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PHOTOELECTRIC MEASUREMENTS OF OB STARS

FOTOELEKTRICKÁ MĚŘENÍ OB HVĚZD

ФОТОЕЛЕКТРИЧЕСКИЕ ИЗМЕРЕНИЯ ОВ-ЗВЕЗД

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1. INTRODUCTION

Photoeletric photometry has proved to be one of the most effective methods in research into the Galaxy structure. In order that this Institute could also actively participate in such research, it was decided several years ago to build a mirror telescope 65 cm in diameter (26″) with a photoelectric photometer. In 1962 the first large series of observations of OB stars was obtained with this instrument. Several groups of stars were particularly studied, chosen from the lists of the Hamburg observatory (Hardorp et al. 1959, Stock et al. 1960). Because the colour system of the equipment in 1962 was quite different from today's (at that time the primary mirror was silvered and the colour filters were also different; now the system is very similar to the standard UBV system), we are publishing these observations independently, despite the fact that in many places they require supplementing — new observations are added in only a few cases.

The present paper contains a description of the instrument, the method of reduction and the results of observations.

2. TELESCOPE

The telescope is intended exclusively for photoelectric observations and is therefore only of the Cassegrain type. The primary mirror is parabolic, 65 cm in diameter and with a light gathering power of 1 : 3.6; the resultant focal length of the system is 11.3 m (light gathering power 1 : 17.5). These dimensions were dictated by the parallactic mounting and dome available for the construction and location of the telescope. The parallactic mounting is from the firm Carl Zeiss, Jena size VII (intended particularly for refractors and thus for the short tube of the reflector has superfluously high column), the dome is the so-called central dome of Ondřejov observatory of the Czechoslovak Academy of Sciences, only 450 cm in diameter. The optical work was done by Mr. V. Gajdušek. The telescope tube, of very light construction, was made in the Institute workshop in cooperation with the Ondřejov observatory. The end of the eyepiece, rotatable in the position angle, is easily accessible and although the telescope is operated only manually it is easily controlled. It is thus suitable for photoelectric work and its good properties led inter alia to the fact that the Ondřejov observatory is building another telescope of practically the same design.

3. PHOTOMETER

The photoelectric photometer is of normal construction. In the optical path is first a tipping mirror which passes the light to the field eyepiece with a cross-wire. This is followed by several diaphragms of different diameter, placed on a rotating drum, then a movable prism for checking the position of the star in the diaphragm, a drum with filters (coaxial with drum of diaphragms), a quartz Fabry lens and finally a photo-multiplier in a holder, the position of which can be adjusted so that the light falls on the most sensitive part of the photo-cathode. One position of the drum is used as the shutter — when in use the light is unable to reach the photo-multiplier. A contact, connected only in this position of the drum of the filters, permits illumination of the diaphragm and cross-wire. Instead of another filter there is a disc with radiactive colour for checking the sensitivity. The photometer is connected by two coaxial cables (for input of high voltage and output of signal from anode) to the room below the dome where the electronic equipment is located. A telephone is installed between this room and the dome.

4. ELECTRONIC EQUIPMENT

The electronic equipment of the photometer consists of a stabilized high-voltage source for charging the photo-multiplier, the recording instrument of type EZ 2 and the resistance divider for change in sensitivity with calibration equipment.

During almost the whole period in question a high-voltage source made at the Ondřejov observatory was used. It works on the principle described by O'Toole (1959; also Svoboda 1961). A divider is connected to its output, permitting voltage to be taken in degrees of 150 V to a max. value of 1750 V. Measurement of the source stability showed that short-period stability is satisfactory (better than 0.05 %). It would not be possible to measure with long-term stability because the available high-ohmic resistances necessary for measuring the stability are themselves not stable enough. It is suspected, however, that the differences in voltage at the beginning and end of the night reach several tenths of a percent.

This year a source of the type NBZ 411, made by the Mikrotechna firm, is used for charging the photo-multiplier.

All the measurements described here were made with one photo-multiplier of the type EMI 6094 B, and with the exception of the first two observational nights a charging voltage of 1750 V was used. This voltage does not yet exceed the maximum allowable voltage for the photo-multiplier used but it is already outside the range of voltages for the best signal-to-noise ratio. Due to the small dark current of the photo-multiplier, however, this circumstance did not matter in the measurements — the dark current was equivalent to roughly 16^m (visual). The photo-multiplier was not cooled.

During the development of the photometer various amplifiers were used to amplify the anode current of the photo-multiplier. However, on account of the lack of suitable parts, it was not possible to build a d. c. amplifier which would be stable and reliable enough at the required sensitivity. Two types of amplifier (two-stage symmetrical and three-stage asymmetrical as integration amplifier) proved the best and work is going on to perfect them. The recording instrument of the type EZ 2 made by the firm Laboratorní přístroje is so sensitive that it permits even such weak stars as 13^m to be measured with the equipment described so far (in visual and blue regions).

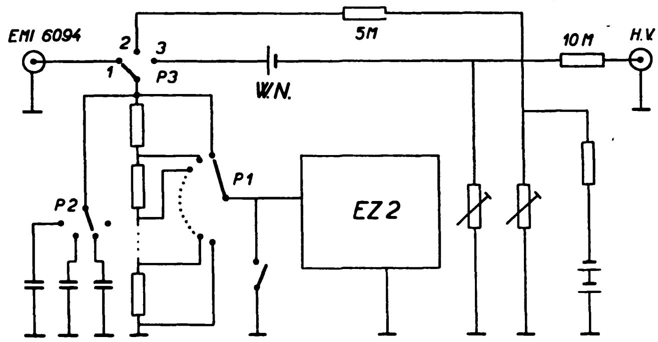

Fig. 2. Connection of measuring equipment.

Instruments of the type EZ are recording potentiometers for recording on paper 28 cm wide with an accuracy and linearity better than 0.2 %, with a sensitivity of up to 100 μ V at full deflection and with an allowable input resistance of up to 2 MΩ. The current sensitivity at full deflection may thus be up to 5×10^{-11} A. But at these extreme values the instrument exhibited considerable instability and the measurements were therefore really carried out at a sensitivity set to 0.5 mV at full deflection and with maximum load resistance of not quite 2×10^5 Ω. This year an input resistance of 2 MΩ was used for the first time.

In order to be able to measure stars the brightness of which differs by several magnitudes the load resistance must of course be variable in a ratio of at least 1 : 1000. The ratio between the different degrees should then be 1 : 1.5 to 1 : 2, so that it is always possible — with the exception of the weakest stars — to measure in the second half of the instrument scale, thereby making full use of its exactness. Due to the requirement that the time constant of the record be easily variable the load resistance is arranged in the form of a series divider (see Fig. 2), and the sensitivity is varied by a switch *P*1. The time constant is varied by switching the condensers (switch *P*2); the condenser may also be switched off and then the recording is influenced only by the rate at which the pen moves. Values giving RC = 1^{sec} are usually used in measuring stars.

Due to the uncertainty in the linearity of the relation between the load resistance and the deflection of the recording instrument, and also due to the possible instability of the resistances used, the sensitivity of the equipment at different degrees of the divider must be occasionally measured. Of course, only the mutual ratios of the sensitivities need be known in order to reduce the observations. The circuit used for measuring the ratios is also drawn in Fig. 1 (switch $P3$ in position 2). The equipment also contains a circuit for measuring the high voltage by the compensation method ($P3$ in position 3). There is also a press-button by which the input of the recording instrument can be short-circuited and thus a time mark made in the record.

When measuring very bright stars, when it is no longer enough to lower the sensitivity by the divider, the recording instrument can be switched to a lower sensitivity — it has ranges of 100 μV, 200 μV, 500 μV, 1 mV, 2 mV and 5 mV built in. However, switching over takes a few minutes.

5. EXTINCTION AND COLOUR SYSTEM

When the equipment is suitable atmospheric extinction represents a fundamental limitation to the accuracy of the photoelectric measurements, at least as regards measurements of the kind dealt with here — measurement of not very weak stars in broad spectral ranges.

Primarily, of course, there are changes in atmospheric extinction which lower the accuracy attainable. Since also the colour system in which measurements are performed is not quite stable (the system changes, for example, due to contamination of the filters, ageing of the mirror surfaces, a change in temperature of the photo-cathode etc.), the calculation of the influence of extinction is usually combined with conversion to a constant colour system.

The observations given here were made at relatively small zenith distances ($z < 50°$). In such a case, as is known, the extinction is proportional to the air mass μ and $\mu = \sec z$. The extinction is of course different in different spectral ranges and if the spectral ranges are wide it may also depend on the colour of the star. In practical work, of course, this dependence is usually considered only for the colour index B—V.

When making the reductions it is customary, as with the stellar magnitude, to treat only measurements in the spectral region near to the visual and to convert other measurements to colour indices. Let us introduce the notation

$\mathrm{v_{obs}}$	observed visual magnitude
$\mathrm{(b—v)_{obs}}$, $\mathrm{(u—b)_{obs}}$	observed blue and ultra-violet colour index
v	visual magnitude in instrumental system
b—v, u—b	colour indices in instrumental system
V, B—V, U—B	the same quantities in the standard system
k_i	quantities characterizing extinction
A_i	quantities characterizing relations of colour systems

Then

$$\mathrm{b—v} = \mathrm{(b—v)_{obs}} - [k_1 + k_2\,\mathrm{(b—v)}]\mu,$$

$$\mathrm{B—V} = A_1 + A_2\,\mathrm{(b—v)},$$

$$\mathrm{v} = \mathrm{v_{obs}} - k_3\mu,$$

$$\mathrm{V} = \mathrm{v} + A_3 + A_4\,\mathrm{(B—V)},$$

$$\mathrm{u—b} = \mathrm{(u—b)_{obs}} - k_5\mu,$$

$$\mathrm{U—B} = A_5 + A_6\,\mathrm{(u—b)}.$$

By eliminating the quantities of the instrumental system one obtains equations analogous to these given e. g. by Mitchell (1960); his notation has been partly taken over here.

Since measurements in the UBV system are known for a number of the stars measured by us, we choose this system as standard. The deviations of the instrumental system used in 1962 from the UBV system are large however. In the first place, the primary mirror was silvered; only the secondary mirror was aluminium-coated. Moreover, the thicknesses of the filters were different to those recommended by Johnson (1955); the following filters were used:

v Schott 1 mm GG 11
b Schott 1 mm BG 12 + 1 mm GG 13
u Schott 1 mm UG 2.

Despite these differences the above linear equations for converting v and b—v to V and B—V are undoubtedly quite justified. Since only stars from a narrow range of spectral types were measured, the linear equation for converting u—b to U—B is sufficient, as will be shown later.

In contrast to calculation of the extinction made in reducing the observations at the observatories with a good astronomical climate, in central Europe one must assume quite large changes in the extinction during one night since there are very few nights when the extinction is constant (and small) and there is nothing for it but to treat measurements from worse nights as well. The constants k_i and A_i were therefore calculated for several intervals shorter than 3 hours, in which several observations of stars with known UBV data were made. On account of the large number of unknowns and the small number of observations, however, the results are quite unsatisfactory. One can only deduce from them that for our observations $k_2 = 0$ is suitable, obviously because the B—V range of the stars observed only in exceptional cases exceeds 1^m; moreover, the quantities A_1, A_3 and A_5 vary by more than 0.1.

Reduction of the observations therefore had to be made in an unusual way. Use was made of the fact that always stars were observed in groups, in regions of at least 2° in diameter. Extinction, which must be regarded as a function of two variables, the zenith distance and the time, is in such a case a function of only one variable, e. g. the time. Differential extinction, caused by the different positions of the stars, was considered. Here, of course, it was enough to consider the average values of the extinction coefficients (the night coefficients were calculated for several nights with enough observations; they differed from the given averages by up to 50%):

$$k_1 = 0.17, \quad k_3 = 0.30, \quad k_5 = 0.30.$$

At 50% deviations from these values the errors caused by differential extinction in our observations would not exceed 0.006^m for b—v and 0.010^m for v and u—b. Since stars with known UBV data were quite often observed in all the observed groups, the curve of the extinction between these observed values could be interpolated.

The measurements were always performed for a diaphragm diameter in the photometer equal to 35″.

6. OBSERVATIONS

This paper gives the observations from three regions around the open star clusters NGC 663, NGC 1893 and Stock 8, and NGC 6823. The stars observed more frequently in these regions and their measurements in the UBV system known from the work of Hiltner (1956) and Hoag et al. (1961), are given in Tab. 1. The coefficients in the equations for conversion from the instrumental

Table 1. Standard Stars

HD, HDE or BD Number	Hiltner's or Hoag's Number	v	b—v	u—b	UBV Values V	B—V	U—B	Our Values V	B—V	U—B
				Field NGC 663						
+60°311	155	10.017	0.335	1.534	9.96	0.28	—.48	9.99	0.284	—.44
+60°322	161	9.734	0.549	1.607	9.73	0.54	—.33	9.67	0.546	—.35
10 756	171	7.578	0.467	1.653	7.54	0.44	—.27	7.53	0.445	—.30
+61°315	654—2	9.618	0.822	2.205	9.45	0.90	+.35	9.50	0.881	+.36
				Field NGC 1893 and Stock 8						
35 619	451	8.572	0.274	1.298	8.60	0.23	—.69	8.58	0.232	—.68
35 633	452	8.061	0.347	1.312	8.04	0.32	—.66	8.06	0.321	—.66
+33°1028*)	1893—2	9.253	1.075	2.838	9.15	1.21	+.95	9.11	1.213	
243 018	1893—7	10.720	0.320	1.333	10.70	0.30	—.62	10.72	0.288	—.63
				Field NGC 6823						
+23°3745	815	8.797	0.667	1.601	8.73	0.66	—.38	8.76	0.665	—.36
186 746	822	7.116	0.885	1.929	7.03	0.93	+.05	7.04	0.932	+.02
+22°3200	826	9.590	0.396	1.457	9.61	0.33	—.52	9.60	0.333	—.53
+24°3866	825	9.671	1.079	1.946	9.57	1.18	+.02	9.55	1.169	+.05

*) Not early type.

to the standard system were determined from observations of these stars and some others, the observations of which will be published later:

$$A_2 = 1.225, \quad A_4 = -0.150, \quad A_6 = 1.195.$$

Since not enough observations were made in order to join up the different regions, the corrections of zero points (the quantities A_1, A_3 and A_5) were determined for each region separately. The observations of these stars were also used to determine the errors of one measurement (the procedure in each measurement was v—b—u of star, v—b—u of sky, v—b—u of star; as a rule each deflection lasted 20 sec):

$$v: \pm 0.013, \quad b-v: \pm 0.012, \quad u-b: \pm 0.015.$$

As a rule each star was measured on two nights.

After conversion to the standard system, probably both for a small number of standard stars and for the difference in the instrumental and standard systems, the errors of the resulting data are much larger:

$$V: 0.025, \quad B-V: 0.010, \quad U-B: 0.025.$$

The tables of the results of measurements in each region give the results converted to the UBV system as well as the data in the instrumental system in the u—b region since here the conversion is least exact and sometimes even impossible. The values denoted by a colon have lower accuracy. The tables also give the actual colours of the stars, calculated using the chart in Johnson's paper (1958), the interstellar absorption (three times the colour excess) and the visual magnitude corrected for absorption.

7. NEIGHBOURHOOD OF NGC 663

The cluster NGC 663 ($\alpha_{1950} = 01^h42.6^m$, $\delta_{1950} = +61°00'$, $l'' = 129.5°$, $b'' =$ $= -1.0°$) has been studied several times. The spectral types of several of its members are given by Hiltner (1956): B8 Iab, B5 Iab, B6 Iab, B2 II. Photoelectric and photographic measurements are found in the paper by Hoag et al. (1961); the distance of the cluster according to Johnson et al. (1961) is 2300 ps. The Gonzáleses (1953) found in its neighbourhood a series of stars with emission lines. According to Hardorp et al. (1959) there is also a not very pronounced densification of the OB stars in the neighbourhood. There are several other

Table 2. NGC 663

BD Number	LS Number	V	B—V	u—b	U—B	$(B—V)_0$	A_V	V_0
	60—171	11.48	+.33	1.54	—.43	—.23	1.68	9.80
	60—173	10.92	.33	1.572	.40	.21	1.62	9.30
	60—174	11.19	.40	1.504	.48	.26	1.98	9.21
	60—175	11.04	.29:	1.477	.51	.24	1.59	9.45
	60—176	10.69	.48	1.58:				
	60—177[1])	10.66	.50	1.662	.29	.22	2.16	8.50
	60—178[1])	10.50	.54	1.57	.40	.27	2.43	8.07
+60°322	60—180[2])	9.81	.51	1.60	.37	.25	2.28	7.53
	60—181	11.53:	.39	1.63	.33	.21	1.80	9.73
+60°326	60—182	9.81	.49	1.63	.32	.22	2.13	7.68
+60°344	60—185[3])	10.09	.58	1.74	.20	.21	2.37	7.72
	60—190	11.26	.36	1.68	.27	.18	1.62	9.64
	60—193[3])	11.53	.58	1.80:				
	60—194	11.55	.33	1.64	.31	.19	1.56	9.99
+59°334	60—195	10.36	.22	1.38	.62	.26	1.44	8.92
+60°365	60—196[4])	10.21	.71	2.024	+.14	.13	2.52	7.69
+60°307	61—212	10.56	.54	1.605	—.36	.25	2.37	8.19
+61°310	61—213	9.23	.64	1.746	.19	.22	2.58	6.65
	61—217	10.91	.71	1.788	.14	.22	2.79	8.12
	61—218	11.49	.75	1.766	.16	.24	2.97	8.52
	61—219	11.49	.64	1.675	.27	.25	2.67	8.82
	61—222[5])	10.64	.82	1.879	.03	.21	3.09	7.55
	61—224	11.19	.55	1.671	.28	.23	2.34	8.85
	61—225	12.18	.56					
	61—226	12.33	.73					
	61—228[3])	10.01	.45	1.44	.56	.30	2.25	7.76
+60°337	61—231	9.90	.86	2.47				
	61—235[2])	11.34	.88	1.64:				
	61—237[2])	10.83	.51	1.72	.22	.20	2.13	8.70
	61—238	10.84	.57	1.72	.22	.21	2.34	8.50
	61—240	11.09	.54	1.49:				
	61—242	11.50	.41	1.68:				

[1]) Members of NGC 659
[2]) About 10′from the centre of NGC 663
[3]) Members of NGC 663
[4]) Member of Berkeley 6
[5]) Member of NGC 654

star clusters in the sky in the neighbourhood of the cluster: NGC 654 at a distance of 1550 ps (Johnson et al.), NGC 659 and Berkeley 6. In all these clusters, lying in a circle 1.5° in diameter, there are OB stars according to Hardorp et al.

In the given region, denoted as the association of Cas VIII in the catalogue of Alter et al. (1958), Hiltner's catalogue gives the data for six other stars. The dispersion of their distance moduli is large, $11^m.0$ to $12^m.9$; the earliest star is of the type B0 II (+60°345). In some respects the NGC 663 and its surroundings thus recalls the association χ and h Perseus. A more detailed study of the stars of this region should show if the similarity goes further and if we are indeed justified in calling the region NGC 663 an association.

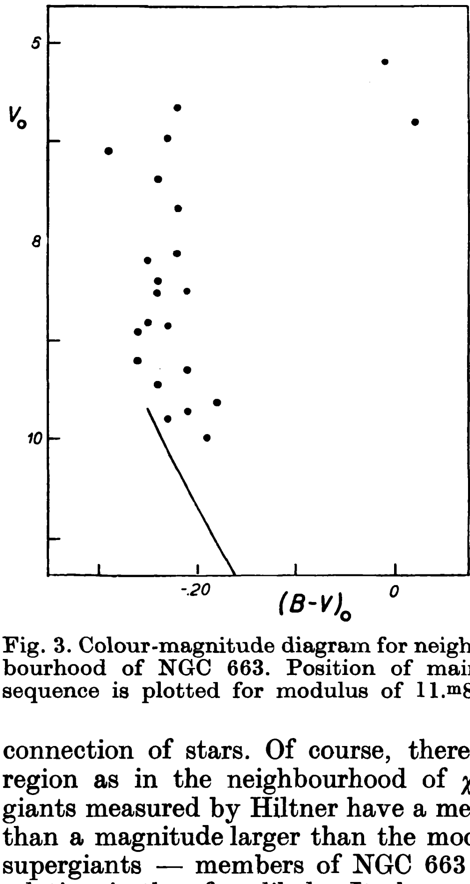

Fig. 3. Colour-magnitude diagram for neighbourhood of NGC 663. Position of main sequence is plotted for modulus of $11.^m8$.

The results of our observations are given in Tab. 2. The UBV observations themselves cannot of course solve the problem with final validity. It is obvious from the observations that there are probably no earlier types such as B1 in the region (only one star, 61—228, has $(B—V)_0$ —0.30 but it is a member of NGC 663). The colour-magnitude diagram for this region is given in Fig. 3. Apart from the stars-non-members of the clusters in Tab. 2, the stars from the surroundings of NGC 663 measured by Hiltner are also drawn here. The faintest stars, apart from two supergiants, are the reddest, which speaks for the spatial connection of stars. Of course, there are not so many supergiants in the region as in the neighbourhood of χ and h Per, and, moreover, the supergiants measured by Hiltner have a mean distance modulus of $12^m.9$, i. e. more than a magnitude larger than the modulus given for NGC 663. However, the supergiants — members of NGC 663 — have modulus $12^m.7$, and an interrelation is therefore likely. It thus seems that in the neighbourhood of the investigated cluster there indeed exists an association, similarly as χ and h Per, of a relatively late type, and quite poor compared with χ and h Per.

The catalogue of Hardorp et al. (1959) gives B6 Ib as the type for the star BD + 60°365, member of the star cluster Berkeley 6. If this classification were correct, the distance modulus of this star would be $13^m.5$. However, Pesch showed (1963) that in many cases the absolute magnitude of the stars is lower than would correspond to the classification in catalogues of Luminous Stars. Probably the star +60°365 is such a case.

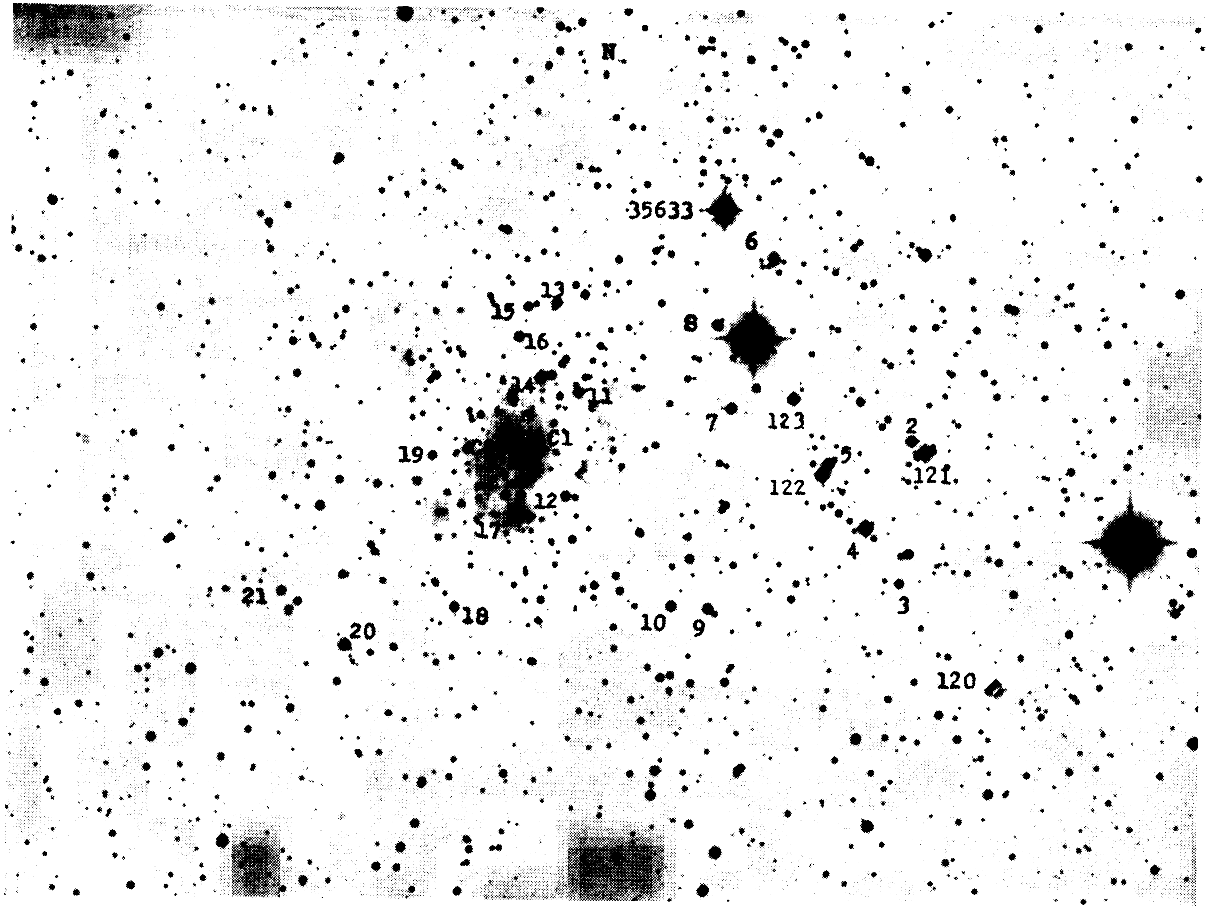

Fig. 4: Map of star cluster Stock 8. Bright star near centre is φ Aur.

Table 3. NGC 1893 and Stock 8

HD, HDE or BD Number	Other Name	V	B—V	u—b	U—B	$(B—V)_0$	A_V	V_0
243 035	T 117	10.90	+.29	1.377	—.58	—.26	1.65	9.25
243 070		10.84	.31	1.358	.60	.28	1.77	9.07
+34°1043	T 120	9.43	.16	1.284	.69	.27	1.29	8.14
	1	10.91	.30	1.456	.49	.24	1.60	9.31
+34°1045	T 121[1])	9.77	.16	1.282	.69	.27	1.29	8.48
	2	11.46	.21	1.416	.54	.23	1.32	10.14
	3	12.16	.24	1.56	.36	.18	1.26	10.90
	4	10.06	.25	1.404	.55	.24	1.48	8.58
	5	10.94	.54	1.69	.21	.20	2.24	8.70
	T 122	10.01	.67	1.597	.32	.28	2.84	7.17
	T 123	10.70	.94	1.809	.07	.26	3.58	7.12
+34°1047	6	9.57	1.54	3.66:				
	7	11.85	.28	2.20:				
	8	11.71	.74	2.18:				
	9	11.24	.40	1.524	.41	.24	1.90	9.34
	10	11.16	.65	2.06:				
	11	11.44	.21	1.91				
	12	11.74	.32	1.57	.35	.20	1.54	10.20
	13	11.66	.33	1.520	.41	.22	1.65	10.01
+34°1053	14	10.92	.27	1.365	.27	.26	1.60	9.32
	15	12.57	.27	1.58	.34	.18	1.34	11.23
+34°1054	C 1[2])	8.96	.18	1.318	.65	.26	1.32	7.64
	C 2[3])	10.95	.18	1.34	.63	.25	1.30	9,65
	16	11.89	.28	1.52	.41	.20	1.44	10.45
+34°1056	17	9.87	.19	1.292	.68	.28	1.40	8.47
	18	11.89	.25	1.958				
	19	12.22	.43	1.64	.27	.20	1.88	10.34
	20	10.68	.20	1.838	.03			
	21	12.27	.39	1.52	.41	.23	1.86	10.41
35 652		8.4	.23	1.299	.67	.28	1.53	6.9

[1]) BDS 2722 A [2]) ADS 4053 ABCD [3]) ADS 4053 E

8. NGC 1893 AND STOCK 8

NGC 1893 (α_{1950} = 05^{h}19.4^m, δ_{1950} = +33°21′, l'' = 173.6°, b'' = —1.7°) is a well-known star cluster of the type 0, surrounded by an emission nebula IC 410. The cluster contains the multiple system ADS 3943 (BD + 33°1026), studied by Sharpless (1954). Hiltner (1956) gives the spectral types of four stars in this cluster (O5, O6, O8 and B1 IV?), in HDE there are the spectra of another two members (B3, B). The photoelectric and photographic photometry of the cluster is to be found in a paper by Hoag et al. (1961). Johnson et al. (1961) give for the cluster a distance of 4000 ps, linear diameter 35 ps and compare it with association in Orion. A pronounced effect in the cluster is the existence of many star chains, often following the structure of the nebula.

No detailed data are given in the liretarure for the cluster Stock 8 (α_{1950} = = 05^{h}24.3^m, δ_{1950} = +34°23', l'' = 173.3°, b'' = —0.3°). It is submerged in the emission nebula IC 417 (Cederblad (1946) states that the source of radiation of this nebula is an anonymous star cluster). It contains the multiple system ADS 4053 (BD + 34°1054):

A — 8.5^{m}, B — 10.0^{m}, C — 14.1^{m}, D — 13.8^{m}, E — 10.2^{m}, F — 11.5^{m},

AB — 1″.0, AC — 3″.8, AD — 12″.0, AE — 18″.3, AF — 27″.8

(after ADS). Not far away is the star HD 35 633, for which Hiltner (1956) gives the type B0.5 IV and distance 1200 ps. In the immediate neighbourhood there are four more stars of high luminosity found by the Gonzáleses (1955). Due to these properties Stock 8 is therefore probably a cluster of the type O. It is not quite 1.5° from the cluster NGC 1893 and in their structure and dimensions the two clusters are quite similar. In the broader neighbourhood of both clusters there are several more early stars with moduli of at least 12^{m} (35 619: O7, modulus 12^{m}.0; +33°1056: B0 III, modulus 13^{m}.4; +34°1059: B0IV—V, modulus 12^{m}.2, all according to Hiltner (1956)). Schmidt (1958) gives the association Aur II in the position $l'' = 173°$ to $175°$, $b'' = -2°$ to $+2°$.

The results of the observations in this region are given in Tab. 3. The first two stars are members of NGC 1893, and in the map in the paper by Hoag et al. (1961) they have the coordinates (here the spectrum after Wilson (1952) is also given):

	X	Y	Sp
HDE 243 035	+16.6	+16.1	B0
HDE 243 070	+21.7	+16.3	B2

The last star in the table, HD 35 652, is 20′ from the cluster Stock 8 and although obviously of the early type has not yet been observed*). The other stars are in the region of the cluster Stock 8, and are identified on the enlargment of the Palomar atlas in Fig. 4. The stars for which $E_{(B-V)}$ is not given

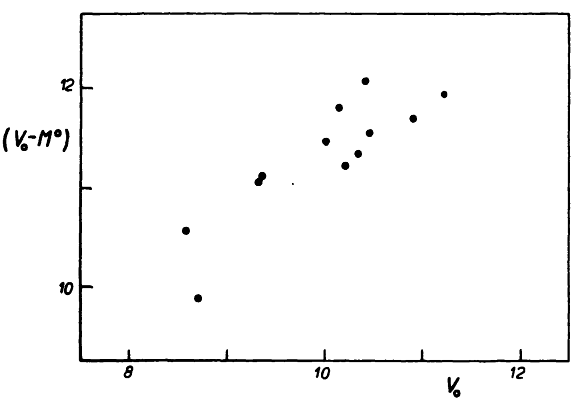

Fig. 5. Evolutionary deviation curve for Stock 8.

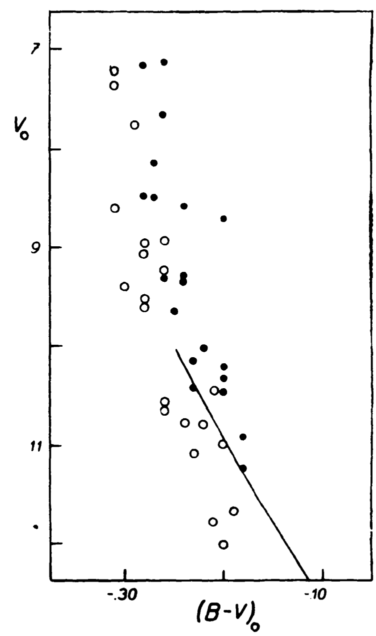

Fig. 6. Colour-magnitude diagram for clusters NGC 1893 (circles) and Stock 8 (points). Main sequence is plotted for modulus of 12^{m}.1.

*) Spectral type B2 after HDE. Eclipsing variable.

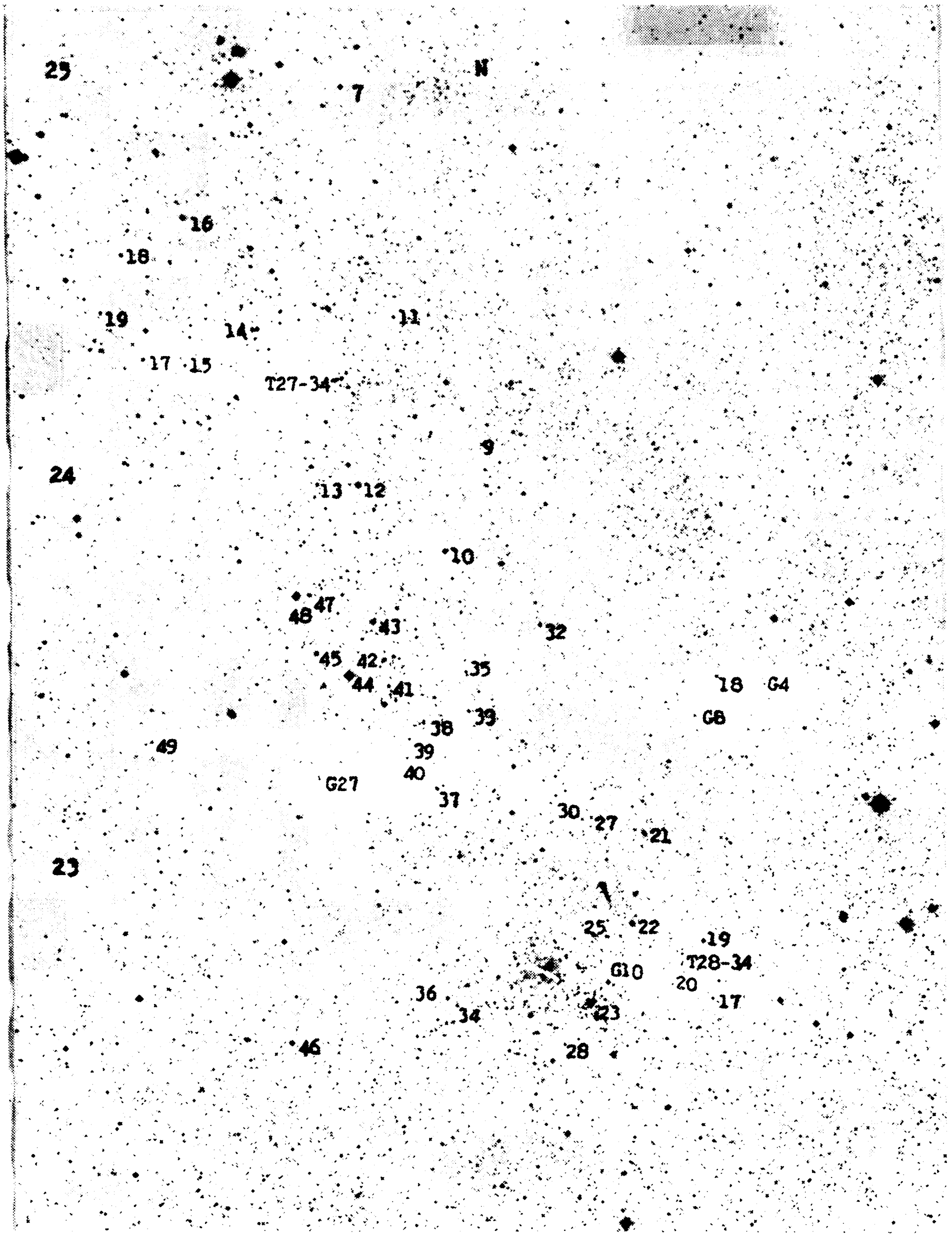

Fig. 7: Map of neighbourhood of NGC 6823. Stars not contained in paper by Stock et al. (1960) but denoted OB have numbers G if from paper by Grigoreva (1962) or T if from paper by Iriarte and Chavira (1954) — number of page and star is given.

in the table are not members of the cluster according to photometric data and as a rule not even U—B can be given for them (the conversion relation from u—b is satisfactory only for early types). It is obviously from the diagram in Fig. 5, compiled according to Johnson's method (1960), that all the stars observed by us are evolved and thus the determination of the distance is not reliable. The colour-magnitude diagram is given in Fig. 6. Members of the cluster NGC 1893 according to the photoelectric measurements of Hoag et al. are plotted here together with the members of the cluster Stock 8. There is indisputably a difference of around 1^m in the distance moduli of the two clusters. The modulus of cluster Stock 8 can be estimated at $12^m.1 \pm 0^m.4$, the distance is thus about 2600 ps. There are obviously no stars of the type O in the cluster Stock 8. But then its connection with a nebula is surprising. (About 20′ from the cluster and at roughly the same distance there is the star HD 35 619 — possibly the latter is responsible for the nebula radiation).

The cluster Stock 8 and NGC 1893 are thus independent in space. It is possible, however, that the cluster Stock 8 forms an association together with some other stars. The star HD 35 633, projecting into the region of the cluster, is a star of the foreground if its classification is correct (difference between distance moduli is larger than $1^m.5$).

9. NGC 6823 AND ITS NEIGHBOURHOOD

The cluster NGC ($\alpha_{1950} = 19^h41.0^m$, $\delta_{1950} = +23°11'$; $l'' = 59.4°$, $b'' = -0.1°$) is a known star cluster of the type O, surrounded by an emission nebula NGC 6820. Its core, the multiple system BD + 22°3782, studied by Sharpless (1954), has at least 14 members in a region 40″ in diameter. The photoelectric and photographic measurements of the cluster are given in the paper by Hoag et al. (1961). Many OB stars were discovered in the neighbourhood of the cluster. They are given in the papers by Iriarte and Chavira (1954), Stock et al. (1960), Grigoreva (1962). In the region of the NGC 6823 these stars form a pronounced densification reaching in the direction of growing galactic length of about 2° (see Fig. 7). The middle part of this densification, around the star BD + 23°3760 (HD 186 746), is regarded by Roslund (1960) as an independent star cluster (No. 2 in his list). Hiltner's catalogue (1956) gives the data for 13 stars in this region.

The properties of the cluster NGC 6823 and the large number of early stars in its neighbourhood points to the existence of an association; it is given under the name Vulpecula I. There is some doubt, however, about whether the whole elongated densification belongs to this association. Photoelectric observations may contribute towards solving this problem. However, the high absorption in this region and the small sensitivity of our equipment permitted observation of only the brighter stars and even then the measurements in the U region are rather inaccurate. The results are given in Tab. 4.

In discussing the distances of the objects in this region let us first pay attention to the cluster NGC 6823 itself. Johnson et al. (1961) give the distance modulus as $11^m.1 \pm 0^m.4$. However a much larger modulus is obtained from the members of the cluster given in Hiltner's catalogue. When using the absolute magnitudes from the paper by Johnson and Iriarte (1958) and the actual colours from the paper by Johnson (1958) we get the moduli of four members

Table 4. NGC 6823

BD Number	LS Number	V	B—V	u—b	U—B	$(B—V)_0$	A_V	V_0
	G 4	11.81	+.70	2.01	+.12:	—.13	2.49	9.32
	G 8	11.51	.78	2.26	+.42:	—.05	2.49	9.02
	G 10[1])	11.60	.54	1.61	—.36:	—.25	2.37	9.23
	T 34	10.41	.70	1.96	+.06:	—.15	2.55	7.86
	23—17	10.42	.78	1.742	—.20	—.26	3.12	7.30
	23—18	10.46	.62	1.588	—.39	—.28	2.70	7.76
	23—19	9.44	.75	1.61	—.36:	—.31	3.18	6.26
	23—20	11.84	.65					
	23—21	11.12	.61	1.68	—.28:	—.25	2.58	8.54
+23°3747	23—25[2])	10.34	.59	1.63	—.34:	—.26	2.55	7.79
	23—28	11.73	.83	1.71	—.25	—.30	3.39	8.34
	23—29	10.72	.34	1.47	—.52	—.26	1.80	8.92
	23—31	10.99	.45	1.54	—.44	—.26	2.13	8.86
	23—32	10.44	.79	1.69	—.27	—.29	3.24	7.20
	23—33	10.70	.78	1.64	—.33:	—.31	3.27	7.43
	23—34	11.82	.48	1.54	—.44:	—.26	2.22	9.60
	23—36	10.58	.54	1.63	—.34:	—.25	2.37	8.21
+23°3758	23—42[3])	9.99	.70	1.64	—.32:	—.28	2.94	7.05
+23°3759	23—43[2])	8.75	.79	1.61	—.36:	—.32	3.36	5.39
+23°3762	23—45[2])	9.29	.78	1.64	—.33:	—.31	3.27	6.02
	23—47	10.81	.72	1.72	—.23:	—.26	2.94	7.87
+23°3767	23—48[2])	7.88	.72	1.70	—.25:	—.26	2.94	4.94
	23—49	11.63	.72					
+24°3843	24— 8	10.36	.97	1.934	+.03	—.23	3.60	6.76
+23°3756	24—10	9.06	1.03	2.38	+.56:	—.07	3.30	5.76
+23°3761	24—12[2])	8.80	.64	1.52	—.47:	—.32	2.88	5.92
+23°3763	24—13	10.02	.74	1.662	—.30	—.29	3.09	6.93
+24°3873	24—14	9.93	.68	1.63	—.34:	—.28	2.88	7.05
+24°3880	24—15	10.80	.59	1.52	—.47:	—.30	2.67	8.13
+24°3881	24—16[2])	9.14	.68	1.53	—.46:	—.32	3.00	6.14
+24°3883	24—17	10.22	.71	1.66	—.30:	—.28	2.97	7.25
	24—18	10.66	.73	1.55	—.43:	—.33	3.18	7.48
	24—19	10.90	.74	1.68	—.28:	—.28	3.06	7.84
+25°3970	25—11	11.19	.68	1.76	—.18:	—.23	2.73	8.46

[1]) Measured by Hoag and others (No. 7).
[2]) Measured by Hiltner.
[3]) ADS 12 871. Both stars measured altogether.

as $12^m.2$, $12^m.5$, $12^m.2$, $12^m.3$. The dispersion of the moduli is thus insignificant and the mean value is $12^m.3$.

The difference 1.2^m compared with that found by Johnson et al. can easily be partly explained by the great density of the star field in which the NGC 6823 lies: the determination of the distance by Johnson's method may be influenced too much by the large number of stars in the foreground. If only the practically certain members of the cluster are taken into consideration, i. e. stars with known early spectra, members of a multiple system and stars which are of the early type according to photometric data, the distance modulus of the cluster seems to be near to 12^m, as is borne our by Fig. 8.

Hiltner's catalogues gives the moduli of stars in the region of the star cluster Roslund 2 as $11^m.3$, $11^m.7$, $10^m.9$, $11^m.1$, $11^m.8$, an average value of $11^m.4$. The difference between this and the modulus $12^m.3$ of stars of the cluster is thus considerable. Figure 9 is the colour-magnitude diagram of the stars of this region. The certain members of NGC 6823 mentioned above (this time only measured photoelectrically) are given here together with the stars of the cluster Roslund 2 and with stars of a wide neighbourhood, according to Tab. 4 and the measurements of Hiltner. The diagram indicates the difference in the distance moduli of clusters NGC 6823 and Roslund 2 but the conclusion is quite uncertain. The question of a connection between the two clusters investigated thus remains unanswered and will require further research.

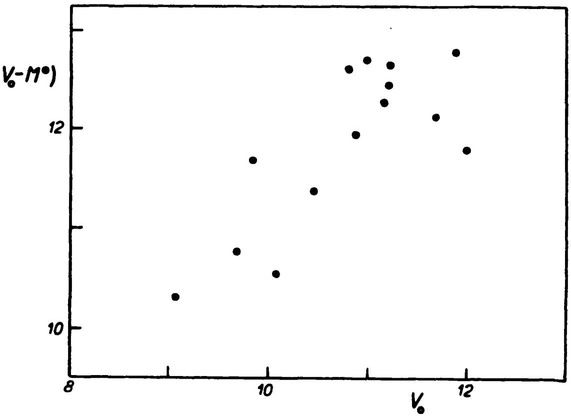

Fig. 8. Evolutionary deviation curve for NGC 6823 (certain members).

10. CONCLUSION

Photoelectric observations of the kind described here are not usual in the countries of central Europe. The reason is not only the small number of cloudless nights (about 30 annually in Ondřejov) but also that the extinction on such bright nights fluctuates considerably. The latter fact is certainly the main cause of the not very high accuracy in our observations; another cause of low accuracy were also some instabilities in our equipment in 1962. The accuracy could be increased in particular by more frequent observation of standard stars. The observations must thus be performed as quickly as possible in order to make the most perfect use of the small number of suitable nights. We hope that the photometer for the simultaneous observation of the star and sky in different spectral regions, just designed, will permit speedier observations and thus more accurate ones.

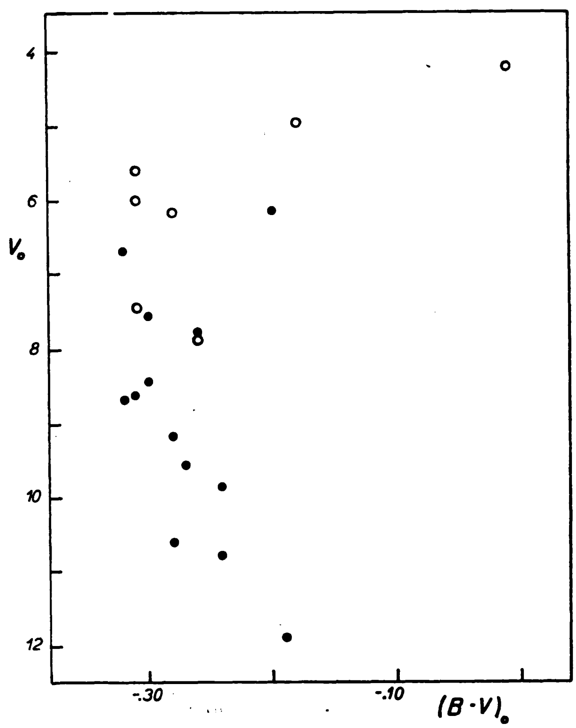

Fig. 9. Colour-magnitude diagram for NCG 6823 (points) and Roslund 2 (circles).

A number of people participated in building the telescope and photometer as well as in the observations themselves. The author sincerely thanks

members of the workshop and of the stellar department of Ondřejov observatory, Czechoslovak Academy of Sciences, as well as his colleagues at the Astronomical Institute of Charles University, for their great help, and Mr. J. Brejla, former mechanic at this institute, for his exact work. Special thanks go to Dr. J. M. Mohr, director of the Astronomical Institute of Charles University, for making this work possible and for his full support.

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SOUHRN

V práci je popsán 65 cm reflektor Astronomického ústavu Karlovy university, umístěný na hvězdárně v Ondřejově. Dalekohled je Cassegrainova typu, a používá se pro fotoelektrickou fotometrii. Fotometr s násobičem EMI 6094 je připojen přímo k registračnímu přístroji EZ 2, a je schopen měřit hvězdy i slabší jak 13^m v UBV systému. V roce 1962 však byl barevný systém odlišný, a měření z tohoto roku jsou publikována samostatně. Přesnost měření byla snižována především změnami extinkce. Byly měřeny OB hvězdy v několika oblastech, v místech pravděpodobných O-asociací. Pro hvězdokupu Stock 8 je nalezen modul vzdálenosti $12{,}1 \pm 0{,}4$; s kupou NGC 1893 kupa Stock 8 pravděpodobně nesouvisí. Asociace v okolí NGC 663 se zdá být reálnou,

a je typu podobného χ a h Per. Souvislost kupy NGC 6823 s okolím hvězdy HD 186 746 (kupa Roslund 2) je sporná, a modul vzdálenosti NGC 6823 je asi větší než hodnota udávaná Johnsonem a dalšími.

SUMMARY

The paper describes a 65 cm reflector of the Astronomical Institute of Charles University, located at the observatory in Ondřejov. The telescope is of the Cassegrain type and is used for photoelectric photometry. The photometer with photomultiplier EMI 6094 is connected directly to the recording instrument EZ 2, and is able to measure stars even weaker than 13^m in the UBV system. In 1962, however, the colour system was different and measurements from that year are being published independently. The accuracy of the measurements was lowered primarily by changes in atmospheric extinction. OB stars were measured in several regions, in places of probable O-associations. The association in the neighbourhood of NGC 663 seems to be real and is of a type similar to χ and h Per. The distance modulus found for the star cluster Stock 8 is 12.1 ± 0.4; the cluster Stock 8 is probably not connected with the cluster NGC 1893. The connection between the cluster NGC 6823 and the neighbourhood of the star HD 186 746 (cluster Roslund 2) is questionable, and the distance modulus of NGC 6823 is probably larger than the value given by Johnson et al.

РЕЗЮМЕ

В работе приводится описание 65 см. рефлектора Астрономического института Карлова униврвитета, установленного в астрономической обсерватории в Ондржейове. Телескоп типа Кассегрена, используется для фотоелектрической фотометрии. Фотометр с умножителем EMI 6094, непосредственно соединенный с регистрирующим прибором EZ 2, способен измерять звезды слабее чем 13^m в системе UBV. Однако цветная система в 1962 г. была иная и данные измерений, полученные тогда были самостоятельно опубликованы. Точность измерений понизилась прежде всего в результате изменений экстинкций. Измерялись OB звезды в нескольких областях — в местах вероятных O - ассоциаций. Ассоциация в окрестности NGC 663, по-видимому, носит реальный характер и относится к типу похожим на χ и h Per. Для звездного скопления Stock 8 был найден модуль расстояния, равный 12.1 ± 0.4; звездное скопление Stock 8, по-видимому, не связано со звездным скоплением NGC 1893. Связь скопления NGC 6823 с окрестностями звезды HD 186 746 (скопление Roslund 2) ставится под вопрос; модуль же расстояния NGC 6823, по-видимому, превышает величину, приводимую Джонсоном и др.