Wide-Field Plate Database: a Decade of Development

M. K. Tsvetkov
Sofia Sky Archive Data Center, IA/SRI, Bulgarian Academy of Sciences,
72 Tsarigradsko Shosse Blvd. BG-1784, Sofia, Bulgaria

Abstract
The development of the Wide-Field Plate Database (WFPDB) over the last
decade, as an initiative of the IAU Working Group on Sky Surveys, hosted
by Commission 9, is presented. The latest version of the Catalogue of
the Wide-Field Plate Archives (CWFPA) contains descriptive information
practically for all of the existing professional wide-field photographic ob-
servations stored in 414 archives, comprising more than 2,130,000 plates
obtained with professional telescopes at 125 observatories worldwide. The
WFPDB is now the basic source of information for the archived observa-
tions and provides access to more than 25% of the archives’ total num-
ber. Following the requirements of the Centre de Donnes Astronomiques
de Strasbourg (CDS) and the International Virtual Observatory Alliance
(IVOA), the WFPDB offers digitized plate preview images along with plate
raw data. The WFPDB team continues filling the database with information
submitted or retrieved from the photographic plates, which would eventually
enable the astronomical community to complement their studies with
data going more than 130 years back in time.

1 Introduction

During the 21st International Astronomical Union General Assembly in Buenos
Aires, Argentina (August 1991), a Working Group on Wide-Field Imaging was
organized as successor of the Working Group on Astronomical Photography.
One of the main tasks of the group according to the proposal by its Chairman,
Richard West [1], was the creation of a database containing descriptive informa-
tion for all of the wide-field photographic plates (with field of view larger than

∗This review paper is dedicated to my teachers: Veneta Zaharieva and Avram Paparo, Malina
Popova and Bogomil Kovachev, Victor Ambartsumian and Ludvik Mirzoyan, Waltraut Seitter
and Richard West
Richard West suggested that the preparation of the list of the wide-field photographic plates be carried out by the Bulgarian astronomers, who had taken active participation in the Working Group. We did not imagine at that time the full scale of the work involved and felt flattered by the proposal. The same day, in a rather informal atmosphere, with the help of Richard West and his collaborator Claus Madsen from the European Southern Observatory (ESO) a draft letter was prepared and sent later from Sofia to more than 200 astronomical institutions worldwide [5]. At that time our use of BITNET was possible only through the Center of Communication and Computing Technologies of the Bulgarian Academy of Sciences (BAS), where with help from its director, Prof. Kiril Bojanov, our information exchange speed was accelerated.

Finally, we could start work on the list, which contained (in 1991) only plate archives obtained by wide-field astronomical instruments. This was the first step towards the implementation of the ambitious WFPDB project.

For me personally, it was also a new scientific challenge, but based on my experience with the wide-field telescopes in Armenia, Hungary, Germany, Chile, etc., the task seemed rather interesting and prestigious. I had not even imagined that this work will replace my scientific interests in the field of nonstable stars (in particular, flare stars).

The prerequisite for starting a project of such magnitude in Bulgaria was the support of my colleagues and students, who accept the idea with great enthusiasm. From the very beginning I would like to mention the names of Katya Tsvetkova, Konstantin Stavrev, Evgeni Semkov, Vasil Popov, Hristo Lukarski, along with Assen Moutafov, Michail Michailov, Zvezdelin Borisov, and Nikolai Lazarov (students at that time), who started the initiative and established the grounds for the project.

The next generation of young scientists, namely Ana Borisova, Galin Borisov, Damyan Kalaglasky, Svetoslav Hristov, Dimitar Lukarski, and Rumen Bogdanovski with their works and ideas contributed to the progress and further development of the database and the establishment of the Sofia Sky Archive Data Center (SSADC) at BAS. We have to acknowledge the comprehension of Peter Ivanov (Director of the former Computer Center of Physics – the supporting institution up to 1996) during the starting stage of the project, and that of Petar Getsov (Director of the Space Research Institute, BAS) for its administrative management for the period of 1997–2005.

Without going into details on all of the difficulties encountered during the project implementation, I would like to mention its coincidence with the period of political changes in Bulgaria and the economical reforms and stagnation, which followed. This reflected negatively on the scientific research at BAS, which was forced to limit the science funding down to a minimum.

In that situation, the support of the BAS authority provided by the scientific secretary for physical sciences, the late Alexander Vavrek, was extremely valu-
able. The same words could be repeated for Georgi Ivanov, Valeri Golev (col-
leagues from the Department of Astronomy at the University of Sofia), Alexander Antov (Director of the Belogradchik Observatory at that time), and Dim-
itar Jordanov from the Space Research Institute, BAS.

The grants of the Bulgarian Ministry of Science and Education coming
I-529/1996, F-650/1996, I-1103/2001, etc.), despite the limitation of the funds,
were especially important.

I would like to mention the continuous support and help from the Alexander
von Humboldt Foundation and the Center of Informatics and Communications
of the Münster University (Germany) chaired by Dr. Wilhelm Held. They pro-
vided by some directed donations the core of computer hardware, which made
the development of the studies practically feasible. Following a proposal from
Richard West and Preben Grosbol, a precise microdensitometer PDS 1010 used
for the plate digitization was donated by ESO in 1998. The German Research
Foundation (DFG) granted projects with both Bamberg and Potsdam observato-
ries within the framework of the bilateral academic exchange with BAS.

The further development in the information technologies over the last
decade, and especially that of the WorldWide Web – INTERNET, as well as the
use of super-fast computers and data storage with automatic online access, along
with the implementation of precise commercial flatbed scanners contributed sig-
nificantly for the progress in WFPDB.

The wide-field photographic observations are some of the main information
sources in astronomy, especially for events dating back in time. There are about
$2 \times 10^6$ plates stored in the astronomical archives worldwide, as an outcome of
the work of more than 400 professional wide-field telescopes for more than a
century [4, 6]. The re-use of this exceptionally rich stock of observational mate-
rial was hampered so far, because of the lack of centralized and easily accessible
information system.

The WFPDB aims at facilitating the active use of this rich observing ma-
terial, and, therefore, discoveries of new objects and events, or determination
(or more precise definition) of the astronomical objects characteristics, or other
results important for the contemporary astronomy could be expected.

Six years passed since the Workshop “Treasure-Hunting in Astronomical
Plate Archives” in Sonneberg Observatory [5], where a broad discussion on the
plate archives preservation and digital access took place. In the meantime the
progress in the development of Astronomical DataGrid and the Virtual Astron-
omical Observatories brought us to the requirements of the new era of the wide-
field astronomy. The purpose of the present forum supported by the COST 283
iAstro1 action is to mark the new developments in astronomical plate archiving
and to outline the prospectives, problems, and links to future virtual astronomi-
cal observatories. We hope that the applications and use of the huge information

\(^1\)http://www.iastro.org
hidden in the astronomical plate archives could be good examples of the virtual platforms based on the new GRID technologies.

2 Predecessors of the Plate Archive Catalogues

The lists of Hauck [1, 2] based on the archive data of 36 institutes/observatories are perhaps the first efforts to collect existing plate values. At that time (1982) only 6 archives were in computer-readable form. It is worth noting that from the 141 astronomical institutions, addressed later on by Jaschek [3, 4], only 68 reported that they posses plate archives, and at only 20 of them data were partially, or completely in computer-readable form. These pioneer works along with the data obtained by 89 wide-field telescopes at the 44 observatories, which answered to our inquiry letter, became the base of the first published by us list of wide-field plate archives [6].

We received a considerable help at this stage of the WFPDB project from Peter Kroll and Hans-Jürgen Bräuer, who supplied us with a copy of the Sonneberg catalogues for about 200,000 plates [10, 11] during the ESO/OAT International Workshop “Handling and Archiving Data from Ground-Based Telescopes” in 1993. The project then got its real form, i.e. from mere preparation of the list of the archives it was possible to go on with starting the building of the database itself. The Sonneberg catalogues and the Schmidt telescope catalogue of the Kiso Observatory provided by Keiichi Ishida and Yoshikaru Nakada served as a sample for the WFPDB format. Later on this format was improved, accepted, and published as a first online Wide-Field Plate Database [12]. Thanks to the experience gained, the catalogues of the 2 m RCC telescope and 50/70 cm Schmidt telescope of the Bulgarian National Observatory in Rozhen were first prepared in the WFPDB computer-readable form [13–15].

3 The Catalogue of Wide-Field Plate Archives

Our work on the Catalogue of Wide-Field Plate Archives (CWFPA) together with the analysis of its last version (v. 5.0) is described in the next paper in these proceedings [4]. This paper includes only remarks about the catalogue compilation as one of the main stages in the creation of the database.

During the correspondence with the observatories and the work on the Catalogue we basically used the data from the existing astronomical wide-field optical telescopes and observatories from: The Astronomical Almanac (for the period 1991-2005), published by U.S. Naval Observatory, Astronomical Application Department,1 and Rutherford Appleton Laboratory, Space Science and Technology Department, Her Majesty’s Natural Almanac Office;2 Landolt Börnstein Online3 [16]; “Les Observatoires Astronomiques et Les Astronomes”

1http://asa.usno.navy.mil
2http://asa.nao.rl.ac.uk
3http://www.springer.com/sgw/cda/frontpage/0,11855,1-10119-12-146681-0,00.html
The current version 5.0 of the CWFPA was completed in 2004–2005 and updated for the present workshop. The previous four versions had evolved from the List of Wide-Field Plate Archives [6], and contained information from 174 separate archives at 49 observatories, according to the 1992 data. The present version 5.0 contains information for more than twice as many archives, namely 414, obtained at 125 observatories worldwide.

The distribution of the archives obtained with the corresponding wide-field instrument vs. the year of beginning of operation, is shown in Figure 1. Three periods can be clearly distinguished: 1872-1912 (A), 1913-1940 (B), and 1941-1999 (C). They reflect the observing activity, and correlate with the participation of the respective countries in the World War I and II military campaigns.

The A period can be associated with the first global survey programmes for the Northern and Southern hemispheres. The Carte du Ciel (CdC) and Kapteyn Selected Areas (SA) programmes have to be mentioned at this point. The basic instruments for implementation of these two programmes were small survey telescopes, the so called “normal astrographs” (with objective diameters of up to 0.4 m, a focal length of 3.47 m, and a corresponding scale of 60 arcsec/mm).

The B period summarizes the observing activity between the two world wars and is characterized with increasing activity and completion of the sky surveys. The systematic patrol observations for discovery and investigation of variable stars and Solar system small planets were started at that time. A considerable event for that period is the newly invented catadioptric telescope system of Bernard Schmidt [19, 20] with field free of aberrations (later called the Schmidt telescope). The Schmidt telescopes marked a new era of systematic sky surveys. The new sensitive photographic emulsions from Kodak, AGFA, etc. contributed to carrying out more effective observations.

In the C period, when the photographic observations reached their peak, the
Palomar Schmidt telescope (California, USA) and the Tautenburg Schmidt telescope (Germany), ESO (La Silla, Chile), UKSTU (Siding Spring, Australia), Byurakan (Armenia), etc. began their operation. The photographic observations ranged from the ultraviolet region all the way up to the near infrared regions. The limit of the photographic stellar magnitude reached 20\textsuperscript{m}, and with the introduction of the 4 m Ritchey-Creathien telescopes was improved to 23–24\textsuperscript{m}. The invention of the respective sensitive emulsions in the different regions of the optical electromagnetic spectrum contributed to this progress. The main sky surveys, which had begun in the end of 19\textsuperscript{th} century, ended in this period. The new surveys based on the big Schmidt telescopes came upon the stage. The progress of astronomy of the second half of the 20\textsuperscript{th} century based on the photographic surveys de facto. The development of the new Charge-Couple Devices (CCDs) and the progress of space astronomy lead first to reduction and then even to the end of production of photographic emulsions by Kodak, ORWO, etc., which was the reason for the decrease of the photographic observations and became premises for the end of the photographic astronomy.

During these three periods more than 400 professional telescopes had been in use. In the WFPDB installed in Sofia we have data (see Figure 1) from 464,373 plates distributed as follows: (A) — 13,994, or 3%; (B) — 83,228, or 18%; and (C) — 367,151, or 79%, which were obtained with a total of 105 telescopes. They represent only about 25% of all wide-field plates in existence.

4 WFPDB Milestones

The basic stages of the WFPDB creation, formulated from in the beginning of the project [6], were:

- Creation of the catalogue of the wide-field plate archives. It was accomplished practically by the end of 2000 [4]. This catalogue now contains all of the basic astronomical plate collections. Thus the total number of all wide-field plates that ever existed was estimated to around \(2.2 \times 10^6\).
- Creation of the database with possible search for existing plates by known equatorial coordinates, time of observation, object, etc. to be compiled into a general Index Plate Catalogue (IPC).
- Beginning of the scanning stage for the plate archives, preparation of the strategy and coordination for their inclusion into the database and easy access to the existing or prepared digitized archives.

While the execution of the first two tasks were clear from the beginning of the project, its third part was merely conceptual, because of the difficulties associated with the scanning techniques available at that time and the worldwide access to the databases. (The INTERNET was developed much later.)
4.1 Cataloging

In the period 1994–96 the Index Plate Catalogue contained mainly the information about more than 217,000 Sonneberg plates (65%), and the plate information from the observatories, like Asiago, Kiso, Heidelberg, and Rozhen.

The main problem faced by such a global database was the preparation of unified files, because the plate archives received were specific and inhomogeneous as a rule.

This reduction was done by using text editors, such as AURORA,\(^1\) and complex programs written for every particular catalogue. Such work was less effective, while involving additional errors and problems with operation, flexibility, and support. Other obstacles also appeared — the creation of doubled files, impossibility for some users to work with a single file, and difficult control of the versions. One can expect progress in this direction after the work of Daniela Doneva [22], which tries to unify the experience from the IBM/PL program package REDUCT developed by Konstantin Stavrev and used until 1996 [23].

The data homogeneity problem, seemed a technical one at first, but practically it turned to be a pivot requiring expertise from professional astronomers experienced in astronomical photography. The conclusions [24] were that the preparation times of the computer-readable versions of the plate catalogues were compatible with the plate scanning times with the use of the new commercial flatbed scanners. But the systematic scanning is not practically possible without preparation of the plate catalogue. This fact seems obvious, but is nevertheless constantly ignored or underestimated when considering the problem of plate scanning and archive digitization. Immediate emphasis on the scanning process, its workmanship or lack of funds for buying, is to be made.

With a sad sense of humor, Dave Monet [30, 31] remarked that: “The astronomers degrade faster than the plates ...”.

The loss of information sources becomes fatal, and can transform their further processing into nonsense, or turn the plates into useless pile of dirty glass.

Thus, according to our previous estimations [24] more than 40 years of effective labour would be needed in order to catalogue the remaining of all of the 1,500,000 known plates. This estimation is made on the basis of experience acquired from the preparation of computer-readable versions of the plate catalogues in Sonneberg, Harvard, Bamberg, Rozhen, etc. This is also the basis for the pessimistic prediction that the WFPDB will hardly be able to operate in the near future with data volume of 1,500,000 wide-field astronomical photographic observations. The price decrease of the novel commercial flatbed scanners along with the increasing of the quality of their scanning parameters are our hope for the feasibility of the global plate scanning, and thus for the implementation of urgent catalogue preparation. The most remarkable example, confirming this attempt of the entire plate archive digitization, is the success of the Sonneberg Observatory programme [25].

\(^1\)http://aquila.skyarchive.org/wfpdb/Aurora_editor.
WFPDB: A DECADE OF DEVELOPMENT

Figure 2. Example of the WFPDB MainData file.

It is essential to mention that with the conversion of the computer-readable forms of the existing hard copy versions (card or logbooks) of the catalogues it would be important to have at least the coordinates of the center of the observed region for a given epoch and the time of observation — the beginning (UT) of the exposure and its duration. This is the minimum requirement. Of course it is not so informative but better than nothing!

Among the known plate catalogues the information about the plates in the Bamberg Southern Sky Survey can be considered the fullest [26], while for the Harvard and Sonneberg archives only basic information is provided. As a rule, there is no information in the files QUALITY, OBSERVER plate emulsion, etc. But even in this way the preparation of the Sonneberg catalogues (∼220,000 plates) mainly by B. Fuhrmann took about 10–15 years.

The excerpt of the file MainData (MDF) is given in Figure 2.

4.2 DataBase System

The general requirement for the structure of the main files of the chosen relational database is to make the web-interface similar to the one used in the VizieR system [27], which has become well established as a standard tool for searching through astronomical archives. This interface was included in the link the WFPDB Search page to the VizieR system, Aladin [28] for visualization with summarized reference of the system Access Logs, and the Readme link to the short description of the functionality and user help.

The description of the main WFPDB files can be downloaded from the CDS server of ViZier system1 and from the Sofia Sky Archive Center.2 The description contains the catalogue’s concrete form and an optimal number of parameters characterizing every archive and set of plates (MD-File) as in Figure 2. It also

1http://vizier.u-strasbg.fr/cats/VI.htx  
2http://aquila.skyarchive.org/wfpdb/v90/ReadMe

17
M. K. Tsvetkov

Figure 3. Single entry form of the CWFPA - the case of the Palomar Observatory Schmidt telescope plate archive (PAL122). The visualization routine is developed by Damyan Kalaglarsky.

includes information about the quality of the plate, general notes, name of the observer, plate availability, digitization of the plate (QNOAD files). Unlike the VizieR (VI/90), the WFPDB catalogue of the CWFPA is now integrated and developed within the database search routine. We can have visualization of the information for every single catalogue/palte archive presented in the WFPDB (see example of PAL122 in Figure 3).

More detailed description of the WFPDB structure is made by Damyan Kalaglasky [21], who developed it. Our efforts, and gained experience respectively, passed through a series of attempts for personal database creation [29] or the use of commercial database management systems like ORACLE, MS ACCESS, etc. For instance, during the 24th IAU General Assembly in Manchester in 2000, we offered the WFPDB on CDROM for autonomous use with a database management system under MS ACCESS.

The Firebird SQL server was chosen as the database management system (DBMS). It possesses an open source code, developed by Borland/Inprise as an Interbase and appeared to be an extremely good choice. The good ANSI-SQL support, flexibility of working with BLOB, support for some triggers of the same type, the unique architecture of record closing (rather lack of closing),
Figure 4. The Entity–Relationship (ER) diagram of the 5.0 version of the WFPDB.
Figure 5. Search Page of the WFPDB installed in Sofia.
the support for large files (> 4 GB), its easy administration (Firebird practically adjusts itself), facilitate our work considerably.

The Entity-Relationship (ER) model prepared using Microsoft Visio for Enterprise Architects environment, presents the relations in the database and the relation integrity in Figure 4.

The present version of the system is installed on the web-server of the SSADC and can be found at http://www.skyarchive.org/search. The system works under Linux Slackware 8.0 with Apache 2.0 web-server and the Firebird 1.0 database management system.

4.3 Search routines

The user interface is the part of the system, which makes it accessible and maximally intuitive, suitable, flexible, and powerful [21]. Such a specialized system (oriented to the professional astronomers in our case) has to obey also all conventions and accepted designations in the corresponding field.

The full data for the instruments, which the archives had been obtained with, is currently included in both constituting parts of the database, namely the Catalogue of the Wide-Field Plate Archives and the Index Plate Catalogue.

In the last 5.0 version of the WFPDB, a dedicated novel search routine is introduced in the user interface (see Figure 5).

In the Search Form the particular constraints of a search are given. The different options for the interpretation upon the user request are also indicated.

Figure 6. Result from a user request for searching for Carte du Ciel plates in the ROB033 archive.
M. K. TSVETKOV

An interface is created for searching for plates with centers in a given region and the possibility for setting constraints to limit stellar magnitude, as well as visualization of the plate distribution in a given archive, etc.

There is a link to the visualization system “StarGazer”© developed by R. Bogdanovski [32]. It is a web-based system for star map generator and works currently with GSC-ACT, SAO, YBS, a subset of USNO-A2 (all stars up to 16.3m) and a few other catalogues. The last development including the drawing of the General Catalogue of Variable Stars (GCVS) is present in [33].

A specific result from the user request for searching for Carte du Ciel plates in the ROB033 archive is shown in Figure 6.

4.4 WFPDB data analysis

A database, even comprising 25% of all existing photographic plates worldwide, allows making a picture of the photographic observations taken over the last 120 years. Even though these results are only preliminary, they confirm the previous results. The distribution of the included plates in the WFPDB up to the present is shown in Figure 7. The minimum for the period 1943–58 is due to the influence of the World War II.

The steep increase of the photographic observations after 1929 and after 1959 is due to the invention of the new wide-field cameras of B. Schmidt and to the heightened interest to astronomy in general after the launch of the first artificial satellite. The development of the new CCDs technologies, the drastic increase of the plate price, and the cease of the plate production of the most widely used emulsions from Kodak and ORWO marked the end of the era of astronomical photographic observations.

![Figure 7. Time distribution of the plate number in the 5.0 version of the WFPDB (464,373 plates).](image-url)
Figure 8. All sky (in Molveide projection) distribution of the plates in the 5.0 version of the WFPDB (total number of 464,373 plates). Some spots of higher density related to special monitoring programmes as M31, Pleiades, Orion Nebulae (M42/43), Large and Small Magellanic Clouds, can be noticed. The two major strips of higher density are related with the plate centers respectively fields of intensive monitoring in the Ecliptic plane, mainly for search of small planets (the SINUSOIDAL band) and the Milky Way plane patrol observations (OMEGA strip).
Figure 9. Plate distribution of selected plate collections (in Molveide projection) as an illustration of the different sky surveys programmes: **HAR041** — Harvard College MC Northern Survey; **HAR025** — Harvard and Bamberg Northern/Southern surveys; **BUC038** - Bucharest survey for small planets in the Ecliptic plane; **TOR060** — Torun Schmidt spectral survey in the field of the Galactic plane; **BYU102** — Byurakan(Markarian) The First Byurakan Spectral Survey; and **ROB033** - Brussels, Uccle Carte du Ciel +32° to +39° zone.

The all sky distribution (in Molveide projection) of the plate centres (464,373 plates) is shown in Figure 8. This distribution is the most representative result of the WFPDB and was first published in 1996 [34, 35].

This distribution has not changed significantly with the introduction of new catalogues into the database. One can easily see in the distribution the bands with higher density resulting from the patrol observations in the Ecliptic and Galaxy planes for minor planets’ searches in the Solar system and the Galaxy structure studies. The patrol observations in M31, LMC/SMC, the Pleiades, the Orion nebula M42/M43, etc. can be clearly distinguished in this distribution. That is why this distribution was chosen as a logo for the WFPDB and the SSADC.¹ Figure 8 updates automatically every day (at 3:00h) to include the new data in the database.

A sample of the plate distribution visualization for different types of surveys, which reflect the conducted observing programmes, is shown in Figure 9. The Harvard archives (HAR041 and HAR025) were suited for the monitoring of the

¹http://www.skyarchive.org/SSADC/
Northern and Southern hemispheres. The Bucharest observations (archive identifier BUC038) were carried out according to the programme for searching and study of the Solar system bodies. The Torun archive (TOR060) is mainly concerned with objective prism observations at the Milky Way. The work of 1 m Byurakan Schmidt telescope (BYU102) is illustrated by the First Markarian Spectral Survey. The Cdc plates in the zone from $+32^\circ$ to $+39^\circ$ were obtained with the Uccle 0.33 m normal astrograph of the Royal Observatory of Belgium. This visualization of the plate distribution for entire collection included in the WFPDB archive is available due to the new organization of the database’s interface.
The distribution of plate numbers vs. instrument diameters shows that the most of plates were taken with telescope apertures of up to 0.40–0.70 m, which means that the limit stellar magnitude is of the order of 14–15 m. This restricted the type of objects requiring long-term photographic observations. But the luminosity function of the local portion of the Galaxy shows that there are about 100,000 stars within this magnitude interval. The number of plates obtained with instrument apertures bigger than 0.70 m is limited, which has to be taken into account while choosing an object. Other important factors to consider are that the half of all existed wide-field plates are in the archives of American and German observatories (Figure 10) and that Harvard and the Sonneberg observatories play a key role. The latter two observatories possess about 50% of all photographic observations.

The Sonneberg Observatory plates cover mainly the Northern hemisphere (Figure 11), whereas the Harvard plates spread also over the Southern hemisphere, thanks to the Harvard expeditions in South America (Peru, Arequipa) and South Africa (Bloomfontein).

Among the European Southern WF observations, the most significant are the Edinburgh programme UKSTU observations from Australia, ESO Schmidt survey (Chile), and the Bamberg Southern Sky Survey carried out in South Africa in the period 1963–75 [26].

The distribution of the rest 56% of all plates in the WFPDB (remaining after the exclusion of the Sonneberg plates) is shown in Figure 12. One can see that the distribution shape is almost the same. The conclusion is that there are objective factors, which determine this data set, namely that there are social political, and economic changes throughout the time period and that the technical progress plays a role in the distribution.

Besides the direct plates there is information in the WFPDB on the objective prism spectral observations. These are mainly the observations in Australia.
Figure 12. Plate distribution versus time in the WFPDB without the Sonneberg input (247,891 plates or 56% of all.)

(UKSTU), Byurakan, Torun, Konkoly, etc. The analysis of such observations (a mere 3% of all plates) can be seen in [36].

5 Different Approaches to Plate Digitization

This has been the most delicate and disputable part throughout the establishment of the project. The difficulties in creating a centralized database of digitized plate images are of different origins. The plate digitization process is always dependent on the stage of the technical progress. The introduction of plate scanning in the 70s of the last century was associated with designing of special scanners (monsters) for the purpose, which were intended only for special surveys. The main disadvantage of this approach, although it met its intended goals, was the slow scanning speed — 10 cm²/min — and only about $10^5$ plates were scanned. The scanners in Edinburgh (Galaxy, Cosmos and Super-Cosmos), created mainly for the Southern Survey of UKSTU, are worth mentioning, as are those in: Flagstaff (PPM); Cambridge (APM), Minneapolis (APS), Baltimore (LAMA1/2), Muenster (PDS⁺²), dedicated to the Schmidt telescopes surveys in Palomar and ESO, etc.; Paris (MAMA) — for the French part of the Carte du Ciel survey, Washington (StarScan), used for AGK2 plate measurements, etc. In many observatories the mass design scanners at that time were Perkin-Elmer PDS 1010 with slight modifications. Their accuracies reached about 2 µm/pixel, and photometric accuracy achieved up to 4.0 D. Such scanners obviously were not intended for mass plate digitization. According to Kroll [37] the rough estimates of the necessary time for digitization of $2 \times 10^6$ plates were of the order of
30 years of effective time. This estimation had to be extended for practical purposes. At the beginning of 21st century most of these scanners stopped working or their use was minimal.

New ideas for solving this problem were appearing already at that stage and new home made scanners with CCD line were invented as compromise solutions: Tautenburg (TPS), Pulkovo (FANTASIA), Kiev (PARSESC), Sonneberg (DIANA, HSS). But this kind of symbioses between the CCD and the old technologies were not very successful and relatively small number of plates were actually scanned.

It was only with the appearance of commercial scanners from EPSON, HP, AFGA, UMAX, etc., when the premises and projects for mass scanning of the photographic archives started becoming feasible. The global Italian national plate digitization programme is a good example for this with its usage of uniform type of professional scanners (EPSON 1640XL and EPSON 1680; see Figure 13) [38]. Their experience and the software developed converting the scans to FITS format were used for the scanning of the Byurakan Markarian survey [39], the Bamberg Southern Survey [26], in Zvenigorod, Moscow [40] and Sofia [41]. Similar A3 type scanners were used at observatories like Maria Mitchel (AGFA T5000) [42], Konkoly (UMAX-3000PL) [43], Caussols (AGFA HorizonPlus) [44], Moscow (Creo), Kiev (Microtek Scanmaker 9600XL), etc.

The start of the digitization project of the Mt. Wilson Solar Ca K Photographic monitoring plates obtained in the period 1915–75, was based on the use of the Esko-Graphics EskoScan F14 scanner1 and is one of the successful

---

1http://www.astro.ucla.edu/ulrich/MWSPADP/
WFPDB: A DECADE OF DEVELOPMENT

projects during the latter years. But the most effective one in this direction is cer-
tainly the digitization of a total of 133,000 $13 \times 13 \text{ cm}^2$ plates of the Sonneberg patrol for two years using four HP7400 scanners [25, 45] Using such profes-
sional flatbed scanners the quality necessary for mass plate digitization will be jus-
tified. Their success is based on their scanning stability at the scanning, result repetition, and low price. Of course, the skepticism for their use has been not completely overcome because of the nostalgia for the former big scanning complexes. But the test results of the flatbed scanners used for the plate digitization endorse their advantages. More information about suitable flatbed scanners can be found at:

http://prepressworld.de/buyersguide/gruppe.htm$31$ (A3)
http://prepressworld.de/buyersguide/gruppe.htm$29$ (A4)
http://prepressworld.de/buyersguide/gruppe.htm$5$ (DIA-Films)

Encouraged by the needs of the printing industry and the increased require-
ments for preprint preparation, the commercial scanners have become the future of the mass astronomical archive digitization. The use of commercial flatbed scanners does not oppose to the idea of developing modern specialized scanners like those of Harvard Colleague Observatory, or ROB Brussels, which are dedi-
cated to digitizing the largest astronomical plate archives worldwide. There are 500,000 Harvard plates and more than 100,000 aerial photographs plates in the National Geographic institute and Royal Observatory of Belgium [46,47]. These cases are considered by well-funded national programmes. Unfortunately, this approach is not applicable for most of the observatories, which possess relatively small plate collections and have limited funds.

Other problems in the creating of the centralized database of scanned astro-
nomical plates were associated with the copyright for free use, or with access to the raw data in view the total data volume and the low speeds of network data ex-
change. The copyright issue is more of juridical matter, while the issue of online access is related to technological requirements and will need time to get solved. At present-day data speeds the transfer of a plate (about 200 MB) takes hours or days. Progress may be expected by providing a GB-speed of networking and the development of the information structure of the International Virtual Observ-
yory, which is now under construction. Maybe it would be more appropriate not to establish a centralized complex of digitized astronomical plates after all, but to use the digitized plate images stored on site in the respective institutions.

The protocols of standard and possible software decisions (VOTable) for access and use of the wide-field observations have to be developed for the cases of digitized plates. Because of the low speeds of data exchange we came to the idea of offering preview images of the requested plate (For a preview a given plate is scanned with relatively low resolution from 250 dpi up to 600 dpi, i.e. $100–40 \mu m/\text{pixel}$, see Figure 14.

This approach turned out to be sufficient for transfers worldwide and effec-
tive in comparison with the ‘blind’ use of the database. Such presentation of
visual plate information in many cases can be enough for further decision making and project developments. Such plate previews are already included into the WFPDB for the archives in Bamberg, Potsdam, Brussels, etc.

6 Wide-Field Plate Database Applications

The Sofia WFPDB offered possibilities for using information on demand for about 500,000 astronomical photographic observations. The use of the database increases constantly — for the first three years after its establishment (1997–2000), the WFPDB was among the 100 most popular catalogues, according to their frequency of usage in VizieR. According to the statistics from the Access Log (AWStat) in the “Search Page” of the database installed in Sofia since 2002 the Bandwidths are respectively: 2002 (second half) — 1.96 GB; 2003 — 15.12 GB; 2004 — 43.15 GB; 2005 — 47.84 GB. These data illustrate the increasing interest in using the database. We shall mention only some of the impacts of the WFPDB applications, namely the studies of the stellar long term brightness changes as a result of observations conducted in different observatories. Recently the use of the WFPDB has allowed a study of the unusual pre-Main Sequence variable star KH19D making clear the period

\[1\text{http://www.skyarchive.org/cgi-bin/awstats.pl}\]
of variability of the double system to be 48 days [50]. The observations of seven observatories were used in that case: Asiago, Kiso, Kitt-Peak, Mt. Wilson, Palomar, Tautenburg and Rozhen over the period of 1954–97 (i.e. 43 years).

Studies of the brightness variations of the Southern spotted star CF Oct on the archival Bamberg astrograph observations confirmed the period of variability to be of 20.15 days, while allowing even digital-camera shots to be used successfully for the preliminary analysis (see Figure 15).

The results of the work of Fröhlich et al. [53] on long term variability of HK Lac (RSCVn type) with period of 13.2±0.2 years, based on more than 2000 Sonneberg Sky-patrol plates, show that the comparatively long-term series of photographic photometry allowed for detecting even the star’s mean rotational period of 24.35 days. In this case it was achieved with an internal accuracy of 0.07m.

The WFPDB could be used successfully for studies of the long term variability of active galaxies, quasars, etc. as was in the case of 3C273 (Figure 16). The brightness curve was expanded over a period of 50 more years.

In 1998 Gershberg officially drew the attention of the owners of the plate collections related to flare stars in star clusters and associations [54]. His appeal was initiated after our discussions in Sonneberg in 1994 and is to be considered as a plan for establishing of respective databases of observations in the Pleiades [55–57], Orion, Praesepe, NGC 7000, etc., which are soon to be accomplished. The flare-up of a new flare star in the region of the North America nebula from the collection of monitoring plates of the Asiago Observatory is shown in Figure 17.
Figure 16. The historical brightness curve of quasar 3C273 in the period 1932-1975, mainly based on the Harvard College Observatory plate archives data [51]. Using the WFPDB service for additional plates the time interval could be extended with 50 more years [52].

Figure 17. Flare star search in the field of the NGC7000/IC5070 star formation region using the Asiago Schmidt (ASI067) plate collection.
We have to mention also some of the failures in the beginning of the WFPDB creation (1994-1995), when the database was still not online and the user requests had to be fulfilled by e-mail. At that stage the urgent request for finding other observations to confirm the discovery of the supernova SN1993ak by C. Pollas [58] could not be satisfied in time practically, because of insufficient information. In the meantime, H. Meusinger [59] published independently data for the same supernova, using the information offered by Tautenburg Observatory’s plate archive. This case manifested the inefficiency of the so-called “blind” search in the database at that time. The critical remarks followed, as well as offers from colleagues, which stimulated us to proceed our work in order to propose online services.

6.1 Historical plate archives

The distribution of the existing wide-field observations (Figure 1) shows that the photographic surveys up to 1920 are considerably poor. While collecting the information for the wide-field archives we approached with great admiration the observations from the beginning of the era of astronomical photography. The first astronomical multiple picture of the Moon saved at the Harvard Plate Library, was taken on September 1st, 1949 by the photographer Samuel Dwight Humphrey (see the reproduction in Figure 18) [60]. Practically it was the first attempt to take the full Moon’s picture employing different exposures to focus it.

The oldest wide-field observation series of Benjamin Gould are also part of the Harvard Observatory plate stacks along with the archive of Oswald Lohse’s,

Figure 18. First photographic picture of the full Moon taken by Samuel Humphrey on September 1st, 1849. Courtesy Martha Hazen and Alison Doane, Harvard College Observatory Plate Library.
Figure 19. Reproductions of the plate No. 77 of B. Gould, Córdoba’s survey, taken on December 26th, 1872 in the Pleiades field (left) and O. Lohse No. 213 plate, taken with the Potsdam Second Heliographic Objective mounted at the 0.30cm Grosse Refractor, on January 10th, 1888 in the Orion M42/M43 region (right). Courtesy by A. Doane, HCO Plate Archive and R. v. Berlepsch, AIP Library.

which survived two world wars at the plate collection of the Potsdam Astrophysical Institute. The reproductions of two plates from these archives are presented in Figure 19.

Gould’s plates of the Pleiades are obtained through wet-plate collodion process in 1872 in Córdoba, where he carried out the photographic survey of stellar clusters and double stars, stimulated and supported by Lewis Rutherfurd. About 1000 plates from this archive have been stored in Harvard and described by Martha Hazen [61]. Our ambition is to digitize his first astronomical wide-field photographic survey and to include it into the WFPDB. So far only the Pleiades Gould’s plates [62] have been digitized using the UMAX 3000PL flatbed scanner. During our search through the Potsdam plate archives, we found accidentally in 1998 a part of the Lohse wide-field survey in the Great Refractor tower in Potsdam. Only 67 plates obtained in the period 1885–89 had survived by chance. All these plates were scanned at the Münster University Astronomical Institute with PDS2020Plus and in Berlin (DRL) with EPSON 1640XL scanner, and are now included into the WFPDB (POT030 and POT013B [63]. Due to the initiative of Klaus Staubermann, the photographic Lohse’s camera (the first professional photographic camera) was restored according to its description as well as pictures from Konkoly and Potsdam. The camera-replica (Figure 20) was prepared in SSADC, attached to the 7” Grubb refractor of the Sofia University
WFPDB: A DECADE OF DEVELOPMENT

Figure 20. The photographic Lohse Camera-Replica, attached at the Sofia University Observatory 7" Grubb refractor by Ivan Parov.

Observatory, and tested with photographic plates made specially for the purpose by Tsveta Petrova according to the Elder’s original recipes from the 1880s at the Bulgarian Academy of Sciences, Central Laboratory of Optical Storage and Processing of Information. Similar plates and plate processing technique were used by O. Lohse.

Moreover, we would like to mention the historic plate archive of the Szombathelly Observatory made by Gothard Jenö — one of the pioneer of astronomical photography in Europe, described in details by I. Vincze and I. Jankovics [64].

All astronomical photographic archives compiled until 1920 are extremely valuable and we intend to include them in the WFPDB regardless of their field size. Such exceptions would help to enhance the database to better cover this period and, therefore, to increase the possibilities for studying the sky objects over that period of time.

6.2 Towards a Bulgarian Virtual Observatory

The data access problem to the digitized wide-field plates underwent drastic positive changes during the last 10 years. The digitized sky survey plates taken with the big wide-field telescopes (Palomar, ESO, UKSTU) are now accessible online in one way or another. The First Digital Sky Survey (DSS) of Barry Lasker [65] marked the first step in this direction and served as a standard. Digital Terabytes surveys like SLOAN DSS, DENIS, Palomar-Quest (PQ) Variability Survey, 2-Micron All Sky Survey (2MASS) LSST (Large Synoptic Survey Telescope) Survey, VLA Sky Survey, Chandra X-ray Observatory survey, etc. are

---

1The requirement was the field size to be larger than 1 sq. degree.
tracing the way to the multiwavelength astronomy, are already becoming very popular. Nevertheless the most quoted catalogues are still based on the photographic observations. The most quoted catalogues in the VizieR system based on the digitized wide-field photographic surveys [66] are listed below:

- (I/255) The HST Guide Star Catalog, Ver. GSC-ACT (Lasker+1996-99)
- (I/271) The GSC 2.2 Catalogue (STScI, 2001)
- (I/284) The USNO-B1.0 Catalog (Monet+ 2003)
- (I/289) UCAC2 Catalogue (Zacharias+ 2003)
- (I/259) The Tycho-2 Catalogue (Hog+ 2000)
- (I/275) The AC 2000.2 Catalogue (Urban+ 2001)
- (I/238A) Yale Trigonometric Parallaxes, 4th Edit. (van Altena+ 1995).

The use of these catalogues online, the visualization of the data, and the production of science from present and next generation data archives connected via powerful and easy-to-use computer networks, could necessary focus on adapting data mining tools to facilitate operating with large data sets. These tools would comprise a “next generation VO-search engine” for object grouping, identification and analytic methods for unsupervised classification based on cluster analysis.

The development of the INTERNET and the use of the GB high-speed channels for connecting in the near future would allow for operation with raw data arrays from the digitized plates.

The modern wave is to develop a new approach — VO approach to world federation of data archives and their use for searching, analysis and discovering unknown phenomena. This would involve getting access to the petabyte amount of data produced from various new multiwave instruments. Through the organization of the distributed databases and suitable VO-infrastructure the issue of accessing and using of the data arrays from the digitized plates on site while avoiding the problems associatied with the concept of a centralized archive could be solved.

Where is the place of the WFPDB in this scheme and what could be our contribution?

In addition to our experience in collecting data for the existing but yet unaccessible photographic observations, the Bulgarian astronomers could take part in the VO project as coordinators of the project for world federation of photographic plates data archives. It would be necessary to develop and support a set of standards according to the international VO-technology requirements, while providing for the interoperability of heterogeneous data for solving various classes of astronomical problems. Our 10 year experience along with the establishment of the Sofia Sky Archive Data Center with its main purpose of serving WFPDB would be the necessary infrastructure, around which the efforts of the Bulgarian astronomers for the creation and development of the Bulgarian Virtual Observatory (in which we already participate informally) would have to
WFPDB: A DECADE OF DEVELOPMENT

consolidate. The organization of the present workshop in Sofia could be considered as an example in this direction.

Our optimism is also based on the support from our colleagues at the Institute of Astronomy, who have already begun collecting the data from galaxy observations\(^1\) developed by Georgi Petrov, and the Solar observations\(^2\) — by Momchil Dechev. Other possible resources for the BGVO would be the processing of data arrays and their presentation in VO standard done in the two projects of the Institute of Space research:

- **INTERBOL/MAGION:** on Ultra Low Frequency (ULF, 0.33 Hz) Wave Measurements Aboard the Magion-4,5 Subsatellite of the Interball-1 spacecraft: monochromatic Wave Events Observed Near the magnetopause Regions (Dimitar Teodosiev),
- The data collected from the 15 experiments conducted at the Bulgarian satellite “BULGARIA-1300” (Georgi Stanev and Georgi Bankov).

It would also be interesting to process and include the first space wide-field photographic observations with the “ROZHEN” complex used at the MIR Space Station and the Meteor database of the Varna Observatory in the BGVO.

We would like to mention here our participation in the HYPERLEDA project (Valery Golev, Rumen Bogdanovski, etc.) with active mirror at the SSADC since 2004.\(^3\) There are plans for activating mirrors of such known astronomical resources like the ADS abstract service, the possible use of selected VizieR catalogues, etc. With these activities the BGVO project is supposed to become a national priority project in 2006 and to be included in the IVOA.

The participation in the Bulgarian Grid Forum \([67]\) would be the necessary step in this direction along with the management of the astronomical test clusters put in operation recently at the SSADC.

One of the recent results from the use of WFPDB is the virtual link of the scanned direct plates with the concrete publications based on these plates offered by IBVS and ADS \([68]\) as a demonstration of the profit from the VO technology approach — the most visible GRID layer.

7 Summary

The skepticism over the establishment of WFPDB in Bulgaria under the conditions of severe financial stagnation was demonstrated several times by the authorities of the Institute of Astronomy and by individual colleagues. This served as a stimulus to a certain degree for us to prove our approach and justify the efficiency of our efforts, which led to the creation of this virtual instrument for the benefit of the entire astronomical community. That is why much bigger is our

---

\(^1\)http://www.astro.bas.bg/petrov/gvo/indexgvo.html
\(^2\)http://www.astro.bas.bg/sun/SVO/index.html
\(^3\)http://draco.skyarchive.org/hyperleda/
M. K. TSVETKOV

satisfaction from the work accomplished throughout this decade, which was re-
ported at this forum, and respectively much greater is our gratitude to those who
supported and encouraged us. During the most difficult moments of our work
I was remembering very often one of the sentences of Mark Twain: Always do
right. This will gratify some people, and astonish the rest.

We would like to summarize and announce herein the establishment of a
working environment — the WIDE-FIELD PLATE DATABASE at the Sofia
Sky Archive Data Center. It is a virtual unique instrument-telescope, which al-
 lows searching for necessary plate index information in the available world plate
vaults for the period of the last 130 years — the era of photographic astronomy.
If we were to simply summarize the aperture diameters of the working wide-field
instruments from the CWFPA, we would formally have about a 100 m diameter
single instrument, which was used for monitoring the sky over the last century,
and on the observational material of which our scientific overlook now is mostly
based.

How shall we continue? Certainly along the lines of incorporating WFPDB
into the Global VO infrastructure. Of course, we plan to increase the power
of the datasets in the database at first, while dreaming to have at least 50% of
the existing plate archives at our disposal. It is not such an easy task but we
hope very much to succeed in this goal up to the deadline, as was according to
Napoleon Hill: “A goal is a dream with a deadline”.

Regarding the on-line service of the raw data information from the digitized
plates, we need to improve the set of the VO-standards for wide-field plate im-
geages and definitely link it with the Virtual Observatory opportunities [69, 70].
The Virtual Observatory could become this magic scientific instrument of the
future, through which we could expect to realize one more time on a higher
level the motto of the KODAK company: You push the button we do the rest!

Acknowledgements

I am grateful to Ulrich Heber, Gotthard Richter, Petra Böhme, Preben Grøsbol,
Peter Kroll, Lajos Balás, Olga Dlazhnevskaya, Cesare Barbieri, Francesca Ram-
pazzi, Gerald Hahn, François Ochsenbein, Rüdiger Knigge, Milan Dimitrijevic,
Magda Stavinschi, George Bocsa, Vasile Mioc, Tanya Sergeeva, Areg Micke-
lian, Lubos Kohoutek, Ingrid van Houten, Rene Hudec, Elizabeth Griffin, Patri-
cia Lampens, David Duval, Alain Fresneau, Alison Doane, Regina von Berlep-
sch, Gerhard Scholz, Klaus Staubermann, Spass Coleff, Vasil Popov, Miroslav
Iliev, Ivan Dimov, and to all colleagues who contributed to various degree to the
establishment of WFPDB creation in Sofia.

Of course in the fundament of the implementation of this project a leading
place is reserved for Richard West, to whom I am especially grateful for his
permanent attention and support.

Thanks are due to COST and personally to the chairman of the Action 283,
Fionn Murtagh for their support over the last 4 years and for their assistance dur-
ing the organization of the present workshop, as well as for the financial support for our visit to Harvard College Observatory in 2004.

This project was funded by several grants from the Bulgarian Ministry of Science and Education — the Scientific Investigation Fund, the Bulgarian Academy of Sciences, Alexander von Humboldt Foundation and the Deutsche Forschungsgemeinschaft (DFG), to which I am deeply grateful and am hoping their continuous support in the future.

Finally I am affectionately thankful to my family for their help and patience throughout all these years.

References

M. K. TSVETKOV


[27] http://vizier.u-strasbg.fr/viz-bin/VizieR.


WFPDB: A DECADE OF DEVELOPMENT


M. K. TSVETKOV


