Colour equivalents of 191 stars near the North Pole

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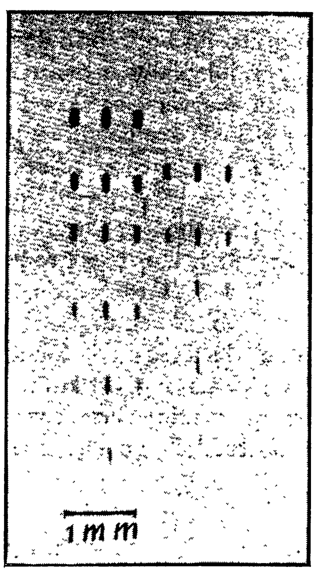
COMMUNICATION FROM THE OBSERVATORY AT LEIDEN.

Colourequivalents of 191 stars near the north pole, by *N. W. Doorn.*

It is well known that refractors are much less fit for the determination of effective wavelengths than are reflectors, because of the disturbing influence of the secondary spectrum of the former. Thus small changes in focus may give rise to serious changes in effective wavelength, as has been found by H. ROSENBERG (*A.N.* Bd **213**, 329). Professor HERTZSPRUNG suggested that this trouble may be partly avoided by allowing the diffraction images to trail at right angles to the dispersion. In order to try which accuracy may be obtained in this way use was made of the double Zeisscamera, carrying two Tessars of aperture 104 mm. and focal length 522.5 mm. The plate can be moved so that a star image describes a rectangle the sides of which can be altered independently of each other. In this way it was possible to make the stars describe small trails of ·25 mm. length in a direction perpendicular to the dispersion of the grating. Every 20 seconds the direction of motion is reversed by the mechanism and the trails are described again. The use of this device instead of the daily motion of the stars for trailing has the advantage that all stars are trailed in the same way independent of their declination. In order to eliminate the magnitude equation six exposures of 20, 40, 80, 160, 320 and 640 sec. were made on each plate. Between the exposures the objectives were moved in a direction perpendicular to their axis and the dispersion of the grating. The figure shows images obtained in this way. The stars are B. D. 83°640 and 83°647, Greenwich photographic magnitude 6·05 and 7·42, spectrum K5 and B9 respectively.



The plates used were Seed 30 and Eastman 40. The 42 plates were measured on the Repsold measuring machine. The reductions were made in revolutions of the screw.

The different exposures of a star were numbered as follows: I was the faintest measurable image, II the next, and so on. In that way on all the plates the images with the same number are of about the same blackness. II was taken as standard blackness. To reduce the measures of the images I to blackness II the measures were arranged according to colour, for which the sum of the measures I and II was taken and then divided into groups. For each group the mean values of I and I—II were computed and represented graphically. From the graph the reductions from I to II were tabulated. In the same way the corrections of III and IV to II were determined. *) For the images of one star on a plate the means of the measures I, II, III and IV so reduced were formed, taken with weight 1, 2, 2, 1 respectively. After that the mean for all plates on which a star was measured was taken. These final means were plotted against the Yerkes colour index (from the *Yerkes Aktinometry* by J. A. PARKHURST *A.J.* **36**, 169, 1912). This gave a linear relation. The spreading was rather large, but was improved considerably after omission of stars which occured on less than three plates. **) The stars were divided into 3 groups on the graph and a least square solution gave for 155 stars

$$I = 6{\cdot}60\ (l - 5{\cdot}5469),$$

where I is the colour index, l the effective wavelength in revolutions of the measuring screw. ***)

In order to compare the colour index derived from

*) These corrections proved to be rather constant for intermediate colours, but considerably different for extremely white and yellow stars, the curve representing the connection between colour and correction to the image II having in each case an *S*-like shape.

**) These stars have therefore been disregarded.

***) The grating constant was ·499 m.m., and $\lambda = 758{\cdot}0\ l$.

the Leiden effective wavelengths with other colour equivalents the following sources have been used

1. Colour index from Yerkes Actinometry.
2. Greenwich effective wavelengths.
3. Leiden effective wavelengths.
4. Göttingen photographic magnitude combined with Potsdam visual magnitude.
5. Pulkovo photographic magnitude combined with Kharkow visual magnitude.
6. Greenwich photographic magnitude combined with Harvard photometric magnitude.

The colour equivalents from "Photographic and photovisual magnitudes of stars near the north pole" by SEARES *Mt. W. Contr.* **97**, 1915 were not included on account of the small number of bright stars contained therein.

The colour equivalents have been reduced to the Yerkes colour index I by means of a formula of the form

$I = a + b\lambda$ for effective wavelengths and
$I = a + b\, m_{pg} + c\, m_v$ for magnitudes, except in the case of the Greenwich photographic magnitudes, where a quadratic term was added.

1. Colour index from Yerkes Aktinometry. These were taken from the Yerkes Actinometry, zone $+ 70°$ to $+ 90°$ by J. A. PARKHURST *A.J.* **36**, 169; 1912.

2. Greenwich effective wavelengths. In *B.A.N.* **134**. Prof. HERTZSPRUNG derived a relation between the effective wavelengths in "Determination of effective wavelengths of stars. Royal Observatory Greenwich 1926" and Yerkes colour index, which can be written as

$$I = \cdot 005163\ \lambda - 21\cdot 821 \qquad \lambda \text{ in } \mathring{A}.$$

3. Leiden effective wavelengths. These have been explained above.

4. Göttingen photographic magnitudes and Potsdam visual magnitudes. The photographic magnitudes were taken from the Göttinger Aktinometrie. *Astr. Mitt. Göttingen* Bd **14** *); the visual from the *Potsdam Publ.* **17**, General Catalogue.

From 139 stars was found

$$I = -\cdot 1498 + \cdot 9667\ m_{Gt} - \cdot 9007\ m_{Pd}.$$

5. Pulkovo photographic magnitudes and Karkow visual magnitudes. These were taken from "Grandeurs photographiques des étoiles du B. D. jusqu'à $9^m \cdot 0$ entre 75° et 90° de déclinaison boréale" par S. BELJAWSKY, *Bull. de l'Obs. central Nicolas à Poulkovo.* Vol. VI 12, 1915 and "Photometrical catalogue of 1155 stars" by B. FESSENKOFF, Kharkow 1926.

From 120 stars we found the relation

$$I = -\cdot 0002 + \cdot 9915\ m_{Pk} - \cdot 9913\ m_{Kk}.$$

6. Greenwich photographic magnitude and Harvard photometric magnitude. The former were taken from "Photographic magnitudes of stars brighter than $9^m \cdot 0$ between decl. $+ 75°$ and the pole." Royal Observatory Greenwich 1913, and the same Between decl. 65° and 75°, 1914. The latter were taken from the Draper Catalogue.

The stars were divided into 5 groups according to the Yerkes coulour index. $I_{Yk} < \cdot 01$; $\cdot 01 - \cdot 50$; $\cdot 51 - 1\cdot 00$; $1\cdot 01 - 1\cdot 50$; $> 1\cdot 50$.

In each group the stars were arranged according to the sum $m_{Grw} + m_{Hv}$. The stars for which this sum was greater than 16·0 were not included (If the limit had been set by photographic magnitude only, there would have been a tendency to remove the red stars and the stars accidentally measured too faint at Greenwich. Then means were formed for about 10 stars. In this manner the stars were divided into 54 groups of 10 stars, 1 of 12, 2 of 9 and 2 of 8, in total 586 stars. To each of the 59 groups equal weight was given.

Two solutions were made, a linear and a quadratic one.

$$I = \cdot 6153 + 1\cdot 3975\,(m_{Grw} - 7\cdot 214) - 1\cdot 2799\,(m_{Hv} - 6\cdot 848)$$
$$I = \cdot 6936 + 1\cdot 4385\,(m_{Grw} - 7\cdot 214) - 1\cdot 3783\,(m_{Hv} - 6\cdot 848) - \cdot 1209\,(m_{Grw} - 7\cdot 214)^2$$

In Table 1 the residuals are given for both formulas. The residuals from the linear formula show a relative curvature of the Greenwich and Harvard scales. In the second colour group the residuals are negative at both ends. The other groups confirm this curvature. In the fifth group, for instance, the stars are faint. The residuals are first positive and then negative.

The quadratic form was adopted. In the group marked * B. D. 81°706 was included. Afterwards it was found that this star has probably been measured too faint at Harvard. Only one observation is found in H.A. Although the large residuals suggested that no great harm was done a new quadratic solution was made in which this star was omitted. The coefficients were only slightly altered.

Weights. The mean square of the differences between two series of observations is equal to the sum of the squares of their mean errors. By combining every two out of three series the mean error of each of the

*) Stars from the Göttinger Aktinometrie which occur on only one plate have been omitted.

TABLE I.

m_{Grw}	m_{Hv}	I_{Yk}	Residuals from linear formula $O-C$	Residuals from quadratic formula $O-C$	m_{Grw}	m_{Hv}	I_{Yk}	Residuals from linear formula $O-C$	Residuals from quadratic formula $O-C$
5·157	5·103	—·243	—·217	+·129	5·689	4·941	+ ·724	—·201	—·123
5·704	5·653	—·168	—·213	—·061	6·650	6·132	+ ·778	+·034	—·053
6·189	6·181	—·092	—·129	—·103	7·018	6·495	+ ·851	+·058	—·043
6·429	6·547	—·073	+·023	+·022	7·204	6·845	+ ·730	+·125	+·047
6·671	6·803	—·125	—·039	—·064	7·409	6·968	+ ·798	+·064	—·006
6·955	7·140	—·105	+·015	—·015	7·588	7·174	+ ·796	+·075	+·031
7·218	7·334	—·071	—·070	—·101	7·671	7·307	+ ·732	+·066	+·039
7·573	7·647	—·179	+·223	—·272	*7·743	7·522	+ ·692	+·200	+·200*
					8·024	7·543	+ ·772	—·084	—·050
5·448	5·130	+·181	—·450	+·037	8·165	7·667	+ ·792	—·104	—·031
5·911	5·696	+·216	—·053	+·014					
6·210	6·057	+·203	—·022	—·015	6·068	5·085	+1·309	+·039	—·007
6·323	6·278	+·126	+·026	+·024	6·830	6·101	+1·148	+·113	—·005
6·516	6·353	+·247	—·026	—·066	7·219	6·461	+1·157	+·039	—·077
6·547	6·507	+·194	+·074	+·044	7·410	6·641	+1·361	+·207	+·105
6·634	6·601	+·173	+·052	+·014	7·518	6·809	+1·202	+·112	+·028
6·736	6·718	+·214	+·100	+·056	7·629	6·976	+1·166	+·135	+·073
6·886	6·814	+·202	+·002	—·054	7·950	7·229	+1·234	+·078	+·072
6·898	7·008	+·147	+·178	+·141	8·097	7·255	+1·226	—·102	—·083
7·070	6·954	+·334	+·056	—·004	8·168	7·384	+1·245	—·017	+·028
7·036	7·150	+·152	+·172	+·135	8·279	7·525	+1·202	—·035	+·047
7·173	7·136	+·244	+·055	+·007	8·351	7·631	+1·239	+·037	+·145
7·292	7·179	+·225	—·076	—·124	8·541	7·766	+1·216	—·079	+·092
7·292	7·325	+·168	+·054	+·020	8·900	7·842	+1·247	—·452	—·158
7·360	7·359	+·266	+·101	+·069					
7·389	7·405	+·300	+·153	+·126	6·682	5·535	+1·719	+·167	+·015
7·486	7·441	+·277	+·041	+·018	7·448	6·382	+1·649	+·110	—·017
7·547	7·481	+·194	—·076	—·093	7·779	6·753	+1·655	+·129	+·056
7·639	7·639	+·255	+·058	+·062	8·154	7·074	+1·601	—·039	—·026
7·892	7·590	+·318	—·395	—·273	8·392	7·278	+1·657	—·054	+·029
7·918	7·868	+·237	—·057	—·003					
8·069	7·940	+·333	—·189	+·003					
							$\Sigma\,(O-C)^2$	1·1846	·4574

series can be computed. In that way series 1, 2, 3 and 4, 5, 6 were combined. This gave

$$\mu_{Yk} = \pm\,\overset{m}{\cdot}096\,(104) \quad \mu_{Grw} = \pm\,\overset{m}{\cdot}130\,(77) \quad \mu_{Ld} = \pm\,\overset{m}{\cdot}138\,(72)$$

$$\mu_{Gt\,Pd} = \pm\,\cdot115\,(76) \quad \mu_{Pk\,Kk} = \pm\,\cdot119\,(70) \quad \mu_{Grw\,Hv} = \pm\,\cdot210\,(23)$$

The numbers in parentheses denote the corresponding weight. The unit of weight corresponds to a mean error of $\pm\,1^{m}$. The weights of Greenwich and Leiden effective wavelengths are about the same. The number of expositions on each plate is 6, but the average number of plates on which a star is measured is 3·0 for Greenwich and 6·9 for Leiden. Therefore, notwithstanding the trailing of the refractor images, they are still markedly inferior to those obtained with a reflector as used at Greenwich.

The weight of the combination Greenwich—Harvard is rather low. This is for a considerable part due to the large coefficient of about 1·4 for the difference $m_{Grw} - m_{Hv}$, in accordance with the well known fact that the colour effect of the visual Harvard magnitudes is nearer to that of photographic magnitudes than is that of the visual Potsdam or photovisual Yerkes magnitudes, the visual Harvard magnitudes having a relatively short effective wavelength.

The table. In forming the mean values of the different colour equivalents for each star the weights were divided by 10 and rounded off to the nearest integer, Table 2 contains:

B. D. number, α and δ for 1900.

I_{Yk} colour index taken from Yerkes Aktinometry.

I_{Grw} „ „ derived from Greenwich effective wavelengths.

I_{Ld} colour index derived from Leiden effective wavelengths.

$I_{Gt.Pd}$ colour index derived from Göttingen photographic and Potsdam visual magnitudes.

$I_{Pk.Kk}$ colour index derived from Pulkovo photographic and Kharkow visual magnitudes.

$I_{Grw.Hv}$ colour index derived from Greenwich photographic and Harvard photometric magnitudes.

(The numbers in parentheses are the weights).

The table further gives the weighted mean, the mean error, Yerkes spectrum from Yerkes Aktinometry, Draper spectrum and Groningen spectrum from "Determination and discussion of the spectral classes of 700 stars mostly near the north pole" by G. H. TEN BRUGGEN CATE, Groningen 1920.

Six stars south of + 79° are included because they occur in the list of standard stars for effective wavelengths given by BERGSTRAND and ROSENBERG in *A. N.* **215**, 449. In this case the Greenwich effective wavelengths were taken from "Effective wavelengths and spectral classification of faint stars. Standards of reference", by C. R. DAVIDSON and E. MARTIN, *M. N.* lxxxiv p. 429, 1924. *) Two values between brackets in the table were not used in forming the mean.

TABLE 2.

B. D.	α 1900	δ 1900	I_{Yk} (10)	I_{Grw} (8)	I_{Ld} (7)	$I_{Gt.Pd}$ (8)	$I_{Pk.Kk}$ (7)	$I_{Grw.Hv}$ (2)	Mean	Mean error	Spectrum Yerkes	Spectrum Draper	Spectrum Gron.
°	h m	° ′											
79 10	0 20·7	79 30	− ·20	—	+ ·20	—	—	− ·38	− ·07	± ·07	B8	B9	
81 13	32·2	81 57	+ ·62	+ ·38	+ ·54	+ ·54	+ ·72	+ ·74	+ ·57	·05	F5	F8	
82 20	45·5	83 10	+ ·12	+ ·26	+ ·09	·00	—	+ ·31	+ ·14	·05	A1	A2	
79 24	52·1	80 00	+ ·34	—	+ ·44	+ ·46	+ ·43	+ ·34	+ ·41	·05	F0	F2	
83 20	52·8	84 04	+ ·21	+ ·32	+ ·05	+ ·20	+ ·39	+ ·21	+ ·23	·05	A4	F5p	
85 19	0 55·0	85 43	+ 1·22	+ 1·64	+ 1·35	+ 1·24	—	+ 1·06	+ 1·34	± ·05	G4	K0	
88 4	55·6	88 29	− ·02	+ ·18	·00	+ ·04	—	+ ·03	+ ·05	·05	A1	A2	
86 17	0 59·1	86 37	+ 1·21	+ 1·22	+ 1·16	+ 1·18	+ 1·11	+ 1·03	+ 1·18	·05	G5	K0	G8
79 29	1 00·7	79 29	+ ·99	—	+ 1·05	—	—	+ ·87	+ 1·00	·07	G2	K0	
78 34	03·6	78 08	− ·27	+ ·21	+ ·19	—	—	− ·26	− ·01	·06	B9	A0	
79 36	1 07·7	79 23	+ ·41	—	+ ·49	—	—	+ ·39	+ ·44	± ·07	F1	F2	
80 35	09·7	80 20	+ ·41	+ ·23	+ ·17	+ ·58	+ ·12	+ ·26	+ ·31	·05	F0	F0	
80 36	10·1	80 22	+ ·05	+ ·06	+ ·01	·00	+ ·10	− ·07	+ ·04	·05	A1	A0	
80 50	29·6	80 55	·00	− ·01	− ·10	·00	− ·06	− ·13	− ·05	·05	A0	A0	
80 55	38·8	80 23	+ ·08	− ·04	− ·03	+ ·17	+ ·04	− ·53	+ ·01	·05	A0	A0	
80 57	1 39·8	80 53	+ ·17	+ ·17	+ ·06	+ ·18	+ ·23	− ·11	+ ·15	± ·05	A0	A0	
79 61	55·7	80 11	+ ·13	—	+ ·09	+ ·23	+ ·18	− ·14	+ ·14	·05	A2	A2	
80 64	57·1	80 49	+ ·08	+ ·21	+ ·01	+ ·02	+ ·03	+ ·31	+ ·08	·05	A2	A0	
80 65	1 57·9	81 00	+ ·19	+ ·22	+ ·11	+ ·35	+ ·19	+ ·29	+ ·22	·05	A4	A3	
82 51	2 01·4	83 05	+ ·92	+ 1·12	+ ·70	+ 1·10	+ 1·01	+ ·48	+ ·95	·05	G2	K0	
80 86	2 33·4	81 01	+ 1·34	+ 1·34	+ 1·27	+ 1·49	+ 1·22	+ 1·69	+ 1·35	± ·05	K2p	K0	
79 86	41·8	79 42	+ ·02	—	+ ·03	—	—	+ ·18	+ ·04	·07	A2	A0	
78 103	52·8	78 01	+ 1·87	+ 1·83	+ 1·69	—	—	+ 2·04	+ 1·82	·06	M	Ma	
80 97	2 56·2	81 05	+ ·16	+ ·21	+ ·08	+ ·26	—	+ ·11	+ ·16	·05	A4	A2	
79 94	3 01·4	79 45	+ 1·09	—	+ ·76	—	+ 1·14	+ ·95	+ 1·00	·06	G4	K0	
84 59	3 08·6	84 33	+ ·93	+ ·92	+ ·94	+ ·99	+ 1·15	+ 1·03	+ 1·02	± ·05	G0	K0	
83 91	33·7	83 14	− ·33	+ ·02	− ·05	− ·12	+ ·09	+ ·21	− ·08	·05	B7	B9	
86 51	33·9	86 20	+ ·35	+ ·26	+ ·25	+ ·36	+ ·62	+ ·24	+ ·36	·05	F0	F5	
80 125	3 53·3	80 25	+ ·51	+ ·53	+ ·53	+ ·50	—	+ ·26	+ ·50	·05	F4		
80 127	4 01·1	80 17	+ 1·15	+ ·86	+ 1·00	+ 1·05	—	+ ·83	+ 1·01	·05	G4	K0	
81 147	4 02·0	81 43	− ·03	+ ·10	+ ·04	+ ·05	+ ·18	+ ·08	+ ·06	± ·05	A0	A0	
83 104	05·0	83 34	− ·46	− ·35	+ ·03	− ·31	—	− ·25	− ·29	·05	B6	B3	
85 63	05·1	85 17	+ ·50	+ ·50	+ ·47	+ ·51	+ ·66	+ ·37	+ ·52	·05	F6	F8	F9
82 113	08·0	83 06	+ ·72	+ ·77	+ ·83	+ ·82	—	+ ·47	+ ·76	·05	G0	G5	
80 133	09·6	80 35	+ 1·29	+ 1·46	+ 1·25	+ 1·35	—	+ 1·24	+ 1·33	·05	K2p	K0	
80 134	4 12·0	80 42	+ ·10	+ ·21	+ ·18	+ ·25	—	− ·06	+ ·17	± ·05	A2	A2	
80 140	19·2	80 40	+ ·27	+ ·34	+ ·11	+ ·19	—	+ ·26	+ ·24	·05	A5	F0	
83 114	21·5	83 50	+ 1·05	+ 1·03	—	—	—	+ ·97	+ 1·03	·07	G2	K0	K0
79 150	28·8	79 28	+ ·05	—	+ ·04	—	—	·00	+ ·05	·07	A1	A0	
80 155	41·6	81 02	+ 1·41	+ 1·53	+ 1·40	+ 1·38	—	+ 1·38	+ 1·43	·05	K4	K0	

*) As the star B. D. + 77°699 only occured on two plates taken with the double Zeiss-camera, its Leiden colour equivalent was only given weight 3.

B. D.	α 1900	δ 1900	I_{Yk} (10)	I_{Grw} (8)	I_{Ld} (7)	$I_{Gt.Pd}$ (8)	$I_{Pk.Kk}$ (7)	$I_{Grw.Hv}$ (2)	Mean	Mean error	Spectrum Yerkes	Spectrum Draper	Spectrum Gron.
°	h m	° ′											
85 74	4 56·3	85 50	+ ·30	+ ·38	+ ·30	+ ·28	+ ·39	+ ·16	+ ·32	± ·05	A5	A5	A6
79 169	5 06·1	79 07	+ ·15	—	+ ·46	—	—	+ ·27	+ ·28	·07	F5	F8	
85 78	09·9	85 35	— ·11	+ ·11	+ ·04	·00	+ ·14	— ·07	+ ·02	·05	A0	A0	A0
83 141	11·8	83 47	+ ·01	+ ·13	+ ·10	+ ·23	+ ·03	— ·34	+ ·08	·05	A0	A0	A0
85 80	5 29·9	85 09	+ 1·58	+ 1·70	+ 1·67	+ 1·56	+ 1·55	+ 1·64	+ 1.61	·05	K5	K0	G0
86 79	6 08·0	86 46	+ 1·24	+ 1·31	+ ·96	+ 1·10	+ 1·24	+ 1·49	+ 1·19	± ·05	K1	G5	G7
79 202	16·6	79 02	+ 1·27	—	+ 1·07	—	—	+ 1·54	+ 1·22	·07	G8	K0	
79 208	23·1	79 41	+ ·09	—	+ ·07	—	+ ·02	+ ·30	+ ·08	·06	A1	A0	
82 177	23·4	82 12	+ ·06	+ ·18	+ ·11	+ ·14	+ ·08	+ ·55	+ ·13	·05	A3	A2	A2
79 212	29·2	79 40	+ ·43	—	+ ·42	—	—	+ ·16	+ ·40	·07	F5	F8	
87 51	6 53·7	87 12	+ 1·75	+ 1·63	+ 1·85	+ 1·62	—	+ 1·87	+ 1·67	± ·05	K5 +	Ma	K5
80 230	7 05·8	80 48	+ 1·22	+ 1·10	—	—	—	+ 1·05	+ 1·22	·07	G5	K0	K0
81 242	06·4	81 26	— ·03	— ·04	— ·14	— ·23	— ·12	— ·03	— ·10	·05	B8	B9	B9
82 201	10·0	82 36	+ 1·72	+ 1·58	+ 1·45	+ 1·73	—	+ 2·24	+ 1·67	·05	M	Mb	M
81 252	16·4	81 06	+ 1·21	+ 1·00	+ 1·03	+ 1·03	+ 1·01	+ 1·15	+ 1·07	·05	G5	K0	K
82 213	7 27·7	81 55	— ·07	— ·29	— ·18	·00	— ·01	+ ·34	— ·09	± ·05	A0	B9	B9
81 257	38·9	81 36	+ 1·39	+ 1·45	—	—	—	+ 1·67	+ 1·44	·07	K2	K2	K0
80 238	39·8	80 31	+ ·79	+ ·70	+ ·80	+ ·67	+ ·61	+ ·96	+ ·73	·05	G1	G5	G5
79 265	49·1	79 45	·00	—	— ·12	—	—	— ·05	— ·05	·07	A0	A0	
84 169	53·0	84 21	·00	+ ·01	— ·03	— ·05	—	— ·06	— ·02	·05	A0	A0	A0
89 13	7 58·0	88 56	+ ·16	+ ·15	+ ·20	+ ·20	(+ ·77)	+ ·20	+ ·18	± ·05	A3	A0	A
82 235	8 05·2	82 44	— ·05	+ ·02	— ·16	— ·08	+ ·02	+ ·06	— ·04	·05	B9	A0	A0
85 128	25·3	85 24	+ ·36	+ ·32	—	+ ·28	+ ·60	+ ·39	+ ·38	·05	F3	F2	G0
82 253	28·3	82 36	+ ·01	— ·03	— ·14	— ·13	— ·05	+ ·03	— ·06	·05	A0	A0	B9
80 272	40·8	80 24	— ·12	+ ·03	— ·11	— ·23	— ·18	·00	— ·12	·05	B9	A0	
84 196	8 54·5	84 35	+ ·21	+ ·29	+ ·28	+ ·27	+ ·30	+ ·70	+ ·29	± ·05	A6	F0	A7
81 282	8 56·3	81 14	+ ·49	+ ·26	+ ·12	+ ·23	+ ·36	+ ·01	+ ·29	·05	F1	F2	
83 256	9 20·5	83 22	+ ·42	+ ·27	+ ·17	+ ·37	+ ·39	+ ·36	+ ·33	·05	F2p	F5	
81 302	22·8	81 46	+ 1·34	+ 1·69	+ 1·51	+ 1·59	—	+ 1·27	+ 1·51	·05	K2p	K2	
83 262	26·4	82 49	+ ·06	+ ·16	+ ·02	+ ·06	+ ·06	+ ·24	+ ·08	·05	A3	A0	
79 319	9 35·4	79 36	+ ·19	—	+ ·12	—	+ ·17	+ ·30	+ ·17	± ·06	A7	F0	
84 225	9 52·6	84 24	+ 1·74	+ 1·65	+ 1·53	+ 1·47	+ 1·70	+ 1·86	+ 1·64	·05	K5	K0	
79 328	10 05·8	79 27	+ ·10	—	— ·13	—	+ ·01	+ ·28	+ ·03	·06	A2	A0	
83 287	11·7	83 18	+ 1·07	+ 1·06	+ ·83	+ ·90	+ ·99	+ 1·26	+ ·99	·05	G ±	K0	
84 234	15·2	84 46	+ ·18	+ ·25	—	+ ·18	+ ·26	+ ·17	+ ·21	·05	A4	A3	A4
83 297	10 18·9	83 04	+ ·32	+ ·22	+ ·17	+ ·33	—	+ ·19	+ ·26	± ·05	A8	F2	
85 161	20·8	84 55	+ ·84	+ ·84	—	+ ·70	+ ·83	+ ·79	+ ·80	·05	G0	K0	G2
81 343	25·7	81 01	+ 1·28	+ ·99	+ ·68	+ ·91	+ 1·20	+ 1·14	+ 1·03	·05	K0	G5	
81 349	10 33·6	80 57	+ ·22	+ ·06	— ·08	+ ·07	+ ·21	+ ·02	+ ·10	·05	A1	A0	
82 325	11 02·2	82 17	+ ·66	—	—	—	+ ·55	+ ·94	+ ·65	·07	F8	G0	F8
86 161	11 02·5	86 11	+ ·19	+ ·21	+ ·20	+ ·23	+ ·20	+ ·32	+ ·21	± ·05	A5	A2	A3
88 64	04·2	88 11	— ·18	+ ·06	— ·01	— ·08	— ·22	— ·16	— ·09	·05	B9	B8	B9
85 183	24·4	85 15	+ ·91	+ ·89	—	+ ·85	+ 1·09	+ ·97	+ ·93	·05	G1	K0	G5
81 373	24·8	81 41	+ ·14	+ ·25	+ ·14	+ ·17	+ ·26	+ ·18	+ ·19	·05	A2	A0	A0
86 170	28·3	86 10	+ ·36	+ ·13	+ ·07	+ ·35	+ ·42	+ ·21	+ ·27	·05	A8	F0	A7
81 389	11 55·1	81 25	+ 1·64	+ 1·59	+ 1·39	+ 1·50	+ 1·42	+ 1·77	+ 1·53	± ·05	K8	Ma	M
86 176	11 59·7	86 09	+ ·53	+ ·49	+ ·48	+ ·43	+ ·62	+ ·47	+ ·51	·05	F5	F5	F3
82 356	12 06·5	82 16	+ 1·23	+ 1·66	—	+ 1·38	—	+ 1·63	+ 1·42	·06	K2	K0	G6
78 412	07·5	78 10	+ ·20	+ ·40	+ ·22	—	—	+ ·49	+ ·29	·06	A4	A5	
87 107	13·9	86 59	+ ·42	+ ·28	+ ·26	+ ·38	+ ·41	+ ·38	+ ·36	·05	F0	F2	F1
88 71	12 14·4	88 15	+ ·29	+ ·23	+ ·40	+ ·17	+ ·27	+ ·37	+ ·27	± ·05	F0	F0	
81 400	31·1	80 48	+ ·22	+ ·21	+ ·18	+ ·54	+ ·36	+ ·10	+ ·29	·05	A6	F2	A5
80 389	34·1	79 46	+ ·50	—	+ ·57	—	+ ·65	+ ·58	+ ·57	·06	F—Gp	G0	
86 182	34·6	86 17	+ ·16	+ ·19	+ ·11	+ ·18	+ ·30	+ ·34	+ ·19	·05	A3	F0	A2
84 286	37·8	84 12	+ ·48	+ ·58	+ ·30	+ ·55	—	+ ·81	+ ·50	·05	F5p	G0	G0
81 402	12 41·9	81 10	+ ·11	+ ·22	— ·03	+ ·07	—	+ ·17	+ ·10	± ·05	A3	A0	A2
83 369	53·2	83 04	+ 1·28	+ 1·26	—	+ 1·07	—	+ 1·22	+ 1·21	·06	G—K ±	K0	G6
81 412	58·6	81 25	+ ·76	+ ·67	—	+ ·88	+ ·81	+ ·70	+ ·77	·05	G0	G0	G7
86 187	12 59·7	86 25	+ ·37	+ ·32	—	—	—	+ ·34	+ ·35	·07	F2	F8	
80 404	13 11·2	80 11	+ 1·34	+ 1·23	—	—	—	+ 1·07	+ 1·27	·07	K0	K0	

B.D.	α 1900	δ 1900	I_{Yk} (10)	I_{Grw} (8)	I_{Ld} (7)	$I_{Gt.Pd}$ (8)	$I_{Pk.Kk}$ (7)	$I_{Grw.Hv}$ (2)	Mean	Mean error	Spectrum Yerkes	Spectrum Draper	Spectrum Gron.
°	h m	° ′											
81 416	13 11·5	81 00	+ 1·05	+ ·99	+ ·78	+ 1·01	+ 1·03	+ 1·02	+ ·98	± ·05	G3	G5	F4
85 222	18·7	85 17	+ ·40	+ ·35	—	+ ·58	+ ·40	+ ·33	+ ·43	·05	F5p	G0	
84 311	26·7	83 49	+ ·70	+ ·71	—	+ ·68	—	+ ·77	+ ·70	·06	F9	G5	G6 F5
80 421	42·2	80 42	+ 1·67	+ 1·65	—	—	—	+ 1·69	+ 1·16	·07	K5	K5	
83 397	45·2	83 15	+ ·95	+ 1·18	+ ·82	+ 1·04	—	+ ·96	+ 1·00	·05	G3	G5	G5
80 422	13 49·9	80 25	+ 1·05	+ 1·05	—	—	—	+ 1·01	+ 1·05	± ·07	G5	G5	
79 431	50·4	79 29	+ 1·24	—	—	—	+ 1·08	+ 1·60	+ 1·21	·07	G8	G5	
81 452	52·4	81 16	+ 1·30	+ 1·28	—	+ 1·17	+ 1·28	+ 1·24	+ 1·26	·05	K2	K0	G5
86 201	13 59·4	86 14	+ ·47	+ ·27	+ ·20	+ ·51	+ ·51	+ ·07	+ ·38	·05	F2	F0	
81 482	14 33·0	81 15	+ ·92	+ ·88	—	+ ·79	+ ·74	+ ·45	+ ·82	·05	G0	G5	
80 448	14 36·4	80 06	+ 1·48	+ 1·54	—	+ 1·40	+ 1·27	+ 1·90	+ 1·46	± ·05	K3	K0	
86 217	49·7	86 22	+ 1·02	+ 1·10	—	—	—	+ 1·14	+ 1·06	·07	G3	K0	K0
81 495	55·0	81 09	+ ·03	+ ·11	—	+ ·04	—	— ·18	+ ·04	·06	A1	A0	
83 431	14 57·0	82 55	+ ·71	+ ·60	+ ·36	+ ·60	—	+ ·67	+ ·59	·05	F8	G0	G6
84 335	15 01·7	84 20	+ 1·59	+ 1·46	—	—	—	+ 1·46	+ 1·52	·07	K2	K0	K0
87 143	15 09·4	87 37	+ 1·63	+ 1·53	—	—	—	+ 1·38	+ 1·56	± ·07	K5	K0	K0
81 517	36·0	81 06	+ 1·06	+ ·80	—	+ ·92	—	+ 1·05	+ ·94	·06	G2	K0	
82 463	38·1	82 36	+ ·24	+ ·14	+ ·48	+ ·41	+ ·40	+ ·25	+ ·32	·05	F0	F0	
85 263	42·5	85 09	+ 1·09	+ ·98	—	+ 1·09	+ 1·00	+ ·87	+ 1·03	·05	G1	K0	
81 523	42·9	80 56	+ ·98	+ ·91	—	+ 1·06	—	+ ·95	+ ·98	·06	G5 ±	G5	
80 487	15 45·1	80 18	+ ·42	+ ·25	—	+ ·31	+ ·41	+ ·34	+ ·35	± ·05	F0	F2	
81 531	51·4	81 14	+ 1·51	+ 1·58	—	—	—	+ 1·60	+ 1·55	·07	K5	K2	
83 453	53·8	83 15	+ ·20	+ ·11	+ ·35	+ ·21	+ ·29	+ ·07	+ ·22	·05	A3	A2	
85 269	15 57·4	85 35	+ ·25	+ ·16	—	+ ·12	+ ·14	— ·23	+ ·15	·05	A5	A5	
81 541	16 07·5	80 54	+ ·97	+ 1·01	—	—	—	+ 1·16	+ 1·01	·07	G ±	K0	
84 361	16 33·6	83 55	+ ·26	+ ·17	+ ·26	+ ·18	+ ·25	+ ·21	+ ·22	± ·05	A4	A2	
80 519	37·8	80 00	+ ·63	—	—	—	+ ·55	+ ·60	+ ·60	·07	F—G	G0	
82 498	16 56·2	82 12	+ ·59	+ ·91	+ ·84	+ ·84	—	+ 1·00	+ ·79	·05	G2	G5	
81 568	17 04·8	81 00	+ 1·11	+ ·96	—	+ 1·08	+ 1·00	+ 1·08	+ 1·05	·05	G5	G5	
80 544	27·2	80 14	+ 1·76	+ 1·62	—	+ 1·77	+ 1·59	+ 1·58	+ 1·69	·05	K5+	K2	
83 512	17 32·6	83 25	+ ·59	+ ·25	—	—	—	+ ·66	+ ·46	± ·07	F+	F8	
86 269	18 04·6	86 37	— ·16	+ ·12	+ ·13	— ·17	—	— ·85	— ·08	·05	B9	A0	B9
85 294	07·2	85 41	+ ·25	+ ·29	—	+ ·18	+ ·35	+ ·20	+ ·26	·05	A7	F0	
86 272	07·8	87 00	+ ·18	+ ·20	+ ·20	+ ·09	+ ·22	— ·06	+ ·17	·05	A0	A3	
82 540	22·9	82 54	— ·20	— ·22	— ·18	— ·11	— ·18	— ·14	— ·18	·05	B8	B9	
84 412	18 24·6	84 37	+ ·44	+ ·14	+ ·49	+ ·52	+ ·28	+ ·08	+ ·36	± ·05	F2	F2	
77 699	34·6	77 28	+ 1·33	+ 1·36	+* 1·21	—	—	+ 1·13	+ 1·26	·07	K2	K0	
83 535	36·4	83 18	+ 1·13	+ ·95	—	—	+ ·92	+ 1·10	+ 1·02	·06	G3	G5	
83 536	37·4	83 06	— ·03	+ ·13	— ·08	·00	— ·06	— ·01	— ·01	·05	A0	A2	
86 282	47·8	86 35	+ 1·69	+ 1·55	—	—	—	+ 1·62	+ 1·63	·07	M	Ma	K0
79 604	18 52·7	79 49	+ ·32	—	+ ·30	—	+ ·15	+ ·30	+ ·27	± ·06	A4	A5	
83 547	19 04·0	83 46	+ ·09	+ ·18	— ·03	·00	+ ·09	+ ·07	+ ·07	·05	A2	A2	A2
82 572	04·7	82 14	— ·03	— ·02	+ ·01	— ·01	— ·12	— ·13	— ·04	·05	B9	A0	
80 607	14·4	80 34	+ 1·07	+ ·77	—	—	+ ·91	+ ·87	+ ·92	·06	G0	K2	
80 609	15·5	80 35	+ ·20	+ ·04	—	+ ·36	+ ·08	+ ·18	+ ·17	·05	A2	A2	
88 112	19 22·5	88 59	+ 1·86	+ 1·48	—	—	+ 1·60	+ 1·76	+ 1·67	± ·06	M	Mb	M
79 628	27·8	79 24	— ·12	—	+ ·10	—	—	+ ·26	·00	·07	A2	A2	
83 552	19 28·0	83 16	+ ·17	+ ·22	+ ·06	+ ·06	+ ·08	+ ·48	+ ·14	·05	A2	A2	A1
77 764	20 12·2	77 25	— ·41	+ ·05	+ ·11	—	—	— ·92	— ·21	·06	B5	B9	
84 451	14·0	84 23	+ ·17	+ ·26	+ ·17	+ ·12	— ·03	+ ·27	+ ·15	·05	A2	A2	A0
81 699	20 15·6	81 55	+ ·48	+ ·23	—	+ ·55	+ ·51	+ ·43	+ ·44	± ·05	Fp	F5	
80 650	20·2	80 13	— ·11	— ·21	—	— ·05	— ·15	— ·23	— ·13	·05	B9	A0	
84 462	24·5	84 14	+ ·28	+ ·29	+ ·42	+ ·49	+ ·03	+ ·37	+ ·31	·05	A8	F0	F
84 463	24·6	84 49	+ ·59	+ ·46	+ ·46	+ ·62	+ ·59	+ ·50	+ ·54	·05	F5	F8	G
81 706	28·7	82 02	+ ·54	+ ·27	+ ·64	+ ·54	+ ·50	(— 1·24)	+ ·50	·05	F2	F5	F8
79 675	20 30·6	79 53	— ·14	—	—	—	— ·14	— ·20	— ·15	± ·07	A0	A0	A0
80 657	33·2	81 06	+ 1·10	+ ·99	+ 1·32	+ 1·19	+ 1·08	+ ·68	+ 1·11	·05	G4	K0	G3
82 617	34·4	82 50	+ 1·05	+ 1·01	+ 1·47	+ 1·07	+ ·84	+ 1·05	+ 1·08	·05	G2	G5	G4
80 659	34·5	81 05	+ 1·05	+ 1·12	+ 1·27	+ 1·25	+ 1·06	+ ·89	+ 1·13	·05	G4	K0	K0
80 660	35·2	80 45	+ 1·00	+ 1·00	+ 1·21	+ ·92	+ 1·09	+ ·92	+ 1·03	·05	G2	K0	K

* Ld only 2 measures, weight 3.

B.D.	α 1900	δ 1900	I_{Yk} (10)	I_{Grw} (8)	I_{Ld} (7)	$I_{Gt.Pd.}$ (8)	$I_{Pk.Kk}$ (7)	$I_{Grw.Hv}$ (2)	Mean	Mean error	Spectrum Yerkes	Spectrum Draper	Spectrum Gron.
°	h m	° ′											
83 588	20 39·1	83 17	+ ·16	+ ·26	+ ·26	+ ·01	+ ·20	+ ·36	+ ·18	± ·05	A2	A2	A1
78 716	40·0	78 05	— ·32	— ·57	— ·09	—	—	— ·43	— ·34	·06	B2	B3	
81 712	41·6	81 39	+ 1·19	+ 1·41	—	—	+ 1·27	+ 1·33	+ 1·29	·06	K±	K0	
81 718	49·8	82 10	— ·03	+ ·13	+ ·15	— ·18	—	— ·13	·00	·05	B8	A0	A0
80 672	20 52·1	80 11	+ 1·18	+ 1·21	+ 1·61	+ 1·35	—	+ ·98	+ 1·30	·05	G8	K0	K0
80 679	21 08·1	80 45	+ ·25	+ ·18	+ ·31	+ ·31	+ ·28	+ ·31	+ ·27	± ·05	A6	F0	F0
80 682	11·1	80 37	+ 1·36	+ 1·40	—	—	+ 1·29	+ 1·85	+ 1·39	·06	G—K±	K2	K
80 688	16·7	80 23	+ ·01	+ ·02	+ ·17	—	+ ·08	— ·03	+ ·06	·05	A1	A0	A1
80 690	17·5	80 49	+ ·16	+ ·07	+ ·20	+ ·03	—	+ ·25	+ ·12	·05	A2	A2	A0
86 319	19·6	86 37	— ·02	+ ·18	—	·00	— ·01	— ·02	+ ·03	·05	A2	A3	A0
83 603	21 21·5	83 50	+ 1·30	+ 1·36	—	—	+ 1·17	+ 1·24	+ 1·28	± ·06	K±	G5	G
79 707	27·8	80 05	+ ·78	—	+ 1·02	—	+ 1·21	+ ·85	+ ·84	·06	G1	K0	F
83 618	21 50·4	83 34	+ ·27	+ ·19	+ ·20	+ ·14	+ ·14	+ ·55	+ ·21	·05	A4	A5	A4
83 630	22 20·9	84 00	+ ·04	+ ·08	+ ·11	+ ·02	+ ·24	— ·18	+ ·08	·05	A1	A0	A0
85 383	21·3	85 36	— ·18	·00	— ·08	— ·02	—	— ·56	— ·10	·05	B8	A0	A1
85 384	22 21·7	85 43	+ 1·38	+ 1·32	+ 1·15	+ 1·15	+ 1·22	+ 1·13	+ 1·25	± ·05	K0	K0	K
81 775	23·7	81 26	+ ·53	+ ·24	+ ·28	—	+ ·39	+ ·19	+ ·36	05	F3	F2	
87 205	24·3	87 34	+ ·05	+ ·13	— ·09	+ ·18	+ ·10	+ ·03	+ ·07	·05	A2	A2	A
79 739	26·2	80 11	+ 1·19	—	+ 1·04	—	+ 1·11	+ 1·17	+ 1·13	·06	G6	K0	K0
80 731	39·2	80 52	+ ·78	+ ·66	+ ·53	+ ·73	+ ·73	+ ·69	+ ·69	·05	F5	F8 A5	A5
79 750	22 43·2	79 55	+ ·82	—	+ ·92	—	+ ·77	+ ·82	+ ·83	± ·06	G0	K0	
82 703	47·9	82 37	+ 1·50	+ 1·47	+ 1·51	+ 1·42	—	+ 1·32	+ 1·47	·05	K2	K0	K0
79 756	48·4	79 50	+ ·95	—	—	—	+ ·89	+ ·65	+ ·90	·07	G1	K0	
84 513	50·0	84 15	+ 1·10	+ 1·23	—	—	+ 1·10	+ 1·06	+ 1·14	·06	G5	K0	K
84 517	53·5	84 50	+ 1·51	+ 1·14	+ 1·38	+ 1·45	—	+ 1·29	+ 1·37	·05	K4	K5	K
83 640	22 55·2	83 49	+ 1·62	+ 1·70	+ 1·60	+ 1·58	—	+ 1·46	+ 1·62	± ·05	K6	K5	K0
79 761	22 59·5	80 15	+ ·22	+ ·16	+ ·21	+ ·19	+ ·36	+ ·12	+ ·22	·05	A5	A3	
79 769	23 05·5	80 02	+ ·12	—	+ ·08	+ ·17	+ ·10	+ ·06	+ ·12	·05	A3	A2	
85 399	24·4	85 52	+ ·29	+ ·31	+ ·19	+ ·35	+ ·10	+ ·16	+ ·25	·05	A6	F0	A8 G0
86 344	27·8	86 45	+ ·08	+ ·23	+ ·17	+ ·14	—	+ ·02	+ ·14	·05	A4	F0	F0
82 748	23 57·6	86 45	+ ·11	+ ·12	+ ·05	+ ·16	+ ·16	— ·06	+ ·11	± ·05	A0	A0	