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DIGITAL PRESERVATION AND WEB ACCESS TO THE KONKOLY OBSERVATORY SCHMIDT TELESCOPE PLATE ARCHIVE*

Katya Tsvetkova, Milcho Tsvetkov, András Holl

Abstract. The digital preservation of the Konkoly Observatory Schmidt telescope plates, as well as the web access to the plate previews, aim for the preservation of this scientific heritage and the re-use of the astronomical photographic plates in time domain astronomy. The photographic plates used as detectors and information storage at astronomical observations with the Konkoly Schmidt telescope had been obtained in the period 1962–1996. The work on the digital plate preservation and web access started in 2001 with creation of an electronic plate catalogue and the digitization of selected representative plates as well as with interlinking of the publishing in Konkoly Observatory Information Bulletin on Variable Stars (IBVS) with the Wide-Field Plate Database (WFPDB) developing in Sofia. We describe the process of the digitization of the Konkoly Schmidt telescope plates.

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1. Introduction. The Konkoly Schmidt plate archive consists of more than 12700 plates obtained in the period 1962–1996 with the 60/90/180cm Schmidt telescope (scale: 115"/mm, circular field size: 5^0) installed in Piszkéstetö (Mátra Mountain Station). The information for the plates is described in a computer-readable plate catalogue. The plates are of size 16×16 cm and limiting magnitude 19 (B) in the Johnson wide band photographic system—UBVRI, or in pg. An exposure duration less than or equal to 30 min was used mostly. The most observed objects were selected sky regions and stellar clusters, supernovae, individual galaxies, flare stars in stellar clusters and associations [1]. The information on the plates can be obtained through the Wide-Field Plate Database (WFPDB, [2]) installed in Sofia and mirrored in Potsdam since 2007 [3] or since 2010 in Sofia [4] with instrument identifier KON060. It includes the all-sky distribution of the plate centres, the number of plates according to the type of the observed objects (asteroids, planets, comets, variable stars, open or globular clusters, galaxies, etc.), the exposure duration influencing the plate limit, the exposure multiplicity as a method of observation required by different programmes (search for asteroids, investigations of different types of variable stars, etc.), the used emulsions and filters, the plate size concerning the plate digitization. In the WFPDB-Sofia Search Page there is online access for quick plate visualization (plate preview) for all digitised plates.

The processes of the Schmidt telescope plate preservation and web access to the plate previews (since 2001) is a part of the Konkoly Observatory Digital Archive Project [5] for preservation and re-use of the observatory plates with the aim of saving scientific heritage as well as creating a repository in time domain astronomy, from where the past of the astronomical objects can be seen again. For creation of the specialized digital plate collections in the frames of eScience and the interlinking Information Bulletin on Variable Stars (IBVS, [6]) with WFPDB the organization of the information on the existing plates is the first stage of the programme. It includes organization of the cataloguing of the plates, online access to the contents of the prepared plate catalogues and tools for data mining—certain objects, spatial plate distribution on the sky region, temporal coverage, observing method used and special techniques, purpose of the plates as a part of sky survey or sky patrol, magnitude limit of the plates, plate quality, etc. Having a computer-readable catalogue of the given plate archive, it is easier to proceed to the execution of the plate scanning, making the digitized plate images practically identical with the originals, as a second stage before the systematic astronomical research. The plate digitization procedure is also an ad-

ditional tool for an improvement of the catalogue. Thus, during the scanning some mistakes and misprints in the existing Schmidt telescope plate catalogue were noticed. The analysis of the mistakes and misprints revealed that they are of the following types: wrongly written name of the object, difference in the exposure times given in the catalogue and written on the plate envelope; difference in the number of exposures; different method used (as focus plate, with objective prism). Additionally, while handling the plates during the scanning some important notes concerning the plate quality as bad plate, out of focus, extra-focal plate, elongated images, cracked plate glass, existence of emulsion strips with different densities, lack of emulsion in one plate edge, broken plate edge, etc., were added to the catalogue. An atypical case was the lack of any information for an existing plate in the original plate catalogue. The reason might be that the date of the observation does not coincide with the serial and chronological plate number. The corrections in the Schmidt plate catalogue will be made in the WFPDB with the serial upgrading of the database.

The preparation of the digitized plate image database containing low-resolution images for quick plate visualization and high-resolution images with suitable photometric and astrometric accuracy is the last stage of plate archiving.

2. Scanning Konkoly Schmidt telescope plates.

2.1. Used scanners. At the moment there are two flatbed scanners available in Konkoly Observatory: UMAX PowerLook 3000 (since 2001) and EPSON Perfection V750 PRO (since 2009). Their main parameters including optical density (Dmax), color depth (bit internal/bit external), gray scale depth (bit internal/bit external), maximum hardware resolution (dpi), and transparency scanning area (mm), are presented in Table 1.

Table 1. Main parameters of the available flatbed scanners in Konkoly Observatory.

Scanner	Density Dmax	Color depth	Gray scale depth	Resolution (dpi)	Scanning area (mm)
UMAX PowerLook 3000	3.6	24/42	8/14	1220×3048 3048×3048	215×279
EPSON Perfection V750 PRO	4	42/42	16/16	4800×9600	203×254

The software used for scanning with the UMAX PowerLook 3000 is MagicScan, and the output files for low/high resolution images are in TIFF file format. With EPSON Perfection V750 PRO the used software for making low-resolution (preview) images in TIFF and JPEG is Adobe Photoshop, and for the high-resolution scans in FITS format (required image file format of the Virtual Observatory), the programme Scanfits developed by S. Mottola [7].

2.2. Choice of scanning parameters. The plate scanning was made within the whole density range (0–255) and Gamma = 1.00. The chosen resolution is a compromise between the output file size and the astronomical task. The chosen colour depth is dependent also on the task: for low-resolution (preview) images in order to save the observer's marks made often with different colours on the plate, the image type is 8-bit 24 bit colour; for the high-resolution scans, 16-bit greyscale. The scanning procedure (making preview and high-resolution scans plus plate cleaning) took about 20 minutes.

2.2.1. Low-resolution plate scanning. With the aim of easier web accessibility and storing the observer's marks on the plate, a system for quick plate visualization – plate previews – was developed. For the choice of resolution for quick plate visualization the decision was a compromise between the possibility of saving as much detail on the plates as possible (contained objects, emulsion character and status, marks made on the glass of the plates) and the need of small file volume for easier and quick web access. The preview images are made from 100 up to 1200 dpi in TIFF format and JPEG format (often compressed to 2000×2000 pxl).

Table 2 summarizes the data for preview scanning of the Konkoly Schmidt plates with both scanners used: resolution (dpi) and output file (TIFF and JPEG) volumes in MB.

Table 2. Low-resolution (previews) plate scans in Konkoly Observatory

Used Scanner	Resolution (dpi)	JPEG (MB)	TIFF (MB)
UMAX PowerLook 3000	100		0.68
	300		6
	600		26
EPSON Perfection V750 Pro	600	1.65	53
	1200		

2.2.2. High resolution scans. The high-resolution scans (intended for use for photometric or astrometric tasks) are made with optimal big resolution 1600 (or 2400) dpi. In order to have adequate web archiving among the variety of file formats we adhere to the FITS format for digitized plate images. Table 3 presents the data for the high-resolution scans (TIFF or FITS) for the Konkoly Schmidt plates (mostly with an exact scanned area of 158.0×158.0 mm).

Table 3. High-resolution plate scans in Konkoly Observatory

Used Scanner	Resolution (dpi)	TIFF (MB)	FITS (MB)
UMAX PowerLook 3000	1200	102	
	1600	172–178	
EPSON Perfection V750 Pro	2400		409–425

Some of the high-resolution scans of Konkoly multiple exposure plates were used for experiments with the polyspline wavelets [8] for image compression, as well as, later on, polyharmonic subdivision wavelets (of Daubechies type) for better image compression [9].

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 is a current task (see, for example, a Virtual Observatory standard technique, the Simple Image Access Specification of the Vatican Observatory Schmidt Archive [10] or Archive of Historic Carte du Ciel Scans in the Astrophysical Institute Potsdam [11]).

3. Observing programmes executed. Here we present some examples of collections organised by observing programmes.

3.1. The Pleiades digital collection. The Pleiades stellar cluster contains many red dwarf stars showing long-term brightness variations. Most of the red dwarf stars are flare stars—the statistical evaluation of the total number of all flare stars in the Pleiades registered and unregistered up to now is about 1000. According to the Flare Stars Database [12], [13] the total number of the registered flare stars in the Pleiades is 547, although for some of them better observations are needed to confirm the classification [14]. For further automated search for long-term brightness variations more than 3100 Pleiades plates obtained in the period 1885–1998 were found in observatories in Asiago (Italy), Sonneberg (Germany), Harvard (USA), Kyiv (Ukraine), Moscow (Russia), Rozhen (Bulgaria),

Konkoly (Hungary), Byurakan (Armenia), Potsdam (Germany), Edinburgh (UK) and Bamberg (Germany). Now the Pleiades digital plate archive contains more than 1500 scans included into the developed Pleiades Plate Data Base [15]. This database gives the opportunity to obtain an almost continuous photometric data set for the red dwarf stars in the cluster.

From the 557 Pleiades plates obtained with the Konkoly Schmidt telescope according to its catalogue all 255 available plates (or 46%) are scanned as of now. The rest of the Pleiades plates are stored mostly in Gothard Astrophysical Observatory (Szombathely, Hungary) and Lorand Eötvös University (Budapest, Hungary). The plates are taken with single exposure or with 5–6 exposures for flare stars search. Fig. 1 presents an example—the plate with Schmidt telescope serial number 4144 (or with the WFPDB identifier KON060_004144) taken on September 17, 1971 by multiple exposure method. The plate digitization is made with low resolution in JPEG file format, compressed, 2000×2000 pxls, 256 colours, with file volume 1.9 MB. This scan is available for online access and can also be retrieved from the WFPDB.

3.2. Digital collection of patrol flare stars. The plates were obtained during the Konkoly Observatory observational campaign for search and investigations of flare stars in stellar clusters and associations in the period 1970–1990. The plate digitization makes possible the automatic search for brightness increase, which yielded the discovery of 50% more flare stars in comparison with the usual plate checking. Another aim of such a digital plate archive is the interlinking with the electronic IBVS, where the discovered flare stars are published with the WFPDB, where one can find the scanned plates containing the images of the respective plates [16]. Among the observed stellar clusters and associations are the Pleiades, Praesepe, North America Nebula (NGC 7000), Cone Nebula with the Christmas Tree cluster (NGC 2264) and the Iris Nebula (NGC 7023). NGC 7023 is practically also an open cluster within a reflection nebula, but was observed as a sample of the general galactic field where searches for flare stars were conducted for comparison with searches for flare stars in rich stellar clusters and associations.

The Flare Stars Search programme plates were taken by the multiple exposure method, i.e., with 5–6 exposures of the observed region with each exposure shifted along Right Ascension and with duration of 5–10 min.

For standardization of data according to the Virtual Observatory requirements we made a cross-identification of objects, published in IBVS with the Flare

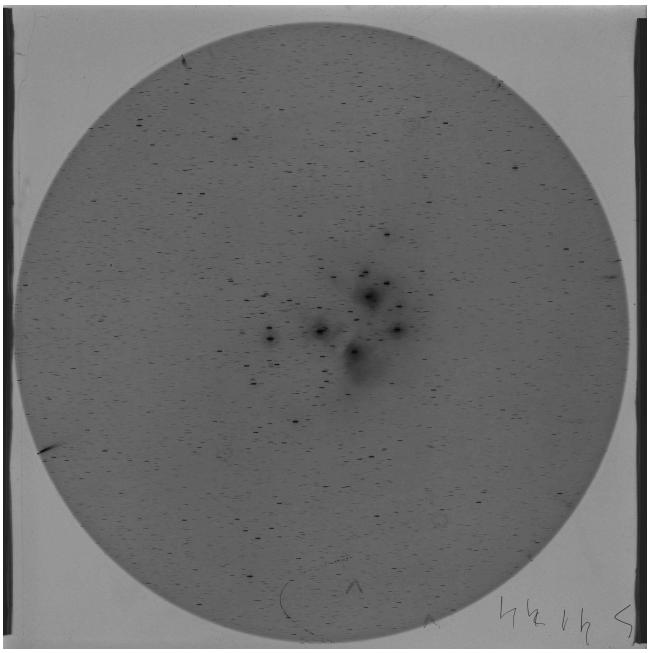

Fig. 1. Digitized copy of KON060_004144 plate taken in the Pleiades by multiple exposure method

Stars Database [12], [13] and with the General Catalogue of Variable Stars [17].

3.3. Supernova digital collection. The Konkoly Supernova Digital Plate Archive [18] is an example of a digital archive of representative plates obtained according to the supernova search programme. The goal is to use the archive for future scientific investigations and education. The Konkoly Supernova Search programme was a part of the international campaign initiated by F. Zwicky, and has been one of the important observing programmes carried out with the Schmidt telescope since the end of 1963 for a more than 30-year period. For confirmation one can compare the time distribution of all obtained plates with the time distribution of the supernovae discovered at Konkoly Observatory. The comparison reveals a coincidence between the maxima of the observational activity and the time of the supernova discoveries according to [18]: at the maximum in 1967–1968 6 SN, in 1973–1973 2 SN, in 1976 6 SN and in 1982 5 SN were discovered. The Konkoly Supernova Search programme included monitoring some controlled fields with two successive plates taken with exposure duration of 15 min.

The selection of the plates with a supernova registration was done on the basis of the compiled list of all 50 supernovae discovered at Konkoly Observatory and using the search procedure provided by the WFPDB. There are two successive plates (KON060_002315 and KON060_002317 taken on April 24, 1968) with two SN (SN 1968I and SN 1968aa) discovered on each plate. In Fig. 2 the regions around the two registered supernovae on the scanned plate KON060_002317 are shown. The 106 selected available plates with the best temporal and positional coincidence with the discovered supernovae were scanned with the marks of the observer and for quick plate visualization at low resolution (from 300–1200 dpi). After cleaning the marks, the plates were scanned at high resolution (for UMAX PowerLook 3000 FB scanner, 1600 dpi allowing maximal area for photometric tasks; for EPSON PERFECTION V750 Pro scanner, 2400 dpi). The regions around the supernovae were scanned with a maximal resolution of 3048 dpi. The information is summarized in Table 4.

Recently some plates from the controlled SN fields (mostly different regions in Hercules) were added to the digital archive having in view that for the statistics of the supernova frequency the SN observations, where no supernovae were discovered, are also important.

Table 4. Supernovae digital data

Used Scanner	Resolution (dpi)	JPG	TIFF (MB)	FITS (MB)
UMAX PowerLook 3000	300		6	25
	600		25	
	1600		170	
	3048		20–50	
EPSON Perfection V750 Pro	1200	1.6	53	430
	2400			

The present SN digital plate collection contains 147 plates scanned in the period 2007–2010 with available information about the plate WFPDB identifier, the name of the plate scan file, file size, the data of scanning, the scanner and the resolution used.

The plate visualization scans (preview scans made at low resolution) can be accessed online in WFPDB. The high-resolution scans are presently stored on the servers of the WFPDB and in Konkoly Observatory and can be obtained upon request.

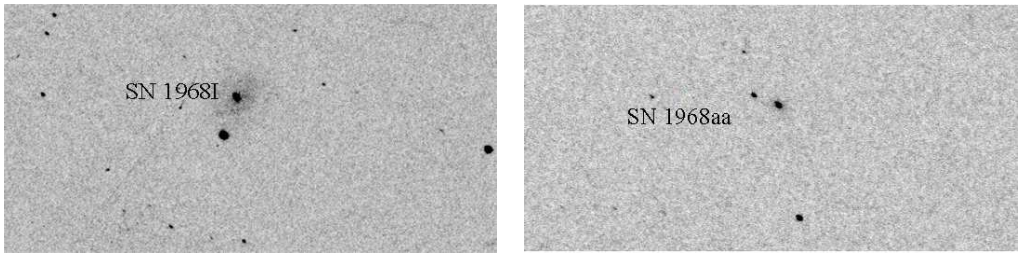

Fig. 2. The two discovered SN: 1968I and 1968aa registered on KON060_002317 plate

3.4 Digital collection of variable stars. The number of variable stars according to the last version (March 2011) of the General Catalogue of Variable Stars [17] is more than 78600 with a rate of increase of 1500 every year. Among these 78600 variable stars the total number of designated variable stars is 41638. For better classification of the variability type the light curves with larger statistical basis supplied by the plate observations are essential.

Having access to the Schmidt telescope plates taken in the period 1962–1996, we choose some interesting variable stars in the Orion region and scanned the selected plates in order to compose their light curves later.

The computer-readable plate catalogue definitely makes the search and digitization of the plates easier.

4. Conclusions. The procreation of digital archives of representative Konkoly plates is an on-going process aiming for the preservation and re-use of the plates in time domain astronomy. Another aim is interlinking IBVS with the WFPDB. Before systematic astronomical research we need an organization of plate data and plate digitization. The preparation of a plate catalogue and the digitization of plates are two interrelated processes: existence of a computer-readable catalogue is a necessary condition for plate digitization, on the other hand the plate digitization procedure is an additional tool for complementing and improving the catalogue.

The number of all scanned Konkoly Schmidt telescope plates up to October 2010 reached about 600. The scans are available with the following information: a WFPDB plate identifier, coordinates, date, scanner used, file format (compressed JPEG, TIFF, FITS format), volume, scanning resolution, etc. The current tasks are the development of a software system for object plate identification, for searching in an image database with many data storage variants, as well as plate processing and data analysis for astronomical tasks.

The work on the preservation of Konkoly Observatory Schmidt telescope plates continues, aiming archiving of more plates or broadening the topics of the observing programmes, as well as development of the WFPDB and of the connection with the IBVS.

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Katya Tsvetkova
Institute of Mathematics and Informatics
Bulgarian Academy of Sciences
Acad. G. bonchev Str., Bl. 8
1113 Sofia, Bulgaria
e-mail: katya@skyarchive.org

Milcho Tsvetkov
Institute of Astronomy and
National Astronomical Observatory
Bulgarian Academy of Sciences
e-mail: milcho@skyarchive.org

András Holl
Konkoly Observatory
of the Hungarian Academy of Sciences
Library of the Hungarian Academy of Sciences
Budapest, Hungary
e-mail: holl@konkoly.hu

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