Five-colour observations of 24 classical Cepheids

Walraven-Terlinden, J.H.; Tinbergen, J.; Walraven, T.

B.A.N. 17, no. 7, 520–536; *Communication from the Observatory at Leiden*

FIVE-COLOUR OBSERVATIONS OF 24 CLASSICAL CEPHEIDS

J. H. WALRAVEN*, J. TINBERGEN and TH. WALRAVEN*

Received October 5, 1964

This paper presents light-curves and colour-curves for 24 Cepheids, mostly of type I. The periods vary from 5^d to 79^d, but are mainly concentrated around 9^d.
The observations were made with the simultaneous five-channel photometer attached to the 36-inch "light-collector" of the Leiden Southern Station on the Departmental Grounds near Hartebeespoortdam, Transvaal, Republic of South Africa. The reduction took place at the Mount Stromlo Observatory of the Australian National University, Canberra A.C.T., Australia. The number of observations per Cepheid varies from 20 to 95. Each observation was accompanied by an observation of a nearby comparison star, while often standard stars were observed also.
Table 8 gives the variations of brightness and colours of the Cepheids relative to those of the comparison stars. Table 3 gives the brightness and colours of the comparison stars in the natural photometric system of the telescope. A conversion to the *UBV* system is given for V and $V - B$ only.
The properties of the light and colour variations of the Cepheids are discussed briefly in section 5. A discussion of the stability of the comparison stars and standard stars, using the observations of the previous years, will be found in section 4. Of the 28 comparison stars, chosen at random near the Cepheids, four were identified by us as supergiants of type F or G.

1. Introduction

While studying the results of simultaneous five-colour observations of early-type stars, it was noticed that appreciable effects of spectral class and luminosity can also be observed for supergiants of a somewhat later type. Consequently the need was felt for a more detailed and complete knowledge of the colours of the various types of supergiants in the five-colour system. For this purpose numerous supergiants, both in the Magellanic Clouds and in the Galaxy, were observed. This led to the study of a number of classical Cepheids, which provide another extension to the system of supergiants. The Cepheids are especially valuable for this purpose, since the observations of one variable during its cycle of variation are equivalent to the study of a sequence of stars of different spectral types, but otherwise under constant conditions such as distance and reddening and, it may be assumed, with nearly constant luminosity.

Our interest was directed mainly towards the more luminous Cepheids. These may form a continuation of the supergiants of classes Ia and Ib, which we had already observed. Since the most luminous Cepheids with the longest periods are rare, most of the programme stars have periods around 9 days. Since we considered an investigation of the homogeneity of the colours as more important, we restricted ourselves to stars of this group, rather than studying a wide variety of periods and various types of population. Another reason for concentrating on the 9-day period group was that the sharp change of shape in the light-curve takes place at about this period. It may well be that the detailed study of these shapes will lead us to a better definition of the luminosity class, which, in view of the use of Cepheids as distance indicators, is highly important.

* Mount Stromlo Observatory, Canberra, Australia.

2. Programme

The stars selected for detailed observation are listed in table 1. The periods and epochs have all been taken from the second General Catalogue of Variable Stars (KUKARKIN *et al.*, 1958).

The two longer-period variables KN Cen and QT CrA were included in the programme at a later stage and have not been observed intensively. Likewise some variables of other types were included in the programme originally, but were abandoned soon after the observations were started, when it became apparent that no time would be available for these stars in a regular programme. The results of these observations are not discussed in this paper and these stars are not included in table 1. Only one star of a different type, i.e. Kappa Pav, was kept on the list.

Table 1

Cepheids and comparison stars

CEPHEID	P	J.D. 2 400 000 +	R.A. 1960	DEC. 1960	N	HD	R.A. 1960	DEC. 1960	N	REMARKS
V381 Cen	5ᵈ.07878	34932.29	13ʰ48ᵐ02ˢ	-57°23′.0	69	120 459	13ʰ48ᵐ25ˢ	-57°16′.6	34	
V636 Sco	6.79663	34906.47	17 19 50	-45 34.8	81	156 623	17 17 54	-45 22.8	41	
R Mus	7.50990	34847.38	12 39 35	-69 11.3	84	110 080	12 38 03	-70 19.6	28	
						110 716	12 42 33	-68 36.7	16	
IT Car	7.5356	24214.92	11 10 27	-60 32.3	57	97 670	11 11 46	-59 24.1	43	
W Sgr	7.594710	34587.26	18 02 28	-29 35.2	69	164 972	18 02 30	-25 36.6	32	
						165 118	18 03 07	-29 16.9	30	
ER Car	7.717806	26777.62	11 07 58	-58 37.2	56	97 670	11 11 46	-59 24.1	43	1
						97 093	11 08 02	-58 29.0	12	
						97 000	11 07 28	-58 30.0	12	
IQ Nor	8.2317	34234.3	15 09 49	-54 36.5	95	134 600	15 10 02	-54 36.3	34	
							15 09 04	-54 36.3	34	
S Sge	8.38216	33131.80	19 54 13	+16 31.6	27	189 090	19 55 55	+16 40.8	15	
V500 Sco	9.31665	34925.64	17 46 04	-30 28.0	55	161 665	17 45 40	-32 39.5	26	
SX Vel	9.54993	21015.95	8 43 32	-46 11.8	75	74 868	8 43 28	-44 23.9	28	
						75 026	8 44 31	-46 08.8	19	
YZ Sgr	9.55345	34931.42	18 47 10	-16 46.3	48	174 467	18 49 00	-17 12.2	26	
S Mus	9.65869	34580.62	12 10 35	-69 55.7	82	105 119	12 04 03	-68 54.2	40	
S Nor	9.75418	34586.39	16 15 31	-57 48.4	81	145 782	16 12 31	-57 48.8	40	2
AQ Car	9.77014	23967.41	10 20 01	-60 52.2	47	90 454	10 23 32	-58 22.4	49	
XX Cen	10.956130	19846.821	13 37 39	-57 24.8	82	119 020	13 39 38	-58 25.1	43	
UU Mus	11.63641	34835.12	11 50 18	-65 10.8	66	103 338	11 51 45	-65 04.0	32	
XY Car	12.43519	23074.034	11 00 40	-64 02.8	46	95 752	11 00 14	-64 05.3	56	
SV Vel	14.09707	34869.92	10 43 20	-56 04.7	66	93 563	10 45 20	-56 32.8	28	
						93 319	10 43 42	-56 12.9	11	
XX Car	15.71624	34917.03	10 55 37	-64 55.2	51	95 752	11 00 14	-64 05.3	56	3
XZ Car	16.6499	20304.64	11 02 34	-60 45.8	41	96 829	11 06 25	-60 36.5	21	
YZ Car	18.1631	34907.04	10 26 49	-59 08.7	44	90 454	10 23 32	-58 22.4	49	4
WZ Sgr	21.849708	24625.350	18 14 47	-19 05.5	34	167 499	18 14 04	-16 49.0	16	
KN Cen	34.019	35247.63	13 33 58	-64 22.0	20	118 294	13 35 17	-66 02.0	8	
QT CrA	79.145	26550.	18 06 35	-40 12.6	24	166 618	18 10 43	-41 24.0	11	
Kappa Pav	9.0696	34693.11	18 52 51	-67 17.4	31	174 787	18 53 15	-66 23.1	17	5

1. Cf. IT Car
2. In cluster NGC 6087
3. Cf. XY Car
4. Cf. AQ Car
5. Population II cepheid

The criteria used to select the comparison stars were proximity to the variable, matching brightness, and sufficient ultraviolet intensity. The latter consideration meant that stars of type K and M were excluded. The comparison stars are also listed in table 1. The programme included occasional observations of main standards for calibration purposes.

Only the first half of the night was available for the Cepheid programme, the other half being devoted to observations of the Magellanic Clouds. As a rule no observations were made in the week around full Moon; although at the time this was considered a welcome rest, the lack of these observations was regretted later.

No attempt was made to determine in advance the phase of the variable, but the observations were made at random times.

3. Observations

As described in an earlier publication (Th. and J. H. Walraven, 1960), the five-colour photometer yields simultaneous measurements in five wavelength regions with an integration time of one minute. This integration time could not be varied and the variations in light intensity were taken up mostly by changing the attenuation in the recording devices (10 steps of $0^m.5$) or by changing the integrating capacitors (1 step of $2^m.5$). A neutral optical attenuator could be switched in for the brighter stars, reducing the light by nearly three magnitudes.

The greatest loss of observing time was due to the necessity to connect each of the five channels in turn to the recording potentiometer. Since this is done manually, it takes about one minute, as much as the integration time itself. During the minute of integration, the coordinates of the star under observation were noted down and the controls of the telescope preset to the coordinates of the star to be observed next.

As a rule a Cepheid was observed twice, once before and once after the comparison star. Now and again during the night, main standards were observed in the usual way, i.e. three or four stars at widely different hour angles, observed one after the other, so that the extinction coefficient could be determined. At a later period this standard procedure was neglected somewhat and we made supplementary determinations of the extinction from the many observations of the comparison stars.

4. Reduction

For normal programmes the reduction of the observations consists of the following steps:

a) Reading the deflections on the Brown recorder chart.

b) Multiplication by the attenuation factor.

c) Subtraction of the sky background.

d) Determination of the logarithms of intensity.

e) Determination of the difference between the logarithms of intensities in the different wavelength bands.

f) Determination of the extinction coefficients for brightness and colours by comparison of standard stars at large and small zenith distances.

g) Reduction of the brightness and colours to zenith.

h) Plotting, for each night, the deviations from the standard values for the known standard stars against time. These deviations are produced by so far unknown instrumental effects.

i) Drawing smooth curves (the "instrumental curves") through these plots.

j) Correction of the observations of other stars with the values read off these "instrumental curves".

Due to the enormous observing capacity of the telescope, these reductions are very time-consuming. In the case of the Cepheids we therefore applied a shortened procedure. The determinations of the extinction were omitted and constant average values were used. These values are given in the table below.

Extinction coefficient
(logarithm of intensity)

V	$V-B$	$B-U$	$U-W$	$B-L$
0.100	0.065	0.110	0.175	0.065

These average values are based on the results of other programmes, which proceeded in the normal way described above. The brightness and colours of the Cepheids were determined relative to the comparison stars, so that the correction mentioned above under g) could be omitted.

The brightness and colours of the comparison stars were determined by the normal method described above, except that the constant average values of the extinction coefficients were used. This method can be applied only to those nights where a sufficient number of main standard stars with known brightness and colours were observed. The number of such determinations of the brightness and colours of the comparison stars varies between nine and zero.

Using the mean preliminary values of the comparison stars in addition to those of the standard stars, we constructed for every observing night new instrumental curves, now with more comprehensive data. Using these, we obtained new values of brightness and colours, now for all observations. These values were plotted against the data for all comparison stars and standards in order to detect signs of possible variability.

The diagrams show remarkable conformity. In all cases the scatter in the brightness is considerably larger than that in the colours. Moreover the scatter is consistently the same for all the stars, increasing only when the signals become fainter. No indication of variability could be found amongst the comparison stars. Obviously the atmospheric disturbances and instrumental effects produce most of the scatter, while for the faint stars the random fluctuations in the photocurrent become more important.

Table 2 lists the mean value of the deviation for one

TABLE 2
Mean absolute deviation for some standard stars

HD	V	V-B	B-U	U-W	B-L
74 575	.0034	.0017	.0016	.0019	.0014
104 337	.0064	.0020	.0019	.0020	.0017
135 382	.0061	.0018	.0029	.0025	.0017
144 470	.0055	.0020	.0018	.0021	.0018
164 402	.0045	.0016	.0014	.0016	.0011
178 175	.0103	.0020	.0046	.0023	.0027

observation, for some standard stars. It should be noted that the mean deviation shown in the table is still larger than necessary, because a constant value of extinction has been assumed and also because iteration of the procedure starting from h) with the new mean values would certainly have reduced the scatter. However, it seems superfluous to repeat the procedure when we consider the difference between the preliminary values and the new values which we derived. The mean absolute value of this difference for all 28 comparison stars, expressed in logarithm of intensity, is shown in the table below.

V	$V-B$	$B-U$	$U-W$	$B-L$
0.0038	0.0008	0.0009	0.0020	0.0008

These figures represent primarily the errors of the preliminary values of the brightness and colours, since they are larger than one would expect from the data in table 2. The large value for $U-W$ is due to the fact that the comparison stars of the Cepheids are on the average of a later spectral type than the standards and therefore have a very low intensity in the ultraviolet. On the whole, however, the differences between the preliminary and new values are sufficiently small and we decided not to repeat the procedure, but to consider the new values as definite. They are given in table 3 and are discussed at the end of this paper.

In table 4 we give the brightness and the colours of the standard stars, determined in the same way as those of the comparison stars of the Cepheids. In this table are also given the preliminary values used, which are based on the reductions of observations of preceding years and have much more significance. These

TABLE 3

Brightness and colours of comparison stars

HD	V_J	$(B-V)_J$	SP	V	V-B	B-U	U-W	B-L	N
74 868	6.54	.555	G3 IV	0.121	.2323	.3456	.1999	.2674	28
75 026	8.00	.194	B3	-0.456	.0808	.2569	.1185	.0720	19
90 454	5.91	.320	FO	0.377	.1318	.4353	.1863	.2116	49
93 563	5.13	-.074	B8	0.698	-.0226	.2637	.0728	.0569	28
93 319	8.40	.986	KO	-0.632	.4300	.5232	.3208	.4613	11
95 752	6.93	.476	FO	-0.034	.1984	.6150	.3613	.1870	56
96 829	7.31	.253	B8	-0.181	.1047	.0635	.0582	.0280	21
97 670	5.73	-.090	B3	0.458	-.0273	.0532	.0110	.0006	43
97 093	8.69	.020	A2	-0.729	.0112	.4211	.1050	.1386	12
97 000	7.93	.080	A2	-0.426	.0348	.4628	.1592	.1432	12
103 338	7.48	.158	B5	-0.248	.0663	.1077	.0561	.0309	32
105 119	7.16	.569	GO	-0.128	.2386	.3411	.1996	.2529	40
110 080	7.39	.252	AO	-0.214	.1045	.4835	.1601	.2151	28
110 716	6.15	.687	GO	0.273	.2909	.5299	.3259	.2866	16
118 294	8.51	.345	A3	-0.662	.1418	.4644	.1859	.2114	8
119 020	7.90	.229	FO	-0.418	.0948	.4355	.1622	.2016	43
120 459	7.95	.204	A2	-0.437	.0847	.5068	.1766	.1890	34
134 600	10.26	.060	AO	-1.356	.0268	.3790	.0857	.1399	34
*	10.43	.562	-	-1.435	.2357	.3697	.1992	.2383	34
145 782	5.61	.137	A2	0.502	.0580	.4852	.1495	.1883	40
156 623	7.23	.086	AO	-0.146	.0373	.4276	.1021	.1950	41
161 756	6.37	.151	B3	0.198	.0634	.1730	.0642	.0640	4
161 665	7.33	.138	A2	-0.188	.0581	.4326	.1299	.2078	26
164 972	7.17	.508	FO	-0.132	.2123	.5450	.2977	.2422	32
165 118	7.27	.087	A2	-0.162	.0377	.4417	.1177	.1942	30
166 618	9.31	.186	A3	-0.982	.0776	.4844	.1637	.2006	11
166 162	9.67	.556	F5	-1.132	.2331	.4066	.2200	.2297	44
165 244	7.32	.275	A5	-0.188	.1140	.4458	.1604	.2225	45
167 499	9.02	.174	AO	-0.865	.0727	.4578	.1375	.1738	16
174 467	6.83	.304	AO	0.009	.1254	.5666	.2794	.1512	26
174 787	7.61	.332	FO	-0.302	.1371	.3535	.1520	.1846	17
177 171	5.17	.533	GO	0.671	.2272	.3316	.2037	.2232	73
189 090	5.55	-.048	B9	0.528	-.0136	.3592	.0845	.1137	15

* COORDINATES 1960: R.A. $15^h\ 09^m\ 40^s$, DEC. $-54°\ 36'.3$

TABLE 4

Brightness and colours of standard stars: adopted standard values (1961) and results of Cepheid programme (1962)

HD	YEAR	V	V-B	B-U	U-W	B-L	N
74 575	1962 1961	+1.288 +1.287	-.0536 -.0539	-.0140 -.0151	-.0168 -.0182	-.0234 -.0219	45 -
93 030	1962 1961	+1.661 +1.661	-.0717 -.0717	-.0706 -.0731	-.0437 -.0433	-.0451 -.0463	8 -
104 337	1962 1961	+0.650 +0.649	-.0637 -.0646	-.0056 -.0044	-.0177 -.0178	-.0164 -.0155	95 -
122 980	1962 1961	+1.016 +1.010	-.0643 -.0694	+.0310 +.0330	-.0166 -.0181	+.0035 +.0048	9 -
135 382	1962 1961	+1.598 +1.594	+.0125 +.0126	+.4516 +.4537	+.1329 +.1305	+.1287 +.1292	32 -
144 470	1962 1961	+1.174 +1.172	+.0025 +.0020	+.0004 +.0002	+.0010 +.0008	+.0020 +.0011	63 -
164 402	1962 1961	+0.458 +0.453	+.0072 +.0078	-.0348 -.0358	-.0001 -.0012	-.0155 -.0161	24 -
61 068 *	1962 1961	+0.498 +0.476	-.0548 -.0566	-.0117 -.0128	-.0286 -.0204	-.0166 -.0167	8 -
178 175 **	1962 1961	+0.524 +0.560	-.0149 -.0129	+.0782 +.0698	+.0143 +.0190	+.0176 +.0134	28 -

* SEC Z > 2.00
** VARIABLE

values form the link by which the colours of the Cepheids are finally connected with those of the super-giants of another programme. They have been obtained by a process of repeated approximation which included the closing of a belt of such standards around the sky. The final results for these standards can be obtained only by a discussion of all the observations, which is not given in this paper.

In table 5 we show the differences between the adopted values (1961) and the values derived from the Cepheid programme (1962) in the sense 1962 minus 1961. The differences are similar to those for the Cepheid comparison stars, but reveal a systematic component, which is shown in the last line of table 5. Since the reduction procedure used is such that we should find back the values that were originally used, there must be some external cause for this systematic deviation. It seems probable that variability of one of the standard stars, HD 178 175, is responsible for it, because for this star the discrepancy between 1962 and 1961 is appreciable (see table 4).

This is illustrated more clearly in table 6, where the differences 1962 – 1961 have been corrected with the systematic value of table 5. The table shows, that HD 178 175 has decreased in brightness, has become bluer in the $V-B$ and $U-W$, and redder in the $B-U$ and $B-L$. The most strongly varying colour is $B-U$. A similar effect has been found also for other stars in the B star programme, in each case the colour $B-U$ varying most, $V-B$ somewhat less, but in opposite sense, while the changes in colour are accompanied by relatively

TABLE 5

Differences (1962 – 1961) of brightness and colours of standard stars

HD	V	V-B	B-U	U-W	B-L	N
61 068	.0005	.0000	.0025	-.0004	.0012	8
74 575	.0011	.0003	.0011	.0014	-.0015	45
104 337	.0011	.0009	-.0012	.0001	-.0009	95
122 980	.0063	.0021	-.0020	.0015	-.0013	9
135 382	.0041	-.0001	-.0021	.0024	-.0005	32
144 470	.0021	.0005	.0002	.0002	.0009	63
164 402	.0054	-.0006	.0010	.0011	.0006	24
WEIGHTED MEAN	.0022	.0005	-.0003	.0007	-.0004	

small changes in brightness. In one case, HD 20 340, the variation in $B-U$ amounts to $0^m.07$, but in many other cases the variations are only of the order of $0^m.01$ and their reality could only be suspected. It is an important result of the present discussion that a variation in the colour $B-U$ of only $0^m.02$ is established with certainty. We have the impression that the variation is always in the same sense as for HD 178 175. So far the effect has only been noted for B stars.

Apart from these cases of colour variability, the colours of the stars are in general surprisingly stable, as is shown by the values in table 6.

TABLE 6
Final differences (1962 − 1961) of brightness and colours of standard stars

HD	V	V-B	B-U	U-W	B-L	N
61 068	-.0017	-.0005	.0028	-.0011	.0016	8
74 575	-.0011	-.0002	.0014	.0007	-.0011	45
104 337	-.0011	.0004	-.0009	-.0006	-.0005	95
122 980	.0041	.0016	-.0017	.0008	-.0009	9
135 382	.0019	-.0006	-.0018	.0017	-.0001	32
144 470	-.0001	.0000	.0005	-.0005	.0013	63
164 402	.0032	-.0011	.0013	.0004	.0010	24
178 175	-.0384	-.0025	.0087	-.0054	.0046	28

The unweighted means, without regard to sign, of the residuals shown in table 6, excluding HD 178 175, are:

	V	$V-B$	$B-U$	$U-W$	$B-L$
Log intensity	0.0019	0.0006	0.0015	0.0008	0.0009
Magnitudes	$0^m.0047$	$0^m.0015$	$0^m.0038$	$0^m.0020$	$0^m.0022$

These values are larger than would be expected from the mean error of observation, as shown in table 2. Rather than being due to instrumental errors, they seem to reflect the intrinsic changes in brightness and colours of the stars over a period of a year. This is supported by the fact that the character of the fluctuations is different in the two cases; the instrumental errors are smallest for the colour $B-L$, while the intrinsic variations are smallest for $V-B$.

Independent of whether the deviations are due to an intrinsic or an instrumental cause, it may be concluded that the colours of stars in general do not vary by more than a few thousandths of a magnitude.

So far we have discussed the brightness and colours of the comparison and standard stars only as they are determined from the observations, i.e. the natural values for the instrument. The reason for this is that it turned out to be rather difficult to transform our colours to those of standard photometric systems such as the *UBV* system. Such transformations are non-linear and multivalued. For $B-L$ and $U-W$ no comparison exists, while for $U-B$ the transformation is very complicated. The comparison of $V-B$ with $(B-V)_J$ of the *UBV* system is the only one worth while, although even here the relation is strongly non-linear and multivalued. The cause of this complication is that the spectral regions used in the *UBV* system are too wide. For the band U, which contains the Balmer discontinuity, this is obvious, but for the band B, which includes the region containing the higher members of the Balmer series, the undesirable effects are perceptible too.

Instead of forcing our colours into an unsatisfactory transformation, we decided to discuss the results in terms of natural colours. In order to make the confusion with colours of other systems less likely, we give the results not in magnitudes, but as logarithms of intensity. However, to make possible at least a rough comparison of our results with those obtained by other types of photometry, we give the two transformations which have reasonable accuracy.

By comparing our observations of about 240, mostly bright, field stars with those made at the Royal Observatory at the Cape (1963), and with some other sources, we found the following preliminary relations.

The relation between the V_J magnitude in the *UBV* system and our brightness V is

$$V_J = 6.87 - 2.5[V + 0.05(V-B)].$$

The relation between $(B-V)_J$ and $V-B$ is strongly nonlinear, viz. we find both the very blue and the very red stars to be redder than in the *UBV* system. The deviation reaches $0^m.08$ for the bluest O stars and $0^m.25$ for M-type stars. The transformation is given in table 7.

In this table may be noted the gradual changes from Orion stars to supergiants, due to the decreasing strength of the hydrogen lines included in the band B of the *UBV* system but not in our band B. The table gives the magnitudes to three decimal places; the actual accuracy is difficult to estimate and varies for the

TABLE 7

Transformation for $V-B$ of the five-colour system to $(B-V)_J$ of the UBV system

V-B		(B-V)J MAGNITUDES		
LOG INT	2.5 LOG INT	ORION STARS	FIELD STARS	SUPER-GIANTS
-0.1000	-0.250	-0.329	-0.329	
-0.0900	-0.225	-0.295	-0.295	
-0.0800	-0.200	-0.262	-0.262	
-0.0700	-0.175	-0.229	-0.229	
-0.0600	-0.150	-0.189	-0.195	
-0.0500	-0.125	-0.148	-0.162	
-0.0400	-0.100	-0.110	-0.130	
-0.0300	-0.075	-0.078	-0.098	
-0.0200	-0.050	-0.050	-0.068	-0.078
-0.0100	-0.025	-0.025	-0.038	-0.051
0.0000	0.000	0.000	-0.010	-0.025
0.0100	0.025		0.017	-0.002
0.0200	0.050		0.042	0.028
0.0300	0.075		0.067	0.054
0.0400	0.100		0.092	0.080
0.0500	0.125		0.117	0.106
0.0600	0.150		0.142	0.132
0.0700	0.175		0.167	0.158
0.0800	0.200		0.192	0.182
0.0900	0.225		0.217	0.208
0.1000	0.250		0.241	0.232
0.1500	0.375		0.365	0.358
0.2000	0.500		0.480	0.478
0.2500	0.625		0.595	0.595
0.3000	0.750		0.708	0.708
0.3500	0.875		0.816	0.816
0.4000	1.000		0.924	0.924
0.4500	1.125		1.029	1.029
0.5000	1.250		1.132	1.132
0.5500	1.375		1.235	1.235
0.6000	1.500		1.334	1.334
0.6500	1.625		1.432	1.432
0.7000	1.750		1.528	1.528
0.7500	1.875			1.625

different parts of the table. In particular the supergiants showed a larger scatter in the comparison, which probably indicates a tendency to instability in these stars.

The transformations were applied to the V and $V-B$ of the Cepheid comparison stars and the results are given in table 3 as V_J and $(B-V)_J$.

5. Discussion

The brightness and colours of the Cepheids are given in table 8 at the end of this paper. The values are given as logarithms of intensity and represent the difference between the Cepheid and the comparison star. The brightness and colour of the latter in the natural photometric system may be found in table 3. By adding these values to those in table 8, the brightness and colours of the Cepheids may be found, also in the natural photometric system. By means of the transformations given in the previous section, the brightness V and the colour $V-B$ may be translated into the UBV system.

It may be remarked here that the nonlinearity of the transformation has serious consequences for the discussion of the properties of the Cepheids. This should be kept in mind if the results in this paper are compared with the observations of Cepheids in the UBV system. For example a typical unreddened Cepheid may vary in $V-B$ from $+0.2000$ to $+0.4000$, i.e. over a range of 0.50 magnitude. According to table 7 the range in $(B-V)_J$ would be 0.45 magnitude, which is considerably less. If the same star is reddened by 0.5 magnitude, the range in $(B-V)_J$ would decrease to 0.41 magnitude. Here again we see the influence of the wide band of the UBV system. In this case the increasing strength of the metallic lines may be responsible for a considerable displacement of the effective wavelength. The apparent reduction of the amplitude is relative to the five-colour system, where the displacement of effective wavelength is much smaller. However, even in the five-colour system a small effect of the same kind may be present compared to the ideal system. It is difficult to estimate the strength of any such effect, but if present, it will make the discrepancies in the UBV system still larger.

A general discussion of the colours will be included in a forthcoming paper on the intrinsic colours of supergiants in the five-colour system. In the present paper we restrict ourselves to presenting the variations with phase of the brightness and colour, together with a few comments. The light-curves and colour-curves are shown in figures 1 to 23. The curves for KN Cen and QT CrA are not shown, because the limited number of observations did not permit us to study the shape of their curves to the same extent as those of the other stars. Curves of the colour $U-W$ are not shown; except for a few bright stars, the accuracy for this colour is very low, due to the extreme weakness of the far ultraviolet (band W) for later type stars. In those cases where the accuracy is better, it appears that the amplitude variation in colour $U-W$ is rather small. In figures 1 to 22 we have drawn a smooth line through the dots representing the individual observations. In cases where uncertainty exists, a broken line has been drawn. In the case of S Sge ($P = 8^d.38216$), only a limited number of observations exist and the line drawn in figure 8 was given approximately the same shape as that in figure 7 (IQ Nor, a Cepheid of similar period: $P = 8^d.2317$). For Kappa Pav, an abnormal Cepheid, no such comparison was available and the curves are very uncertain. The vertical lines denote zero phase (maximum brightness) according to the ephemerides given in table 1, which were taken from the second General Catalogue of Variable Stars (KUKARKIN *et al.*, 1958). Clearly some of the ephemerides need revision. A study of figures 1 to 23 leads to the following general remarks:

a) The scatter is not unduly large for any of the Cepheids. In the case of S Nor, a number of observations of previous years were available which fit the curves remarkably well. The deviations do not exceed the scatter of the other points in figure 13. In general the classical Cepheids seem to repeat their variations with high regularity.

b) The changes in character of the curves for $B - V$ relative to those for V (and of $B - L$ relative to $V - B$ and so on) are similar for all stars. The curve for $V - B$ is shifted to an earlier phase relative to V. This is a well known effect of the classical Cepheids and has been interpreted as evidence of variation in the radius of the star. In the curve for $B - U$, which on the whole is rather flat, a hump often shows at the phase of increasing brightness. Consequently the relation between $B - U$ and $V - B$ is not singlevalued. The same effect, to a lesser extent, is seen in the comparison of $B - L$ with $V - B$. It presents itself as a shift in phase, $B - L$ coming earlier, and as a slight bulging upward of the ascending part of the curve for $B - L$.

In the colour-colour diagrams the Cepheids describe a rather elongated loop. Our observations show that this a a general property of the Cepheids.

c) The variation in the colour $B - L$ is remarkably strong, considering that the difference in effective frequency between bands B and L is much smaller than that between V and B. On the other hand, the amplitude of $B - U$ is smaller than would be expected from the change in temperature gradient.

It is interesting to compare this behaviour with that shown by variables with very short periods (J. PONSEN, 1961, 1963) e.g. V 703 Sco, RS Grus, EH Lib, BS Aqr, AI Vel (unpublished). The curve for $B - U$ for these stars resembles the curve for $V - B$, inverted, while $B - L$ shows hardly any variation. These differences in behaviour are to be expected, if one notes that in the colour-colour diagram the narrow closed loop described by the variable lies along a line of constant luminosity.

d) Figures 1 to 22 strongly suggest that the humps on the light-curves are a normal aspect of the classical Cepheids. Except that they tend to weaken when the amplitude is smaller than normal for the period, they are strongly pronounced in all light-curves for periods around 9 days. Their position and amplitude show a pronounced systematic relation with the period. The Cepheids V 500 Sco ($P = 9^d.31665$) and YZ Sgr ($P = 9^d.55345$) show, within the errors of observation, identical curves for V, and for $B - L$, $V - B$ and $B - U$. Likewise the behaviour of S Nor is practically identical with that of AQ Car in all respects.

All this gives the impression of regularity, so that there is no reason to classify the Cepheids in groups according to the character of the humps. In fact only S Mus ($P = 9^d.65869$) stands out clearly from the general pattern. This star is abnormal in the following respects (figure 12):

a) The amplitude is small, while the humps are clearly pronounced.

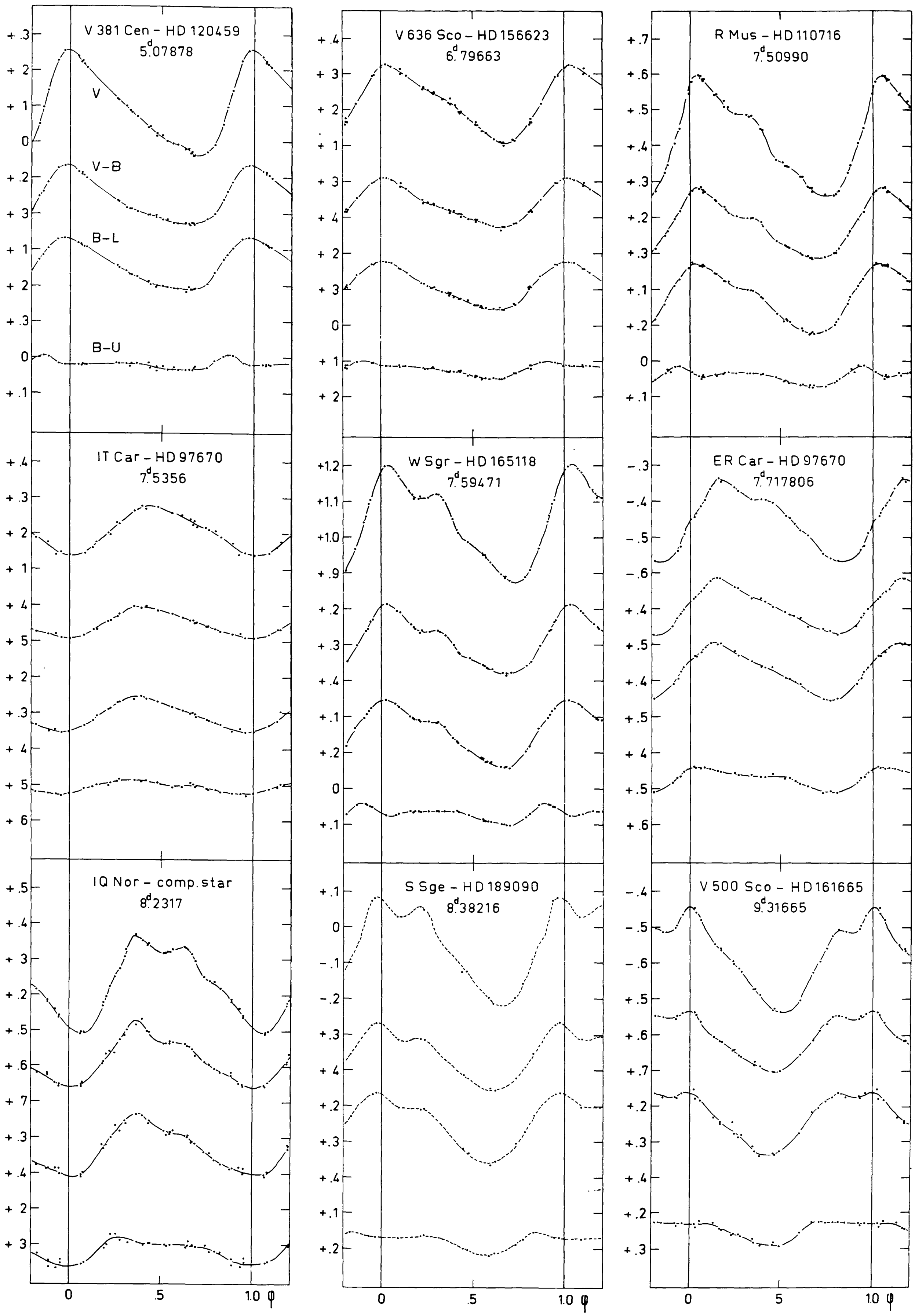
b) The colour-curve $B - U$ is unlike that of other stars of the same period.

c) The intrinsic colours are abnormal as regards position in the colour-colour diagrams.

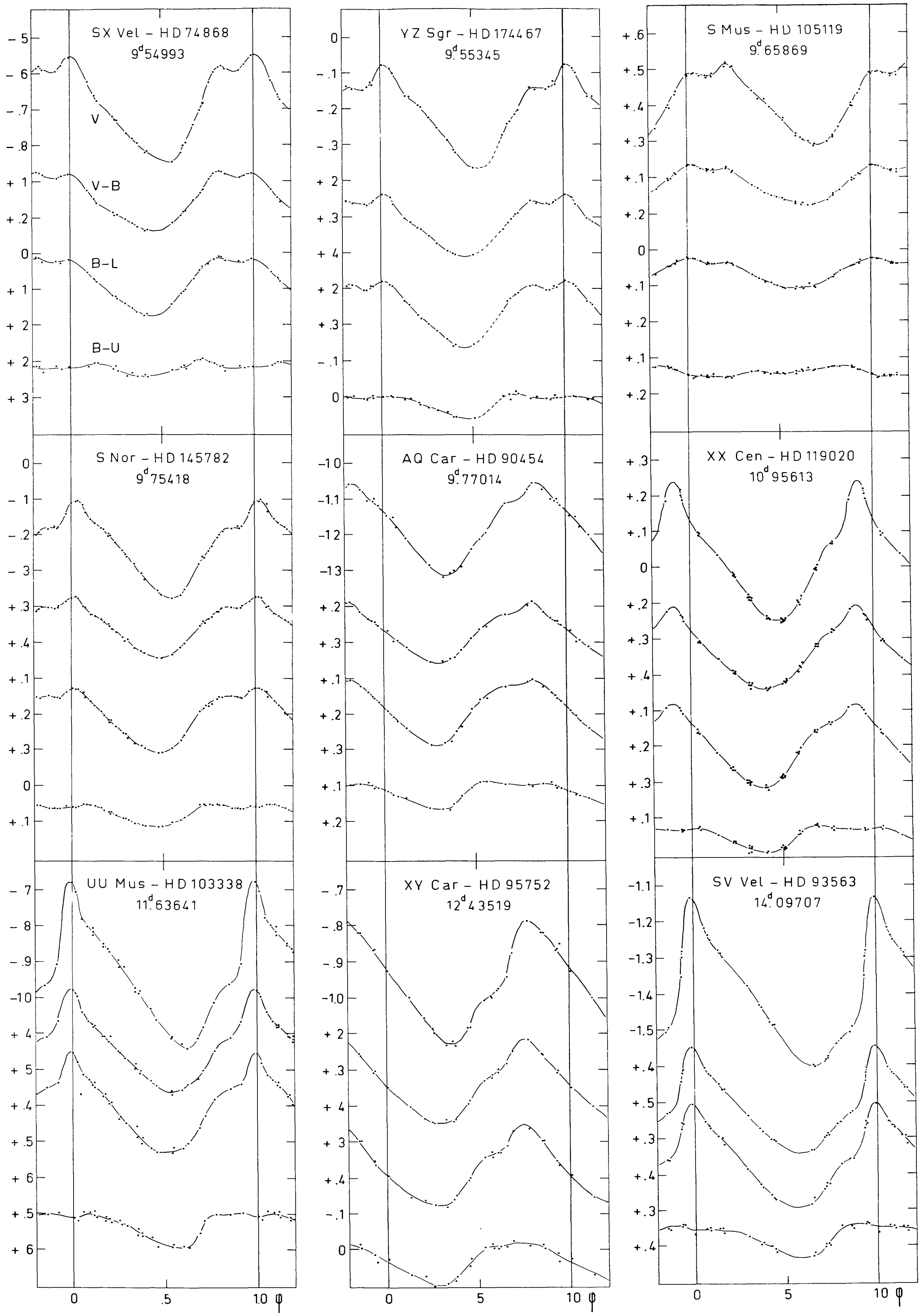
d) The intrinsic colours are abnormal as regards the tilt of the loops in the colour-colour diagrams.

With its abnormal behaviour S Mus stands out from all the other Cepheids observed by us (except of course Kappa Pav). The most probable explanation for this abnormality is the assumption that this star has an invisible companion.

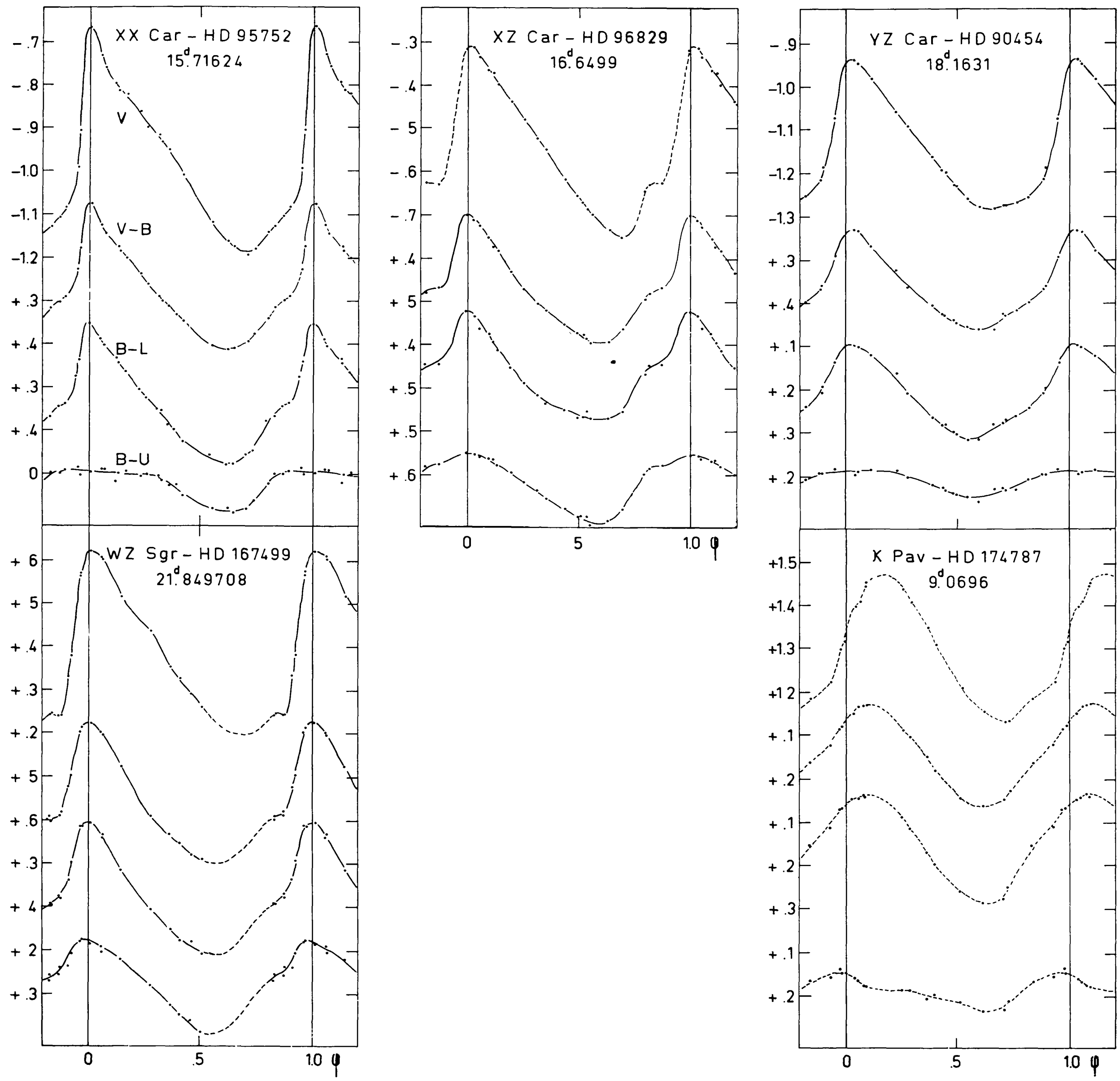
A remark could be made about some of the comparison stars. As described in the previous section, these stars were chosen at random, in the vicinity of the Cepheids. Four of the 28 comparison stars are F or G-type supergiants. This fraction is somewhat larger than one would expect. It might be interesting to in-



Figures 1–9. Light-curves and colour-curves of Cepheids. V, $V - B$, $B - L$ and $B - U$ are expressed in logarithms of intensity.



Figures 10–18. Light-curves and colour-curves of Cepheids. V, $V-B$, $B-L$ and $B-U$ are expressed in logarithms of intensity.



Figures 19–23. Light-curves and colour-curves of Cepheids. *V*, *V* – *B*, *B* – *L* and *B* – *U* are expressed in logarithms of intensity.

vestigate whether the numbers of supergiants are normally under-estimated, either in general or perhaps in the vicinity of Cepheids. The four stars, whose supergiant character is established beyond any doubt from the colours *U* – *W* and *B* – *L*, are

HD 95752	GC 15166	6.^m96	F0	(near XX and XY Car)
HD 110716	GC 17325	6.34	G0	(near R Mus)
HD 164972	GC 24603	7.25	F0	(near W Sgr)
HD 174467	GC 25852	6.70	A0	(near YZ Sgr).

TABLE 8

Brightness and colours of 24 Cepheids relative to their comparison stars

J. D.: Julian Day + 2 437 000
PHASE: Phase, computed from KUKARKIN *et al.*, 1958
V, $V-B$, $B-U$, $U-W$ and $B-L$ are expressed in logarithms of intensity

Acknowledgement

We conclude our paper with an expression of gratitude to Professor Bart J. Bok, Head of the Department of Astronomy of the Australian National University, for making available to us all the facilities of the Observatory at Mount Stromlo, including time on the IBM 1620 computer of the Australian National University, which greatly increased the speed of the reductions.

References

B. V. KUKARKIN, P. P. PARENAGO, YU. I. EFREMOV and P. N. KHOLOPOV, 1958, *General Catalogue of Variable Stars*, 2nd Edition (U.S.S.R. Academy of Sciences, Moscow)

J. PONSEN, 1961, *B.A.N.* **15** 325 (No. 508)

J. PONSEN, 1963, *B.A.N.* **17** 29

TH. WALRAVEN and J. H. WALRAVEN, 1960, *B.A.N.* **15** 67 (No. 496)

V 381 Cen - HD 120 459

J.D.	PHASE	V	V-B	B-U	U-W	B-L
798.38	564.326	.0905	.2842	.0229	.1876	.1670
803.36	565.307	.1023	.2827	.0182	.1500	.1578
804.35	565.502	.0206	.3178	.0244	.2076	.1978
807.35	566.093	.2076	.2008	.0199	.1529	.0912
812.36	567.079	.2181	.1953	.0189	.1517	.0901
814.35	567.471	.0291	.3113	.0257	.1874	.1981
815.37	567.672	-.0374	.3284	.0290	.1904	.2093
817.36	568.064	.2222	.1902	.0197	.1555	.0870
818.35	568.259	.1216	.2638	.0142	.1773	.1422
820.37	568.656	-.0301	.3320	.0345	.1804	.2094
821.38	568.855	.0985	.2395	-.0057	.1408	.1133
822.35	569.046	.2394	.1834	.0202	.1483	.0799
825.38	569.643	-.0148	.3284	.0329	.1638	.2012
826.34	569.832	.0516	.2611	-.0016	.1448	.1270
829.35	570.424	.0415	.3026	.0126	.1791	.1838
840.32	572.584	-.0063	.3276	.0359	.1566	.2069
841.33	572.783	-.0081	.3015	.0101	.1687	.1615
842.28	572.970	.2528	.1685	.0205	.1385	.0682
844.28	573.364	.0724	.2930	.0174	.1728	.1724
845.28	573.561	-.0019	.3256	.0278	.1803	.2064
851.28	574.742	-.0266	.3168	.0300	.1580	.1946
852.27	574.937	.2280	.1752	.0154	.1388	.0703
854.28	575.333	.0852	.2869	.0150	.1678	.1694
855.27	575.528	.0071	.3150	.0332	.1598	.2024
871.26	578.676	-.0337	.3295	.0270	.1827	.2082
872.30	578.881	.1458	.2139	-.0036	.1366	.0948
873.23	579.064	.2240	.1884	.0214	.1498	.0846
874.26	579.267	.1186	.2640	.0166	.1532	.1488
875.28	579.468	.0204	.3038	.0443	.1803	.2025
876.28	579.665	-.0251	.3254	.0384	.1573	.2098
885.27	581.435	.0466	.3033	.0304	.1735	.1966
886.25	581.628	-.0192	.3258	.0358	.1810	.2162

V 636 Sco - HD 156 623

J.D.	PHASE	V	V-B	B-U	U-W	B-L
799.44	425.648	.1109	.4370	.1508	.2571	.2494
803.38	426.227	.2641	.3596	.1187	.2444	.1835
804.38	426.375	.2308	.3856	.1306	.2553	.2098
807.36	426.813	.1769	.3814	.1224	.2464	.1922
812.36	427.549	.1408	.4169	.1521	.2594	.2520
815.39	427.994	.3170	.2954	.1136	.2392	.1240
817.38	428.287	.2491	.3664	.1198	.2573	.1974
818.36	428.431	.1930	.3982	.1290	.2600	.2266
820.41	428.733	.1174	.4158	.1363	.2634	.2420
822.38	429.023	.3254	.2930	.1132	.2382	.1254
825.42	429.470	.1774	.4040	.1412	.2559	.2292
826.38	429.611	.1185	.4266	.1484	.2661	.2553
829.38	430.053	.3178	.2983	.1158	.2372	.1276
839.36	431.521	.1566	.4073	.1464	.2567	.2464
840.35	431.667	.1000	.4263	.1494	.2610	.2554
841.36	431.815	.1641	.3716	.1128	.2480	.1947
842.30	431.954	.2895	.3066	.1082	.2347	.1322
844.31	432.250	.2506	.3578	.1229	.2409	.1910
845.31	432.397	.2109	.3807	.1308	.2560	.2222
850.33	433.135	.2924	.3230	.1168	.2450	.1536
851.32	433.281	.2412	.3638	.1192	.2574	.1968
852.33	433.430	.1881	.3933	.1318	.2598	.2274
853.28	433.569	.1357	.4192	.1486	.2598	.2499
854.32	433.722	.1127	.4176	.1356	.2454	.2403
855.30	433.867	.2135	.3504	.1043	.2392	.1616
871.30	436.221	.2552	.3504	.1251	.2484	.1844
872.34	436.374	.2164	.3826	.1315	.2528	.2109
873.29	436.513	.1634	.4110	.1407	.2630	.2450
874.29	436.661	.1101	.4252	.1506	.2588	.2546
875.31	436.811	.1631	.3824	.1138	.2564	.1932
876.31	436.958	.2916	.3040	.1081	.2351	.1314
877.28	437.100	.2984	.3158	.1136	.2474	.1434
885.29	438.279	.2444	.3635	.1210	.2438	.1980
886.28	438.425	.1940	.3912	.1297	.2564	.2278
899.25	440.333	.2280	.3728	.1275	.2590	.2075
906.29	441.369	.2189	.3794	.1306	.2525	.2184
907.30	441.517	.1567	.4079	.1464	.2585	.2463
909.24	441.803	.1594	.3846	.1208	.2540	.1990
911.27	442.101	.3126	.3072	.1162	.2328	.1431

TABLE 8 *(continued)*

R Mus - HD 110 080

J.D.	PHASE	V	V-B	B-U	U-W	B-L
798.33	392.941	.4494	.1893	.0165	.1532	.0744
799.34	393.076	.5769	.1363	.0430	.1589	.0403
801.34	393.342	.4837	.2065	.0342	.1697	.1065
803.33	393.607	.3144	.3074	.0676	.1848	.2113
804.32	393.739	.2590	.3148	.0713	.1888	.2188
807.34	394.141	.5450	.1604	.0420	.1707	.0595
812.34	394.807	.2752	.2903	.0504	.1710	.1848
814.32	395.071	.5854	.1330	.0416	.1494	.0351
815.36	395.209	.5054	.1926	.0309	.1534	.0816
817.34	395.472	.3624	.2708	.0433	.1916	.1712
818.33	395.605	.3150	.2079	.0666	.1948	.2164
820.35	395.873	.3468	.2428	.0240	.1744	.1244
821.35	396.007	.5794	.1309	.0318	.1466	.0293
822.33	396.137	.5408	.1574	.0370	.1544	.0584
825.35	396.539	.3435	.2885	.0621	.1873	.1914
826.32	396.668	.2733	.3199	.0696	.2007	.2255
829.33	397.069	.5805	.1339	.0426	.1553	.0366
839.32	398.399	.4473	.2304	.0368	.1746	.1277
840.30	398.530	.3443	.2882	.0569	.1858	.1895
841.31	398.664	.2826	.3183	.0720	.1958	.2218
842.27	398.792	.2672	.3032	.0566	.1790	.1932
844.27	399.059	.5929	.1204	.0500	.1408	.0389
845.27	399.192	.5075	.1840	.0330	.1707	.0802
846.29	399.328	.4812	.2082	.0341	.1686	.1043
850.29	399.860	.3249	.2540	.0362	.1657	.1440
851.26	399.989	.5426	.1398	.0316	.1442	.0430
853.23	400.252	.4876	.1996	.0340	.1681	.0997
854.26	400.389	.4483	.2182	.0376	.1737	.1256
855.25	400.521	.3464	.2856	.0538	.1676	.1838
871.24	402.650	.2844	.3145	.0700	.1955	.2258
872.26	402.786	.2616	.3036	.0596	.1820	.2014
873.22	402.913	.4081	.2114	.0145	.1590	.0926
874.23	403.048	.5930	.1252	.0418	.1566	.0380
875.25	403.184	.5256	.1745	.0360	.1486	.0798
876.25	403.317	.4838	.2083	.0345	.1686	.1044
885.24	404.514	.3537	.2814	.0585	.1858	.1914
886.23	404.646	.2877	.3125	.0765	.1929	.2282

IT Car - HD 97 670

J.D.	PHASE	V	V-B	B-U	U-W	B-L
798.30	1802.561	-0.9202	.4262	.5088	.3454	.3881
799.29	1802.693	-0.9572	.4498	.5050	.3234	.4126
801.30	1802.959	-1.0294	.4915	.5319	.3674	.4574
803.30	1803.225	-0.9887	.4440	.4953	.3972	.3890
804.30	1803.357	-0.9124	.4062	.4904	.3340	.3631
807.29	1803.754	-0.9654	.4596	.5166	.3295	.4240
808.29	1803.887	-1.0014	.4776	.5253	.3656	.4530
812.31	1804.420	-0.9076	.4046	.4903	.3546	.3636
814.28	1804.682	-0.9416	.4484	.5077	.3542	.4070
815.33	1804.821	-0.9859	.4724	.5212	.3655	.4368
817.31	1805.084	-1.0302	.4798	.5132	.3623	.4379
818.30	1805.215	-0.9755	.4458	.5021	.3389	.3921
820.31	1805.481	-0.9027	.4180	.4969	.3533	.3711
821.31	1805.615	-0.9252	.4318	.5066	.3550	.3959
822.30	1805.746	-0.9616	.4574	.5126	.3649	.4210
825.33	1806.148	-0.9990	.4660	.5008	.2824	.3989
826.29	1806.276	-0.9486	.4225	.4857	.3529	.3732
829.30	1806.675	-0.9526	.4418	.5006	.3372	.4035
839.30	1808.002	-1.0340	.4900	.5274	.3667	.4552
840.27	1808.131	-1.0152	.4662	.5090	.3468	.4256
841.28	1808.265	-0.9446	.4300	.4924	.3443	.3737
842.25	1808.394	-0.8998	.4050	.4935	.3298	.3567
844.25	1808.659	-0.9349	.4406	.4967	.3638	.4038
845.25	1808.792	-0.9692	.4664	.5160	.3596	.3292
846.26	1808.926	-1.0337	.4835	.5272	.3694	.4469

W Sgr - HD 165 022

J.D.	PHASE	V	V-B	B-U	U-W	B-L
839.39	428.210	1.0995	.2588	.0668	.2112	.1161
840.38	428.340	1.0998	.2699	.0659	.2133	.1289
841.38	428.472	0.9822	.3356	.0749	.2293	.1932
842.32	428.596	0.9277	.3667	.0920	.2352	.2274
844.32	428.859	0.9635	.3004	.0484	.2088	.1332
850.35	429.653	0.8930	.3771	.0982	.2340	.2396
851.35	429.785	0.8844	.3541	.0808	.2213	.1994
852.36	429.918	1.0545	.2542	.0482	.1930	.0970
854.34	430.178	1.1025	.2538	.0664	.2115	.1093
855.35	430.311	1.1133	.2624	.0656	.2058	.1170
871.33	432.415	1.0103	.3228	.0672	.2180	.1729
872.36	432.551	0.9466	.3573	.0903	.2284	.2160
873.30	432.675	0.8818	.3778	.1024	.2390	.2402
874.31	432.808	0.9044	.3437	.0711	.2196	.1828
875.33	432.942	1.0986	.2290	.0517	.1928	.0792
876.33	433.074	1.1840	.2038	.0753	.1934	.0660
877.30	433.202	1.1018	.2648	.0638	.2110	.1099
885.31	434.256	1.1056	.2608	.0630	.2120	.1174
886.30	434.387	1.0462	.2988	.0654	.2148	.1602
895.31	435.573	0.9398	.3633	.0919	.2280	.2268
899.27	436.094	1.1630	.2088	.0702	.2002	.0739
906.31	437.021	1.1914	.1858	.0770	.1882	.0546
907.32	437.154	1.1258	.2424	.0630	.2086	.1004
909.26	437.410	1.0141	.3200	.0623	.2198	.1704
910.32	437.549	0.9505	.3548	.0856	.2234	.2153
911.29	437.677	0.8856	.3826	.1012	.2263	.2408
913.26	437.936	1.0884	.2331	.0506	.2019	.0872
928.23	439.908	1.0378	.2604	.0448	.1950	.1049
930.23	440.171	1.1136	.2501	.0684	.2020	.1072
931.22	440.301	1.1174	.2598	.0640	.2055	.1202
933.23	440.566	0.9485	.3612	.0924	.2306	.2279
934.24	440.699	0.8747	.3754	.1045	.2381	.2433

ER Car - HD 97 670

J.D.	PHASE	V	V-B	B-U	U-W	B-L
798.27	1427.951	-.5237	.4152	.4647	.3269	.3783
799.28	1428.082	-.3994	.3470	.4412	.3184	.3101
801.27	1428.340	-.3966	.3728	.4605	.3346	.3478
803.29	1428.602	-.4809	.4286	.4846	.3458	.4111
804.28	1428.730	-.5470	.4580	.5088	.3740	.4530
807.28	1429.117	-.3672	.3264	.4440	.3110	.2986
808.28	1429.248	-.3634	.3416	.4572	.3226	.3204
812.30	1429.769	-.5592	.4641	.5050	.3508	.4566
814.27	1430.024	-.4432	.3735	.4378	.3216	.3337
815.30	1430.158	-.3373	.3180	.4504	.3156	.3007
817.30	1430.417	-.3985	.3834	.4657	.3294	.3650
818.29	1430.545	-.4480	.4188	.4689	.3344	.3972
820.30	1430.806	-.5665	.4736	.5097	.3516	.4512
821.29	1430.934	-.5353	.4259	.4694	.3518	.3956
822.29	1431.063	-.4114	.3544	.4426	.3135	.3249
825.32	1431.456	-.4048	.3968	.4590	.3302	.3650
826.27	1431.579	-.4645	.4220	.4761	.3374	.4081
829.29	1431.970	-.4901	.4036	.4519	.3313	.3650
839.29	1433.266	-.3714	.3449	.4615	.3157	.3318
840.27	1433.393	-.3967	.3728	.4684	.3266	.3642
841.27	1433.523	-.4430	.4114	.4704	.3328	.3938
842.24	1433.648	-.4954	.4437	.4918	.3478	.4312
844.24	1433.908	-.5513	.4438	.4817	.3390	.4100
845.25	1434.038	-.4333	.3633	.4409	.3190	.3348
846.25	1434.168	-.3530	.3188	.4524	.3198	.2988

TABLE 8 *(continued)*

IQ Nor - comparison star

J.D.	PHASE	V	V-B	B-U	U-W	B-L
820.38	435.643	.3286	.5427	.3060	.3908	.3002
822.36	435.883	.1855	.6252	.3454	.3930	.3885
825.39	436.251	.2500	.5616	.2724	.2778	.2704
826.31	436.363	.3679	.4861	.2956	.3033	.2382
829.36	436.734	.2484	.5889	.3074	.3434	.3424
839.34	437.946	.1404	.6508	.3507	.4044	.4023
840.33	438.066	.0921	.6552	.3564	.4929	.4121
841.30	438.184	.1688	.5917	.3102	.3996	.3214
842.29	438.304	.3050	.5169	.2871	.3341	.2567
844.29	438.547	.3190	.5380	.3008	.3506	.2886
845.29	438.669	.3138	.5529	.3040	.3433	.3176
846.30	438.792	.2342	.6050	.3218	.3222	.3637
850.31	439.270	.2725	.5260	.2887	.3929	.2847
851.29	439.398	.3498	.4700	.3021	.3373	.2414
852.28	439.518	.3161	.5384	.3030	.3928	.2838
853.26	439.637	.3315	.5379	.3100	.3577	.2993
854.29	439.762	.2375	.5985	.3230	.3542	.3438
855.28	439.882	.1825	.6179	.3614	.3733	.3908
871.27	441.825	.2167	.6193	.3238	.3962	.3783
872.27	441.946	.1424	.6569	.3408	.3635	.3879
873.25	442.065	.0950	.6559	.3545	.3698	.4071
874.27	442.189	.1794	.5878	.3104	.3404	.3335
875.29	442.313	.3269	.4993	.2961	.4171	.2621
876.29	442.435	.3332	.5052	.2982	.3188	.2554
877.24	442.550	.3193	.5307	.3027	.3675	.2910
885.28	443.527	.3173	.5379	.3063	.5330	.2931
886.26	443.646	.3268	.5443	.2944	.3524	.2985
899.24	445.223	.2236	.5594	.2743	.3270	.3010
906.28	446.078	.0990	.6472	.3508	.5472	.3976
907.29	446.201	.1957	.5660	.3012	.3236	.3206
909.23	446.436	.3414	.5072	.2993	.3823	.2606
910.30	446.566	.3255	.5321	.2991	.3549	.2806
911.26	446.683	.2916	.5702	.3100	.3526	.3192
913.24	446.923	.1600	.6482	.3677	.2070	.3868

S Sge - HD 189 090

J.D.	PHASE	V	V-B	B-U	U-W	B-L
899.36	568.775	-.1582	.3969	.1760	.2704	.2760
906.40	569.615	-.2112	.4591	.2140	.2823	.3559
907.37	569.730	-.1975	.4237	.1896	.2724	.3074
909.35	569.967	.0809	.2718	.1676	.2472	.1652
910.37	570.088	.0278	.3182	.1742	.2538	.2067
911.38	570.209	.0570	.3152	.1686	.2610	.2114
913.33	570.441	-.1242	.4161	.1982	.2813	.3190
928.31	572.228	.0480	.3179	.1664	.2582	.2079
930.31	572.466	-.1209	.4272	.2030	.2804	.3296
931.29	572.584	-.1956	.4526	.2204	.2814	.3653
933.31	572.825	-.0895	.3568	.1538	.2484	.2294
934.29	572.942	.0798	.2752	.1633	.2432	.1666

V 500 Sco - HD 161 665

J.D.	PHASE	V	V-B	B-U	U-W	B-L
839.36	312.743	-.5604	.4692	.2275	.3209	.1884
840.36	312.851	-.5144	.4496	.2280	.3102	.1744
841.37	312.959	-.4676	.4396	.2286	.3053	.1656
842.31	313.060	-.4798	.4644	.2220	.2944	.1834
844.27	313.270	-.6172	.5546	.2598	.3450	.2864
850.34	313.922	-.5072	.4544	.2280	.3172	.1764
851.33	314.028	-.4481	.4362	.2298	.3174	.1640
852.34	314.137	-.5500	.5036	.2284	.3182	.2322
853.29	314.238	-.5974	.5409	.2606	.3477	.2473
854.33	314.350	-.6740	.5815	.2744	.3415	.3118
855.33	314.457	-.7306	.5999	.2895	.3232	.3306
871.32	316.174	-.5648	.5172	.2434	.3283	.2431
872.35	316.284	-.6240	.5578	.2636	.3547	.2797
873.30	316.386	-.6877	.5838	.2899	.3472	.3386
874.30	316.495	-.7361	.5986	.2920	.3190	.3246
875.32	316.603	-.7025	.5519	.2538	.3852	.2732
876.32	316.710	-.5968	.4854	.2233	.3090	.2044
877.28	316.813	-.5058	.4456	.2273	.3060	.1671
885.30	317.674	-.6272	.5116	.2224	.3366	.2174
886.29	317.781	-.5234	.4467	.2273	.3094	.1770
899.26	319.173	-.5610	.5147	.2446	.3465	.2479
906.30	319.928	-.4978	.4471	.2351	.2966	.1790
907.31	320.037	-.4620	.4413	.2412	.3278	.1804
909.25	320.245	-.6017	.5392	.2464	.3290	.2667
910.31	320.359	-.6724	.5710	.2810	.3121	.3261
911.28	320.463	-.7261	.6018	.2813	.3968	.3353

SX Vel - HD 74 868

J.D.	PHASE	V	V-B	B-U	U-W	B-L
799.22	1757.420	-.8152	.2336	.2472	.2200	.1704
801.23	1757.631	-.7936	.1810	.2230	.1638	.1028
803.23	1757.840	-.5904	.0812	.2302	.1271	.0253
804.27	1757.949	-.5792	.0868	.2216	.1545	.0299
807.22	1758.258	-.7306	.1910	.2294	.1815	.1291
808.25	1758.366	-.7954	.2254	.2440	.1892	.1660
811.23	1758.678	-.7428	.1518	.2018	.1717	.0738
812.24	1758.784	-.6005	.0789	.2076	.1533	.0213
814.20	1758.989	-.5548	.0803	.2176	.1389	.0198
815.24	1759.098	-.6222	.1242	.2167	.1622	.0566
817.23	1759.306	-.7726	.1981	.2424	.2243	.1407
818.24	1759.412	-.8222	.2356	.2397	.1945	.1741
820.23	1759.620	-.8012	.1860	.2136	.1418	.1091
821.22	1759.724	-.6868	.1231	.1951	.1634	.0411
822.20	1759.827	-.5816	.0774	.2136	.1585	.0128
825.22	1760.143	-.6779	.1599	.2057	.1782	.0822
826.19	1760.244	-.7297	.1919	.2116	.1997	.1183
829.20	1760.560	-.8477	.2190	.2271	.2120	.1474
839.20	1761.607	-.8220	.1959	.2203	.1680	.1154
840.20	1761.711	-.7065	.1313	.1948	.1543	.0508
841.20	1761.816	-.5838	.0739	.2152	.1439	.0119
842.19	1761.920	-.5935	.0912	.2150	.1531	.0258
844.20	1762.130	-.6618	.1492	.2052	.1540	.0715
845.19	1762.234	-.7213	.1850	.2233	.1776	.1207
846.19	1762.339	-.7803	.2147	.2345	.1532	.1545
850.19	1762.758	-.6286	.0953	.2046	.1765	.0335

TABLE 8 *(continued)*

YZ Sgr - HD 174 467

J.D.	PHASE	V	V-B	B-U	U-W	B-L
820.42	302.404	-.3219	.4034	.0543	.1429	.3536
852.38	305.749	-.2020	.2898	-.0102	.1103	.2122
854.35	305.955	-.1334	.2565	.0020	.1130	.1966
855.36	306.061	-.1024	.2640	-.0025	.1082	.1918
871.35	307.735	-.2142	.2968	-.0125	.1176	.2178
872.39	307.844	-.1446	.2622	-.0024	.1038	.1900
873.38	307.947	-.1263	.2610	-.0039	.1071	.1952
874.35	308.049	-.0890	.2558	-.0028	.1048	.1893
875.36	308.155	-.1666	.3135	.0017	.1110	.2450
876.37	308.260	-.2236	.3522	.0288	.1234	.2988
877.32	308.360	-.2881	.3938	.0400	.1416	.3390
885.36	309.201	-.1910	.3304	.0128	.1155	.2734
886.34	309.304	-.2533	.3716	.0347	.1282	.3175
899.32	310.663	-.2742	.3344	-.0038	.1088	.2534
906.36	311.400	-.3156	.4024	.0534	.1384	.3576
907.35	311.503	-.3628	.4054	.0580	.1100	.3529
909.31	311.708	-.2344	.3084	.0066	.1122	.2288
910.35	311.817	-.1393	.2537	.0010	.0820	.1928
911.34	311.921	-.1413	.2682	.0064	.0897	.2037
913.31	312.127	-.1720	.3042	.0059	.0863	.2373
928.28	313.694	-.2412	.3140	-.0082	.1050	.2336
930.28	313.903	-.1492	.2656	.0038	.1093	.2053
931.26	314.006	-.0784	.2400	-.0012	.0940	.1800
933.28	314.217	-.1976	.3354	.0214	.1116	.2817

S Mus - HD 105 119

J.D.	PHASE	V	V-B	B-U	U-W	B-L
798.32	333.140	.4892	.0831	.1474	.0865	.0386
799.32	333.244	.5083	.0807	.1502	.0667	.0412
801.32	333.451	.3932	.1485	.1442	.0508	.0910
803.32	333.658	.3008	.1764	.1275	.0140	.0942
804.32	333.762	.2993	.1608	.1275	.0356	.0811
807.32	334.072	.4844	.0757	.1486	.0574	.0314
812.33	334.591	.3172	.1706	.1432	.0224	.1042
814.30	334.795	.3110	.1422	.1248	.0352	.0708
815.34	334.903	.3930	.1024	.1279	.0341	.0438
817.33	335.109	.4778	.0804	.1506	.0576	.0401
818.32	335.211	.5208	.0700	.1523	.0632	.0356
820.34	335.420	.4184	.1388	.1444	.0474	.0894
821.34	335.524	.3650	.1586	.1474	.0283	.1052
822.33	335.626	.3057	.1699	.1377	.0198	.1090
825.35	335.939	.4414	.0890	.1326	.0711	.0280
826.31	336.038	.4896	.0665	.1526	.0573	.0280
829.32	336.350	.4400	.1202	.1366	.0496	.0678
839.31	337.384	.4180	.1284	.1365	.0526	.0782
840.29	337.486	.3745	.1514	.1308	.0388	.0980
841.30	337.590	.3193	.1700	.1384	.0186	.1063
842.26	337.690	.2909	.1732	.1340	.0120	.1032
844.26	337.897	.4034	.1011	.1279	.0432	.0474
845.27	338.001	.4832	.0638	.1476	.0590	.0238
846.27	338.105	.4810	.0797	.1529	.0520	.0405
850.28	338.520	.3575	.1570	.1441	.0384	.1040
851.24	338.619	.3092	.1726	.1346	.0266	.1030
853.23	338.825	.3384	.1308	.1273	.0334	.0682
854.25	338.931	.4306	.0878	.1338	.0534	.0404
855.24	339.034	.4887	.0656	.1574	.0500	.0278
871.23	340.689	.2890	.1712	.1344	.0089	.1024
872.24	340.794	.3174	.1457	.1272	.0208	.0759
873.21	340.894	.3988	.1040	.1249	.0468	.0460
874.22	340.999	.4861	.0665	.1471	.0552	.0245
875.24	341.104	.4776	.0776	.1496	.0622	.0351
876.24	341.208	.5069	.0716	.1557	.0636	.0382
885.24	342.140	.4809	.0772	.1502	.0542	.0398
886.22	342.241	.5070	.0726	.1538	.0681	.0392

S Nor - HD 145 782

J.D.	PHASE	V	V-B	B-U	U-W	B-L
798.41	329.297	-.3509	.3972	.0934	.2176	.2567
799.43	329.401	-.4250	.4294	.1117	.2285	.2926
803.37	329.805	-.3000	.3138	.0570	.2022	.1545
804.37	329.908	-.2785	.3051	.0646	.2011	.1538
807.36	330.214	-.3030	.3641	.0739	.2138	.2164
812.39	330.730	-.3660	.3469	.0583	.1945	.1782
814.36	330.932	-.2803	.2994	.0654	.1839	.1580
815.38	331.037	-.2057	.2766	.0588	.1928	.1324
817.37	331.241	-.3232	.3708	.0830	.2247	.2370
818.36	331.342	-.3814	.4134	.1056	.2310	.2811
820.39	331.550	-.4785	.4330	.1023	.2292	.2959
822.38	331.754	-.3493	.3336	.0558	.2009	.1787
825.41	332.065	-.2193	.3008	.0540	.1966	.1391
826.36	332.162	-.2818	.3362	.0643	.2084	.1954
829.38	332.472	-.4558	.4418	.1168	.2232	.3091
839.35	333.494	-.4690	.4440	.1171	.2226	.3052
840.34	333.595	-.4702	.4144	.0994	.2235	.2718
841.35	333.699	-.3818	.3544	.0532	.2060	.1936
842.30	333.796	-.3110	.3148	.0540	.1970	.1604
844.30	334.001	-.2118	.2753	.0604	.1904	.1300
845.30	334.104	-.2592	.3196	.0554	.1964	.1735
846.31	334.208	-.3056	.3522	.0745	.2180	.2200
850.32	334.619	-.4526	.4024	.0904	.2168	.2583
851.31	334.720	-.3637	.3421	.0532	.2067	.1863
852.32	334.824	-.2939	.3046	.0556	.1950	.1562
853.27	334.921	-.2851	.3023	.0663	.2063	.1564
854.30	335.027	-.2094	.2755	.0616	.1966	.1312
855.29	335.128	-.2705	.3268	.0582	.2026	.1782
871.29	336.768	-.3344	.3297	.0568	.2074	.1742
872.33	336.875	-.2852	.3018	.0637	.1989	.1512
873.26	336.970	-.2430	.2876	.0586	.1964	.1402
874.28	337.075	-.2400	.3006	.0538	.1985	.1554
875.30	337.180	-.2866	.3426	.0704	.2109	.2054
876.30	337.282	-.3459	.3847	.0921	.2211	.2532
877.27	337.382	-.4084	.4233	.1084	.2333	.2886
885.29	338.204	-.3017	.3514	.0770	.2138	.2222
886.27	338.304	-.3611	.3913	.0960	.2232	.2676

AQ Car - HD 90 454

J.D.	PHASE	V	V-B	B-U	U-W	B-L
811.25	1416.954	-1.1032	.2442	.1044	.1651	.1540
812.26	1417.058	-1.1532	.2976	.1216	.1702	.2043
814.22	1417.258	-1.2820	.3543	.1590	.1768	.2806
815.27	1417.366	-1.3065	.3457	.1623	.1570	.2733
817.24	1417.567	-1.1953	.2547	.0853	.1405	.1540
818.25	1417.671	-1.1414	.2220	.0926	.1718	.1306
820.24	1417.874	-1.0759	.2151	.0906	.1377	.1210
821.24	1417.977	-1.1196	.2540	.1038	.1792	.1628
822.23	1418.078	-1.1795	.2948	.1263	.1994	.2187
825.25	1418.387	-1.3006	.3415	.1482	.1362	.2441
826.21	1418.485	-1.2402	.2880	.1006	.1627	.1822
829.22	1418.793	-1.0757	.1970	.0940	.1628	.1068
839.23	1419.818	-1.0596	.1892	.0990	.1516	.1026
840.21	1419.918	-1.1040	.2330	.0880	.1676	.1374
841.22	1420.022	-1.1487	.2684	.1128	.1810	.1888
842.21	1420.123	-1.2093	.3128	.1305	.1789	.2381
844.21	1420.328	-1.3164	.3522	.1608	.2412	.2758
845.20	1420.429	-1.2874	.3209	.1246	.2170	.2311
846.20	1420.531	-1.2115	.2638	.0878	.1579	.1568
850.20	1420.941	-1.1066	.2424	.0976	.1782	.1493

TABLE 8 *(continued)*

XX Cen - HD 119 020

J.D.	PHASE	V	V-B	B-U	U-W	B-L
798.36	1638.493	-.1410	.4231	.1858	.1835	.2851
799.37	1638.585	-.0958	.3903	.1536	.2212	.2176
801.38	1638.768	.0628	.2834	.1332	.2008	.1331
803.34	1638.947	.2126	.2338	.1375	.1908	.0933
804.33	1639.038	.0976	.3086	.1335	.2300	.1524
807.34	1639.312	-.0762	.4240	.2041	.2872	.2964
812.35	1639.770	.0636	.2772	.1309	.2135	.1366
814.33	1639.950	.2001	.2351	.1424	.2096	.1003
815.36	1640.044	.0856	.3057	.1303	.2190	.1645
817.35	1640.226	-.0166	.3886	.1748	.2399	.2613
818.34	1640.316	-.0870	.4246	.1921	.2321	.3012
820.36	1640.501	-.1493	.4204	.1859	.2346	.2799
821.36	1640.592	-.1002	.3750	.1512	.2231	.2205
822.34	1640.681	-.0063	.3200	.1283	.2050	.1613
825.38	1640.959	.1857	.2501	.1404	.2420	.1094
826.33	1641.046	.0918	.3073	.1407	.2256	.1651
829.34	1641.320	-.0856	.4393	.1852	.2452	.2988
839.33	1642.232	-.0227	.3904	.1714	.2410	.2633
840.30	1642.321	-.0880	.4278	.1870	.2692	.2987
841.32	1642.414	-.1446	.4407	.2067	.2409	.3062
842.27	1642.501	-.1486	.4202	.1866	.2506	.2798
844.28	1642.684	-.0102	.3205	.1258	.2287	.1600
845.28	1642.775	.0631	.2770	.1400	.2230	.1382
846.30	1642.868	.1819	.2208	.1378	.1984	.0922
850.30	1643.233	-.0244	.3938	.1696	.2462	.2580
851.27	1643.322	-.0918	.4270	.1858	.2824	.3016
852.26	1643.412	-.1370	.4392	.2022	.2449	.3126
853.25	1643.503	-.1519	.4208	.1887	.2396	.2884
854.26	1643.595	-.1080	.3769	.1438	.2214	.2142
855.26	1643.686	-.0056	.3154	.1293	.2048	.1564
871.25	1645.146	.0322	.3546	.1530	.2538	.2160
872.29	1645.241	-.0290	.3957	.1730	.2304	.2652
873.22	1645.325	-.0939	.4230	.1892	.2359	.2992
874.25	1645.419	-.1419	.4376	.2002	.2676	.3134
875.27	1645.513	-.1478	.4148	.1908	.2553	.2802
876.27	1645.604	-.0796	.3652	.1424	.2314	.2058
877.24	1645.692	.0040	.3140	.1308	.2129	.1546
885.26	1646.424	-.1454	.4350	.2040	.2558	.3186
886.24	1646.514	-.1442	.4113	.1916	.2201	.2828

UU Mus - HD 103 338

J.D.	PHASE	V	V-B	B-U	U-W	B-L
812.33	255.853	-0.9662	.4151	.5062	.3493	.3505
814.29	256.021	-0.7102	.3008	.5198	.3389	.2789
815.34	256.112	-0.8258	.3799	.5056	.3366	.3421
817.32	256.282	-0.9166	.4693	.5332	.3424	.4451
818.31	256.367	-0.9880	.5080	.5550	.3862	.4842
820.33	256.540	-1.1111	.5702	.5875	.3383	.5123
821.32	256.626	-1.1182	.5444	.5960	.3969	.4981
822.31	256.711	-1.0838	.5038	.5195	.4054	.4272
826.30	257.054	-0.7862	.3436	.4968	.3320	.3122
839.31	258.172	-0.8580	.4105	.5120	.3763	.3673
840.28	258.255	-0.9166	.4540	.5233	.4286	.4311
841.29	258.342	-0.9772	.4988	.5591	.5862	.4818
842.26	258.425	-1.0332	.5331	.5674	.3792	.5143
844.26	258.597	-1.1314	.5564	.5926	.3618	.5154
845.26	258.683	-1.1161	.5277	.5564	.5070	.4604
846.26	258.769	-1.0155	.4492	.5052	.3456	.3803
850.27	259.113	-0.8080	.3808	.4966	.3472	.3320
851.22	259.195	-0.8702	.4228	.5224	.3366	.3932
853.22	259.367	-0.9845	.5108	.5610	.3313	.4992
854.24	259.455	-1.0645	.5470	.5938	.3030	.5236
855.23	259.540	-1.1150	.5599	.5958	.5263	.5280
871.22	260.914	-0.9114	.3683	.4992	.3992	.3370
872.23	261.001	-0.6854	.2830	.5116	.3400	.2524
873.20	261.084	-0.8030	.3689	.4976	.3505	.3248
874.21	261.171	-0.8554	.4102	.5176	.3654	.3690
875.23	261.258	-0.8984	.4524	.5291	.4098	.4274
876.24	261.345	-0.9866	.4845	.5451	.3414	.4519
885.23	262.118	-0.8242	.3811	.5126	.3114	.3436

XY Car - HD 95 752

J.D.	PHASE	V	V-B	B-U	U-W	B-L
811.28	1185.124	-1.0014	.4098	.0700	.0143	.3509
812.29	1185.205	-1.0584	.4358	.0735	.0724	.3605
814.26	1185.364	-1.1230	.4445	.0880	.0435	.3563
815.30	1185.448	-1.0848	.3947	.0471	.0310	.2988
817.28	1185.607	-0.9816	.3093	-.0012	.1118	.2265
818.28	1185.687	-0.8794	.2506	-.0217	.0759	.1682
820.29	1185.849	-0.8233	.2568	-.0152	.0878	.1954
821.28	1185.928	-0.8716	.3096	.0013	.0688	.2510
822.27	1186.006	-0.9294	.3498	.0281	.0156	.2923
825.31	1186.253	-1.0884	.4465	.1008	.2642	.3457
826.25	1186.328	-1.1331	.4382	.0956	.0802	.3786
829.27	1186.571	-0.9974	.3227	-.0164	.0501	.2243
839.27	1187.375	-1.1351	.4378	.0742	.0808	.3460
840.24	1187.453	-1.0842	.3852	.0253	.0608	.3048
841.25	1187.534	-1.0090	.3304	-.0040	.0514	.2413
842.23	1187.613	-0.9784	.2990	-.0067	.0362	.2294
844.23	1187.774	-0.7905	.2188	-.0104	.0213	.1620
845.23	1187.854	-0.8228	.2608	-.0030	.0718	.1937
846.24	1187.936	-0.8649	.3012	.0136	.0965	.2621
850.24	1188.257	-1.0996	.4483	.1096	-.0187	.3718
854.21	1188.577	-1.0019	.3144	.0038	-.0434	.2402
855.21	1188.657	-0.9451	.2838	-.0058	.0447	.2071

SV Vel - HD 93 563

J.D.	PHASE	V	V-B	B-U	U-W	B-L
798.26	207.727	-1.5714	.5895	.3982	.5572	.4227
799.25	207.797	-1.5206	.5514	.3417	.4698	.3698
801.25	207.939	-1.2820	.4060	.3385	.3498	.2558
803.28	208.083	-1.2510	.4258	.3510	.3861	.2713
804.28	208.154	-1.2993	.4632	.3598	.2874	.3152
807.26	208.365	-1.4350	.5789	.3886	.4355	.4322
808.27	208.437	-1.4857	.6059	.4163	.3743	.4684
812.28	208.721	-1.5786	.5858	.3949	.3435	.4230
814.24	208.860	-1.4911	.5267	.3509	.3552	.3574
815.28	208.934	-1.2977	.4203	.3373	.3249	.2534
817.27	209.075	-1.2373	.4210	.3463	.3294	.2643
818.27	209.146	-1.2886	.4627	.3483	.3378	.2981
820.26	209.287	-1.3770	.5384	.3714	.3582	.3835
821.26	209.358	-1.4312	.5718	.3930	.3314	.4263
822.25	209.429	-1.4870	.6038	.4060	.4058	.4612
825.28	209.644	-1.5955	.6307	.4044	.4258	.4486
826.24	209.712	-1.5799	.5945	.3939	.3599	.4341
829.25	209.925	-1.3495	.4404	.3401	.3301	.2728
839.25	210.635	-1.6000	.6322	.4274	.3508	.4802
840.23	210.704	-1.5848	.5966	.4009	.3396	.4399
841.24	210.776	-1.5372	.5580	.3520	.3832	.3862
842.22	210.845	-1.5028	.5300	.3478	.3806	.3563
844.22	210.987	-1.1342	.3472	.3642	.3352	.2036
845.22	211.058	-1.2190	.4054	.3460	.3208	.2518
846.22	211.129	-1.2800	.4491	.3479	.3608	.2943
850.22	211.413	-1.4764	.6009	.4001	.4158	.4538

TABLE 8 *(continued)*

XX Car - HD 96 752

J.D.	PHASE	V	V-B	B-U	U-W	B-L
811.28	184.164	-0.8342	.2071	-.0091	.0670	.1670
812.29	184.229	-0.8714	.2430	.0015	.0436	.2082
814.26	184.354	-0.9591	.3177	.0283	.0900	.2878
815.30	184.420	-1.0185	.3502	.0456	.0277	.3240
817.28	184.546	-1.1234	.4058	.0774	.0647	.3526
818.28	184.610	-1.1657	.4132	.0774	.0380	.3785
820.30	184.738	-1.1819	.3805	.0565	.0472	.3435
821.26	184.799	-1.1453	.3458	.0196	-.0116	.2769
822.26	184.863	-1.1096	.3054	-.0034	.0142	.2418
825.30	185.056	-0.7431	.1345	.0100	.0805	.0925
826.24	185.116	-0.8092	.1821	.0163	.0380	.1359
829.26	185.308	-0.9276	.2960	.0027	.0378	.2508
839.26	185.945	-0.9997	.2327	-.0166	.0428	.1765
840.24	186.007	-0.6802	.0856	-.0028	.0212	.0552
841.24	186.071	-0.7700	.1516	-.0118	.0897	.1081
842.22	186.133	-0.8234	.1916	-.0043	.0218	.1476
844.22	186.260	-0.9093	.2664	-.0006	.0310	.2246
845.23	186.324	-0.9406	.3044	.0139	.0816	.2544
846.23	186.388	-0.9874	.3356	.0228	.0473	.2987
850.23	186.642	-1.1791	.4116	.0868	.0194	.3728
851.21	186.705	-1.1983	.3985	.0774	.1506	.3512
853.20	186.831	-1.1309	.3198	.0034	.0998	.2694
854.20	186.895	-1.0882	.2946	.0096	-.0306	.2390
855.20	186.959	-0.9150	.1812	-.0004	.0036	.1414

XZ Car - HD 96 829

J.D.	PHASE	V	V-B	B-U	U-W	B-L
812.30	1051.517	-.6695	.5772	.6939	.3189	.5589
814.26	1051.635	-.7289	.5914	.7040	.3147	.5670
815.31	1051.698	-.7480	.5636	.6774	.2752	.5488
817.29	1051.817	-.6256	.4797	.5820	.3171	.4442
818.29	1051.877	-.6399	.4686	.5771	.3152	.4435
820.30	1051.998	-.3216	.3058	.5512	.3512	.3222
821.28	1052.057	-.3360	.3299	.5606	.3500	.3621
822.28	1052.117	-.3751	.3767	.5666	.3713	.3930
826.26	1052.356	-.5480	.5210	.6521	.3635	.5308
829.28	1052.537	-.6833	.5862	.6926	.3526	.5478
839.28	1053.138	-.4008	.3849	.5789	.3749	.4119
840.25	1053.196	-.4394	.4329	.5972	.3662	.4503
841.26	1053.257	-.4795	.4722	.6156	.3755	.4856
842.23	1053.315	-.5234	.5026	.6349	.3484	.5137
844.24	1053.436	-.6146	.5522	.6749	.3410	.5465
845.24	1053.496	-.6528	.5712	.6930	.2912	.5624
846.24	1053.556	-.6970	.5834	.7122	.3468	.5630
850.26	1053.797	-.6409	.4938	.5980	.3158	.4648
854.23	1054.036	-.3167	.3136	.5553	.3610	.3342
855.22	1054.095	-.3684	.3560	.5648	.3560	.3733

YZ Car - HD 90 454

J.D.	PHASE	V	V-B	B-U	U-W	B-L
811.26	159.894	-1.1854	.3634	.1920	.2138	.1956
812.27	159.949	-1.0754	.2994	.1824	.2300	.1396
814.23	160.057	-0.9506	.2400	.1885	.2276	.1062
815.27	160.114	-0.9849	.2762	.1833	.2030	.1250
817.26	160.223	-1.0594	.3290	.1860	.2462	.1635
818.26	160.279	-1.0932	.3563	.1996	.2578	.2105
820.25	160.388	-1.1629	.4085	.2168	.2174	.2628
821.25	160.444	-1.1972	.4297	.2292	.2717	.2812
822.24	160.498	-1.2268	.4466	.2374	.2532	.3009
825.26	160.664	-1.2786	.4595	.2238	.1751	.2773
826.22	160.717	-1.2714	.4304	.2260	.2150	.2692
829.23	160.883	-1.2145	.3703	.1911	.1837	.2092
839.24	161.434	-1.1915	.4266	.2242	.2664	.2816
840.22	161.488	-1.2254	.4419	.2355	.1970	.2988
841.23	161.544	-1.2562	.4550	.2436	.2688	.3121
842.21	161.598	-1.2752	.4560	.2564	.2159	.3120
844.21	161.708	-1.2718	.4265	.2218	.2408	.2755
845.21	161.763	-1.2642	.4181	.2259	.2483	.2601
846.21	161.818	-1.2516	.3998	.2046	.2348	.2412
850.21	162.038	-0.9434	.2394	.1940	.2364	.1010

WZ Sgr - HD 167 499

J.D.	PHASE	V	V-B	B-U	U-W	B-L
872.41	606.281	.4350	.5967	.2733	.3256	.4030
874.35	606.370	.3542	.6371	.3197	.3586	.4496
875.35	606.415	.3286	.6559	.3422	.3894	.4772
876.36	606.462	.2908	.6824	.3582	.3772	.4802
885.35	606.873	.2465	.5933	.2524	.3278	.3730
886.33	606.918	.3332	.5284	.2364	.3450	.3376
899.31	607.512	.2623	.6921	.3832	.3786	.5062
906.35	607.834	.2462	.5970	.2556	.3868	.3910
907.34	607.880	.2464	.5852	.2350	.2954	.3802
909.30	607.969	.5604	.4030	.1774	.3118	.2163
910.34	608.017	.6162	.3823	.1818	.2548	.2100
911.33	608.062	.6034	.4048	.1894	.3082	.2410
913.30	608.152	.5132	.4809	.2184	.3247	.3183
928.26	608.837	.2476	.6026	.2520	.3652	.3045
930.27	608.929	.3795	.4999	.2026	.3478	.3034
931.25	608.974	.5704	.3943	.1749	.3133	.2164
933.27	609.066	.5956	.4108	.2124	.2874	.2348

KN Cen - HD 118 294

J.D.	PHASE	V	V-B	B-U	U-W	B-L
872.28	77.152	-.3332	.4461	.2055	.2197	.1956
874.24	77.211	-.3808	.4904	.2089	.1960	.2434
875.26	77.240	-.3996	.5156	.2266	.1400	.2430
876.26	77.269	-.4434	.5453	.2283	.1320	.2650
885.25	77.534	-.5902	.6497	.2226	-.0516	.2934
886.23	77.562	-.6210	.6477	.1728	-.0074	.2590
899.22	77.944	-.7706	.6417	.1179	-.0934	.2206
909.22	78.238	-.4106	.5042	.2372	.1314	.2460
911.25	78.298	-.4502	.5508	.2172	.1286	.2608
913.23	78.356	-.4906	.5770	.1900	.1530	.2528

QT CrA - HD 166 618

J.D.	PHASE	V	V-B	B-U	U-W	B-L
872.38	143.059	-.5224	.5942	.3142	.6948	.2638
874.32	143.083	-.0626	.6100	.3150	.2926	.3114
876.34	143.109	-.0734	.6366	.3207	.8832	.3147
885.32	143.222	-.1842	.6416	.3458	.3856	.3521
899.28	143.398	-.1530	.5576	.1666	.2098	.2613
906.33	143.488	-.1252	.5078	.1226	.4828	.2102
909.28	143.525	-.0970	.4837	.0886	.4260	.1824
911.30	143.551	-.0382	.4943	.0692	.3405	.1801
913.28	143.575	-.0458	.4666	.0619	.2092	.1548
928.24	143.764	.0848	.4479	.0829	.3612	.1735
930.24	143.790	.1271	.4722	.0884	.2464	.1837
933.25	143.828	.1072	.4988	.1280	.2516	.2039

Kappa Pav - HD 174 787

J.D.	PHASE	V	V-B	B-U	U-W	B-L
876.38	350.982	1.3144	.0817	.1450	.1598	.0683
877.33	351.087	1.4492	.0342	.1766	.1533	.0424
885.37	351.974	1.2988	.0886	.1360	.1619	.0716
886.35	352.082	1.4409	.0362	.1738	.1674	.0392
899.33	353.513	1.2118	.2466	.2100	.1932	.2566
906.38	354.290	1.4028	.1061	.1864	.1844	.1132
907.36	354.398	1.3102	.1806	.1944	.1952	.1938
909.32	354.614	1.1566	.2635	.2332	.2030	.2810
910.36	354.729	1.1366	.2289	.2100	.1954	.2466
911.35	354.838	1.1860	.1664	.1670	.1703	.1524
913.32	355.055	1.4045	.0393	.1639	.1606	.0457
928.29	356.706	1.1335	.2479	.2282	.1923	.2718
930.30	356.928	1.2237	.1228	.1544	.1663	.1106
931.28	357.036	1.3950	.0526	.1577	.1532	.0478
933.30	357.258	1.4332	.0920	.1862	.1890	.0893
934.28	357.366	1.3475	.1543	.1850	.1883	.1686

ERRATA

In *B.A.N.* **17,** 311, 1964 ("The formation of molecular lines in the solar spectrum" by A. SCHADEE) on p. 322, eq. (III, 26) should read as follows:

$$\psi(\alpha\beta) \equiv \psi'(\alpha\beta)/kT\,.$$

On p. 323 in eq. (III, 30):

$$\text{for}\ \frac{N(\xi^{++})}{N(\xi)}\ \text{read}\ \frac{N(\xi^{++})}{N(\xi^{+})}\,.$$

In eq. (III, 36):

$$\text{for}\ \frac{\pi\varepsilon^2}{m_e c^2}\ \text{read}\ \frac{\pi\varepsilon^2}{m_H m_e c^2}\,.$$

On p. 325 the left-hand side of eq. (III, 50) should read:

$$\varphi(\mathrm{H})\,p_g\left[1+\frac{p(\mathrm{H}_2)}{p_g}\right].$$

In *B.A.N.* **17,** 381, 1964 ("The neutral hydrogen in the central region of the Galactic System" by G. W. ROUGOOR) on p. 382, right column, line 3:

for section 5.7
read section 4.7.

On p. 387, table 2, column 8:

for 1 of 8 channels
read 1 or 8 channels.

On p. 424, left column, line 2:

for at (λ = 3 cm)
read (at λ = 3 cm).