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THREE-COLOR OBSERVATIONS OF 108 STARS INTENDED FOR USE AS PHOTOMETRIC STANDARDS

H. L. Johnson
Lowell Observatory

AND

D. L. Harris III
Yerkes and McDonald Observatories
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ABSTRACT

Three-color observations on the (*U*, *B*, *V*) system have been made for 108 stars, including the 10 primary standards. These observations, which are of relatively high weight, are intended, along with the three standard regions—Praesepe, the Pleiades, and IC 4665—for use as standards for the three-color photometric system.

In this paper are presented magnitudes and colors on the (*U*, *B*, *V*) system (Johnson and Morgan 1953) for a total of 108 stars which are intended for use as standards of the system. The measures have been made over the time interval from 1950 to 1954, both at the McDonald Observatory and at the Lowell Observatory. With the exception of the ten primary standards, the average number of nights on which the stars were observed is 7.3. As many as possible of the primary standards were observed on each night. In addition to these stars, there are three standard regions—the Pleiades (Johnson and Morgan 1953), Praesepe (Johnson 1952), and IC 4665 (Johnson 1954). These stars and standard regions could be considered as defining the photometric system.

The 108 stars are listed in Table 1, where the first column givest the HD numbers of the stars; the second, the names or BD numbers; the third, fourth, and fifth, the measured magnitudes and colors; the sixth, the number of nights on which the stars were observed; and the last column the spectal type by W. W. Morgan on the MK system.

The values given for the ten primary standards (the last ten stars in Table 1) are slightly different from those originally given (Johnson and Morgan 1953). Additional observations that have been made since 1951 have been used to make these small changes, but it is not known whether these changes are due to variability of the stars. When transformations to the system are made, it is best not to use the primary standards alone but, instead, to use at least 20 stars of all types selected from Table 1 or the standard regions. In this way the effects of small variations in the standard stars can be reduced. In general, unless one is working in a very small region of the sky, it is better to use standards scattered over a considerable area of the sky; such a procedure will help to minimize systematic regional errors that might appear in the transformations.

If stars of a particular type not available in Table 1 are required, it may be possible to select suitable stars from Johnson and Morgan (1953, Table 3). One must keep in mind, however, that these latter observations are of lower weight than those given in Table 1.

TABLE 1—THE PHOTOMETRIC STANDARDS

HD	Name	V	$B-V$	$U-B$	n	Sp.
886	γ Peg	2.83	−0.23	−0.87	6	B2 IV
1280	θ And	4.61	+0.06	+0.04	6	A2 V
4727	ν And	4.53	−0.15	−0.58	5	B5 V
6961	θ Cas	4.33	+0.17	+0.11	5	A7 V
8538	δ Cas	2.68	+0.13	+0.12	5	A5 V
9270	η Psc	3.62	+0.97	+0.76	5	G8 III
10476	107 Psc	5.23	+0.83	+0.50	5	K1 V
10700	τ Cet	3.50	+0.72	+0.20	5	G8 Vp
11636	β Ari	2.65	+0.13	+0.10	5	A5 V
...	−18°359	10.18	+1.53	+1.16	3	...
...	+2°348	10.03	+1.44	+1.08	3	...
15318	ξ² Cet	4.28	−0.06	−0.13	5	B9 III
16160	HR 753 A	5.82	+0.97	+0.79	11	...
...	HR 753 B	11.65	+1.61	+1.12	3	...
20630*	κ Cet	4.82	+0.68	+0.18	7	G5 V
21120	ο Tau	3.59	+0.89	+0.62	5	G8 III
21447	HR 1046	5.08	+0.05	+0.03	5	A1 V
22049	ε Eri	3.73	+0.89	+0.57	6	K2 V
27371*	γ Tau	3.65:	+0.99	+0.82	6	K0 III
27697*	δ Tau	3.76:	+0.98	+0.82	6	K0 III
28305	ε Tau	3.54	+1.02	+0.88	6	K0 III
30652	π³ Ori	3.19	+0.45	−0.01	11	F8 V
30836	π⁴ Ori	3.69	−0.17	−0.80	9	B2 III
32630	η Aur	3.17	−0.18	−0.67	6	B3 V
33111	β Eri	2.80	+0.13	+0.10	8	A3 III
35299	...	5.70	−0.22	−0.87	15	B5 V
35468	γ Ori	1.64	−0.23	−0.87	5	B2 III
35497	β Tau	1.65	−0.13	−0.49	5	B7 III
36395	−3°1123	7.97	+1.47	+1.21	17	M1 V
36512	υ Ori	4.63	−0.26	−1.07	11	B0 V
36591	...	5.35	−0.20	−0.94	9	B1 V
37043	ι Ori	2.77	−0.25	−1.08	5	O9 III
37128	ε Ori	1.70	−0.19	−1.04	6	B0 Ia
38678	ζ Lep	3.55	+0.10	+0.06	5	...
38899	134 Tau	4.90	−0.07	−0.18	5	B9 IV
...	+17°1320	9.63	+1.50	+1.18	4	...
47105	γ Gem	1.93	0.00	+0.03	5	A0 IV
...	+5°1668	9.82	+1.56	+1.12	3	...
56537	λ Gem	3.58	+0.11	+0.10	6	A3 V
58946	ρ Gem	4.16	+0.32	−0.03	6	F0 V
62345	κ Gem	3.57	+0.93	+0.68	5	G8 III
71155	HR 3314	3.90	−0.02	−0.02	5	A0 V
76644	ι U Ma	3.14	+0.18	+0.07	6	A7 V
79469	θ Hya	3.88	−0.06	−0.13	6	A0 p
...	−12°2918	10.06	+1.53	+1.15	2	...
82885	11 LMi	5.41	+0.77	+0.45	14	G8 IV–V
87696	21 LMi	4.48	+0.18	+0.08	7	A7 V
87901	α Leo	1.36	−0.11	−0.36	7	B8 V
89021	λ U Ma	3.45	+0.03	+0.06	6	A2 IV
...	+1°2447	9.63	+1.52	+1.19	3	...
91316	ρ Leo	3.85	−0.14	−0.95	6	B1 Ib
100600	90 Leo AB	5.95	−0.16	−0.64	23	...
102647	β Leo	2.14	+0.09	+0.07	8	A3 V
102870	β Vir	3.61	+0.55	+0.10	9	F8 V
103095	HR 4550	6.45	+0.75	+0.17	25	G8 Vp

* The stars indicated by asterisks:

20630 κ Cet has been found to be variable in magnitude by Kron, White, and Gascoigne (1953). Our data, however, do not definitely show this variation.

27371, 27697 These two Hyades giants appear to be variable in magnitude with an amplitude of about 0.1 mag. The third Hyades giant in the table, ε Tau, does not show this variation.

116658 Eclipsing variable.

+4°3561 Barnard's proper-motion star.

TABLE 1—*Continued*

HD	Name	V	$B-V$	$U-B$	n	Sp.
103287	γ U Ma	2.44	0.00	+0.01	6	A0 V
106591	δ U Ma	3.31	+0.08	+0.07	9	A3 V
106625	γ Crv	2.60	−0.11	−0.35	5	B8 III
....	+0°2989	8.49	+1.41	+1.26	3	M0.5 V
113139	78 U Ma	4.93	+0.36	+0.01	16	F2 V
114710	β Com	4.28	+0.57	+0.07	11	G0 V
115617	61 Vir	4.75	+0.71	+0.25	5	G5 V
116658*	α Vir	0.96	−0.23	−0.94	7	B1 V
116842	80 U Ma	4.01	+0.16	+0.08	15	A5 V
117176	70 Vir	4.98	+0.71	+0.26	8	G5 V
121370	η Boo	2.69	+0.58	+0.19	8	G0 IV
130109	109 Vir	3.74	0.00	−0.03	7	A0 V
130819	α¹ Lib	5.16	+0.41	−0.04	7	....
130841	α² Lib	2.75	+0.15	+0.08	8	....
....	−7°4003	10.56	+1.61	+1.20	6	....
141003	β Ser A	3.67	+0.06	+0.07	8	A2 IV
141004	λ Ser	4.43	+0.60	+0.10	7	G0 V
142860	γ Ser	3.85	+0.48	−0.03	6	F6 V
....	−12°4523	10.13	+1.60	+1.18	5	....
149757	ζ Oph	2.56	+0.02	−0.86	10	O9.5 V
154363	−4°4225	7.73	+1.16	+1.05	5	K5 V
....	−4°4226	10.07	+1.43	+1.09	5	M3.5 V
157881	+2°3312	7.54	+1.36	+1.26	5	K7 V
159561	α Oph	2.08	+0.15	+0.10	11	A5 III
161096	β Oph	2.77	+1.16	+1.24	10	K2 III
161868	γ Oph	3.75	+0.04	+0.04	9	A0 V
........*.....	+4°3561	9.54	+1.74	+1.29	9	M5 V
....	−3°4233	9.38	+1.52	+1.21	5	....
172167	α Lyr	+.04	0.00	−0.01	10	A0 V
176437	γ Lyr	3.25	−0.05	−0.09	10	B9 III
177724	ζ Aql	2.99	0.00	−0.01	6	....
....	+4°4048	9.13	+1.49	+1.16	6	M3.5 V
184279	+3°4065	6.82	+0.02	−0.83	5	....
184915	κ Aql	4.96	−0.01	−0.87	6	B0.5 III
187642	α Aql	0.77	+0.22	+0.08	14	A7 IV, V
188512	β Aql	3.71	+0.86	+0.48	16	G8 IV
196867	α Del	3.77	−0.06	−0.22	6	B9 V
198001	ε Aqr	3.77	+0.01	+0.04	5	A1 V
....	−15°6290	10.17	+1.60	+1.15	4	....
216494	74 Aqr	5.81	−0.08	−0.32	6	....
218045	α Peg	2.49	−0.05	−0.06	7	B9 V
222368	ι Psc	4.13	+0.51	0.00	8	F7 V
....	+1°4774	8.98	+1.48	+1.09	5	M2 V
	The Ten Primary Standards					
12929	α Ari	2.00	+1.151	+1.12	std	K2 III
18331	HR 875	5.17	+0.084	+0.05	std	A1 V
69267	β Cnc	3.52	+1.480	+1.78	std	K4 III
74280	η Hya	4.30	−0.195	−0.74	std	B3 V
135742	β Lib	2.61	−0.108	−0.37	std	B8 V
140573	α Ser	2.65	+1.168	+1.24	std	K2 III
143107	ε CrB	4.15	+1.230	+1.28	std	K3 III
147394	τ Her	3.89	−0.152	−0.56	std	B5 IV
214680	10 Lac	4.88	−0.203	−1.04	std	O9 V
219134	HR 8832	5.57	+1.010	+0.89	std	K3 V

The estimated probable errors of the observations given in Table 1 are listed in Table 2, which is self-explanatory.

These observations have been compared with the red and infrared observations of Kron, White, and Gascoigne (1953), with results not significantly different from those given by them. The numbers of stars in the comparisons are now greater, but the scatter

TABLE 2

ESTIMATED PROBABLE ERRORS OF THE OBSERVATIONS

No. of Observations	Probable Errors (Mag.) of		
	V	$B-V$	$U-B$
2	±0.020	±0.010	±0.020
3	± .016	± .008	± .016
4	± .014	± .007	± .014
5 or more	±0.012	±0.006	±0.012

and general trends of the diagrams are not changed. The reader is referred to Figures 1 and 2 of Kron *et al.* (1953).

REFERENCES

Johnson, H. L. *Ap. J.*, **116**, 640, 1952.
———. *Ap. J.*, **119**, 181, 1954.
Johnson, H. L., and Morgan, W. W. *Ap. J.*, **117**, 313, 1953.
Kron, G. E.; White, H. S.; and Gascoigne, S. C. B. *Ap. J.*, **118**, 502, 1953.