On some Bamberg wide-field plate catalogues recently incorporated into WFPDB

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The Dr. Remeis-Sternwarte (Bamberg Observatory) hosts about 40000 astronomical photographic plates taken from the early 20th century to mid of the 1970th. In an ongoing long-term project the Bamberg wide-field plate catalogues are being incorporated into the Wide-Field Plate Database (WFPDB). Here, we describe the recent integration of seven Bamberg catalogues in the framework of a project to digitize and preserve the plates funded by the German Science Foundation. These catalogues include information about 8400 plates obtained in the period 1931 – 1963 with three Tessar cameras (WFPDB identifiers BAM003A, BAM003B and BAM009A), a Xenon camera (BAM006), a Vierlinser camera (BAM008), an Ernostar camera (BAM009B), and a Dogmar camera (BAM011). The plate observations aimed at investigations of variable stars in the Northern sky. Some of the cameras were first mounted on an astrograph in Bamberg in preparation and testing of the Bamberg large-scale project for variable star research in the Southern sky in the period 1963 – 1976.

Currently information on 31 Bamberg plate archives containing 34200 plates from the Bamberg Northern- and Southern Sky Survey can be found in the WFPDB.

1 Introduction

The Wide-Field Plate Database (WFPDB) currently includes information about 610 000 plates from 144 plate archives[1]. The latest version (7.1, November 2015) of the Catalogue of Wide-Field Plate Archives (CWFPAs[2] contains description of 509 archives with more than 2 500 000 plates from 163 observatories, available in CSV, ASCII and VOT file format. The accumulation of plate data and archive information required changes

[1]wfpdb.org/allsky.html
[2]www.wfpdb.org/catalogue.html

of CWFPAs attributes which complement the WFPDB instrument identifier in order to form the unique identifier for every archive (in version 7.0, February 2014). These are a new archive code (coded as $1, 2, 3, \ldots$) – needed when parts of archive plates are stored in different observatories, and a site code (coded as a, b, c, ...) – needed when the instrument operated at different locations.

The current development of the WFPDB aims at the integration into the Virtual Observatory (VO) structures and usage of the disciplines of Astroinformatics. The German Astrophysical Virtual Observatory will turn the WFPDB into a fully featured VO service (Rothmaier et al. 2016)[3]. The plate digitization (the same criteria and parameters for plate digitization, output files in FIT file format), the preprocessing and photometric calibration of digitized plates, and the open access to the files of digitized photographic plates via the VO tools, have been done according to the VO standards. The homogenized data for the existing astronomical plate observations, their plate archives and contents, and the preservation of plates via digitization as cultural and scientific heritage and re-use for astronomical research, are tightly connected with the disciplines of Astroinformatics as information retrieval methods, data mining, knowledge extraction, information visualization, sky-based and catalogue-based indexing techniques. A software solution AstroWEB[4] has been built for the purpose of visualization and accessing data of WFPDB, which are the observatory geographical location, plate archives and their content, as well as plate previews. AstroWEB uses a web-based open source Geographical Information System (Kolev et al. 2012). Software tools (Kirov et al. 2015) have been established for time conversion (Local Sidereal Time or Local Daylight Saving Time to Universal Time), and coordinates conversion (equatorial coordinates to J2000 for standard WFPDB catalogue content and data structure, methods of image processing (Laskov et al. 2013, Ivanov and Tsvetkov 2016), and image compression (Kounchev et al. 2009). Accurate World Coordinate System (WCS) fits of some plates were carried out using ASTROMETRY.NET[5].

The work on the worldwide plate archives assumes multilateral academic collaboration with the observatories possessing plate collections – for plate archives inventory (only about 25% from all existing plates are visible via WFPDB), as well as for upgrading of the plate catalogues already included. The collaboration to provide data for the plate archives worldwide, computational services, and user-based research tools, is the main aim of the recently established Humboldt Astroinformatics Networking[6]. Besides the exchange of available data for operations and tools for analyzing and/or storing very large data sets, as well as for the development of standards and protocols development, it aims also at

[3]The digitized plates are being made available in the APPLAUSE data base, `www.plate-archive.org/applause/`

[4]`wfpdb.org:8000/chameleon/astroweb/astroweb.phtml`

[5]`nova.astrometry.net`

[6]`www.humboldtastroinformatics.net`

the data preservation and restoration through innovative use of information technologies, as well as to facilitate the historical and cultural heritage research.

We present here the work done recently in the framework of the collaboration with Dr. Remeis-Observatory Bamberg about the plate inventory and the incorporation of the electronic catalogues of the Bamberg Northern Sky Survey plates into WFPDB.

2 The Bamberg Northern Sky Survey for variable stars

A collaborative survey to discover new variable stars and investigate known ones was proposed by P. Guthnick (Babelsberg) to the three observatories – Berlin-Babelsberg (principal investigator: P. Guthnick), Bamberg (E. Zinner) and Sonneberg (C. Hoffmeister) in 1926. The participation of three observatories should assure better sky coverage under different weather conditions. The survey, supported by the "Notgemeinschaft der deutschen Wissenschaft (NDW)", was executed with identical wide-field 13.5 cm Ernostar cameras. In Bamberg the Ernostar camera was mounted on the astrograph constructed by Nusser in 1913. The astrograph was completely rebuilt in 1928 at the Berlin-Babelsberg Observatory and subsequently in Bamberg, and it was provided also with dedicated cassettes. Plates with size 16x16 cm and with Matter (Mannheim) emulsion sensitive to wavelengths in the range 400 – 500 nm were used. The spectral sensibility of these old astronomical plates is given according to Dokuchaeva (1994). Every month such plates with the same exposure time (30 min) reaching up to 13.5 limiting magnitudes covered the assigned Northern sky regions - for more details concerning the centres of plates of the sky regions assigned to the three observatories, and the development of the project see Zinner (1939). In Bamberg the plates were checked to detect variability through blink-comparator. Three assistants were appointed during that period at Bamberg observatory – H. Rügemer (August 1930 – July 1935), S. Böhme (August 1935 – July 1939), and K. Himpel (August 1939 – December 1939). According to Zinner's annual reports about 6534 Ernostar plates were obtained in the period from October 1938 to December 1939. But the number of the stored plates is 5785 (Tsvetkova et al. 2006). For the brighter stars a 3 cm Tessar camera (Tessar Ideal) was mounted on the astrograph in late 1931. By the end of 1939 about 3000 plates (known in the observatory as T- and T1-plates) were obtained (Zinner 1939). 2592 T- and T1-plates were obtained in the period 1931-1939 according to the prepared electronic catalogue. Another camera with an 11 cm Goerz-Dagor lens was also mounted in 1930 at the heliometer and moved to the astrograph in 1931 for some special observations. In 1934 the camera was rebuilt by Kachelmann as Dogmar camera. Twenty one plates (known in the observatory as D-plates) were obtained in the period 1931 – 1939 according to the prepared electronic version of the catalogue. Table 1 & 2

present the main parameters and the efficiency of the objectives of the Bamberg Northern Sky Survey, respectively, used in the period 1928 – 1939. Figure 1 shows the set-up of the cameras mounted on the astrograph in 1936[7].

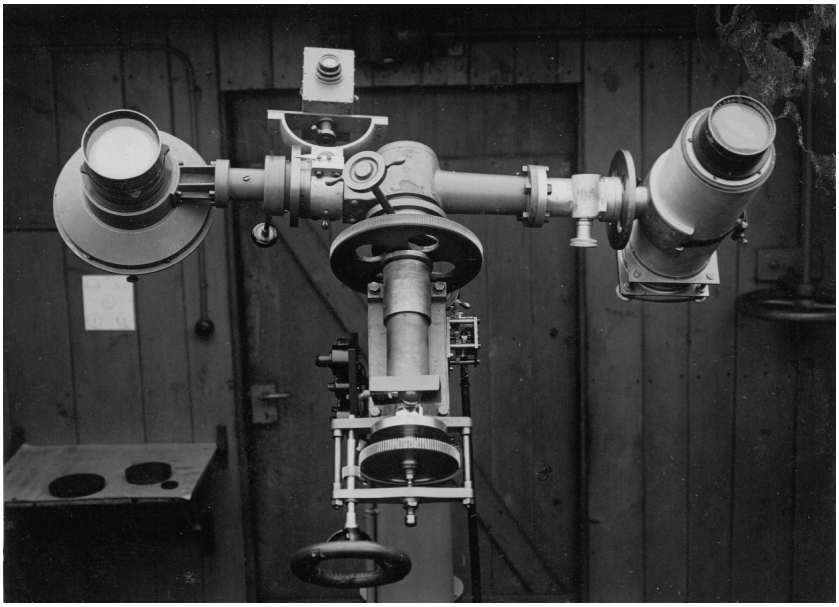

Figure 1: The Bamberg astrograph in 1936

The results of the Bamberg Northern Sky Survey, based mainly on the plates obtained with the Ernostar and Tessar cameras, were published in 10 publications of Zinner (in the period 1932 – 1939), 6 publications of Rügemer (in 1932 – 1935), and 6 publications of Böhme (in 1937 – 1939). When all assigned zones were covered by plates the observations were interrupted at the end of 1939.

Table 1: Main parameters of the objectives used in the period 1928-1939

Objective	Diameter (cm)	Focal length (cm)	Scale (”/mm)	Field of view (degree)
Ernostar	13.5	24	859	30x30
Tessar Ideal	3.0	13	1528	38x48
Dogmar	11.0	55	417	10.2x13.8

In 1941 the Bamberg Ernostar camera was lent to Sonneberg Observatory, from where the camera disappeared by the end of World War II and never returned back to Bamberg.

[7]Photograph from the Bamberg Observatory library archives

Table 2: Efficiency of the objectives used in the period 1928 – 1939

Objective	Year of operation	Plate size (cm)	Number of plates (obtained/stored)
Ernostar	Nov 1928-Dec 1939	16x16	6534/5785
Tessar Ideal	Apr 1931-Aug 1939	9x12	3000/2592
Dogmar	Sep 1931-Feb 1939	9x12	unknown/21

The second World war interrupted the survey and further observations were delayed because the Ernostar lens was lost. The available two cameras in the observatory at that time were the Dogmar and Tessar Ideal. The investigations of the variable stars in Bamberg were slowly resumed after World War II by H.-U. Sandig, who reported results in 6 publications from 1947 to 1951, mainly based on the old Ernostar and Tessar Ideal plates, as well as on episodic photographic observations with the Dogmar and Tessar Ideal cameras, conducted by him and L. Stiegler. The investigations of the old plate material was continued by E. Zinner, H.-U. Sandig and L. Stiegler (Zinner 1952). The objects from the Zinner list of 2191 suspected variable stars (Zinner 1929), some stars from the Prager catalogues of 5829 suspected variables (Prager 1934, 1937) as well as known and unknown stars showing variability were the targets of these investigations. In 1951 R. Kippenhahn replaced H.-U. Sandig in the variable stars investigations and in the observation programme with the Dogmar and Tessar cameras. He put also all Dogmar plates in order. Both cameras (the old Tessar Ideal camera and next to it – the Dogmar camera), were mounted at the astrograph in a way to cover the sky simultaneously with parallel strips approximately 30 degrees and 10 degrees, respectively. Kippenhahn (1953) published the results including new serial Tessar and Dogmar plates obtained in 1952.

The second period of the Bamberg Northern Sky Survey started in 1952 with the purchase of a second Tessar objective (known as Tessar 2) with the same diameter of 3 cm. Simultaneous observations with Dogmar and Tessar 1 or Dogmar and Tessar 2, or even Dogmar, Tessar 1 & 2 were executed by R. Kippenhahn up to the end of 1953, when the Northern sky was covered at least with 1-2 plates per region. The best Dogmar plates (60 min. exposures) reached 14.5 mag.

The following tasks were defined for the observing programme in Bamberg: Discovery of previously unknown variable; Search for a periodicity in the brightness variations; Derivation of the elements, mainly of eclipsing variables and Cepheids; Ensuring the derived elements on the basis of as much as possible larger time interval and plate material of Bamberg, and other observatories in Babelsberg, Sonneberg, and Harvard; Checking the elements by a light curve, using all available plates; Classification of the light curves, as basis for subsequent photoelectric and spectroscopic measurements; Link between the shape and amplitude of the provisional light curve and the spectral type; Detecting any period changes.

In order to carry out the ambitious project, Prof. Dr. W. Strohmeier, the newly appointed director of the Dr. Remeis-Sternwarte, acquired new objectives (rented or purchased) for the survey: a loaned 8.9 cm Tessar objective (by Wecker, Heilbronn, in 1954); a 9.1 cm Ernostar objective rented from Hamburg Observatory (in 1955) and mounted in a camera in the Bamberg workshop in 1957; a 6.2 cm Xenon objective (in 1957); an 8 cm Busch-Vierlinser (in 1958); an Ernostar objective loaned from Sonneberg Observatory (in 1959); a 10 cm Tessar objective of Bausch and Lomb (in 1959); and 3 Aero-Tessar 10 cm objectives (in 1961). To increase efficiency, the following eight cameras were mounted on the astrograph – the 10 cm Aero-Tessar, the 10 cm Aero-Tessar, the 10 cm Aero-Tessar, the 8.9 cm Tessar, Vierlinser, the Dogmar, 9.1 cm Ernostar, and the 10 cm Aero-Ektar (see Figure 2). The usage of the objectives is given in Table 3 in chronological order according to the Bamberg Observatory library archives.

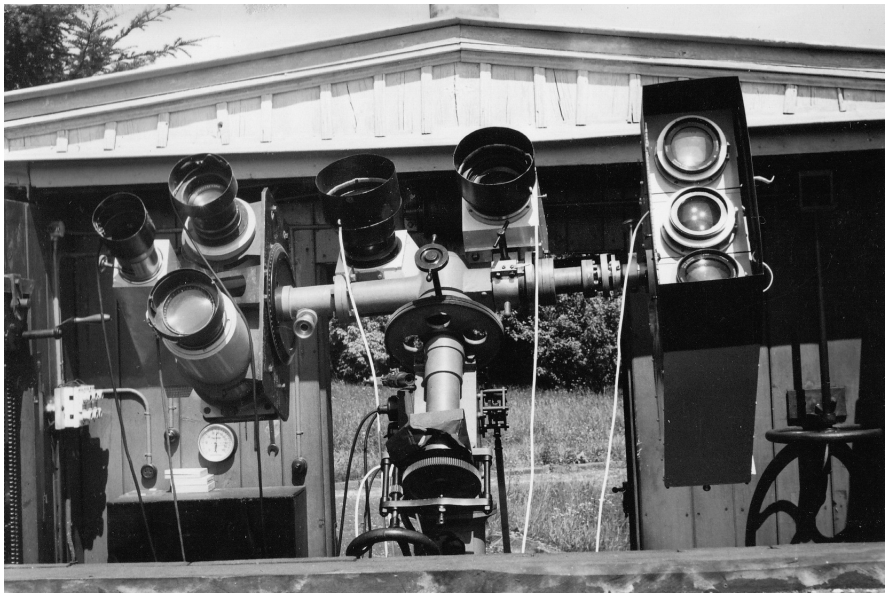

Figure 2: The Bamberg astrograph in 1961

1961 was a particularly successful year when observer R. Knigge obtained no less than 1100 plates. W. Strohmeier, R. Knigge and H. Ott processed the plates and the number of the newly discovered variable stars reached 390 – eclipsing variables, cepheids, long-periodic variables.

In 1962 the Bamberg Northern Sky Survey continued with limited extent and stopped in the end of 1963 when all efforts were directed towards the Southern Sky Survey of the Bamberg Observatory which started with 6 Aero-Tessar 10 cm objectives. Three of these Aero-Tessar objectives were tested on the Bamberg astrograph.

Table 3: Usage of the objectives in the period 1952 – 1963

Year	Objective	Covered zone
Apr 1957	Dogmar; 8.9 cm Tessar	mounted in parallel
June 1958	Dogmar; 8.9 cm Tessar; 9.1 cm Ernostar	10 deg parallel strips
Sep 1958	Dogmar; 8.9 cm Tessar; 9.1 cm Ernostar; Xenon	+70, +80, +53, +30
Sep 1960	Dogmar; 8.9 cm Tessar; 9.1 cm Ernostar	+30, +40, –4,
	Vierlinser, 10 cm Aero Tessar; 13.5 cm Ernostar	+35, +53, +10
Aug 1961	Aero-Tessar; Aero-Tessar; Aero-Tessar; Tessar;	+58, +45, +32, +80
	Vierlinser; Dogmar; 9.1 cm Ernostar; Aero-Ektar	+75, +70, +15, –4

The exposure time for all plates taken in the period 1952 – 1963 was 60 minutes. Instead of Agfa plates (with spectral sensibility in the wavelenght range of 400 – 520 nm) the Persenso-plates of the Perutz company (with spectral sensibility in the range 400 – 700 nm) were used. The average limiting magnitude was about 12-13 mag.

The main parameters of the objectives used in the period 1952 – 1963 are summarized in Table 4 in chronological order. The efficiency of the objectives for the period 1952 – 1963 is present in Table 5.

Table 4: Main parameters of the objectives used in the period 1952 – 1963

Objective	Diameter (cm)	Focal length (cm)	Scale ("/mm)	Field of view (degree)	Plate size (cm)	Lim. magnitude
Dogmar	11.0	50	417	10.2x13.8	9x12	14.2
Tessar Ideal (T/T1)	3.0	13.5	1528	38x48	9x12	13.0
Tessar (T2)	3.0	13.5	1528	38x48	9x12	13.0
Tessar	8.9	40	509	12.7x17	9x12	13.5
Ernostar	9.1	16.5	1246	31x41.5	9x12	13.5
Xenon	6.5	13	1587	39.7x52.9	9x12	12.5
Vierlinser	8.0	65	316	7.9x10.5	9x12	13.0
Ernostar	13.5	24	859	38x38	16x16	14.0
3 Aero-Tessar	10.0	61	338	15x15	16x16	12.5
Aero Ektar	10.0	61	338	15x15	16x16	12.5

The Bamberg astronomers not only used the material obtained in the observatory, but also from Babelsberg (W. Strohmeier in 1958 – 1959), as well as from Sonneberg (E. Geyer in 1958).

Table 5: Efficiency of the objectives used in the period 1952 – 1963

Objective	Years of operation	Number of stored plates
Dogmar (D)	Jun 1952-Oct 1963	1672*
Tessar Ideal (T/T1)	March 1952-Jan 1954	136**
Tessar (T2)	March 1952-Dec 1953	191
8.9cm Tessar (T)	May 1957-Oct 1963	1291
9.1cm Ernostar (E)	Oct 1957-Sep 1962	936
Xenon (X)	Nov 1958-July 1960	663
Vierlinser (V)	Feb 1960-Oct 1963	491
13.5 cm Ernostar (E)	Aug 1960-March 1961	61

*There are 96 plates obtained in the period June 1948 – December 1951, which were taken outside the series of the Northern Sky Survey.
**There are 5 plates obtained in the period August 1948 – November 1951, which were taken outside the series of the Northern Sky Survey.

3 Incorporation of the Bamberg plate catalogues into the WFPDB

Logbooks of the Bamberg plate archives from the Northern Sky Survey were not found. That is why the metadata for all stored 8421 plates (including the plates from the Appendix) are taken directly from the plate envelopes. This metadata file, readable by Topcat, has been sorted by different columns. The detected errors have two origins: made by the observers and from the typewriting.

Errors made by the observers were found because of:
- no correspondence between other given data on the envelopes (JD, dates, serial plate number);
- digit reversal;
- implausible data (e.g. written day of the month written as 35 instead of 25);
- some missing data which can be deduced and added (as dates, plate numbers);
- duplication of plate numbers.

These errors were corrected and mentioned in the notes.

The errors from typewriting such as reverse mode of date notation, wrong plate number because of deviations from the chronological order, and omitted file serial numbers, have been corrected in the metadata file too.

All plates although being taken with different instruments have consecutive serial number.

Table 6 presents information about the plate catalogues in Bamberg Observatory previously incorporated into WFPDB. For the Northern Sky Survey the information is based

on the work of Tsvetkova et al. (2006), for the Southern Sky Survey – on Tsvetkov et al. (2005). Twenty four Bamberg plate catalogues containing metadata for 26106 plates had been included into WFPDB by 2006.

Table 6: WFPDB previously incorporated Bamberg plate catalogues

WFPDB designation	Number of plates	WFPDB designation	Number of plates
BAM014B*	5785	BAM010 L	1456
BAM010 A	2053	BAM010 M	177
BAM010 B	2065	BAM010 N	1172
BAM010 C	2053	BAM010 O	134
BAM010 D	52	BAM010 P	139
BAM010 E	169	BAM010 Q	135
BAM010 F	174	BAM010 R	136
BAM010 G	191	BAM010 S	136
BAM010 H	1952	BAM010 T	129
BAM010 I	1942	HAR008C	467
BAM010 J	1939	HAR025	2138
BAM010 K	1437	HAR081	15

*From the Northern Sky Survey, all other designations are from the Southern Sky Survey.

The newly incorporated Bamberg plate catalogues are listed in Table 7 along with their WFPDB identifier.

Table 7: Newly incorporated Bamberg plate catalogues

WFPDB identifier	Observatory name and designation	Years of operation	Number of plates
BAM003A	Tessar Ideal (T, T1)	Apr 1931 - Jan 1954	2733
BAM003B	Tessar Ideal (T2)	March 1952 - Dec 1953	191
BAM006	Xenon (X)	Nov 1958 - July 1960	663
BAM008	Vierlinser (V)	Feb 1960 - Oct 1963	491
BAM009A	Tessar (T)	May 1957 - Oct 1963	1291
BAM009B	Ernostar (E)	Oct 1957 - Sept 1962	936
BAM011	Dogmar (D)	Sep 1931 - Oct 1963	1789

Individual exposure times are available for 55% of all plates (or for 4647 plates) only. From the plates with known exposure duration there are only 148 plates taken by single-exposure method with duration of less than 60 min and 20 plates with longer exposures – up to 120 min. There are also 52 plates (or 0,6% from the plates with known exposure

duration), which were obtained by the multi-exposure method – with 2,3,4, and 5 exposures, most of them (42 plates) were taken in the period May 1957 – November 1957, when Comet Arend-Roland had been observed. In addition forty plates had been taken in trailing mode at constant declination. For the remaining 45% of all plates there is no information about exposure duration. But it is fairly safe to assume that they were also exposed for 60 minutes as claimed in the annual reports. Concerning the plate emulsions, there is scarce information written on the plate envelopes (for 26 plates only). It is worthwhile to mention that some plates with Agfa Infrarot 730 emulsion (with spectral sensibility in the entire visible spectrum up to 800 nm) were used, taken in 1933 when in the same period in Potsdam W. Becker laid the grounds of his RGU system of photographic photometry using Agfa Infrarot 730 emulsion with Schott filter RG1. Obviously, this has been tried in Bamberg Observatory too. Panchromatic emulsions (sensitive to all wavelengths of visible spectrum) were used in the period 1951 – 1953, while in 1954 some blue and red emulsions were tested.

In the WFPDB search page, using the respective WFPDB identifier of the Bamberg plate catalogues, the all-sky distribution of the plate centres (presented in Figure 3 for the BAM011 catalogue as the largest catalogue) and the plate number distribution by years (Figure 4) can be found.

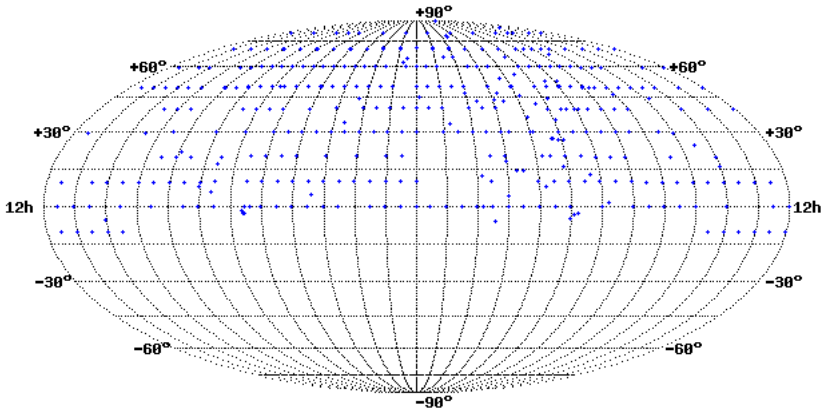

Figure 3: All-sky distribution of the BAM011 (Dogmar) plate centres

The main targets of the Bamberg Northern Sky Survey remained the variable stars, both the search for new and the investigation of known variables. In addition meteors (19 plates with 2 bolides), comets (Arend-Roland in 1957, Burnham in 1960) and the Moon (153 plates in the period 1933 – 1961) are among the observed objects.

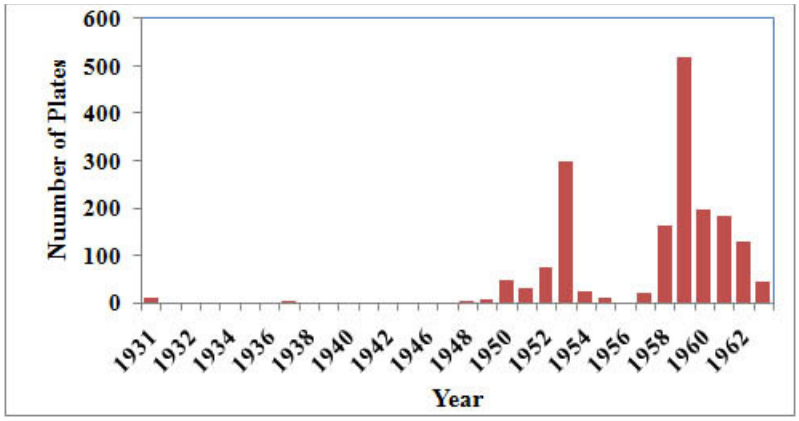

Figure 4: BAM011 (Dogmar) plate number distribution by years

4 Conclusions

The photographic plates have been obtained in the frameworks of surveys for variable stars of the Bamberg Observatory - executed for the Northern as well as for the Southern sky. With the work presented here we have added seven catalogues to the WFPDB containing metadata for 8094 plates and increased the number of Bamberg plate catalogues in WFPDB to 31 containing metadata for 34200 plates. The last publication, concerning the plates taken for the Northern Sky Survey for the entire period 1928 – 1963, dates from 1966 (Strohmeier 1966).

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Appendix

There are about 257 plates, for which there is no designation for the objective used. There are 27 plates with objective designation "G". It is quite possible that this designation refers to the 11 cm Goerz-Dagor lens, which was mounted exactly in 1930 at the heliometer and, thereafter, on the astrograph in 1931. There is also one plate with objective designation

Table 8: Number of plates with unclear objective designation

Objective designation	Period of operation	Number of plates
None	July 1931 - May 1960	257
UV	August 1932	1
T17	July 1957 - March 1958	21
TII	Sep 1963	11
TIII	May 1957	10
G	June 1930 - Sep 1938	27
Totally:		327

"UV", which refers to the 13.5 cm Steinheil camera with UV lens for measurements of the transparency and quietness of the air and mounted subsequently on the astrograph or at the Bamberg heliometers. The UV Steinheil camera had been at disposal still in 1928 and the number of obtained plates counted according to Zinner's annual reports in the period of operation 1928 – 1933 is about 100, but up to the moment only one plate has been found in the observatory depository. There are plates with unclear objective designation "TII", "TIII" and "T17". Maybe these plates were obtained with the Aero Ektar and with the three Aero Tessar objectives. All these plates of uncertain origin (see Table 8) have not been included in the WFPDB.