1960BAN....15..199O

BULLETIN OF THE ASTRONOMICAL INSTITUTES OF THE NETHERLANDS

1960 DECEMBER 30 VOLUME XV NUMBER 501

COMMUNICATION FROM THE OBSERVATORY AT LEIDEN

THREE-COLOUR PHOTOMETRY IN THE U, B, V SYSTEM OF 51 NORTHERN CEPHEIDS

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Photo-electric magnitudes, V, and colours, $(B-V)$ and $(U-B)$, of a number of northern Cepheids are discussed. The observations were made with the 20-inch reflecting telescope of Mount Palomar. The observed magnitudes and colours for 52 variables have been listed in Table 3. The variable V 724 Aql proved to be an eclipsing variable of the W UMa type. Light-curves and colour curves are shown in the Figures 1 *a*, *b*, *c* and *d*.

Figure 4 shows the relation between the amplitude of the yellow light-curves and the logarithm of the periods. This diagram does not permit an easy division into EGGEN's *A*-, *B*-, and *C*-type Cepheids. For periods shorter than about 6.3 days the observed Cepheids seem to belong to types *A* or *C* only. Those of type *A* show quite different amplitudes for the same period.

The Figures 5 and 6 show the relations between the amplitudes of the yellow light-curve and of the two colour curves. Many of the deviations from the average relations $\Delta(B-V) = .522\,\Delta V$ and $\Delta(U-B) = .816\,\Delta(B-V)$ are certainly significant. The deviations from these two relations have been plotted against each other in Figure 7. Long-period Cepheids like SZ Cyg have a rather large range in the $(B-V)$ colour curve, larger than would be expected from the range of the yellow light-curve. The range of the $(U-B)$ curve is very large. For stars like AW Per and V Lac the situation is reversed. The range of the $(B-V)$ curve is smaller than normal and the range of the $(U-B)$ curve is very small. For these last stars the observations could be understood by the presence of a very blue companion. According to Dr PRESTON the violet part of the spectrum of AW Per shows that the spectrum is probably composite and that this Cepheid has a blue companion.

From 18 Cepheids with values of log P between .6 and .8 the slope of the reddening line in the $(U-B)-(B-V)$ diagram was found to be .787 ± .035.

In computing individual distances we used the intrinsic colours as derived by KRAFT (1960), $A_V = 3.0\,E_{(B-V)}$ and SHAPLEY's slope of the period-luminosity relation, while the zeropoint of this relation was adjusted so as to fit the absolute magnitudes derived from Cepheids in galactic clusters. The spatial distribution of the Cepheids as projected on the galactic plane is shown in Figure 11. There is no clear sign of spiral structure. From 35 Cepheids the constant A of differential galactic rotation was found to be 18.0 ± 2.0 km/sec/kpc.

In Figure 12 the position of the Cepheids in the $(U-B)-(B-V)$ diagram has been compared with that of six F- and G-type supergiants. In the last paragraph some remarks have been made concerning six Cepheids which belong to population II.

In the summer and autumn of 1959 the author spent about ten weeks at the Mount Palomar Observatory. Through the kindness of Dr I. S. BOWEN, the Director of the Observatory, the 20-inch reflecting telescope had been put at my disposal during this time. This instrument has a very short tube and settings can be made very quickly. Therefore it is a suitable telescope for photo-electric work on relatively bright stars. Its effective focal length is approximately 6.5 metres, giving a scale of 1 mm = 32″ in the focal plane.

As WALRAVEN, MULLER and OOSTERHOFF (1958) had observed photo-electrically most of the bright Cepheids in the southern hemisphere, I intended to make photo-electric measures of those bright Cepheids in the northern hemisphere for which no such measures had been published. An observing list had been prepared of all northern Cepheids brighter than the 13th magnitude in minimum for which no photo-electric measures existed. In the paper mentioned above WALRAVEN, MULLER and OOSTERHOFF measured the southern Cepheids in blue and yellow light only and, further, their measures were restricted to the phases around maximum light. In the present investigation I have tried to obtain complete light-curves and I observed in three colours, which practically are identical with the U, B and V of JOHNSON and MORGAN (1953). As the observing conditions were rather poor in the first part of the season and as the 12th magnitude proved to be the limit for U,B,V-photometry of rather red stars, nearly half the number of stars of my original observing list had to be dropped. In this paper I shall discuss the observations of 52 stars of the list, of which one proved to be an eclipsing variable.

The photometer, the electronic equipment and the Brown recorder were put at my disposal by the Palomar Observatory. The photometer was identical with the photometers used at the 60″ and 100″ Mount Wilson telescopes. The 1P21 multiplier was cooled by means of dry ice. As amplifier I used a Type No 1230 A DC amplifier and electrometer from the General Radio Company. This amplifier has a set of load resistors going up by factors of ten. The exact proportion between two successive resistors can be measured with the instrument itself. The instrument therefore provided a gain in steps of 2.5 magnitudes. The observatory added to the amplifier a special device by which these steps could be subdivided into steps of 0.5 magnitude. I want to express here my thanks to Dr BAUM and Dr ARP and to Messrs BLACKEE and VAN HOOK, who gave me valuable assistance in making the mechanical and electronic equipment fool-proof.

To obtain light-curves of high accuracy the best method would be to observe a comparison star close to each Cepheid. These comparison stars should then be tied to U,B,V standards. However, as my time was limited, I did not want to spend half of it on measuring comparison stars and so I decided to observe Cepheids for about one hour and U,B,V standards for about half an hour alternately. With a perfect sky this procedure will yield accurate results. If the observing conditions are not so good the dispersion in the light-curves will increase, but as each individual observation is tied independently to the U,B,V standards, the light-curves will be systematically correct. Observations were obtained in 54 different nights. During several of them observing conditions were poor. But I worked nevertheless, because I was rather pressed for time. It is due to this fact that part of the observations is not of high quality.

During two weeks, from August 25 until September 7, observing conditions were nearly perfect. I have used the observations of these 14 nights for a study of the magnitudes and colours of the standard stars. First the observations of the standard stars were reduced to "no atmosphere" with the aid of the values of the extinction coefficients k_{12} $(B-V)$, k_{34} (V) and k_{45} $(U-B)$ as given by ARP (1959). Calling these provisional magnitudes and colours, which still have an arbitrary zeropoint: V', $(B-V)'$ and $(U-B)'$, we have solved for each night separately the coefficients in the linear relations between the provisional magnitudes and the standard magnitudes. The latter were taken from the paper by JOHNSON and HARRIS (1954) and if they did not occur in this article, from the work of JOHNSON and MORGAN (1953). The equations used are:

$$\begin{aligned}(B-V)' &= a + b\,(B-V)\\ (U-B)' &= a + b\,(U-B)\\ V' = V &+ a + b\,(B-V)'\end{aligned}$$

Later the equations have been reversed in order to reduce the provisional magnitudes and colours into the U,B,V, system.

The results of these solutions are given in Table 1 (a, b, and c).

TABLE 1 a

date	n	$(B-V)_{\text{comp.}}$	m.e.	m.e. correct.
25 Aug.	22	+ 1.102 + .999 $(B-V)'$	± .012	± .011
26 „	23	+ 1.109 + .997 „	± .016	± .012
27 „	23	+ 1.108 + 1.002 „	± .016	± .011
28 „	21	+ 1.112 + 1.004 „	± .013	± .011
29 „	25	+ 1.108 + 1.003 „	± .016	± .011
30 „	23	+ 1.104 + 1.007 „	± .015	± .011
31 „	25	+ 1.110 + .997 „	± .021	± .017
1 Sept.	25	+ 1.112 + 1.003 „	± .014	± .010
2 „	19	+ 1.118 + 1.001 „	± .013	± .008
3 „	23	+ 1.112 + 1.008 „	± .012	± .010
4 „	26	+ 1.111 + 1.008 „	± .015	± .010
5 „	24	+ 1.112 + 1.007 „	± .012	± .009
6 „	22	+ 1.112 + 1.010 „	± .010	± .011
7 „	25	+ 1.110 + 1.008 „	± .013	± .008

TABLE 1 b

date	n	$(U-B)_{\text{comp.}}$	m.e.	m.e. correct.
25 Aug.	22	− 1.188 + 1.005 $(U-B)'$	± .014	± .012
26 „	23	− 1.172 + 1.000 „	± .018	± .016
27 „	23	− 1.189 + 1.006 „	± .021	± .016
28 „	21	− 1.170 + .997 „	± .022	± .015
29 „	25	− 1.189 + 1.003 „	± .023	± .015
30 „	23	− 1.182 + 1.003 „	± .016	± .015
31 „	25	− 1.201 + 1.010 „	± .026	± .021
1 Sept.	25	− 1.182 + 1.002 „	± .019	± .014
2 „	19	− 1.172 + .994 „	± .014	± .010
3 „	23	− 1.195 + 1.005 „	± .017	± .011
4 „	26	− 1.191 + 1.003 „	± .023	± .014
5 „	24	− 1.189 + 1.004 „	± .018	± .011
6 „	22	− 1.188 + 1.002 „	± .023	± .015
7 „	25	− 1.199 + 1.007 „	± .020	± .013

TABLE 1 c

date	n	$(V-V')_{\text{comp.}}$	m.e.	m.e. correct.
25 Aug.	22	+ 1.336 − .026 $(B-V)'$	± .029	± .015
26 „	23	+ 1.355 − .028 „	± .026	± .011
27 „	23	+ 1.323 − .034 „	± .025	± .014
28 „	21	+ 1.352 − .025 „	± .026	± .011
29 „	25	+ 1.297 − .025 „	± .024	± .010
30 „	23	+ 1.293 − .026 „	± .027	± .016
31 „	25	+ 1.315 − .022 „	± .024	± .012
1 Sept.	25	+ 1.338 − .027 „	± .026	± .011
2 „	19	+ 1.335 − .024 „	± .029	± .010
3 „	23	+ 1.313 − .022 „	± .030	± .019
4 „	26	+ 1.292 − .022 „	± .029	± .007
5 „	24	+ 1.302 − .028 „	± .027	± .009
6 „	22	+ 1.302 − .030 „	± .024	± .008
7 „	25	+ 1.308 − .037 „	± .027	± .010

The second column indicates how many times a standard star was measured during the night or in other words the number of equations of condition.

In the fourth column the mean error of an equation of condition is shown. The corrected mean error in the last column will be explained below. From the third column in 1*a* and 1*b* it is clear that the observed colours $(B-V)'$ and $(U-B)'$ are practically identical with the standard colours, apart from a constant. The third column in Table 1*c* proves that there exists a small colour equation between the observed yellow magnitude V' and the standard magnitude V. The mean errors in the fourth column do not only include the errors in the observed magnitudes, but also those in the standard magnitudes. For several of the standard stars the residuals for $(B-V)$, $(U-B)$ or $(V-V')$ are of a systematic character. For some of them the residuals are all positive, for others they are all negative throughout the 14 nights. Consequently I have determined corrections to the standard magnitudes and colours. During the 14 nights considered here, 12 different standard stars had been used. The original and the corrected values of V, $B-V$ and $U-B$ are shown in Table 2.

TABLE 2

H.D.		V	$(B-V)$	$(U-B)$	V_c	$(B-V)_c$	$(U-B)_c$	Spect.
3651	54 Psc	5.84	+ .86	+ .56	5.878	+ .862	+ .573	K0 V
17378		6.25	+ .89	+ .48	6.199	+ .892	+ .507	A5 Ia
18331		5.17	+ .084	+ .05	5.153	+ .100	+ .070	A1 V
35299		5.70	− .22	− .87	5.658	− .209	− .867	B2 V
141004	λ Ser	4.43	+ .60	+ .10	4.433	+ .598	+ .103	G0 V
143107	ε CrB	4.15	+1.230	+1.28	4.143	+1.231	+1.247	K3 III
147394	τ Her	3.89	− .152	− .56	3.896	− .148	− .553	B5 IV
166620		6.40	+ .87	+ .59	6.392	+ .879	+ .597	K2 V
195593	44 Cyg	6.17	+1.02	+ .73	6.200	+1.003	+ .728	F5 Iab
214680	10 Lac	4.88	− .203	−1.04	4.871	− .209	−1.051	O9 V
216735	ρ Peg	4.89	+ .01	.00	4.907	+ .007	− .005	
219134		5.57	+1.010	+ .89	5.541	+1.019	+ .894	K3 V

The mean absolute value of the corrections is: .007 for $(B-V)$, .011 for $(U-B)$ and .021 for V. No correlation between the corrections and the spectrum and luminosity class could be found. The relations of Table 1 *a*, *b*, and *c* between the observed magnitudes and colours and the standard values have then been recomputed with the corrected standard values. The new solutions yield the mean errors given in the last column of Table 1 *a*, *b*, *c*. The root mean square error for all 14 nights is: ± .011 for $(B-V)$, ± .014 for $(U-B)$ and ± .012 for V. These figures indicate the accuracy obtained during really clear nights for the bright stars. From the new equations I derived the relations (apart from a constant) between my magnitudes and colours and those of the standard system:

$$V = V' - .027\,(B-V)',\ (B-V) = 1.004\,(B-V)' \text{ and}$$
$$(U-B) = 1.003\,(U-B)'.$$

The reduction of my measures of Cepheids and standard stars was then performed as follows. The measures were first reduced to "no atmosphere" with the aid of the extinction coefficients given by ARP (1959). Then they were reduced to the standard U,B,V system by means of the equations given above. Then for each night separately the differences were determined between my magnitudes and colours for the standard stars and those of the standard system. These differences were plotted against time. If the differences were constant in time, their mean value was applied to my measures as the last step in the reduction to the U,B,V system. When the variations with time of these differences were strong and irregular, the observations of that night were rejected. When the variations were moderate and not too irregular, values of the differences for the Cepheids were interpolated between those of the standard stars. As I used ARP's extinction coefficients throughout, it is clear that for nights with a heavier extinction, errors are introduced which depend on the zenith distance. However the extra extinction at the average zenith distance of the measures is taken care of by the differences mentioned above. Only the dispersion in the zenith distances will cause errors and this dispersion is usually not large as I have avoided to observe at large zenith distances. Moreover I have assigned a lower weight to all measures made during heavy or irregular extinction.

Before August 25 and after September 7 I have used some more standard stars than given in Table 2. For those no corrections to the standard magnitudes or colours could be derived, with the exception of one. From measures in three nights it was found that the magnitude V of the star HD 48434, B0 III, needs a rather large correction. Its yellow magnitude is given as 5.91, while I found 5.823. My measures of the colours agree with those given by JOHNSON and MORGAN (1953).

TABLE 3

J.D. Hel.	Phase	V	$B-V$	$U-B$
KL Aql	d^{-1} .16372			
2436751.781	.402	10.50	1.07	—
6752.785	.565	10.54	1.07	.96
6773.726	.994	10.060	.903	.764
6774.712	.156	10.32	1.05	.82
6776.740	.488	10.48	1.20	.84
6777.792	.660	10.24	.93	.64
6778.770	.820	9.830	.758	.501
6784.726	.795	9.822	.762	.515
6785.714	.957	9.960	.892	.644
6787.702	.283	10.349	1.085	.94
6789.760	.620	10.42	1.01	.79
6806.684	.390	10.471	1.130	.870
6807.689	.555	10.555	1.114	.809
6808.680	.717	10.074	.843	.570
6809.678	.880	9.912	.798	.574
6810.677	.044	10.136	.952	.680
6811.683	.209	10.307	1.042	.756
6815.674	.862	9.886	.798	.575
6816.648	.022	10.086	.942	.655
6843.659	.444	10.58	1.16	—
6845.634	.767	9.858	.779	.491
6846.644	.933	9.980	.861	.623
V572 Aql	d^{-1} .26467			
2436751.792	.997	11.01	.65	—
6752.794	.262	11.14	.74	—
6776.753	.603	11.44	.80	.52
6778.781	.140	11.060	.638	.56
6784.755	.721	11.339	.776	.459
6785.723	.977	11.028	.621	.46
6786.716	.240	11.20	.73	.51
6787.713	.504	11.416	.829	.61
6789.768	.048	11.026	.627	.422
6791.825	.592	11.437	.834	.49
6792.711	.827	11.241	.691	—
6793.706	.090	11.06	.65	.40
6808.687	.055	10.992	.625	.489
6809.685	.319	11.310	.761	.45
6812.666	.108	10.999	.674	.479
6813.661	.372	11.277	.840	.536
6815.683	.907	11.079	.656	.462
6816.663	.166	11.080	.704	.492
6819.674	.963	11.039	.652	.364
6841.688	.790	11.265	.809	.52
6845.641	.836	10.96:	.89:	.44:
6846.650	.103	11.027	.657	.44
V724 Aql	d^{-1} 3.8646	(W UMa-type variable)		
2436751.749	.809	11.11	.44	—
6752.752	.685	11.20	.43	.15
6775.735	.505	11.48	.45	.06
6776.714	.289	11.38	.54	.09
6777.760	.331	11.41	.63	.21
6778.731	.084	11.12	.51	.18
6779.837	.358	11.55	.44	.16
6784.719	.225	11.314	.453	.127
6785.697	.005	11.102	.493	.16
6786.695	.861	11.128	.472	.062
6791.775	.494	11.52	.50	.08
2436792.693	.041	11.127	.433	.050
6793.688	.887	11.20	.50	.15
6805.695	.289	11.359	.467	.106
6806.668	.049	11.127	.477	.157
6807.674	.937	11.097	.450	.104
6808.656	.732	11.179	.467	.124
6809.661	.616	11.325	.477	.111
6810.670	.515	11.475	.463	.100
6811.676	.403	11.530	.485	.115
6815.657	.788	11.140	.450	.090
6816.657	.653	11.267	.457	.101
6817.656	.513	11.459	.482	.059
6818.674	.448	11.553	.473	.121
6819.666	.281	11.347	.432	.149
6841.680	.357	11.572	.434	.093
6843.652	.978	11.118	.471	.106
6845.628	.614	11.36	.45	.03
6846.630	.486	11.526	.517	.156
6848.671	.374	11.503	.449	.13
6849.644	.134	11.127	.475	.141
Y Aur	d^{-1} .25910			
2436815.997	.025	9.871	1.094	.676
6816.995	.283	9.909	.996	.651
6817.999	.544	9.245	.761	.506
6818.986	.799	9.646	.977	.596
6819.991	.060	9.915	1.074	.655
6845.021	.545	9.265	.785	.481
6845.998	.798	9.627	1.009	.592
6846.997	.057	9.937	1.086	.684
6849.000	.576	9.293	.798	.480
6849.986	.831	9.674	.984	.621
SY Aur	d^{-1} .09858			
2436818.007	.119	9.336	1.199	.817
6818.980	.215	9.307	1.172	.775
6819.951	.311	9.195	1.083	.708
6844.996	.780	8.997	1.046	.648
6845.992	.878	9.089	1.130	.715
6846.990	.976	9.220	1.184	.767
6848.974	.172	9.356	1.181	.773
6849.979	.271	9.30	1.10	.70
AN Aur	d^{-1} .09717			
2436817.966	.502	10.715	1.297	.767
6818.965	.599	10.538	1.205	.670
6819.934	.693	10.276	1.141	.608
6844.981	.127	10.336	1.217	.699
6845.961	.222	10.439	1.244	.93
6846.944	.318	10.562	1.332	.81
BK Aur	d^{-1} .12496			
2436816.988	.851	9.206	.995	.629
6817.974	.974	9.316	1.060	.703
6818.973	.099	9.518	1.153	.767
6819.944	.220	9.646	1.241	.928
6844.990	.350	9.807	1.232	.809
6845.985	.474	9.649	1.111	.736
6846.985	.599	9.219	.928	.582

Table 3 (*continued*)

J.D. Hel.	Phase	*V*	*B−V*	*U−B*
2436848.968	.847	9.222	.994	.601
6849.972	.973	9.336	1.039	.692
RW Cam	d^{-1} .06090			
2436812.992	.911	8.797	1.369	.697
6813.985	.972	8.418	1.280	.694
6814.990	.033	8.190	1.208	.743
6815.970	.093	8.237	1.271	.749
6816.974	.154	8.326	1.324	.779
6817.939	.212	8.401	1.381	.828
6818.902	.271	8.479	1.428	.831
6819.884	.331	8.554	1.466	.844
6844.924	.856	8.789	1.369	.701
6845.931	.917	8.799	1.346	.676
6846.929	.978	8.380	1.255	.682
6848.910	.099	8.258	1.236	.766
RS Cas	d^{-1} .15884			
2436774.920	.128	9.796	1.486	—
6783.960	.564	10.295	1.656	—
6784.857	.707	10.210	1.548	—
6786.907	.032	9.714	1.342	1.04
6787.894	.189	9.906	1.494	1.08
6789.986	.521	10.24	1.58	—
6791.892	.824	9.704	1.302	.909
6792.825	.972	9.592	1.327	.891
6793.868	.138	9.835	1.470	1.07
6807.800	.351	10.016	1.591	1.10
6808.810	.511	10.213	1.621	1.22
6809.793	.668	10.275	1.570	1.26
6810.848	.835	9.640	1.300	.848
6811.809	.988	9.599	1.357	.853
6816.790	.779	9.888	1.417	.96
6817.794	.938	9.559	1.316	.952
6845.754	.380	10.091	1.555	1.22
6846.763	.540	10.233	1.649	1.20:
6848.784	.861	9.561	1.254	.891
6849.763	.016	9.650	1.395	.96
RY Cas	d^{-1} .08241			
2436774.958	.324	9.574	1.231	.895
6784.906	.144	9.803	1.245	.92
6787.934	.394	9.738	1.302	.99
6791.921	.722	10.251	1.595	—
6792.879	.801	10.322	1.556	—
6793.892	.885	10.323	1.545	1.17
6806.819	.950	10.244	1.474	1.17:
6807.809	.032	10.053	1.396	.93
6808.863	.118	9.906	1.314	.944
6809.829	.198	9.557	1.178	.848
6810.865	.283	9.455	1.154	.805
6811.873	.366	9.701	1.292	.950
6812.867	.448	9.849	1.347	1.001
6813.861	.530	9.961	1.430	1.24
6814.821	.609	10.098	1.521	1.10
6844.796	.080	9.955	1.339	.91
6845.797	.162	9.755	1.244	.908
6846.794	.244	9.396	1.093	.849
SW Cas	d^{-1} .18379			
2436768.936	.063	9.96	1.22	—
6772.963	.803	9.759	1.195	.76
6773.948	.984	9.906	1.285	.85:
6774.896	.158	9.906	1.196	.74
6785.982	.196	9.77	1.19	.66
6786.898	.364	9.325	.923	.611
6787.888	.546	9.59	1.04	.64
6791.854	.275	9.549	1.014	.651
6792.817	.452	9.368	.984	.663
6793.819	.636	9.57	1.15	.70
6805.818	.841	9.88	1.09	.87
6806.801	.022	9.934	1.224	.845
6808.801	.390	9.318	.938	.635
6810.797	.756	9.690	1.214	.796
6811.800	.941	9.875	1.211	.915
6812.798	.124	9.956	1.214	.93
6813.790	.306	9.429	.970	.650
6814.805	.493	9.440	1.021	.692
6815.793	.675	9.667	1.138	.814
6817.778	.039	9.949	1.209	.894
6819.775	.406	9.341	.951	.642
6844.788	.004	9.945	1.212	.83
6845.745	.179	9.88	1.15	.80
6846.754	.365	9.326	.938	.58
6847.777	.553	9.505	1.067	.714
SY Cas	d^{-1} .24564			
2436766.955	.235	10.14	1.17	.71
6768.918	.717	9.57	.91	—
6772.982	.715	9.584	.860	.71
6784.975	.661	9.503	.817	.537
6787.976	.398	10.148	1.110	.70
6791.983	.383	10.199	1.066	.72
6792.933	.616	9.45	.77	.57
6793.950	.866	9.80	1.01	.67
6805.927	.808	9.720	.945	.611
6806.907	.049	10.021	1.102	.808
6808.889	.535	9.562	.854	.541
6812.885	.517	9.659	.875	.587
6813.877	.761	9.656	.913	.633
6814.890	.010	9.963	1.109	.702
6815.825	.239	10.181	1.176	.78
6816.868	.495	9.812	.903	.615
6817.785	.721	9.592	.881	.563
6818.748	.957	9.913	1.057	.717
6844.842	.367	10.206	1.123	.81
6845.812	.605	9.408	.791	.564
6846.808	.850	9.778	.991	.701
6848.814	.343	10.210	1.142	.70
6849.794	.583	9.429	.793	.581
SZ Cas	d^{-1} .07342			
2436805.996	.696	9.995	1.554	1.10 :
6806.989	.769	9.967	1.507	1.22
6807.992	.843	9.906	1.490	1.09
6808.992	.916	9.826	1.420	1.00
6809.984	.989	9.663	1.416	.908
6810.991	.063	9.599	1.352	.898
6811.971	.135	9.610	1.383	.938

Table 3 (*continued*)

J.D. Hel.	Phase	V	$B-V$	$U-B$
2436812.943	.206	9.688	1.426	1.03
6813.938	.279	9.728	1.491	1.02
6814.975	.355	9.820	1.490	1.13
6815.946	.427	9.886	1.548	1.11
6816.933	.499	9.927	1.604	1.12
6817.897	.570	9.968	1.570	1.21
6818.883	.642	10.005	1.602	1.20
6845.886	.625	10.006	1.570	1.08 :
6849.907	.920	9.796	1.426	.92
TU Cas	d^{-1} .46744			
2436751.960	.136	7.86	.64	.32
6766.842	.093	8.12	.73	.43
.908	.123	8.02	.69	.39
.947	.142	7.95	.69	.34
6768.826	.020	7.99	.70	.45
.906	.057	7.94	.68	.39
6769.952	.546	7.51	.47	.38
6774.909	.863	7.86	.69	.35
6783.835	.036	8.25	.64	.40
.842	.039	8.05	.71	.38
.846	.041	8.04	.71	.38
.881	.057	8.02	.68	.40
.890	.062	8.00	.68	.36
.899	.066	7.99	.70	.36
.910	.071	7.98	.70	.36
.919	.075	7.95	.66	.39
.930	.080	7.93	.68	.34
.971	.099	7.92	.65	.34
.981	.104	7.91	.65	.33
.991	.109	7.89	.66	.34
6784.001	.113	7.90	.63	.26
.985	.573	7.659	.567	.317
6791.990	.848	7.943	.722	.419
6792.941	.292	7.11	.32	.31
6793.958	.768	7.95	.72	.40
6805.938	.368	7.570	.511	.316
6806.916	.825	7.858	.703	.397
6807.893	.282	7.233	.348	.291
6808.896	.750	7.938	.747	.440
6809.911	.225	7.522	.487	.303
6810.924	.698	7.800	.657	.355
6811.920	.164	7.966	.682	.392
6812.914	.629	7.700	.594	.366
6813.884	.082	8.112	.746	.435
6814.896	.555	7.753	.660	.369
6815.873	.012	7.989	.706	.385
6816.876	.481	7.475	.496	.313
6817.803	.914	7.971	.738	.415
6818.760	.361	7.189	.359	.336
.791	.376	7.255	.378	.334
6819.798	.846	7.980	.752	.437
6845.818	.009	8.070	.760	.433
6846.815	.475	7.665	.600	.339
6848.821	.413	7.266	.418	.285
6849.822	.881	7.996	.735	.410
VV Cas	d^{-1} .16109			
2436792.995	.284	10.71	1.18	.82 :
6806.980	.536	11.032	1.353	.68 :
6807.958	.694	11.179	1.402	.96
2436808.954	.854	10.952	1.146	.88
6809.968	.018	10.271	.947	.625
6810.976	.180	10.545	1.080	.77
6813.923	.655	11.110	1.298	.87
6814.944	.819	11.098	1.215	.83
6815.938	.979	10.312	.885	.639
6816.927	.139	10.399	1.050	.610
6845.871	.801	11.119	1.245	.91 :
6846.875	.963	10.324	.937	.618
6848.880	.286	10.692	1.160	.76 :
6849.850	.442	10.850	1.220	.94 :
VW Cas	d^{-1} .16684			
2436792.956	.337	10.70	1.27	.77
6806.963	.674	11.035	1.419	.79 :
6807.940	.837	10.805	1.208	.75
6808.937	.003	10.389	1.061	.74
6809.935	.170	10.571	1.140	.82
6811.940	.504	10.884	1.337	.94
6814.931	.003	10.352	1.052	.691
6815.898	.164	10.565	1.175	.66
6817.868	.493	10.885	1.336	.92
6818.806	.650	11.009	1.400	.98
6819.832	.821	10.824	1.239	.96
6844.855	.996	10.389	1.021	.71
6849.834	.826	10.830	1.234	.86
XY Cas	d^{-1} .22214			
2436792.948	.985	10.16	1.20	.69
6805.987	.882	10.224	1.297	.79
6806.954	.097	9.839	1.032	.639
6807.931	.314	9.772	1.040	.716
6808.929	.535	10.012	1.215	.790
6809.928	.757	10.171	1.250	.91
6810.938	.982	10.200	1.184	.80
6811.933	.203	9.647	.958	.651
6812.927	.424	9.904	1.117	.748
6815.889	.082	9.930	1.043	.664
6816.911	.309	9.751	1.068	.707
6846.822	.953	10.211	1.222	.82
6848.834	.400	9.877	1.116	.673
6849.828	.621	10.072	1.200	.82
BY Cas	d^{-1} .31045			
2436792.964	.876	10.50	1.32	.84
6806.972	.224	10.338	1.273	.81
6807.950	.528	10.178	1.202	.751
6808.946	.837	10.481	1.351	.87
6809.961	.152	10.398	1.268	.83
6810.968	.465	10.156	1.170	.79
6811.947	.769	10.407	1.332	.78
6812.935	.076	10.521	1.312	.89
6813.916	.380	10.179	1.172	.79
6814.937	.697	10.354	1.303	.79
6815.906	.998	10.548	1.361	.91
6816.919	.313	10.226	1.218	.783
6817.876	.610	10.254	1.241	.79
6818.813	.900	10.505	1.343	.81
6845.825	.286	10.238	1.200	.74
6846.869	.610	10.273	1.214	.78
6849.842	.533	10.186	1.194	.79

Table 3 (*continued*)

J.D. Hel.	Phase	V	$B-V$	$U-B$
CD Cas	d^{-1} .12818			
2436784.865	.684	10.880	1.623	—
6786.918	.947	11.05	1.66	—
6787.908	.074	10.910	1.49	.87
6791.910	.587	10.637	1.498	1.14 :
6793.884	.840	11.12	1.57	—
6805.840	.373	10.525	1.388	.93 :
6806.810	.497	10.556	1.406	1.02
6810.857	.016	11.058	1.600	—
6811.865	.145	10.614	1.307	.94
6812.859	.272	10.388	1.240	.84
6813.827	.396	10.552	1.379	.86
6819.782	.160	10.534	1.316	.99
6845.763	.490	10.578	1.363	.93 :
CG Cas	d^{-1} .22908			
2436784.923	.290	11.004	1.009	.76 :
6786.970	.759	11.435	1.388	—
6787.950	.984	11.657	1.364	—
6791.964	.903	11.572	1.428	—
6792.896	.117	11.73	1.36	—
6793.929	.353	10.888	1.010	.76
6805.909	.098	11.730	1.444	—
6806.881	.320	10.918	.977	.72
6807.872	.547	11.197	1.163	.74
6809.868	.005	11.691	1.370	—
6810.881	.237	11.252	1.206	.83
6811.881	.466	11.014	1.127	.62
6814.876	.152	11.639	1.426	—
6815.817	.367	10.898	1.067	.60
6819.790	.277	11.067	1.049	.64
DD Cas	d^{-1} .10192			
2436774.970	.505	9.63	1.06	.72
6784.914	.518	9.631	1.064	.719
6786.959	.727	9.703	1.179	.891
6787.940	.827	9.858	1.287	1.07
6791.930	.234	9.992	1.268	.94
6792.886	.331	9.89	1.17	.75
6793.900	.434	9.76	1.14	.76
6805.899	.657	9.628	1.126	.785
6807.861	.857	9.907	1.334	.984
6808.872	.960	10.069	1.382	1.14
6809.858	.061	10.162	1.392	1.12
6810.873	.164	10.108	1.372	1.00
6814.868	.571	9.555	1.067	.741
6815.810	.667	9.661	1.160	.871
6844.824	.624	9.623	1.123	.736
6849.771	.129	10.170	1.330	.98
DL Cas	d^{-1} .12500			
2436751.969	.996	9.15	1.27	1.05
6766.863	.858	8.96	1.23	.84
6768.890	.111	9.22	1.38	1.02
6769.972	.246	9.19	1.25	.80
6805.968	.746	8.833	1.158	.831
6806.944	.868	8.974	1.246	.871
6807.899	.987	9.087	1.308	.932
6809.919	.240	9.168	1.272	.860
2436810.930	.366	8.912	1.118	.737
6811.926	.491	8.666	1.061	.676
6812.919	.615	8.797	1.137	.741
6813.910	.739	8.830	1.176	.825
6814.924	.866	8.963	1.264	.830
6815.880	.985	9.100	1.319	.909
6816.904	.113	9.229	1.336	.943
6817.809	.226	9.191	1.303	.886
6818.798	.350	8.918	1.156	.782
6819.826	.478	8.651	1.057	.700
6844.848	.606	8.77	1.11	.73
6848.828	.104	9.215	1.352	.982
DW Cas	d^{-1} .20009			
2436791.901	.991	11.019	1.378	—
6792.868	.185	11.20	1.54	—
6793.877	.387	11.32	1.54	—
6805.828	.778	10.792	1.298	.76
6809.821	.577	11.199	1.472	.79
6812.830	.179	11.240	1.535	—
6813.800	.373	11.356	1.521	—
6814.813	.576	11.238	1.409	.85
6815.802	.774	10.826	1.283	.80
6816.825	.979	10.994	1.479	.71
FM Cas	d^{-1} .17213			
2436751.951	.213	9.14	.92	.70
6766.851	.778	9.15	1.12	.76
6768.811	.115	9.41	1.14	.84
6769.941	.310	8.87	.83	.55
6772.974	.832	9.23	1.10	.72
6773.969	.003	9.368	1.180	.852
6784.943	.892	9.267	1.125	.805
6786.987	.244	9.05	.94	.55
6787.959	.411	8.851	.862	.594
6793.944	.442	8.88	.89	.56
6805.919	.503	8.953	.911	.633
6806.900	.672	9.099	1.052	.727
6808.881	.013	9.386	1.147	.826
6809.904	.189	9.205	1.021	.623
6810.918	.363	8.846	.860	.529
6811.896	.532	8.974	.971	.607
6814.883	.046	9.399	1.177	.802
6816.861	.386	8.872	.870	.545
6818.740	.710	9.114	1.074	.753
6844.831	.201	9.164	.995	.654
6845.804	.368	8.822	.836	.560
6846.801	.540	8.978	1.005	.597
6848.809	.885	9.298	1.124	.794
6849.786	.054	9.407	1.157	.799
IX Cas	d^{-1} .10945			
2436784.936	.611	11.17	.55	.51
6786.979	.835	11.43	.73	.36 :
6787.969	.943	11.646	.854	—
6791.974	.382	11.427	.538	.30
6792.906	.484	11.25	.55	.32
6793.937	.596	11.26	.56	.32
6806.892	.014	11.673	.874	.48
6807.883	.123	11.668	.797	.60

Table 3 (*continued*)

J.D. Hel.	Phase	V	$B-V$	$U-B$
2436809.880	.341	11.501	.546	.44
6810.911	.454	11.287	.565	.31
6811.890	.561	11.236	.510	.41
6812.877	.669	11.324	.632	.44
6813.870	.778	11.438	.675	.47
6816.835	.103	11.726	.810	.47
6849.778	.708	11.373	.602	.35
CR Cep	d^{-1} .16043			
2436772.917	.579	9.49	1.39	—
6773.890	.735	9.588	1.547	—
6774.875	.893	9.69	1.55	—
6777.967	.389	9.44	1.34	.89
6785.967	.673	9.56	1.46	1.08
6787.868	.978	9.76	1.56	1.15
6789.971	.315	9.53	1.37	.91
6806.791	.013	9.797	1.538	1.26
6807.777	.172	9.754	1.480	1.04
6808.783	.333	9.503	1.371	.968
6809.778	.493	9.435	1.391	.976
6810.783	.654	9.562	1.467	1.015
6811.778	.814	9.631	1.521	1.07
6812.781	.974	9.773	1.553	1.12
6813.774	.134	9.803	1.539	1.04
6814.790	.297	9.584	1.387	.940
6815.749	.451	9.439	1.357	.936
6816.774	.615	9.525	1.426	1.087
6817.737	.770	9.637	1.490	1.06
6819.766	.095	9.833	1.539	1.22
6845.702	.256	9.64	1.41	.96
6846.740	.422	9.443	1.340	.897
6849.736	.903	9.721	1.509	1.06
SZ Cyg	d^{-1} .06619			
2436751.852	.905	9.28	1.40	—
6773.790	.357	9.842	1.789	—
6774.730	.419	9.83	1.74	—
6775.759	.487	9.63	1.57	1.30 :
6777.830	.625	9.471	1.421	1.01
6778.805	.689	9.03	1.25	.90
6784.760	.083	9.49	1.67	1.52
6785.758	.149	9.62	1.70	—
6786.742	.214	9.69	1.76	1.60
6787.744	.281	9.77	1.79	—
6789.772	.415	9.822	1.701	1.56
6791.726	.544	9.57	1.51	1.19
6792.738	.611	9.54	1.47	1.10
6793.741	.678	9.07	1.29	.90
6807.723	.603	9.571	1.480	1.17
6808.728	.670	9.116	1.287	.955
6809.715	.735	8.957	1.254	.936
6810.717	.801	9.017	1.347	1.001
6811.690	.866	9.159	1.439	1.156
6812.680	.931	9.232	1.507	1.312
6813.680	.997	9.371	1.580	1.38
6819.716	.397	9.866	1.712	1.47
TX Cyg	d^{-1} .06799			
2436774.803	.619	9.88	2.00	—
6777.860	.827	9.19	1.67	1.12
2436784.778	.297	9.64	2.08	1.54 :
6785.806	.367	9.76	2.12	.168
6786.772	.433	9.91	2.10	—
6787.760	.500	9.966	2.097	—
6789.816	.640	9.84	2.05	—
6791.831	.777	9.653	1.813	1.44
6792.755	.839	9.02	1.59	1.18
6793.748	.907	8.90	1.57	1.15
6805.712	.720	9.72	1.89	1.52
6806.729	.790	9.598	1.837	1.38
6808.737	.926	8.982	1.644	1.191
6809.723	.993	9.139	1.730	1.305
6810.732	.062	9.242	1.829	1.34
6811.727	.129	9.365	1.890	1.41
6812.723	.197	9.458	1.959	1.62
6813.724	.265	9.611	1.998	1.75
6817.714	.536	10.025	2.104	—
VX Cyg	d^{-1} .04968			
2436751.874	.433	10.57	1.83	—
6774.792	.572	10.30	1.76	—
6777.850	.724	9.533	1.456	1.03
6784.768	.067	10.097	1.922	—
6785.782	.118	10.15	1.93	—
6786.759	.166	10.24	1.98	—
6787.752	.216	10.34	1.96	—
6789.810	.318	10.52	1.95	—
6810.725	.357	10.541	1.966	—
6811.717	.406	10.576	2.012	—
6812.717	.456	10.433	1.894	—
6813.717	.505	10.329	1.773	1.25
6814.744	.556	10.333	1.758	1.41
6815.727	.605	10.192	1.681	1.24
6816.711	.654	9.712	1.475	1.10
6817.683	.702	9.537	1.437	.998
6818.682	.752	9.602	1.461	1.094
6819.680	.802	9.703	1.545	1.16
6841.729	.897	9.819	1.654	1.52
VY Cyg	d^{-1} .12728			
2436771.755	.909	9.90	1.37	—
6772.868	.051	9.97	1.48	—
6773.858	.177	9.890	1.382	—
6774.819	.299	9.42	1.14	.73
6777.888	.690	9.41	1.20	.79
6784.675	.553	9.386	1.199	.811
6785.841	.702	9.43	1.24	.87
6786.812	.825	9.705	1.351	1.03 :
6787.767	.947	9.837	1.415	1.04
6789.824	.209	9.82	1.33	1.01
6791.712	.449	9.26	1.14	.79
6792.763	.583	9.38	1.18	.82
6805.744	.235	9.74	1.28	.80
6806.737	.361	9.217	1.035	.780
6807.733	.488	9.335	1.215	.765
6808.743	.617	9.327	1.189	.800
6811.734	.998	9.921	1.472	1.13
6812.731	.124	10.003	1.449	1.13
6813.731	.252	9.687	1.253	.809
6814.752	.382	9.207	1.044	.772
6815.734	.507	9.372	1.179	.823

Table 3 (*continued*)

J.D. Hel.	Phase	*V*	*B*−*V*	*U*−*B*
2436816.718	.632	9.334	1.180	.817
6845.676	.318	9.38	1.11	.72
6846.685	.446	9.269	1.097	.769
6847.758	.583	9.385	1.195	.843
6849.721	.832	9.709	1.392	.92
VZ Cyg	d^{-1} .20557			
2436751.890	.986	9.20	1.02	.76
6766.756	.042	9.244	1.032	.72
6768.757	.453	8.69	.79	.57
6769.895	.687	8.93	.95	.58
6772.907	.306	8.65	.73	.47
6773.880	.507	8.738	.849	.535
6784.852	.762	9.032	1.009	.672
6785.946	.987	9.24	1.06	.73
6786.845	.172	9.140	.977	.611
6787.824	.373	8.62	.69	.47
6792.797	.395	8.612	.736	.453
6793.805	.602	8.88	.89	.56
6805.773	.063	9.26	1.05	.70
6806.783	.270	8.795	.786	.467
6809.771	.885	9.150	1.030	.716
6810.777	.091	9.260	1.054	.711
6811.750	.291	8.701	.742	.477
6816.769	.323	8.620	.719	.487
6844.768	.079	9.27	1.07	.72
6845.695	.270	8.82	.78	.46
6846.733	.483	8.726	.793	.546
6847.770	.696	8.992	.953	.618
6848.771	.902	9.189	1.037	.707
BZ Cyg	d^{-1} .09861			
2436751.863	.801	10.51	1.58	—
6773.804	.965	10.063	1.552	—
6774.740	.057	10.06	1.49	—
6777.839	.363	10.15	1.59	—
6778.830	.460	10.25	1.65	—
6785.769	.145	10.06	1.50	1.13
6786.748	.241	9.98	1.52	.92
6789.780	.540	10.368	1.655	—
6791.762	.736	10.475	1.727	—
6792.746	.833	10.35	1.66	—
6805.703	.110	10.04	1.51	.96
6806.720	.211	10.020	1.482	1.02
6812.709	.801	10.420	1.665	—
6813.708	.900	10.219	1.554	1.03
6814.737	.001	10.064	1.464	1.05
6815.720	.098	10.047	1.479	1.12
6816.703	.195	10.011	1.475	1.12
6841.705	.661	10.527	1.729	—
6844.731	.959	10.10	1.51	1.14
6845.648	.049	10.01	1.46	1.18
6846.678	.151	10.037	1.49	1.12
6847.750	.257	10.043	1.531	1.10 :
CD Cyg	d^{-1} .05858			
2436751.799	.520	8.94	1.39	1.31
6752.803	.579	9.00	1.51	1.39
6766.707	.394	8.741	1.27	1.12
6768.713	.511	8.90	1.48	1.23
2436769.859	.578	8.98	1.53	—
6770.794	.633	9.11	1.54	—
6771.726	.688	9.29	1.65	—
6772.824	.752	9.33	1.64	—
.848	.753	9.35	1.62	—
6773.737	.806	9.424	1.656	—
6774.771	.866	9.47	1.62	—
6775.742	.923	9.40	1.65	—
6777.799	.043	9.22	1.42	—
6778.790	.102	9.20	1.33	.94
6793.733	.977	9.37	1.52	1.24
6808.714	.854	9.486	1.685	1.69
6810.683	.970	9.400	1.538	1.29
6813.668	.145	8.636	1.009	.765
6814.730	.207	8.431	1.014	.747
6815.689	.263	8.492	1.051	.776
6816.670	.321	8.578	1.148	.871
6817.674	.379	8.678	1.256	.988
6848.757	.200	8.424	1.016	.685
6849.707	.256	8.492	1.076	.816
GH Cyg	d^{-1} .12791			
2436751.770	.619	10.24	1.40	—
6752.759	.745	10.30	1.42	—
6773.714	.426	9.924	1.382	.98
6774.698	.552	10.17	1.40	1.02
6776.726	.811	10.23	1.36	—
6777.780	.946	9.93	1.27	.67 :
6778.741	.069	9.53	1.11	.68
6785.705	.960	9.830	1.236	.806
6786.703	.087	9.57	1.13	.79
6787.694	.214	9.710	1.244	.828
6791.754	.733	10.31	1.40	.98
6792.700	.854	10.189	1.348	.78
6793.696	.982	9.76	1.18	.77
6806.676	.642	10.246	1.420	1.06
6807.681	.770	10.336	1.381	.89
6808.672	.897	10.076	1.288	.87
6809.652	.023	9.600	1.101	.761
6810.651	.150	9.665	1.167	.836
6811.664	.280	9.751	1.226	.814
6812.648	.406	9.885	1.333	.853
6817.647	.045	9.569	1.069	.737
6846.637	.753	10.32	1.45	1.09
6848.678	.014	9.63	1.12	.80
MW Cyg	d^{-1} .16794			
2436751.845	.905	9.71	1.41	—
6752.824	.069	9.85	1.48	—
6773.781	.589	9.300	1.314	1.01
6774.721	.747	9.55	1.42	—
6777.806	.265	9.54	1.36	.90
6778.798	.431	9.15	1.19	.79
6785.751	.599	9.37	1.33	1.00
6787.736	.932	9.681	1.492	1.18
6806.691	.116	9.863	1.550	1.13
6807.715	.288	9.483	1.290	.929
6808.720	.456	9.190	1.179	.823
6809.708	.622	9.388	1.318	.945
6810.710	.791	9.525	1.431	1.064
6812.672	.120	9.866	1.513	1.21

Table 3 (*continued*)

J.D. Hel.	Phase	V	$B-V$	$U-B$
2436813.675	.289	9.508	1.298	.875
6816.677	.793	9.541	1.401	1.076
6819.709	.302	9.464	1.291	.908
6841.698	.995	9.817	1.521	1.08
6844.724	.503	9.24	1.27	.86
6849.713	.341	9.296	1.186	.853
	d^{-1}			
V386 Cyg	.19022			
2436774.865	.715	9.66	1.66	—
6777.906	.293	9.34	1.38	—
6784.832	.611	9.55	1.56	1.11
6785.911	.816	9.77	1.66	1.26
6786.820	.989	9.926	1.678	1.14
6787.801	.176	9.79	1.57	1.25
6789.881	.571	9.47	1.53	1.05 :
6792.770	.121	9.91	1.68	1.13
6793.764	.310	9.27	1.37	.92
6805.760	.592	9.56	1.54	1.13
6809.738	.348	9.258	1.378	1.012
6812.738	.919	9.870	1.680	1.37
6815.742	.490	9.432	1.470	1.024
6816.732	.679	9.649	1.589	1.21
6818.689	.051	9.953	1.702	1.17
6819.724	.248	9.546	1.471	.972
6841.738	.435	9.328	1.421	1.050
6846.691	.378	9.273	1.387	.962
	d^{-1}			
V402 Cyg	.22910			
2436751.808	.839	10.13	1.13	.86
6752.812	.069	9.86	.87	.63
6766.720	.256	9.646	.969	.56
6768.725	.715	10.16	1.09	.78
6769.872	.978	10.17	.86	—
6770.806	.192	9.60	.82	.52
6771.740	.406	9.889	1.012	.61
6772.858	.662	10.12	1.09	.72
6773.746	.865	10.205	1.096	.79
6774.780	.102	9.75	.84	.57
6775.750	.324	9.74	.96	.64
	d^{-1}			
V459 Cyg	.13791			
2436777.895	.739	10.92	1.66	—
6784.789	.690	11.00	1.67	—
6785.849	.836	10.70 :	1.30 :	.98
6786.783	.965	10.28	1.30	.92
6787.793	.105	10.41	1.40	.91 :
6789.830	.385	10.72	1.54	1.22
6791.839	.663	10.97	1.69	—
6793.756	.927	10.30	1.31	.85
6805.751	.581	10.93	1.62	—
6808.775	.998	10.289	1.285	.90
6809.729	.130	10.509	1.366	1.08
6810.740	.269	10.476	1.498	.98
6816.724	.094	10.433	1.381	1.04
6817.723	.232	10.546	1.476	1.18
	d^{-1}			
V532 Cyg	.30455			
2436751.882	.286	8.96	.94	.72
6766.742	.811	9.213	1.131	.76
2436768.743	.421	8.94	1.00	—
6769.883	.768	9.14	1.11	—
6772.879	.680	9.155	1.032	.70
6773.869	.982	9.211	1.118	.76
6777.917	.215	8.99	1.04	.71
6785.919	.652	9.14	1.12	.74
6786.829	.929	9.25	1.12	.74
6787.808	.227	9.00	1.01	.67
6791.719	.418	8.96	1.00	.70
6793.790	.049	9.16	1.10	.72
6806.745	.994	9.206	1.126	.721
6807.739	.297	8.933	.996	.666
6811.741	.516	8.993	1.034	.696
6812.767	.828	9.231	1.153	.733
6813.739	.124	9.106	1.063	.678
6814.759	.435	8.951	1.000	.788
6816.760	.044	9.193	1.085	.680
6817.731	.340	8.942	.984	.672
6818.722	.642	9.123	1.084	.724
6819.731	.949	9.244	1.140	.745
6845.682	.852	9.25	1.14	.78
6846.697	.162	9.057	1.044	.66
6847.763	.486	8.965	1.022	.667
6848.765	.791	9.229	1.156	.717
	d^{-1}			
V538 Cyg	.16343			
2436777.939	.719	10.40	1.32	—
6784.841	.847	10.50	1.36	—
6785.938	.026	10.67	1.35	—
6786.835	.172	10.68	1.38	1.01
6787.814	.332	10.38	1.24	.81
6789.933	.679	10.39	1.28	—
6791.848	.992	10.639	1.383	1.06
6793.797	.310	10.45	1.21	.76
6805.767	.267	10.53	1.31	.76
6806.751	.427	10.193	1.168	.768
6807.746	.590	10.284	1.230	.89
6809.762	.919	10.554	1.434	1.05
6810.769	.084	10.693	1.460	1.15
6812.774	.412	10.242	1.182	.80
6813.767	.574	10.297	1.224	.88
6818.729	.385	10.290	1.161	.84
6819.738	.550	10.275	1.193	.85
6841.748	.147	10.73	1.51	—
6844.740	.636	10.34	1.27	.89 :
6845.688	.791	10.50	1.32	.88
6846.703	.957	10.58	1.43	1.00
6849.728	.451	10.22	1.13	.77
	d^{-1}			
UY Eri	.45183			
2436817.951	.555	11.338	.440	.20
6818.927	.996	11.476	.484	.09
6819.987	.475	11.239	.489	.122
6844.919	.740	11.457	.535	.10
6845.903	.184	10.949	.361	.069
6846.902	.636	11.409	.558	.04
6847.936	.103	11.122	.409	—
6848.904	.540	11.312	.517	.16
6849.924	.001	11.46	.52	.06

Table 3 (*continued*)

J.D. Hel.	Phase	V	$B-V$	$U-B$
BB Gem	d^{-1} .43323			
2436846.004	.894	11.60	1.00	.76
6847.005	.328	10.817	.578	.445
6849.007	.195	11.665	.885	—
6850.008	.629	11.29	.90	.45
V Lac	d^{-1} .20066			
2436751.935	.843	9.03	.98	.66
6766.823	.831	8.98	1.01	.68
6768.789	.225	9.41	1.11	—
6769.915	.451	8.42	.63	.52
6772.928	.056	9.21	1.09	.74
6785.975	.674	8.75	.89	.55
6792.803	.044	9.21	1.10	.67
6805.804	.653	8.724	.862	.531
6807.785	.050	9.218	1.096	.704
6808.791	.252	9.355	1.096	.730
6809.787	.452	8.410	.682	.513
6811.786	.853	9.013	1.011	.686
6814.798	.457	8.430	.679	.506
6844.774	.472	8.431	.673	.482
6845.732	.665	8.76	.85	.55
6848.777	.276	9.350	1.084	.687
X Lac	d^{-1} .18367			
2436751.943	.129	8.59	1.00	.71
6766.836	.865	8.43	.97	.64
6768.801	.226	8.59	1.01	.72
6769.929	.433	8.24	.84	.59
6772.937	.985	8.51	1.00	.71
6774.886	.343	8.458	.938	.57
6786.885	.547	8.22	.82	.52
6787.876	.729	8.30	.88	.62
6789.979	.115	8.58	1.04	.69
6792.810	.635	8.212	.859	.544
6793.811	.819	8.37	.94	.62
6805.810	.023	8.545	1.005	.695
6807.793	.387	8.344	.881	.586
6810.791	.938	8.479	1.002	.676
6811.793	.122	8.558	1.033	.688
6812.790	.305	8.502	.986	.613
6813.784	.488	8.202	.834	.559
6816.782	.038	8.550	1.023	.688
6817.744	.215	8.578	1.020	.640
6844.780	.181	8.593	1.028	.639
6845.738	.357	8.41	.90	.57
6846.747	.542	8.209	.830	.534
CC Lyr	d^{-1} .04164			
2436751.725	.142	12.20	.70	—
6752.752	.185	12.24	.73	—
6773.704	.057	12.12	.54	—
6777.729	.225	12.18	.71	—
6778.700	.265	12.18	.73	—
6783.729	.474	12.12	.50	.20
6784.704	.515	12.019	.371	.16
6785.684	.556	11.830	.363	.25
6786.676	.597	11.79	.37	.23
6787.674	.639	11.752	.302	.28 :
2436789.749	.725	11.808	.387	.202
6790.676	.764	11.848	.430	.164
6791.791	.810	11.82	.57	.22 :
6792.681	.847	11.859	.562	.26
6793.677	.889	12.02	.63	.05
6805.683	.389	12.44	.68	.16
6806.657	.429	12.409	.630	.27
6807.663	.471	12.311	.579	.04
6817.664	.888	11.927	.617	.21
6818.663	.929	11.986	.585	.13
6819.657	.971	11.996	.616	.29
6845.619	.052	12.10	.68	.39 :
6846.620	.093	12.127	.641	.29 :
6848.654	.178	12.37	.59	—
6849.635	.219	12.40	.808	.31 :
CN Lyr	d^{-1} .42809			
2436751.736	.351	11.41	.80	—
6752.740	.780	11.17	.43	—
6774.685	.175	11.507	.653	—
6775.719	.618	11.55	.62	.16
6776.697	.036	11.38	.62	.12
6777.741	.483	11.64	.61	—
6778.715	.900	11.22	.52	.18
6786.684	.312	11.54	.70	.27
6787.687	.741	11.288	.492	.182
6792.668	.873	11.115	.447	.277
6810.660	.575	11.641	.658	.31
6811.656	.002	11.323	.584	.39
6812.656	.430	11.596	.645	.21
6813.649	.855	11.174	.437	.281
6818.653	.997	11.299	.584	.234
6819.648	.423	11.644	.620	.33
6843.640	.694	11.29	.48	.26
6848.663	.844	11.29	.54	.32
6849.653	.268	11.681	.615	—
BH Oph	d^{-1} .09046			
2436751.713	.760	12.40	.61	—
6752.724	.851	12.00	.54	—
6775.707	.930	11.68	.45	.40
6776.686	.019	11.62	.49	.35
6777.712	.112	11.78	.54	.32
6778.686	.200	11.98	.73	—
6779.819	.302	12.21	.76	—
6784.691	.743	12.429	.669	—
6791.783	.385	12.22	.76	—
6805.670	.641	12.41	.85	—
6807.655	.820	12.195	.432	.27
6808.663	.912	11.768	.433	.25
6809.668	.003	11.626	.413	.33
6815.663	.545	12.38	.81	.52
SX Per	d^{-1} .23309			
2436817.957	.198	11.287	1.268	.86
6818.907	.419	11.470	1.292	.97
6819.918	.655	10.875	1.016	.64
6844.934	.486	11.486	1.278	.86
6845.939	.720	10.712	.951	.69
6846.936	.952	11.029	1.153	.66

Table 3 (*continued*)

J.D. Hel.	Phase	V	$B-V$	$U-B$
2436848.946	.421	11.51	1.24	—
6849.931	.650	10.89	1.01	.79
UY Per	d^{-1} .18639			
2436812.984	.872	11.040	1.435	1.19
6813.979	.058	11.275	1.68	—
6815.962	.427	11.733	1.78	—
6816.967	.614	11.432	1.610	1.047
6817.907	.790	10.869	1.346	1.10
6818.894	.974	11.143	1.545	1.06
6819.876	.157	11.424	1.682	—
6844.909	.823	10.919	1.375	1.08 :
6845.893	.006	11.242	1.533	—
6846.893	.192	11.455	1.640	—
6848.895	.566	11.596	1.691	—
6849.914	.755	10.847	1.334	—
VX Per	d^{-1} .09179			
2436766.916	.135	9.08	1.13	.73
6768.967	.323	9.04	1.09	—
6774.981	.876	9.545	1.347	—
6784.993	.795	9.696	1.406	—
6805.976	.721	9.641	1.434	—
6808.963	.995	9.290	1.183	.792
6809.977	.088	9.085	1.086	.745
6810.984	.180	9.143	1.126	.805
6813.931	.451	9.227	1.282	.889
6814.953	.545	9.364	1.365	1.036
6817.886	.814	9.661	1.391	1.095
6818.822	.900	9.462	1.245	.843
6819.868	.996	9.266	1.162	.781
6844.900	.293	8.96	1.06	.71
6845.879	.383	9.174	1.186	.792
6846.884	.475	9.265	1.254	.841
6848.886	.659	9.592	1.410	1.09
6849.899	.752	9.697	1.413	1.106
(VY Per	d^{-1} .18077)			
2436809.001	.863	11.991	.640	.24
6811.994	.404	11.971	.615	.09
6812.974	.581	11.891	.745	.23
6813.970	.761	11.934	.686	.18
6814.982	.944	11.954	.663	.17
6815.954	.120	11.938	.757	.06
AS Per	d^{-1} .20110			
2436812.998	.094	9.754	1.444	1.04
6813.992	.294	9.915	1.535	1.17
6814.996	.496	10.049	1.484	1.10
6815.990	.696	9.182	1.133	.849
6816.981	.895	9.463	1.317	.911
6844.966	.523	10.020	1.439	1.04
6845.947	.720	9.224	1.139	.876
6846.952	.922	9.511	1.332	.969
6848.955	.325	10.00	1.50	1.17
6849.960	.527	10.00	1.43	1.10
AW Per	d^{-1} .15472			
2436806.995	.178	7.522	1.070	.602
6808.000	.334	7.050	.906	.601
6809.007	.490	7.277	1.031	.648
6809.990	.642	7.407	1.112	.655
6810.996	.797	7.637	1.196	.679
6811.976	.949	7.769	1.224	.701
6813.006	.108	7.791	1.171	.635
6814.001	.262	7.072	.910	.582
6815.004	.417	7.155	.985	.615
6818.958	.029	7.833	1.205	.678
6819.927	.179	7.522	1.069	.596
6844.974	.054	7.833	1.201	.625
6845.954	.206	7.410	1.022	.575
6846.959	.361	7.086	.926	.605
6848.962	.671	7.45	1.12	.65
6849.967	.827	7.72	1.21	.66

I just mentioned that I assigned a lower weight to observations made under unfavourable observing conditions. I have assigned a lower weight to some observations for another reason. All observations which were obtained with a high gain have been rejected when the amplitude between sky and star on the Brown recorder remained below a certain value. I assigned a low weight to them, when this amplitude was larger than the value just mentioned, but smaller than another critical value. These critical values were chosen rather arbitrarily for the different gains. I have not tried to derive relative weights for good and poor observations. All the good observations are given in three decimals, whereas the poor observations are given in two. The errors can become quite large for faint variables observed under poor conditions.

The observed magnitudes and colours for 53 variables have been listed in Table 3. The first column gives the heliocentric Julian Day, the second column the phase computed with the formula: phase = P^{-1}. (J.D. — 2430000). The value of the reciprocal period used has been indicated in Table 3 behind the name of the variable. Observations indicated by a colon are very uncertain. These observations have not been plotted in Figure 1 *a*, *b*, *c* and *d*, in which the light- and colour curves are shown. V724 Aql, which proved to be a variable of the W UMa type, and TU Cas, which has a pronounced secondary period, are not shown in Figure 1. Neither have the observations of VY Per been plotted. I must have made a mistake in the identification of this variable, because the observed magnitude is practically constant. Assuming that the

FIGURE 1*a*

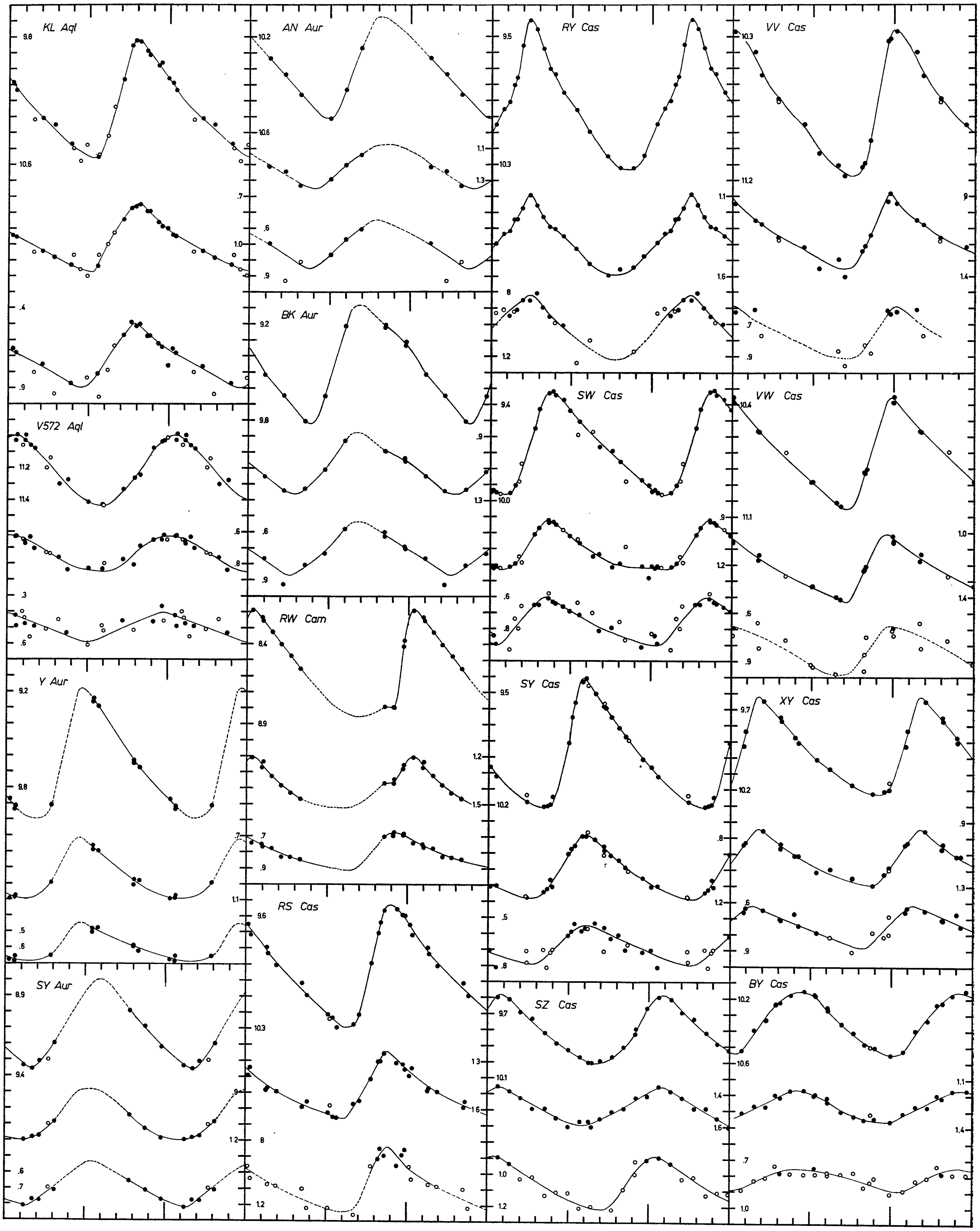

KL Aql
9.8
10.6
.7
1.0
.4
.9
AN Aur
10.2
10.6
1.1
1.3
.6
.9
RY Cas
9.5
10.3
1.1
1.6
.8
1.2
VV Cas
10.3
11.2
1.1
1.4
.7
.9
V572 Aql
11.2
11.4
.6
.8
.3
.6
BK Aur
9.2
9.8
.9
1.3
.6
.9
SW Cas
9.4
10.0
.9
1.2
.6
.8
VW Cas
10.4
11.1
1.0
1.4
.6
.9
RW Cam
8.4
8.9
1.2
1.5
.7
.9
Y Aur
9.2
9.8
.7
1.1
.5
.6
SY Cas
9.5
10.2
.8
1.2
.5
.8
XY Cas
9.7
10.2
.9
1.3
.6
.9
RS Cas
9.6
10.3
1.3
1.6
.8
1.2
SY Aur
8.9
9.4
.9
1.2
.6
.7
SZ Cas
9.7
10.1
1.4
1.6
1.0
1.2
BY Cas
10.2
10.6
1.1
1.4
.7
1.0

FIGURE 1 *b*

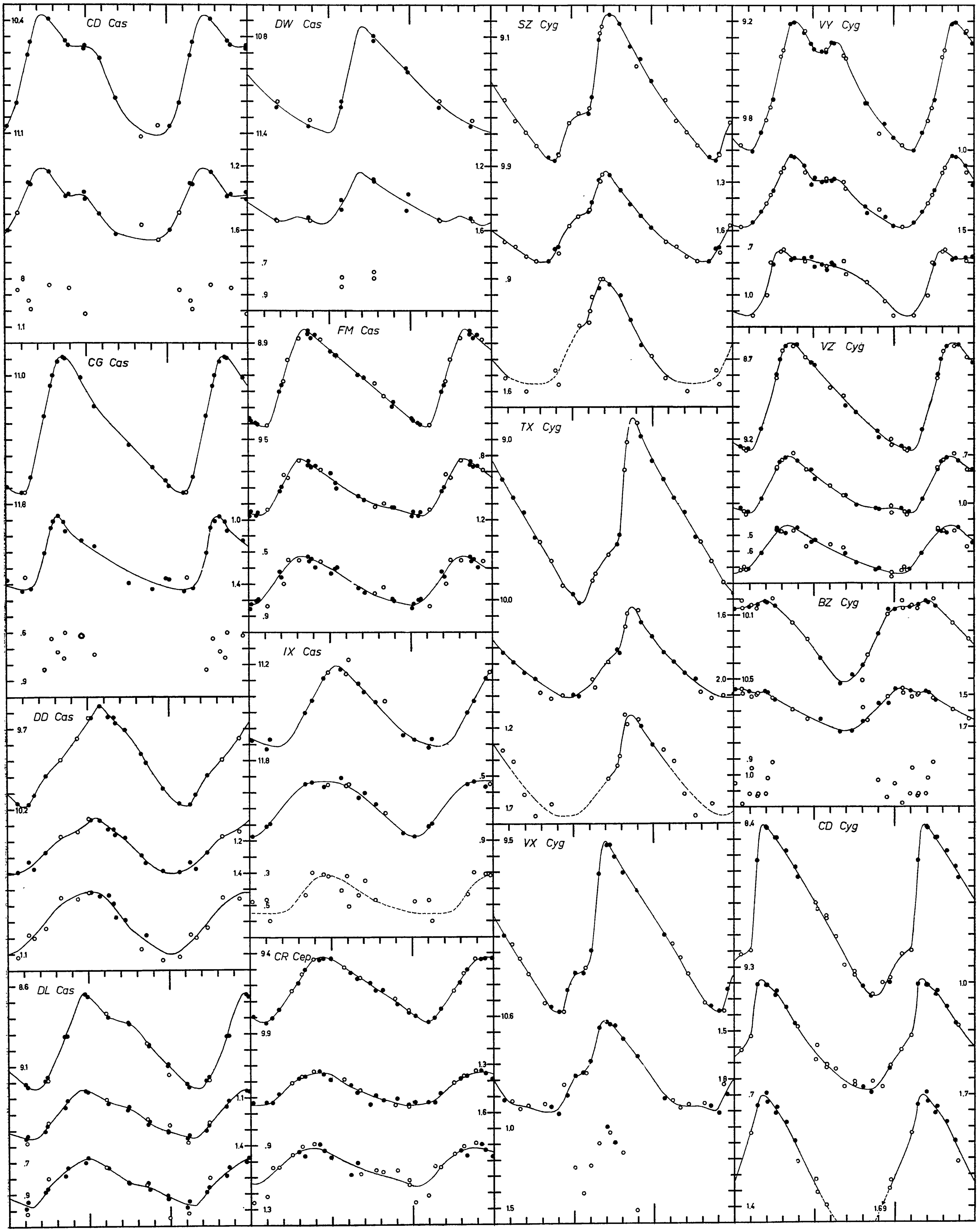

CD Cas
10.4
11.1
1.2
1.6
.8
1.1
CG Cas
11.0
11.8
1.0
1.4
.6
.9
DD Cas
9.7
10.2
1.2
1.4
1.1
DL Cas
8.6
9.1
1.1
1.4
.7
.9
DW Cas
10.8
11.4
1.2
1.6
.7
.9
FM Cas
8.9
9.5
.8
1.2
.5
.9
IX Cas
11.2
11.8
.5
.9
.3
.5
CR Cep
9.4
9.9
1.3
1.6
.9
1.3
SZ Cyg
9.1
9.9
1.3
1.6
.9
1.6
TX Cyg
9.0
10.0
1.6
2.0
1.2
1.7
VX Cyg
9.5
10.6
1.5
1.8
1.0
1.5
VY Cyg
9.2
9.8
1.0
1.3
1.5
.7
1.0
VZ Cyg
8.7
9.2
.7
1.0
.5
.6
BZ Cyg
10.1
10.5
1.5
1.7
.9
1.0
CD Cyg
8.4
9.3
1.0
1.5
1.7
.7
1.4
1.69

FIGURE 1c

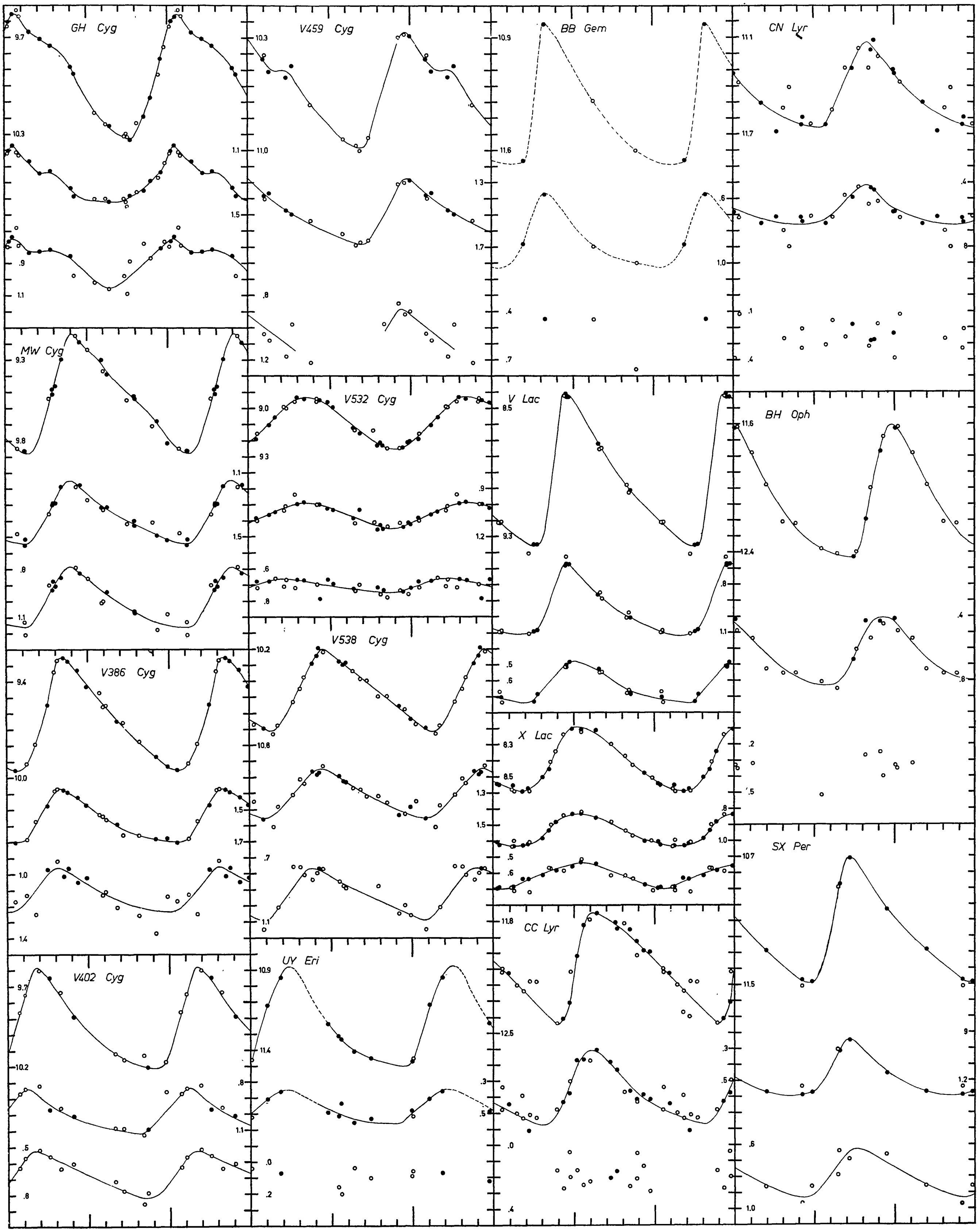
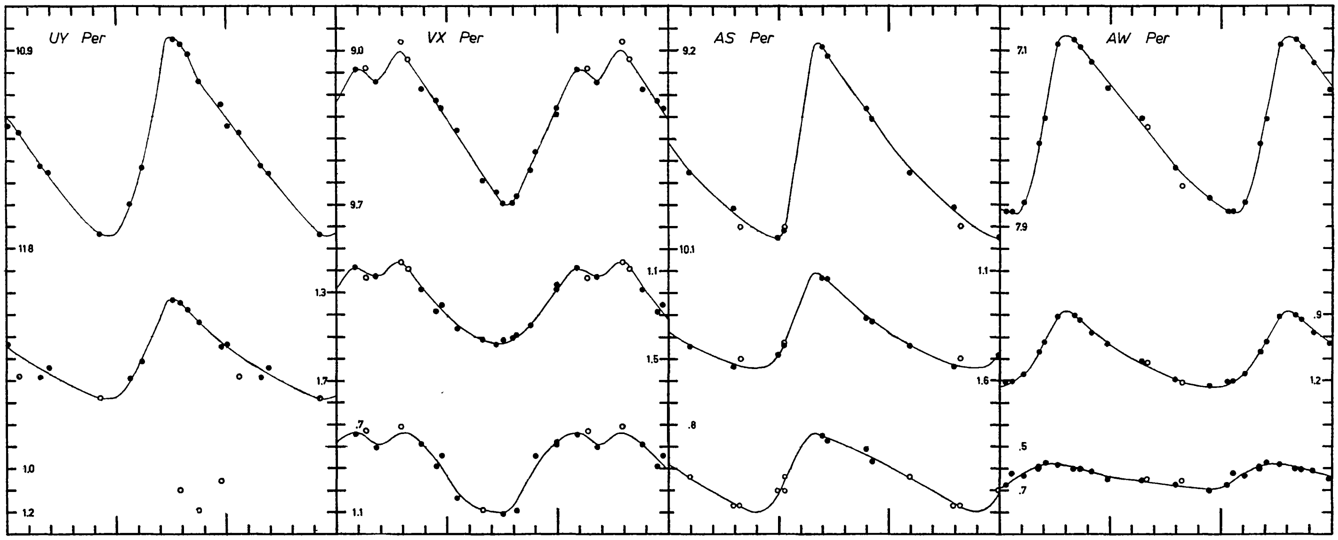

GH Cyg
9.7
10.3
1.1
1.5
.9
1.1
V459 Cyg
10.3
11.0
1.3
1.7
.8
1.2
BB Gem
10.9
11.6
.6
1.0
.4
.7
CN Lyr
11.1
11.7
.4
.8
.1
.4
MW Cyg
9.3
9.8
1.1
1.5
.8
1.1
V532 Cyg
9.0
9.3
.9
1.2
.6
.8
V Lac
8.5
9.3
.8
1.1
.5
.6
BH Oph
11.6
12.4
.4
.8
.2
.5
V386 Cyg
9.4
10.0
1.5
1.7
1.0
1.4
V538 Cyg
10.2
10.8
1.3
1.5
.7
1.1
X Lac
8.3
8.5
.8
1.0
.5
.6
SX Per
10.7
11.5
.9
1.2
.6
1.0
V402 Cyg
9.7
10.2
.8
1.1
.5
.8
UY Eri
10.9
11.4
.3
.5
.0
.2
CC Lyr
11.8
12.5
.3
.5
.0
.4

FIGURE 1 *d*



star is constant, I find the following values: V = 11.946, $B-V$ = .684 and $U-B$ = .16 with a mean error for one observation of ± .034, ± .057 and ± .073 respectively. This gives an indication of the accuracy of the observations for stars of about the 12th magnitude.

In the following remarks on the individual variables I have derived improved ephemerides which will be useful for extrapolation. As I did not make a complete analysis of each individual variable, references for the old epochs will be omitted.

Remarks on individual Cepheids

KL Aql	max.	E	$O-C$
	2425857.84	0	+ .25
	6199.38	56	— .26
	2433950.66	1325	+ .02
	6784.73	1789	— .01

max. 2436784.74 + 6.10796 E
± 16

*V*572 *Aql* The period 3.83 from the *General Catalogue of Variable Stars* does not represent the observations. The following elements seem satisfactory:

max. 2436789.74 + 3.778 E

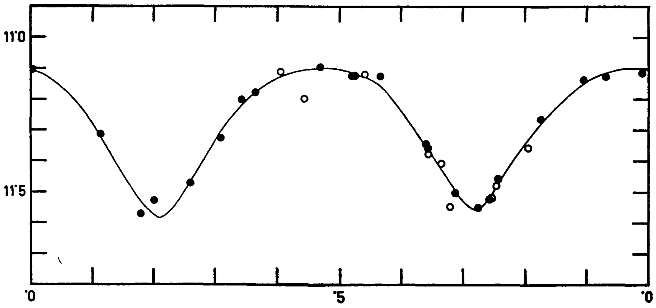
The counting of periods between this epoch and the old epoch 2428397.31 is uncertain.

V 724 *Aql* P. AHNERT (1949) classified this star as a Cepheid with a period of 11.104 days. This period does not agree with the observations. A period of 7.1 days seemed indicated. But as the colours ($B-V$) and ($U-B$) do not change with phase the variable cannot be a Cepheid. Observations made at extreme hour angles could not be represented by the period 7.1, which indicated that the period is shorter than one day. The star is an eclipsing variable of the W UMa type. The two minima are about equally deep. The best elements are:

min. 2436818.672 + .51752 E

The light-curve is shown in Figure 2.

FIGURE 2



V 724 Aql, phase = 1·9323 (J. D. – 2430000)
Light-curve in V.

If we assume the colour to be constant with phase we find the following mean errors for a colour observation:

colour in three decimals:

± .021 for ($B-V$) and ± .031 for ($U-B$),

colour in two decimals:

± .062 for ($B-V$) and ± .053 for ($U-B$).

The mean yellow magnitude of the variable is about 11.3.

Y Aur	max.	E	$O-C$
	2415420.64	0	— .07
	9866.90	1152	+ .07
	2420368.58	1282	+ .01
	2436844.69	5551	— .02

max. 2436844.71 + 3.859485 E
± 17

SY Aur	max.	E	$O-C$
	2417934.41	0	− .11
	9172.08	122	+ .02
	2423260.14	525	+ .14
	2436842.47:	1864	− .04

$$\text{max. } 2436842.51 + 10.14377\,E$$
$$\pm \quad 9$$

AN Aur	max.	E	$O-C$
	2418289.89	0	+ .42
	8936.84	63	− .90
	9009.72	70	− .05
	2425513.34	702	+ .25
	9043.38	1045	+ .80
	2436821.34:	1801	− .53

$$\text{max. } 2436821.87 + 10.29006\,E$$
$$\pm \quad 44$$

BK Aur	max.	E	$O-C$
	2419002.20	0	+ .20
	2422699.06	462	− .10
	5499.93	812	− .11
	8396.83	1174	− .11
	2436847.71	2230	+ .12

$$\text{max. } 2436847.59 + 8.00251\,E$$
$$\pm \quad 8$$

RW Cam	max.	E	$O-C$
	2420876.58	0	− .05
	8575.08	469	+ .11
	2436814.94	971	− .05

$$\text{max. } 2436814.99 + 16.41437\,E$$
$$\pm \quad 19$$

RS Cas	max.	E	$O-C$
	2417263.2	0	+ .11
	9617.58	374	− .10
	2425126.38	1249	− .03
	2436849.00	3111	+ .02

$$\text{max. } 2436848.98 + 6.295687\,E$$
$$\pm \quad 45$$

RY Cas	max.	E	$O-C$
	2417354.44	0	+ .22
	2424502.72	589	− .35
	2433423.95	1324	.00
	6846.79	1606	+ .13

$$\text{max. } 2436846.66 + 12.13726\,E$$
$$\pm \quad 24$$

SW Cas	max.	E	$O-C$
	2417809.2	0	+ .24
	9403.03	293	− .11
	2421176.72	619	− .16
	2432080.42	2623	− .05
	6846.78	3499	+ .07

$$\text{max. } 2436846.71 + 5.44091\,E$$
$$\pm \quad 6$$

SY Cas	max.	E	$O-C$
	2417911.62	0	+ .04
	2425951.70	1975	− .06
	2436849.79	4652	+ .03

$$\text{max. } 2436849.76 + 4.070976\,E$$
$$\pm \quad 24$$

SZ Cas The period of this variable is not constant. The epochs of maximum can be satisfactorily represented by quadratic elements.

max.	E	$O-C$
2416746.08	− 1474	− .26
8827.30	− 1321	+ .34
2420187.05	− 1221	− .06
1261.72	− 1142	− .05
3520.50	− 976	+ .18
4309.75	− 918	+ .16
6269.14	− 774	− .30
2434617.00	− 161	− .18
6811.09	0	+ .17

$$\text{max. } 2436810.92 + 13.6274\,E + 1.02\;10^{-5}\,E^2$$
$$\pm \quad 7 \qquad\qquad \pm\, 6$$

TU Cas No light-curve has been given for this variable in Figure 1, because the variable has a pronounced secondary period, which causes the light-curve to change shape and amplitude continuously. I have computed phase ψ of the secondary period with the formula:

$$\psi = .19118\ (\text{J.D.} - 2430000).$$

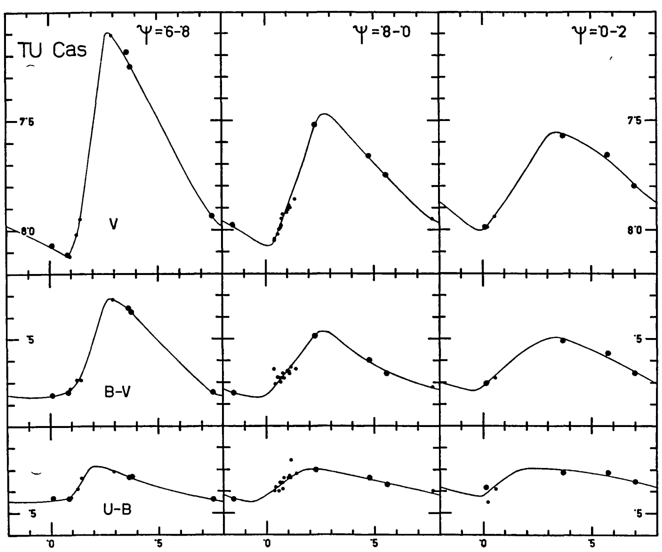
In Figure 3 light- and colour curves have been plotted for three intervals of phase ψ, which are indicated in the figure.

The few observations in the phase interval $\psi = .4 - .6$, which have not been plotted, indicate a range which is only little smaller than that in the first column of Figure 3, while those in the interval $\psi = .2 - .4$ indicate an intermediate range. The observations fully confirm the value of the secondary period derived by OOSTERHOFF (1957). The range of the V light-curve varies from 1.00 to .45 magnitudes, that of the $(B-V)$ colour curve from .45 to .25 magnitudes, whereas the range of the $(U-B)$ colour curve is small and does not seem to change much. The maximum of the $(U-B)$ curve falls clearly at an earlier phase than the maxima of the yellow light-curve and of the $(B-V)$ curve. As the number of new observations is small, I shall not try to derive an improved value of the secondary period. The following solution for the primary period was made from some very bright maxima.

max.	*E*	*O−C*
2419291.39	0	.00
2432105.81	5990	+ .06
2441.55	6147	− .07
5113.61	7396	+ .01
6792.94	8181	.00

max. 2436792.94 + 2.139292 *E*
± 8

FIGURE 3



VV Cas	max.	*E*	*O−C*
	2417113.63	0	− .07
	2420999.56	626	− .03
	2514.16	870	− .05
	6319.60	1483	+ .20
	9156.28	1940	+ .05
	2434656.13	2826	+ .07
	6809.89	3173	− .17

max. 2436810.06 + 6.207487 *E*
± 46

VW Cas	max.	*E*	*O−C*
	2416124.08	0	− .01
	2423484.47	1228	− .07
	5174.82	1510	+ .01
	9142.86	2172	+ .12
	2431851.98	2624	+ .02
	6814.79	3452	− .08

max. 2436814.87 + 5.993851 *E*
± 30

XY Cas	max.	*E*	*O−C*
	2418534.86	0	+ .02
	9403.78	193	+ .09
	2422793.38	946	− .06
	4337.44	1289	− .08
	4346.49	1291	− .03
	6606.33	1793	− .04
	6700.93	1814	+ .02
	2431774.30	2941	− .01
	6811.76	4060	+ .06

max. 2436811.70 + 4.501691 *E*
± 17

BY Cas The period may be variable. Observations of the last ten years give the following results.

max.	*E*	*O−C*
2433189.32	0	− .21
3543.37	110	− .26
3949.34	236	+ .10
3952.50	237	+ .04
4229.41	323	+ .11
4239.43	326	+ .47
4454.50	393	− .14
6810.89	1125	− .13

max. 2436811.02 + 3.21910 *E*
± 29

CD Cas From the observations by HOFFMEISTER (1943) and my own the following elements were derived:

max. 2436812.53 + 7.80089 *E*
± 24

CG Cas If the counting of periods between the epoch given in the *General Catalogue of Variable Stars* and my own is correct, the elements are:

max. 2436793.93 + 4.36572 *E*

DD Cas The best elements seem to be:

max. 2436814.87 + 9.81102 *E*

DL Cas	max.	*E*	*O−C*
	2429131.40	0	.00
	2436051.84	865	+ .01
	6219.63	886	− .01
	6227.62	887	− .02
	6819.68	961	+ .02

max. 2436819.66 + 8.00027 *E*

The magnitudes and colours derived here agree closely with the observations by H. ARP, A. SANDAGE and C. STEPHENS (1959). Comparing the results we find:

		max.	min.	ampl.
V	A.S. and S.	8.69	9.27	.58
	Oo.	8.65	9.24	.59
B−V	A.S. and S.	1.05	1.37	.32
	Oo.	1.05	1.35	.30
U−B	A.S. and S.	.70	.98	.28
	Oo.	.68	.97	.29

DW Cas	max.	*E*	*O−C*
	2417064.45	0	− .49
	2427784.70	144	+ .08
	8754.30	338	+ .12
	9144.15	416	+ .14
	9474.00	482	+ .14
	9553.95	498	+ .13
	2436805.44	1949	− .13

max. 2436805.57 + 4.99776 *E*
± 16

FM Cas	max.	*E*	*O−C*
	2415037.0	0	− .51
	7065.2	349	+ .22
	8529.2	601	+ .25
	2427812.6	2199	+ .26
	8556.0	2327	+ .06
	9014.8	2406	− .08
	2430467.2	2656	− .02
	6845.73	3754	− .19

max. 2436845.92 + 5.80938 *E*
± 8

IX Cas Although quite a number of old observations is available I have not succeeded in deriving elements which satisfy them all. The most probable elements for the present time seem to be:

max. 2436811.56 + 9.1486 *E*

CR Cep	max.	*E*	*O−C*
	2415005.7	0	− .19
	7200.2	352	+ .23
	2427783.9	2050	.00
	8082.7	2098	− .40
	8538.2	2171	+ .08
	8744.2	2204	+ .39
	9148.8	2269	− .17
	9473.2	2321	+ .10
	2436846.91	3504	− .03

max. 2436846.94 + 6.23318 *E*
± 8

SZ Cyg	max.	*E*	*O−C*
	2415097.07	0	− .09
	2426399.22	748	+ .12
	2431808.45	1106	+ .13
	6809.41	1437	− .17

max. 2436809.58 + 15.10955 *E*
± 17

TX Cyg	max.	*E*	*O−C*
	2422290.94	0	− .02
	7071.16	325	+ .02
	2436793.28	986	− .01

max. 2436793.29 + 14.70825 *E*

VX Cyg	max.	*E*	*O−C*
	2415879.77	0	− .31
	8054.93	108	+ .61
	2423127.28	360	− .26
	9005.91	652	− .12
	2433656.32	883	− .17
	6777.17	1038	+ .25

max. 2436776.92 + 20.13183 *E*
± 43

VY Cyg	max.	*E*	*O−C*
	2423497.23	0	+ .03
	5964.24	314	− .03
	2436814.66	1695	+ .01

max. 2436814.65 + 7.85690 *E*

VZ Cyg	max.	*E*	*O−C*
	2420642.13	0	− .06
	3507.51	589	+ .08
	2436792.60	3320	− .01

max. 2436792.61 + 4.86458 *E*
± 4

BZ Cyg. The maximum is broad and ill-defined. The elements given in the *General Catalogue of Variable Stars* (1958) agree with the present observations.

CD Cyg	max.	*E*	*O−C*
	2421500.71	0	− .33
	3191.68	99	+ .57
	9148.66	448	− .36
	2436848.33	899	+ .12

max. 2436848.21 + 17.07138 *E*
± 8

GH Cyg	max.	*E*	*O−C*
	2424738.76	0	− .12
	6138.40	179	+ .08
	2433542.28	1126	+ .18
	6817.76	1545	− .14

max. 2436817.90 + 7.81814 *E*
± 15

MW Cyg	max.	*E*	*O−C*
	2426572.45	0	− .04
	9418.75	478	− .03
	2430895.63	726	+ .10
	6808.41	1719	− .03

max. 2436808.44 + 5.95460 *E*
± 7

V 386 *Cyg*	max.	*E*	O-C
	2428066.70	0	+ .08
	2431320.80	619	− .13
	6809.67	1663	+ .05

max. 2436809.62 + 5.25737 *E*
± 13

V 402 *Cyg* max.	*E*	*O—C*
2413842.12	0	— .09
5287.05	331	+ .07
2428748.30	3415	+ .08
2430961.19	3922	— .01
6770.78	5253	— .05

max. 2436770.83 + 4.364862 *E*
± 19

V 459 *Cyg* The best elements are probably:

max. 2436808.50 + 7.25125 *E*

V 532 *Cyg* If the assumed counting of periods between the epoch of the *General Catalogue of Variable Stars* (1958) and my own is correct, the elements are:

max. 2436817.73 + 3.28339 *E*

V 538 *Cyg* From the epoch of the *General Catalogue* and my own the following elements were derived:

max. 2436806.86 + 6.11867 *E*

UY Eri From the epoch of the *General Catalogue* and my own the following elements were derived:

max. 2436846.03 + 2.21327 *E*

BB Gem max.	*E*	*O—C*
2426000.79	0	— .02
2430723.41	2046	+ .03
3317.80	3170	+ .01
6847.00	4699	— .02

max. 2436847.02 + 2.308195 *E*

V Lac max.	*E*	*O—C*
2416666.74	0	+ .03
8032.16	274	— .02
2420050.46	679	— .03
2433535.88	3385	+ .13
6809.79	4042	— .10

max. 2436809.89 + 4.983468 *E*
± 26

X Lac max.	*E*	*O—C*
2416674.38	0	.00
8890.51	407	+ .20
9750.55	565	.00
2429049.37	2273	— .46
2436814.01	3699	+ .26

max. 2436813.75 + 5.44454 *E*
± 11

CC Lyr The period is probably variable. Provisional elements are:

max. 2436787.22 + 24.013 *E*

CN Lyr max.	*E*	*O—C*
2427770.31	0	+ .08
9870.34	899	— .11
2436813.59	3871	+ .03

max. 2436813.56 + 2.336176 *E*
± 49

BH Oph max.	*E*	*O—C*
2424385.54	0	— .10
4761.55	34	+ .10
2436809.37	1124	.00

max. 2436809.37 + 11.05314 *E*
± 16

SX Per max.	*E*	*O—C*
2418210.07	0	— .12
8240.25	7	+ .03
2420501.04	534	— .02
1642.28	800	+ .07
9145.60	2549	+ .15
2436845.94	4344	— .10

max. 2436846.04 + 4.290019 *E*
± 31

UY Per max.	*E*	*O—C*
2417208.42	0	+ .02
2420926.38	693	— .01
5486.70	1543	.00
6334.36	1701	— .02
2436849.91	3661	+ .01

max. 2436849.90 + 5.365064 *E*
± 7

VX Per The best elements for the second and highest maximum are:

max. 2436844.81 + 10.89364 *E*

AS Per max.	*E*	*O—C*
2423459.98	0	— .04
8631.23	1040	+ .02
2436815.89	2686	+ .02

max. 2436815.87 + 4.972420 *E*
± 26

AW Per The epoch from the *General Catalogue* combined with my own yields the elements:

max. 2436807.78 + 6.46342 *E*

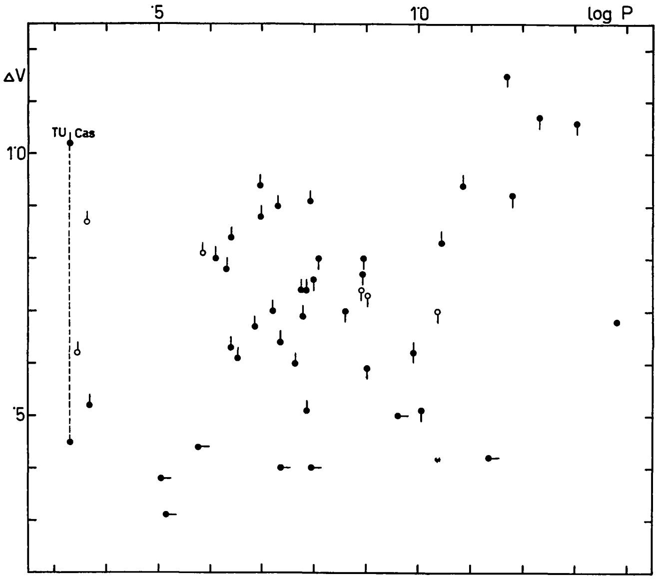
Discussion of the light-curves and colour curves

For the 51 Cepheids observed the extreme values of *V*, (*B*—*V*) and (*U*—*B*) at maximum and at minimum were read off the light-curves of Figure 1 and they have been collected in Table 4. Values indicated by a colon are rather uncertain, whereas values given in brackets are very uncertain. The accuracy with which the extreme values can be read off the curves depends as well on the number of observations near maximum and minimum as on their accuracy. For TU Cas two sets of values have been entered in the table. They refer to the left-hand and the right-hand diagram in Figure 3. From the figures in Table 4 median values of V, $(B-V)$ and $(U-B)$ can be easily computed.

TABLE 4

Var.	log P	max.			min.			type
		V	$B-V$	$U-B$	V	$B-V$	$U-B$	
KL Aql	.786	9.82	.75	.50	10.56	1.17	.90	A
V572 ,,	.577	11.00	.63	.41:	11.44	.85	.59:	C
Y Aur	.586	9.18:	.72:	.45:	9.99:	1.09:	.69:	A
SY ,,	1.006	(8.80)	(.89)	(.54)	9.35	1.20	.81	—
AN ,,	1.012	(10.08)	(1.08)	(.56)	10.71	1.35	(.85)	—
BK ,,	.903	9.08:	.88:	.54:	9.81	1.26	.87:	B
RW Cam	1.215	8.18	1.21	.68	(8.85)	(1.52)	(.91)	B?
RS Cas	.799	9.53	1.24	.83	10.29	1.66	1.24:	B?
RY ,,	1.084	9.39	1.09	.82	10.33	1.58	1.22:	A
SW ,,	.736	9.32	.93	.61	9.96	1.23	.90:	A
SY ,,	.610	9.41	.79	.55	10.21	1.18	.79:	A
SZ ,,	1.134	9.59	1.36	.89	10.01	1.59	1.22:	C
TU ,,	.330	7.10	.31	.28:	8.12	.77	.45:	A
,, ,,	,,	7.55	.49:	.29:	8.00	.73:	.42:	
VV ,,	.793	10.26	.89	.59	11.17	1.35	.91:	A
VW ,,	.778	10.36	1.01	.68:	11.05	1.43	.98:	A?
XY ,,	.653	9.62	.95	.62	10.23	1.29	.88:	A
BY ,,	.507	10.16	1.17	.75:	10.54	1.36	.89:	C
CD ,,	.892	10.37	1.22	(.82)	11.11:	1.66:	—	B
CG ,,	.640	10.89	.98	(.61)	11.73	1.43:	—	A
DD ,,	.992	9.56	1.06	.72	10.18	1.40	1.10:	AB
DL ,,	.903	8.65	1.05	.68	9.24	1.35	.97	B
DW ,,	.699	(10.74)	(1.24)	—	(11.39)	(1.57)	—	
FM ,,	.764	8.82	.82	.53	9.42	1.17	.83	A
IX ,,	.961	11.21	.53	.32:	11.71	.87	.55:	C
CR Cep	.795	9.43	1.35	.92:	9.83	1.55	1.16:	C
SZ Cyg	1.179	8.94	1.23	.91	9.86	1.79	1.55:	B
TX ,,	1.168	8.87	1.55	1.13	10.02	2.11	(1.75)	B
VX ,,	1.304	9.51	1.43	1.00	10.57	2.00	—	B
VY ,,	.895	9.20	1.04	.73	10.00	1.48	1.13:	B
VZ ,,	.687	8.60	.71	.46	9.27	1.06	.74	A
BZ ,,	1.006	10.01	1.46	(1.07)	10.52	1.72	—	B
CD ,,	1.232	8.41	.98	.70:	9.48	1.67	—	B
GH ,,	.893	9.56	1.08	.75:	10.33	1.42	1.05:	B
MW ,,	.775	9.14	1.15	.79	9.88	1.54	1.16:	A
V386 ,,	.721	9.25	1.37	.96	9.95	1.70	1.23:	A
V402 ,,	.640	9.58	.84:	.53:	10.21	1.12:	.82:	A?
V459 ,,	.860	10.28	1.28	.89:	10.98	1.68	—	B
V532 ,,	.516	8.93	.99	.66	9.24	1.15	.75	C
V538 ,,	.787	10.20	1.15	.77:	10.71	1.44	(1.09)	A
UY Eri	.345	10.88:	.35:	(.05)	11.50	.56:	(.17)	A?
BB Gem	.363	10.81:	.57:	—	11.68:	(1.03)	—	A?
V Lac	.697	8.42	.67	.50	9.36	1.11	.74	A
X ,,	.736	8.19	.83	.54	8.59	1.03	.70	C
CC Lyr	1.380	11.75	.31	(.18)	12.43	.75:	—	
CN ,,	.368	11.13	.42:	—	11.65	.66:	—	A?
BH Oph	1.044	11.61	.39	—	12.44	.84:	—	A
SX Per	.632	10.71	.95	.63:	11.49	1.29	.94:	A
UY ,,	.730	10.84	1.33	—	11.74	1.78:	—	A
VX ,,	1.037	9.00:	1.06:	.74:	9.70	1.43	1.10	B
AS ,,	.697	9.17	1.11	.84	10.05	1.54	1.19	A
AW ,,	.810	7.04	.89	.58	7.84	1.23	.69	B?

FIGURE 4



In Figure 4 the amplitudes of the yellow light-curves have been plotted against the logarithm of the period. There is hardly any correlation between the range and the period, although the three largest ranges occur for long periods. The diagram is very unlike the combination of the Figures 25 and 36 in EGGEN's paper (1951), in which the Cepheids which he classified as type *A* and type *B* are nicely arranged on two parallel lines in the amplitude-log *P* diagram. The present Figure 4 has more resemblance to Figure 9 in the paper by WALRAVEN, MULLER and OOSTERHOFF (1958) for Cepheids in the southern hemisphere and to Figure 6*b* in the article by EGGEN, GASCOIGNE and BURR (1957). In this article the authors maintained EGGEN's (1951) classification of the Cepheids into three groups *A*, *B* and *C*. The light-curves of the Cepheids of type *A* show an asymmetric and smooth shape, those of type *B* have asymmetric light-curves with a secondary hump, whereas the Cepheids of type *C* show light-curves which are nearly sinusoidal. According to their Figure 6*b* the amplitude of the light-variation at a given period increases from type *C* over type *B* to type *A*, if we omit all values of log *P* larger than 1.1. As my Figure 4 has no stars in common with the investigation by EGGEN, GASCOIGNE and BURR, it is interesting to see whether their conclusions are confirmed by this new material. The following eight variables, Y Aur, SY Cas, VV Cas, CG Cas, V Lac, SX Per, UY Per and AS Per form a rather isolated group in Figure 4 with amplitudes between .75 and .95 and with values of log *P* between .58 and .80. Without exception these eight Cepheids have light-curves which are of type *A*, with a steep rising branch, a sharp maximum and without secondary humps or variations. I have tried to assign EGGEN's types to all Cepheids of Figure 4. The results are given in the last column of Table 4. There are 7 *C*-type Cepheids, which have been indicated by a horizontal line to the right of the dot in Figure 4. They are the seven stars with the smallest value of the yellow amplitude. EGGEN, GASCOIGNE and BURR would have classified RY Cas also as a Cepheid of type *C*, but this variable has a very large range and an extremely sharp maximum. Although the time interval between minimum and maximum is about .40 period, the light-curve is very unlike a sinusoid and I have classified it as A-type. In Figure 4 the *A*-type variables have been indicated by a vertical line above the dot, those of the *B* type by a vertical line below the dot. Disregarding the *C*-type variables we find that all Cepheids with log *P* smaller than .8, or with periods below 6.3 days, are of the A type. All Cepheids with larger periods show secondary humps and are of type *B* with the exception of RY Cas and BH Oph. The classification of DD Cas is rather dubious. EGGEN, GASCOIGNE and BURR would have made it a *C*-type variable on account of the asymmetry criterion. But as the maximum is quite sharp, I have classified it as *A* or *B*. Several of the light-curves published by EGGEN (1951), by EGGEN, GASCOIGNE and BURR (1957) and by myself in this paper have been insufficiently covered by observations to make sure whether secondary humps are present or not. There probably are a few Cepheids of population II among the variables of Table 4 and Figure 4. We shall discuss them later. It seems to me that we cannot draw definite conclusions from Figure 4. It is interesting to see that the critical value of the period of 6.3 days beyond which most of the Cepheids show secondary humps agrees exactly with the value derived by HERTZSPRUNG in his classical paper (1926). The question whether the eight Cepheids with values of log *P* between .55 and .8 and with large amplitudes form a separate group, must remain open until a much larger material will be available.

We shall now investigate the relation between the yellow amplitude ΔV and the amplitude of the $(B-V)$ colour curve. The relevant data are given in Table 5. The observations have been plotted in Figure 5.

The observations marked in Table 5 as uncertain, have been plotted as open circles. The following relation was derived by least squares, in which uncertain observations were omitted:

$$\Delta(B-V) = \underset{\pm\ 8}{.522}\ \Delta V.$$

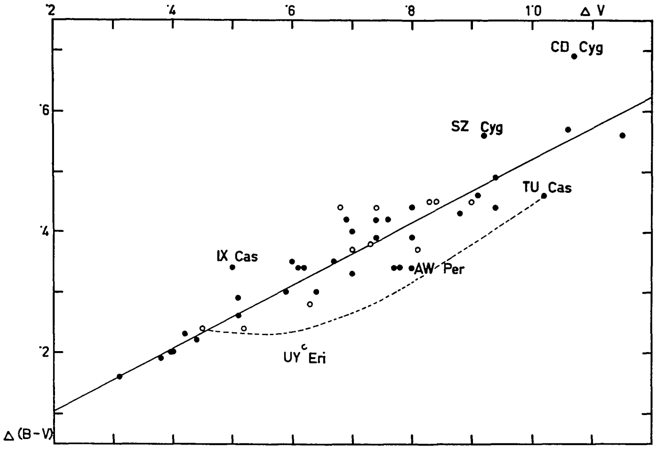
The mean error of one equation of condition is $\pm\ {}^{\mathrm{m}}.045$. The residuals from this equation are given

TABLE 5

	ΔV	$\Delta(B-V)$	$(O-C)_1$	$\Delta(U-B)$	$(O-C)_2$
KL Aql	.74	.42	+ .03	.40	+ .06
V572 ,,	.44	.22	− .01	.18:	.00:
Y Aur	.81:	.37:	− .05:	.24:	− .06:
BK ,,	.73:	.38:	.00:	.33:	+ .02:
RS Cas	.76	.42	+ .02	.41:	+ .07:
RY ,,	.94	.49	.00	.40:	.00:
SW ,,	.64	.30	− .03	.29:	+ .05:
SY ,,	.80	.39	− .03	.24:	− .08:
SZ ,,	.42	.23	+ .01	.33:	+ .14:
TU ,,	1.02	.46	− .07	.17:	− .21:
,, ,,	.45	.24:	+ .01:	.13:	− .07:
VV ,,	.91	.46	− .02	.32:	− .06:
VW ,,	.69	.42	+ .06	.30:	− .04:
XY ,,	.61	.34	+ .02	.26:	− .02:
BY ,,	.38	.19	− .01	.14:	− .02:
CD ,,	.74:	.44:	+ .05:		
CG ,,	.84	.45:	+ .01:		
DD ,,	.62	.34	+ .02	.38:	+ .10:
DL ,,	.59	.30	− .01	.29	+ .05
FM ,,	.60	.35	+ .04	.30	+ .01
IX ,,	.50	.34	+ .08	.23:	− .05:
CR Cep	.40	.20	− .01	.24:	+ .08:
SZ Cyg	.92	.56	+ .08	.64:	+ .18:
TX ,,	1.15	.56	− .04		
VX ,,	1.06	.57	+ .02		
VY ,,	.80	.44	+ .02	.40:	+ .04:
VZ ,,	.67	.35	.00	.28	− .01
BZ ,,	.51	.26	− .01		
CD ,,	1.07	.69	+ .13		
GH ,,	.77	.34	− .06	.30:	+ .02:
MW ,,	.74	.39	.00	.37:	+ .05:
V386 ,,	.70	.33	− .04	.27:	.00:
V402 ,,	.63	.28:	− .05:	.29:	− .02:
V459 ,,	.70	.40	+ .03		
V532 ,,	.31	.16	.00	.09	− .04
V538 ,,	.51	.29	+ .02		
UY Eri	.62	.21:	− .11:	.12::	− .05::
V Lac	.94	.44	− .05	.24	− .12
X ,,	.40	.20	− .01	.16	.00
CC Lyr	.68	.44:	+ .09:		
CN ,,	.52	.24:	− .03:		
BH Oph	.83	.45:	+ .02:		
SX Per	.78	.34	− .07	.31:	+ .03:
UY ,,	.90	.45:	− .02:		
VX ,,	.70:	.37:	.00:	.36:	+ .06:
AS ,,	.88	.43	− .03	.35	.00
AW ,,	.80	.34	− .08	.11	− .17

in the fourth column of Table 5 under $(O-C)_1$. In Figure 5 the names have been indicated for some variables with large residuals. Stars below the full-drawn line, like UY Eri, AW Per and TU Cas, have an abnormally small range in colour as compared with the range of the light-curve, whereas stars like IX Cas, SZ Cyg and CD Cyg have an abnormally large range in colour.

FIGURE 5



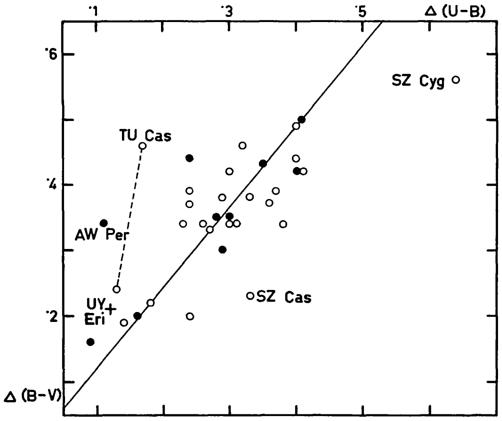
In the fifth column of Table 5 the range of the $(U-B)$ colour curves has been given. Very many of them are rather uncertain. In Figure 6 the values of $\Delta(B-V)$ and $\Delta(U-B)$ have been plotted against each other. Omitting UY Eri, we found the following relation:

$$\Delta(U-B) = .816\,\Delta(B-V).$$
$$\pm 14$$

The mean error of one equation of condition is $\pm^{m}.078$. Variables like AW Per and TU Cas, which lie above the full-drawn line in Figure 6, have too small a range in the $(U-B)$ colour curve with respect to the range of their $(B-V)$ colour curve, whereas SZ Cas and SZ Cyg have a very large range in the $(U-B)$ colour curve. The residuals from the mean relation are given in the last column of Table 5 under $(O-C)_2$.

Finally in Figure 7 I have plotted the residuals $(O-C)_1$ and $(O-C)_2$ of Table 5 against each other. Stars in the lower-left quadrant of this figure have a small range in both colour curves, while stars in the upper-right quadrant have a larger range than could be expected from the range of the yellow light-curve. Although the $(U-B)$ curve of CD Cyg has not been completely observed, it seems clear from the observations of Figure 1*b*, that this star

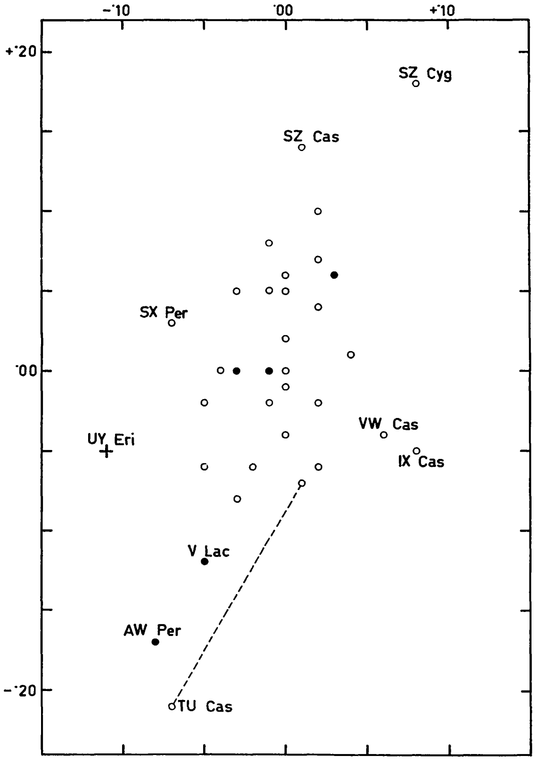
FIGURE 6



should fall in Figure 7 far in the upper right-hand corner. One should keep in mind that the observational dispersion in Figure 7 will be rather large. Especially the $(U-B)$ colours are not very accurate and in addition several of the light- and colour curves have not been sufficiently covered with observations for an accurate determination of the extreme values. Nevertheless there seems to exist a correlation between the values of $(O-C)_1$ and $(O-C)_2$. UY Eri belongs no doubt to population II, and IX Cas is rather peculiar and may also belong to this population. However the difference in position in this diagram between AW Per and SZ Cyg is certainly significant. One has only to look at the light- and colour curves of these two Cepheids in Figures 1*b* and 1*d*. Omitting UY Eri and IX Cas we find a correlation coefficient of + .56. It is interesting to note that the two stars in the upper right-hand corner of Figure 7 and also CD Cyg, which has been mentioned above, have long periods, 13.62 for SZ Cas, 15.11 for SZ Cyg and 17.07 for CD Cyg. No other Cepheids with a value of log P larger than 1.1 occur in Figure 7. It would be interesting to investigate whether all Cepheids with periods longer than 13 days have such a large range in the violet.

The three Cepheids in the other extreme corner of Figure 7 are TU Cas, AW Per and V Lac. TU Cas is a peculiar variable with very pronounced secondary variations. But the remaining two Cepheids seem to be normal in all other respects. AW Per has a period of 6.46 days and V Lac one of 4.98 days. Several Cepheids with similar periods occur near the centre of Figure 7. If AW Per would be intrinsically a normal Cepheid the observed phenomena could be explained by the assumption that the variable has a companion of early spectral type. If such a companion would be an early B-type star, about two magnitudes fainter than the Cepheid in visual light, the range of the yellow light-curve would hardly be affected, but the colour curve in $(B-V)$ would show a slightly smaller range, whereas the range of the colour curve in $(U-B)$ could be greatly reduced. Now it is well known that δ Cephei has a B8 or B9 companion and in three galactic clusters, which have been carefully analyzed on account of the fact that they count a Cepheid among their physical members, quite a number of B-type stars have been found. See for example the article by SANDAGE (1958) on NGC 7790, that by ARP (1958) on NGC 6664, that by ARP, SANDAGE and STEPHENS (1959) on NGC 129 and that by ARP on the cluster around CV Mon. Consequently the association of Cepheids with B-type stars does not seem to be uncommon. It should be possible to decide whether such an early-type companion is present or not by a study of the spectrum in the ultraviolet during the minimum of the Cepheid. Dr G. W. PRESTON has been so kind to take a spectrum of AW Per a few hours before the predicted minimum at J.D. 2437038.875. He used the 4-inch camera of the X spectrograph of the 60-inch telescope at Mount Wilson, which gives a dispersion of 80 A/mm. As the star was already far in the west the exposure was not long enough to get into the far ultraviolet. Dr PRESTON writes: "The spectrum appears to be peculiar and in the sense that it is composite. There are no conspicuous peculiarities longward of 4000 A. The K line of Ca II, however, has a peculiar structure—a sharp core with diffuse wings—as if an early-type star were filling in the wings of a normal G-type K line. Furthermore, the higher members of the Balmer series appear to be broader than Hδ and Hγ". As the hypothesis of an early-type companion seems to be proved in the case of AW Per, it would be important to have a similar check made for V Lac. The observations of this Cepheid are accurate and its position in Figure 7 is probably not due to observational errors. The case of TU Cas is more complicated. At the time when the maximum is at its lowest, the star is situated quite close to the centre of Figure 7, but when the range of the maximum reaches its maximum value, the variable lies very close to AW Per in the lower left-hand corner of the diagram. Therefore an investigation of the far ultra-violet part of the spectrum of this Cepheid seems indicated. It is rather remarkable that the so-called BLAZHKO effect,

FIGURE 7



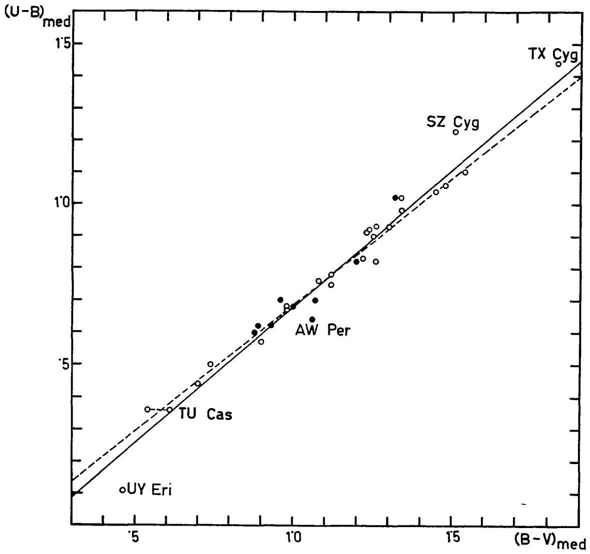
caused by the interference of a primary and a secondary period, is not at all uncommon for RR Lyrae-type variables, but quite rare for the classical Cepheids. Therefore the question could be raised tentatively whether the strong secondary fluctuations of TU Cas could not be induced by a very close companion.

Figure 7 clearly proves that three-colour observations, including the ultraviolet, provide important information which cannot be derived from two-colour work. A further search for Cepheids which are spectroscopic binaries will be of the greatest importance as they may yield information concerning their mass.

TABLE 6

	V_{med}	$(B-V)_{med}$	$(U-B)_{med}$	$(O-C)$
KL Aql	10.19	.96	.70	+ .04
V572 ,,	11.22	.74	.50:	
Y Aur	9.59:	.90:	.57:	
BK ,,	9.44:	1.07:	.70:	
RS Cas	9.91	1.45	1.04:	− .01
RY ,,	9.86	1.34	1.02:	
SW ,,	9.64	1.08	.76:	+ .01
SY ,,	9.81	.98	.67:	− .01
SZ ,,	9.80	1.48	1.06:	
TU ,,	7.61	.54	.36:	
,, ,,	7.78	.61:	.36:	
VV ,,	10.72	1.12	.75:	− .04
VW ,,	10.70	1.22	.83:	− .03
XY ,,	9.92	1.12	.75:	− .04
BY ,,	10.35	1.26	.82:	
CD ,,	10.74:	1.44:	—	
CG ,,	11.31	1.20:	—	
DD ,,	9.87	1.23	.91:	
DL ,,	8.94	1.20	.82	
FM ,,	9.12	1.00	.68	− .01
IX ,,	11.46	.70	.44:	
CR Cep	9.63	1.45	1.04:	− .01
SZ Cyg	9.40	1.51	1.23:	
TX ,,	9.44	1.83	1.44::	
VX ,,	10.04	1.72	—	
VY ,,	9.60	1.26	.93:	
VZ ,,	8.94	.88	.60	.00
BZ ,,	10.26	1.59	—	
CD ,,	8.94	1.32	—	
GH ,,	9.94	1.25	.90:	
MW ,,	9.51	1.34	.98:	+ .02
V386 ,,	9.60	1.54	1.10:	− .02
V402 ,,	9.90	.98:	.68:	.00
V459 ,,	10.63	1.48	—	
V532 ,,	9.08	1.07	.70	
V538 ,,	10.46	1.30	.93::	.00
UY Eri	11.19:	.46:	.11::	
BB Gem	11.24:	.80::	—	
V Lac	8.89	.89	.62	+ .02
X ,,	8.39	.93	.62	− .02
CC Lyr	12.09	.53:	—	
CN ,,	11.39	.54:	—	
BH Oph	12.02	.62:	—	
SX Per	11.10	1.12	.78:	− .01
UY ,,	11.29	1.56:	—	
VX ,,	9.35:	1.24:	.92:	
AS ,,	9.61	1.32	1.02	+ .08
AW ,,	7.44	1.06	.64	

FIGURE 8



Only very little is known about physical double stars among Cepheids. We have already mentioned δ Cephei itself, which has a B8-type companion at a distance of about 40″. Also Polaris has a visual companion. A very interesting visual double star is CE Cas, which consists of two Cepheids at a distance of 2″.18, as discovered by STARIKOVA (1949). Another very peculiar star which should be mentioned in this respect is BM Cas. According to G. THIESSEN (1956) this variable, which had been classified as a β Lyrae-type star, consists of an A5 supergiant and a Cepheid with a period of 27 days, which form an eclipsing system.

In Table 6 I have collected the median values of V, $(B-V)$ and $(U-B)$. In their work on Cepheids in galactic clusters ARP, SANDAGE and STEPHENS have used mean values. The median values will be systematically somewhat smaller than the mean values, as a typical light-curve shows a sharp maximum and a shallow minimum. In the case of RY Cas this difference amounts to .07 magnitude. For most Cepheids the difference will be of this order. In Figure 8 I have plotted the median values of $(B-V)$ and $(U-B)$ against each other.

The observed points lie very close to a straight line. This is due to the fact that the reddening line in the $(B-V)$ and $(U-B)$ diagram runs very nearly parallel to the sequence of F- and G-type supergiants. From 36 Cepheids, omitting UY Eri, we find the relation:

$$(U-B)_{med} = -.158 + .843\,(B-V)_{med}\,.$$
$$\pm 26$$

This relation has been drawn in Figure 8 as a full-drawn line. The mean error of one equation of condition is ± .043 magnitude. If all Cepheids would have the same intrinsic median colour, the coefficient .843 would be the ratio between the colour excesses in $(U-B)$ and $(B-V)$. The population II Cepheid UY Eri is stronger than normal in the ultra-violet and the same holds for AW Per, in which case the deviation can be attributed to the blue companion. The two red Cepheids SZ Cyg and TX Cyg, both with long periods, fall slightly above the line. The assumption of equal intrinsic median colours is certainly not correct. Therefore we can derive a more accurate value of the ratio between the two colour excesses from 18 Cepheids in Table 6, with values of log P between .6 and .8. This solution yields the equation:

$$(U-B)_{\rm med} = -\ .096 + .787\ (B-V)_{\rm med}.$$
$$\pm\ 35$$

The residuals from this equation are given in the fifth column of Table 6 under the heading $(O-C)$. The mean error of one residual is ± .030 magnitude. The mean error of the coefficient is rather large, due to the fact that the range in colour is not very large for these 18 stars. The observed colours lie between .88 and 1.54 for $(B-V)$ and between .60 and 1.10 for $(U-B)$. The relation derived from these 18 Cepheids is shown in Figure 8 by a broken line. The inclination of this line, as given by the coefficient .787 ± .035, agrees quite closely with the equation derived by HILTNER and JOHNSON (1956): $\frac{E_{(U-B)}}{E_{(B-V)}} = .72 + .05\,E_{(B-V)}$. With a mean colour excess in $(B-V)$ of about .60 for the Cepheids concerned, the equation yields a coefficient of .75.

In the Figures 9 and 10 we have plotted the observed median colours against the logarithm of the period for $(B-V)$ and $(U-B)$ respectively. Both diagrams show the well-known picture that the Cepheids with long periods are systematically much redder than those with short periods. In Figure 9 there are three variables which are abnormally white with respect to their period and in Figure 10 one such star is present. It is quite remarkable that these three stars are the faintest of my programme, CC Lyr and BH Oph being of the 12th magnitude and IX Cas of magnitude 11.5. We shall see later that these three stars should be classified as population II objects.

To compute the colour excesses for the Cepheids plotted in the Figures 9 and 10, we must know the intrinsic values of the colours. This problem has been extensively studied in recent years. A considerable amount of new information was presented at the Joint Discussion on the luminosity of Cepheids at the Moscow meeting of the I.A.U. in 1958. In this article we shall use the intrinsic colours in $(B-V)$ as given by KRAFT (1960). The two lines, giving maximum and median unreddened colours, in his Figure 11, have been indicated in our Figure 9. The colours adopted by KRAFT are about .10 magnitude redder than the colours used by WALRAVEN, MULLER and OOSTERHOFF in their work on southern Cepheids. KRAFT's curves are in close agreement with the results derived from Cepheids in galactic clusters. However we should remember that none of these Cepheids has a period longer than eight days. KRAFT has investigated whether the A-, B- and C-type Cepheids differ systematically in intrinsic colour, but no conclusive evidence was found. However, in Figure 4 we have shown that Cepheids with about the same period can have very different amplitudes of the light-curve and this is also true for

FIGURE 9

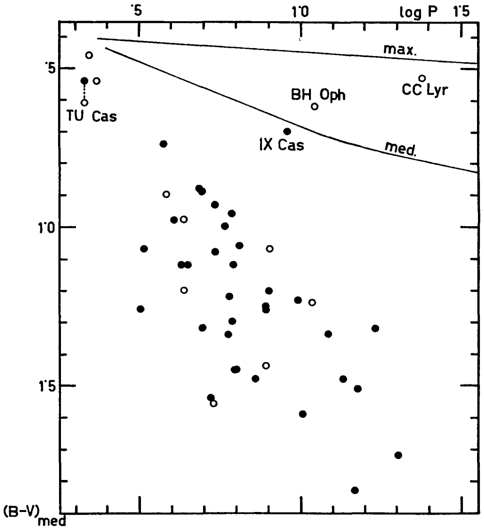
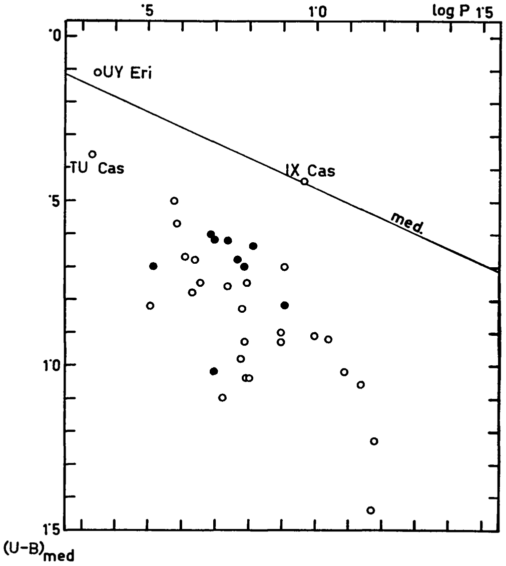


FIGURE 10



the colour curves. Therefore we must expect a genuine scatter of the observations around KRAFT's curves for maximum and median unreddened colour. His two curves practically intersect at log $P = .3$, but we know that some variables with short period have a considerable amplitude in the $(B-V)$ colour curve. With the aid of KRAFT's curves we have computed colour excesses E from the maximum and median values of the observed $(B-V)$ colours. These colour excesses are given in the fifth and sixth columns of Table 7. In the third and fourth columns of this table are given the galactic longitudes and latitudes of the Cepheids with respect to the galactic pole recommended by Subcommission 33b of the I.A.U. (1959). For the variables IX Cas, UY Eri, CC Lyr, CN Lyr and BH Oph the colour excess is very small or even negative. We shall see later that these Cepheids belong to population II. In the seventh column we have given the differences ΔE between the colour excesses derived from the median and maximum values of the $(B-V)$ colour index. As could be expected, the eight stars which form an isolated group of large amplitude in Figure 4 all give differences varying between $+.06$ and $+.10$, whereas most of the C-type Cepheids give negative differences. TU Cas and BB Gem with short period and large amplitude also yield a positive difference. In the eighth column the mean value of the colour excesses is given, which we shall use in the following discussion. Adopting the relation:

$$A_V = 3.0\, E_{(B-V)}$$

we have computed the V_{med} values corrected for interstellar absorption. These corrected magnitudes V°_{med} are given in the next column of Table 7.

For the period-luminosity relation we have adopted SHAPLEY's slope as derived for photographic magnitudes, KRAFT's relation between $(B-V)_{\text{med}}$ and log P, while the zero-point was adjusted so as to fit the absolute visual magnitudes of six Cepheids which are physical members of galactic clusters. These Cepheids are: CF Cas (SANDAGE 1958), EV Sct (ARP 1958), DL Cas (ARP, SANDAGE and STEPHENS 1959), CV Mon (ARP 1960) and S Nor and U Sgr (IRWIN 1958). The resulting relation is:

$$M_V \text{ med} = -1.66 - 2.08 \log P \; (\log P < 10 \text{ days})$$
$$M_V \text{ med} = -1.49 - 2.25 \log P \; (\log P > 10 \text{ days})$$

These formulae give the following residuals for the six cluster Cepheids:

	absolute visual median magnitude		
	observed	computed	residual
CF Cas	− 3.24	− 3.09	− .15
EV Sct	− 2.51	− 2.68	+ .17
DL Cas	− 3.61	− 3.54	− .07
CV Mon	− 3.00	− 3.18	+ .18
S Nor	− 3.57	− 3.72	+ .15
U Sgr	− 3.69	− 3.38	− .31

From the absolute magnitudes computed from these formulae, we have derived the distances in parsecs as given in column 10 of Table 7. The next column shows the distance from the galactic plane: $z = r \sin b$. It is evident that the following Cepheids belong to population II: V 572 Aql, IX Cas, UY Eri, CC Lyr, CN Lyr and BH Oph. If we assume their absolute magnitudes to be 1.5 magnitude fainter than for the normal Cepheids, their distances r and their distances from the galactic plane z must be halved. In view of their distance from the galactic plane KL Aql and SX Per are somewhat doubtful cases.

The mean distance from the galactic plane and the dispersion around this value for the Cepheids of population I are found to be:

n	42	40
z	− 47 pc	− 31 pc
m.e.	± 19	± 15
disp.	± 120	± 97

For the values in the last column KL Aql and SX Per have been omitted. These values agree reasonably well with the results derived by WALRAVEN, MULLER and OOSTERHOFF (1958) for a much larger number of southern Cepheids.

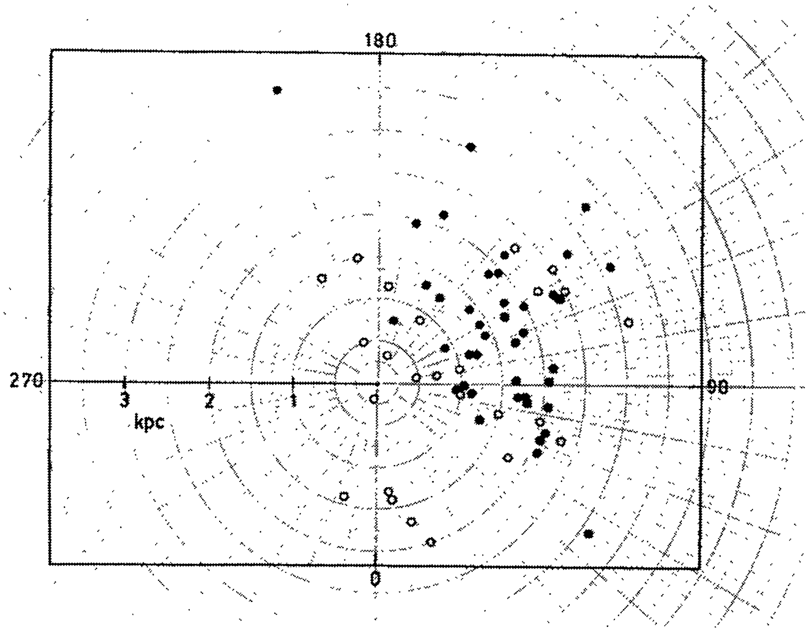
For 35 of the present Cepheids radial velocities are available. They have been corrected for solar motion: $V_{\odot} = 20$ km/sec, $A_{\odot} = 270°$ and $D_{\odot} = +30°$. These corrected radial velocities have been given in Table 7 under the heading V'_r. The value of OORT's constant A was then derived. In this solution the two population II stars CN Lyr and BH Oph were omitted, as well as the two stars KL Aql and SX Per, which are more than 300 parsecs away from the galactic plane and which in a provisional solution gave large residuals in the radial velocity. As many of the remaining Cepheids have distances over 2000 parsecs, second-order terms in the coefficient of the constant A were included. The resulting value is: $A = 18.0 \pm 2.0$ km/sec/kpc. The dispersion of the radial velocities was found to be: ± 11.2 km/sec. The residuals $(O-C)$ of the radial velocities are given in column 13 of Table 7. For 51 southern Cepheids WALRAVEN, MULLER and OOSTERHOFF (1958) derived a value of A of $+17.4$ km/sec /kpc and a dispersion in the radial velocities of ± 11.9 km/sec, but in that article the second-order terms were neglected.

In Figure 11 I have plotted the distribution of the Cepheids of this article in the galactic plane. The aggregates of blue giants, published by MORGAN, WHITFORD and CODE (1953), have been indicated by open circles. In the direction of Cygnus the Cepheids appear to be intermingled with the aggregates. It is interesting to see that the distribution comes to an abrupt stop at a distance of 2100 pc. This may well be

TABLE 7

Var	log P	$l^{\rm II}$	$b^{\rm II}$	$E_{\rm med}$	$E_{\rm max}$	ΔE	$\bar{E}$	$V^{\circ}_{\rm med}$	r	z	V'_r	$(O-C)$	$(U-B)^{\circ}_{\rm med}$
		°	°	m	m	m	m	m					
KL Aql	.786	55.1	− 7.6	+ .36	+ .32	+ .04	+ .34	9.17	3110	− 411	+14.8	(−25.3)	+ .44
V572 ,,	.577	41.9	−15.4	+ .23	+ .21	+ .02	+ .22	10.56	4830	−1280			
Y Aur	.586	166.7	+ 4.3	+ .39:	+ .30:	+ .09:	+ .34:	8.57	1950	+ 146	+ 2.6	+18.4	+ .31
SY ,,	1.006	164.8	+ 2.1										
AN ,,	1.012	164.9	− 1.0										
BK ,,	.903	159.0	+ 5.9	+ .43:	+ .44:	− .01:	+ .44:	8.12	2150	+ 221			+ .36
RW Cam	1.215	144.8	+ 3.7		+ .75		+ .75	6.3 :	1270:	+ 82	−24.6	− 2.6	
RS Cas	.799	114.5	+ .8	+ .85	+ .81	+ .04	+ .83	7.42	1410	+ 20	−15.2	+ 7.3	+ .39
RY ,,	1.084	115.3	− 3.2	+ .62	+ .64	− .02	+ .63	7.97	2400	− 134	−61.0	−18.5	+ .39
SW ,,	.736	109.7	− 1.6	+ .50	+ .50	.00	+ .50	8.14	1850	− 52	−27.3	− .1	+ .37
SY ,,	.610	118.2	− 4.1	+ .46	+ .37	+ .09	+ .42	8.55	1980	− 142	−35.1	+ .2	+ .34
SZ ,,	1.134	134.8	− 1.2	+ .75	+ .91	− .16	+ .83	7.31	1860	− 39	−39.0	− 2.8	+ .41
TU ,,	.330	118.9	−11.4	+ .14	− .09	+ .23	+ .02	7.55	910	− 180	−15.5	− 1.1	+ .31
,, ,,	,,	,,	,,	+ .21:	+ .09:	+ .12:	+ .15:	7.33					
VV ,,	.793	130.4	− 2.1	+ .52	+ .46	+ .06	+ .49	9.25	3250	− 119	−45.8	+21.9	+ .37
VW ,,	.778	124.6	− 1.1	+ .63	+ .58	+ .05	+ .60	8.90	2730	− 52	−51.9	+ 3.2	+ .36
XY ,,	.653	122.8	− 2.8	+ .58	+ .53	+ .05	+ .56	8.24	1790	− 87	−35.1	− 1.4	+ .31
BY ,,	.507	129.6	− .7	+ .78	+ .76	+ .02	+ .77	8.04	1420	− 17	−38.8	−11.8	+ .22
CD ,,	.892	115.5	+ 1.1	+ .80:	+ .78	+ .02:	+ .79	8.37	2380	+ 46			
CG ,,	.640	116.8	− 1.3	+ .66:	+ .56	+ .10:	+ .61	9.48	3120	− 71	−78.1	−17.8	
DD ,,	.992	116.8	+ .5	+ .55	+ .62	− .07	+ .58	8.13	2350	+ 20	−61.9	−19.2	+ .46
DL ,,	.903	120.2	− 3.0	+ .56	+ .61	− .05	+ .58	7.20	1410	− 74	− 3.3	+21.5	+ .37
DW ,,	.699	113.8	− 2.2										
FM ,,	.764	117.8	− 6.2	+ .41	+ .39	+ .02	+ .40	7.92	1710	− 185			+ .37
IX ,,	.961	115.4	−12.0	+ .03	+ .09	− .06	+ .06	11.28	9720	−2020			
CR Cep	.795	107.6	+ .3	+ .85	+ .92	− .07	+ .88	6.99	1150	+ 6			+ .35
SZ Cyg	1.179	84.4	+ 4.0	+ .76	+ .77	− .01	+ .76	7.12	1790	+ 125	− .3	+ .2	+ .64
TX ,,	1.168	84.4	− 2.3	+1.09	+1.10	− .01	+1.10	6.14	1130	− 45	− 3.1	− 4.2	+ .58
VX ,,	1.304	82.2	− 3.5	+ .95	+ .97	− .02	+ .96	7.16	2070	− 126	− 2.4	− 3.1	
VY ,,	.895	82.9	− 4.6	+ .62	+ .60	+ .02	+ .61	7.77	1810	− 145	+ 5.3	+ 4.2	+ .45
VZ ,,	.687	91.6	− 8.5	+ .33	+ .29	+ .04	+ .31	8.01	1660	− 245	− 2.8	+ 4.6	+ .36
BZ ,,	1.006	84.8	+ 1.4	+ .91	+1.02	− .11	+ .96	7.38	1690	+ 41	− .6	+ .1	
CD ,,	1.232	71.1	+ 1.4	+ .56	+ .52	+ .04	+ .54	7.32	2070	+ 51	+ 7.0	− 7.9	
GH ,,	.893	66.5	− .1	+ .61	+ .64	− .03	+ .62	8.08	2090	− 4	+ 1.6	−18.6	+ .42
MW ,,	.775	70.9	− .6	+ .75	+ .72	+ .03	+ .74	7.29	1300	− 14	+ 4.7	− 6.5	+ .40
V386 ,,	.721	85.4	− 4.8	+ .97	+ .94	+ .03	+ .96	6.72	950	− 80	− 1.2	− 1.9	+ .35
V402 ,,	.640	74.1	+ 2.3	+ .44:	+ .42:	+ .02:	+ .43:	8.61	2090	+ 84			+ .34
V459 ,,	.860	90.5	+ .7	+ .85	+ .84	+ .01	+ .84	8.11	2050	+ 25			
V532 ,,	.516	89.0	− 3.0	+ .59	+ .58	+ .01	+ .58	7.34	1030	− 54			+ .25
V538 ,,	.787	95.3	− .4	+ .70	+ .72	− .02	+ .71	8.33	2120	− 15			+ .22
UY Eri	.345	193.3	−52.6	+ .05:	− .05:	+ .10:	.00:	11.19	5170	−4110			
BB Gem	.363	199.4	+ 2.2	+ .38::	+ .17:	+ .21:	+ .28:	10.40	3660	+ 141			
V Lac	.697	106.5	− 2.6	+ .33	+ .24	+ .09	+ .28	8.05	1710	− 78	− 8.6	−13.9	+ .34
X ,,	.736	106.6	− 2.5	+ .35	+ .40	− .05	+ .38	7.25	1230	− 54	−15.1	− .2	+ .24
CC Lyr	1.380	60.2	+17.2	− .26:	− .16	− .10:	− .21	12.09	21700	+6400			
CN ,,	.368	58.0	+14.7	+ .12:	+ .02:	+ .10:	+ .07:	11.18	5260	+1330	+41.8		
BH Oph	1.044	43.4	+13.3	− .08:	− .06	− .02:	− .07	12.02	14900	+3430	+52.0		
SX Per	.632	158.9	− 6.4	+ .59	+ .53	+ .06	+ .56	9.42	3010	− 336	+ .6	(+37.5)	+ .34
UY ,,	.730	135.9	− 1.4	+ .99:	+ .90	+ .09:	+ .94	8.47	2140	− 52	−55.9	−14.0	
VX ,,	1.037	132.8	− 3.0	+ .54:	+ .61:	− .07:	+ .58:	7.61	1940	− 101	−29.1	+ 8.9	+ .47
AS ,,	.697	154.1	− .9	+ .76	+ .68	+ .08	+ .72	7.45	1290	− 20	−28.2	− 9.7	+ .30
AW ,,	.810	166.6	− 5.4	+ .45	+ .46	− .01	+ .46	6.06	760	− 72	+ 6.4	+12.5	+ .28

FIGURE 11



connected with the high density of interstellar neutral hydrogen, which at this longitude sets in at about the same distance. In the direction of Cassiopeia and Perseus the distribution of the Cepheids does not show any indication of spiral structure.

Assuming the ratio between the $(U-B)$ colour excess and the $(B-V)$ colour excess to be .78 as derived above, we have computed the unreddened $(U-B)$ median colours. They are given in column 14 of Table 7. It is clear that there exists a relation between these median intrinsic colours and the values of log P. A least-squares solution yields the equation:

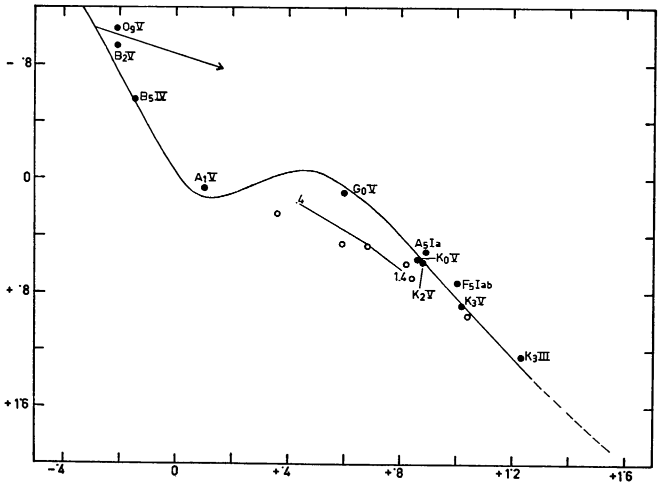
$$(U-B)^{\circ}_{\rm med} = +.459 \log P \atop \pm \;\; 11$$

This relation is shown by the full-drawn line in Figure 10. The mean error of one observation is $\pm\,^{\rm m}.064$. With the aid of the relation derived by KRAFT (1960) between $(B-V)^{\circ}_{\rm med}$ and log P and of the equation given above, we find the following intrinsic median colours:

log P	$(B-V)^{\circ}_{\rm med}$	$(U-B)^{\circ}_{\rm med}$
.4	+ .44	+ .18
.6	+ .52	+ .28
.8	+ .60	+ .37
1.0	+ .68	+ .46
1.2	+ .75	+ .55
1.4	+ .80	+ .64

These values have been plotted against each other in Figure 12. They have been connected by a full-drawn line. In the same figure we have drawn the standard relation between $(B-V)$ and $(U-B)$ for stars on the main sequence. The arrow in the upper left-hand corner indicates the reddening line according to JOHNSON and MORGAN (1953). As we remarked already in connection with Figure 8 the colour relation for the Cepheids does not differ much from the direction of the reddening line. In the same figure I have plotted the colours, uncorrected for reddening, of the standard stars used in this paper. MORGAN's spectral classes have been indicated. Finally I have plotted, as open circles, the intrinsic colours of six F- and G-type supergiants for which

FIGURE 12



KRAFT (1960, page 347) has derived accurate values of the colour excess in $(B-V)$. On the whole the Cepheid relation agrees satisfactorily with that of the normal supergiants, although the two supergiants of early spectral type fall slightly below the line for the Cepheids.

From a study of the distance from the galactic plane we decided that V 572 Aql, IX Cas, UY Eri, CC Lyr, CN Lyr and BH Oph definitely belong to population II. KL Aql and SX Per were somewhat dubious cases. It is well known (see for example: EGGEN, GASCOIGNE and BURR (1957) or WALRAVEN, MULLER and OOSTERHOFF (1958)) that for many Cepheids of population II the maximum of the $(B-V)$ colour curve occurs at an earlier phase than the maximum of the visual light-curve. This phenomenon is confirmed by the present observations for IX Cas and BH Oph in a pronounced way and to a lesser degree for V 572 Aql, UY Eri and CC Lyr. CN Lyr can hardly be distinguished according to this criterion from population I Cepheids and KL Aql and SX Per not at all. For the population II Cepheids the $(U-B)$ colour curve seems to be practically in phase with the $(B-V)$ colour curve. For some of the population I Cepheids the maximum of the $(U-B)$ curve falls at an earlier phase than the maximum of the $(B-V)$ curve. This effect is most pronounced for RW Cam, TU Cas and VY Cyg, but it is also found for V 532 Cyg, AW Per and CR Cep. CV Mon, observed by ARP (1960), shows the same characteristics. RR Lyrae stars like RR Lyr (HARDIE 1955) and AN Ser (SPINRAD 1959) have a $(U-B)$ colour curve, which shows a sharp maximum at a phase considerably earlier than the maxima of the $(B-V)$ colour curve and of the visual light-curve. But for these variables the shape of the $(U-B)$ colour curve is very different from the $(B-V)$ colour curve, whereas for the Cepheids the two colour curves are more or less comformable. Spectroscopic observations in the blue and violet part of the spectrum with high dispersion will be required to decide whether the shock-wave model, proposed by ABT (1959) for RR Lyrae, can also be used to explain the phase shift between the two colour curves for some of these galactic Cepheids.

My sincere thanks are due to Dr I. S. BOWEN, the Director of the Mount Wilson and Palomar Observatories, for the privilege to work with the 20-inch telescope. I am grateful to the United States Educational Foundation in the Netherlands for a Fulbright travel grant and to the "Stichting Het Leids Kerkhoven-Bosscha-fonds" for a grant which allowed me to stay four months in the United States.

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