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THE CURRENT STATE OF THE ODESSA COLLECTION OF ASTROPHOTONEGATIVES

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Abstract. We present the status, tasks and opportunities of the Astronomical observatory of the Mechnikov Odessa National University astrophotonegatives collection. It contains one of the most valuable plates archives as it is listed in the Wide-Field Plate Database (wfpdb.org) with more than 100,000 plates – the second plate collection in Europe after the Sonnenberg plate collection with 250,000 plates and the third in the world after the Harvard plate collection with 500,000 plates.

The Odessa plate collection provides an opportunity to follow a brightness history of selected sky objects during an almost 100-year period. We describe the plans of the observatory of salvaging this important world astronomical heritage and the first steps of digitization of an important part of the plate collection. The inventory and incorporation of the metadata from the logbooks in the computer readable form according to the International Virtual Observatory and the WFPDB standards are discussed.

1. INTRODUCTION

There are 414 archives known in the world, which contain more than 2.1 million wide-field images (of which about 64,000 – are spectral images). The largest number of images is stored in the archives of the Harvard Observatory – more than 500 thousand. In the Sonneberg Observatory there are about 270 thousand. The total amount of plates in the Odessa collections is more than 100 thousand that covered period of 1909-1998. The key difference of the Odessa collection from others is that the images are made in two spectral bandwidth –

photographic and photovisual, that makes possible to determine not only magnitudes but also color indices of celestial objects.

2. ODESSA PLATE ARCHIVE

The Odessa archive consists of three collections: the Simeiz collection, the Old collection and the collection obtained on the Seven-camera astrograph.

2.1. Simeiz Collection (1909-1953)

The collection of near 8,000 plates was obtained at the Simeiz Observatory on Double 120-mm astrograph (Fig. 1) during the period 1909-1953. In 1966, the archive of the Simeiz observatory was moved from Crimea to Odessa by agreement between director of Simeiz observatory A.B. Severnyy and director of Odessa observatory V.P. Tsesevich for study the variable stars on these plates. Thus, the Simeiz collection became part of the Odessa archives of astrophotonegatives.

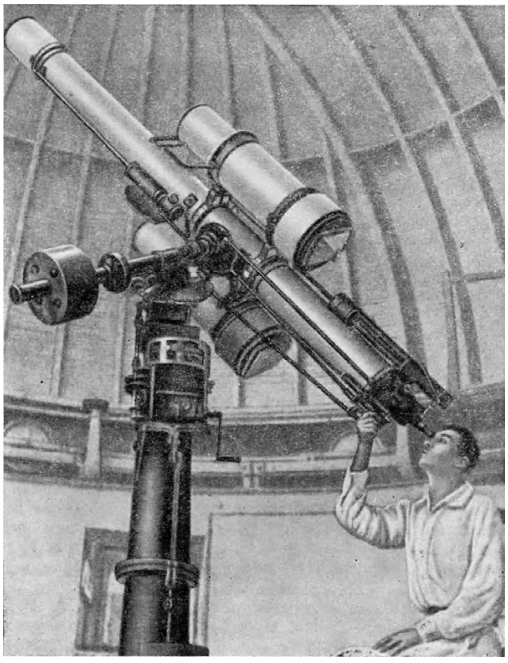

Figure 1: Double astrograph with 120 mm Unar Lenses by Carl Zeiss (worked since 1908).

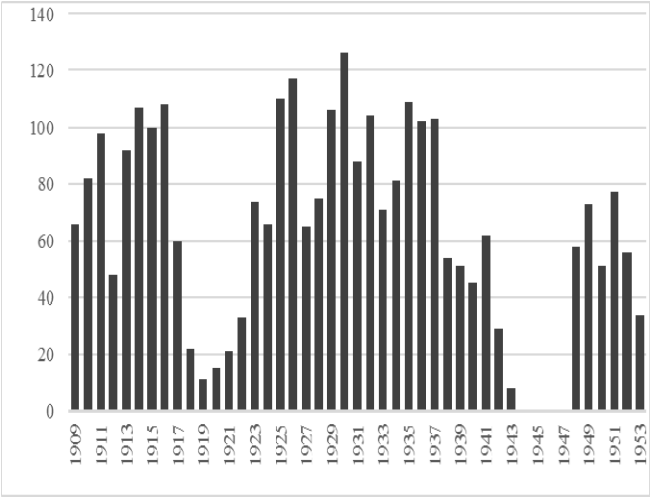

Figure 2: Annual number of observation nights in Simeiz from 1909 to 1953.

Characteristics of the Simeiz Double astrograph:
- *locations of astrograph:* Simeiz, Kitab
- *Lenses:* Two 120 mm Unar lenses by Carl Zeiss
- *operation period:* from JD 2418405 to 2434725 (1909-1953) (Fig. 2)
- *plates size*: 127 x 178 mm (5x7 inches)
- *emulsions*: more than 10 varieties of photo emulsions
- *field of view*: 11.9 x 16.2 deg
- *limiting photographical magnitude*: ~ 15^m
- *exposure time*: up to 2 hours
- *number of plates*: about 8,000

During the World War II in evacuation (1942-1944) in Kitab (Uzbekistan), observations were made on the Double astrograph by Bredikhin.

The Simeiz collection of plates contains mainly observations of small bodies of the Solar system (asteroids), Major planets and their satellites. Several hundred plates contain images of various objects and phenomena: comets, variable stars, lunar eclipses, etc. The field centers are determined by the position of small planets and comets and by their expected region of presence. Coordinates are specified on plates envelopes.

2.2. The Old Collection (1951-1957)

The Old collection of starry-sky imagery was obtained on three instruments: "Large" astrograph, "Small Two-camera" Astrograph and Three-camera astrograph "Hedgehog". During working of these three astrographs in 1951-1957, more than 10,000 plates were obtained, first of all, for studying of variable stars.

In pre-war years, the camera "Large" astrograph" with a long focus was installed on the telescope-refractor by T. Cooke & Sons (165 mm) (Fig. 3).

The cycle of patrol observations on this astrograph was organized already in the first years of his directorate in 1945, V. P. Tsesevich (1907-1983). The "Large Astrograph" was replaced by a "Small Astrograph", which already had two cameras, and then the "Three-camera" astrograph ("Hedgehog"), with short-focus cameras.

Figure 3: T. Cooke & Sons refractor with “Large” astrograph.

Characteristics of old astrographs of Odessa Observatory*:*

- *location of astrographs*: Odessa, Taras Shevchenko park
- *period of observations:* from JD 2433812 to 2435776 (1951-1956)
- *plates sizes*: 130x180, 180x180 and 180x240 mm
- *emulsions*: Ilford, Agfa Astro, "Isoorto" with yellow, red filters and without filters
- *field-of-view*: 24x33 degrees
- *number of guide stars*: 64 (+35 single stars)
- *limiting photographical magnitude*: ~ 13.5^{m}
- *exposure times*: from 0.5 to 3 hours
- *storage of plates*: observation station Mayaki

Table 1: Characteristics of astrographs "Old collection" of Odessa Observatory (Karetnikov et al. 1994).

Instrument	No. of cameras	Lenses type	D, mm	F, mm	FoV, °	Photom. System	FoV center shift from guide star, °
"Large" astrograph	1	Tessar SOI	148	1000	9 x 12	pg	0
"Small 2-camera" astrograph	1 2	Industar-17 Zeiss Triplet	100 100	500 500	22 x 15 22 x 15	pg, pr pg, pv	0 0
3-camera astrograph "Hedgehog"	1 2 3	Industar-163 Xenon Epostar	67 60 60	300 120 120	20 x 30 20 x 30 20 x 30	pv pv pv	0 -25 +25

In the "Old Collection" there is a small number of plates exposed in photored light (pr). For these plates different guide stars were chosen. These stars are specified on the plates envelopes. The plate centers listed in Table 1 are given as offset relative to the corresponding guide star (in degrees of declination).

2.3. Collection of the Seven-Camera Astrograph (1957-1998)

The largest collection in the Odessa archive contains about 84,000 photographic plates (12,225 exposures) obtained on the Seven-camera astrograph (Fig. 4) over 40 years of observations. The Seven-camera astrograph was created in 1957 during the preparation for the International Geophysical Year (IGY) at the suburban astronomical station in Mayaki (40 km from the city of Odessa) by initiative of V.P. Tsesevich. The collection was created for observing, first of all, variable stars. In addition, twilight phenomena, comets, asteroids, satellites, quasars (for example, 3C 273) were photographed, the outburst of gamma-busters and others was investigated.

Characteristics of the Seven-camera astrograph:

- *location of 7-camera astrograph*: Odessa region, Belyaevsky district, Mayaki, Observation Station of Mechnikov Odessa National University
- *observation period*: 1957-1998 years
- *plates sizes*: 130x180, 180x240 mm
- *emulsions*: Agfa Astro, ORWO ZU1, ZU-2, ZU-21without filters, ZP-1, ZP-3 with yellow filters
- *field-of-view*: 30 x 80 deg
- *guide stars*: main stars – 39, more than 75 were used from 1 to 15 times
- *limiting photographical magnitude*: ~ 14.5^{m}

- *limiting photovisual magnitude*: ~ 12^m
- *exposure time:* 30 min
- *number of plates*: about 84,000

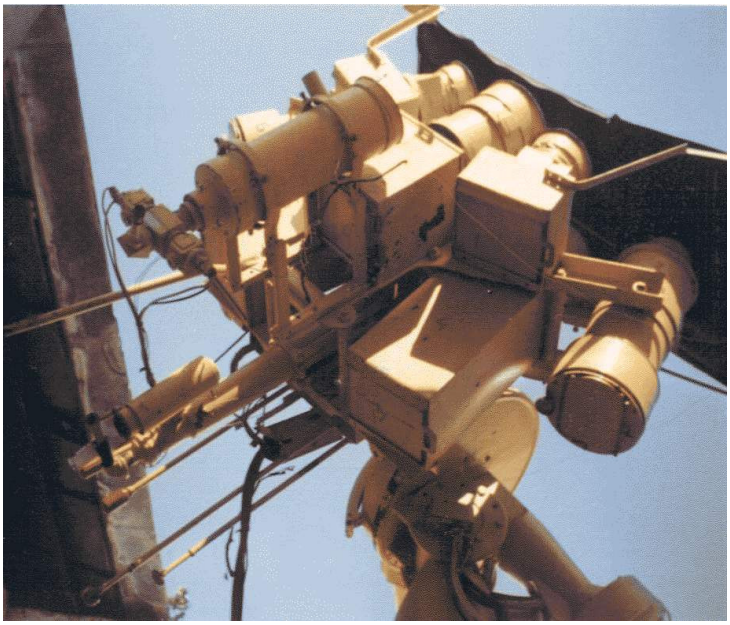

Figure 4: The Seven-camera astrograph.

The astrograph was twice modernized. Some cameras changed to more efficient ones, their fields of view also changed and shifted. Thus, all the photographic plates of the Seven-camera astrograph are divided into 3 series: the Old (1957-1959), the New (1959-1966) and the Third (1966-1998) series (Table 2).

Photographic materials were produced by a German firm, which first produced photographic materials called Agfa Astro, and then - ORWO. There were only two types of photographic materials: non-sensiblised ZU-1, ZU-2 and ZU-21 and panchromatic ZP-1 and ZP-3, which gave homogeneous photometric systems. All changes of photometric systems were investigated in the work of A. N. Rudenko (Rudenko, 1988).

Table 2: Characteristics of the Seven-camera astrograph.

Name of series and dates	No. of camera	Type of objective	D, mm	F, mm	Field-of-view, °	Photom. system	FoV center shift from guide star, °
The Old series. From 19.07.1957 to 08.04.1959	1	Uran-9	100	250	30 x 40	pg, pv	+13
	2	Uran-9	100	250	30 x 40	pg, pv	-13
	3	Uran-9	100	250	35 x 25	pg	+25
	4	Vierlinser	160	720	13 x 18	pg	+08
	5	Vierlinser	160	720	13 x 18	pg	-08
	6	Uran-9	100	250	30 x 40	pg	-27
	7	Tessar SOI	148	100	9 x 12	pg	0
The New series. From 09.04.1959 to 08.06.1966	1	Uran-9	100	250	30 x 40	pv	+10
	2	Uran-9	100	250	30 x 40	pv	-10
	3	Triplet	100	500	22 x 15	pg	+30
	4	Vierlinser	160	720	13 x 18	pg	+18
	5	Vierlinser	160	720	13 x 18	pg	-18
	6	Industar 17	100	500	22 x 15	pg	-33
	7	Uran-12	200	500	18 x 24	pg, pv	0
The Third series. From 09.06.1966 to 31.10.1998	1	Uran-9	100	250	30 x 40	pv	+13
	2	Uran-9	100	250	30 x 40	pv	-13
	3	UNAR	120	600	16 x 11	pg	+23
	4	Vierlinser	160	720	13 x 18	pg	+08
	5	Vierlinser	160	720	13 x 18	pg	-08
	6	UNAR	120	600	16 x 11	pg	-23
	7	Uran-12	200	500	18 x 24	pv	0

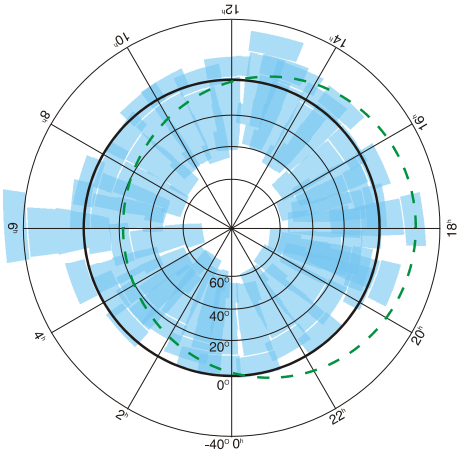

Figure 5a: Celestial sphere covering by fields of view of cameras No. 3, 4, 5 and 6, The Third series.

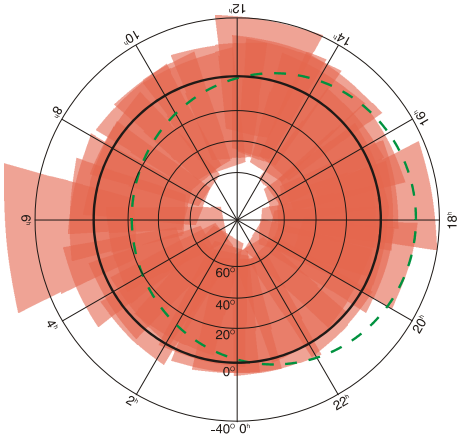

Figure 5b: Celestial sphere covering by fields of view of cameras No. 1, 2 and 7, The Third series.

The yellow filters were installed on the 1st and 2nd cameras from July 12, 1958 and on the 7th camera from June 18, 1965.

The number of clean nights based on the data of the 7-camera astrograph (Kashuba et al., 2015) can be traced from the statistics of patrol images (Figure 6):

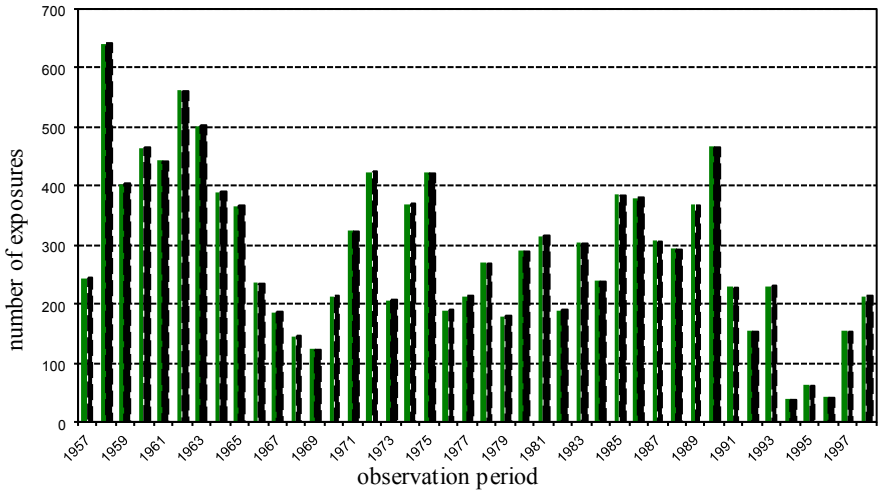

Figure 6: Statistics patrol images on the Seven-camera astrograph for the period 1957-1998.

3. DIGITIZATION OF THE ODESSA ASTROPHOTONEGATIVE ARCHIVE

The main goal of the digitization of the entire archive is to preserve the historical heritage of the Odessa Observatory, to update the archive as a resource for obtaining full photometry and astrometry results for the greater part of the northern sky, as an extension of the observatory's resource base. In other words, make the archive available to scientific community.

For the first time, the digitization of the Odessa archive of plates was started in 1999. The project of digitization was proposed by A. Yushchenko, et al. (Karetnikov et al., 2007), but was not launched for financial difficulties. In 2002, only the original metadata was prepared in the form of a machine-readable catalog recorded for 2 collections: the Simeiz and the Seven-camera astrograph (Pikhun et al, 2002).

Digitization of the Odessa archive began in 2013 in the Main Astronomical Observatory of National Academy of Science of Ukraine using the flatbed scanner Epson Expression 10000XL. About 500 digitized 16-bit grayscale images from the Simeiz collection were obtained with resolution of 1200 dpi and included in the combined digital archive of Ukrainian Virtual Observatory Joint Observation Data Archive (JDA) (Vavilova, 2012). To date, the JDA contains 600 metadata records

and more than 400 digitized images of selected plates collection in the 1950s (http://gua.db.ukr-vo.org/createlist.php?aid=CRI012A).

In the summer of 2014 to glass library of the Odessa observatory located in the village Mayaki, sponsors have presented the Epson Perfection V700 Photo scanner (the A4 format, optical resolution 6400x9600 dpi, depth of color, bit: 48) complete with office equipment serving the scanner. From this date digitization of the Odessa archive began to be conducted locally, not taking out of its far from its storage place.

The attestation of the Epson Perfection V700 Photo scanner was carried out by V. Andruk (Andruk et al, 2015). As a result, he came to the conclusion that for rectangular coordinates mean-square error of value of one difference determination is σ_{xy} = 0.023 pixels for the 1200 dpi scanning mode; for instrumental stellar magnitudes, the mean-square error value of one difference determination is $\sigma_m = 0.013^m$ (Kashuba et al, 2017).

On Epson Perfection V700 Photo scanner, up to 2018, about 4,000 plates of the Simeiz collection were digitized. In 2016 about 400 of the collection of the Seven-camera astrograph (4 cameras, γ Cyg, III series) were digitized for the purpose of researching stars for their variability in brightness. The plates were digitized in TIFF format, 16 bit, 20 microns/pixel, the file size is ~ 90 MB (for 1200 dpi resolution) and ~ 350 MB (for 2400 dpi resolution).

A parallel process for placing material in an open access database is the digitization of the corresponding observational logbooks and envelopes of plates, as well as the creation of machine-readable data for each plate in a single WFPDB format.

Wide-Field Plate Database - Sofia
Search Result

WFPDB | WFPDB@VizieR | Aladin | All WFPDB Archives

Constraints: IDobs: "**SIM**", IDins: "**12**", IDsuf1: "**a**"

Details	IDobs	IDins	IDsuf1	IDno	IDsuf2	RAJ2000	DECJ2000	CCOD	Date	UT	TCOD	preview
more	SIM	012	A	000001		03 23 40	46 34 36		1909 03 22	08 52 18		no
more	SIM	012	A	000005		11 34 47	27 29 49		1909 03 28	12 30 00		no
more	SIM	012	A	000008		05 17 05	46 11 54		1909 04 07		M	no
more	SIM	012	A	000010		14 15 07	19 08 11		1909 04 07		M	no
more	SIM	012	A	000012		18 37 16	38 44 12		1909 04 07		M	no
more	SIM	012	A	000013		12 51 10	27 39 39		1909 04 08	09 53 00		no
more	SIM	012	A	000014		18 56 07	62 14 51		1909 04 08	11 51 00		no

Figure 7: Screenshot of the SIM012A catalog page in WFPDB (www.wfpdb.org**).**

The processing of archival data with unified standards gives objective unique information about the astronomical object. Tsvetkov et al. (Tsvetkov, 2005), using the example of the Pleiades, showed how to create an almost continuous database, overlapping in different archives, to determine the sky area from 1872 to 1996. The data obtained from the Odessa archive will be a reasonable addition to these combined structures.

In May 2018, 887 records of the Simeiz collection SIM012A (80 GB) of the period 1909-1915 were placed in the database of the Bulgarian Data Processing Center (WFPDB) (Figure 7) (Tsvetkov, 2006).

4. POSSIBLE SCIENTIFIC OBJECTIVES

Speaking about the relevance of the archive, usually given examples of scientific problems based on archival data. Let us give an example of our own photometric studies.

One of the first objects of research by processing digitized images was the star KIC 8462852, also known in the literature as the star of Tabbi.

Interest in this star is caused by irregular blackouts on the light curve discovered by Kepler's mission, as well as by unusual interpretations of such changes. Two years ago, Bradley Shafer published the results of a photometric study of the star KIC 8462852 on the plates of the Harvard archive for a period of 90 years (Schaefer, 2016). He found tendency of magnitude reducind by 0.16 mag in a hundred years (Figure 8, graph above).

A similar work was done on the plates of the Seven-camera astrograph. The lower graph (Fig. 8) shows magnitude estimates by processing 380 digitized plates of the Seven-camera astrograph. A photometric series of the star KIC 8462852 was obtained, covering interval from 1966 to 1998 - the trend of decreasing the brightness of the star is noticeable.

And in conclusion quote from page Digital Access to the Sky Century @ Harvard (DASCH): “The stars photographed on glass plates between 1880s-1990s operate as time capsules, allowing astronomers to study how the sky has changed over one hundred years”.

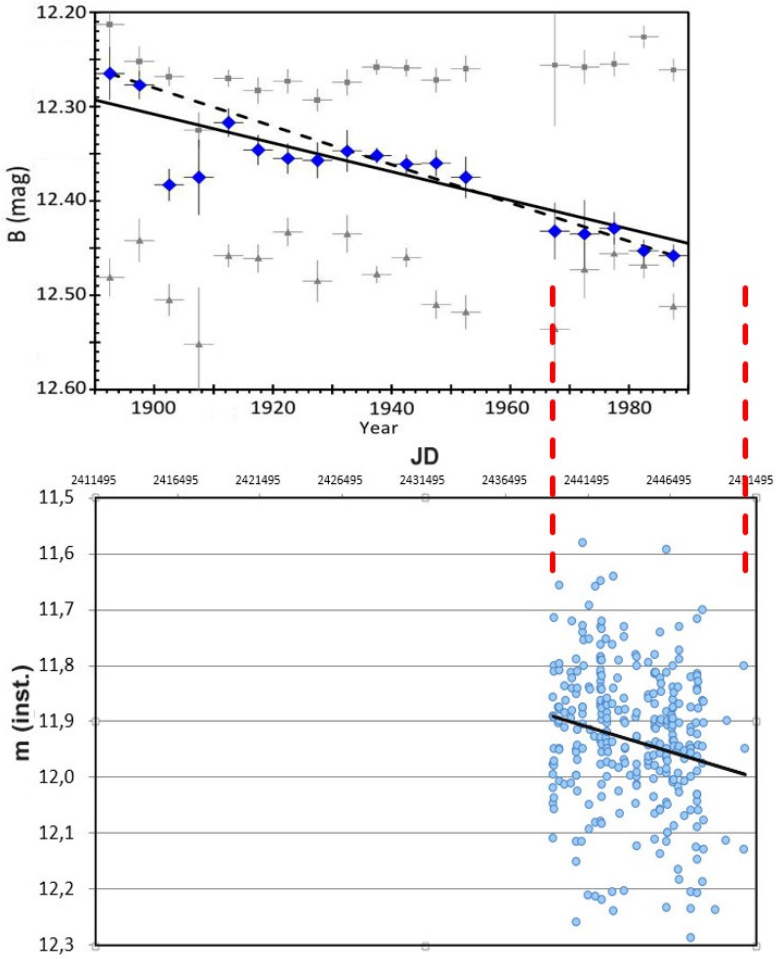

Figure 8: Photometric row on the plates of the Harvard archive (above) (https://arxiv.org/abs/1601.03256), on the plates of the seven-camera astrograph (below).

Acknowledgments

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