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Lohse's Historic Plate Archive

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The description and the analysis of Oswald Lohse's astrophotographic plate archive, made in the Astrophysical Observatory Potsdam in the period 1879 – 1889, are presented. 67 plates of the archive, taken with the greatest instrument of the observatory at that time – the refractor (D = $0.30m$, F = $5.40m$, scale = $38''/mm$) and with the second heliographic objective (D = $0.13m$, F = $1.36m$, scale = $152''/mm$) survived two world wars in relatively good condition. The plate emulsions are from different manufacturers in the beginning of astrophotography (Gädicke, Schleussner, Beernaert, etc.). The sizes of the plates are usually $9{\times}12$ cm^2, which corresponds to fields of $1.2°$ and $5°$ respectively for each instrument mentioned above. The average limiting magnitude is 13.0(pg). Besides of the plates for technical experiments (work on photographic processes, testing of new instruments and methods of observations), the scientific observations follow programs for studies of planet surfaces, bright stars, some double stars, stellar clusters and nebulous objects. Lohse's archive is included into the Wide Field Plate Database (http://www.skyarchive.org) as the oldest systematic one, covering the fields of Orion (M42/43), Pleiades, h & χ Persei, M37, M3, M11, M13, M92, M31, etc. With the PDS 2020 GM$^+$ microdensitometer of Münster University 10 archive plates were digitized.

Key words: astronomical databases: catalogues — astronomical instrumentation, methods and techniques: telescopes — astronomical instrumentation, methods and techniques: image processing

1. Introduction

Wilhelm Oswald Lohse (1845-1915) is the astronomer, who first applied in the Astrophysikalischen Observatorium Potsdam photography to astronomical observations taking astrophotographic plates with images of the Sun, Moon, planets (Venus, Mars, Jupiter and Saturn), stars, comets, stellar clusters and nebulous objects. He moved to Potsdam together with Hermann Carl Vogel (1841-1907) from the private observatory of chamberlain Friedrich Gustav von Bülow in Bothkamp (Brandt 1998). In Bothkamp observatory Vogel and his assistant Lohse established the astrophysics in Germany making spectroscopic and photometric investigations on the ground of visual as well as of new involved photographic astronomical observations with the largest refractor (0.29/4.90 m) in Germany at that time. Still in Bothkamp, realizing the importance of photography for astronomy, they followed and applied the discoveries in photography for astronomical observations.

In Potsdam Lohse began to make photographic observations with the so called Grosser Refractor since its first light. Unfortunately, from 217 plates, listed in his logbook, the first 148 from 1879 to 1885 are not found. All plates had been stored in the dome of the Grosser Refractor. On April 14, 1945 a bomb detonated near the dome, which obviously caused the loss (Wempe 1974, Dick 1988).

2. Telescope and plates used

The main instrument of the just founded Astrophysikalischen Observatorium Potsdam was a 0.30 m Grosser Refractor with 5.40 m focal length and scale $38''/mm$ (Hassenstein 1941). The instrument, put in operation in 1879, was well equipped with spectroscopes, objectives for photographic plates, thread micrometers and objective prism. The Grosser Refractor deserved its name because up to 1889 it had been the greatest telescope with which photographic plates were taken as can be seen from the Catalogue of Wide Field Plate Archives - version 3.1, May 1998 (http://www.skyarchive.org/catalogue.html). Table 1 presents an extract from this catalogue of all known wide field plate archives, which were started in the last century. An information about the instrument, its type and years of operation, as well as the location of the archive is given. The Grosser Refractor has identifier POT030A in the Wide Field Plate Database (WFPDB, Tsvetkov et al. 1997), which according to the accepted rule contains the name of the observatory as well as the telescope aperture and suffix (A, B, ...) for each following instrument with the same aperture.

Since December 1888 Lohse attached to the Grosser Refractor the second heliographic objective (D = 0.13m, F = 1.36m, scale = $152''/mm$) and continued to observe. This instrument has the WFPDB identifier POT013B in Table 1.

Table 1: List of wide field plate archives started before 1901

WFPDB Identifier	Type	Years of operation	Location
POT030A	Rfr	1879-1930	Potsdam
POT020	Rfr	1879-1908	Potsdam
POT013A	Rfr	1879-1908	Potsdam
POT013B	Cam	1888-1889	Potsdam
HAR020A	Rfr	1885	Cambridge USA
HAR020B	Rfr	1889-1946	Cambridge USA
POT032	Rfr	1889-1920	Potsdam
RGO033	Ast	1891-1988	Cambridge UK
HAR061A	Rfr	1893-1950	Cambridge USA
PUL034	Ast	1893	Pulkovo
BOR033	Ast	1893	Floirac
STE010	Cam	1895-1958	Moscow
STE016	Cam	1895-1958	Moscow
RGO066	Ast	1897-1988	Cambridge UK
HAR004A	Rfr	1898-1957	Cambridge USA
POT080	Rfr	1899-1969	Potsdam
HAR003	Rfr	1899-1954	Cambridge USA
HEI040	Ast	1900-1981	Heidelberg
BON030A	Rfr	1900-1993	Bonn

The sizes of the plates are usually 9×12 cm^2, which corresponds to fields of 1.2° and 5° respectively for each instrument. The average limiting magnitude is 13.0(pg). In the Astrophysikalischen Observatorium Potsdam since 1881 English ordinary plates produced by Wratten and Wainwright with an average sensitivity and exceptional pure emulsion layer according to Lohse (1889), have been used. Nevertheless in the logbook of the archive Lohse mentioned especially some other emulsions from different manufacturers in the beginning of astrophotography (Gädicke, Schleussner, Beernaert, etc.). The plates taken after November 1887 are mainly with orthochromatic emulsions sensitive up to 580 nm.

Table 2: List of Lohse's plates

LS No.	Date d m y	RA DEC 2000.0	UT Begin.	Object	Code	Exp. (min)	Emulsion	Plate Size(cm)
149	31 03 1885	$02^h19^m00^s$ $+57°09''00'$	19^h28^m	H PER	S4			09-09
150	18 04 1885	$13^h42^m11^s$ $+28°22''32'$	22^h18^m	M3	S4			09-09
151	14 11 1885			MOON	A2	0.1		08-12
152	17 11 1885			MOON	A2	0.1		09-12
153	04 12 1885	$03^h47^m29^s$ $+24°06''18'$	22^h19^m	PLEIADES	S4	10		10-12
154	18 03 1886	$03^h45^m49^s$ $+24°22''12'$	19^h00^m	MAIA NEB	S4	15	GAEDICKE	09-12
155	23 03 1886	$03^h47^m29^s$ $+24°06''18'$	18^h48^m	PLEIADES	S4	61		10-12
156	11 04 1886	$05^h52^m19^s$ $+32°33''12'$	19^h46^m	M37	S4	60	GAEDICKE 294	10-12
157	13 04 1886	$05^h52^m19^s$ $+32°33''12'$	19^h57^m	M37	S4	58.4		10-12
158	18 05 1886			JUPITER	A1		BEERNAERT	07-09
159	19 05 1886			JUPITER	A1	61		07-09
160	19 05 1886	$16^h41^m41^s$ $+36°27''37'$	22^h28^m	M13	S4	60	BEERNAERT	09-12
161	20 05 1886			JUPITER	A1	10		04-09
162	20 05 1886	$16^h41^m41^s$ $+36°27''37'$	21^h44^m	M13	S4	60		09-12
163	21 05 1886	$09^h46^m59^s$ $+23°38''48'$	20^h52^m	C/WINNECKE	A5	60		09-12
164	25 05 1886	$16^h41^m41^s$ $+36°27''37'$	23^h41^m	M13	S4	60		09-12

165	25 08 1886	$00^h42^m46^s$	$+41^\circ16''18'$	22^h48^m	AND NEB	G1	59.2	BEERNAERT	09-12
166	26 08 1886	$00^h42^m46^s$	$+41^\circ16''18'$	20^h53^m	AND NEB	G1	60		09-12
168	28 08 1886	$00^h42^m46^s$	$+41^\circ16''18'$	20^h22^m	AND NEB	G1	120		09-12
169	29 08 1886	$00^h42^m46^s$	$+41^\circ16''18'$	20^h32^m	AND NEB	G1	127		09-12
170	30 08 1886	$00^h42^m46^s$	$+41^\circ16''18'$	20^h43^m	AND NEB	G1	120	BEERNAERT	10-11
171	01 09 1886	$02^h20^m00^s$	$+57^\circ08''00'$	20^h48^m	H&CHI PER	S4	120		09-12
172	03 09 1886	$18^h53^m35^s$	$+33^\circ01''43'$	22^h45^m	RING NEB	S7	90		09-12
173	13 09 1886	$17^h17^m07^s$	$+43^\circ08''11'$	20^h41^m	M92	S4	120		09-12
174	16 09 1886	$19^h50^m47^s$	$+08^\circ52''06'$	20^h20^m	ALPHA AQL	S1	120		10-12
175	20 09 1886	$19^h50^m47^s$	$+08^\circ52''06'$	19^h22^m	ALPHA AQL	S1	120		10-12
176	01 10 1886	$00^h56^m43^s$	$+60^\circ43''00'$	18^h44^m	GAMMA CAS	S1	117.5		10-12
177	04 10 1886	$03^h24^m19^s$	$+49^\circ51''40'$	21^h48^m	ALPHA PER	S1	27	JODEOSIN	10-12
178	05 10 1886	$00^h56^m43^s$	$+60^\circ43''00'$	18^h41^m	GAMMA CAS	S1			10-12
179	06 10 1886	$00^h56^m43^s$	$+60^\circ43''00'$	18^h41^m	GAMMA CAS	S1	120	JODEOSIN	09-12
180	09 10 1886	$00^h56^m43^s$	$+60^\circ43''00'$	18^h04^m	GAMMA CAS	S1	120	JODEOSIN	10-12
181	11 10 1886	$00^h56^m43^s$	$+60^\circ43''00'$	19^h14^m	GAMMA CAS	S1	90		10-12
182	13 10 1886	$01^h25^m49^s$	$+60^\circ14''07'$	17^h50^m	DELTA CAS	S1	101		10-12
183	18 10 1886	$00^h42^m46^s$	$+41^\circ16''18'$	17^h44^m	AND NEB	G1	60		10-12
184	19 10 1886	$00^h40^m30^s$	$+56^\circ32''14'$	17^h49^m	ALPHA CAS	S1	120	BEERNAERT	09-12
185	20 10 1886	$00^h40^m30^s$	$+56^\circ32''14'$	17^h16^m	ALPHA CAS	S1	120		09-12
186	27 10 1886	$18^h51^m06^s$	$-06^\circ16''00'$	17^h47^m	M11	S4	60		09-12
187	28 10 1886	$19^h46^m16^s$	$+10^\circ36''48'$	17^h23^m	GAMMA AQL	S1	120		09-12
188	29 10 1886	$19^h46^m16^s$	$+10^\circ36''48'$	17^h35^m	GAMMA AQL	S1	120		09-12
189	01 11 1886	$00^h49^m06^s$	$+57^\circ48''55'$	17^h25^m	ETA CAS	S1	105		09-12
190	01 12 1886	$05^h16^m41^s$	$+45^\circ59''53'$	17^h19^m	ALPHA AUR	S1	65		09-12
191	28 02 1887	$05^h55^m10^s$	$+07^\circ24''25'$	18^h22^m	ALPHA ORI	S1	120		09-12
192	01 03 1887	$05^h55^m10^s$	$+07^\circ24''25'$	18^h10^m	ALPHA ORI	S1	120		09-12
193	10 03 1887	$05^h55^m10^s$	$+07^\circ24''25'$	18^h48^m	ALPHA ORI	S1	120	BEERNAERT	09-12
194	01 11 1887	$21^h14^m21^s$	$-04^\circ15''55'$	17^h05^m		F	40		08-09
195	02 11 1887	$19^h50^m47^s$	$+08^\circ52''06'$	17^h20^m	ALPHA AQL	S1			08-09
196	03 11 1887	$19^h50^m47^s$	$+08^\circ52''06'$	18^h28^m	ALPHA AQL	S1	25	SCHLEUSSNER	08-09
197	12 11 1887			04^h07^m	CANCER	F	31		09-12
199	03 12 1887	$23^h04^m46^s$	$+15^\circ12''19'$		ALPHA PEG	S1		ORTHOCHROM	09-12
200	03 12 1887	$23^h04^m46^s$	$+15^\circ12''19'$	18^h16^m	ALPHA PEG	S1	21	ORTHOCHROM	09-12
201	07 12 1887	$00^h08^m23^s$	$+29^\circ05''25'$	18^h38^m	DELTA PEG	S1	20	ORTHOCHROM	09-12
202	07 12 1887	$00^h08^m23^s$	$+29^\circ05''25'$	19^h04^m	DELTA PEG	S1	12	ORTHOCHROM	09-12
203	16 11 1888			04^h23^m	MOON	A2			09-12
204	17 11 1888	$19^h50^m47^s$	$+08^\circ52''06'$		ALPHA AQL	S1	0.2	SCHLEUSSNER	08-09
205	01 12 1888	$20^h22^m14^s$	$+40^\circ15''24'$	01^h37^m	GAMMA CYG	S1	30	BEERNAERT	09-10
206	04 12 1888	$03^h47^m29^s$	$+24^\circ06''18'$	03^h14^m	PLEIADES	S4	30		09-10
207	04 12 1888	$05^h35^m31^s$	$-05^\circ16''12'$		ORION NEB	F			09-10
208	05 12 1888	$18^h36^m56^s$	$+38^\circ47''01'$		ALPHA LYR	S1	10		09-10
209	05 12 1888	$03^h47^m29^s$	$+24^\circ06''18'$		PLEIADES	S4			10-13
210	06 12 1888	$20^h22^m14^s$	$+40^\circ15''24'$	00^h05^m	GAMMA CYG	S1	30	ORTHOCHROM	09-10
211	09 01 1889	$05^h35^m31^s$	$-05^\circ16''12'$	01^h38^m	ORION NEB	F	60	ORTHOCHROM	09-10
212	10 01 1889							ORTHOCHROM	09-10
213	10 01 1889	$05^h35^m31^s$	$-05^\circ16''12'$	01^h47^m	ORION NEB	F	60	ORTHOCHROM	09-12
214	13 01 1889	$05^h35^m31^s$	$-05^\circ16''12'$	01^h35^m	ORION NEB	F	60	ORTHOCHROM	09-12
215	24 01 1889	$05^h35^m31^s$	$-05^\circ16''12'$	23^h22^m	ORION NEB	F	30	ORTHOCHROM	09-12
216	02 02 1889	$05^h35^m31^s$	$-05^\circ16''12'$		ORION NEB	F		ORTHOCHROM	09-12
217	03 02 1889	$05^h35^m31^s$	$-05^\circ16''12'$	23^h22^m	ORION NEB	F	12	ORTHOCHROM	09-12

3. The Archive

The existing archive includes 67 plates obtained in the period March 1885 - February 1889 (Table 2). The distribution of the number of plates over the time is shown in Fig. 1. The plates have original serial numbers starting with 149 up to 217. Among these numbers two plates are missing - No. 167 (in the field of Andromeda nebula) by unknown reason and No. 198 (in the field of Cancer) with a note on the envelope that the plate was missing already in 1915.

A computer readable version of the plate catalogue was prepared from the very accurate logbook of Lohse. It was converted to the accepted format of the WFPDB using the software package REDUCT. The analysis of the

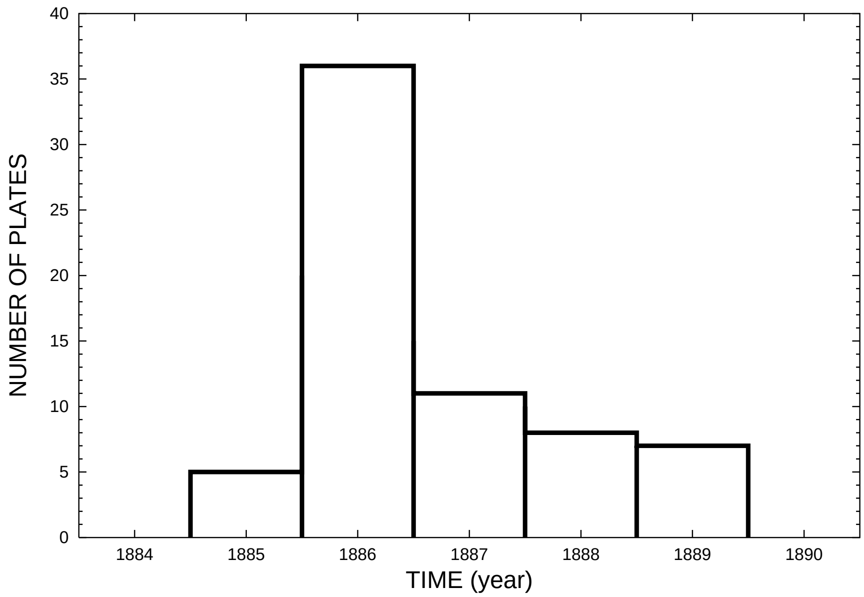

Fig. 1: Distribution of the number of plates versus the time of observation

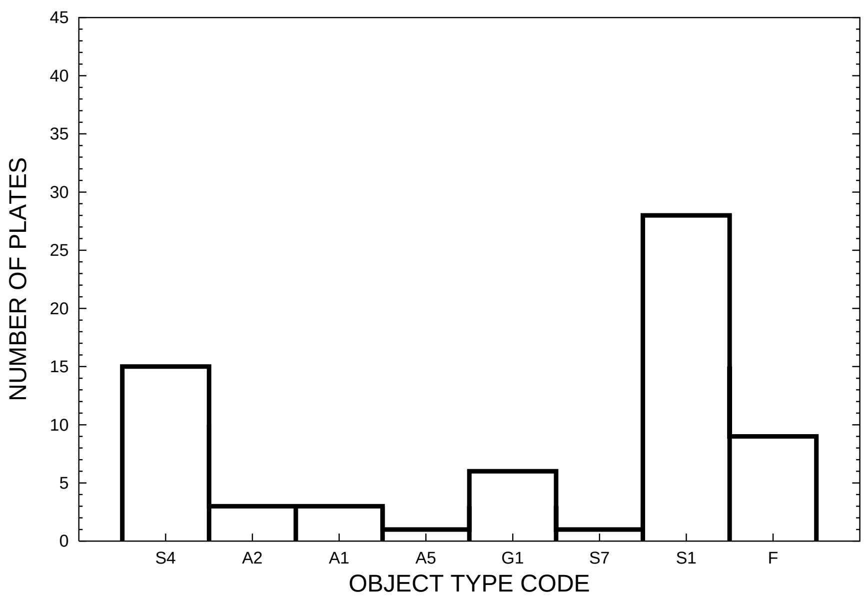

Fig. 2: Distribution of the number of plates versus object type code

archive is made on the ground of this form of the catalogue.

According to the notes of Lohse, it is possible to divide the observations in two groups: technical experiments and scientific observations. The technical experiments include mainly works on photographic processes (application of different kinds of emulsions, the advantages of gelatin as a carrier of silver salts - silver-bromine and sometimes experimental silver-iodine, and testing of developers and fixings, sometimes self prepared). Testing of new instruments (photographic camera, plate holder, new objective), focus plates and tests of new methods of observations have to be considered here, too. The scientific observations were made according to the following programmes:

- observations of the surfaces of the giant planets (Jupiter and Saturn),
- observations of stellar clusters (Pleiades, Orion, h and χ Persei, etc.), aiming their classification (Lohse 1886),
- observations of stars in order to determine their parallaxes and their magnitudes,
- observations of double stars,
- observations of nebulous objects (Maia nebula, Andromeda nebula, etc.).

The distribution of the number of plates versus object type code used in the WFPDB is given in Fig. 2. According to the appropriate codes in the WFPDB, A1 is used for planets, A2 - moon, A5 - comets, S1 - stars, S4 - star clusters, S7 - planetary nebulae, G1 - galaxies and F - for fields observed. In addition, the number of observations of certain objects is given in Table 3. The names of the objects according to Lohse's logbook, which are from Sir John Herschel's General Catalogue of Nebulae and Clusters of Stars, and their cross-identifications with Messier numbers taken from the New General Catalogue (Dreyer 1888) are given.

Table 3: Observations of certain objects in Lohse's archive

Name	Period of observations			Number of plates
Moon	Nov. 1885	-	Nov. 1888	3
Jupiter	May 1886	-	May 1886	3
Alpha Aql	Sept. 1886	-	Nov. 1888	5
Gamma Cas	Oct. 1886	-	Oct. 1886	5
Alpha Ori	Febr. 1887	-	March 1887	3
Alpha Cas	Oct. 1886	-	Oct. 1886	2
Alpha Peg	Dec. 1887	-	Dec. 1887	2
Delta Peg	Dec. 1887	-	Dec. 1887	2
Gamma Cyg	Dec. 1888	-	Dec. 1888	2
Gamma Aql	Oct. 1886	-	Oct. 1886	2
Orion Nebula (M 42/43)	Dec. 1888	-	Febr. 1889	7
Pleiades (M 45)	Dec. 1885	-	Dec. 1888	5
h and chi Persei	March 1885	-	Sept. 1886	2
Gen. Cat. 1295 (M 37)	Apr. 1886	-	Apr. 1886	2
Gen. Cat. 4230 (M 13)	May 1886	-	May 1886	3
Gen. Cat. 4294 (M 92)	Sept. 1886			1
Gen. Cat. 3636 (M 3)	Apr. 1885			1
Gen. Cat. 4437 (M 11)	Oct. 1886			1
Andromeda Neb. (M 31)	Nov. 1885	-	Nov. 1888	6

Lohse used mainly exposures with duration 30, 60 and 120 minutes as one can see from Fig. 3, where the distribution of the number of plates by duration of the exposure is given.

Having in mind the passing of 114 years since the beginning of Lohse's observations and the survival of two world wars, the archive is found to be in relatively good condition. There are 5 plates (Nos. 155, 182, 190, 194 and 203), which emulsions are completely detached from the glass or have begun to detach. Some of the plates have yellow spots with different sizes (Nos. 173, 174, 175, 179, 193, 206) up to the full lack of images (Nos. 156, 157, 166). It is known that the aging of the plates influences the image silver and as a result an appearence of golden spots and destruction of the image information take place. The experiments of Budell (1998) with aging simulation show that the plates with emulsions susceptible to yellow spots have not any spots when they are fixed and rinsed unusual long time. Lohse (1889), having big interest to photography and thinking about the storage of the plates, recommended a rinsing of the plates several hours in the shower bath, which obviously contributed to the relatively good state of the archive.

Table 4: List of the digitized Lohse's plates

LS. No.	Object	Coordinates R.A. — D.(2000.0)	Date	Exp. (min)	Lim. mag(pg)	Scan size(mm)	Scan vol.(MB)
152	Moon	————	17.11.1885	0.1	-	60/60	72
154	Pleiades	$03^h45^m49^s$ $+24°22'12''$	18.03.1886	12.0	11:	114/92	210
162	M13	$16^h41^m41^s$ $+36°27'37''$	20.05.1886	60.0	12:	117/92	215
168	M31	$00^h42^m46^s$ $+41°16'18''$	28.08.1886	120.0	12.5	111/91	202
171	h&chi Per	$02^h20^m00^s$ $+57°08'00''$	01.09.1886	120.0	13.5	88/111	194
206	Pleiades	$03^h47^m24^s$ $+24°06'18''$	04.12.1888	30.0	12.5	78/85	133
210	Gamma Cyg	$20^h22^m14^s$ $+40°15'24''$	06.12.1888	30.0	12.5	95/83	158
211	Orion-M42	$05^h35^m31^s$ $-05°16'12''$	09.01.1889	60.0	13.5	97/85	165
213	Orion-M42	$05^h35^m31^s$ $-05°16'12''$	10.01.1889	60.0	13.5	88/120	211
215	Orion-M42	$05^h35^m31^s$ $-05°16'12''$	24.01.1889	30.0	12.0	114/82	187

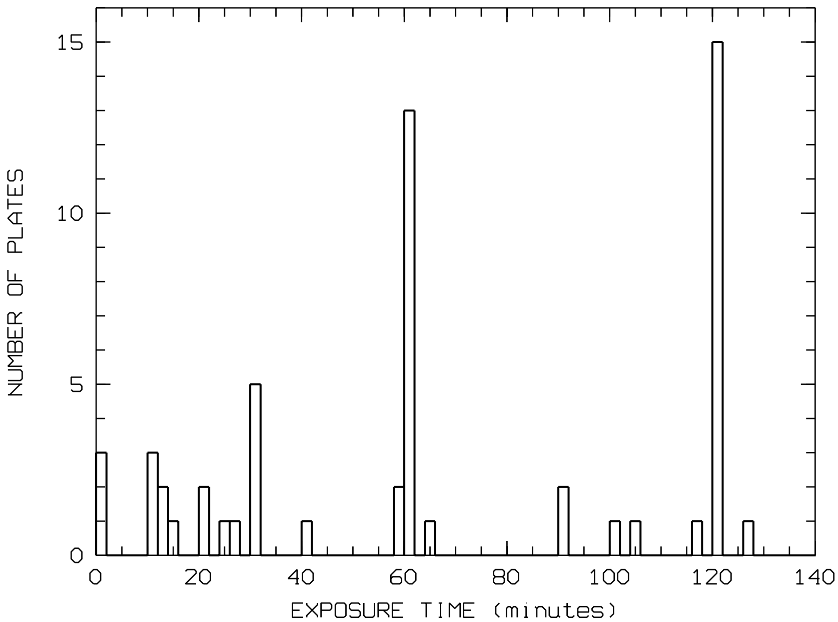

Fig. 3: Distribution of the number of plates by duration of the exposure

4. Plate Digitalization

10 of Lohse's plates have been chosen for digitalization with the PDS 2020 GM^+ microdensitometer of Münster University in July 1998. The standard square diaphragm of 10 microns and a step size of 10 microns was used. Table 4 summarizes the scanning parameters and results.

The measurements of 12 stars in B light from the photometric sequence of Andrews (1970) in Orion nebula (M42) show an average photographic photometry deviation of $\sigma = \pm 0.13^m$ (Fig. 4). In Fig. 4. and Fig. 5. the pictures of the stellar cluster h Persei (NGC 884) and Orion nebula (M42/M43) processed from the original Lohse's plate scans (LS 171, LS 213) with MIDAS are shown.

5. Conclusions

Lohse's historic plate archive will be very soon incorporated into the WFPDB, which is on-line accessible at http://vizier.u-strasbg.fr/cats/VI.htx - catalogue number VI/90. Lohse's archive shows not only the development of astronomy as a science, but also the progress of the application of photography for astronomical purposes. In this respect the time influence on such old astrophotographic plates certainly is of interest for other newer plate collections. This is a very important task as the wide-field plate collections up to now are most valuable data sources for optical sky surveys taken in this century. The plate examination leads to the definitive conclusion for urgent scanning of the archive in order to save the information from the plates and make it accessible for the astronomical community.

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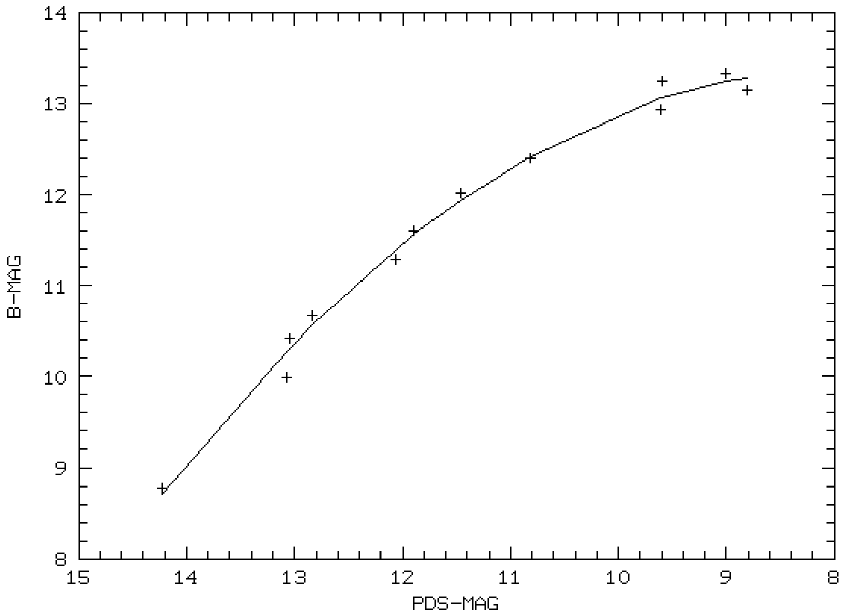

Fig. 4: Polynomical regression for B-photoelectric sequence of Andrews in Orion (M42/M43) field vs. PDS measurements of Lohse's plate LS 213, plotted using MIDAS

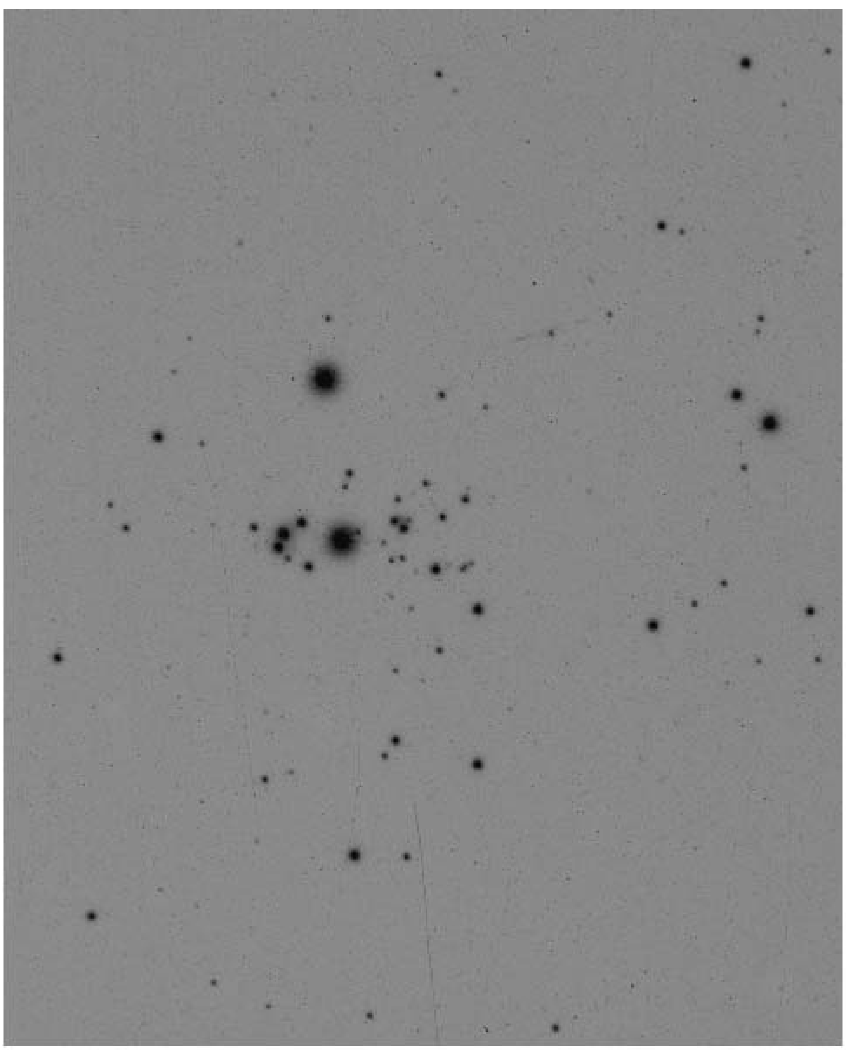

Fig. 5: h Persei cluster field plotted from the original Lohse's plate LS 171 taken with the Grosser Refractor. (Nord is on the top, West is on the left; the scale is $9''/mm$)

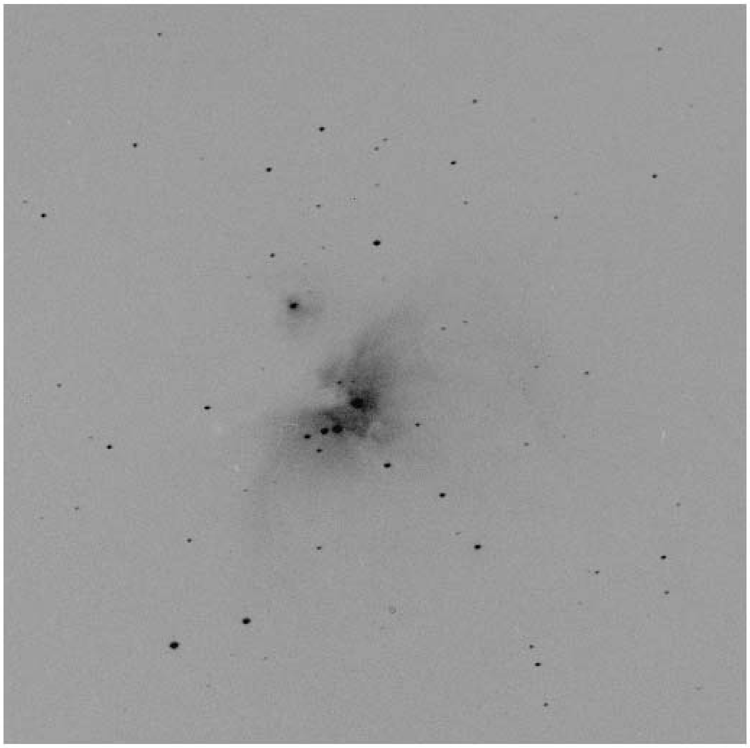

Fig. 6: Orion M42/M43 field plotted from the original Lohse's plate LS 213 taken with the second heliographic objective. (Nord is on the top, West is on the left; the scale is $34''/mm$)

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