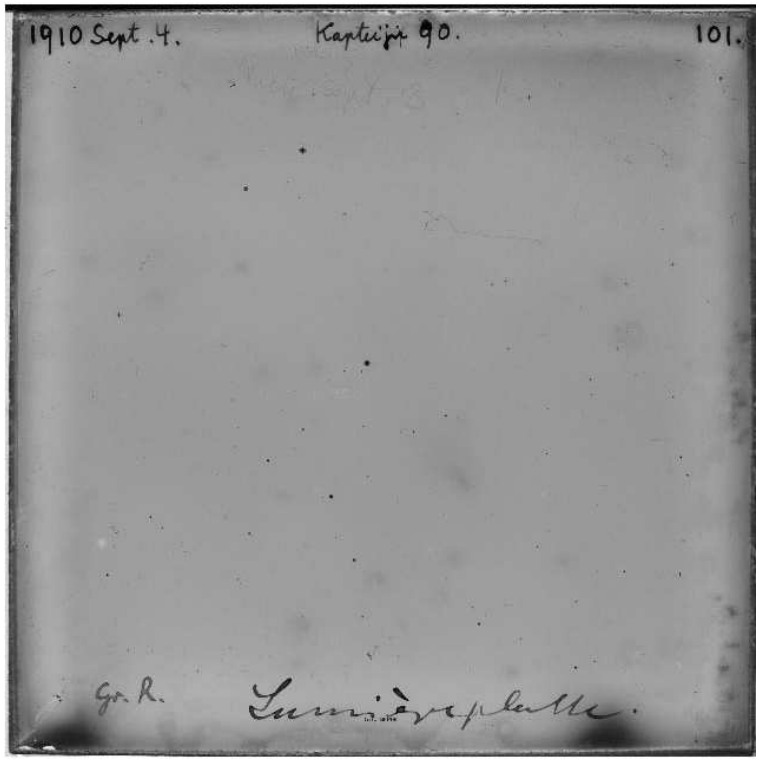

Fig. 2. Preview image of the POT080 000101 plate

original plate number 101 it looks as POT080 000101; the preview image of the POT080 000101 plate is presented in Fig. 2). The user can display details for the archive to which a selected plate belongs with a map of the all-sky distribution of the observations from this archive, as well as an additional page with details on the selected observation, including, if available, notes, observer name, and information about the plate availability and plate digitization.

An analysis of the CdC Potsdam catalogue in the context of the usage in the Virtual Observatory frames according to the observation parameters as coordinates, time, name of the object, number and duration of exposures, type of the emulsion, etc., can be found in [9].

4. Plate digitization and digital curation. The digitization of the Potsdam astronomical photographic plates provides digital preservation and storing of information, as well as re-use of plates, avoiding any movement of

fragile plates. The digital curation includes collection, maintenance, selection and retrieval of the digital material, as well as preservation in standard data file format and archiving of already digital plates using various techniques. The digitized plate images with low or high resolution can be obtained online according to the copyright policy of the observatory.

Currently about 1500 Potsdam photographic plates from five archives (with web-based searchable catalogues) have been digitized, among them the plates from the oldest systematic WFPDB archives of Lohse, the Potsdam CdC plates, the Kapteyn Selected Areas plates, as well as some selected plates in the Pleiades region, and plates with Comet Halley images. Lohse's plates needed urgent preservation because of the continuing deterioration of their quality caused by the noticeable aging of the photographic emulsion.

The systematic digitization of the Potsdam plates began immediately after the installation of the EPSON EXPRESSION 10000XL flatbed scanner in 2006 and after test scans and choosing the right scanning parameters—plate preview for visual examination and easy online access (with 600 dpi resolution) and for astronomical task image processing (with 2400 dpi resolution or 10μ/pix). In order to complete the plate digitization on time a second EPSON flatbed scanner was involved in the work—EPSON PERFECTION V700 PHOTO.

In Table 1 the main parameters of both EPSON flatbed scanners used in Potsdam are presented: Optical density (Dmax), Colour depth (bit internal/bit external), Grayscale depth (bit internal/bit external), and Maximum hardware resolution (dpi).

The plate scanning is done with whole density range (0–255) and Gamma = 1.00 for saving as much as possible detail for the emulsion and status. The chosen resolution is a compromise between the outcome file size and the astronomical task. The chosen colour depth is also dependent on the task: for preview images in order to save the observer's marks on the plate, the image type is 8-bit or 24-bit colour, and for the scans with high resolution, 16-bit greyscale. The sizes of the plate image files depend on the chosen resolution of scanning and on the plate size.

As a rule, the Potsdam plates were scanned using the orientation North

Table 1. Main parameters of the available Potsdam EPSON flatbed scanners

Scanner	Dmax	Colour depth	Grayscale depth	Resolution (dpi)
EXPRESSION 10000XL	3.8	42/42	16/16	2400×4800
PERFECTION V700 PHOTO	4	42/42	16/16	4800×9600

up, East left. For this purpose the observer marks (the written number of the plate in the same plate corner) were used (nevertheless it is not guaranteed). For cleaning the glass side 99% alcohol with cotton pads was used for stubborn dirt or ink, and a soft brush brushing away cotton debris from the emulsion.

The Potsdam CdC plates were scanned twice for producing preview scans with resolution 1200 dpi for quick plate visualization and saving of the observer marks. High resolution (2400 dpi) is used for scans intended for astronomical tasks. The preview scans were stored in TIFF and after additional compression to a resolution of 318 dpi or 2000×2000 pixels in JPEG file formats, the scans with high resolution were stored in FITS file format. The file sizes of the scanned plates with low and high resolution are given in Table 2. All files are installed on the German Astrophysical Virtual Observatory (GAVO) Potsdam server [10].

Adobe Photoshop was used for the CdC plates preview scanning. The *ad hoc* developed software Scanfits [11] was applied for the scans with high resolution in FITS format. In both cases the transformed flop-images to suit to celestial equatorial coordinates and to enable the image identification were made subsequently. For the scanning of POT015 and POT080 plates at high resolution, VueScan scanner software [12] was used.

Table 2. Potsdam CdC digital plates images

WFPDB Identifier	Used Scanner	Number of Scanned Plates	TIFF (MB)	JPEG (MB)	FITS (MB)
POT032	Perfection V700 Photo	153	160	2	440
POT032	Expression 10000 XL	824	160	2	440

After the technical scanning the process of plate digitization includes:

– Estimation of the quality of the digitization data;

– Linkage of the scanned plate images (e.g. of the preview scans) for the users of the WFPDB for online access;

– Digitization of the related logbooks and observer's notes;

– Creating a link between a needed plate in WFPDB and the page in the logbook describing this plate.

The data from the preview scanning of 015 and POT080 plates with 1200 dpi resolution (20 μ/pix) and colour grayscale image for the respective plate archive plates, scanner used, file volumes for the 2000×2000 pixels JPEG file format in MB (done for better presentation in WFPDB) and the software used for scanning, as well as at high resolution in FITS file format, is summarized in Table 3.

Table 3. Digital plate images for the Kapteyn SA plates

WFPDB Identifieret	Scanner Used	Plate Size (cm)	JPEG (MB)	FITS (MB)
POT015	Expression 10000 XL	20×20	2.0–3.0	681
POT080	Perfection V700 Photo	16×16	1.8–2.0	193

The samples for standards and metadata for digitized photographic plates, providing indexing, accessing, preserving, and searching for plate images and developed for the Potsdam CdC plates, could served as examples [10]. The search interface for the scanned plates gives information about the plate identifier, coordinates, date, file type (compressed JPEG, TIFF, FITS format), header of the FITS file, file size, and the scan.

The headers of the FITS format files contain all necessary information: equatorial coordinates of the plate centres in the original epoch, name of the observed areas, name of the observer, etc. The header contents are processed according to the respective requirements in GAVO [10]. Software for automatic generation of FITS files header of the scanned plates on the basis of the relevant plate catalogue was developed [13].

For some astronomical photometric tasks scanning of a wedge together with the plate is needed. For this reason the test scans with EPSON EXPRESSION 10000 XL flatbed scanner supplied with a special frame, made in the institute workshop for two neutral step wedges of type TG13 and TG21S [14], were made in September 2010. The wedges have respectively 13 and 21 greyscale steps. Each step is 0.15D in the range of densities 0.15—1.95D, and 0.05—3.05D, respectively. A new technology for scanning with a wedge is applied. It consists of:

- Plate scanning with VueScan scanner software [12];
- Conversion of TIFF output file in FITS file format (see [13]);
- Separation of plate image from the wedge image (see [13]);
- Saving images as separated files.

All available logbooks for the CdC plates—first and second epoch of observations, and for the 15 cm Zeiss Triplet Kapteyn SA plates, were scanned, as well as the available observer remarks (Beobachtungszettel) on loose sheets of paper for the CdC plates (Fig. 3) and the Kapteyn SA plates taken with the

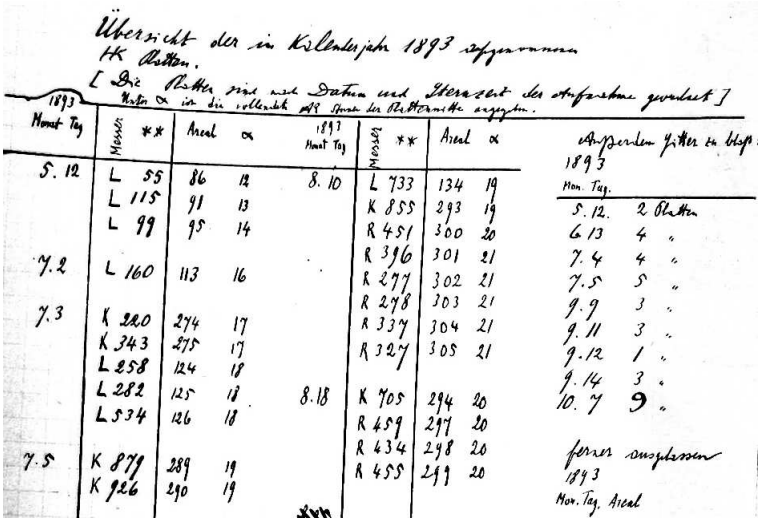

Fig. 3. Scanned copy of a part of an observer note concerning the obtained CdC plates in 1893

80 cm Large Refractor. Work is in progress on access to the information for plates and plate archive locations and contents, and to the information on plate envelopes, observing log books, card catalogue or other paper file, as well as to the published papers as scientific output of the usage of plates [15].

The complete installation of the Potsdam CdC plate scans on the GAVO Potsdam server finished in Autumn 2008. Since that time there is online access for applications of the astronomical community. The POT032 plate previews are also accessible on-line via the WFPDB. For better online access to the Potsdam high-resolution plate scans a mirror ftp-site of the WFPDB (the version installed and upgraded in Sofia, regularly updated) has been made at AIP since December 2007 [16]. For the other plates (POT050, POT025, POT080, POT015) only access to the preview plate images is currently possible.

For the scans with high resolution an implementation of Wavelet transformation methods for additional compression of raw scans because of the huge volume of scanned plate data [17–18] is applied. The current tasks are the organization of the plate scans in an image database and the development of a software system for object plate identifications and for searching in an image database with many data storage variants.

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