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MULTIVARIABILITY OF RS BOOTIS

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MULTIVARIABILITY OF RS BOOTIS

ABSTRACT

3420 photoelectric observations obtained between 1971 and 1978 are reported. The long period variation obtained by Oosterhof has been confirmed and its change defined ($P_1 = 533$ days). A shorter cycle of 62 days has been found superimposed on the long period. The brightening of the star during the cycle of 62 days is yellowish or cool. The secular change in the pulsation period has been found ($\beta = 10^{-11}$ day cycle^{-1}). Detached O-C_2 residuals give a curve of sinusoidal form which, in a binary system, could be due to an orbit period motion of 70 years.

INTRODUCTION

The light variability of RS Boo (=BD +32°2489) was discovered by Harwig and Pracka (1907). A period of light variation of 0.37722 day was first disclosed by Pracka (1910). The colour variation of RS Boo was announced by Seares and Shapley (1914) and shortly after, its spectrum was given B8 in Max. and F0 in Min. by Pease (1914). Two independent sets of visual and photographic observations in an interval of several years were discussed by Seares and Shapley (1918). There was some evidence of irragular fluctuations in light, but no certain indication of a variation in the period. The change in colour agreed closely with that inferred from Pease's spectrograms. A new period of P = 0.37733506 day was also disclosed.

Although many observers were attracted to observing RS Boo, they were unable to get conspicuously new results because of the lack of any long sets of observation. However it is interesting to note that Lause (1931) found a significant variation in the phase and the height of maximum light.

The first long sets of observations were carried out by Oosterhof (1945). These new sets of very accurate photographic observations ranged over a time-interval of five years and resulted in 22 very nice light curves. During the years 1938-1944, 2418 photographic observations were obtained which have an internal mean error of ±0.036 magn.

Oosterhof derived the new epoch

$$E = 2428972^{d}.6633 + 0^{d}.37733657\ t$$

for the fundamental period, moreover he was able to determine a very long secondary period of 537 days, which is the longest one up till now among the RR Lyrae stars. The shape and the period both appeared to be subjected to a variation of secondary period. Oosterhof stated that any earlier observation had had too short sets for determining the long secondary period of RS Bootis.

Having analysed his own data he suspected some light variation above the two periods. He stated: "It may be ... that a secular or long period change of the period still makes itself felt in the six years of observation or that other minor variation of unknown type have remained undiscovered."

OBSERVATIONS

The first sets of photoelectric observation were carried out by Csank and Geffert in 1959 using the 60 cm Newton telescope at Budapest. However, the long sets of observation were initiated by the author and fifty valuable light curves were obtained at Konkoly Observatory in the period 1971-1978.

The photoelectric observations were carried out using a 24 inch telescope equipped with an unrefrigerated photometer with an EMI 9502 B type tube. The following filters were employed: Schott GG 11 in V, BG 12+GG 13 in B and UG 1 in U.

Valuable U observations were not obtained because of the faintness of the variable star and the atmospheric condition at Budapest. The comparison star BD $+32^{\circ}2486$ was close to the variable, no correction has been made for differential extinction. The accuracy of individual B,V observations was about 0.01 magn. The photoelectric observations have been transformed into the UBV system in the traditional way. The verification of a possible shorter secondary variation suspected by Oosterhof was the main purpose of our observation. In view of this it considered necessary to get light curves distributed smoothly on the supposed shorter secondary period.

Our results confirmed a very long period of 533 days which is slightly shorter than that obtained by Oosterhof. Moreover, a shorter cycle of 62 days was found which was superimposed on the long period of 533 days.

LIGHT CURVE AND PHASE VARIATION

Although the amplitude and phase variation in the cycle of 62 days have no comparable values with the variation of period of 533 days, even so they are significant and much higher values than the inaccuracy of the observations (Kanyó, 1980). The obtained cycle of 62 days does not offer evidence for definitive periodicity partly because of the irreducible perturbation of the long period variation.

The most important features of the cycle of 62 days are:

- The maxima and minima of the light curves together show both increasing or decreasing variation superimposing on the long period (Fig. 1,2). Therefore the secondary period seems to be an independent event from the fundamental and long periods, which periods, however, do not seem to be independent (Fig. 3).

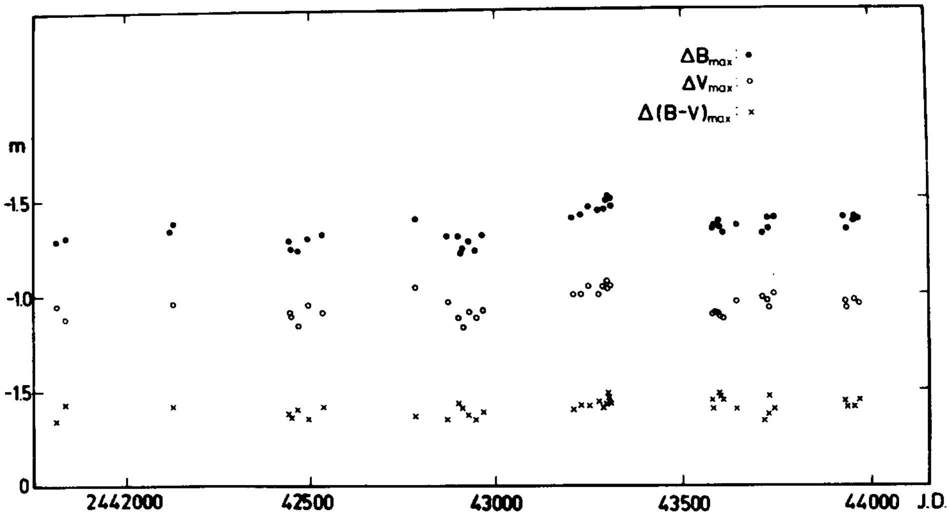

Fig. 1

- The blue amplitude of the cycle of 62 days is not higher than the yellow one. That is, the brightening during the cycle does not show a shift to the blue colour, rather it shifts to the yellow. In contrast the long period produces the blue shift due to the increase in temperature of the variable star.

- The light curves show some O-C variation in both the secondary and the long periods. However these O-C variations are not significant in relation to the size of the respective period. The amplitude of O-C variation in 62 days

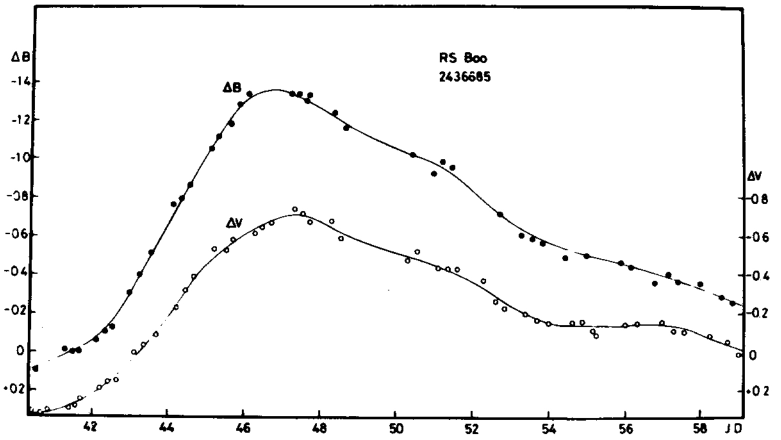

Fig. 2a

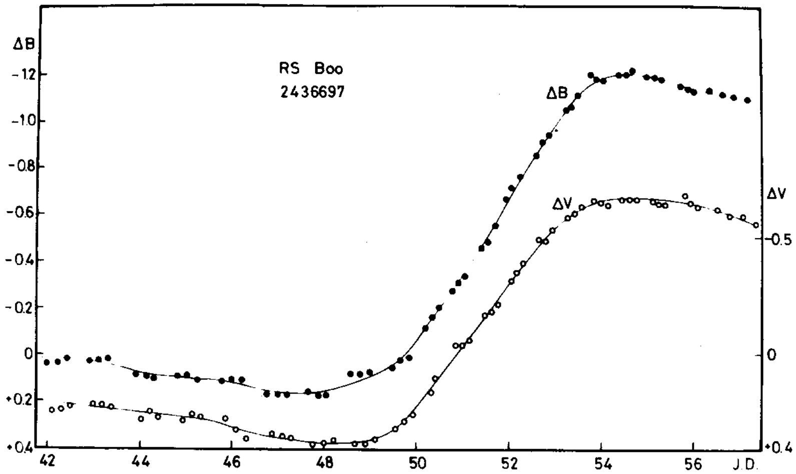

Fig. 2b

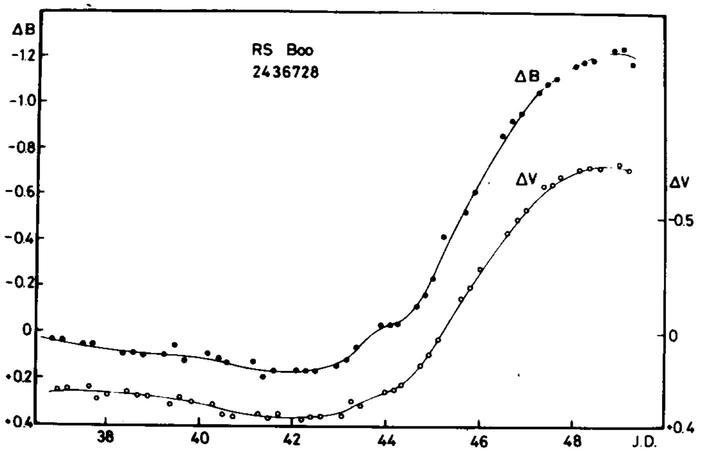

Fig. 2c

is about 0.01 day, and 0.03 day in the long period. The small variations of O–C suggest that the effects interacting in the respective periods seem to be relatively small.

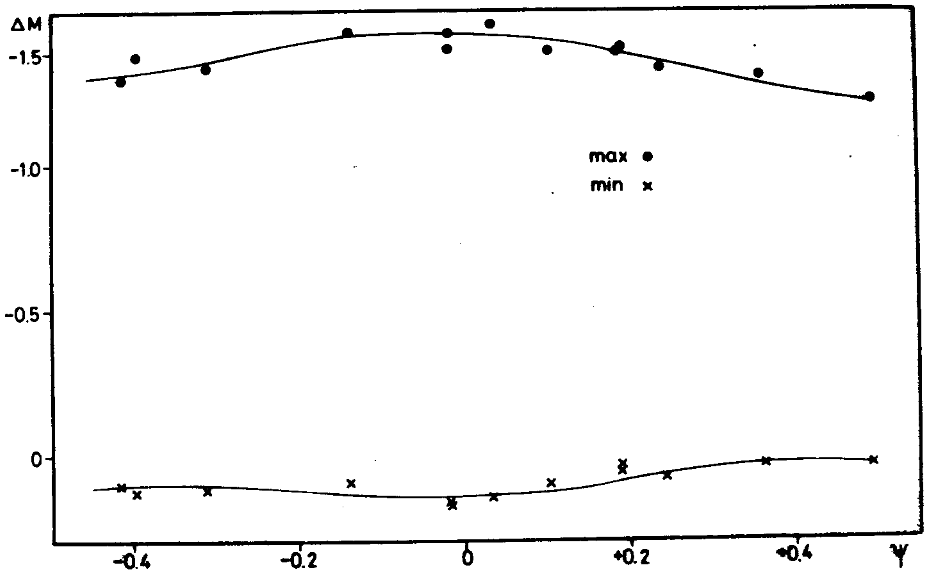

Fig. 3

Since a great number of photometric observations have been collected over the past 60 years it makes it possible to construct O–C residuals in a continuous long term (Fig. 4).

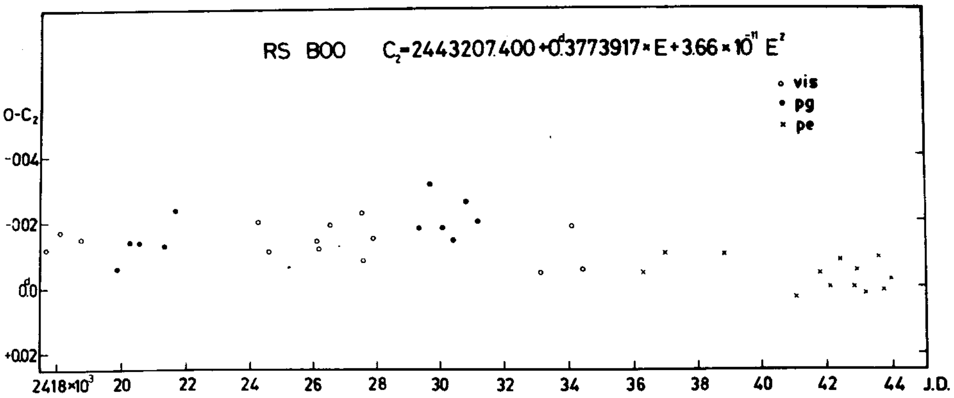

Fig. 4

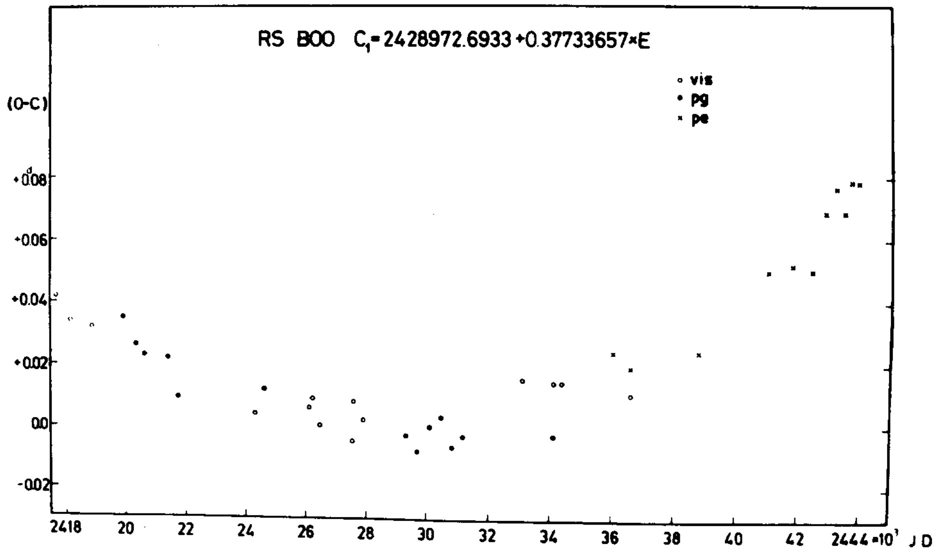

Fig. 5

The moment of maxima are collected in Table 1. The O-C_1 residuals are calculated by the linear elements:

$$\text{J.D.max.hel.} = 2428972.6933 + 0.37733657 \times E.$$

A parabolic curve (Fig. 5) fit yielded the quadratic term:

$$+ 3.66 \times 10^{-11} E^2.$$

The O-C_2 residuals calculated by the quadratic formula show a remarkable fluctuation which is partly due to the O-C variation in the long period (Table 2). In addition it is apparently a very long cycle of small amplitude. However this suspected long period requires more definitive verification in order to be able to calculate the orbit parameters of a presumable binary system (Szeidl, 1983).

SUMMARY

The most important result of our investigation is a new cycle of 62 days of the variable stars.

This 62-day cycle does not seem to be related to the fundamental period (i.e. to the pulsation) since the light curve appears to be superimposed on the cycle of 62 days. The brightening of the star during the cycle is cool one. This phenomenon is explainable by the supposition of a new, physically strongly independent, and cooler source of light. A well known old standing fact is the irregularity of RS Boo, that it belongs to the RR_c subclass due to its short period, and to the RR_{ab} subclass due to the shape of its light curve. The long (Blashko) period of 533 days of the star discovered by Oosterhof is an extraordinarily long one among the RR Lyrae stars, but the long period effect is small in both the amplitude and the O-C variations.

The parabolic shape of the $O-C_1$ residuals refers to a continuous increasing of the fundamental period ($\beta = 3.66.10^{-11}$ day cycle^{-1}). If the parabolic curve is separated from the O-C, the remnant shows a curve of sinusoidal, wave form which gives a very long period. Supposing that this curve were due to the orbit motion of a binary system the orbit period would be about 70 years.

Certainly, the behaviour of the cyclic variation of 62 days and the secular variation of $O-C_2$ residuals, both confirm the suspicion of a possible binary system.

Since there are a number of open questions the continued investigation of RS Bootis is desirable and reasonable.

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Table 1.

J.D.max./$JD_{\odot}$/	$O-C_1$	$O-C_2$	$\overline{O-C}_2$	Rem.	Obs.
2417668.109	-0.012	+0.042	+0.042	Pr	vis
18117.889	0.014	0.037		SS	vis
118.638	0.020	0.032		SS	vis
139.775	0.014	0.037	+0.034	SS	vis
153.728	0.021	0.029		SS	vis
178.638	0.016	0.035		SS	vis
879.726	0.015	0.032	+0.032	SS	vis
19923.442	0.006	0.035	+0.035	Ro	pg
20331.711	0.014	0.026	+0.026	Sh	pg
577.733	0.014	0.024	+0.023	Jo	pg
594.709		0.020		Jo	pg
603.770		0.025		Jo	pg
21372.402	0.013	0.022	+0.022	Ok	pg
724.444	0.024	0.009	+0.009	MP	pg
24292.592	0.020	0.004	+0.004	He	vis
610.317	0.011	0.012	+0.012	Pa	pg
26089.470	0.014	0.006	+0.006	Ts	vis
166.448	0.012	0.007	+0.009	La	vis
206.444	0.014	0.005		La	vis
214.378	0.004	0.015		La	vis
217.389	0.012	0.007		La	vis
248.333	0.010	0.010		La	vis
331.716	0.017	0.001		La	vis
420.390	0.018	0.001	0	La	vis
427.561	0.017	+0.003		La	vis
452.458	0.023	-0.004		La	vis
475.481	0.018	+0.001		La	vis
487.557	0.017	+0.002		La	vis
489.437	0.023	-0.004		La	vis
515.479	0.018	+0.002		La	vis
518.496	0.019	0		La	vis
523.400	0.021	-0.002		La	vis
546.420	0.018	+0.001		La	vis
27308.276	0.003			Do	vis
538.809	0.023	-0.005	-0.005	So	vis
615.422	0.008	+0.008	+0.008	Do	vis
909.738	0.015	+0.002	+0.002	So	vis
29326.630	0.022	-0.005	-0.003	Oo	pg
373.428	0.013	+0.003		Oo	pg
694.532	0.022	-0.006	-0.007	Oo	pg
726.614	0.014	+0.002		Oo	pg
730.376	0.026	-0.009		Oo	pg
751.501	0.032	0.015		Oo	pg
30066.589	0.019	0.003	0	Oo	pg
071.496	0.017	-0.001		Oo	pg
092.632	0.012	+0.004		Oo	pg
114.510	0.020	-0.004		Oo	pg
168.476	0.024	+0.003		Oo	pg
442.426	0.010	0.007	+0.003	Oo	pg
443.557	0.009	+0.006		Oo	pg
465.436	0.017	-0.001		Oo	pg
488.456	0.015	+0.002		Oo	pg

Table 1. cont.

J.D.max./JD$_\odot$/	O-C$_1$	O-C$_2$	$\overline{\text{O-C}}_2$	Rem.	Obs.
2430514.492	-0.015	+0.002		Oo	pg
517.510	0.015	+0.001		Oo	pg
790.688	0.030	-0.013	-0.009	Oo	pg
812.580	0.023	0.006		Oo	pg
849.556	0.026	0.009		Oo	pg
31200.486	0.019	0.002	-0.003	Oo	pg
223.502	0.021	-0.004		Oo	pg
33135.108	0.004	+0.015	+0.015	Fa	vis
34104.489	0.003	0.019	+0.014	Po	vis
112.396		0.001		Po	vis
120.322	0.018	0.003		Al	pg
132.401		0.008		Po	vis
147.494	0.014	0.007		Ju	vis
166.372	0.003	0.018		Ju	vis
171.298		0.031		Ju	vis
180.330	0.007	0.015		Ju	vis
455.411	0.005	0.018	+0.014	Po	vis
472.384		0.010		Po	vis
478.421		0.010		Po	vis
484.465		0.017		Po	vis
36314.932	0.004	0.024	+0.024	Sp	pe
661.306	0.026	0.003	+0.010	Ln	vis
664.330		0.008		Ln	vis
667.360		0.020		Ln	vis
670.366		0.007		Ln	vis
703.961	0.010	0.019	+0.019	Pp	pe
37026.591		0.026	+0.026	Ah	vis
38845.732	0.005	0.028	+0.028	Fi	pe
41056.561	-0.007	0.042	+0.050	Pp	pe
076.570	+0.009	0.052		Pp	pe
084.498	+0.007	0.056		Pp	pe
810.490	-0.002	0.052	+0.052	Pp	pe
835.387	-0.009	0.045		Pp	pe
42120.666	+0.002	0.058		Pp	pe
128.586	-0.002	0.054		Pp	pe
443.658	0.008	0.050	+0.050	Pp	pe
449.697	0.006	0.051		Pp	pe
454.600	0.009	0.049		Pp	pe
465.540	0.012	0.046		Pp	pe
493.466	0.009	0.049		Pp	pe
532.336	0.005	0.054		Pp	pe
786.673	0.005	0.066	+0.069	Pp	pe
870.436	0	0.070		Pp	pe
899.490	-0.002	0.071		Pp	pe
905.523	0.006	0.067		Pp	pe
910.434	0.001	0.072		Pp	pe
927.410	0.005	0.068		Pp	pe
947.408	0.006	0.067		Pp	pe
964.389	0.005	0.068		Pp	pe
43207.399	0.001	0.073	+0.077	Pp	pe
219.475	0	0.075		Pp	pe
227.397	-0.002	0.073		Pp	pe

Table 1. cont.

J.D.max. /JD$_\odot$/	O-C$_1$	O-C$_2$	$\overline{\text{O-C}}_2$	Rem.	Obs.
2443228.535	+0.004	+0.079		Pp	pe
251.555	0.006	0.081		Pp	pe
276.454	0.001	0.076		Pp	pe
288.531	0.003	0.078		Pp	pe
298.340	0.001	0.076		Pp	pe
302.491	0.001	0.077		Pp	pe
304.380	0.003	0.079		Pp	pe
308.533	+0.006	0.081		Pp	pe
580.582	-0.007	0.071	+0.069	Pp	pe
583.596	0.012	0.066		Pp	pe
597.559	0.010	0.067		Pp	pe
599.444	0.012	0.066		Pp	pe
608.506	0.006	0.072		Pp	pe
645.486	0.005	0.073		Pp	pe
716.426	-0.004	0.073	+0.079	Pp	pe
727.377	+0.003	0.082		Pp	pe
730.394	0.001	0.080		Pp	pe
744.357	0.003	0.081		Pp	pe
931.515	+0.001	0.081	+0.079	Pp	pe
954.530	-0.002	0.078		Pp	pe
957.546	0.005	0.075		Pp	pe
967.360	0.002	0.079		Pp	pe

Remarks to Table 1.: Pr = Pracka /1910/; SS = Seares-Shapley /1914,1918/; Ro = Robinson /1930/; Sh = Shapley /1914/ = SS ; Jo = Jordan /1926/ ; Ok = Okunev /1932/; MP = Martin-Plummer /1918/; He = Hellerich /1925/; Pa = Parenago /1930/; Ts= Tsessewich /1931/; La = Lause /1931/; Do = Dombrovski /1935/; So = Soloviev /1935/; Oo = Oosterhoff /1945/; Fa = Fatkina /1950/; Po = Pohl /1953/; Al = Alania /1953/; Ju = Judkina /1953/; Sp= Spinrad /1961/; Ln = Lange /1959/; Ah = Ahnert /1961/; Fi = Fitch /private communication/; Pp = Present paper

Table 2

A few characteristics of the light and colour curves

Epoch of maximum /$JD_{\odot}$/	ΔV_{max}	ΔB_{max}	ΔV_{min}	ΔB_{min}	/B-V/$_{max}$
2441076	-1.00	-1.40	+0.18	+0.17	-0.40
41084	0.98	1.49	0.20	0.15	0.51
41810	0.95	1.29	-	-	0.34
41835	0.88	1.31	-	-	0.43
42120	-	1.34	-	0.12	-
42128	0.96	1.38	0.22	0.13	0.42
42443	0.91	1.29	-	-	0.38
42449	0.89	1.25	-	-	0.36
42465	0.84	1.24	-	-	0.40
42493	0.95	1.30	-	-	0.35
42532	0.91	1.32	-	-	0.41
42786	1.04	1.40	0.2	0.1	0.36
42870	0.96	1.31	-	-	0.35
42899	0.88	1.31	0.14	0.04	0.43
42905	-	1.22	-	0.04	-
42910	0.83	1.24	0.15	0.08	0.41
42927	0.91	1.28	-	-	0.37
42947	0.88	1.23	-	-	0.35
42964	0.92	1.31	-	-	0.39
43207	1.00	1.40	-	-	0.40
43228	1.00	1.42	-	-	0.42
43251	1.04	1.46	0.22	0.17	0.42
43276	1.00	1.44	-	-	0.44
43288	1.04	1.45	-	-	0.41
43298	1.07	1.49	-	-	0.42
43302	1.03	1.51	-	-	0.48
43304	1.04	1.50	-	-	0.46
43308	1.03	1.46	0.2	0.1	0.43
43580	0.89	1.34	-	-	0.45
43583	0.90	1.30	0.15	0.1	0.40
43596	0.88	1.37	-	-	0.49
43597	0.92	1.39	-	-	0.47
43599	0.88	1.35	-	-	0.47
43608	0.87	1.32	-	-	0.45
43645	0.96	1.36	-	-	0.40
43716	0.98	1.32	-	-	0.34
43727	0.97	1.34	-	-	0.37
43730	0.93	1.40	-	-	0.47
43744	1.00	1.40	-	-	0.40
43931	0.96	1.40	-	-	0.44
43935	0.93	1.34	0.15	0.08	0.41
43954	0.97	1.38	-	-	0.41
43967	0.95	1.39	-	-	0.44

Table 3.

Photoelectric observations of RS Boo

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436685		2436685		2436697	
.3114	+0.272	.4736	-0.740	.4157	+0.192
.3214	0.262	.4757	0.707	.4208	0.238
.3233	0.193	.4777	0.676	.4229	0.235
.3296	0.254	.4832	0.677	.4250	0.224
.3314	0.228	.4856	0.589	.4299	0.216
.3333	0.236	.5033	0.473	.4317	0.213
.3375	0.239	.5054	0.519	.4338	0.223
.3393	0.249	.5109	0.435	.4403	0.242
.3409	0.248	.5136	0.428	.4421	0.244
.3446	0.253	.5165	0.432	.4440	0.270
.3467	0.222	.5231	0.373	.4493	0.284
.3490	0.236	.5262	0.260	.4514	0.255
.3533	0.233	.5287	0.228	.4535	0.268
.3551	0.234	.5342	0.202	.4587	0.277
.3569	0.240	.5370	0.173	.4611	0.326
.3613	0.225	.5398	0.155	.4632	0.358
.3631	0.228	.5460	0.160	.4688	0.340
.3650	0.248	.5488	0.158	.4708	0.349
.3694	0.276	.5516	0.112	.4729	0.355
.3713	0.233	.5575	0.089	.4778	0.383
.3733	0.288	.5603	0.147	.4799	0.375
.3782	0.246	.5633	0.154	.4820	0.367
.3801	0.263	.5700	0.158	.4868	0.380
.3817	0.259	.5731	0.114	.4889	0.381
.3879	0.304	.5755	0.104	.4910	0.365
.3902	0.294	.5824	0.090	.4955	0.318
.3921	0.308	.5873	0.055	.4976	0.285
.3958	0.269	.5901	0.008	.4991	0.259
.3976	0.283			.5028	0.158
.4000	0.337	2436697		.5042	+0.097
.4042	0.307	.3382	+0.143	.5085	-0.039
.4064	0.323	.3401	0.122	.5099	0.038
.4085	0.300	.3458	0.147	.5113	0.064
.4142	0.291	.3477	0.149	.5148	0.169
.4158	0.279	.3495	0.162	.5162	0.179
.4175	0.241	.3542	0.161	.5176	0.210
.4224	0.184	.3563	0.169	.5203	0.311
.4244	0.153	.3583	0.127	.5217	0.351
.4266	0.146	.3642	0.132	.5231	0.389
.4314	+0.003	.3663	0.127	.5266	0.480
.4343	-0.037	.3684	0.170	.5280	0.485
.4370	0.089	.3750	0.170	.5294	0.529
.4426	0.228	.3771	0.193	.5328	0.585
.4449	0.318	.3792	0.212	.5342	0.601
.4467	0.390	.3963	0.152	.5356	0.628
.4524	0.529	.3982	0.147	.5384	0.655
.4554	0.514	.4030	0.176	.5398	0.649
.4574	0.579	.4049	0.171	.5412	0.642
.4624	0.610	.4067	0.175	.5446	0.664
.4650	0.643	.4120	0.175	.5460	0.666
.4673	0.671	.4139	0.178	.5474	0.666

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436697		2436728		2441076	
.5509	-0.655	.4858	-0.718	.5151	+0.166
.5523	0.638	.4899	0.741	.5165	0.162
.5537	0.642	.4920	0.714	.5182	0.151
.5579	0.678	.4941	0.655	.5214	0.148
.5593	0.651			.5228	0.132
.5607	0.628	2441056		.5242	0.128
.5649	0.622	.5023	+0.184	.5276	0.123
.5677	0.594	.5037	0.173	.5290	0.110
.5705	0.594	.5051	0.190	.5304	+0.017
.5736	0.558	.5086	0.180	.5332	-0.024
		.5103	0.193	.5342	0.056
2436728		.5120	0.208	.5356	0.084
.3694	+0.253	.5155	0.168	.5387	0.170
.3715	0.244	.5169	0.177	.5415	0.277
.3760	0.242	.5190	0.156	.5446	0.353
.3780	0.290	.5225	0.132	.5460	0.422
.3802	0.271	.5239	0.106	.5473	0.481
.3847	0.256	.5253	0.071	.5498	0.609
.3868	0.271	.5291	+0.019	.5512	0.623
.3889	0.275	.5308	-0.020	.5526	0.658
.3938	0.307	.5322	0.033	.5561	0.747
.3958	0.280	.5353	0.116	.5573	0.806
.3979	0.299	.5367	0.152	.5587	0.837
.4031	0.307	.5381	0.156	.5612	0.867
.4052	0.352	.5412	0.286	.5625	0.915
.4073	0.363	.5426	0.382	.5637	0.911
.4129	0.352	.5440	0.375	.5665	0.967
.4149	0.372	.5468	0.441	.5679	0.970
.4170	0.352	.5482	0.508	.5696	0.960
.4219	0.375	.5496	0.552	.5724	0.998
.4240	0.363	.5526	0.652	.5741	1.010
.4260	0.362	.5540	0.730	.5755	0.978
.4306	0.355	.5557	0.789		
.4326	0.297	.5593	0.886	2441084	
.4347	0.312	.5607	0.883	.4413	+0.213
.4399	0.252	.5621	0.856	.4427	0.191
.4418	0.242	.5635	0.859	.4465	0.173
.4432	0.222	.5669	0.904	.4482	0.171
.4473	0.141	.5683	0.889	.4499	0.156
.4492	0.093	.5732	0.876	.4542	0.107
.4510	+0.025	.5746	0.900	.4559	+0.045
.4559	-0.153	.5773	0.868	.4576	-0.024
.4580	0.202			.4611	0.134
.4601	0.284	2441076		.4628	0.173
.4660	0.440	.4977	+0.218	.4645	0.205
.4681	0.499	.4894	0.234	.4690	0.341
.4701	0.540	.5026	0.158	.4724	0.465
.4737	0.643	.5040	0.165	.4764	0.661
.4756	0.651	.5054	0.175	.4784	0.700
.4774	0.686	.5089	0.189	.4798	0.766
.4816	0.715	.5103	0.169	.4839	0.802
.4837	0.720	.5120	0.178	.4856	0.826

J.D.	ΔV
2441084	
.4875	−0.854
.4917	0.912
.4934	0.935
.4951	0.959
.4992	0.979
.5006	0.979
.5023	0.990
.5062	0.967
.5079	0.978
.5096	0.947
2441810	
.4367	+0.013
.4402	0.016
.4419	+0.039
.4537	−0.073
.4558	0.077
.4592	0.152
.4606	0.206
.4620	0.251
.4658	0.320
.4672	0.375
.4721	0.542
.4738	0.580
.4811	0.787
.4829	0.819
.4870	0.868
.4884	0.904
.4905	0.924
.4940	0.946
.4954	0.951
.4974	0.930
.5009	0.923
.5027	0.934
.5040	0.895
2441835	
.3619	−0.319
.3626	0.333
.3645	0.366
.3658	0.357
.3689	0.537
.3703	0.498
.3716	0.576
.3734	0.635
.3744	0.610
.3758	0.654
.3779	0.688
.3793	0.750
.3807	0.787
.3828	0.784
.3838	0.799
2441835	
.3848	−0.786
.3873	0.840
.3887	0.871
.3921	0.855
.3932	0.827
.3946	0.879
.3970	0.881
.3984	0.862
.4008	0.844
.4019	0.836
2442120	
.6008	+0.181
.6025	0.142
.6057	0.137
.6074	0.189
.6091	0.182
.6119	0.219
.6133	0.224
.6154	0.207
.6209	0.059
.6223	0.071
.6244	0.051
.6279	0.029
.6299	+0.020
.6320	−0.032
.6355	0.091
.6372	0.115
.6386	0.220
.6420	0.311
.6434	0.377
.6455	0.524
.6469	0.554
.6480	0.617
.6503	0.576
.6517	0.621
.6536	0.729
.6563	0.868
.6577	0.918
.6591	0.918
.6615	0.953
.6633	1.001
2442128	
.5249	+0.219
.5270	0.212
.5318	0.215
.5350	0.209
.5389	0.198
.5420	0.183
.5463	0.114
.5487	0.102
2442128	
.5532	+0.006
.5556	−0.080
.5573	0.072
.5598	0.178
.5619	0.226
.5636	0.287
.5685	0.453
.5706	0.516
.5727	0.646
.5768	0.782
.5785	0.836
.5806	0.897
.5844	0.942
.5883	0.948
.5932	0.950
.5953	0.970
.5973	0.960
.6015	0.955
2442443	
.6027	+0.047
.6041	0.074
.6079	0.025
.6093	+0.010
.6131	−0.080
.6149	0.062
.6166	0.043
.6204	0.154
.6225	0.166
.6239	0.270
.6274	0.313
.6295	0.379
.6309	0.398
.6340	0.479
.6350	0.531
.6366	0.538
.6399	0.616
.6413	0.662
.6430	0.706
.6461	0.692
.6472	0.761
.6486	0.841
.6517	0.870
.6541	0.886
.6555	0.855
.6583	0.925
.6600	0.893
.6614	0.895
2442449	
.6355	+0.124
.6376	0.140

J.D.	ΔV
2442449	
.6411	+0.091
.6428	+0.079
.6467	-0.079
.6483	0.097
.6501	0.118
.6555	0.288
.6573	0.327
.6615	0.469
.6628	0.399
.6663	0.512
.6751	0.593
.6761	0.618
.6782	0.654
.6792	0.669
.6803	0.685
.6830	0.753
.6840	0.755
.6867	0.798
.6877	0.816
.6886	0.822
.6911	0.821
.6921	0.841
.6931	0.814
.6950	0.832
.6962	0.853
.6972	0.880
.6996	0.866
2442454	
.5373	+0.156
.5394	0.127
.5432	0.096
.5460	0.094
.5498	0.000
.5515	-0.013
.5550	0.063
.5570	0.056
.5607	0.137
.5625	0.191
.5641	0.210
.5678	0.285
.5696	0.347
.5713	0.389
.5751	0.490
.5769	0.552
.5786	0.584
.5822	0.673
.5840	0.704
.5855	0.695
.5894	0.733
.5910	0.754
.5946	0.793

J.D.	ΔV
2442454	
.5965	-0.833
.5980	0.828
.6019	0.841
.6036	0.852
.6054	0.860
.6089	0.848
.6105	0.866
.6126	0.868
.6167	0.842
.6195	0.786
2442465	
.4833	+0.178
.4847	0.106
.4875	0.087
.4888	0.082
.4919	0.090
.4934	0.062
.4965	0.041
.4979	0.000
.5009	+0.007
.5024	-0.021
.5050	0.087
.5064	0.118
.5076	0.136
.5104	0.170
.5118	0.288
.5128	0.368
.5158	0.424
.5173	0.456
.5187	0.478
.5222	0.557
.5234	0.577
.5250	0.588
.5276	0.653
.5289	0.683
.5305	0.700
.5334	0.749
.5350	0.781
.5361	0.807
.5392	0.840
.5407	0.828
.5419	0.838
.5449	0.822
.5463	0.828
.5478	0.828
.5506	0.825
.5520	0.840
.5534	0.839
.5569	0.833

J.D.	ΔV
2442493	
.4419	-0.458
.4432	0.472
.4457	0.575
.4471	0.594
.4499	0.654
.4512	0.718
.4522	0.736
.4555	0.786
.4572	0.825
.4582	0.844
.4607	0.904
.4628	0.922
.4641	0.948
.4673	0.951
.4688	0.923
.4703	0.916
.4731	0.884
.4742	0.908
.4756	0.901
.4784	0.858
.4798	0.898
.4810	0.864
.4843	0.836
.4867	0.813
.4881	0.793
.4909	0.793
.4923	0.816
2442532	
.3207	-0.736
.3219	0.765
.3230	0.774
.3256	0.793
.3269	0.813
.3283	0.845
.3308	0.890
.3323	0.895
.3338	0.900
.3367	0.914
.3379	0.907
.3393	0.912
.3422	0.901
.3436	0.916
.3450	0.894
.3478	0.864
.3492	0.863
.3506	0.862
.3533	0.819
.3547	0.811
.3561	0.784

J.D.	ΔV
2442786	
.5802	+0.184
.5815	0.146
.5840	0.133
.5854	0.178
.5882	0.141
.5892	0.173
.5920	0.174
.5934	0.217
.5958	0.423
.5986	0.196
.6014	0.150
.6035	0.245
.6345	+0.007
.6354	-0.017
.6364	0.059
.6386	0.025
.6396	0.077
.6406	0.104
.6431	0.191
.6444	0.237
.6454	0.263
.6479	0.496
.6493	0.366
.6507	0.484
.6530	0.588
.6541	0.647
.6562	0.650
.6569	0.734
.6580	0.754
.6589	0.783
.6618	0.770
.6632	0.786
.6641	0.801
.6666	0.970
.6677	1.003
.6691	1.021
.6715	1.022
.6729	1.055
.6739	1.018
.6764	1.027
.6781	0.995
.6791	0.958
2442870	
.3965	-0.024
.3982	0.103
.4009	0.152
.4020	0.204
.4028	0.175
.4050	0.238
.4058	0.251
.4085	0.284

J.D.	ΔV
2442870	
.4096	-0.326
.4103	0.339
.4131	0.430
.4144	0.535
.4162	0.543
.4183	0.629
.4206	0.638
.4228	0.694
.4239	0.719
.4253	0.783
.4273	0.824
.4284	0.811
.4297	0.848
.4317	0.905
.4327	0.884
.4336	0.791
.4359	0.957
.4368	0.963
.4378	0.950
.4401	0.921
.4411	0.773
.4449	0.867
.4460	0.869
.4468	0.863
.4496	0.848
.4507	0.835
2442899	
.4188	+0.134
.4195	0.143
.4221	0.145
.4230	0.111
.4285	0.156
.4292	0.097
.4321	0.091
.4337	0.128
.4363	0.146
.4382	0.091
.4431	0.000
.4438	0.033
.4456	0.049
.4485	+0.062
.4518	-0.098
.4523	0.103
.4542	0.177
.4556	0.252
.4577	0.346
.4584	0.337
.4637	0.443
.4641	0.451
.4657	0.462
.4685	0.541

J.D.	ΔV
2442899	
.4702	-0.609
.4707	0.617
.4728	0.616
.4742	0.642
.4765	0.719
.4772	0.724
.4802	0.776
.4820	0.788
.4824	0.806
.4841	0.811
.4854	0.838
.4876	0.855
.4897	0.886
.4907	0.862
.4926	0.867
.4931	0.881
.4952	0.872
.4985	0.862
.4988	0.868
.5029	0.823
.5044	0.852
2442905	
.4615	+0.044
.4646	0.058
.4659	0.016
.4680	0.050
.4692	+0.040
.4716	-0.004
.4726	-0.004
.4748	+0.003
.4759	-0.035
.4782	0.029
.4791	0.021
.4814	0.018
.4825	0.015
.4845	0.024
.4856	0.081
.4879	0.112
.4887	0.154
.4928	0.290
.4959	0.282
.4969	0.406
.5016	0.489
.5025	0.492
.5049	0.574
.5057	0.571
.5070	0.618
.5091	0.585
.5101	0.640
.5113	0.686
.5134	0.710

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2442905		2442910		2442947	
.5143	-0.727	.4328	-0.791	.3733	-0.279
.5153	0.751	.4351	0.820	.3747	0.296
.5178	0.759	.4364	0.845	.3796	0.431
.5186	0.782	.4377	0.831	.3827	0.529
.5195	0.812	.4399	0.827	.3844	0.555
.5210	0.828	.4412	0.823	.3879	0.569
.5219	0.871			.3896	0.614
.5236	0.865	2442927		.3925	0.636
.5259	0.879	.3638	+0.014	.3945	0.683
.5268	0.858	.3648	-0.050	.3986	0.787
.5277	0.864	.3661	0.056	.4001	0.789
.5298	0.846	.3684	0.145	.4036	0.821
.5310	0.851	.3694	0.164	.4053	0.866
.5320	0.852	.3705	0.175	.4086	0.891
.5342	0.862	.3728	0.215	.4108	0.852
.5351	0.877	.3738	0.242	.4136	0.862
.5363	0.868	.3751	0.243	.4158	0.855
		.3775	0.247	.4187	0.777
2442910		.3786	0.259	.4201	0.758
.3691	+0.145	.3798	0.276	.4234	0.765
.3703	0.119	.3821	0.321	.4247	0.763
.3728	0.085	.3833	0.349	.4282	0.775
.3741	0.128	.3843	0.406	.4297	0.745
.3776	0.046	.3868	0.470		
.3783	0.112	.3883	0.501	2442964	
.3811	+0.051	.3896	0.564	.3624	-0.479
.3825	-0.015	.3922	0.551	.3633	0.539
.3832	-0.007	.3935	0.600	.3655	0.580
.3859	+0.023	.3948	0.614	.3666	0.569
.3873	+0.006	.3971	0.653	.3675	0.587
.3887	-0.011	.3982	0.684	.3697	0.628
.3914	0.075	.3996	0.723	.3707	0.656
.3929	0.063	.4021	0.826	.3718	0.669
.3942	0.154	.4034	0.819	.3740	0.739
.3968	0.200	.4045	0.843	.3750	0.759
.3981	0.200	.4073	0.878	.3762	0.784
.3995	0.253	.4084	0.896	.3784	0.805
.4023	0.351	.4097	0.912	.3793	0.816
.4035	0.396	.4121	0.902	.3805	0.844
.4049	0.420	.4132	0.908	.3829	0.804
.4094	0.500	.4144	0.883	.3838	0.833
.4123	0.563	.4168	0.867	.3857	0.895
.4143	0.635	.4179	0.837	.3869	0.904
.4155	0.660			.3878	0.895
.4165	0.689	2442947		.3902	0.940
.4189	0.740	.3514	+0.102	.3912	0.881
.4203	0.744	.3527	-0.005	.3934	0.872
.4241	0.816	.3549	-0.022	.3943	0.878
.4253	0.796	.3562	+0.035	.3964	0.842
.4268	0.799	.3601	-0.062	.3974	0.886
.4290	0.806	.3634	0.129	.3999	0.839
.4314	0.805	.3664	0.147	.4008	0.840

J.D.	ΔV
2442964	
.4028	-0.838
.4037	0.815
.4058	0.792
.4068	0.814
.4089	0.791
.4100	0.780
2443207	
.3880	-0.762
.3907	0.801
.3919	0.846
.3931	0.962
.3958	0.977
.3971	0.996
.3981	0.993
.4012	0.970
.4024	0.977
.4035	0.986
.4063	0.991
.4077	0.984
.4091	0.980
.4117	0.955
.4131	0.952
.4145	0.969
.4174	0.970
.4188	0.942
.4202	0.924
.4232	0.893
.4246	0.875
.4278	0.858
.4291	0.864
2443228	
.4919	+0.194
.4929	0.194
.4952	0.068
.4967	0.071
.4986	+0.078
.5001	-0.063
.5013	0.074
.5037	0.226
.5049	0.171
.5060	0.142
.5086	0.241
.5096	0.284
.5107	0.347
.5130	0.449
.5139	0.503
.5151	0.513
.5174	0.635
.5186	0.725
2443228	
.5195	-0.737
.5221	0.792
.5231	0.808
.5242	0.811
.5265	0.872
.5277	0.901
.5287	0.889
.5309	0.967
.5322	0.968
.5332	0.994
.5354	0.999
.5367	1.017
.5377	0.990
.5401	0.993
.5414	1.005
.5423	0.989
.5457	0.897
.5471	0.946
.5481	0.894
2443251	
.5010	+0.235
.5023	0.212
.5037	0.180
.5064	0.196
.5076	0.191
.5092	0.214
.5122	0.162
.5135	0.115
.5148	0.076
.5175	0.061
.5185	+0.061
.5197	-0.036
.5229	0.120
.5240	0.167
.5253	0.160
.5283	0.303
.5295	0.366
.5308	0.307
.5337	0.539
.5350	0.517
.5364	0.550
.5395	0.768
.5406	0.771
.5418	0.826
.5447	0.908
.5460	0.921
.5472	0.960
.5502	0.979
.5514	1.037
.5525	1.012
2443251	
.5554	-1.048
.5569	1.055
.5597	1.005
.5611	1.015
2443276	
.4515	-0.992
.4526	1.001
.4543	1.000
.4567	0.998
.4581	1.014
.4595	0.976
.4630	0.979
.4644	0.987
.4654	0.980
.4678	0.962
.4692	0.947
.4734	0.894
.4748	0.897
.4762	0.877
.4790	0.840
.4800	0.829
.4810	0.866
2443288	
.5117	-0.506
.5126	0.570
.5135	0.611
.5153	0.641
.5163	0.721
.5177	0.751
.5198	0.828
.5206	0.865
.5215	0.867
.5239	0.954
.5250	0.970
.5260	1.007
.5281	1.017
.5290	1.029
.5302	1.042
.5323	1.041
.5333	1.055
.5342	1.035
.5366	1.015
.5376	1.043
.5385	1.043
.5406	1.006
.5417	0.997
.5429	1.004
.5448	0.983
.5458	0.956

J.D.	ΔV
2443298	
.3447	-1.057
.3454	1.083
.3465	1.064
.3482	1.042
.3491	1.049
.3499	1.021
.3517	1.041
.3526	1.038
.3534	1.037
.3555	1.008
.3564	0.989
.3576	0.961
.3595	0.933
.3606	0.892
.3616	0.805
.3635	0.813
.3645	0.799
.3659	0.849
2443302	
.4746	-0.501
.4754	0.559
.4765	0.584
.4786	0.653
.4796	0.691
.4803	0.723
.4823	0.797
.4831	0.835
.4839	0.893
.4857	0.865
.4868	0.911
.4876	0.933
.4892	0.992
.4899	1.011
.4909	1.051
.4927	1.015
.4936	1.027
.4944	1.014
.4966	0.983
.4975	0.987
.4983	0.985
.5003	0.980
.5012	0.993
2443304	
.3521	-0.096
.3531	0.161
.3556	0.315
.3567	0.387
.3591	0.413
.3604	0.377
.3627	0.471

J.D.	ΔV
2443304	
.3636	-0.514
.3657	0.612
.3669	0.722
.3688	0.765
.3698	0.774
.3722	0.912
.3732	0.908
.3757	0.904
.3767	0.966
.3778	1.008
.3809	1.033
.3819	1.040
.3841	1.034
.3853	1.035
.3862	1.014
.3886	1.009
.3897	0.987
.3908	0.941
2443308	
.4816	+0.210
.4825	0.200
.4850	0.060
.4862	0.026
.4886	0.037
.4898	0.060
.4908	+0.066
.4936	-0.008
.4947	0.021
.4958	0.019
.4982	0.075
.4996	0.053
.5006	0.114
.5033	0.196
.5045	0.222
.5054	0.266
.5082	0.402
.5094	0.424
.5106	0.451
.5133	0.666
.5145	0.708
.5156	0.728
.5187	0.747
.5197	0.805
.5207	0.830
.5232	0.862
.5243	0.893
.5252	0.910
.5277	0.973
.5290	0.966
.5302	1.002
.5326	1.027

J.D.	ΔV
2443308	
.5338	-1.027
.5348	1.039
.5371	0.992
.5378	0.957
.5391	0.958
2443580	
.5453	+0.040
.5460	-0.030
.5476	0.204
.5484	0.212
.5502	0.348
.5510	0.333
.5527	0.363
.5535	0.356
.5543	0.385
.5559	0.415
.5566	0.477
.5583	0.501
.5591	0.495
.5639	0.572
.5647	0.663
.5666	0.659
.5678	0.714
.5698	0.727
.5738	0.779
.5761	0.835
.5771	0.864
.5789	0.859
.5801	0.833
.5823	0.850
.5835	0.870
.5856	0.861
.5865	0.882
.5889	0.884
.5929	0.908
.5942	0.874
.5964	0.850
.5976	0.850
.5994	0.819
.6007	0.791
.6036	0.812
2443583	
.5378	+0.147
.5403	0.163
.5415	0.124
.5427	0.135
.5459	0.138
.5486	0.103
.5511	0.111
.5525	0.113

J.D.	ΔV
2443583	
.5537	+0.115
.5584	+0.003
.5723	-0.431
.5733	0.418
.5743	0.437
.5767	0.458
.5778	0.494
.5787	0.526
.5809	0.584
.5822	0.615
.5831	0.632
.5857	0.773
.5868	0.798
.5915	0.856
.5938	0.857
.5948	0.892
.6017	0.881
.6052	0.897
2443596	
.4016	-0.393
.4030	0.476
.4061	0.474
.4075	0.562
.4103	0.563
.4115	0.663
.4148	0.671
.4160	0.651
.4189	0.667
.4203	0.722
.4249	0.822
.4297	0.866
.4347	0.827
.4358	0.882
.4394	0.879
.4427	0.855
.4438	0.888
.4464	0.882
.4474	0.911
.4495	0.904
2443597	
.5051	+0.237
.5060	0.162
.5087	0.105
.5101	0.106
.5111	0.082
.5139	0.045
.5164	+0.001
.5201	-0.087
.5212	0.085
.5236	0.079
2443597	
.5255	-0.073
.5266	0.091
.5294	0.136
.5306	0.166
.5319	0.301
.5345	0.375
.5358	0.375
.5370	0.444
.5397	0.584
.5407	0.623
.5419	0.599
.5442	0.647
.5455	0.678
.5468	0.682
.5490	0.712
.5502	0.761
.5516	0.825
.5538	0.857
.5551	0.877
.5562	0.907
.5586	0.939
.5595	0.912
.5610	0.895
.5635	0.889
.5649	0.891
.5662	0.886
.5683	0.860
.5704	0.886
.5718	0.856
.5740	0.851
.5752	0.802
2443599	
.3881	+0.172
.3923	0.136
.3947	0.055
.3960	0.063
.3985	+0.035
.3998	-0.019
.4007	+0.019
.4029	-0.011
.4043	0.025
.4054	0.029
.4077	0.044
.4087	0.040
.4100	0.102
.4135	0.252
.4145	0.266
.4157	0.274
.4183	0.393
.4196	0.396
.4208	0.413
2443599	
.4231	-0.448
.4260	0.541
.4282	0.549
.4305	0.632
.4326	0.716
.4337	0.730
.4349	0.737
.4371	0.743
.4381	0.757
.4392	0.794
.4415	0.868
.4424	0.868
.4436	0.891
.4462	0.867
.4485	0.825
.4506	0.848
.4517	0.813
.4529	0.847
.4550	0.803
.4561	0.852
.4572	0.817
.4612	0.827
.4649	0.787
.4658	0.773
2443608	
.4580	+0.091
.4605	+0.038
.4614	-0.039
.4639	0.007
.4649	0.056
.4675	0.094
.4685	0.147
.4716	0.166
.4728	0.232
.4761	0.257
.4772	0.282
.4798	0.405
.4808	0.428
.4830	0.464
.4841	0.500
.4867	0.590
.4878	0.613
.4903	0.700
.4914	0.766
.4951	0.787
.4986	0.749
.5042	0.841
.5052	0.896
.5073	0.869
.5121	0.860
.5147	0.885

J.D.	ΔV
2443608	
.5156	-0.859
2443645	
.4691	-0.676
.4699	0.681
.4736	0.720
.4748	0.819
.4770	0.806
.4781	0.873
.4821	0.914
.4850	0.889
.4864	0.906
.4890	0.958
.4904	0.955
.4935	0.972
.4949	0.901
.4977	0.890
.4991	0.958
.5017	0.906
.5029	0.880
.5060	0.848
.5071	0.821
.5104	0.840
.5118	0.797
2443659	
.4237	-0.319
.4245	0.362
.4277	0.434
.4287	0.479
.4305	0.542
.4314	0.587
.4332	0.621
.4343	0.635
.4364	0.621
.4372	0.696
.4393	0.790
.4407	0.827
.4440	0.876
.4471	0.876
.4502	0.908
2443716	
.3683	+0.209
.3697	0.178
.3735	0.232
.3749	0.198
.3780	0.187
.3794	0.227
.3860	0.187
.3890	0.150
.3905	0.169

J.D.	ΔV
2443716	
.3933	+0.024
.3949	+0.023
.3977	-0.055
.3989	0.077
.4030	0.205
.4048	0.244
.4079	0.363
.4093	0.479
.4105	0.573
.4133	0.706
.4147	0.761
.4178	0.853
.4190	0.906
.4204	0.916
.4236	0.982
.4248	0.996
.4280	0.930
.4291	0.949
.4302	0.917
2443727	
.3393	-0.011
.3419	0.131
.3430	0.222
.3462	0.258
.3475	0.343
.3507	0.376
.3525	0.452
.3600	0.787
.3653	0.835
.3683	0.921
.3722	0.923
.3738	0.949
.3766	0.813
.3780	0.997
.3812	0.957
.3826	0.933
.3869	0.952
2443730	
.3482	+0.044
.3493	0.067
.3520	+0.028
.3533	-0.008
.3558	+0.004
.3571	-0.026
.3600	0.093
.3621	0.095
.3645	0.232
.3658	0.289
.3676	0.362
.3690	0.401

J.D.	ΔV
2443730	
.3703	-0.364
.3725	0.473
.3735	0.485
.3748	0.578
.3773	0.590
.3786	0.675
.3798	0.752
.3823	0.827
.3833	0.818
.3846	0.833
.3874	0.882
.3887	0.879
.3898	0.889
.3929	0.906
.3936	0.924
.3947	0.922
.3971	0.915
.3984	0.941
2443744	
.3235	-0.039
.3263	0.238
.3277	0.173
.3303	0.461
.3315	0.534
.3326	0.627
.3369	0.771
.3381	0.762
.3405	0.778
.3418	0.830
.3428	0.839
.3457	0.781
.3471	0.783
.3485	0.862
.3511	0.840
.3525	0.988
.3566	1.015
.3579	0.995
.3626	0.985
.3641	1.022
2443931	
.4398	+0.084
.4412	0.098
.4540	0.104
.4554	0.126
.4586	0.071
.4599	0.077
.4634	0.019
.4648	+0.022
.4679	-0.021
.4693	0.028

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2443931		2443935		2443954	
.4724	-0.077	.6309	-0.170	.5345	-0.911
.4752	0.164	.6318	0.162	.5372	0.876
.4780	0.169	.6336	0.303	.5390	0.862
.4794	0.256	.6344	0.313	.5428	0.807
.4808	0.242	.6364	0.394		
.4836	0.284	.6374	0.375	2443957	
.4852	0.352	.6390	0.420	.4779	+0.272
.4870	0.448	.6400	0.477	.4815	0.206
.4898	0.480	.6421	0.528	.4827	0.176
.4905	0.541	.6432	0.574	.4859	0.148
.4919	0.531	.6451	0.634	.4908	0.128
.4947	0.562	.6460	0.640	.4934	0.067
.4959	0.554	.6477	0.647	.4944	0.064
.4972	0.615	.6489	0.699	.4985	+0.055
.5002	0.687	.6509	0.766	.4997	-0.008
.5018	0.673	.6519	0.744	.5008	+0.031
.5033	0.655	.6536	0.808	.5032	+0.049
.5065	0.762	.6544	0.804	.5043	-0.023
.5079	0.747	.6562	0.861	.5065	0.053
.5093	0.799	.6569	0.861	.5076	0.144
.5140	0.941	.6584	0.865	.5103	0.181
.5152	0.958	.6591	0.875	.5113	0.176
.5165	0.963	.6607	0.908	.5143	0.192
.5193	0.944	.6616	0.928	.5154	0.260
.5208	0.923	.6631	0.929	.5178	0.376
.5221	0.916	.6640	0.936	.5192	0.365
		.6655	0.943	.5202	0.417
2443935		.6665	0.904	.5237	0.446
.5888	+0.075	.6716	0.866	.5249	0.472
.5900	0.133	.6731	0.868	.5274	0.554
.5919	0.144	.6738	0.822	.5289	0.560
.5940	0.217			.5298	0.652
.5958	0.176	2443954		.5326	0.678
.5973	0.177	.4979	-0.307	.5340	0.742
.6015	0.109	.4997	0.391	.5349	0.737
.6026	0.102	.5046	0.379	.5389	0.810
.6045	0.134	.5060	0.454	.5403	0.885
.6061	0.078	.5076	0.551	.5430	0.882
.6079	0.093	.5100	0.649	.5444	0.856
.6091	0.032	.5112	0.663	.5458	0.890
.6110	0.067	.5126	0.692	.5494	0.878
.6119	0.060	.5153	0.731	.5507	0.852
.6137	0.051	.5164	0.767		
.6144	0.051	.5180	0.792	2443967	
.6162	0.036	.5206	0.817	.3260	-0.129
.6173	+0.007	.5222	0.863	.3270	0.086
.6220	-0.079	.5236	0.861	.3304	0.264
.6231	0.107	.5264	0.952	.3316	0.267
.6249	0.068	.5275	0.936	.3329	0.382
.6261	0.138	.5291	0.985	.3356	0.480
.6280	0.160	.5317	0.964	.3370	0.505
.6290	0.138	.5330	0.965	.3408	0.607

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2443967		2443967		2443967	
.3418	-0.675	.3513	-0.846	.3621	-0.911
.3441	0.715	.3534	0.836	.3631	0.901
.3453	0.703	.3549	0.868	.3654	0.838
.3465	0.727	.3569	0.966	.3664	0.823
.3491	0.768	.3580	0.932	.3805	0.707
.3502	0.812	.3590	0.942	.3814	0.735
		.3610	0.930		

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436685		2436685		2436697	
.3106	+0.006	.4356	-0.513	.3531	-0.069
.3206	-0.026	.4413	0.763	.3552	0.053
.3223	0.025	.4435	0.793	.3573	0.078
.3261	-0.022	.4458	0.863	.3632	0.083
.3305	+0.001	.4515	1.051	.3653	0.083
.3322	0.017	.4533	1.114	.3674	0.070
.3364	0.033	.4564	1.181	.3740	0.013
.3384	0.033	.4641	1.284	.3761	0.062
.3402	0.040	.4662	1.338	.3781	0.051
.3437	0.070	.4726	1.338	.3954	0.072
.3456	0.028	.4745	1.336	.3972	0.059
.3479	0.008	.4766	1.302	.4021	0.047
.3522	0.056	.4822	1.331	.4039	-0.021
.3544	0.036	.4842	1.240	.4058	+0.001
.3560	0.026	.4868	1.160	.4109	0.040
.3603	+0.016	.5044	1.026	.4130	0.034
.3622	-0.005	.5099	0.927	.4148	0.039
.3641	-0.001	.5123	0.987	.4199	0.039
.3680	+0.026	.5148	0.956	.4218	0.035
.3703	0.025	.5273	0.716	.4241	0.020
.3724	0.026	.5328	0.607	.4289	0.027
.3770	0.035	.5356	0.587	.4308	0.026
.3791	0.053	.5384	0.567	.4329	0.021
.3810	0.032	.5443	0.491	.4391	0.090
.3870	0.077	.5473	0.579	.4412	0.096
.3891	0.073	.5498	0.502	.4431	0.105
.3912	0.068	.5589	0.462	.4482	0.095
.3949	0.064	.5679	0.361	.4502	0.091
.3967	0.108	.5714	0.404	.4524	0.108
.3990	0.067	.5741	0.372	.4579	0.115
.4033	0.110	.5797	0.362	.4601	0.108
.4055	+0.097	.5853	0.288	.4622	0.113
.4130	-0.012	.5887	0.262	.4677	0.174
.4151	+0.003			.4698	0.170
.4166	+0.003	2436697		.4719	0.175
.4212	-0.060	.3373	-0.087	.4767	0.157
.4234	0.106	.3391	0.077	.4788	0.174
.4256	0.126	.3449	0.085	.4809	0.167
.4301	0.304	.3468	0.084	.4858	0.085
.4327	0.401	.3486	0.081	.4879	0.086

J.D.	ΔB
2436697	
.4899	+0.077
.4948	0.058
.4965	0.025
.4984	+0.011
.5019	-0.116
.5033	0.158
.5049	0.204
.5078	0.272
.5092	0.307
.5106	0.336
.5141	0.455
.5155	0.481
.5169	0.548
.5196	0.665
.5210	0.708
.5224	0.760
.5259	0.853
.5273	0.907
.5287	0.939
.5321	1.048
.5335	1.060
.5349	1.112
.5377	1.197
.5391	1.182
.5405	1.178
.5439	1.202
.5453	1.198
.5467	1.217
.5502	1.192
.5516	1.190
.5530	1.182
.5572	1.152
.5586	1.138
.5600	1.131
.5636	1.137
.5663	1.118
.5691	1.105
.5719	1.098
2436728	
.3684	+0.031
.3705	0.031
.3750	0.052
.3771	0.047
.3792	0.050
.3837	0.091
.3858	0.087
.3879	0.101
.3927	0.096
.3948	0.057
.3969	0.122
.4021	0.090
2436728	
.4042	+0.107
.4062	0.127
.4118	0.123
.4139	0.195
.4160	0.160
.4208	0.159
.4229	0.161
.4250	0.161
.4295	0.139
.4316	0.113
.4337	+0.057
.4389	-0.037
.4409	0.039
.4425	0.046
.4464	0.122
.4483	0.168
.4501	0.242
.4549	0.425
.4569	0.527
.4590	0.618
.4649	0.860
.4670	0.927
.4691	0.962
.4728	1.053
.4747	1.090
.4765	1.109
.4806	1.169
.4826	1.184
.4847	1.190
.4889	1.239
.4910	1.245
.4931	1.177
2441056	
.5030	+0.121
.5044	0.118
.5079	0.113
.5093	0.103
.5113	0.101
.5148	0.115
.5162	0.079
.5183	0.068
.5218	0.035
.5232	0.027
.5246	+0.016
.5284	-0.067
.5298	0.117
.5315	0.155
.5343	0.249
.5360	0.284
.5374	0.337
.5405	0.454
2441056	
.5419	-0.525
.5433	0.591
.5461	0.759
.5474	0.811
.5489	0.903
.5519	1.004
.5533	1.033
.5547	1.101
.5586	1.200
.5600	1.235
.5614	1.248
.5628	1.250
.5662	1.324
.5676	1.339
.5725	1.295
.5739	1.327
.5766	1.316
2441076	
.4970	+0.156
.4987	0.172
.5017	0.131
.5033	0.158
.5047	0.159
.5082	0.142
.5096	0.142
.5110	0.140
.5144	0.095
.5158	0.075
.5172	0.071
.5207	0.073
.5221	0.066
.5235	0.029
.5265	+0.029
.5283	-0.005
.5297	0.067
.5325	0.124
.5336	0.164
.5349	0.260
.5380	0.377
.5394	0.419
.5408	0.457
.5489	0.584
.5453	0.650
.5467	0.728
.5491	0.860
.5505	0.912
.5519	0.993
.5554	1.082
.5568	1.124
.5580	1.171
.5619	1.311

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2441076		2441810		2442120	
.5631	-1.333	.4665	-0.680	.6126	+0.131
.5644	1.327	.4679	0.700	.6140	0.098
.5672	1.365	.4693	0.740	.6202	+0.012
.5686	1.374	.4728	0.863	.6216	-0.003
.5703	1.383	.4745	0.887	.6233	0.018
.5734	1.404	.4801	1.129	.6272	0.051
.5748	1.388	.4822	1.148	.6286	0.050
.5762	1.385	.4839	1.183	.6309	0.112
		.4877	1.252	.6348	0.277
2441084		.4895	1.261	.6365	0.331
.4403	+0.127	.4912	1.264	.6379	0.389
.4420	0.107	.4947	1.296	.6451	0.566
.4458	0.082	.4961	1.276	.6427	0.649
.4475	0.073	.4981	1.290	.6448	0.747
.4492	+0.075	.5016	1.262	.6462	0.868
.4535	-0.037	.5033	1.239	.6476	0.902
.4552	0.070	.5051	1.202	.6497	0.970
.4566	0.110			.6511	0.980
.4604	0.248	2441835		.6527	1.032
.4621	0.325	.3612	-0.514	.6556	1.209
.4635	0.376	.3623	0.563	.6570	1.230
.4683	0.597	.3640	0.586	.6584	1.273
.4700	0.647	.3651	0.636	.6612	1.333
.4714	0.690	.3682	0.723	.6626	1.332
.4757	0.900	.3696	0.755	.6640	1.336
.4774	0.982	.3710	0.787		
.4791	1.038	.3730	0.794	2442128	
.4829	1.131	.3741	0.869	.5242	+0.125
.4846	1.210	.3751	0.922	.5263	0.136
.4864	1.272	.3774	0.983	.5311	0.110
.4910	1.358	.3786	1.017	.5343	0.126
.4924	1.393	.3800	1.055	.5389	0.076
.4944	1.397	.3824	1.107	.5413	+0.068
.4982	1.388	.3832	1.113	.5463	-0.019
.4999	1.381	.3844	1.136	.5480	+0.023
.5016	1.372	.3866	1.177	.5525	-0.118
.5069	1.399	.3880	1.227	.5549	0.186
.5089	1.402	.3914	1.263	.5566	0.238
.5103	1.355	.3927	1.274	.5605	0.397
		.3939	1.287	.5626	0.466
2441810		.3963	1.296	.5641	0.580
.4339	+0.079	.3977	1.305	.5692	0.790
.4356	0.039	.4001	1.301	.5713	0.899
.4395	+0.003	.4013	1.303	.5734	0.993
.4412	-0.040			.5775	1.160
.4426	0.062	2442120		.5792	1.220
.4530	0.257	.6001	+0.100	.5813	1.260
.4544	0.279	.6015	0.106	.5851	1.316
.4565	0.322	.6050	0.026	.5869	1.333
.4599	0.469	.6064	0.051	.5890	1.362
.4613	0.528	.6084	0.114	.5939	1.376
.4631	0.593	.6112	0.141	.5960	1.385

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2442128		2442449		2442465	
.5978	-1.378	.6916	-1.222	.5016	-0.232
		.6927	1.223	.5044	0.258
2442443		.6935	1.221	.5059	0.310
.6020	+0.029	.6955	1.242	.5069	0.342
.6034	0.014	.6967	1.226	.5099	0.445
.6072	+0.031	.6976	1.258	.5111	0.494
.6086	-0.007	.7001	1.221	.5123	0.547
.6121	0.050			.5152	0.660
.6142	0.116	2442454		.5166	0.686
.6156	0.127	.5366	+0.055	.5180	0.726
.6197	0.268	.5387	0.034	.5215	0.859
.6215	0.345	.5425	+0.037	.5229	0.888
.6232	0.376	.5453	-0.001	.5243	0.936
.6270	0.521	.5491	0.025	.5270	0.998
.6288	0.617	.5509	0.060	.5283	1.024
.6305	0.640	.5544	0.130	.5296	1.069
.6333	0.761	.5564	0.185	.5328	1.113
.6343	0.776	.5600	0.289	.5343	1.126
.6361	0.812	.5618	0.348	.5355	1.141
.6392	0.937	.5637	0.400	.5385	1.185
.6406	0.998	.5671	0.501	.5398	1.206
.6420	0.994	.5689	0.583	.5412	1.219
.6451	1.079	.5706	0.629	.5442	1.236
.6465	1.081	.5744	0.732	.5456	1.243
.6479	1.177	.5762	0.816	.5471	1.253
.6510	1.261	.5780	0.885	.5500	1.242
.6531	1.271	.5816	1.003	.5513	1.240
.6548	1.254	.5833	0.999	.5527	1.217
.6576	1.293	.5850	1.036	.5562	1.185
.6593	1.290	.5887	1.102		
.6607	1.286	.5904	1.128	2442493	
		.5941	1.175	.4412	-0.673
2442449		.5960	1.194	.4426	0.729
.6349	+0.040	.5975	1.199	.4450	0.878
.6369	0.011	.6012	1.244	.4464	0.901
.6407	+0.003	.6030	1.252	.4492	1.000
.6477	-0.152	.6049	1.255	.4506	1.022
.6494	0.220	.6085	1.244	.4516	1.062
.6532	0.435	.6100	1.240	.4548	1.160
.6549	0.468	.6116	1.220	.4565	1.194
.6567	0.496	.6158	1.204	.4577	1.234
.6672	0.808	.6188	1.153	.4600	1.243
.6756	0.920			.4619	1.259
.6766	0.958	2442465		.4634	1.283
.6789	1.019	.4826	+0.115	.4666	1.298
.6798	1.041	.4840	0.075	.4680	1.301
.6808	1.060	.4868	+0.009	.4694	1.308
.6835	1.113	.4881	-0.012	.4721	1.301
.6844	1.132	.4912	0.025	.4735	1.288
.6872	1.136	.4927	0.016	.4749	1.281
.6881	1.138	.4956	0.070	.4779	1.255
.6892	1.193	.4972	0.136	.4791	1.241

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2442493		2442786		2442870	
.4805	-1.231	.6486	-0.639	.4491	-1.224
.4829	1.219	.6500	0.670	.4503	1.223
.4857	1.204	.6524	0.820		
.4874	1.208	.6535	0.807	2442899	
.4903	1.170	.6545	0.835	.4181	+0.025
.4916	1.155	.6566	1.037	.4200	0.007
		.6576	1.052	.4221	0.036
2442532		.6584	1.086	.4225	0.054
.3201	-1.040	.6611	1.186	.4277	0.039
.3213	1.078	.6625	1.238	.4285	0.036
.3225	1.101	.6639	1.264	.4329	+0.014
.3249	1.159	.6661	1.342	.4358	-0.066
.3263	1.238	.6673	1.353	.4375	0.086
.3275	1.289	.6684	1.355	.4424	0.124
.3315	1.324	.6708	1.379	.4451	0.200
.3331	1.300	.6721	1.400	.4478	0.258
.3374	1.259	.6732	1.397	.4511	0.343
.3386	1.268	.6760	1.400	.4529	0.366
.3414	1.288	.6771	1.381	.4549	0.410
.3429	1.309	.6787	1.366	.4553	0.434
.3442	1.263			.4562	0.510
.3471	1.266	2442870		.4591	0.560
.3485	1.274	.3975	-0.297	.4610	0.594
.3499	1.265	.4003	0.299	.4615	0.581
.3525	1.227	.4014	0.338	.4633	0.706
.3540	1.220	.4023	0.405	.4648	0.765
.3554	1.205	.4044	0.425	.4674	0.885
		.4055	0.463	.4680	0.894
2442786		.4090	0.554	.4697	0.904
.5799	+0.034	.4100	0.617	.4711	0.955
.5809	0.041	.4110	0.688	.4732	0.984
.5837	0.017	.4138	0.773	.4737	1.003
.5848	0.017	.4152	0.819	.4777	1.106
.5875	0.064	.4159	0.815	.4795	1.157
.5889	0.087	.4200	0.994	.4798	1.153
.5913	0.104	.4211	1.023	.4814	1.177
.5926	0.092	.4232	1.096	.4827	1.219
.5951	0.097	.4246	1.134	.4846	1.217
.5965	0.094	.4257	1.145	.4849	1.242
.5979	0.103	.4279	1.219	.4867	1.281
.6007	0.099	.4291	1.260	.4880	1.325
.6028	+0.079	.4301	1.258	.4900	1.308
.6340	-0.115	.4322	1.278	.4904	1.302
.6351	0.123	.4332	1.289	.4922	1.303
.6361	0.156	.4364	1.317	.4936	1.302
.6380	0.227	.4374	1.316	.4957	1.259
.6389	0.247	.4382	1.289	.4960	1.265
.6399	0.321	.4405	1.250	.4980	1.240
.6427	0.403	.4415	1.241	.4994	1.235
.6438	0.439	.4444	1.243	.5019	1.200
.6448	0.466	.4454	1.241	.5023	1.220
.6472	0.613	.4464	1.227	.5040	1.200

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2442899		2442910		2442927	
.5053	-1.197	.3686	+0.033	.3827	-0.624
		.3696	0.074	.3839	0.677
2442905		.3721	0.057	.3861	0.743
.4608	+0.037	.3734	+0.071	.3878	0.790
.4619	-0.007	.3769	-0.033	.3889	0.836
.4639	+0.039	.3804	0.071	.3914	0.878
.4674	0.004	.3818	0.106	.3927	0.931
.4687	0.023	.3866	0.143	.3941	0.981
.4709	+0.010	.3880	0.197	.3965	1.080
.4720	-0.001	.3894	0.235	.3977	1.099
.4744	0.038	.3922	0.281	.3989	1.138
.4754	0.008	.3936	0.277	.4016	1.174
.4777	0.024	.3949	0.328	.4027	1.178
.4786	0.065	.3974	0.390	.4039	1.198
.4808	0.091	.3988	0.415	.4062	1.229
.4841	0.189	.4002	0.488	.4080	1.258
.4851	0.218	.4030	0.605	.4090	1.266
.4873	0.283	.4040	0.681	.4115	1.279
.4884	0.291	.4057	0.753	.4127	1.274
.4893	0.333	.4085	0.859	.4139	1.271
.4917	0.354	.4116	0.909	.4163	1.270
.4928	0.379	.4137	0.855	.4173	1.256
.4954	0.508	.4149	0.973		
.4965	0.522	.4159	0.985	2442947	
.4973	0.563	.4184	1.056	.3508	-0.028
.4996	0.690	.4197	1.087	.3521	0.044
.5011	0.730	.4210	1.106	.3542	0.031
.5020	0.719	.4234	1.170	.3556	0.056
.5042	0.812	.4248	1.179	.3584	0.147
.5053	0.848	.4261	1.194	.3598	0.122
.5063	0.864	.4287	1.191	.3619	0.282
.5084	0.936	.4321	1.243	.3629	0.280
.5097	0.959	.4346	1.239	.3726	0.516
.5108	0.988	.4359	1.249	.3740	0.551
.5129	1.035	.4370	1.236	.3758	0.639
.5138	1.040	.4392	1.244	.3786	0.692
.5148	1.057	.4405	1.223	.3821	0.787
.5173	1.109			.3834	0.806
.5181	1.170	2442927		.3869	0.865
.5192	1.186	.3628	-0.057	.3888	0.974
.5205	1.196	.3643	0.109	.3920	1.039
.5216	1.199	.3656	0.169	.3935	1.082
.5225	1.217	.3678	0.253	.3969	1.102
.5254	1.217	.3687	0.278	.3994	1.125
.5263	1.221	.3700	0.335	.4028	1.171
.5271	1.215	.3723	0.362	.4043	1.194
.5293	1.222	.3733	0.418	.4079	1.205
.5305	1.219	.3746	0.429	.4096	1.234
.5314	1.213	.3768	0.482	.4129	1.237
.5337	1.194	.3781	0.477	.4148	1.225
.5348	1.220	.3791	0.502	.4181	1.154
.5358	1.224	.3816	0.609	.4196	1.139

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2442947		2443207		2443251	
.4229	-1.138	.4084	-1.375	.5003	+0.169
.4240	1.148	.4097	1.392	.5017	0.139
.4275	1.142	.4124	1.350	.5030	0.117
.4291	1.123	.4138	1.355	.5058	0.065
		.4152	1.367	.5069	0.070
2442964		.4183	1.359	.5083	0.075
.3617	-0.727	.4195	1.348	.5115	0.032
.3630	0.777	.4209	1.312	.5129	+0.026
.3650	0.840	.4239	1.290	.5142	-0.020
.3660	0.886	.4253	1.292	.5170	0.095
.3671	0.887	.4285	1.242	.5180	0.110
.3691	0.925	.4298	1.222	.5190	0.178
.3701	0.968			.5222	0.273
.3713	0.988	2443228		.5234	0.320
.3734	1.042	.4914	+0.064	.5246	0.339
.3746	1.090	.4926	0.079	.5277	0.498
.3756	1.090	.4947	+0.012	.5289	0.571
.3777	1.159	.4958	-0.014	.5302	0.557
.3789	1.180	.4981	0.105	.5332	0.764
.3799	1.211	.4995	0.152	.5344	0.801
.3823	1.211	.5006	0.157	.5357	0.828
.3832	1.247	.5032	0.219	.5385	1.056
.3853	1.290	.5044	0.289	.5400	1.118
.3863	1.305	.5055	0.315	.5413	1.146
.3874	1.301	.5081	0.469	.5439	1.276
.3897	1.314	.5093	0.500	.5453	1.286
.3908	1.312	.5101	0.589	.5465	1.358
.3926	1.292	.5124	0.652	.5496	1.430
.3938	1.295	.5135	0.741	.5509	1.427
.3961	1.249	.5145	0.795	.5519	1.444
.3970	1.252	.5169	0.918	.5547	1.464
.3993	1.237	.5180	0.948	.5561	1.457
.4003	1.232	.5190	1.021	.5590	1.450
.4024	1.197	.5215	1.093	.5604	1.449
.4033	1.203	.5228	1.124		
.4054	1.178	.5236	1.177	2443276	
.4063	1.125	.5259	1.268	.4508	-1.397
.4084	1.160	.5270	1.290	.4519	1.384
.4094	1.117	.5282	1.344	.4533	1.427
		.5304	1.409	.4560	1.438
2443207		.5315	1.413	.4574	1.442
.3887	-1.090	.5327	1.422	.4588	1.432
.3914	1.174	.5349	1.413	.4623	1.403
.3926	1.225	.5361	1.413	.4637	1.382
.3940	1.233	.5372	1.418	.4651	1.372
.3964	1.328	.5394	1.409	.4672	1.378
.3978	1.375	.5408	1.387	.4685	1.378
.3988	1.399	.5419	1.379	.4731	1.286
.4019	1.388	.5451	1.340	.4741	1.291
.4031	1.392	.5464	1.352	.4755	1.242
.4042	1.391	.5476	1.285	.4783	1.230
.4070	1.383			.4793	1.194

J.D.	ΔB
2443288	
.5114	-0.773
.5121	0.824
.5132	0.859
.5149	0.933
.5158	0.979
.5170	1.050
.5193	1.143
.5201	1.175
.5211	1.219
.5234	1.335
.5344	1.363
.5256	1.366
.5278	1.405
.5285	1.422
.5295	1.438
.5317	1.434
.5327	1.448
.5338	1.440
.5360	1.449
.5371	1.447
.5381	1.437
.5403	1.406
.5413	1.391
.5424	1.377
.5443	1.356
.5454	1.350
2443298	
.3454	-1.457
.3460	1.465
.3469	1.492
.3486	1.481
.3496	1.490
.3504	1.461
.3520	1.438
.3531	1.423
.3539	1.416
.3560	1.386
.3569	1.390
.3580	1.380
.3600	1.299
.3611	1.284
.3621	1.262
.3641	1.257
.3650	1.247
.3663	1.223
2443302	
.4743	-0.773
.4750	0.801
.4760	0.891
.4781	0.976
2443302	
.4790	-1.009
.4799	1.030
.4819	1.126
.4826	1.077
.4835	1.204
.4853	1.214
.4862	1.239
.4871	1.321
.4887	1.374
.4895	1.406
.4904	1.431
.4922	1.454
.4930	1.477
.4939	1.513
.4959	1.505
.4971	1.497
.4979	1.463
.4997	1.431
.5009	1.418
2443304	
.3515	-0.284
.3526	0.318
.3550	0.474
.3561	0.552
.3573	0.665
.3598	0.810
.3609	0.810
.3633	0.896
.3641	0.949
.3664	1.073
.3673	1.128
.3694	1.135
.3702	1.157
.3727	1.255
.3737	1.308
.3760	1.378
.3772	1.447
.3782	1.475
.3813	1.454
.3824	1.437
.3848	1.467
.3859	1.490
.3868	1.494
.3892	1.471
.3903	1.420
.3914	1.397
2443308	
.4810	+0.112
.4820	0.056
.4843	+0.012
2443308	
.4856	-0.014
.4881	0.033
.4892	0.041
.4902	0.053
.4929	0.100
.4943	0.146
.4952	0.165
.4978	0.219
.4991	0.264
.5001	0.311
.5027	0.403
.5040	0.442
.5049	0.497
.5076	0.635
.5089	0.668
.5100	0.690
.5127	0.677
.5138	0.886
.5150	0.965
.5181	1.052
.5192	1.114
.5202	1.171
.5225	1.275
.5237	1.289
.5247	1.304
.5270	1.353
.5284	1.408
.5295	1.426
.5321	1.528
.5333	1.480
.5343	1.474
.5366	1.408
.5376	1.391
.5385	1.389
.5410	1.372
2443580	
.5450	-0.334
.5456	0.389
.5473	0.425
.5480	0.475
.5498	0.517
.5505	0.519
.5524	0.581
.5532	0.576
.5539	0.614
.5555	0.706
.5562	0.762
.5579	0.823
.5587	0.843
.5605	0.921
.5636	0.983

J.D.	ΔB
2443580	
.5643	-0.999
.5661	1.047
.5672	1.106
.5695	1.217
.5734	1.261
.5757	1.247
.5767	1.279
.5785	1.351
.5798	1.332
.5820	1.341
.5828	1.325
.5860	1.337
.5885	1.292
.5895	1.294
.5922	1.334
.5936	1.297
.5959	1.294
.5970	1.297
.5991	1.320
.6001	1.319
.6031	1.278
2443583	
.5373	+0.110
.5396	0.088
.5452	0.089
.5466	0.104
.5503	0.035
.5518	+0.018
.5580	-0.076
.5716	0.543
.5727	0.623
.5738	0.672
.5761	0.722
.5771	0.763
.5782	0.811
.5805	0.889
.5816	0.889
.5827	0.927
.5851	1.034
.5864	1.190
.5898	1.220
.5910	1.285
.5931	1.288
.5966	1.317
.6000	1.267
.6012	1.291
2443596	
.4025	-0.653
.4052	0.785
.4068	0.799

J.D.	ΔB
2443596	
.4097	-0.932
.4108	1.017
.4141	1.081
.4155	1.120
.4183	1.167
.4196	1.191
.4231	1.244
.4276	1.316
.4287	1.328
.4341	1.350
.4391	1.274
.4419	1.272
.4457	1.254
.4469	1.254
.4490	1.210
2443597	
.5045	-0.006
.5056	0.045
.5081	0.024
.5094	0.032
.5106	0.079
.5132	0.147
.5145	0.124
.5160	0.178
.5184	0.221
.5196	0.227
.5207	0.257
.5229	0.310
.5245	0.360
.5260	0.394
.5285	0.486
.5299	0.586
.5312	0.610
.5340	0.647
.5351	0.726
.5365	0.758
.5389	0.843
.5404	0.889
.5413	0.939
.5437	0.998
.5449	1.050
.5462	1.078
.5484	1.138
.5497	1.192
.5512	1.253
.5532	1.281
.5544	1.325
.5558	1.346
.5581	1.380
.5590	1.382
.5602	1.393

J.D.	ΔB
2443597	
.5628	-1.384
.5642	1.375
.5656	1.365
.5677	1.340
.5697	1.338
.5711	1.308
.5734	1.271
.5745	1.285
2443599	
.3864	+0.030
.3877	0.040
.3930	+0.043
.3954	-0.030
.3967	0.002
.4003	0.049
.4013	0.090
.4036	0.171
.4048	0.216
.4059	0.229
.4083	0.268
.4094	0.321
.4112	0.325
.4142	0.477
.4151	0.479
.4164	0.513
.4189	0.654
.4203	0.735
.4213	0.778
.4237	0.859
.4263	0.927
.4299	1.063
.4308	1.056
.4331	1.128
.4343	1.146
.4353	1.211
.4377	1.245
.4387	1.270
.4396	1.279
.4418	1.332
.4430	1.352
.4441	1.344
.4468	1.362
.4491	1.347
.4512	1.330
.4524	1.320
.4535	1.357
.4556	1.304
.4566	1.316
.4578	1.311
.4616	1.242
.4644	1.225

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2443599		2443645		2443716	
.4653	-1.227	.4984	-1.290	.4185	-1.196
		.5010	1.268	.4197	1.236
2443608		.5024	1.280	.4229	1.241
.4575	-0.141	.5053	1.271	.4242	1.298
.4598	0.185	.5067	1.235	.4270	1.314
.4609	0.198	.5099	1.181	.4284	1.317
.4633	0.214	.5113	1.154	.4298	1.327
.4644	0.238	.5139	1.154		
.4668	0.367			2443727	
.4680	0.404	2443659		.3388	-0.148
.4712	0.519	.4200	-0.541	.3413	0.177
.4722	0.538	.4213	0.567	.3426	0.260
.4756	0.676	.4232	0.650	.3455	0.465
.4766	0.705	.4242	0.727	.3469	0.471
.4791	0.809	.4261	0.723	.3500	0.647
.4803	0.836	.4282	0.874	.3517	0.732
.4825	0.925	.4300	0.890	.3565	0.954
.4836	0.955	.4308	0.949	.3606	1.220
.4860	1.051	.4325	1.008	.3646	1.230
.4874	1.074	.4336	1.013	.3690	1.279
.4898	1.115	.4357	1.089	.3703	1.283
.4908	1.153	.4367	1.164	.3729	1.315
.4932	1.194	.4386	1.186	.3745	1.366
.4945	1.218	.4402	1.222	.3819	1.331
.4969	1.221	.4435	1.322	.3833	1.301
.4981	1.265	.4456	1.373	.3875	1.227
.5003	1.284	.4467	1.359		
.5013	1.297	.4489	1.387	2443730	
.5036	1.303	.4495	1.420	.3457	-0.025
.5077	1.279			.3489	0.004
.5105	1.312	2443716		.3500	0.012
.5115	1.314	.3676	+0.176	.3527	0.069
.5143	1.318	.3690	0.148	.3539	0.098
.5152	1.303	.3742	0.107	.3565	0.189
		.3756	0.135	.3609	0.236
2443645		.3801	0.117	.3627	0.365
.4684	-1.086	.3831	0.095	.3652	0.510
.4696	1.092	.3867	0.061	.3666	0.531
.4731	1.199	.3898	+0.032	.3683	0.688
.4742	1.254	.3912	-0.028	.3697	0.732
.4765	1.302	.3940	0.103	.3707	0.705
.4776	1.313	.3957	0.188	.3729	0.896
.4802	1.340	.3985	0.214	.3742	0.941
.4814	1.357	.3995	0.253	.3756	1.013
.4843	1.333	.4037	0.442	.3780	1.165
.4859	1.365	.4055	0.531	.3791	1.216
.4883	1.352	.4085	0.675	.3803	1.243
.4897	1.353	.4100	0.878	.3829	1.303
.4928	1.355	.4111	0.885	.3839	1.285
.4942	1.359	.4139	1.028	.3854	1.341
.4975	1.323	.4155	1.096	.3881	1.336

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2443730		2443931		2443935	
.3893	-1.383	.4912	-0.872	.6421	-0.592
.3905	1.408	.4926	0.908	.6432	0.639
.3930	1.418	.4954	1.001	.6451	0.703
.3941	1.379	.4978	1.086	.6460	0.712
.3952	1.372	.5008	1.234	.6477	0.731
.3978	1.378	.5025	1.262	.6489	0.784
.3991	1.361	.5040	1.290	.6509	0.838
		.5072	1.341	.6519	0.827
2443744		.5086	1.348	.6536	0.892
.3214	-0.141	.5098	1.353	.6544	0.893
.3228	0.141	.5134	1.404	.6562	0.945
.3256	0.269	.5148	1.409	.6569	0.949
.3270	0.280	.5158	1.373	.6584	0.958
.3297	0.602	.5186	1.361	.6591	0.961
.3308	0.708	.5201	1.327	.6607	0.991
.3322	0.772	.5214	1.327	.6616	1.009
.3363	0.847			.6631	1.009
.3398	0.897	2443935		.6640	1.014
.3412	0.922	.5881	+0.074	.6655	1.018
.3450	0.934	.5893	0.065	.6665	0.994
.3464	1.006	.5914	0.088	.6716	0.955
.3478	1.022	.5926	0.117	.6731	0.950
.3505	1.134	.5959	0.061	.6738	0.913
.3518	1.287	.5967	0.068		
.3544	1.360	.5989	0.105	2443954	
.3572	1.414	.6002	0.106	.4973	-0.567
.3603	1.405	.6020	0.098	.4991	0.568
.3618	1.357	.6031	0.072	.5039	0.744
.3631	1.348	.6045	0.113	.5053	0.787
		.6061	0.063	.5067	0.866
2443931		.6079	0.073	.5095	0.979
.4391	+0.063	.6091	0.024	.5106	1.013
.4405	0.114	.6110	0.059	.5118	1.048
.4520	+0.062	.6119	0.051	.5146	1.125
.4547	-0.019	.6137	0.043	.5157	1.164
.4561	+0.018	.6144	0.039	.5173	1.187
.4595	-0.008	.6162	+0.018	.5199	1.268
.4606	0.055	.6173	-0.003	.5214	1.289
.4641	0.056	.6220	0.106	.5227	1.300
.4655	0.066	.6231	0.136	.5256	1.340
.4686	0.105	.6249	0.111	.5271	1.353
.4702	0.181	.6261	0.174	.5282	1.373
.4734	0.245	.6280	0.199	.5309	1.367
.4745	0.299	.6290	0.185	.5324	1.370
.4759	0.356	.6309	0.214	.5337	1.352
.4787	0.362	.6318	0.230	.5360	1.325
.4801	0.403	.6336	0.355	.5382	1.297
.4815	0.478	.6344	0.366	.5435	1.265
.4844	0.601	.6364	0.445		
.4863	0.622	.6374	0.439	2443957	
.4877	0.690	.6390	0.486	.4774	+0.046
.4905	0.798	.6400	0.539	.4783	-0.004

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2443957		2443957		2443967	
.4820	+0.050	.5280	-0.954	.3363	-0.901
.4864	0.026	.5293	0.962	.3374	1.035
.4876	+0.005	.5305	0.981	.3402	1.149
.4915	-0.057	.5333	1.110	.3413	1.134
.4938	0.044	.5344	1.122	.3437	1.170
.4949	0.038	.5354	1.181	.3447	1.189
.4989	0.125	.5382	1.248	.3460	1.206
.5001	0.222	.5396	1.265	.3485	1.239
.5015	0.210	.5409	1.298	.3496	1.264
.5037	0.276	.5437	1.343	.3509	1.335
.5048	0.257	.5451	1.386	.3529	1.350
.5070	0.314	.5469	1.405	.3540	1.343
.5083	0.346	.5499	1.371	.3564	1.351
.5109	0.395	.5514	1.380	.3576	1.384
.5119	0.429			.3585	1.388
.5148	0.546	2443967		.3606	1.401
.5161	0.554	.3254	-0.478	.3615	1.377
.5185	0.613	.3266	0.498	.3627	1.361
.5199	0.697	.3309	0.487	.3649	1.335
.5209	0.739	.3323	0.634	.3659	1.315
.5244	0.845	.3336	0.672	.3805	0.703
.5254	0.803			.3814	0.731

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PHOTOELECTRIC OBSERVATIONS OF SZ LYNCIS

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ABSTRACT

1018 photoelectric observations of SZ Lyn obtained at Kottamia and Konkoly Observatories between 1984 and 1986 are reported. The long-period variation in time of maximum light discovered by van Genderen was investigated and the value of its period (P_B=1173.5 days = 3.213 years) and semiamplitude (A=0.00569 day = 491.6 sec) have been improved, and a secular change in the pulsation period ($\beta = 3 \cdot 10^{-12}$ day·cycle^{-1}) has been found.

INTRODUCTION

SZ Lyncis (=BD+ 44°1718 = HD 67 390) is one of the most interesting high amplitude δ Scuti type variables. It is definitely a member of a binary system, and the duplicity is well reflected by the periodic variation in its period.

Its light variability was discovered by *Hoffmeister* (1949a,b), and since 1961 a great number of photoelectric observations have been carried out (see *Szeidl*, 1983 and references therein; *Braune* et al., 1983; *Fernley* et al., 1984; and *Jiang Shi-yang* et al., 1985).

Van Genderen (1967) was the first to point out that the O-C's produced by a linear ephemeris appeared to follow a sine-curve relation with a period of $P_B = 3.091 \pm 0.051$ years. *Barnes* and *Moffett* (1975) improved the parameters of the long-period variation from a linear element ($P_B = 3.138 \pm 0.028$ years) and interpreted this long-period variation as light travel time effect supposing SZ Lyn to be a member of a binary system with P_B the orbital period. *Garrido* et al. (1979) confirmed that the residuals from a constant period fitted a sine-wave well with a cycle length $P_B = 3.149 \pm 0.028$ years. *Szeidl* (1983) discussed all the photoelectric maxima available up to 1980 and came to the conclusion that the orbital period was longer (P_B=3.203 ± 0.009 years) allowing that the pulsation period of the star might change linearly.

Bardin and *Imbert* (1984) carried out radial velocity measurements of high accuracy. They took into account the previous radial velocity observations of less accuracy and they then derived an even longer orbital period ($P_B = 3.235 \pm 0.004$ years) than was obtained previously.

Szeidl (1983) was the first to try to determine the intrinsic, secular change in the pulsation period (P_0) of SZ Lyn and he obtained $\beta = (+10 \pm 7) \cdot 10^{-13}$ day·cycle^{-1} by a least squares solution. Later, *Jiang Shi-yang* et al. (1985)

supposed that *Barnes* and *Moffett*'s (1975) solution for the periodic long term (sinusoidal) variation had been accurately determined and they corrected the O-C's for this variation; the residual O-C's yielded $\beta=(+6.32\pm0.72)\cdot 10^{-12}$ day·cycle^{-1} by a second order least squares solution.

Although the photoelectric observations of SZ Lyn have covered almost a quarter of a century there are still some uncertainties in the period determinations by the radial velocity measurements and by the light time effect. In an attempt to determine a more accurate value for the periods and the variation in the pulsation period we put the star on our observational programme again for three observational seasons.

THE OBSERVATIONS

The photoelectric observations were carried out at Helwan Institute's Kottamia Observatory and the mountain station of Konkoly Observatory.

The 347 photoelectric observations of Kottamia Observatory were made by the 74 inch telescope on the nights 27/28, 28/29 February and 1/2 March 1984 (J.D. 244 5758, 244 5759, and 244 5761). The photoelectric photometer attached to the f/18 Cassegrain focus had an EMI 9558 B tube with an S-20 photocathode. The amplified output of the tube was fed into a Brown recorder. The time of the observations was estimated from the starting point and the mean moving speed of the strip chart recorder. The U,B and V filters used were very close to the standard system of Johnson and Morgan. BD+44°1714 served as the comparison star: its brightness and colours were determined as follows: V = 9.64 , B-V = +0.63 and U-B = +0.14 . The observations in the natural system obtained at Kottamia Observatory are given in Table 3a,b,c.

During the nights 3/4, 4/5 December 1984 and 4/5, 5/6 February 1986 (J.D. 244 6038, 244 6039, and 244 6466, 244 6467), 671 three-colour photoelectric observations were obtained at the mountain station of Konkoly Observatory. The observations were carried out with the 20 inch Cassegrain telescope equipped with an unrefrigerated photometer. This photometer contained an EMI 9058 QB multiplier tube and the colour filters were nearly on the UBV system: in ultraviolet light UG2, in blue light BG12 + GG13, and in yellow light GG11 Schott filters were used. The observations of Konkoly Observatory were made differentially with respect to the comparison star BD + 45°1544 whose brightness and colours measured by different authors are given in the paper of *Szeidl* (1983). (The accepted values for the comparison star are: V = 9.44 , B-V = +0.45 , U-B = +0.03 .) The individual observations of SZ Lyn have been converted to the standard UBV system and are presented in

Table 4a,b,c. As the comparison star was close to the variable, no correction has been made for differential extinction.

The light variation of SZ Lyn is very regular. The small deviations between the light curves of different observers can be attributed to errors in the transformation from the instrumental system into the UBV system. Apart from these deviations small cycle-to-cycle variations are also present.

An unusual feature in the colour loop during the phase interval 0.32-0.44 was found by *Barnes* and *Moffett* (1975). We examined this part of our light curves but no unusual feature was found. It seems that this behaviour does not reproduce each cycle.

PERIOD ANALYSIS

The early investigation of the period of SZ Lyn carried out by *van Genderen* (1967) revealed that the linear ephemeris produced (O-C)'s which appeared to follow a sine-curve relation with a cycle length of 1129 days. The observations used by *van Genderen* covered only $1.6P_B=5$ years whereas the baseline of coverage was extended to $3.8P_B= 12$ years by *Barnes* and *Moffett* (1975) who obtained a period of 1146 days. This long-period variation in the time of maximum light first found by *van Genderen* was interpreted by *Barnes* and *Moffett* as a modulation of the phase of maximum light by binary motion.

Later on, the value of the long period was improved by *Garrido* et al. (1979) using observations which covered $5.0P_B=16$ years.

Szeidl (1983) used all the photoelectric observations available up to 1980; the baseline of coverage was $6.0P_B= 19$ years. He supposed that the pulsational period underwent intrinsic, secular (evolutionary) changes, therefore he tried to fit the epochs of maximum light of SZ Lyn to the following relation:

$$T_{max} = T_o + P_o \cdot E + \frac{\beta}{2}E^2 - A \cdot \cos 2\pi\left(\frac{P_o}{P_B}E - \phi_o\right) \qquad (1)$$

where T_o is the initial epoch of maximum corresponding to $E = 0$; P_o is the pulsation period of SZ Lyn; P_B is the period of the sinusoid; β is the secular change of the pulsation period during one pulsation cycle; A is the semiamplitude of the sine-curve; and ϕ_o is the phase shift. From a least squares solution of Eq.(1), *Szeidl* (1983) derived an essentially larger value for P_B (=1170 days) than was obtained previously.

Bardin and *Imbert* (1984) using only radial velocity measurements derived an even longer period of the orbital motion: $P_B= 1181.5$ days.

Table 1

Parameters of ephemerides

T_o	P_o	P_B	A	ϕ_o	$10^{12}\beta$	coverage	ref.
2438124.39849 ±21	$0^d.12053493$ ±05	1129^d ±18	$0^d.00569$ ±18	-0.019 ±11	0***	5.0 years	[1]
38124.39828 ±17	0.120534906 ±20	1146 ±10	0.00572 ±19	-0.010 ±08	0***	11.8 years	[2]
38124.39824 ±17	0.120534920 ±13	1150 ±10	0.00573 ±20	-0.007 ±08	0***	16.2 years	[3]
38124.39801 ±12	0.120534934 ±18	1170 ±03	0.00540 ±11	-0.015 ±05	1.0 ±.7	18.9 years	[4]
38124.39828*	0.120534906*	1146*	0.00572*	-0.010*	6.32 ±.62	23.0 years	[5]
-	-	1181.5** ±1.4	-	-	-	19.0 years**	[6]
38124.39811 ±13	0.120534896 ±7	1173.5 ±2.0	0.00569 ±13	-0.017 ±06	2.96 ±.15	24.9 years	[7]

* Barnes and Moffett's parameters were accepted
** From radial velocity measurements
*** Pulsation period assumed to be constant
ref.: [1]: van Genderen (1967); [2]: Barnes and Moffett (1975); [3]: Garrido et al. (1979); [4]: Szeidl (1983); [5]: Jiang et al. (1985); [6]: Bardin and Imbert (1984); [7]: present paper

For comparison, the parameters of the sine-curve relation obtained by different authors are given in Table 1.

In order to determine a more accurate value of the parameters in Eq.(1), we collected all the published times of photoelectric maxima in Table 2. Five maxima have been excluded from the fit to Eq.(1). Four of these maxima (E = 2919 and 2977 observed by *Joshi* and *Srivastava* (1967); E = 18459 by *Wisse* and *Wisse* (1969); and E = 21073 by *Popovici* (1971)) were already reported to deviate significantly from the non-linear ephemeris. The time of the fifth maximum (E=57701), observed by *F. Agerer* (*Braune* and *Mundry*, 1982), is probably given erroneously.

Values of the six parameters in Eq.(1) were determined by the method of least squares giving the same weight to all observations:

$T_o = 2438124.39811 \pm .00013$

$A = 0.00569$ day $\pm .00013$

$P_o = 0.120534896$ day ± 7

$\beta = +2.96 \cdot 10^{-12}$ day·cycle^{-1} $\pm .15$

$P_B = 1173.5$ days ± 2.0

$\phi_o = -0.017 \pm .006$

These new values are also given in Table 1 for comparison purposes. The 145 observed maxima used in this discussion cover almost $8P_B \approx 25$ years.

Table 2

Photoelectrically observed maxima

Epoch of maximum	Rem.	E	$(O-C)_{lin}$	O-C	φ
2437367.441	Sc	-6280	+0.0020	-0.0020	0.372
368.407	Sc	-6272	+0.0038	-0.0003	0.373
642.021	Eg	-4002	+0.0035	-0.0010	0.606
706.2645	Sz	-3469	+0.0019	-0.0011	0.661
707.4695	Sz	-3459	+0.0016	-0.0014	0.662
.5908	Sz	-3458	+0.0024	-0.0007	0.662
718.5587	Sz	-3367	+0.0016	-0.0011	0.671
726.5141	Sz	-3301	+0.0017	-0.0008	0.678
744.3535	Sz	-3153	+0.0019	-0.0001	0.693
780.031	HX	-2857	+0.0011	+0.0001	0.723
.152	HX	-2856	+0.0016	+0.0006	0.724
977.343	HX	-1220	-0.0025	+0.0019	0.892
997.351	HX	-1054	-0.0033	+0.0015	0.909
38001.568	vG	-1019	-0.0051	-0.0002	0.912
.689	vG	-1018	-0.0046	+0.0003	0.912
003.378	HX	-1004	-0.0031	+0.0018	0.914
021.576	vG	-853	-0.0058	-0.0007	0.929
.699	vG	-852	-0.0034	+0.0018	0.929
032.305	HX	-764	-0.0044	+0.0008	0.939
052.4333	Sz	-597	-0.0055	0.0000	0.956
.5545	Sz	-596	-0.0048	+0.0007	0.956
053.276	HX	-590	-0.0065	-0.0010	0.956
055.205	HX	-574	-0.0061	-0.0006	0.958
.3268	Br	-573	-0.0048	+0.0007	0.958
.4463	Br	-572	-0.0058	-0.0004	0.958
.5681	Br	-571	-0.0046	+0.0009	0.958
057.3752	Br	-556	-0.0055	0.0000	0.960
.4964	Br	-555	-0.0048	+0.0007	0.960
.6172	Br	-554	-0.0046	+0.0009	0.960
082.4464	Sz	-348	-0.0056	+0.0001	0.981
114.3880	Br	-83	-0.0057	0.0000	0.008
118.367	vG	-50	-0.0044	+0.0013	0.012
.485	vG	-49	-0.0069	-0.0012	0.012
124.393	vG	0	-0.0051	+0.0006	0.017
140.423	Br	+133	-0.0063	-0.0007	0.031
439.3565	Sz	2613	+0.0007	-0.0006	0.285
.4772	Sz	2614	+0.0009	-0.0004	0.285
457.3173	Sz	2762	+0.0018	0.0000	0.301
.4376	Sz	2763	+0.0016	-0.0002	0.301
460.210	JS	2786	+0.0017	-0.0002	0.303
463.342	JS	2812	-0.0002	-0.0022	0.306
464.189	JS	2819	+0.0030	+0.0010	0.307
465.276	JS	2828	+0.0052	+0.0032	0.308
466.238	JS	2836	+0.0029	+0.0009	0.308
467.200	JS	2844	+0.0006	-0.0014	0.309
471.297	JS	2878	-0.0005	-0.0027	0.313
(476.249	JS	2919	+0.0095	+0.0072	0.317)
(483.241	JS	2977	+0.0105	+0.0080	0.323)
701.8866	Bi	4791	+0.0058	+0.0001	0.509
708.6377	vG	4847	+0.0069	+0.0013	0.515
709.6014	vG	4855	+0.0064	+0.0007	0.516
712.6148	vG	4880	+0.0064	+0.0007	0.518
725.5117	vG	+4987	+0.0061	+0.0004	0.529

Table 2 (cont.)

Epoch of maximum	Rem.	E	$(O-C)_{lin}$	O–C	ψ
2438752.5114	vG	+5211	+0.0059	+0.0005	0.552
788.5505	vG	5510	+0.0051	+0.0001	0.583
809.4022	vG	5683	+0.0043	−0.0004	0.601
830.4949	vG	5858	+0.0034	−0.0009	0.619
834.234	JS	5889	+0.0059	+0.0017	0.622
844.4771	vG	5974	+0.0035	−0.0004	0.631
849.5396	vG	6016	+0.0036	−0.0003	0.635
850.3839	vG	6023	+0.0041	+0.0003	0.636
.5034	vG	6024	+0.0031	−0.0007	0.636
871.3567	vG	6197	+0.0038	+0.0005	0.654
39052.5129	vG	7700	−0.0039	−0.0020	0.808
.6355	vG	7701	−0.0018	+0.0001	0.808
054.5631	vG	7717	−0.0028	−0.0008	0.810
.6846	vG	7718	−0.0018	+0.0002	0.810
092.7726	Bi	8034	−0.0029	+0.0002	0.842
121.7007	Bi	8274	−0.0031	+0.0006	0.867
130.4981	vG	8347	−0.0048	−0.0009	0.874
145.4461	vG	8471	−0.0031	+0.0011	0.887
.5642	vG	8472	−0.0055	−0.0013	0.887
205.4706	vG	8969	−0.0050	+0.0002	0.938
527.5441	Sz	11641	−0.0007	+0.0004	0.213
528.6288	Sz	11650	−0.0008	+0.0002	0.214
531.401	JS	11673	−0.0010	+0.0001	0.216
905.3070	Sz	14775	+0.0058	−0.0001	0.535
40243.3996	Sz	17580	−0.0020	+0.0001	0.823
(349.3521	WW	18459	+0.0003	+0.0047	0.913)
(664.4239	Po	21073	−0.0061	−0.0044	0.181)
41035.443	Sz	24151	+0.0066	+0.0001	0.498
312.4276	Sz	26449	+0.0020	+0.0004	0.734
390.4113	Sz	27096	−0.0004	+0.0003	0.800
678.8475	BM	29489	−0.0042	0.0000	0.046
679.5714	Sz	29495	−0.0035	+0.0007	0.047
.6913	Sz	29496	−0.0041	+0.0001	0.047
683.7909	BM	29530	−0.0027	+0.0014	0.050
.9096	BM	29531	−0.0045	−0.0004	0.050
684.0312	BM	29532	−0.0035	+0.0007	0.050
42106.3947	Sz	33036	+0.0058	−0.0007	0.410
129.5391	KM	33228	+0.0075	+0.0007	0.430
136.2887	KM	33284	+0.0071	+0.0002	0.436
.4091	KM	33285	+0.0070	+0.0001	0.436
.5294	KM	33286	+0.0067	−0.0001	0.436
162.4450	KM	33501	+0.0073	+0.0002	0.458
451.4834	Sz	35899	+0.0031	−0.0005	0.704
454.4971	Sz	35924	+0.0034	−0.0001	0.707
531.7560	Af	36565	−0.0006	−0.0018	0.773
532.7210	Af	36573	+0.0001	−0.0010	0.774
533.6852	Af	36581	+0.0001	−0.0011	0.774
837.3091	Du	39100	−0.0034	−0.0001	0.033
841.2875	Du	39133	−0.0027	+0.0006	0.037
871.4218	KM	39383	−0.0021	+0.0009	0.062
872.3861	KM	39391	−0.0021	+0.0009	0.063
874.3152	KM	39407	−0.0016	+0.0014	0.065
.4352	KM	39408	−0.0021	+0.0008	0.065
43232.4309	HW	42378	+0.0050	−0.0016	0.370
257.3835	GE	+42585	+0.0068	−0.0003	0.391

Table 2 (cont.)

Epoch of maximum	Rem.	E	$(O-C)_{lin}$	O-C	ψ
2443258.4685	GE	+42594	+0.0070	-0.0001	0.392
287.3985	GE	42834	+0.0087	+0.0010	0.417
288.3600	GE	42842	+0.0059	-0.0018	0.417
578.3668	Sz	45248	+0.0057	-0.0002	0.665
879.5758	Sz	47747	-0.0020	-0.0004	0.921
931.4059	Sz	48177	-0.0019	+0.0002	0.965
44222.3817	Ga	50591	+0.0027	+0.0002	0.213
257.4574	Ga	50882	+0.0027	-0.0009	0.243
261.3156	Ga	50914	+0.0038	+0.0001	0.247
.4359	Ga	50915	+0.0036	-0.0002	0.247
262.2787	Ga	50922	+0.0026	-0.0011	0.247
269.2711	Ga	50980	+0.0040	0.0000	0.253
578.2099	JE	53543	+0.0119	+0.0020	0.517
590.1415	JE	53642	+0.0105	+0.0006	0.527
591.3465	JE	53652	+0.0102	+0.0003	0.528
592.1907	JE	53659	+0.0106	+0.0008	0.529
606.2899	JE	53776	+0.0072	-0.0026	0.541
607.1374	JE	53783	+0.0110	+0.0012	0.541
.2570	JE	53784	+0.0100	+0.0003	0.541
610.2709	JE	53809	+0.0106	+0.0008	0.544
611.1149	JE	53816	+0.0108	+0.0011	0.545
999.2205	JE	57036	-0.0059	-0.0067	0.875
45001.1553	JE	57052	+0.0003	-0.0004	0.877
.2758	JE	57053	+0.0003	-0.0005	0.877
002.1192	JE	57060	-0.0001	-0.0008	0.878
.2398	JE	57061	0.0000	-0.0007	0.878
(079.3405	BY	57701	-0.0416	-0.0412	0.944)
390.3636	BE	60281	+0.0014	-0.0025	0.209
739.2014	JE	63175	+0.0112	-0.0004	0.506
740.0449	JE	63182	+0.0110	-0.0006	0.507
.1672	JE	63183	+0.0128	+0.0012	0.507
.2870	JE	63184	+0.0120	+0.0004	0.507
758.3670	Pp	63334	+0.0118	+0.0002	0.522
759.3310	Pp	63342	+0.0115	-0.0001	0.523
761.2612	Pp	63358	+0.0131	+0.0016	0.525
.3813	Pp	63359	+0.0127	+0.0012	0.525
767.0468	JE	63406	+0.0131	+0.0015	0.530
46038.4852	Pp	65658	+0.0069	+0.0009	0.761
.6061	Pp	65659	+0.0073	+0.0013	0.761
039.4493	Pp	65666	+0.0067	+0.0008	0.762
466.5001	Pp	69209	+0.0024	-0.0007	0.126
467.4653	Pp	69217	+0.0033	+0.0002	0.127

Remarks to Table 2: Sc = Schneller (1961); Eg = Eggen (1962); Sz = Szeidl (1983); HX = He Tian-Jian and Xiong Da-run (1964); vG = van Genderen (1963, 1967); Br= Broglia (1963); JS = Joshi and Srivastava (1967); Bi = Binnendijk (1968); WW = Wisse and Wisse (1969); Po = Popovici (1971); BM = Barnes and Moffett (1975); KM = Karetnikov and Medvedev (1977, 1978); Af = Africano (1978); Du = Duerbeck (1976); HW = Hopp and Witzigmann (1979); GE = Garrido et al. (1979); Ga = Garbusov (1980); JE = Jiang Shi-yang et al. (1985); BY = Braune and Mundry (1982); BE = Braune et al. (1983); Pp = Present paper.

In columns 4 and 5 of Table 2 the $(O-C)_{lin}$ residuals from the linear portion of Eq.(1) and the O-C residuals determined by Eq.(1) are given. The

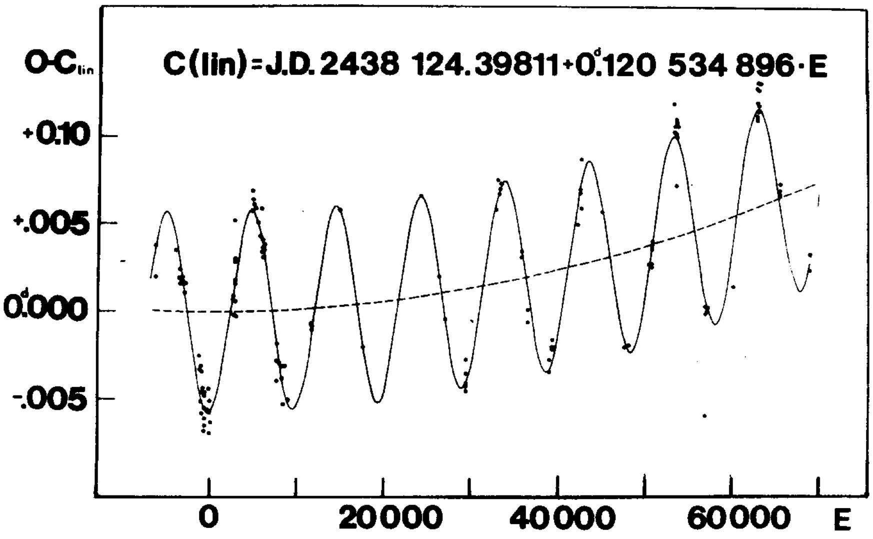

Figure 1. $(O-C)_{lin}$ versus E. The solid line indicates the goodness of fit for the non-linear ephemeris Eq.(1); the dashed line shows the secular variation in the pulsation period.

phases of the sinusoid are also given in column 6 of Table 2. Figure 1 indicates the goodness of the fit for the non-linear ephemeris. It shows the residuals from the linear part in Eq.(1) versus epoch number E and the non-linear fit is drawn in.

CONCLUSIONS

Taking into account all the photoelectric maxima available up to 1986 has led unambiguously to the conclusion that the orbital period of the system is 1173.5 ± 2.0 days. *Bardin* and *Imbert* (1984) obtained a slightly longer period (1181.5 days) probably because they took into account the early radial velocity measurements of low accuracy in their period determination. The difference cannot be explained by the fact that we assumed a circular orbit.

Using our solution for Eq.(1) we can deduce the following characteristics of the binary system if we assume that the orbit is circular:

$$a_{SZ} \cdot \sin i = cA = (147.4 \pm 3.4) \cdot 10^6 \mathrm{km} = 0.99 \pm 0.03 \ \mathrm{AU}$$

$$K_{SZ} = cA\frac{2\pi}{P_B} = 9.13 \pm 0.21 \ \mathrm{km \cdot s^{-1}}$$

$$f(M_2) = (0.093 \pm 0.006) M_\odot$$

As *Bardin* and *Imbert* (1984) derived a large value for the eccentricity (e=0.19) of the orbit from the radial velocity observations, our results can only be regarded as tentative. An attempt to derive the orbital elements from the O-C residuals of light maxima of SZ Lyn allowing non-circular orbit is planned in a forthcoming paper.

We were able to determine an intrinsic secular change of $\beta = (+2.96 \pm 0.15) \cdot 10^{-12}$ day$\cdot$cycle^{-1} in the pulsation period of SZ Lyn. This change is in agreement with the evolutionary theories: the high amplitude δ Scuti star SZ Lyn is evolving off from the main sequence (see, for example, the evolutionary track of the star with a mass of 1.7 $M_\odot$ in *Percy* et al., 1980).

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Table 3a

Yellow observations obtained at Kottamia Observatory
(SZ Lyn - BD+ 44°1714)

J.D.	Δv	J.D.	Δv	J.D.	Δv	J.D.	Δv
2445758		2445758		2445759		2445761	
.2694	-0.334	.4044	-0.229	.3446	-0.463	.3153	-0.120
.2722	.294	.4098	.186	.3477	.433	.3179	.093
.2767	.260	.4127	.169	.3510	.433	.3209	.091
.2797	.234	.4159	.152	.3542	.409	.3243	.083
.2823	.223	.4189	.125	.3554	.385	.3269	.074
.2853	.212	.4239	.093	.3582	.335	.3299	.066
.2882	.193	.4266	.091	.3613	.352	.3345	.051
.2898	.168	.4295	.080	.3644	.327	.3373	.029
.2928	.157	.4323	.059	.3658	-0.301	.3405	.014
.2958	.137	.4350	.067			.3440	.024
.2985	.134	.4377	.055	2445761		.3471	.041
.3017	.114	.4402	.053	.2516	-0.415	.3501	.045
.3121	.060	.4427	.039	.2545	.476	.3644	.198
.3325	.029	.4452	.037	.2574	.511	.3670	.245
.3354	.039	.4619	.034	.2603	.519	.3698	.333
.3386	.049	.4652	.067	.2627	.518	.3728	.419
.3418	.076	.4678	-0.099	.2655	.515	.3765	.493
.3459	.120			.2794	.376	.3799	.534
.3493	.185	2445759		.2821	.343	.3830	.534
.3529	.269	.2905	-0.038	.2847	.319	.3860	.511
.3565	.361	.2940	.053	.2873	.303	.4006	.355
.3604	.493	.2971	.047	.2902	.291	.4034	.345
.3633	.552	.3004	.062	.2930	.264	.4061	.305
.3663	.572	.3037	.087	.2956	.261	.4096	.290
.3690	.573	.3069	.122	.2984	.236	.4124	.262
.3853	.383	.3109	.166	.3014	.217	.4152	.245
.3883	.369	.3143	.227	.3039	.205	.4235	.189
.3914	.330	.3178	.319	.3065	.190	.4259	.182
.3942	.313	.3211	.404	.3090	.174	.4291	.160
.3983	.274	.3244	.512	.3116	.155	.4317	-0.145
.4014	-0.252	.3276	-0.551	.3125	-0.133		

Table 3b

Blue observations obtained at Kottamia Observatory
(SZ Lyn - BD+ 44°1714)

J.D.	Δb	J.D.	Δb	J.D.	Δb	J.D.	Δb
2445758		2445758		2445758		2445758	
.2697	-0.658	.2994	-0.395	.3542	-0.623	.3951	-0.609
.2735	.614	.3025	.359	.3586	.799	.3991	.572
.2776	.569	.3128	.322	.3613	.903	.4023	.541
.2808	.537	.3332	.281	.3642	.953	.4053	.514
.2839	.519	.3363	.299	.3672	.970	.4105	.463
.2862	.502	.3393	.317	.3701	.955	.4136	.441
.2907	.452	.3427	.343	.3862	.747	.4168	.410
.2937	.433	.3468	.415	.3892	.698	.4220	.377
.2966	-0.414	.3506	-0.517	.3923	-0.666	.4246	-0.359

Table 3b (cont)

J.D.	Δb	J.D.	Δb	J.D.	Δb	J.D.	Δb
2445758		2445759		2445761		2445761	
.4275	-0.342	.3187	-0.667	.2829	-0.678	.3447	-0.282
.4304	.324	.3222	.793	.2854	.645	.3480	.304
.4330	.314	.3253	.900	.2880	.619	.3510	.308
.4359	.305	.3283	.914	.2910	.596	.3651	.519
.4384	.304	.3302	.934	.2937	.572	.3677	.609
.4409	.283	.3455	.812	.2965	.553	.3707	.714
.4434	.283	.3488	.779	.2989	.532	.3737	.818
.4459	.282	.3519	.746	.3021	.506	.3774	.893
.4626	.301	.3561	.675	.3046	.490	.3807	.939
.4660	.355	.3592	.623	.3072	.467	.3837	.928
.4686	-0.386	.3623	.631	.3099	.445	.3878	.885
		.3667	-0.568	.3134	.407	.4013	.707
2445759				.3160	.389	.4043	.677
.2919	-0.307	2445761		.3188	.363	.4073	.646
.2949	.310	.2525	-0.802	.3218	.350	.4103	.614
.2984	.303	.2553	.867	.3250	.423	.4133	.576
.3017	.326	.2583	.906	.3276	.320	.4159	.555
.3046	.367	.2610	.911	.3313	.315	.4240	.487
.3076	.398	.2636	.904	.3354	.303	.4266	.468
.3117	.464	.2662	.891	.3380	.266	.4298	.447
.3154	-0.558	.2801	-0.710	.3417	-0.259	.4326	-0.435

Table 3c

Ultraviolet observations obtained at Kottamia Observatory
(SZ Lyn - BD + 44°1714)

J.D.	Δu	J.D.	Δu	J.D.	Δu	J.D.	Δu
2445758		2445758		2445758		2445761	
.2710	-0.537	.3874	-0.594	.4697	-0.327	.2536	-0.727
.2753	.512	.3905	.576			.2564	.767
.2819	.453	.3933	.525	2445759		.2594	.782
.2846	.449	.3962	.505	.2931	-0.220	.2620	.771
.2919	.382	.4005	.499	.2963	.211	.2648	.769
.2950	.358	.4035	.471	.2996	.229	.2675	.757
.2976	.333	.4089	.419	.3029	.246	.2814	.594
.3009	.318	.4120	.399	.3060	.300	.2840	.565
.3037	.303	.4150	.366	.3091	.352	.2865	.542
.3141	.279	.4180	.331	.3133	.437	.2895	.517
.3347	.253	.4230	.315	.3168	.515	.2923	.493
.3375	.268	.4259	.302	.3201	.626	.2949	.486
.3408	.303	.4286	.288	.3236	.710	.2977	.463
.3441	.317	.4314	.260	.3267	.781	.3000	.450
.3483	.422	.4341	.259	.3317	.804	.3032	.430
.3520	.509	.4368	.257	.3467	.681	.3056	.406
.3556	.599	.4393	.240	.3502	.644	.3081	.403
.3597	.715	.4418	.237	.3533	.634	.3109	.370
.3620	.792	.4443	.264	.3575	.585	.3144	.345
.3653	.841	.4470	.248	.3606	.565	.3172	.328
.3681	.821	.4635	.266	.3636	-0.534	.3201	.304
.3710	-0.752	.4669	-0.297			.3229	-0.279

Table 3c (cont)

J.D.	Δu	J.D.	Δu	J.D.	Δu	J.D.	Δu
2445761		2445761		2445761		2445761	
.3260	-0.258	.3492	-0.263	.3820	-0.800	.4143	-0.467
.3287	.277	.3522	.267	.3851	.784	.4168	.426
.3329	.259	.3663	.482	.3890	.755	.4252	.377
.3362	.260	.3689	.567	.4025	.586	.4280	.358
.3392	.200	.3719	.643	.4055	.559	.4310	.341
.3433	.242	.3753	.742	.4085	.531	.4337	-0.327
.3461	-0.249	.3786	-0.799	.4108	-0.493		

Table 4a

Yellow observations obtained at Konkoly Observatory
(SZ Lyn - BD + 45°1544)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2446038		2446038		2446038		2446466	
.4447	+0.169	.5270	+0.008	.6052	-0.357	.4379	+0.098
.4460	.168	.5283	.020	.6065	.362	.4389	.089
.4473	.162	.5297	.028	.6117	.330	.4398	.098
.4487	.153	.5350	.065	.6130	.304	.4407	.107
.4500	.158	.5364	.072	.6143	.295	.4456	.120
.4558	.141	.5377	.079	.6156	.282	.4465	.122
.4571	.136	.5390	.093	.6170	.266	.4474	.125
.4585	.128	.5404	.091	.6223	.198	.4484	.124
.4598	.114	.5462	.119	.6237	.180	.4496	.116
.4611	+0.111	.5476	.120	.6251	.170	.4590	.162
.4705	-0.056	.5488	.125	.6264	.160	.4599	.159
.4718	.097	.5502	.135	.6278	.138	.4609	.159
.4731	.134	.5516	.130	.6334	.111	.4652	.155
.4744	.183	.5571	.160	.6348	.098	.4661	.151
.4758	.229	.5584	.166	.6361	.076	.4671	.159
.4813	.332	.5597	.172	.6374	.071	.4680	.164
.4827	.336	.5611	.171	.6388	-0.062	.4690	.161
.4840	.347	.5624	.194			.4729	.159
.4853	.352	.5679	.204	2446039		.4738	.192
.4867	.341	.5692	.192	.4338	-0.044	.4747	.154
.4918	.311	.5706	.195	.4352	.069	.4757	.164
.4931	.301	.5719	.191	.4365	.107	.4820	.056
.4944	.292	.5733	.176	.4378	.156	.4830	.012
.4958	.283	.5793	.138	.4391	.194	.4840	+0.001
.4971	.279	.5806	.134	.4405	.212	.4849	-0.004
.5030	.193	.5819	.115	.4418	.246	.4888	.140
.5044	.179	.5832	.099	.4432	.246	.4897	.163
.5057	.164	.5846	+0.078	.4487	.354	.4906	.200
.5070	.142	.5901	-0.041	.4501	.353	.4915	.219
.5084	.139	.5915	.064	.4515	.324	.4925	.252
.5137	.071	.5928	.109	.4528	.325	.4964	.334
.5164	.043	.5941	.155	.4581	.283	.4974	.351
.5177	.029	.5955	.186	.4638	-0.252	.4983	.358
.5191	-0.036	.6012	.317			.4993	.363
.5243	+0.021	.6025	.330	2446466		.5002	.358
.5256	+0.001	.6038	-0.348	.4370	+0.093	.5041	-0.347

Table 4a (cont)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2446466		2446466		2446467		2446467	
.5051	-0.341	.5466	+0.035	.4566	-0.246	.4919	-0.111
.5060	.324	.5476	+0.046	.4575	.257	.4928	.097
.5069	.325			.4612	.322	.4937	.095
.5079	.308	2446467		.4621	.335	.4947	.089
.5120	.283	.4304	+0.180	.4630	.338	.4956	.076
.5129	.278	.4314	.185	.4640	.345	.4992	.040
.5138	.272	.4323	.172	.4649	.347	.5002	.028
.5148	.262	.4332	.165	.4688	.341	.5011	.026
.5211	.177	.4342	.168	.4698	.332	.5020	.018
.5220	.173	.4386	.128	.4707	.330	.5030	-0.010
.5229	.173	.4396	.126	.4717	.319	.5068	+0.019
.5276	.117	.4405	.115	.4726	.308	.5077	.021
.5286	.096	.4414	.102	.4765	.278	.5087	.023
.5304	.050	.4423	.085	.4775	.270	.5096	.052
.5356	.031	.4463	.023	.4784	.249	.5105	.046
.5365	.027	.4472	+0.009	.4794	.244	.5220	.121
.5375	.011	.4481	-0.017	.4803	.220	.5229	.124
.5384	.008	.4491	.026	.4843	.188	.5305	.144
.5393	-0.003	.4500	.049	.4853	.172	.5314	.149
.5438	+0.021	.4538	.170	.4862	.156	.5324	.141
.5447	.030	.4547	.202	.4871	.144	.5333	.149
.5457	+0.035	.4556	-0.221	.4881	-0.137	.5342	+0.145

Table 4b

Blue observations obtained at Konkoly Observatory
(SZ Lyn - BD + 45°1544)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2446038		2446038		2446038		2446038	
.4451	+0.071	.4935	-0.535	.5395	-0.020	.5850	-0.066
.4465	.073	.4949	.518	.5408	-0.022	.5905	.213
.4478	.063	.4962	.507	.5467	+0.029	.5919	.235
.4492	.067	.4976	.496	.5480	.031	.5932	.304
.4505	.053	.5034	.401	.5493	.044	.5946	.342
.4562	.021	.5048	.379	.5507	.052	.5959	.412
.4575	.016	.5061	.347	.5520	.061	.6016	.561
.4589	+0.001	.5075	.327	.5575	.077	.6030	.586
.4602	-0.008	.5088	.300	.5588	.086	.6043	.596
.4616	.016	.5142	.219	.5602	.086	.6056	.606
.4709	.235	.5155	.212	.5615	.111	.6070	.605
.4722	.285	.5182	.189	.5629	.095	.6121	.566
.4736	.337	.5195	.176	.5683	.104	.6134	.545
.4749	.388	.5248	.146	.5697	.099	.6148	.524
.4763	.436	.5261	.133	.5710	.097	.6161	.507
.4817	.568	.5274	.120	.5724	.089	.6174	.494
.4831	.583	.5288	.105	.5737	.077	.6228	.399
.4844	.581	.5301	.093	.5797	.022	.6242	.374
.4858	.590	.5354	.058	.5810	+0.011	.6255	.351
.4871	.585	.5368	.038	.5824	-0.002	.6268	.347
.4922	-0.537	.5381	-0.030	.5837	-0.032	.6282	-0.315

Table 4b (cont)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2446038		2446466		2446466		2446467	
.6339	-0.262	.4664	+0.073	.5359	-0.161	.4692	-0.596
.6352	.241	.4673	.076	.5368	.164	.4701	.578
.6365	.221	.4683	.084	.5377	.153	.4710	.571
.6379	.205	.4693	.084	.5387	.143	.4720	.556
.6392	-0.184	.4732	.079	.5396	.137	.4729	.529
		.4742	.097	.5441	.091	.4768	.483
2446039		.4751	.091	.5450	.085	.4778	.464
.4343	-0.252	.4760	+0.051	.5460	.084	.4787	.451
.4356	.303	.4815	-0.079	.5469	.070	.4797	.425
.4369	.344	.4824	.097	.5479	-0.057	.4806	.417
.4383	.393	.4833	.133			.4846	.360
.4396	.446	.4843	.162	2446467		.4856	.344
.4410	.496	.4891	.318	.4307	+0.101	.4865	.336
.4423	.519	.4900	.383	.4317	.096	.4874	.326
.4436	.535	.4909	.416	.4326	.093	.4884	.306
.4492	.616	.4919	.441	.4335	.092	.4922	.266
.4506	.606	.4928	.484	.4345	.081	.4931	.255
.4519	.593	.4968	.568	.4389	.048	.4940	.245
.4532	.554	.4977	.582	.4399	.032	.4950	.233
.4586	.526	.4986	.582	.4408	.021	.4959	.221
.4642	-0.390	.4995	.577	.4417	.019	.4995	.179
		.5004	.586	.4427	+0.002	.5005	.166
2446466		.5044	.565	.4466	-0.100	.5014	.181
.4373	+0.006	.5054	.559	.4475	.127	.5024	.173
.4382	.013	.5063	.550	.4484	.155	.5033	.146
.4392	.031	.5073	.530	.4494	.187	.5071	.124
.4401	.020	.5082	.521	.4503	.222	.5080	.116
.4410	.028	.5123	.488	.4541	.365	.5090	.114
.4459	.042	.5132	.475	.4549	.408	.5099	.064
.4468	.043	.5141	.474	.4559	.446	.5108	-0.066
.4477	.058	.5151	.444	.4569	.474	.5223	+0.041
.4487	.045	.5214	.353	.4578	.496	.5232	.056
.4499	.056	.5223	.347	.4614	.575	.5308	.045
.4593	.091	.5232	.334	.4624	.594	.5317	.051
.4603	.071	.5279	.259	.4633	.598	.5327	.048
.4612	.085	.5289	.230	.4643	.604	.5336	.060
.4655	+0.076	.5307	-0.214	.4652	-0.611	.5345	+0.053

Table 4c

Ultraviolet observations obtained at Konkoly Observatory
(SZ Lyn - BD+45°1544)

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2446038		2446038		2446038		2446038	
.4456	+0.160	.4580	+0.112	.4740	-0.207	.4862	-0.417
.4469	.192	.4593	.111	.4754	.265	.4875	.414
.4483	.185	.4607	.105	.4767	.292	.4926	.374
.4496	.175	.4620	+0.110	.4822	.404	.4940	.363
.4509	.189	.4713	-0.127	.4835	.421	.4953	.349
.4567	+0.133	.4727	-0.174	.4848	-0.416	.4967	-0.347

Table 4c (cont)

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2446038		2446038		2446466		2446467	
.4980	-0.347	.6139	-0.366	.4745	+0.185	.4487	-0.052
.5039	.238	.6152	.333	.4754	.167	.4497	.092
.5052	.217	.6166	.323	.4763	.137	.4506	.109
.5066	.201	.6179	.306	.4818	.027	.4544	.247
.5079	.173	.6233	.222	.4827	+0.004	.4553	.278
.5092	.157	.6246	.203	.4836	-0.027	.4562	.304
.5159	.040	.6259	.192	.4855	.077	.4572	.321
.5173	.022	.6273	.164	.4893	.187	.4581	.346
.5186	.024	.6286	.152	.4903	.241	.4618	.418
.5199	-0.023	.6343	.095	.4912	.256	.4627	.428
.5252	+0.003	.6356	.103	.4922	.296	.4636	.447
.5265	.018	.6369	.078	.4931	.324	.4646	.450
.5279	.048	.6383	.044	.4971	.381	.4655	.448
.5292	.053	.6397	-0.031	.4980	.395	.4695	.433
.5305	.049			.4989	.402	.4704	.413
.5359	.101	2446039		.4999	.401	.4714	.394
.5373	.093	.4347	-0.171	.5008	.418	.4723	.386
.5386	.100	.4360	.193	.5047	.385	.4732	.366
.5399	.115	.4374	.243	.5057	.383	.4772	.301
.5412	.115	.4387	.283	.5066	.356	.4781	.286
.5471	.164	.4401	.314	.5076	.343	.4790	.261
.5484	.161	.4414	.352	.5085	.347	.4800	.245
.5498	.166	.4427	.350	.5126	.314	.4809	.224
.5511	.174	.4441	.362	.5144	.309	.4849	.193
.5524	.181	.4496	.421	.5154	.285	.4859	.174
.5579	.227	.4510	.411	.5226	.181	.4868	.160
.5593	.205	.4523	.405	.5235	.173	.4877	.152
.5606	.210	.4537	.358	.5245	.157	.4887	.142
.5620	.220	.4590	.355	.5282	.112	.4925	.116
.5633	.220	.4646	-0.230	.5292	.092	.4934	.102
.5688	.223			.5310	.067	.4943	.112
.5701	.223	2446466		.5362	.025	.4953	.089
.5715	.215	.4376	+0.117	.5371	.026	.4962	.078
.5728	.214	.4385	.142	.5381	.025	.4999	.037
.5741	.202	.4394	.140	.5390	.021	.5008	.054
.5801	.137	.4404	.143	.5399	-0.009	.5017	.043
.5815	.144	.4414	.138			.5026	.036
.5828	.105	.4462	.161	2446467		.5036	.027
.5842	.071	.4471	.168	.4310	+0.222	.5074	-0.008
.5855	+0.054	.4480	.164	.4320	.223	.5083	+0.007
.5910	-0.086	.4489	.162	.4329	.205	.5093	.028
.5923	.133	.4596	.195	.4338	.208	.5102	.060
.5937	.184	.4606	.182	.4348	.195	.5111	.080
.5950	.223	.4615	.201	.4392	.133	.5226	.148
.5964	.279	.4658	.196	.4401	.131	.5235	.151
.6021	.389	.4668	.177	.4411	.121	.5311	.174
.6034	.420	.4677	.181	.4420	.104	.5320	.175
.6048	.436	.4686	.183	.4430	+0.078	.5330	.184
.6061	.440	.4696	.188	.4469	-0.005	.5339	.185
.6074	.435	.4735	+0.176	.4478	-0.010	.5349	+0.184
.6125	-0.376						

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PERIOD CHANGES OF RR LYRAE STARS II, TW HER, VZ HER, AV PEG AND TU UMA

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PERIOD CHANGES OF RR LYRAE STARS II.

TW HER, VZ HER, AV PEG AND TU UMA

ABSTRACT

Photographic and photoelectric observations obtained at Konkoly Observatory during the past 35 years are presented. Using all available observations the O-C diagrams of TW Her, VZ Her, AV Peg and TU UMa are constructed. The period of TW Her is constant whereas that of VZ Her, AV Peg and TU UMa is changing. The periods of VZ Her and AV Peg show an increase at a rate of $+1.144\times10^{-10}$ day/cycle = 8.20 ms/year and $+1.846\times10^{-10}$ day/cycle = 14.92 ms/year, respectively whereas the period of TU UMa is decreasing at a rate of -0.710×10^{-10} day/cycle = -4.02 ms/year. Superimposed on the parabolic O-C diagrams of AV Peg and TU UMa are cyclic variations which may result from the duplicity of these stars.

INTRODUCTION

In a previous paper (*Oláh* and *Szeidl*, 1978) we commenced the systematic evaluation of photographic and photoelectric observations obtained at Konkoly Observatory on single periodic field RR Lyrae stars during the past 45 years. In the present paper we have extended the investigation to the RR Lyrae type stars TW Her, VZ Her, AV Peg and TU UMa. Using our observations we were able to derive accurate times of maximum light of these variable stars.

In order to construct precise and detailed O-C diagrams of these stars we collected all the available moments of maxima and attempted to treat them critically and rigorously.

As a general rule, because visual observations are inferior to photoelectric observations, the visual observations carried out since the photoelectric technique was introduced have not been taken into account in calculating the new elements of light variation.

In addition, the photographic maxima were, in many cases, poorly determined. The reason for this was that photographic plates with long exposure times taken for discovery or survey purposes were used too. Usually these plates were obtained sporadically and were not well distributed in time; moreover, the brightness data of the variable stars determined from these photographs badly defined the light curves especially near the maximum light.

Over the past 25 years a number of photoelectric observations have been obtained by different authors. In general, these observations were carried out in order to study the physical properties of the stars, but these authors did not determine the observed epochs of maximum. The accurate observations, however, gave us a good chance to fix new times of maximum light.

In subsequent papers we plan to publish our results on further RR Lyrae variables.

OBSERVATIONS

The 16 cm astrograph of Konkoly Observatory was used to obtain photographic observations of the stars VZ Her and AV Peg. Table 1 summarizes the most important data of the photographic observations published here. Kodak Eastman and Guilleminot Superfulgur plates were used and the typical exposure times were 2-5 minutes.

Table 1

	VZ Her			AV Peg	
Plate No.	J.D.	No. of obs.	Plate No.	J.D.	No. of obs.
H 2103 2104	2433427	28	H 2330	2433884	19
			2747	2434598	13
2134	2433475	37	2751	2434600	25
2293	2433836	21	3213	2435343	24
2449	2434154	18	3255	2435393	28
2763	2434605	25	3264	2435395	26
3203	2435339	14		total	: 135
3563	2435991	18			
	total	: 161			

A number of plates were obtained for TW Her as well but the series of one of the neighbouring stars (BD +30^{o}3078) blended with the series of the variable star on the multiple exposure plates thereby preventing TW Her from being measured on these plates.

Up till 1957, photoelectric observations were made in integrated light; since 1958, the UBV system has been utilized. The 60 cm Newton telescope at

Budapest was used for the observations except for those made in 1982 and 1983. These observations were obtained with the 50 cm Cassegrain telescope at Konkoly Observatory's Piszkéstető mountain station.

The photomultipliers and filters used are described elsewhere (*Oláh* and *Szeidl*, 1978).

Most of the photoelectric observations were obtained by Prof. L. Detre, Drs. L. Csank, G. Paál, and the present authors.

The photoelectric observations have been transformed into the UBV system in the traditional way (see e.g. *Hardie*, 1962). The log of the photoelectric observations of TW Her, VZ Her, AV Peg and TU UMa made at Konkoly Observatory is reproduced in Table 2.

Table 2

star	year	kind of obs.	No. of obs.
TW Her	1959	pe ΔV	157
		pe ΔB	110
	1969	pe ΔV	34
		pe ΔB	34
	1978	pe ΔV	50
		pe ΔB	55
	1983	pe ΔV	38
		pe ΔB	38
		pe ΔU	39
VZ Her	1958	pe ΔV	103
		pe ΔB	105
	1959	pe ΔV	135
		pe ΔB	84
	1969	pe ΔV	64
		pe ΔB	64
		pe ΔU	18
	1978	pe ΔV	41
		pe ΔB	42
AV Peg	1954	pe Δm*	50
	1959	pe ΔV	226
		pe ΔB	126
	1969	pe ΔV	15
		pe ΔB	16
AV Peg	1972	pe ΔV	18
		pe ΔB	18
	1973	pe ΔV	31
		pe ΔB	31
	1978	pe ΔV	49
		pe ΔB	52
	1979	pe ΔV	21
		pe ΔB	22
	1982	pe ΔV	24
		pe ΔB	24
	1983	pe ΔV	69
		pe ΔB	70
		pe ΔU	67
TU UMa	1957	pe Δm*	114
	1958	pe ΔV	163
		pe ΔB	178
	1959	pe ΔV	68
		pe ΔB	71
	1978	pe ΔV	19
		pe ΔB	22
	1979	pe ΔV	35
		pe ΔB	36
	1983	pe ΔV	23
		pe ΔB	20
		pe ΔU	18

The photographic and photoelectric observations obtained at Konkoly Observatory are given in Tables 11-14.

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*in integrated light

TW HERCULIS

The variability of the star TW Her = 93.1910 = HV 3279 was discovered by *Cannon* (1910) on Harvard photographs. *Zinner* (1922) was the first to observe the star visually and he published two dates when the star was near maximum brightness (10.3 magn.). These times have been included in the list of times of maximum (Table 4).

Thorough visual observations of TW Her were carried out by *Hoffmeister* (1922) in the years 1917-1920 and he determined the RR Lyrae type character of its light variations and derived the elements:

$$\text{J.D.max.hel.} = 2421545.2376 + 0\overset{d}{.}3995977\cdot E$$

On the basis of further photographic observations in 1925, *Hoffmeister* (1927) rediscussed the elements of light variations and confirmed his previous results. He gave the new formula:

$$\text{J.D.max.hel.} = 2421545.2376 + 0\overset{d}{.}39959954\cdot E$$

The large amplitude of the rapid light variation of the star makes it an easy object for visual observations. Hence TW Her tended to be very popular among visual observers, and a great number of visual observations have been collected in the past sixty years. In particular the Soviet astronomers (*Batyrev*, 1951b; *Bogdanov*, 1972; *Lange*, 1938, 1959, 1960, 1961; *Nachapkin*, 1938; *Soloviev*, 1935a, b, c, 1936a, d, 1937; *Soloviev* and *Shakovskoj*, 1958; *Steinman*, 1958; *Tsessevich*, 1966) were very active. The BAV group (*Braune* and *Hübscher*, 1967; *Braune*, *Hübscher* and *Mundry*, 1970, 1972, 1979; *Braune* and *Mundry*, 1973, 1982; *Domke* and *Pohl*, 1952; *Hübscher* and *Mundry*, 1984) *and Ahnert* (1967, 1970, 1971) supplemented this series of visual observations.

Mention is made of the photographic observations of *Alania* (1954, 1956). Because the exposure times he used were fairly long and the light curves were not well defined the dates of maximum given by him are unreliable and cannot be used for investigating the changes in the period of TW Her.

Photoelectric observations were carried out by *Fitch* et al. (1966), *Sturch* (1966), *Epstein* (1969) and *Stepien* (1972). Although *Sturch*, *Epstein* and *Stepien* did not give any moments of maximum we were able to determine reliable maxima from their observations for the years 1963, 1966 and 1967.

The photoelectric photometry of this star was taken up at Konkoly Observatory in 1959. The comparison star used in our photometry (indicated by "c" in Figure 1) was the same as used by *Sturch* (1966). The brightness and colours of *Stepien*'s (1972) comparison star and of some neighbouring stars measured on one night are also given in Table 3. The identification chart of these objects is shown in Figure 1.

Table 3

Magnitudes and colours of comparison stars of TW Her

star	V	B-V	U-B	References
a = BD +30°3081	10.097	+0.388	+0.035	Stepien (1972)
b = BD +30°3080	10.277	+0.953		present study
c	10.554	+0.266	-0.004	Sturch (1966)
d	10.580	+0.969		present study
e	11.420	+0.561		present study
f	12.109	+0.339		present study

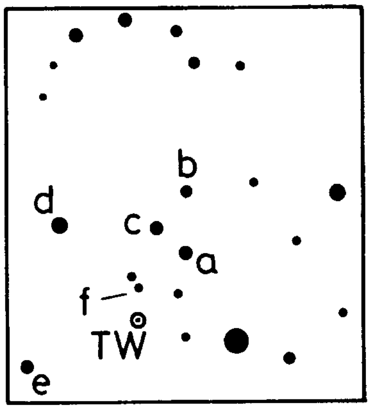

Figure 1: Identification chart of TW Her

The photoelectric observations obtained at Konkoly Observatory (in the sense: variable minus comparison star "c") are given in Table 11 and shown in Figure 2. A comparison of the photoelectric light curves obtained by *Fitch* et al. (1961), *Sturch* (1966), *Epstein* (1969), and *Stepien* (1972) with those published in the present paper provides proof of the stable character of the light variation of TW Her: any kind of light curve variation, i.e. Blazhko effect, is out of the question.

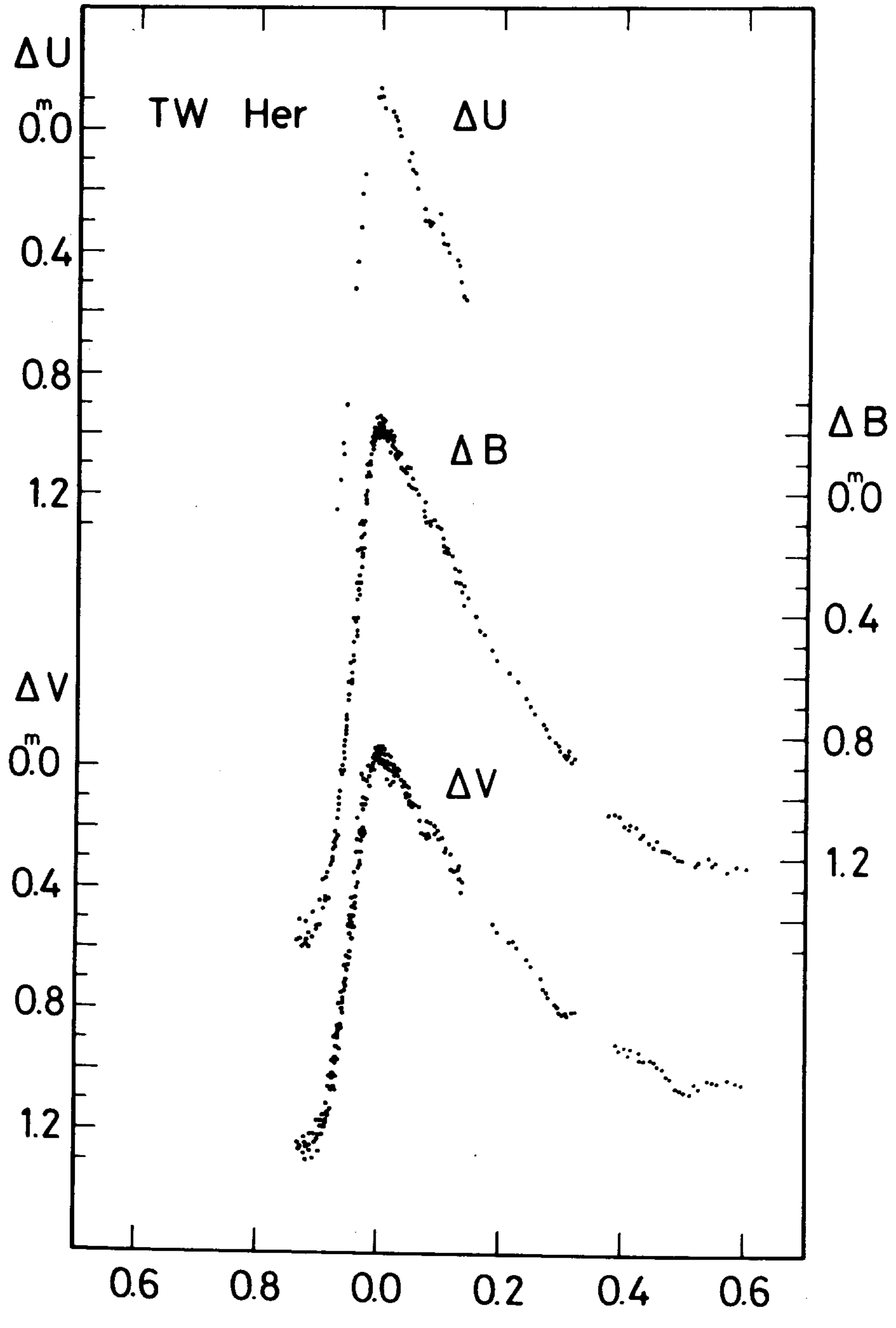

Figure 2: Light curves of TW Her

Table 4

year	J.D.max.hel.	$O - C_1$	$O - C_2$	E	method	w	Reference
1912	2419714.271	+0.0047	+0.0049	-4582	vis	1	Zinner (1922)
1913	20092.283	-0.0050	-0.0048	-3636	vis	1	-"-
1917	21545.253	+0.0190	+0.0191	0	vis	1	Hoffmeister (1922)
1918	21642.732	-0.0044	-0.0043	+ 244	vis	1	-"-
	21665.523	+0.0094	+0.0095	301	vis	1	-"-
	21669.510	+0.0004	+0.0005	311	vis	1	-"-
	21721.453	-0.0046	-0.0046	441	vis	1	-"-
	21731.448	+0.0004	+0.0004	466	vis	1	-"-
	21749.438	+0.0083	+0.0084	511	vis	1	-"-
	21820.560	+0.0015	+0.0016	689	vis	1	-"-
1919	22191.382	-0.0054	-0.0053	1617	vis	1	-"-
1920	22607.371	-0.0001	-0.0001	2658	vis	1	-"-
1925	24376.403	+0.0023	+0.0021	7085	pg	2	Hoffmeister (1927)
	24380.401	+0.0043	+0.0041	7095	pg	2	-"-
	24386.394	+0.0033	+0.0031	7110	pg	2	-"-
	24406.369	-0.0017	-0.0019	7160	pg	2	-"-
	24408.365	-0.0037	-0.0039	7165	pg	2	-"-
	24410.360	-0.0067	-0.0069	7170	pg	2	-"-
1927	24967.407	-0.0023	-0.0025	8564	vis	1	Tsessevich (1966)
	25067.304	-0.0053	-0.0055	8814	vis	1	-"-
	25069.303	-0.0043	-0.0045	8819	vis	1	-"-
	25071.300	-0.0053	-0.0055	8824	vis	1	-"-
	25077.300	+0.0007	+0.0005	8839	vis	1	-"-
	25083.287	-0.0063	-0.0065	8854	vis	1	-"-
	25085.298	+0.0067	+0.0065	8859	vis	1	-"-
	25087.288	-0.0013	-0.0015	8864	vis	1	-"-
	25089.286	-0.0013	-0.0015	8869	vis	1	-"-
	25091.281	-0.0043	-0.0045	8874	vis	1	-"-
	25093.281	-0.0023	-0.0025	8879	vis	1	-"-
	25095.273	-0.0083	-0.0085	8884	vis	1	-"-
	25097.275	-0.0043	-0.0045	8889	vis	1	-"-
	25099.281	+0.0037	+0.0035	8894	vis	1	-"-
	25103.270	-0.0033	-0.0035	8904	vis	1	-"-
	25107.264	-0.0053	-0.0055	8914	vis	1	-"-
1933	27309.463	-0.0025	-0.0029	14425	visN	1	Lange (1938)
1934	27599.1755	-0.0001	-0.0005	15150	visN	1	Soloviev (1935a, b)
1935	27969.202	-0.0033	-0.0037	16076	visN	1	Soloviev (1935c, 1936a, d)
1936	28373.203	+0.0020	+0.0015	17087	visN	1	Soloviev (1937)
	28394.784	+0.0046	+0.0041	17141	visN	1	Soloviev,Shakovskoj (1958)
	28403.508	-0.0626	-0.0631	17163	visN	0	Nachapkin (1938)
1942	30616.1602	+0.0038	+0.0032	22700	vis	1	Tsessevich (1966)
1949	33122.444	-0.0042	-0.0051	28972	vis	1	Batyrev (1951b)
	33191.184	+0.0046	+0.0037	29144	vis	1	-"-
	33203.169	+0.0016	+0.0007	29174	vis	1	-"-
	33211.166	+0.0066	+0.0057	29194	vis	1	-"-
	33217.161	+0.0076	+0.0067	29209	vis	1	-"-
1951	33829.362	+0.0212	+0.0203	30741	pg	0	Alania (1954)
	33858.517	+0.0054	+0.0045	30814	vis	1	Domke, Pohl (1952)
	33872.504	+0.0064	+0.0054	30849	vis	1	-"-
	33898.4795	+0.0079	+0.0069	30914	vis	1	-"-
1953	34577.393	+0.0008	-0.0002	32613	pg	0	Alania (1954)
1955	35364.248	+0.0432	+0.0421	34582	pg	0	Alania (1956)
1957	36090.6842	+0.0064	+0.0053	36400	visN	1	Steinman (1958)

Table 4 (cont.)

year	J.D.max.hel.	O - C_1	O - C_2	E	method	w	Reference
1959	2436756.4066	-0.0050	-0.0062	38066	vis	0	Lange (1959)
	36756.4144	+0.0028	+0.0017	38066	pe	3	present paper
	36758.4059	-0.0037	-0.0049	38071	vis	0	Lange (1959)
	36758.4105	+0.0009	-0.0003	38071	pe	3	present paper
	36760.4006	-0.0070	-0.0082	38076	vis	0	Lange (1959)
	36760.4101	+0.0025	+0.0014	38076	pe	3	present paper
	36762.4010	-0.0046	-0.0058	38081	vis	0	Lange (1959)
	36776.3917	+0.0001	-0.0011	38116	pe	3	present paper
	36784.3767	-0.0069	-0.0081	38136	vis	0	Lange (1959)
1960	37130.4288	-0.0085	-0.0097	39002	vis	0	Lange (1960)
	37134.4272	-0.0061	-0.0073	39012	vis	0	-"-
	37136.4263	-0.0050	-0.0062	39017	vis	0	-"-
	37142.4178	-0.0075	-0.0087	39032	vis	0	-"-
	37144.4160	-0.0073	-0.0085	39037	vis	0	-"-
	37158.4066	-0.0027	-0.0039	39072	vis	0	-"-
	37164.4019	-0.0014	-0.0026	39087	vis	0	-"-
	37170.3930	-0.0043	-0.0055	39102	vis	0	-"-
1961	37494.4695	-0.0035	-0.0047	39913	vis	0	Lange (1961)
	37496.4670	-0.0040	-0.0052	39918	vis	0	-"-
	37518.4453	-0.0037	-0.0049	39973	vis	0	-"-
	37520.4396	-0.0074	-0.0086	39978	vis	0	-"-
	37522.4417	-0.0033	-0.0045	39983	vis	0	-"-
1962	37781.3834	-0.0024	-0.0037	40631	vis	0	Tsessevich (1966)
	37789.3763	-0.0015	-0.0028	40651	vis	0	-"-
	37809.3651	+0.0073	+0.0060	40701	vis	0	-"-
	37813.3563	+0.0025	+0.0012	40711	vis	0	-"-
	37817.3551	+0.0053	+0.0040	40721	vis	0	-"-
	37841.3332	+0.0074	+0.0061	40781	vis	0	-"-
	37847.3290	+0.0092	+0.0079	40796	vis	0	-"-
	37869.2963	-0.0016	-0.0028	40851	vis	0	-"-
	37871.3002	+0.0044	+0.0031	40856	vis	0	-"-
	37872.4926	-0.0020	-0.0033	40859	vis	0	-"-
	37873.2944	+0.0006	-0.0007	40861	vis	0	-"-
	37878.4891	+0.0004	-0.0008	40874	vis	0	-"-
	37881.2878	+0.0020	+0.0007	40881	vis	0	-"-
	37883.2845	+0.0006	-0.0006	40886	vis	0	-"-
	37884.4816	-0.0011	-0.0023	40889	vis	0	-"-
	37899.2738	+0.0059	+0.0047	40926	vis	0	-"-
	37903.2650	+0.0011	-0.0002	40936	vis	0	-"-
	37925.2374	-0.0045	-0.0058	40991	vis	0	-"-
	37943.2207	-0.0032	-0.0045	41036	vis	0	-"-
	37955.2040	-0.0079	-0.0092	41066	vis	0	-"-
	37959.2030	-0.0049	-0.0062	41076	vis	0	-"-
	37961.2018	-0.0041	-0.0054	41081	vis	0	-"-
	37963.2006	-0.0033	-0.0046	41086	vis	0	-"-
1963	38179.3919	+0.0044	+0.0031	41627	vis	0	-"-
	38181.3924	+0.0069	+0.0056	41632	vis	0	-"-
	38207.3591	-0.0004	-0.0018	41697	vis	0	-"-
	38209.3630	+0.0055	+0.0042	41702	vis	0	-"-
	38221.3489	+0.0034	+0.0020	41732	vis	0	-"-
	38223.3438	+0.0003	-0.0011	41737	vis	0	-"-
	38229.3374	-0.0001	-0.0015	41752	vis	0	-"-
	38231.3407	+0.0052	+0.0038	41757	vis	0	-"-

Table 4 (cont.)

year	J.D.max.hel.	$O - C_1$	$O - C_2$	E	method	w	Reference
1963	2438233.3324	-0.0011	-0.0025	41762	vis	0	Tsessevich (1966)
	38235.3365	+0.0050	+0.0036	41767	vis	0	-"-
	38243.724	+0.0009	-0.0005	41788	pe	3	Sturch (1966)
	38259.3038	-0.0037	-0.0051	41827	vis	0	Tsessevich (1966)
	38263.3096	+0.0060	+0.0047	41837	vis	0	-"-
	38267.2995	-0.0001	-0.0014	41847	vis	0	-"-
	38269.2943	-0.0033	-0.0046	41852	vis	0	-"-
	38271.2932	-0.0024	-0.0037	41857	vis	0	-"-
	38273.2908	-0.0028	-0.0041	41862	vis	0	-"-
	38275.2901	-0.0015	-0.0028	41867	vis	0	-"-
	38283.2800	-0.0036	-0.0049	41887	vis	0	-"-
	38285.2765	-0.0051	-0.0064	41892	vis	0	-"-
	38289.2789	+0.0013	0.0000	41902	vis	0	-"-
	38293.2810	+0.0074	+0.0061	41912	vis	0	-"-
	38295.2728	+0.0012	-0.0001	41917	vis	0	-"-
	38297.2778	+0.0082	+0.0069	41922	vis	0	-"-
1964	38559.811	+0.0042	+0.0028	42579	pe	3	Fitch et al. (1966)
1965	38855.530	+0.0191	+0.0177	43319	vis	0	Braune, Hübscher (1967)
	38915.451	+0.0001	-0.0013	43469	vis	0	-"-
	38931.443	+0.0081	+0.0067	43509	vis	0	-"-
	39027.348	+0.0090	+0.0077	43749	vis	0	-"-
	39053.322	+0.0090	+0.0077	43814	vis	0	-"-
	39055.313	+0.0020	+0.0007	43819	vis	0	-"-
	39057.3135	+0.0045	+0.0032	43824	vis	0	-"-
1966	39233.539	+0.0064	+0.0050	44265	vis	0	Braune et al. (1970)
	39263.507	+0.0044	+0.0030	44340	vis	0	Ahnert (1967, 1970)
	39285.489	+0.0084	+0.0070	44395	vis	0	Braune et al. (1970)
	39289.876	-0.0002	-0.0016	44406	pe	3	Epstein (1969)
	39387.376	-0.0026	-0.0041	44650	vis	0	Braune et al. (1970)
	39389.387	+0.0104	+0.0089	44655	vis	0	-"-
1967	39631.9350	+0.0011	-0.0004	45262	pe	3	Stepien (1972)
	39707.8592	+0.0013	-0.0002	45452	pe	3	-"-
1968	40065.512	+0.0120	+0.0105	46347	vis	0	Braune et al. (1970)
	40073.491	-0.0010	-0.0025	46367	vis	0	-"-
1969	40419.5467	+0.0010	-0.0005	47233	pe	3	present paper
1970	40740.428	+0.0034	+0.0019	48036	vis	0	Ahnert (1971)
	40804.368	+0.0074	+0.0059	48196	vis	0	Braune et al. (1972)
1971	41074.493	+0.0027	+0.0012	48872	vis	0	-"-
	41166.404	+0.0057	+0.0041	49102	vis	0	Bogdanov (1972)
	41186.384	+0.0057	+0.0041	49152	vis	0	-"-
	41194.391	+0.0207	+0.0191	49172	vis	0	-"-
	41240.331	+0.0067	+0.0051	49287	vis	0	Braune et al. (1972)
1972	41558.408	+0.0020	+0.0004	50083	vis	0	Braune, Mundry (1973)
	41576.399	+0.0110	+0.0094	50128	vis	0	-"-
1977	43401.359	-0.0027	-0.0045	54695	vis	0	Braune et al. (1979)
1978	43717.4447	-0.0007	-0.0025	55486	pe	3	present paper
	43755.4085	+0.0011	-0.0007	55581	pe	3	-"-
1981	44742.420	+0.0004	-0.0015	58051	vis	0	Braune, Mundry (1982)
	44770.396	+0.0044	+0.0025	58121	vis	0	-"-
1982	45162.397	-0.0023	-0.0043	59102	vis	0	Hübscher, Mundry (1984)
	45226.330	-0.0054	-0.0073	59262	vis	0	-"-
	45238.323	-0.0004	-0.0023	59292	vis	0	-"-
1983	45546.4153	+0.0003	-0.0017	60053	pe	3	present paper

The list of maxima observed by different authors is presented in Table 4. The letter "N" indicates that the maximum is a normal one. The abbreviations "vis","pg","pe" refer to visual, photographic and photoelectric observations, respectively; w gives the weight of the time of maximum which was taken into account in the period analysis, all the published dates before 1959 were used in our analysis except the times of maximum given by *Alania* (1954, 1956) (see the comment above) and the epoch of *Nachapkin* (1938). *Nachapkin*'s observations were reanalysed by *Soloviev* and *Shakovskoj* (1958) and they gave a more reliable epoch.

Since reliable and well-defined photoelectric maxima have been available from 1959, from this time onwards only these epochs were taken into account in investigating the possible period changes of the star; all visual observations after 1958 have been neglected.

Throughout the years the ephemeris given by *Tsessevich* (1966) has been used for calculating the O-C values:

$$C_1 = \text{J.D. max.hel.} = 2421545.2340 + 0\overset{d}{.}399600104 \cdot E$$

The O-C_1 values are given in the third column of Table 4.

A quadratic fit of the O-C diagram yields the elements:

$$\begin{array}{llll} \text{J.D.max.hel.} = & 2421545.2333 & + \; 0\overset{d}{.}399600221 \cdot E & - 0\overset{d}{.}015 \times 10^{-10} \cdot E^2 \\ & \pm .0009 & \pm .000000086 & \pm .016 \end{array}$$

Since the error of the quadratic term exceeds the value itself, this solution shows that a linear fit of the O-C diagram gives satisfactory results:

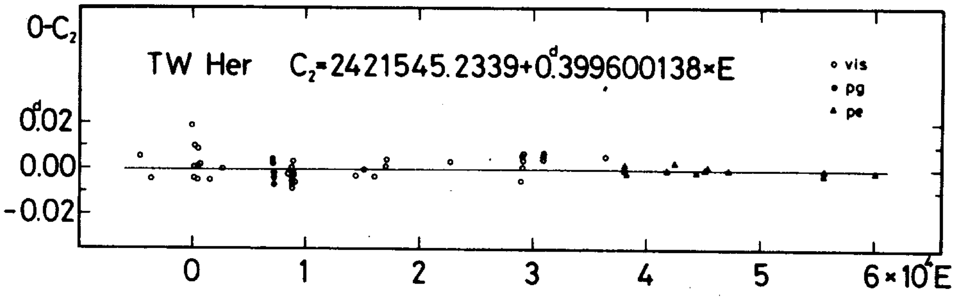

Figure 3: O-C diagram of TW Her

$$C_2 = \text{J.D.max.hel.} = 2421545.2339 + 0\overset{d}{.}399600138\cdot E$$
$$\pm.0007 \quad \pm.000000022$$

The O-C_2 values in Table 4 were calculated by this formula. This analysis shows that the period of TW Her has not undergone noticeable period changes during the past 70 years. The constancy of its period can be taken for granted.

VZ HERCULIS

The variable star VZ Her = 38.1919 (= BV 281) was discovered by *Wolf* (1919) on photographic plates taken at Heidelberg. *Leiner* (1920) determined the RR Lyrae type variability and gave the following elements from his visual observations:

$$\text{J.D.max.hel.} = 2422388.496 + 0\overset{d}{.}44032\cdot E$$

Later *Haas* (1926) obtained some photographic observations but they were very few and cannot be used to determine a reliable moment of maximum light.

Tsessevich (1926) and then *Florja* (1934a) observed the star visually. *Tsessevich* gave the new formula:

$$\text{J.D.max.hel.} = 2422388.500 + 0\overset{d}{.}44032425\cdot E$$

while *Florja* found that the period was linearly increasing:

$$\text{J.D.max.hel.} = 2425004.458 + 0\overset{d}{.}44032419\cdot E + 0\overset{d}{.}987\text{x}10^{-10}\cdot E^2$$

New and very accurate photographic observations were obtained by *Balázs* (1936). She found no changes in the period of the star, and according to her:

$$\text{J.D.max.hel.} = 2425004.4614 + 0\overset{d}{.}44032425\cdot E$$

Payne-Gaposchkin (1954) made use of the Harvard photographs and derived a normal maximum for the years around 1940. From our list of maxima (Table 6) This very uncertain point has been omitted.

Tsessevich (1943, 1966) supplemented his previous visual observations with new ones and carried out a detailed investigation of the changes in the period of VZ Her. He stated that the period changed abruptly around J.D. 2427250 (summer 1933), and before that time the elements were:

$$\text{J.D.max.hel.} = 2425004.4590 + 0\overset{d}{.}44032394 \cdot E$$

and since that time the formula:

$$\text{J.D.max.hel.} = 2425004.4456 + 0\overset{d}{.}44032631 \cdot E$$

has been valid.

Strohmeier and *Bauernfeind* (1968) investigated the star on Bamberg archive plates and determined some 80 instances of light maximum back to the beginning of this century. The O-C's of these maxima have a very large scatter therefore we have taken only the mean maxima from their table.

Photoelectric observations were made by *Sturch* (1966), *Fitch* et al. (1966) and *Butler* et al. (1982). *Fitch* et al. gave two times of light maximum; *Sturch* and *Butler* et al., however, did not publish any time of maximum. Their observations do not cover the light curve around the maximum therefore we fitted the mean photoelectric V light curve obtained at Konkoly Observatory into their observations and in this way we were able to determine two epochs of maximum: one for the year 1964 (from *Sturch*'s observations) and one for the year 1976 (from *Butler* et al.'s observations).

At Konkoly Observatory VZ Her was photographically observed in 1950, 1951, 1952, 1953, 1955 and 1957 (Table 12a). The comparison stars used were taken from *Balázs* (1936). The star was first observed photoelectrically in 1958 on J.D. 2436363. Our photoelectric observations are given in Table 12b, c, d, and are presented in Figure 5. For these observations BD $+36^{\circ}2836$ was used as a comparison star. Secondary comparison stars were also observed. The identification chart of the comparison stars is shown in Figure 4 and their brightness and colours are given in Table 5.

All the observed maxima are listed in Table 6. It is clear from previous investigations that all the maxima cannot be satisfied with one period. *Tsessevich* (1966) stated that with two periods, one before J.D. 2427250 and one after it, the O-C diagram of VZ Her can be well interpreted.

In order to construct the whole O-C diagram we used the mean value of *Tsessevich*'s (1966) two periods:

$$C_1 = \text{J.D.max.hel.} = 2425004.4590 + 0\overset{d}{.}44032512 \cdot E$$

Table 5

Comparison stars for VZ Her

star	V	B–V	U–B	Reference
a = BD $+36^{\circ}2836$ (main)	10.947	+0.510	+0.050	Sturch (1966)
b (secondary)	11.290	+0.522		present study
c (secondary)	11.355	+0.564		present study

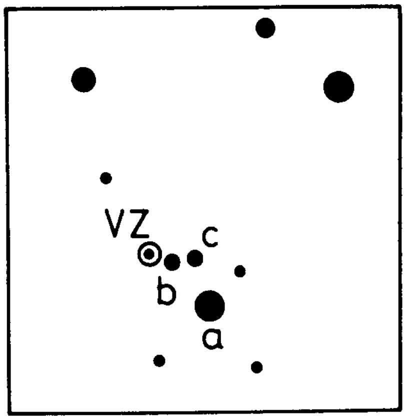

Figure 4: Identification chart of VZ Her

The O–C diagram of VZ Her is shown in Figure 6.

The photoelectric observations made in the 60's and 70's show that *Tsessevich*'s assumption is not correct: the O–C diagram cannot be represented by two straight lines.

The period of the star has increased continuously and we supposed in our calculation that since the observations of *Leiner* (i.e. since 1920) the period has changed linearly. Following our procedure we used the visual observations only before photoelectric observations existed. The O–C's of *Strohmeier* and *Bauernfeind*'s (1968) photographic maxima exhibited a very large scatter therefore they were simply omitted when calculating the elements. The new formula with the quadratic term is:

$$\begin{array}{llll} C_2 = \text{J.D.max.hel.} = & 2425004.4581 & + \; 0\overset{d}{.}440324431 \cdot E & + \; 0\overset{d}{.}572 \times 10^{-10} \cdot E^2 \\ & \pm.0004 & \pm.000000044 & \pm.011 \end{array}$$

These new elements well represent all the observed maxima (except those of *Strohmeier* and *Bauernfeind*). Consequently the period of VZ Her has changed by $+1.144 \times 10^{-10}$ day/cycle = $+8.199 \times 10^{-3}$ sec/year in the past 60 years.

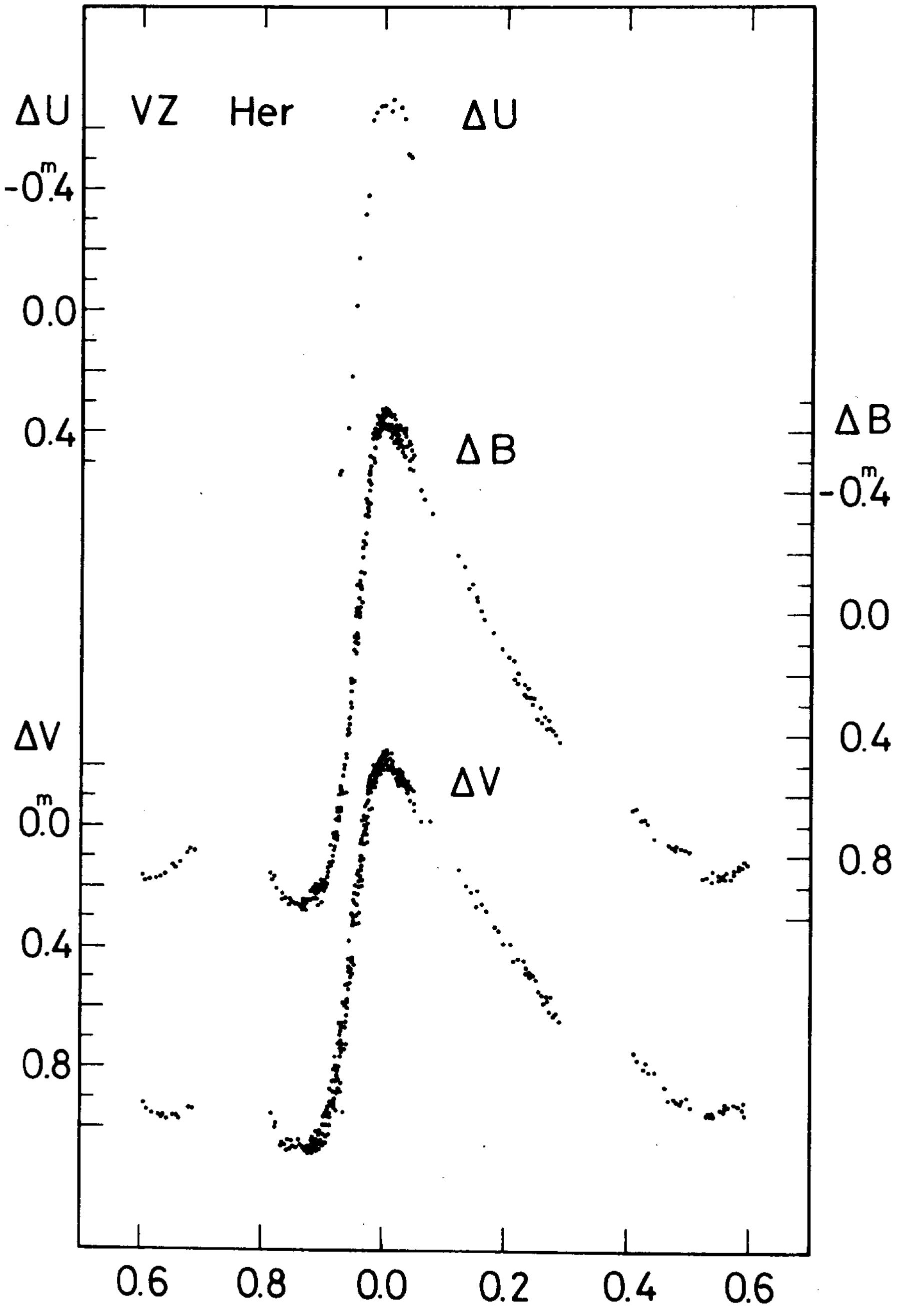

Figure 5: Light curves of VZ Her

Table 6

year	J.D.max.hel.	$O - C_1$	$O - C_2$	E	method	w	Reference
1901	2415663.534	+0.1321	+0.0926	-21214	pgM	0	Strohmeier,Bauernfeind(1968)
1902	15800.915	+0.1317	+0.0932	20902	pgM	0	-"-
1909	18521.609	+0.0567	+0.0351	14723	pgM	0	-"-
1916	21028.789	+0.0255	+0.0155	9029	pgM	0	-"-
1920	22388.496	+0.0085	+0.0033	5941	vis	1	Leiner (1920)
1923	23544.809	+0.0278	+0.0258	3315	pgM	0	Strohmeier,Bauernfeind(1968)
1926	24786.500	+0.0019	+0.0025	495	visN	1	Tsessevich (1926, 1943)
1927	24970.550	-0.0040	-0.0031	- 77	vis	1	Tsessevich (1943)
	25086.357	-0.0025	-0.0015	+ 186	vis	1	-"-
1928	25325.455	-0.010	+0.0004	729	vis	1	-"-
1930	26066.520	-0.0032	-0.0010	2412	vis	1	-"-
	26185.847	-0.0043	-0.0020	2683	vis	1	-"-
1931	26546.476	-0.0016	+0.0010	3502	vis	1	-"-
1932	26921.659	+0.0244	+0.0272	4354	pgM	0	Strohmeier,Bauernfeind(1968)
	26967.425	-0.0034	-0.0006	4458	vis	1	Tsessevich (1943)
1933	27274.328	-0.0070	-0.0041	5155	vis	1	Florja (1934a)
1934	27614.287	+0.0210	+0.0240	5927	visN	0	Soloviev (1935d)
	27667.573	+0.0277	+0.0307	6048	pgM	0	Strohmeier,Bauernfeind(1968)
1935	27973.567	-0.0043	-0.0013	6743	visN	1	Soloviev (1936b, f, 1941)
	27989.421	-0.0020	+0.0010	6779	pg	2	Balázs (1936)
	27993.382	-0.0039	-0.0010	6788	pg	2	-"-
	27996.466	-0.0022	+0.0008	6795	pg	2	-"-
	28003.511	-0.0024	+0.0006	6811	pg	2	-"-
	28045.341	-0.0033	-0.0004	6906	pg	2	-"-
	28075.284	-0.0024	+0.0005	6974	pg	2	-"-
1937	28616.891	+0.0047	+0.0074	8204	pgM	0	Strohmeier,Bauernfeind(1968)
1938	29015.811	-0.0090	-0.0074	9110	pgM	0	-"-
	29089.353	-0.0021	+0.0002	9277	vis	0	Parenago (1947)
1940	29712.894	+0.0385	+0.0402	10693	pgM	0	Strohmeier,Bauernfeind(1968)
1942	30612.440	+0.0003	+0.0007	12736	vis	0	Tsessevich (1943, 1948)
1943	30941.363	+0.0004	+0.0002	13483	vis	0	-"-
1950	33427.446	+0.0078	+0.0009	19129	pg	2	present paper
	33475.443	+0.0093	+0.0023	19238	pg	2	-"-
1951	33836.510	+0.0097	+0.0015	20058	pg	2	-"-
	33856.324	+0.0091	+0.0008	20103	pg	2	Alania (1954)
	33897.278	+0.0129	+0.0044	20196	vis	0	Tsessevich (1957)
1953	34605.320	+0.0121	+0.0008	21804	pg	2	present paper
1955	35339.344	+0.0141	-0.0003	23471	pg	2	-"-
1956	35693.367	+0.0157	-0.0004	24275	vis	0	Tsessevich (1957)
1957	35991.470	+0.0186	+0.0011	24952	pg	2	present paper
1958	36363.5445	+0.0184	-0.0010	25797	pe	3	-"-
	36364.4256	+0.0188	-0.0006	25799	pe	3	-"-
	36405.3750	+0.0180	-0.0016	25892	pe	3	-"-
	36420.3465	+0.0184	-0.0013	25926	pe	3	-"-
1959	36758.5192	+0.0214	0.0000	26694	pe	3	-"-
	36781.407	+0.0123	-0.0093	26746	vis	0	Lange (1959)
	36792.413	+0.0102	-0.0114	26771	vis	0	-"-
	36793.303	+0.0196	-0.0021	26773	vis	0	-"-
	36807.3980	+0.0242	+0.0024	26805	pe	3	present paper
1962	37818.383	+0.0227	-0.0048	29101	vis	0	Tsessevich (1966)
	37848.335:	+0.0326:	+0.0049:	29169	vis	0	-"-
	37851.408	+0.0233	-0.0044	29176	vis	0	-"-
	37855.373	+0.0254	-0.0023	29185	vis	0	-"-
	37869.468	+0.0300	+0.0022	29217	vis	0	-"-

Table 6 (cont.)

year	J.D.max.hel.	O - C_1	O - C_2	E	method	w	Reference
1962	2437873.427	+0.0260	-0.0018	29226	vis	0	Tsessevich (1966)
	37878.270:	+0.0255:	-0.0024:	29237	vis	0	-"-
	37885.320	+0.0303	+0.0024	29253	vis	0	-"-
	37900.285	+0.0242	-0.0038	29287	vis	0	-"-
	37903.365	+0.0219	-0.0061	29294	vis	0	-"-
1964	38577.952	+0.0308	-0.0014	30826	pe	3	Sturch (1966)
1965	38888.826	+0.0353	+0.0011	31532	pe	3	Fitch et al. (1966)
	38936.821	+0.0349	+0.0003	31641	pe	3	-"-
1969	40403.546	+0.0369	-0.0081	34972	vis	0	Derivyagin et al. (1981)
	40418.5239	+0.0438	-0.0013	35006	pe	3	present paper
	40419.4048	+0.0440	-0.0011	35008	pe	3	-"-
1976	42954.821	+0.0682	+0.0021	40766	pe	3	Butler et al. (1982)
1978	43721.4313	+0.0724	-0.0007	42507	pe	3	present paper
1981	44761.495	+0.0882	+0.0049	44869	vis	0	Braune, Mundry (1982)
	44820.495	+0.0846	+0.0007	45003	vis	0	-"-
	44854.396	+0.0806	-0.0037	45080	vis	0	-"-
1982	45105.405	+0.1043	+0.0174	45650	vis	0	Hübscher, Mundry, (1984)
	45227.359	+0.0882	+0.0001	45927	vis	0	-"-

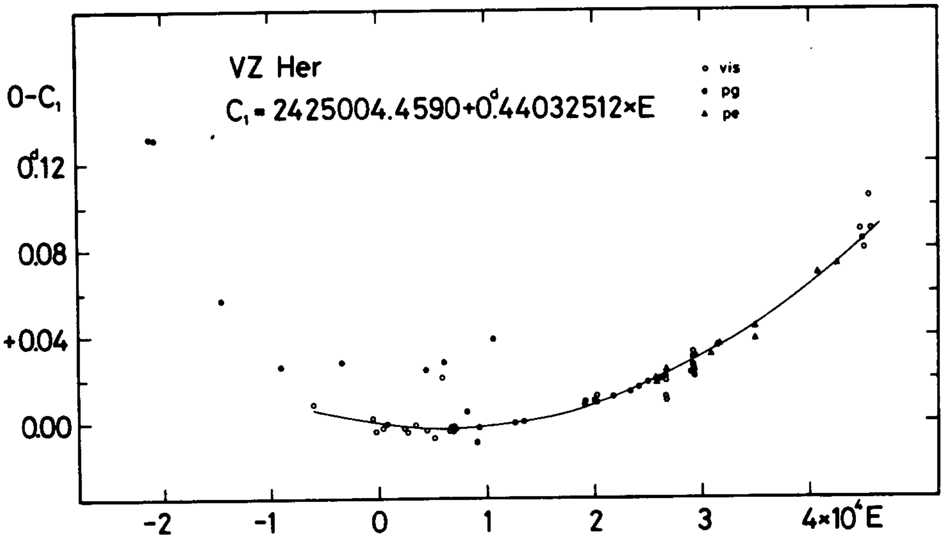

Figure 6: O-C diagram of VZ Her

AV PEGASI

The variability of the star AV Peg = BD $+21^0 4633$ (9.5) = 90.1931 = HV 6181 was discovered by *Hoffmeister* (1931) on Sonneberg plates. When publishing his results *Hoffmeister* indicated the RR Lyrae type characteristics of its light variation.

Florja (1932) definitely determined the RR Lyrae type of the star and based on his 266 visual observations, gave the preliminary elements:

$$\text{J.D.max.hel.} = 2426582.302 + 0^d.3903859 \cdot E$$

Later, *Florja* (1933) published 20 times of light maximum using his own and *Tsessevich*'s visual observations, but he also gave a normal maximum based on this observational material. We have given only this time of maximum in the list of light maxima of AV Peg (Table 8). In a later work *Florja* (1934b) recalculated the light elements and gave:

$$\text{J.D.max.hel.} = 2426582.302 + 0^d.3903698 \cdot E$$

Dombrovsky (1936) gave a new ephemeris with quadratic term:

$$\text{J.D.max.hel.} = 2426582.3015 + 0^d.39037167 \cdot E - 0^d.72 \times 10^{-9} \cdot E^2$$

From three year observations he stated, oddly enough, that the period was decreasing by 1.44×10^{-9} day/cycle = 0.116 sec/year. On the other hand *Balazs* (1934) found no definite change in the period within three years.

In Table 8 we have listed, where possible, the visual normal maximum instead of the long list of maxima observed. *Batyrev* (1950) gave three while *Sacharov* (1964) gave 18 individual maxima, but in Table 8 their normal maxima are given.

Grigor'ev (1975) measured the star on the plates of Odessa Observatory and from 144 observations ha gave nine maxima which are erroneous; we have therefore omitted them from Table 8.

Wenske (1981) observed the star visually on 23 nights in the years 1963-1966 and photoelectrically in integrated light on 35 nights in the years 1967-1973 and 1975, but the times of maximum light have not been given. (*Wenske* published only the epochs of a certain point on the rising branch.)

Times of photoelectric maximum were published by *Fitch* et al. (1966). The excellent observations of *Paczynski* (1965) allowed another one to be determined. Further times of photoelectric maxima could be determined from *Sturch*'s (1966), *Jones*'s (1966) and *Penston*'s (1973) observations by fitting *Paczynski*'s light curve into their photoelectric data.

Photographic observations were made at Konkoly Observatory between 1951 and 1955 (Table 13a) and six times of light maximum could be determined from these data. We chose the same comparison stars as used by *Balázs* (1934).

The first photoelectric observations were obtained at Konkoly Observatory in integrated light in 1954. As a comparison star for these observations (Table 13b) BD +21°4632 was used. UBV observations were commenced in 1959. The comparison star used was the star "b" shown in the identification chart (Figure 7). The brightness and colours of comparison stars used in this paper and by others are given in Table 7.

Table 7

Magnitudes and colours of comparison stars of AV Peg

star	V	B-V	U-B	Reference
a = BD +21°4632	9.34	+0.67	+0.14	Paczynski (1965)
	9.35	+0.66	+0.02	Jones (1966)
	9.345	+0.653	+0.120	Sturch (1966)
b	10.39	+0.24	+0.11	present study
c	10.74	+1.72		Jones (1966)

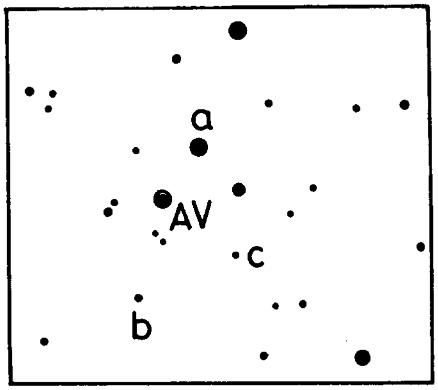

Figure 7: Identification chart of AV Peg

The photoelectric observations made at Konkoly Observatory are given in the sense: variable minus "b" in Table 13c, d, e, and are plotted against phase in Figure 8. From our photoelectric observations 12 times of maximum light could be derived for the years 1954, 1959 (2), 1969, 1972, 1973, 1978 (2), 1979, 1982 and 1983 (2).

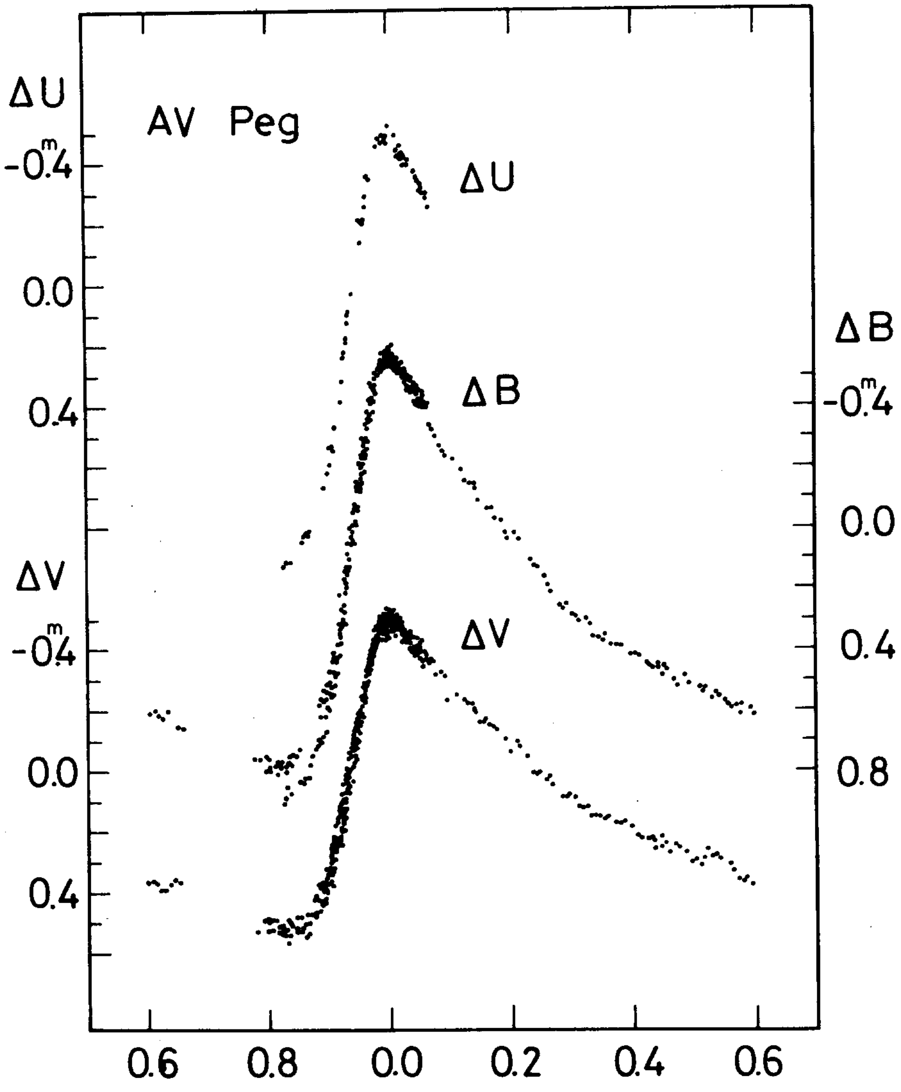

Figure 8: Light curves of AV Peg

Table 8

year	J.D.max.hel.	$O - C_1$	$O - C_2$	E	method	w	Reference
1903	2416347.713	+0.0790	+0.0150	-26218	pgN	2	Payne-Gaposchkin (1954)
1910	18950.26	+0.0422	+0.0049	-19551	pgN	2	Tsessevich (1966)
1931	26582.302	-0.0015	-0.0079	0	visN	1	Florja (1932, 1933)
	26652.561	-0.0087	-0.0152	+ 180	pgN	2	Payne-Gaposchkin (1954)
1932	26970.329	-0.0003	-0.0071	994	vis	1	Okunev (1933)
1933	27312.293	+0.0012	-0.0059	1870	vis	1	Tsessevich (1966)
1934	27616.773	-0.0058	-0.0135	2650	vis	1	Dombrovsky (1936)
	27631.228	+0.0055	-0.0021	2687	visN	1	Soloviev (1935a, b)
	27653.4746	+0.0012	-0.0065	2744	pg	2	Balázs (1934)
	27655.4263	+0.0010	-0.0067	2749	pg	2	-"-
	27660.5002	+0.0001	-0.0076	2762	pg	2	-"-
1935	27981.388	+0.0054	-0.0030	3584	visN	1	Soloviev (1936b, c)
	28098.495	+0.0020	-0.0067	3884	visN	1	Soloviev,Shakovskoj (1958)
	28866.355	+0.0080	-0.0028	5851	visN	1	-"-
1949	33215.468	+0.0306	-0.0062	16992	visN	1	Batyrev (1950)
1950	33527.377	+0.0355	-0.0040	17791	vis	1	Batyrev (1951a)
	33529.324	+0.0307	-0.0089	17796	vis	1	-"-
	33532.457	+0.0407	+0.0012	17804	vis	1	-"-
	33575.391	+0.0343	-0.0057	17914	vis	1	-"-
	33642.144	+0.0343	-0.0063	18085	vis	1	-"-
1951	33884.5675	+0.0393	-0.0036	18706	pg	2	present paper
	33888.478	+0.0461	+0.0032	18716	vis	1	Domke, Pohl (1952)
	33898.627	+0.0455	+0.0026	18742	vis	1	-"-
	33910.339	+0.0465	+0.0034	18772	vis	1	-"-
	33912.283	+0.0386	-0.0045	18777	vis	1	-"-
	33917.3645	+0.0453	+0.0022	18790	vis	1	-"-
	33926.340	+0.0424	-0.0008	18813	vis	1	-"-
	33928.291	+0.0415	-0.0017	18818	vis	1	-"-
1952	34244.495	+0.0474	+0.0011	19628	pg	2	Alania (1954)
	34252.304	+0.0491	+0.0027	19648	pg	2	-"-
1953	34598.5638	+0.0524	+0.0026	20535	pg	2	present paper
	34600.5138	+0.0506	+0.0007	20540	pg	2	-"-
1954	35069.3505	+0.0552	+0.0004	21741	pe	3	-"-
1955	35343.4000	+0.0664	+0.0085	22443	pg	2	-"-
	35393.3620	+0.0612	+0.0029	22571	pg	2	-"-
	35395.3124	+0.0598	+0.0014	22576	pg	2	-"-
1957	36051.555	+0.0937	+0.0277	24257	pg	0	Huth (1966)
	36055.475	+0.1100	+0.0439	24267	pg	0	-"-
	36085.497	+0.0737	+0.0072	24344	pg	0	-"-
	36146.3994	+0.0787	+0.0115	24500	vis	0	Steinman (1958)
1958	36461.440	+0.0923	+0.0212	25307	pg	0	Huth (1966)
1959	36795.5826	+0.0798	+0.0045	26163	pe	3	present paper
	36804.5635	+0.0822	+0.0068	26186	pe	3	-"-
	36808.477	+0.0921	+0.0166	26196	pg	0	Huth (1966)
	36817.479	+0.1156	+0.0400	26219	pg	0	-"-
	36840.491	+0.0959	+0.0200	26278	pg	0	-"-
	36851.431	+0.1056	+0.0295	26306	pg	0	-"-
	36867.414	+0.0835	+0.0072	26347	pg	0	-"-
	36876.391	+0.0820	+0.0056	26370	visN	0	Ahnert (1960)
	36903.356	+0.1116	+0.0349	26439	pg	0	Huth (1966)
1960	37136.366	+0.0719	-0.0079	27036	vis	0	Lange (1960)
1961	37497.468	+0.0835	-0.0013	27961	vis	0	Lange (1961)
	37501.372	+0.0838	-0.0010	27971	vis	0	-"-
	37519.328	+0.0828	-0.0022	28017	vis	0	-"-

Table 8 (cont.)

year	J.D.max.hel.	O - C$_1$	O - C$_2$	E	method	w	Reference
1961	2437528.312:	+0.0884:	+0.0032:	28040	vis	0	Lange (1961)
1962	37669.243	+0.0965	+0.0094	28401	pg	0	Huth (1966)
	37868.317	+0.0828	-0.0071	28911	vis	0	Tsessevich (1966)
	37869.546	+0.1407	+0.0508	28914	pg	0	Huth (1966)
	37871.441	+0.0839	-0.0061	28919	vis	0	Tsessevich (1966)
	37873.398	+0.0890	-0.0010	28924	vis	0	-"-
	37885.501	+0.0906	+0.0005	28955	pg	0	Huth (1966)
	37896.437	+0.0963	+0.0060	28983	visN	0	Sacharov (1964)
	37898.393	+0.1005	+0.0101	28988	vis	0	Tsessevich (1966)
	37900.342	+0.0976	+0.0073	28993	vis	0	-"-
	37902.292	+0.0958	+0.0054	28998	vis	0	-"-
	37903.461	+0.0937	+0.0033	29001	pg	0	Huth (1966)
	37910.499	+0.1051	+0.0145	29019	pg	0	-"-
	37916.343	+0.0935	+0.0029	29034	vis	0	Tsessevich (1966)
	37917.545	+0.1244	+0.0338	29037	pg	0	Huth (1966)
	37918.288	+0.0867	-0.0039	29039	vis	0	Tsessevich (1966)
	37923.377	+0.1009	+0.0102	29052	vis	0	-"-
	37925.322	+0.0941	+0.0034	29057	vis	0	-"-
	37932.347	+0.0924	+0.0016	29075	vis	0	-"-
	37939.374:	+0.0928:	+0.0019:	29093	vis	0	-"-
	37943.271	+0.0861	-0.0048	29103	vis	0	-"-
1963	38268.487	+0.1256	+0.0299	29936	pg	0	Huth (1966)
	38286.422	+0.1036	+0.0077	29982	pg	0	-"-
	38288.403	+0.1328	+0.0368	29987	pg	0	-"-
	38293.8375	+0.1021	+0.0061	30001	pe	3	Paczynski (1965)
	38324.325	+0.1409	+0.0444	30079	pg	0	Huth (1966)
	38340.681	+0.1015	+0.0047	30121	pe	3	Fitch et al. (1966)
1964	38592.502	+0.1351	+0.0345	30766	pg	0	Huth (1966)
	38619.8013	+0.1086	+0.0077	30836	pe	3	Sturch (1966)
	38642.464	+0.1300	+0.0287	30894	pg	0	Huth (1966)
	38651.4215	+0.1090	+0.0076	30917	pe	3	Jones (1966)
	38651.437	+0.1245	+0.0231	30917	pg	0	Huth (1966)
	38658.839	+0.1095	+0.0080	30936	pe	3	Fitch et al. (1966)
	38686.549	+0.1034	+0.0014	31007	pg	2	Harding, Penston (1966)
	38703.723	+0.1012	-0.0010	31051	pe	3	Fitch et al. (1966)
1965	39023.446	+0.1127	+0.0056	31870	pg	0	Huth (1966)
	39025.395	+0.1099	+0.0027	31875	pg	0	-"-
	39034.398	+0.1344	+0.0271	31898	pg	0	-"-
	39055.459	+0.1156	+0.0079	31952	vis	0	Braune, Hübscher (1967)
	39057.420	+0.1247	+0.0170	31957	vis	0	-"-
	39059.351	+0.1039	-0.0038	31962	pg	0	Huth (1966)
	39059.361:	+0.1139:	+0.0062:	31962	vis	0	Braune, Hübscher (1967)
	39061.322	+0.1230	+0.0153	31967	vis	0	-"-
	39063.278:	+0.1272:	+0.0194:	31972	vis	0	-"-
1966	39403.283	+0.1216	+0.0085	32843	vis	0	Braune et al. (1970)
	39406.4055	+0.1212	+0.0080	32851	vis	0	-"-
1969	40506.4775	+0.1360	+0.0044	35669	pe	3	present paper
1970	40836.340	+0.1375	0.0000	36514	vis	0	Braune et al. (1972)
	40848.445	+0.1411	+0.0034	36545	vis	0	-"-
	40859.378	+0.1438	+0.0059	36573	vis	0	-"-
1971	41131.854	+0.1429	+0.0001	37271	pe	3	Penston (1973)
	41233.350	+0.1432	-0.0015	37531	vis	0	Braune et al. (1972)
	41240.375	+0.1416	-0.0032	37549	vis	0	-"-
	41249.358	+0.1461	+0.0012	37572	vis	0	-"-

Table 8 (cont.)

year	J.D.max.hel.	$O - C_1$	$O - C_2$	E	method	w	Reference
1971	2441267.317	+0.1482	+0.0029	37618	vis	0	Braune et al. (1972)
1972	41566.340	+0.1493	-0.0016	38384	vis	0	Braune, Mundry (1973)
	41576.499	+0.1587	+0.0077	38410	vis	0	-"-
	41589.3759	+0.1535	+0.0022	38443	pe	3	present paper
	41598.3545	+0.1536	+0.0022	38466	vis	0	Braune, Mundry (1973)
	41616.308	+0.1502	-0.0016	38512	vis	0	-"-
	41650.270	+0.1501	-0.0023	38599	vis	0	-"-
	41652.228	+0.1563	+0.0039	38604	vis	0	-"-
	41657.297	+0.1505	-0.0020	38617	vis	0	-"-
	41664.320	+0.1469	-0.0058	38635	vis	0	-"-
	41682.297	+0.1670	+0.0140	38681	vis	0	-"-
1973	41931.340	+0.1551	-0.0026	39319	vis	0	Braune et al. (1977)
	41963.3545	+0.1595	+0.0011	39401	pe	3	present paper
	41981.307	+0.1550	-0.0037	39447	vis	0	Braune et al. (1977)
	41990.290	+0.1596	+0.0007	39470	vis	0	-"-
	42008.251	+0.1636	+0.0044	39516	vis	0	-"-
	42047.284	+0.1598	-0.0001	39616	vis	0	-"-
1974	42272.534	+0.1675	+0.0031	40193	vis	0	-"-
1975	42414.231	+0.1609	-0.0063	40556	vis	0	-"-
	42632.448	+0.1621	-0.0094	41115	vis	0	Braune et al. (1981)
	42641.449	+0.1847	+0.0130	41138	vis	0	-"-
	42664.469	+0.1729	+0.0008	41197	vis	0	Braune et al. (1979)
1976	43019.312	+0.1714	-0.0079	42106	vis	0	-"-
	43074.370	+0.1875	+0.0071	42247	vis	0	-"-
1977	43391.344	+0.1826	-0.0044	43059	vis	0	-"-
	43400.324	+0.1842	-0.0030	43082	vis	0	-"-
	43414.375	+0.1819	-0.0056	43118	vis	0	Braune et al. (1981)
1978	43722.3850	+0.1915	-0.0025	43907	pe	3	present paper
	43765.3261	+0.1921	-0.0028	44017	pe	3	-"-
	43790.321	+0.2035	+0.0080	44081	vis	0	Braune et al. (1981)
	43795.388	+0.1957	+0.0001	44094	vis	0	-"-
1979	44133.4508	+0.1998	-0.0031	44960	pe	3	present paper
1980	44545.300	+0.2107	-0.0013	46015	vis	0	Braune, Mundry (1981)
1981	44879.460	+0.2156	-0.0039	46871	vis	0	Braune, Mundry (1982)
	44886.483	+0.2120	-0.0076	46889	vis	0	-"-
1982	45230.4074	+0.2222	-0.0054	47770	pe	3	present paper
	45280.3785	+0.2261	-0.0026	47898	vis	0	Braune et al. (1983)
1983	45561.450	+0.2326	-0.0026	48618	vis	0	Hübscher, Mundry (1984)
	45566.5223	+0.2302	-0.0052	48631	pe	3	present paper
	45622.3449	+0.2301	-0.0066	48774	pe	3	-"-
	45645.385	+0.2385	+0.0013	48833	vis	0	Hübscher, Mundry (1984)

The investigation of the period changes of AV Peg has a long history. *Steinman* (1958) was the first to notice that the period was increasing. In his formula *Tsessevich* (1964) had already given a possible quadratic term:

$$\text{J.D.max.hel.} = 2426582.3035 + 0\overset{d}{.}39036805 \cdot E + 1\overset{d}{.}12\times10^{-10} \cdot E^2,$$

which means that according to him, the period of AV Peg has been increasing by 2.24×10^{-10} day/cycle = 0.018 sec/year.

In order to investigate the period changes of the star in more detail we listed the published maxima in Table 8 with some exceptions (see above). The $O-C_1$ values have been calculated with the formula:

$$C_1 = \text{J.D.max.hel.} = 2426582.3035 + 0\overset{d}{.}39036805 \cdot E$$

A second order least squares solution to the $O-C_1$ values yields the following elements with quadratic term:

$$C_2 = \text{J.D.max.hel.} = \underset{\pm .0010}{2426582.3099} + \underset{\pm .00000007}{0\overset{d}{.}39036827} \cdot E + \underset{\pm .015}{0\overset{d}{.}923} \times 10^{-10} \cdot E^2$$

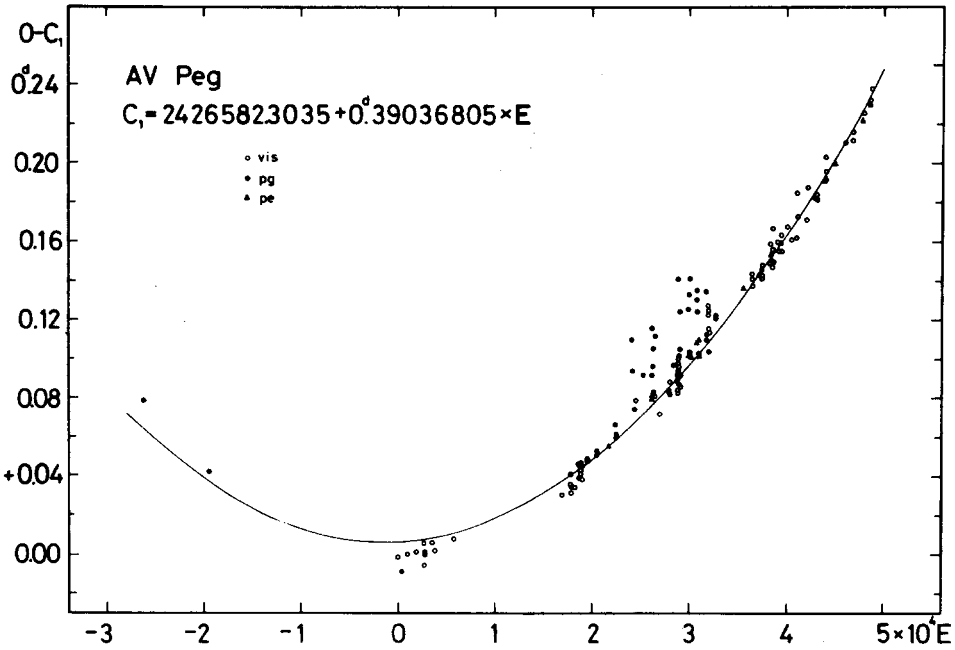

Figure 9a: $O-C_1$ diagram of AV Peg

The systematic deviations of the $O-C_2$ values from the C_2-C_1 parabola show that a cyclic variation is superposed on the linear period change. But we can assume that the period of the star has changed at a rate of $(1.846 \pm 0.030) \times 10^{-10}$ day/cycle = (0.01492 ± 0.00024) sec/year during the past 50 years.

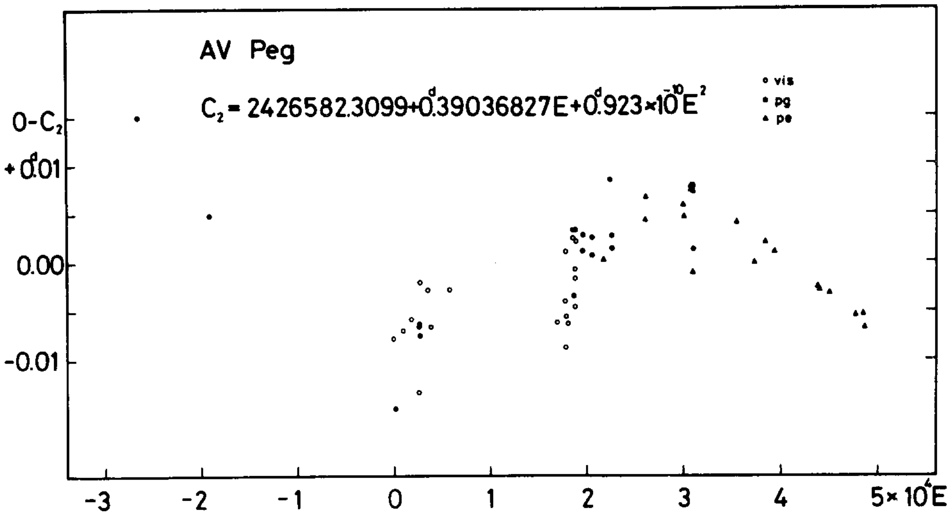

Figure 9b: $O-C_2$ diagram of AV Peg

Balázs (1934) found no light curve changes in her photographic material, and there is no indication for it in the literature. Nevertheless our photographic material suggests that a small variation in the heights of maxima may occur. Our photoelectric observations definitely show that real changes of the light curve are present. The changes are especially conspicious on the rising branches. The variation in the height of maximum probably does not exceed 0.05 magnitude.

TU URSAE MAIORIS

This relatively bright RR Lyrae type variable (TU UMa = BD =30°2162 (8.7) = 1.1929) was discovered by *Guthnick* and *Prager* (1929) on Babelsberg plates. They determined the type of variability and gave the preliminary elements (*Prager*, 1929):

$$\text{J.D.max.hel.} = 2425006.480 + 0^{d}.557650 \cdot E$$

Subsequently the star was studied visually by *Kukarkin* (1929, 1940), *Jacchia* (1929, 1931), *Tsessevich* (1930, 1966, 1974), *Mustel* (1934), *Soloviev*

(1935a, b, c, 1936a, e, 1939), *Dombrovsky* (1936), *Ahnert* (1959), *Oburka* (1967), *Berdnikov* (1973, 1977), *Blasberg* (1981) and by members of the BAV group (*Braune* and *Mundry*, 1973, 1982; *Braune*, *Hübscher* and *Mundry*, 1970, 1977, 1979, 1981, 1983; and *Pohl*, 1955).

Robinson (1933) investigated the star on old Harvard photographs taken before its discovery and determined a time of maximum light for the year 1914. In this way he lengthened the time interval by 15 years and could derive very accurate elements of light variation:

$$\begin{array}{l} \text{J.D.max.hel.} = \underset{\pm.003}{2420160.447} + \underset{\pm.00000047}{0\overset{d}{.}55765826}\cdot E \end{array}$$

which value was slightly corrected by *Soloviev* (1939):

$$\text{J.D.max.hel.} = 2425760.451 + 0\overset{d}{.}5576588\cdot E$$

Poehnitzsch (1951) investigated the star on 322 Sonneberg patrol plates made in 1929-1950. He found no noticeable change in the period of TU UMa and derived essentially the same elements obtained by *Soloviev*:

$$\text{J.D.max.hel.} = 2425760.451 + 0\overset{d}{.}5576593\cdot E$$

At the same time *Silva* (1951) supplemented the previous observations with his own visual observations and made a thorough investigation of the period changes of TU UMa. He found that the period was decreasing at a rate of $0.806\text{x}10^{-9}$ day/cycle = 0.0456 sec/year and the times of heliocentric maximum can be obtained by the formula:

$$\text{J.D.max.hel.} = 2425760.441 + 0\overset{d}{.}557665\cdot E - 4\overset{d}{.}03\text{x}10^{-10}\cdot E^2$$

Photographic maxima were published by *Payne-Gaposchkin* (1954) and *Alania* (1954). *Boenigk* (1957) carried out photographic photometry of the star in order to study its colour variations. The photographic observations were published and made the determination of a time of light maximum possible.

The star has been photoelectrically observed since 1957. Using these observations the period changes of the star can be studied in detail. *Geyer* (1961), *Preston* et al. (1961), *Preston* and *Paczynski* (1964), *Fitch* et al. (1966) and *Sturch* (1966) made UBV observations. *Fitch* et al. (1966) and *Geyer* (1961) each published a maximum, but from *Fitch* et al.'s data another time of light maximum could be determined. The excellent and very accurate observations of *Preston* et al. (1961) and *Preston* and *Paczynski* (1964) made the determination of three new epochs possible. *Sturch*'s (1966) observations were somewhat unluckily distributed in phase and could not be used for timing the maximum.

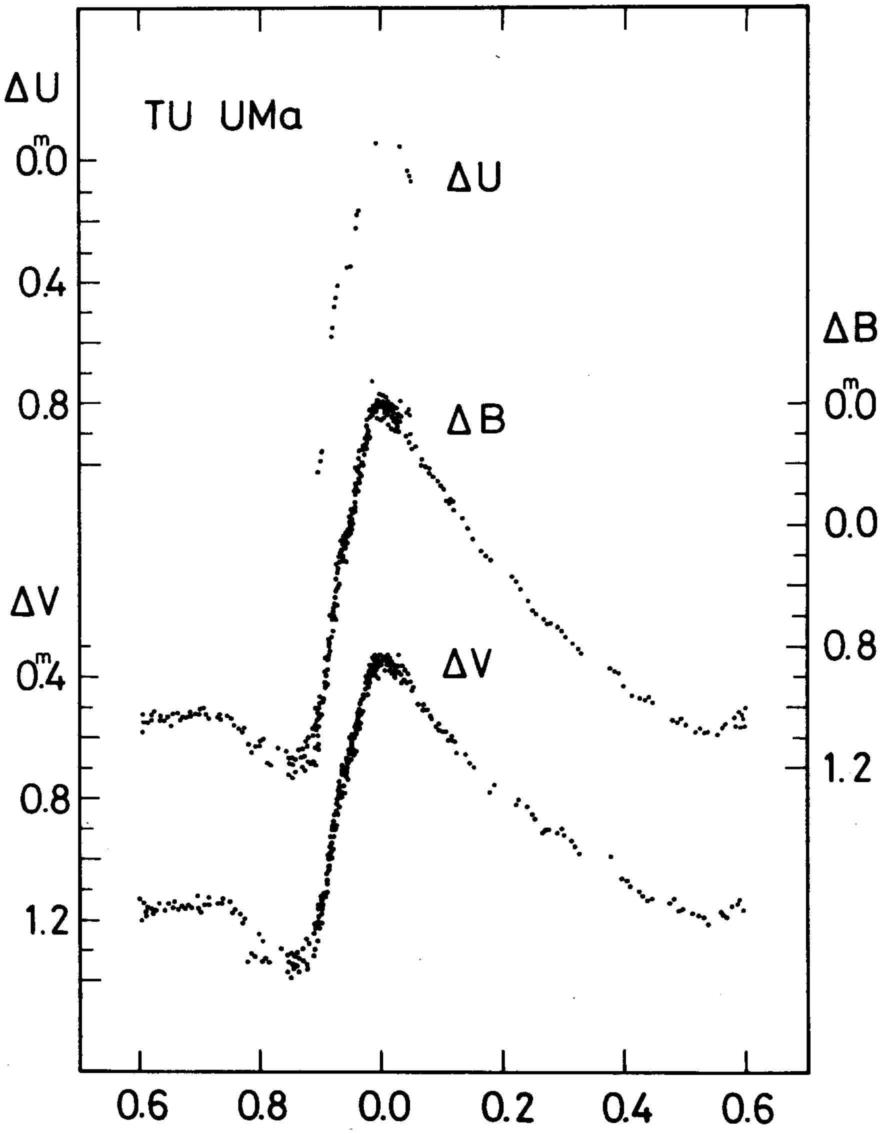

Figure 10: Light curves of TU UMa

Epstein (1969) and *Butler* et al. (1982) carried out their photometry in the uvby system. The observations of *Epstein* were lacking at maximum so no time of maximum could be deduced from these data. Fortunately, *Butler* et al. observed the star around the light maximum and we were able to determine a time of maximum from their observations.

Photoelectric observations of TU UMa were commenced at Konkoly Observatory in 1957. First the photometry was carried out in integrated light, but since 1958 the observations have been obtained in the UBV system. As the comparison star we used BD +30°2165 (8.4) (V = 8.97, B-V = +0.51, U-B = +0.05 adopted from *Geyer*, 1961; or V = 8.941, B-V = +0.558, U-B = +0.067 taken from *Sturch*, 1966). The photoelectric observations made at Konkoly Observatory are given in Table 14a-d in the sense: variable minus BD +30°2165, and are plotted against phase in Figure 10. The time of maximum light is chosen as phase 0.

Although the period of TU UMa is nearly the same as the period of RR Lyrae, there is no evidence of Blazhko effect in TU UMa which is very striking in RR Lyrae. The small differences in the height of maximum light (especially in blue light) are rather a consequence of the error in transformation into the UBV system.

The times of light maxima published or derived from observations are collected and listed in Table 9. The photoelectric and photographic maxima are taken into account using the weightings 3 and 2, respectively, while for the early visual observations w=1 was used. The visual observations made since 1957 (the first photoelectric observations) are not included in the study of period changes. A least squares solution led to the linear elements:

$$C_1 = \text{J.D.max.hel.} = \underset{\pm.0021}{2425760.4559} + \underset{\pm.00000011}{0\overset{d}{.}55765860} \cdot E$$

or the second oder approximation yields:

$$C_2 = \text{J.D.max.hel.} = \underset{\pm.0020}{2425760.4519} + \underset{\pm.00000020}{0\overset{d}{.}55765962} \cdot E - \underset{\pm.061}{0\overset{d}{.}355} \times 10^{-10} \cdot E^2$$

During the course of the last 70 years the period of TU UMa has decreased at a rate of 0.710×10^{-10} day/cycle = 0.0040 sec/year. The O-C_1 and O-C_2 values are also given in Table 9 and are plotted against epoch number in Figure 11a,b.

Cycles with a length of 23 years may be superimposed in the parabola. This may be a consequence of the duplicity of the star.

Table 9

year	J.D.max.hel.	$O - C_1$	$O - C_2$	E	method	w	Reference
1914	2420160.447	-0.0012	+0.0166	-10042	pgN	2	Robinson (1933)
1927	25006.480	-0.0215	-0.0160	- 1352	pgN	2	Guthnick, Prager (1929)
1929	25732.544	-0.0290	-0.0249	- 50	visN	1	Kukarkin (1929)
	25760.450	-0.0059	-0.0019	0	visN	1	Jacchia (1929)
1930	26066.595	-0.0155	-0.0120	+ 549	visN	1	Tsessevich (1966)
1933	27248.291	+0.0020	+0.0035	2668	visN	1	Mustel (1934)
1934	27593.480	+0.0003	+0.0013	3287	visN	1	Soloviev (1935a, b)
	27620.810	+0.0050	+0.0060	3336	visN	1	Dombrovsky (1936)
1935	27894.613	-0.0024	-0.0018	3827	visN	1	Soloviev (1935c)
1938	29040.610	+0.0062	+0.0054	5882	pgN	2	Payne-Gaposchkin (1954)
1946	32101.038	+0.0038	+0.0008	11370	visN	1	Silva (1951)
1952	34082.382	-0.0132	-0.0165	14923	vis	1	Pohl (1955)
	34091.311	-0.0067	-0.0100	14939	vis	1	-"-
	34121.420	-0.0113	-0.0146	14993	vis	1	-"-
1953	34451.5555	-0.0097	-0.0130	15585	vis	1	-"-
	34455.459	-0.0098	-0.0131	15592	vis	1	-"-
	34478.322	-0.0108	-0.0141	15633	vis	1	-"-
	34478.345	+0.0122	+0.0089	15633	pgN	2	Alania (1954)
	34484.4605	-0.0065	-0.0098	15644	vis	1	Pohl (1955)
	34498.400	-0.0085	-0.0118	15669	vis	1	-"-
1957	35925.4628	+0.0059	+0.0032	18228	pe	3	present paper
	35934.3850	+0.0056	+0.0028	18244	pe	3	-"-
	35955.572	+0.0016	-0.0012	18282	pgN	2	Boenigk (1957)
	35963.3834	+0.0058	+0.0030	18296	pe	3	present paper
	35992.3810	+0.0051	+0.0023	18348	pe	3	-"-
1958	36230.5029	+0.0068	+0.0041	18775	pe	3	-"-
	36231.6175	+0.0061	+0.0034	18777	pe	3	-"-
	36264.5207	+0.0074	+0.0048	18836	pe	3	-"-
	36278.4617	+0.0069	+0.0043	18861	pe	3	-"-
	36288.5010	+0.0084	+0.0058	18879	pe	3	-"-
1959	36604.6944	+0.0094	+0.0070	19446	pe	3	-"-
	36611.3818	+0.0049	+0.0025	19458	pe	3	Geyer (1961)
	36659.357	+0.0214	+0.0191	19544	vis	0	Ahnert (1959)
	36674.9590	+0.0090	+0.0066	19572	pe	3	Preston et al. (1961)
	36677.7450	+0.0067	+0.0043	19577	pe	3	-"-
1963	38038.9910	+0.0080	+0.0068	22018	pe	3	Preston, Paczynski (1964)
1964	38510.755	-0.0071	-0.0079	22864	pe	3	Fitch et al. (1966)
	38516.3843	+0.0456	+0.0448	22874	vis	0	Oburka (1967)
	38532.529	+0.0182	+0.0174	22903	vis	0	-"-
	38544.774	-0.0053	-0.0060	22925	pe	3	Fitch et al. (1966)
1966	39233.468:	-0.0197:	-0.0196:	24160	vis	0	Braune et al. (1970)
	39266.4555	+0.0660	+0.0661	24219	vis	0	-"-
1972	41376.549	-0.0207	-0.0174	28003	visN	0	Berdnikov (1977)
	41394.3875	-0.0273	-0.0240	28035	vis	0	Braune, Mundry (1973)
	41395.502	-0.0281	-0.0248	28037	vis	0	-"-
1973	41766.352	-0.0210	-0.0171	28702	vis	0	Braune et al. (1977)
	41776.388	-0.0229	-0.0189	28720	vis	0	-"-
	41781.411	-0.0188	-0.0148	28729	vis	0	-"-
	41805.369	-0.0401	-0.0361	28772	vis	0	Tsessevich (1974)
1975	42521.417	-0.0258	-0.0204	30056	vis	0	Braune et al. (1977)
	42530.351	-0.0143	-0.0089	30072	vis	0	-"-
1976	(42822.495	-0.0834	-0.0774	30596	pe	0)	Braune et al. (1979)
	42835.387	-0.0176	-0.0115	30619	vis	0	-"-
	42840.387	-0.0365	-0.0304	30628	vis	0	-"-

Table 9 (cont.)

year	J.D.max.hel.	$O - C_1$	$O - C_2$	E	method	w	Reference
1976	2442840.414	-0.0095	-0.0034	30628	pe	3	Braune et al. (1979)
	42859.373	-0.0109	-0.0048	30662	vis	0	-"-
	42869.402	-0.0197	-0.0136	30680	vis	0	-"-
	42899.519	-0.0163	-0.0101	30734	vis	0	-"-
	42954.729	-0.0145	-0.0082	30833	pe	3	Butler et al. (1982)
1979	43954.6141	-0.0113	-0.0028	32626	pe	3	present paper
	43977.488	-0.0014	+0.0072	32667	vis	0	Braune et al. (1981)
1980	44364.4777	-0.0268	-0.0173	33361	visN	0	Blasberg (1981)
1981	44717.491	-0.0113	-0.0010	33994	vis	0	Braune, Mundry (1982)
1983	45403.432:	+0.0096	+0.0217	35224	vis	0	Braune et al. (1983)
	45471.4485	-0.0083	+0.0040	35346	pe	3	present paper

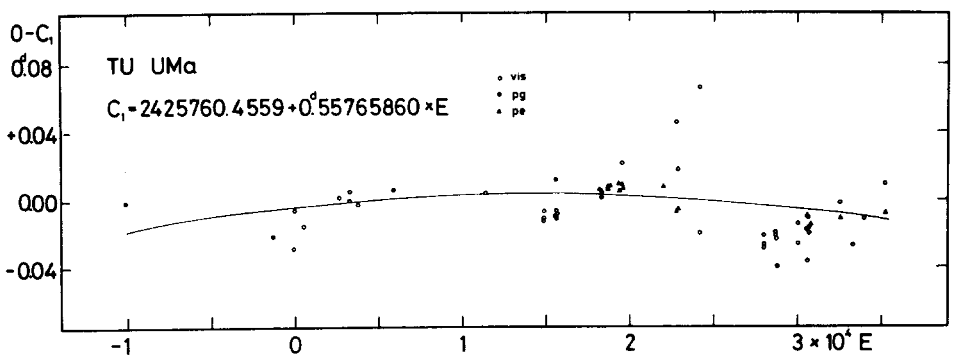

Figure 11a: $O-C_1$ diagram of TU UMa

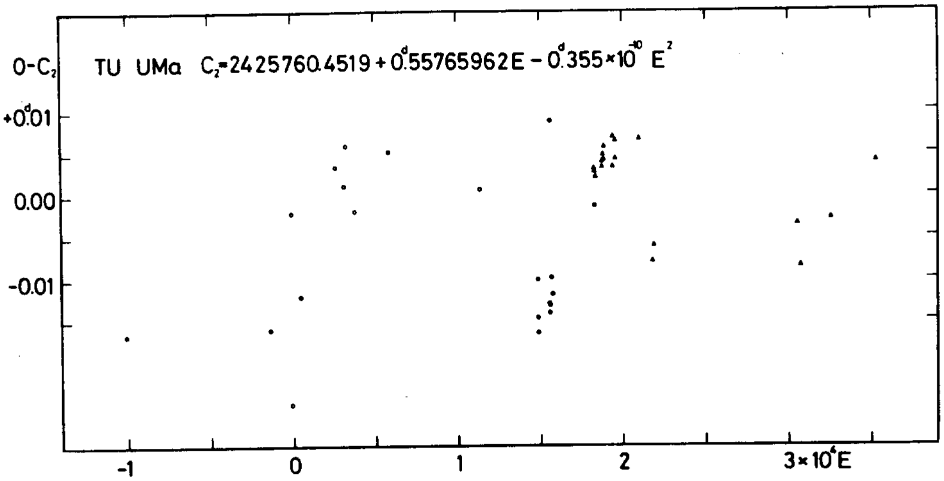

Figure 11b: $O-C_2$ diagram of TU UMa

CONCLUSIONS

In our previous paper (*Oláh* and *Szeidl*, 1978) and here we have discussed the period changes of a total of nine RR Lyrae type variable stars (AT And, SU Dra, TW Her, VZ Her, RR Leo, TT Lyn, AV Peg, AR Per and TU UMa). Table 10 summarizes the most important results on period changes.

Table 10

Parameters of period changes

star	period	Δs	period changes	time base	remark
AV Peg	$0^d.390$	0	$(+4.73\pm0.08)\cdot10^{-10}$day/day	$75\text{x}10^3\cdot P_{AV}$	cyclic var.
TW Her	0.400	2	constant	$65\text{x}10^3\cdot P_{TW}$	
AR Per	0.426	0	$(+0.55\pm0.07)\cdot10^{-10}$day/day	$63\text{x}10^3\cdot P_{AR}$	
VZ Her	0.440	4	$(+2.60\pm0.05)\cdot10^{-10}$day/day	$50\text{x}10^3\cdot P_{VZ}$	
RR Leo	0.452	8	$(+8.68\pm0.57)\cdot10^{-10}$day/day	$55\text{x}10^3\cdot P_{RR}$	cyclic var.
TU UMa	0.558	6	$(-1.27\pm0.22)\cdot10^{-10}$day/day	$45\text{x}10^3\cdot P_{TU}$	cyclic var.
TT Lyn	0.597	10	constant	$11\text{x}10^3\cdot P_{TT}$	
AT And	0.617	3	abrupt: $+710\text{x}10^{-8}$ and $-544\text{x}10^{-8}$ days	$43\text{x}10^3\cdot P_{AT}$	
SU Dra	0.660	10	constant	$40\text{x}10^3\cdot P_{SU}$	fluctuations

Even though it is untimely to conclude on any trend of changes in the periods from the few observational data, nevertheless it is striking that there is only one decreasing period.

It is worth mentioning that there are cyclic variations superimposed on the parabolic O-C diagrams of three stars: RR Leo, AV Peg and TU UMa, and the cycle lengths are 25000 $P_{RR} \approx$ 11300 days ≈ 31 years; 60000 $P_{AV} \approx$ 23400 days ≈ 64 years and 15000 $P_{TU} \approx$ 8400 days ≈ 23 years, respectively (see Figure 8 in the paper of *Oláh* and *Szeidl*, 1978, and Figures 9b and 11b of this paper). The very long cyclic variations can probably be explained by the duplicity of these stars (*Coutts*, 1971), but random fluctuations of cumulative nature in the periods may also present an explanation (*Balázs* and *Detre*, 1965).

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Table 11a

Photoelectric yellow observations of TW Her

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436756		2436758		2436761		2436776	
.4026	+0.232	.4110	-0.028	.4257	+1.022	.3974	-0.013
.4074	+0.062	.4124	.029	.4284	1.031	.4004	+0.009
.4153	-0.067	.4138	-0.019	.4312	1.035	.4011	.010
.4234	0.000	.4173	+0.020	.4382	1.020	.4018	.004
.4255	+0.022	.4188	.013	.4444	1.036	.4032	.003
.4279	.041	.4216	.029	.4472	+1.040	.4086	.046
.4335	.108	.4271	+0.066			.4096	.067
.4363	.123			2436776		.4107	.093
.4390	.132	2436760		.3547	+1.225	.4117	.098
.4446	.166	.3591	+1.253	.3554	1.216	.4128	.122
.4474	.179	.3632	1.256	.3569	1.209	.4138	.121
.4502	.190	.3653	1.250	.3573	1.186	.4147	+0.129
.4585	.264	.3740	1.145	.3596	1.189		
.4613	.285	.3761	1.112	.3608	1.170	2440419	
.4668	.321	.3802	1.013	.3617	1.172	.5137	+1.172
.4696	.379	.3823	0.977	.3638	1.128	.5151	1.144
.4890	.516	.3844	.868	.3650	1.054	.5177	1.057
.4918	.538	.3886	.701	.3659	1.057	.5190	1.016
.5002	.576	.3907	.625	.3687	0.930	.5209	0.896
.5029	.570	.3927	.566	.3694	.873	.5218	.880
.5057	.589	.3969	.320	.3701	.813	.5227	.854
.5113	.632	.3990	+0.212	.3707	.767	.5246	.766
.5140	.653	.4052	-0.004	.3714	.738	.5255	.717
.5168	.691	.4073	.031	.3721	.719	.5264	.652
.5224	.732	.4094	.031	.3745	.656	.5283	.608
.5244	.739	.4136	.047	.3752	.627	.5292	.523
.5257	.756	.4157	.010	.3758	.609	.5302	.506
.5299	.784	.4177	-0.002	.3765	.567	.5321	.464
.5313	.791	.4226	+0.031	.3772	.528	.5330	.394
.5327	.807			.3779	.489	.5338	.379
.5355	.809	2436761		.3786	.452	.5357	.199
.5369	.812	.3649	+0.913	.3807	.331	.5366	.190
.5382	.810	.3670	.931	.3814	.283	.5375	.099
.5410	.805	.3712	.921	.3821	.217	.5399	.037
.5424	+0.804	.3732	.948	.3828	.201	.5408	+0.015
		.3753	.919	.3835	.140	.5417	-0.029
2436758		.3795	.935	.3842	.124	.5436	.042
.3789	+1.053	.3816	.962	.3849	.105	.5445	.036
.3819	1.032	.3837	.963	.3872	.033	.5454	.041
.3858	0.924	.3878	.954	.3879	.005	.5475	.071
.3895	.774	.3899	.961	.3886	+0.010	.5484	.060
.3909	.717	.3920	.979	.3890	-0.020	.5493	.061
.3937	.550	.3962	.991	.3900	.026	.5519	.022
.3951	.517	.3982	1.011	.3907	.032	.5533	.028
.3965	.466	.4003	1.020	.3914	.021	.5547	-0.011
.3992	.309	.4045	1.053	.3932	.030	.5568	+0.003
.4006	.210	.4066	1.055	.3939	.030	.5582	.002
.4020	.121	.4087	1.059	.3946	.016	.5596	+0.008
.4055	+0.013	.4146	1.065	.3953	.016		
.4069	-0.008	.4173	1.036	.3960	.016	2443717	
.4083	-0.018	.4201	+1.051	.3967	-0.001	.3949	+0.262

Table 11a (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2443717		2443717		2443755		2445546	
.3976	+1.276	.4508	+0.042	.4061	-0.050	.4255	+0.018
.3990	1.299	.4528	.055	.4090	.042	.4268	.031
.4018	1.259	.4535	.050	.4102	.058	.4318	.039
.4032	1.296	.4556	+0.046	.4129	.022	.4332	.058
.4060	1.235			.4143	-0.010	.4345	.065
.4074	1.265	2443755				.4358	.092
.4185	1.024	.3558	+1.236	2445546		.4372	.129
.4199	0.972	.3595	1.220	.3868	+0.963	.4423	.183
.4223	.862	.3612	1.242	.3881	.893	.4436	.217
.4230	.773	.3643	1.210	.3895	.866	.4450	.223
.4251	.671	.3662	1.207	.3908	.777	.4463	.221
.4258	.670	.3689	1.165	.3921	.743	.4476	.229
.4278	.487	.3705	1.166	.3977	.427	.4530	.218
.4285	.460	.3770	1.020	.3990	.349	.4543	.206
.4313	.280	.3784	0.964	.4004	.239	.4556	.234
.4341	.223	.3819	.854	.4017	+0.164	.4570	.233
.4369	+0.038	.3838	.801	.4113	-0.035	.4583	.280
.4390	-0.012	.3866	.651	.4126	.051	.4639	.338
.4417	.045	.3912	.486	.4139	.073	.4652	.344
.4424	.041	.3926	.428	.4153	.063	.4666	.341
.4445	.039	.3957	.246	.4215	.046	.4679	.368
.4452	.044	.3973	.130	.4228	.037	.4692	+0.415
.4473	-0.032	.4002	+0.015	.4241	-0.007		

Table 11b

Photoelectric blue observations of TW Her

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436756		2436756		2436758		2436758	
.4015	+0.203	.4821	+0.461	.3778	+1.267	.4257	-0.081
.4061	-0.065	.4877	.511	.3812	1.218		
.4085	.148	.4904	.545	.3828	1.152	2436760	
.4146	.198	.4988	.582	.3848	1.037	.3580	+1.468
.4160	.210	.5043	.614	.3888	0.871	.3622	1.486
.4224	.173	.5099	.668	.3902	.766	.3642	1.494
.4245	.116	.5127	.694	.3930	.615	.3709	1.420
.4265	.089	.5154	.725	.3944	.528	.3729	1.365
.4321	.035	.5210	.756	.3958	.469	.3750	1.333
.4349	.021	.5237	.771	.3985	.288	.3792	1.202
.4377	-0.016	.5251	.795	.3999	.206	.3813	1.159
.4432	+0.025	.5288	.816	.4013	+0.091	.3834	1.042
.4488	.086	.5306	.829	.4048	-0.101	.3875	0.778
.4543	.139	.5320	.844	.4062	.158	.3896	.681
.4571	.180	.5348	.856	.4076	.178	.3917	.592
.4599	.203	.5362	.863	.4103	.205	.3959	.328
.4654	.250	.5376	.855	.4117	.200	.3979	.178
.4682	.299	.5403	.882	.4131	.184	.4000	+0.030
.4710	.342	.5417	+0.864	.4166	.174	.4042	-0.150
.4765	.399			.4180	.139	.4063	.187
.4793	+0.447	2436758		.4202	-0.125	.4084	-0.201

Table 11b (cont.)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436760		2440419		2443717		2443755	
.4125	−0.184	.5250	+0.787	.4282	+0.487	.4138	−0.197
.4146	.187	.5259	.746	.4303	.346		
.4167	.176	.5278	.632	.4310	.314	2445546	
.4216	−0.126	.5287	.589	.4331	.178	.3872	+1.107
		.5297	.552	.4338	.091	.3886	1.001
2436761		.5316	.454	.4358	+0.006	.3899	0.976
.3597	+1.053	.5325	.404	.4365	−0.057	.3912	.894
.3639	1.052	.5334	.272	.4386	.098	.3925	.852
.3660	1.054	.5352	.142	.4393	.170	.3981	.413
.3701	1.091	.5361	.100	.4414	.195	.3995	.289
.3722	1.103	.5370	+0.022	.4421	.223	.4008	.185
.3743	1.083	.5394	−0.113	.4442	.236	.4022	+0.095
.3784	1.092	.5403	.135	.4449	.257	.4117	−0.179
.3805	1.129	.5412	.189	.4469	.246	.4131	.261
.3826	1.120	.5431	.208	.4476	.239	.4144	.212
.3868	1.144	.5440	.209	.4497	.211	.4157	.227
.3889	1.156	.5449	.203	.4504	.201	.4219	.182
.3909	1.136	.5470	.207	.4525	.190	.4232	.209
.3951	1.165	.5479	.237	.4532	.161	.4246	.187
.3972	1.168	.5488	.225	.4553	.145	.4259	.128
.3993	1.174	.5512	.208	.4560	−0.137	.4273	.136
.4034	1.186	.5526	.193			.4322	.070
.4055	1.198	.5540	.186	2443755		.4336	.093
.4076	1.200	.5561	.147	.3550	+1.401	.4349	.088
.4159	1.216	.5575	.129	.3596	1.413	.4363	.053
.4187	1.212	.5589	−0.139	.3643	1.381	.4376	−0.003
.4243	1.194			.3690	1.342	.4427	+0.056
.4271	1.220	2443717		.3724	1.268	.4441	.071
.4298	1.208	.3928	+1.467	.3736	1.249	.4454	.094
.4368	1.243	.3969	1.490	.3764	1.222	.4467	.101
.4430	1.224	.3983	1.471	.3776	1.173	.4481	.087
.4508	+1.232	.4011	1.446	.3810	1.033	.4534	.104
		.4025	1.466	.3830	0.919	.4547	.113
2440419		.4053	1.435	.3875	.658	.4561	.169
.5130	+1.339	.4067	1.422	.3905	.487	.4574	.188
.5144	1.337	.4178	1.144	.3919	.426	.4588	.193
.5171	1.215	.4192	1.070	.3952	.237	.4643	.244
.5186	1.144	.4219	0.915	.3966	+0.139	.4657	.289
.5204	1.022	.4226	.814	.3995	−0.013	.4669	.290
.5213	0.980	.4247	.730	.4046	.169	.4683	.323
.5222	.908	.4254	.620	.4061	.191	.4697	+0.373
.5241	+0.833	.4275	+0.555	.4124	−0.181		

Table 11c

Photoelectric uv observations of TW Her

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2445546		2445546		2445546		2445546	
.3877	+1.251	.3903	+1.035	.3930	+0.902	.3999	+0.430
.3890	+1.148	.3917	+1.073	.3985	+0.523	.4012	+0.324

Table 11c (cont.)

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2445546		2445546		2445546		2445546	
.4026	+0.210	.4250	-0.028	.4431	+0.260	.4579	+0.379
.4039	+0.145	.4263	-0.002	.4445	.302	.4592	.404
.4122	-0.106	.4277	+0.023	.4458	.304	.4648	.432
.4135	.140	.4327	.106	.4472	.310	.4661	.448
.4149	.108	.4340	.073	.4485	.308	.4674	.501
.4161	.072	.4354	.128	.4538	.276	.4688	.549
.4224	.058	.4367	.139	.4551	.337	.4701	+0.557
.4237	-0.048	.4380	+0.195	.4565	+0.374		

Table 12a

Photographic observations of VZ Her

J.D.	m_{pg}	J.D.	m_{pg}	J.D.	m_{pg}	J.D.	m_{pg}
2433427		2433475		2433836		2434154	
.4037	12.22	.4061	12.19	.4892	11.06	.4653	10.79
.4058	12.10	.4102	11.92	.4921	10.79	.4684	10.77
.4078	12.03	.4123	11.96	.4947	10.81		
.4099	12.07	.4144	11.64	.4976	10.52	2434605	
.4120	12.02	.4165	11.66	.5003	10.24	.3126	10.06
.4141	11.90	.4186	11.39	.5031	10.25	.3154	10.06
.4169	11.71	.4206	11.08	.5060	10.04	.3182	9.98
.4190	11.69	.4227	10.92	.5086	9.97	.3209	10.04
.4210	11.44	.4248	10.92	.5115	10.06	.3237	10.05
.4231	11.17	.4304	10.39	.5142	9.98	.3265	10.08
.4252	11.22	.4324	10.34	.5170	10.06	.3293	10.02
.4273	11.01	.4345	10.23	.5198	10.17	.3320	10.04
.4294	10.84	.4408	10.09	.5281	10.14	.3376	10.18
.4328	10.57	.4429	10.07	.5336	10.23	.3487	10.29
.4349	10.65	.4449	10.06	.5392	10.42	.3515	10.32
.4405	10.28	.4470	10.02	.5421	10.51	.3543	10.35
.4426	10.16	.4512	10.10	.5448	10.55	.3584	10.47
.4467	10.03	.4533	10.27	.5475	10.52	.3626	10.57
.4488	10.13	.4554	10.34			.3653	10.56
.4508	10.27	.4575	10.24	2434154		.3682	10.64
.4530	10.16	.4595	10.24	.4246	10.34	.3709	10.64
.4572	10.42	.4616	10.32	.4288	10.26	.3737	10.60
.4613	10.45	.4637	10.45	.4309	10.26	.3793	10.65
.4634	10.46	.4658	10.38	.4329	10.33	.3848	10.78
.4655	10.53	.4679	10.43	.4350	10.45	.3876	10.73
.4696	10.51	.4699	10.59	.4392	10.44	.3904	10.77
.4717	10.57	.4720	10.48	.4413	10.40	.3932	10.74
.4759	10.70	.4741	10.62	.4434	10.47	.3959	10.87
		.4762	10.63	.4454	10.56	.3987	10.86
2433475		.4783	10.64	.4475	10.52		
.3852	12.23	.4804	10.63	.4496	10.56	2435339	
.3894	12.20			.4538	10.69	.3197	11.20
.3956	12.24	2433836		.4559	10.67	.3218	11.11
.3977	12.29	.4810	11.84	.4580	10.65	.3260	11.01
.3998	12.29	.4836	11.55	.4600	10.75	.3281	10.59
.4040	12.12	.4865	11.57	.4621	10.67	.3302	10.48

Table 12a (cont.)

J.D.	m_{pg}	J.D.	m_{pg}	J.D.	m_{pg}	J.D.	m_{pg}
2435339		2435339		2435991		2435991	
.3322	10.34	.3542	10.20	.4415	11.73	.4651	10.16
.3343	10.24			.4443	11.59	.4776	10.10
.3364	10.01	2435991		.4470	11.42	.4804	10.08
.3385	10.01	.4276	12.19	.4498	11.26	.4845	10.27
.3406	10.05	.4304	12.14	.4526	10.72	.4915	10.36
.3447	9.94	.4359	11.96	.4554	10.59	.4943	10.46
.3468	9.97	.4387	11.98	.4595	10.44	.4970	10.40
.3500	10.05						

Table 12b

Photoelectric yellow observations of VZ Her

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436363		2436364		2436399		2436420	
.4645	+0.951	.4026	+0.499	.4501	+0.939	.3468	-0.244
.4674	0.982	.4075	.288	.4558	.929	.3521	.219
.4733	1.054	.4104	.182	.4586	.927	.3565	.189
.4762	1.040	.4137	+0.054	.4613	.925	.3596	.177
.4798	1.061	.4169	-0.059	.4666	.921	.3657	-0.135
.4849	1.055	.4190	.147	.4693	.918		
.4878	1.063	.4211	.173	.4721	.905	2436728	
.4935	1.083	.4233	.207	.4777	.922	.5196	+1.077
.4995	1.075	.4255	.222	.4804	.942	.5214	1.061
.5025	1.049	.4277	.212	.4832	.955	.5274	1.075
.5056	0.988	.4319	.196	.4888	.963	.5293	1.073
.5112	.944	.4342	.155	.4916	.963	.5335	1.055
.5146	.851	.4364	.132	.4943	.973	.5376	1.015
.5176	.721	.4386	.148	.4999	.961	.5429	0.883
.5234	.457	.4408	-0.141	.5027	.960	.5448	+0.880
.5265	.322			.5047	.978		
.5295	+0.198	2436398		.5106	.933	2436758	
.5357	-0.060	.3856	+0.138	.5131	+0.937	.4408	+0.999
.5386	.130	.3897	.198			.4453	1.058
.5418	.167	.3982	.261	2436405		.4475	1.052
.5480	.222	.4028	.254	.3474	+0.948	.4517	1.072
.5510	-0.202	.4061	.279	.3532	.492	.4537	1.043
		.4117	.333	.3557	.323	.4633	1.073
2436364		.4143	.346	.3584	+0.144	.4656	1.063
.3584	+1.067	.4171	.385	.3613	-0.022	.4708	1.049
.3637	1.058	.4260	.445	.3657	.112	.4736	1.046
.3697	1.033	.4288	.440	.3687	.170	.4764	1.026
.3724	1.069	.4343	.484	.3784	.207	.4819	0.923
.3753	1.033	.4370	.497	.3916	.110	.4847	.881
.3801	1.053	.4458	.556	.3968	.052	.4875	.843
.3827	1.021	.4489	.561	.4024	.016	.4930	.573
.3855	0.985	.4517	+0.560	.4079	-0.014	.4945	.523
.3890	.965					.4959	.475
.3938	.870	2436399		2436420		.4992	.298
.3967	.741	.4441	+0.953	.3280	+0.295	.5006	.205
.3998	+0.633	.4469	+0.945	.3346	+0.029	.5022	+0.138

Table 12b (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436758		2436807		2436808		2440418	
.5056	+0.008	.3575	+0.946	.3895	+0.507	.5406	-0.137
.5070	-0.010	-3581	.936	.3910	.546	.5434	.123
.5084	.057	.3613	.871	.3956	.585	.5448	-0.122
.5119	.154	.3620	.845	.3971	.582		
.5133	.166	.3627	.802	.4004	.612	2440419	
.5154	.169	.3635	.798	.4020	.633	.3732	+0.828
.5188	.191	.3643	.763	.4036	.621	.3753	.716
.5209	.197	.3662	.720	.4069	+0.645	.3795	.606
.5260	.167	.3670	.692			.3816	.480
.5281	.146	.3678	.681	2440418		.3857	.230
.5302	.155	.3687	.668	.4733	+1.082	.3878	+0.152
.5354	.119	.3694	.649	.4747	1.067	.3920	-0.003
.5382	.084	.3714	.579	.4774	1.061	.3941	.081
.5409	.072	.3721	.526	.4788	1.056	.3982	.173
.5465	-0.020	.3728	.464	.4816	1.053	.4003	.207
		.3735	.438	.4830	1.023	.4045	.200
2436760		.3743	.376	.4856	0.977	.4066	.191
.4624	+0.748	.3760	.290	.4865	.951	.4107	.181
.4645	.772	.3768	.244	.4883	.928	.4128	.176
.4690	.802	.3776	.253	.4892	.904	.4170	.166
.4711	.779	.3784	.198	.4913	.839	.4191	.158
.4732	.811	.3807	.060	.4923	.812	.4232	.152
.4773	.813	.3816	.047	.4941	.758	.4253	-0.127
.4854	.862	.3824	+0.036	.4950	.723		
.4882	.902	.3831	-0.019	.4969	.668	2443721	
.4910	.905	.3839	.031	.4978	.647	.3833	+1.008
.4924	.908	.3848	.066	.4997	.539	.3842	1.040
.4938	.913	.3868	.111	.5006	.440	.3861	1.009
.4975	.901	.3875	.135	.5024	.329	.3870	1.046
.5009	.898	.3883	.134	.5033	.315	.3898	0.990
.5030	.927	.3891	.155	.5052	.224	.3916	.992
.5176	.947	.3898	.168	.5062	.160	.3926	.962
.5197	.956	.3918	.191	.5080	.111	.3944	.915
.5259	.939	.3926	.183	.5089	.101	.3953	.913
.5280	.920	.3935	.191	.5108	+0.019	.3972	.917
.5343	.915	.3943	.191	.5117	-0.076	.3981	.877
.5405	.933	.3952	.175	.5135	.112	.4000	.789
.5426	+0.949	.3972	.206	.5145	.138	.4009	.748
		.3980	.188	.5163	.154	.4027	.740
2436807		.3990	.202	.5173	.184	.4037	.672
.3423	+1.069	.3999	.190	.5191	.198	.4055	.596
.3443	1.068	.4041	.204	.5200	.202	.4064	.581
.3451	1.068	.4080	.171	.5219	.227	.4092	.452
.3459	1.060	.4123	-0.137	.5228	.228	.4111	.322
.3467	1.060			.5247	.233	.4120	.258
.3475	1.040	2436808		.5256	.224	.4139	.185
.3509	1.061	.3431	+0.219	.5274	.223	.4148	.167
.3517	1.053	.3466	.216	.5284	.214	.4166	.110
.3524	1.025	.3723	.393	.5309	.184	.4176	+0.063
.3532	1.043	.3814	.445	.5323	.185	.4194	-0.033
.3554	0.961	.3830	.471	.5351	.172	.4222	.137
.3561	.963	.3846	.487	.5365	.168	.4231	.154
.3568	+0.956	.3879	+0.489	.5392	-0.138	.4250	-0.202

Table 12b (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2443721		2443721		2443721		2443721	
.4259	-0.208	.4314	-0.230	.4368	-0.244	.4423	-0.160
.4277	.209	.4333	.251	.4382	.219	.4451	.147
.4287	.222	.4342	-0.241	.4409	-0.169	.4465	-0.133
.4305	-0.223						

Table 12c

Photoelectric blue observations of VZ Her

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436363		2436364		2436399		2436728	
.4628	+0.855	.4200	-0.590	.4791	+0.882	.5267	+0.916
.4660	.865	.4222	.620	.4818	.878	.5284	.904
.4720	.921	.4266	.653	.4874	.876	.5325	.897
.4747	.938	.4308	.619	.4902	.865	.5344	.898
.4778	.944	.4332	.609	.4929	.860	.5365	.871
.4834	.961	.4353	.606	.4985	.830	.5416	.767
.4863	.940	.4375	.610	.5013	.839	.5439	.731
.4920	.946	.4396	.598	.5037	.821	.5462	+0.590
.4979	.964	.4420	-0.552	.5096	.787		
.5010	.955			.5117	.779	2436758	
.5041	.893	2436398		.5145	+0.783	.4389	+0.880
.5097	.778	.3839	-0.196			.4442	.906
.5128	.686	.3879	.162	2436405		.4465	.946
.5161	.592	.3912	.086	.3488	+0.593	.4516	.962
.5219	.253	.3978	.056	.3545	.134	.4548	.952
.5249	+0.096	.4010	-0.011	.3571	+0.007	.4598	.965
.5280	-0.039	.4045	+0.025	.3598	-0.136	.4621	.965
.5341	.371	.4103	.062	.3628	.338	.4644	.953
.5371	.500	.4157	.113	.3672	.548	.4694	.922
.5403	.602	.4214	.134	.3695	.591	.4722	.915
.5464	.624	.4246	.151	.3759	.625	.4750	.901
.5496	-0.582	.4273	.188	.3863	.573	.4805	.824
		.4329	.227	.3930	.505	.4833	.801
2436364		.4356	.239	.4038	.382	.4861	.744
.3570	+0.946	.4385	.274	.4093	-0.336	.4938	.365
.3624	.954	.4444	.305			.4952	.308
.3682	.974	.4475	.335	2436420		.4985	+0.079
.3711	.984	.4503	+0.348	.3292	-0.006	.4999	-0.012
.3787	.940			.3456	.622	.5013	.095
.3814	.909	2436399		.3480	.615	.5050	.270
.3841	.880	.4427	+0.870	.3505	.609	.5063	.370
.3869	.832	.4455	.866	.3549	.572	.5077	.408
.3924	.719	.4485	.878	.3581	.554	.5112	.515
.3952	.638	.4544	.857	.3612	.554	.5126	.579
.3983	.476	.4572	.857	.3672	-0.522	.5140	.584
.4012	.339	.4600	.848			.5181	.611
.4061	+0.066	.4652	.856	2436728		.5195	.618
.4089	-0.083	.4679	.836	.5186	+0.953	.5209	.605
.4119	.232	.4707	.832	.5205	.939	.5250	.595
.4153	-0.443	.4763	+0.857	.5249	+0.938	.5271	-0.571

Table 12c (cont.)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436758		2436808		2440418		2443721	
.5291	-0.551	.3903	+0.344	.5196	-0.637	.3865	+0.879
.5340	.518	.3935	.356	.5214	.655	.3884	.921
.5368	.482	.3964	.374	.5223	.650	.3893	.903
.5396	.477	.3997	.377	.5242	.667	.3912	.857
.5451	-0.414	.4012	.383	.5251	.664	.3921	.838
		.4028	.398	.5270	.668	.3939	.827
2436760		.4063	+0.420	.5279	.652	.3949	.824
.4614	+0.641			.5302	.655	.3967	.778
.4634	.641	2440418		.5316	.641	.3977	.740
.4680	.679	.4728	+0.915	.5344	.623	.3995	.675
.4700	.677	.4740	.902	.5358	.624	.4004	.655
.4721	.687	.4767	.893	.5385	.612	.4023	.513
.4763	.738	.4781	.912	.5399	.583	.4032	.501
.4875	.761	.4809	.884	.5427	.567	.4051	.389
.4903	.764	.4823	.888	.5441	-0.542	.4060	.377
.4917	.766	.4851	.840			.4078	.316
.4931	.770	.4860	.761	2440419		.4088	.224
.4965	.768	.4878	.726	.3725	+0.648	.4106	.095
.4999	.775	.4887	.682	.3746	.567	.4115	+0.083
.5020	.779	.4909	.654	.3788	.394	.4134	-0.026
.5187	.846	.4918	.645	.3809	.218	.4143	.097
.5228	.874	.4937	.586	.3850	+0.002	.4162	.188
.5249	.867	.4946	.536	.3871	-0.111	.4171	.243
.5270	.869	.4964	.463	.3913	.346	.4189	.324
.5312	.870	.4973	.400	.3934	.465	.4199	.364
.5332	.855	.4992	.299	.3975	.601	.4217	.428
.5353	.848	.5001	.232	.3996	.656	.4227	.486
.5394	.831	.5020	.124	.4038	.676	.4245	.585
.5415	.815	.5029	+0.076	.4059	.682	.4273	.644
.5436	+0.821	.5048	-0.018	.4100	.676	.4282	.633
		.5057	.056	.4121	.657	.4301	.605
2436808		.5075	.138	.4163	.617	.4310	.618
.3422	-0.099	.5084	.220	.4184	.609	.4328	.611
.3456	+0.061	.5103	.336	.4225	.564	.4338	.615
.3736	.214	.5112	.381	.4246	-0.517	.4375	.590
.3756	.232	.5131	.472			.4402	.586
.3805	.265	.5140	.519	2443721		.4416	.568
.3822	.273	.5158	.581	.3828	+0.912	.4444	.530
.3839	.275	.5167	.617	.3838	.891	.4458	-0.519
.3872	+0.296	.5187	-0.632	.3856	+0.897		

Table 12d

Photoelectric uv observations of VZ Her

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2440419		2440419		2440419		2440419	
.3718	+0.543	.3864	-0.173	.4031	-0.669	.4156	-0.671
.3759	.527	.3906	.317	.4052	.671	.4177	.630
.3781	.384	.3927	.380	.4093	.656	.4218	.504
.3802	+0.214	.3968	.631	.4114	-0.697	.4239	-0.501
.3843	-0.017	.3989	-0.655				

Table 13a

Photographic observations of AV Peg

J.D.	m_{pg}	J.D.	m_{pg}	J.D.	m_{pg}	J.D.	m_{pg}
2433884		2434600		2435343		2435393	
.5414	10.89	.4768	11.10	.3941	9.73	.3878	10.13
.5441	10.67	.4796	11.00	.4024	9.63	.3941	10.31
.5462	10.36	.4823	10.94	.4079	9.65	.3961	10.29
.5482	10.41	.4851	10.84	.4135	9.69	.3982	10.28
.5524	10.21	.4879	10.50	.4163	9.72	.4107	10.45
.5546	10.13	.4907	10.63	.4191	9.85	.4128	10.52
.5566	10.02	.4935	10.27	.4218	9.92	.4170	10.46
.5587	10.10	.4962	10.20	.4246	9.86	.4189	10.54
.5607	10.05	.4990	10.10	.4274	9.95		
.5629	9.84	.5018	9.95	.4302	9.96	2435395	
.5670	9.85	.5046	10.07	.4329	10.15	.2895	10.79
.5711	9.91	.5073	9.81	.4357	10.16	.2916	10.68
.5733	9.89	.5101	9.86	.4385	10.13	.2937	10.44
.5753	10.06	.5129	9.75	.4413	10.23	.2957	10.37
.5775	10.00	.5157	9.86			.2978	10.35
.5795	10.15	.5185	9.80	2435393		.2999	10.15
.5817	10.21	.5240	9.94	.3378	10.48	.3041	9.92
.5837	10.11	.5268	10.02	.3390	10.50	.3062	9.86
.5858	10.22	.5296	10.00	.3420	10.42	.3082	9.78
		.5323	9.90	.3441	10.27	.3103	9.67
2434598		.5351	9.98	.3461	10.26	.3124	9.73
.5461	10.29	.5379	10.07	.3503	9.96	.3166	9.85
.5489	10.09	.5407	10.16	.3524	10.07	.3187	9.87
.5517	9.91	.5435	10.30	.3545	10.03	.3207	9.84
.5572	9.84			.3566	9.73	.3228	9.85
.5600	9.73	2435343		.3586	9.76	.3249	10.03
.5628	9.74	.3538	11.18	.3607	9.81	.3270	10.02
.5656	9.65	.3566	11.22	.3628	9.74	.3291	10.13
.5684	9.83	.3593	10.90	.3649	9.85	.3312	10.19
.5711	9.71	.3621	10.93	.3670	9.79	.3353	10.18
.5739	9.95	.3649	10.60	.3691	9.93	.3374	10.12
.5795	9.89	.3732	10.42	.3711	9.87	.3395	10.19
.5822	10.07	.3760	10.32	.3753	9.95	.3416	10.37
.5850	10.11	.3788	10.17	.3795	9.98	.3437	10.36
		.3885	9.79	.3836	10.07	.3499	10.45
2434600		.3913	9.69	.3857	10.11	.3582	10.65
.4740	11.25						

Table 13b

Photoelectric observations of AV Peg in integrated light

J.D.	Δm	J.D.	Δm	J.D.	Δm	J.D.	Δm
2435069		2435069		2435069		2435069	
.3133	+1.356	.3208	+1.077	.3272	+0.880	.3332	+0.661
.3143	.342	.3219	.068	.3282	.866	.3341	.636
.3152	.307	.3228	.061	.3291	.843	.3351	.609
.3162	.276	.3236	1.026	.3299	.790	.3361	.564
.3176	+1.215	.3242	+0.984	.3305	+0.772	.3368	+0.535

Table 13b (cont.)

J.D.	Δm	J.D.	Δm	J.D.	Δm	J.D.	Δm
2435069		2435069		2435069		2435069	
.3399	+0.442	.3498	+0.401	.3581	+0.395	.3679	+0.468
.3409	.422	.3505	.389	.3614	.451	.3687	.476
.3419	.419	.3513	.381	.3623	.442	.3693	.501
.3430	.401	.3545	.363	.3630	.435	.3700	.506
.3467	.398	.3552	.362	.3638	.452	.3708	.503
.3474	.394	.3559	.375	.3646	.452	.3716	.515
.3481	.382	.3566	.382	.3653	+0.464	.3724	+0.525
.3491	+0.394	.3573	+0.388				

Table 13c

Photoelectric yellow observations of AV Peg

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436795		2436804		2436804		2436804	
.5057	+0.498	.4983	+0.504	.5281	+0.170	.5460	-0.296
.5077	.530	.5013	.480	.5285	.155	.5464	.333
.5117	.532	.5029	.478	.5288	.152	.5469	.332
.5135	.529	.5043	.480	.5292	.128	.5473	.345
.5154	.524	.5078	.503	.5295	.120	.5497	.385
.5191	.497	.5085	.472	.5299	.137	.5500	.397
.5223	.515	.5091	.498	.5302	.113	.5504	.397
.5230	.520	.5098	.469	.5306	.102	.5506	.403
.5397	.438	.5105	.467	.5309	.078	.5510	.398
.5442	.317	.5129	.418	.5311	.098	.5515	.417
.5463	.265	.5135	.412	.5328	.070	.5518	.413
.5484	.224	.5142	.412	.5331	.031	.5524	.425
.5532	+0.046	.5149	.384	.5335	.012	.5530	.431
.5560	-0.005	.5156	-378	.5338	.013	.5532	.444
.5588	.076	.5163	.386	.5341	.002	.5551	.427
.5640	.198	.5170	.369	.5345	+0.004	.5554	.437
.5661	.248	.5190	.397	.5348	-0.006	.5558	.448
.5682	.308	.5194	.381	.5352	.009	.5561	.448
.5734	.436	.5198	.364	.5355	.043	.5565	.458
.5761	.465	.5201	.369	.5358	.061	.5568	.442
.5789	.476	.5205	.362	.5372	.093	.5572	.453
.5845	.462	.5208	.370	.5375	.106	.5575	.456
.5883	.492	.5212	.315	.5379	.115	.5579	.471
.5907	-0.479	.5215	.360	.5382	.127	.5581	.468
		.5219	.337	.5387	.107	.5600	.458
2436804		.5221	.329	.5390	.139	.5608	.469
.4754	+0.532	.5234	.303	.5393	.133	.5615	.486
.4804	.492	.5237	.293	.5397	.166	.5622	.495
.4832	.488	.5241	.251	.5400	.154	.5629	.518
.4846	.527	.5244	.248	.5403	.156	.5635	.508
.4860	.487	.5248	.241	.5420	.191	.5642	.495
.4892	.487	.5251	.242	.5424	.203	.5675	.488
.4906	.512	.5255	.236	.5427	.194	.5691	.503
.4920	.510	.5258	.230	.5443	.245	.5705	.491
.4955	.488	.5262	.223	.5450	.244	.5748	.462
.4969	+0.501	.5264	+0.227	.5455	-0.280	.5770	-0.443

Table 13c (cont.)

J.D.	ΔV
2436804	
.5800	-0.439
.5816	.421
.5830	.430
.5846	.393
.5888	.371
.5904	.361
.5925	.314
.5953	.326
.5971	.312
.5985	-0.228
2436805	
.5125	+0.252
.5170	.250
.5194	.235
.5215	.264
.5264	.243
.5284	.250
.5337	.264
.5357	.300
.5378	.297
.5420	.309
.5441	.286
.5462	.255
.5503	.277
.5524	.280
.5545	.287
.5607	.305
.5628	.327
.5670	.354
.5691	.359
.5712	.350
.5753	.371
.5774	.370
.5795	.363
.5837	.370
.5857	.396
.5878	.396
.5923	.372
.5951	.354
.5979	+0.365
2436814	
.3639	-0.247
.3695	.234
.3710	.219
.3738	.217
.3751	.203
.3765	.191
.3793	.160
.3807	.163
.3821	.170
.3861	-0.152
2436814	
.3882	-0.145
.3903	.137
.3956	.104
.3986	.063
.4028	.097
.4049	.082
.4091	-0.047
.4132	+0.005
.4153	.010
.4174	.006
.4216	.028
.4236	.021
.4257	.048
.4316	.084
.4337	.084
.4358	.081
.4400	.091
.4420	.119
.4441	.121
.4483	.123
.4504	.149
.4525	.149
.4566	.152
.4587	.162
.4608	.155
.4660	.167
.4688	.174
.4716	.173
.4771	.183
.4799	.211
.4827	.218
.4870	.219
.4883	.224
.4903	.230
.4945	+0.209
2440506	
.4451	+0.215
.4465	.153
.4493	+0.037
.4507	-0.002
.4674	.464
.4688	.479
.4715	.478
.4757	.522
.4771	.482
.4799	.473
.4813	.475
.4840	.492
.4854	.472
.4882	.447
.4896	-0.444
2441589	
.3606	-0.293
.3620	.353
.3634	.374
.3662	.401
.3676	.436
.3690	.451
.3710	.489
.3724	.498
.3738	.485
.3766	.475
.3780	.474
.3794	.471
.3822	.459
.3836	.451
.3850	.447
.3877	.436
.3891	.419
.3905	-0.403
2441963	
.3145	+0.335
.3159	.276
.3194	.174
.3235	.128
.3245	.157
.3273	.059
.3287	+0.035
.3308	-0.030
.3322	.052
.3350	.121
.3364	.161
.3391	.241
.3401	.313
.3426	.335
.3440	.377
.3467	.464
.3481	.495
.3506	.487
.3520	.498
.3544	.507
.3558	.493
.3585	.506
.3599	.461
.3627	.456
.3641	.435
.3669	.398
.3683	.395
.3710	.379
.3720	.386
.3745	.372
.3759	-0.345
2443722	
2443722	
.3388	+0.420
.3399	.384
.3723	.388
.3461	.367
.3473	.340
.3498	.255
.3511	.248
.3536	.190
.3548	+0.153
.3609	-0.073
.3619	.091
.3644	.104
.3656	.149
.3682	.213
.3695	.238
.3728	.335
.3753	.394
.3790	.443
.3800	.432
.3824	.429
.3834	.445
.3857	.434
.3868	.458
.3893	-0.445
2443765	
.2886	+0.383
.2913	.316
.2927	.219
.2955	.169
.2969	.102
.2997	+0.027
.3011	-0.050
.3038	.171
.3052	.191
.3080	.239
.3094	.274
.3122	.314
.3136	.369
.3163	.425
.3177	.467
.3205	.485
.3219	.519
.3247	.535
.3261	.531
.3288	.503
.3302	.488
.3330	.469
.3344	.431
.3372	.441
.3386	-0.403
2444133	

Table 13c (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2444133		2445230		2445566		2445622	
.4199	+0.245	.3744	+0.238	.4802	+0.416	.3041	+0.396
.4211	.198	.3757	+0.192	.4815	.357	.3055	.384
.4242	+0.067	.3818	-0.065	.4829	.342	.3068	.359
.4284	-0.036	.3831	.127	.4901	.230	.3082	.324
.4300	.098	.3845	.130	.4914	.194	.3095	.296
.4331	.193	.3859	.167	.4928	.126	.3151	.137
.4347	.233	.3873	.174	.4941	.095	.3164	.106
.4375	.290	.3928	.287	.4954	+0.053	.3178	.058
.4390	.353	.3942	.319	.5031	-0.204	.3191	+0.009
.4418	.437	.3956	.368	.5044	.233	.3205	-0.013
.4437	.471	.3969	.394	.5058	.254	.3265	.185
.4465	.489	.3983	.417	.5071	.279	.3279	.227
.4482	.502	.4044	.457	.5085	.341	.3292	.272
.4515	.479	.4057	.482	.5144	.481	.3305	.315
.4531	.488	.4071	.502	.5157	.492	.3318	.353
.4563	.476	.4085	.485	.5171	.510	.3388	.474
.4577	.479	.4099	-0.498	.5184	.520	.3402	.490
.4608	.460			.5240	.529	.3415	.489
.4623	.453	2445566		.5291	.468	.3428	.492
.4655	.402	.4530	+0.536	.5304	.454	.3442	.497
.4668	-0.400	.4543	.543	.5317	.439	.3499	.521
		.4557	.565	.5331	.430	.3512	.488
2445230		.4571	.543	.5344	.417	.3526	.473
.3577	+0.473	.4645	.527	.5418	.392	.3539	.469
.3590	.478	.4658	.508	.5431	.358	.3553	.447
.3604	.459	.4672	.544	.5445	.373	.3611	.408
.3632	.423	.4685	.498	.5458	.384	.3625	.415
.3702	.334	.4698	.534	.5472	-0.361	.3639	.392
.3716	.293	.4775	.457			.3652	.390
.3730	+0.259	.4789	+0.436	2445622		.3666	-0.372

Table 13d

Photoelectric blue observations of AV Peg

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436795		2436795		2436804		2436804	
.5046	+0.753	.5574	+0.049	.4797	+0.759	.5698	-0.528
.5067	.787	.5629	-0.151	.4825	.803	.5733	.509
.5108	.773	.5650	.214	.4839	.760	.5747	.498
.5126	.777	.5671	.294	.4853	.798	.5763	.459
.5145	.767	.5720	.474	.4885	.783	.5793	.440
.5182	.773	.5748	.513	.4899	.807	.5807	.424
.5202	.778	.5775	.540	.4913	.777	.5823	.412
.5211	.748	.5831	.533	.4948	.803	.5837	.408
.5386	.622	.5873	.532	.4962	.776	.5881	.341
.5432	.541	.5893	-0.517	.4976	.752	.5897	.326
.5452	.470			.5022	.752	.5916	.303
.5473	.443	2436804		.5036	+0.733	.5946	.273
.5518	.216	.4747	+0.757	.5668	-0.518	.5962	.253
.5546	+0.138	.4784	+0.760	.5682	-0.508	.5978	-0.243

Table 13d (cont.)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436805		2436814		2441589		2443722	
.5114	+0.458	.4327	+0.264	.3815	-0.540	.3638	-0.066
.5159	.460	.4348	.250	.3829	.531	.3650	.057
.5180	.486	.4389	.286	.3843	.526	.3675	.144
.5205	.464	.4410	.288	.3870	.508	.3688	.207
.5253	.500	.4431	.312	.3884	.494	.3712	.331
.5274	.518	.4473	.303	.3898	-0.481	.3723	.352
.5326	.482	.4493	.319			.3748	.431
.5347	.509	.4514	.358	2441963		.3759	.455
.5409	.520	.4556	.362	.3138	+0.566	.3785	.512
.5430	.539	.4577	.373	.3152	.535	.3795	.535
.5451	.526	.4598	.351	.3187	.413	.3819	.543
.5493	.563	.4646	.385	.3228	.339	.3830	.578
.5514	.543	.4674	.387	.3242	.315	.3852	.551
.5534	.552	.4702	.387	.3266	.232	.3863	.551
.5576	.565	.4757	.420	.3280	.156	.3888	.524
.5597	.579	.4785	.419	.3301	.028	.3899	-0.519
.5618	.592	.4813	.418	.3315	+0.011		
.5659	.586	.4861	.445	.3343	-0.118	2443765	
.5680	.608	.4877	.453	.3357	.160	.2906	+0.547
.5701	.579	.4893	.456	.3384	.252	.2920	.480
.5743	.594	.4934	+0.444	.3394	.297	.2948	.383
.5764	.615			.3419	.370	.2962	.310
.5784	.604	2440506		.3433	.408	.2990	.132
.5826	.597	.4444	+0.386	.3460	.491	.3004	+0.052
.5847	.616	.4458	.266	.3474	.498	.3031	-0.017
.5868	.626	.4486	.172	.3499	.524	.3045	.068
.5909	.600	.4500	+0.082	.3513	.553	.3073	.119
.5965	.652	.4667	-0.461	.3537	.553	.3087	.175
.6010	+0.660	.4681	.487	.3551	.567	.3115	.237
		.4708	.523	.3578	.534	.3129	.285
2436814		.4722	.520	.3592	.536	.3156	.385
.3622	-0.228	.4750	.565	.3620	.508	.3170	.440
.3681	.192	.4764	.558	.3634	.517	.3198	.514
.3703	.155	.4792	.552	.3662	.466	.3212	.541
.3731	.144	.4806	.558	.3676	.445	.3240	.569
.3745	.145	.4833	.544	.3703	.415	.3254	.595
.3758	.131	.4847	.514	.3717	.405	.3281	.567
.3786	.091	.4875	.480	.3738	.403	.3295	.561
.3851	.063	.4889	-0.455	.3752	-0.395	.3323	.530
.3872	.063					.3337	.522
.3893	.031	2441589		2443722		.3365	.517
.3934	-0.024	.3599	-0.274	.3393	+0.582	.3379	-0.505
.3955	+0.019	.3613	.341	.3418	.564		
.3976	.034	.3627	.385	.3430	.567	2444133	
.4018	.016	.3655	.463	.3454	.516	.4194	+0.359
.4059	.038	.3669	.490	.3467	.508	.4204	.303
.4122	.106	.3683	.499	.3492	.424	.4235	.196
.4143	.126	.3703	.539	.3506	.430	.4248	.129
.4164	.133	.3717	.544	.3529	.315	.4277	+0.042
.4205	.158	.3731	.559	.3542	.322	.4293	-0.016
.4226	.187	.3759	.545	.3569	.176	.4324	.125
.4247	.211	.3773	.545	.3581	+0.151	.4339	.182
.4306	+0.256	.3787	-0.541	.3614	-0.010	.4369	-0.259

Table 13d (cont.)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2444133		2445230		2445566		2445622	
.4383	-0.352	.3932	-0.297	.4932	+0.252	.3073	+0.554
.4410	.422	.3946	.350	.4945	.184	.3086	.522
.4425	.471	.3960	.420	.4959	+0.137	.3099	.477
.4457	.518	.3974	.457	.5035	-0.203	.3155	.276
.4474	.533	.3988	.492	.5049	.231	.3169	.212
.4506	.530	.4048	.527	.5062	.236	.3182	.140
.4523	.534	.4062	.573	.5076	.291	.3196	.103
.4554	.522	.4076	.557	.5089	.366	.3209	+0.047
.4569	.517	.4090	.576	.5148	.508	.3270	-0.179
.4600	.499	.4104	-0.564	.5161	.550	.3283	.239
.4616	.495			.5175	.577	.3296	.288
.4645	.463	2445566		.5189	.577	.3310	.327
.4662	-0.448	.4535	+0.909	.5245	.599	.3323	.381
		.4548	.890	.5262	.555	.3393	.548
2445230		.4562	.852	.5295	.527	.3406	.553
.3581	+0.749	.4575	.874	.5308	.522	.3419	.566
.3594	.733	.4649	.838	.5322	.506	.3433	.570
.3609	.720	.4662	.842	.5335	.490	.3446	.571
.3636	.706	.4676	.824	.5349	.492	.3503	.557
.3707	.530	.4690	.823	.5422	.415	.3517	.534
.3720	.485	.4703	.782	.5436	.419	.3530	.534
.3734	.441	.4780	.700	.5449	.421	.3544	.515
.3748	.426	.4793	.687	.5463	.395	.3557	.507
.3762	+0.362	.4806	.622	.5476	-0.407	.3616	.479
.3822	-0.002	.4820	.589			.3630	.462
.3836	.049	.4833	.546	2445622		.3643	.456
.3850	.076	.4905	.347	.3046	+0.634	.3657	.450
.3864	.136	.4918	+0.300	.3059	+0.595	.3670	-0.431
.3877	-0.143						

Table 13e

Photoelectric uv observations of AV Peg

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2445566		2445566		2445566		2445566	
.4539	+0.931	.4963	+0.098	.5340	-0.393	.3173	+0.193
.4566	.908	.5040	-0.211	.5353	.407	.3187	.128
.4579	.910	.5053	.195	.5427	.302	.3200	.090
.4654	.849	.5066	.213	.5440	.332	.3213	+0.033
.4667	.826	.5080	.287	.5454	.277	.3274	-0.137
.4681	.825	.5094	.354	.5467	.296	.3287	.203
.4694	.832	.5153	.452	.5480	-0.255	.3301	.254
.4708	.809	.5166	.481			.3314	.289
.4797	.671	.5180	.462	2445622		.3328	.344
.4824	.621	.5193	.489	.3050	+0.621	.3397	.474
.4837	.536	.5249	.529	.3063	.595	.3410	.466
.4910	.387	.5267	.493	.3077	.535	.3424	.487
.4923	.317	.5299	.454	.3090	.547	.3437	.480
.4936	.225	.5313	.432	.3104	.470	.3451	.460
.4950	+0.175	.5326	-0.389	.3160	+0.243	.3508	-0.439

Table 13e (cont.)

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2445622		2445622		2445622		2445622	
.3521	-0.422	.3562	-0.417	.3634	-0.354	.3661	-0.323
.3535	.413	.3621	-0.369	.3647	-0.340	.3674	-0.302
.3548	-0.415						

Table 14a

Photoelectric observations of TU UMa in integrated light

J.D.	Δm	J.D.	Δm	J.D.	Δm	J.D.	Δm
2435925		2435934		2435934		2435963	
.4287	+0.614	.3028	+1.334	.3707	+0.246	.3918	+0.162
.4303	.609	.3039	1.290	.3730	.248		
.4315	.566	.3096	1.307	.3810	.177	2435992	
.4334	.563	.3106	1.307	.3831	.186	.3509	+0.663
.4356	.516	.3116	1.309	.3854	.188	.3523	.633
.4376	.482	.3130	1.294	.3881	.165	.3536	.619
.4394	.434	.3141	1.338	.3956	.181	.3550	.588
.4410	.397	.3180	1.292	.3985	.203	.3562	.562
.4488	.258	.3192	1.269	.3999	.237	.3601	.443
.4504	.203	.3203	1.263	.4118	.282	.3613	.449
.4520	.204	.3220	1.266	.4136	.295	.3626	.395
.4537	.193	.3232	1.245	.4151	.271	.3641	.395
.4602	.146	.3274	1.160	.4167	.283	.3655	.391
.4625	.129	.3289	1.113	.4181	.307	.3669	.333
.4646	.132	.3300	1.089	.4286	.387	.3708	.281
.4667	.137	.3312	1.053	.4298	+0.413	.3721	.278
.4692	.166	.3326	1.020			.3734	.288
.4761	.226	.3382	0.906	2435963		.3752	.259
.5201	.451	.3399	.843	.3638	+0.359	.3799	.243
.5228	.507	.3414	.818	.3648	.331	.3811	.238
.5258	.495	.3428	.787	.3666	.345	.3824	.232
.5284	+0.494	.3445	.719	.3679	.310	.3835	.256
		.3513	.604	.3693	.319	.3847	.246
2435934		.3534	.580	.3731	.221	.3888	.258
.2916	+1.340	.3547	.564	.3742	.195	.3898	.279
.2941	1.282	.3572	.528	.3755	.182	.3911	.251
.2952	1.294	.3588	.495	.3785	.163	.3923	.275
.2963	1.293	.3637	.403	.3819	.168	.3938	.290
.3007	1.301	.3657	.324	.3833	.152	.3982	.296
.3017	+1.309	.3684	+0.282	.3872	+0.166	.3994	+0.296

Table 14b

Photoelectric yellow observations of TU UMa

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436230		2436230		2436230		2436230	
.4353	+1.365	.4608	+0.890	.4684	+0.763	.4736	+0.682
.4475	+1.205	.4634	+0.833	.4709	+0.702	.4795	+0.639

Table 14b (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436230		2436231		2436267		2436288	
.4820	+0.566	.6314	+0.378	.5525	+1.135	.4838	+0.512
.4846	.526	.6421	.421	.5566	1.130	.4877	.437
.4909	.396	.6476	.438	.5731	1.137	.4943	.395
.4938	.376	.6570	.489	.5779	1.129	.4968	.406
.4967	.362	.6602	.510	.5821	1.169	.4998	.372
.4990	.365	.6630	.536	.5855	1.160	.5028	.379
.5047	.358	.6709	.552	.5954	1.175	.5099	.376
.5075	.346	.6742	.579	.5995	1.179	.5136	+0.380
.5100	.343	.6771	.581	.6037	1.187		
.5158	.391	.6837	.595	.6075	1.214	2436604	
.5186	.393	.6863	+0.617	.6186	1.173	.6110	+1.309
.5214	.419			.6222	1.180	.6138	1.317
.5318	.446	2436264		.6258	1.189	.6163	1.309
.5362	.487	.3965	+1.342	.6453	1.202	.6218	1.295
.5416	.511	.4001	1.313	.6488	+1.190	.6246	1.266
.5488	.540	.4031	1.323			.6274	1.281
.5524	.566	.4104	1.334	2436272		.6329	1.246
.5561	.576	.4140	1.328	.2944	+0.725	.6357	1.205
.5640	.610	.4181	1.340	.2971	.722	.6385	1.181
.5679	.609	.4342	1.370	.3042	.598	.6437	1.074
.5716	.651	.4368	1.393	.3071	.508	.6458	1.028
.5798	.655	.4397	1.358	.3138	.462	.6478	0.951
.5848	.687	.4458	1.371	.3166	+0.410	.6531	.806
.5887	.699	.4490	1.336			.6551	.763
.6021	.780	.4521	1.351	2436278		.6572	.721
.6062	.755	.4622	1.227	.4004	+1.301	.6614	.709
.6254	.821	.4654	1.210	.4057	1.161	.6635	.686
.6287	.802	.4688	1.131	.4119	1.109	.6656	.653
.6375	.825	.4715	1.038	.4147	0.982	.6701	.555
.6411	.853	.4743	0.998	.4175	.967	.6721	.549
.6445	.868	.4785	.839	.4251	.798	.6746	.511
.6515	.915	.4816	.795	.4293	.726	.6794	.427
.6545	.903	.4884	.729	.4362	.589	.6819	.411
.6572	.904	.4946	.655	.4425	.474	.6840	.386
.6640	.915	.4976	.574	.4480	.423	.6885	.351
.6672	.901	.5122	.523	.4508	.382	.6906	.335
.6702	.920	.5045	.467	.4543	.366	.6926	.333
.6780	.943	.5078	.412	.4657	.364	.6965	.335
.6810	.957	.5114	.366	.4688	.383	.6985	.343
.6840	+0.980	.5147	.366	.4723	.388	.7006	+0.332
		.5184	.352	.4765	.386		
2436231		.5219	.338	.4796	+0.395	2436647	
.5743	+0.925	.5254	.342			.3990	+1.152
.5771	.841	.5291	.365	2436288		.4029	1.142
.5802	.777	.5323	+0.405	.4377	+1.322	.4044	1.128
.5886	.638			.4401	1.271	.4092	1.173
.5917	.640	2436267		.4437	1.208	.4111	1.129
.5954	.589	.5207	+0.993	.4472	1.116	.4149	1.144
.6049	.438	.5286	1.067	.4593	0.891	.4168	1.175
.6095	.360	.5329	1.070	.4658	.786	.4184	1.159
.6215	.346	.5369	1.090	.4690	.740	.4224	1.164
.6251	.346	.5447	1.103	.4724	.676	.4241	1.180
.6284	+0.350	.5482	+1.121	.4811	+0.551	.4259	+1.173

Table 14b (cont.)

J.D.	ΔV	J.D.	ΔV	J.D.	ΔV	J.D.	ΔV
2436647		2443848		2443954		2443954	
.4296	+1.145	.5656	+1.294	.5697	+0.889	.6318	+0.418
.4346	1.167	.5721	1.314	.5710	.852	.6332	.417
.4386	1.147	.5736	1.340	.5738	.773		
.4413	1.159	.5790	1.349	.5753	.744	2445471	
.4434	1.142	.5807	1.349	.5783	.704	.3890	+1.216
.4481	1.168	.5847	1.328	.5797	.719	.3903	1.189
.4503	1.154	.5967	1.212	.5825	.711	.3917	1.152
.4522	1.160	.5986	1.226	.5839	.693	.3976	1.048
.4565	1.154	.6022	1.162	.5863	.613	.4016	0.961
.4601	1.157	.6038	1.147	.5876	.605	.4029	.931
.4641	1.123	.6071	1.114	.5901	.564	.4043	.882
.4656	1.161	.6087	1.086	.5915	.567	.4056	.852
.4675	1.176	.6148	0.905	.5940	.532	.4069	.822
.4717	1.147	.6160	.898	.5959	.462	.4170	.673
.4734	1.147	.6191	.853	.6002	.405	.4183	.675
.4753	1.126	.6203	.774	.6016	.424	.4209	.631
.4842	1.147	.6235	.695	.6047	.386	.4245	.549
.4861	1.147	.6308	.598	.6061	.381	.4259	.521
.4883	1.130	.6318	+0.593	.6091	.353	.4272	.513
.4948	1.140			.6135	.336	.4286	.481
.4970	1.182	2443954		.6153	.343	.4397	.335
.4990	1.168	.5583	+1.144	.6184	.353	.4416	.329
.5045	1.181	.5599	1.132	.6198	.345	.4647	.324
.5065	1.208	.5623	1.124	.6225	.359	.4687	.360
.5084	1.197	.5634	1.076	.6240	.364	.4716	.377
.5222	1.248	.5659	0.997	.6271	.364	.4729	.387
.5260	+1.271	.5672	+0.980	.6285	+0.366	.4743	+0.417

Table 14c

Photoelectric blue observations of TU UMa

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436230		2436230		2436230		2436231	
.4448	+1.127	.5088	+0.018	.5996	+0.502	.5729	+0.772
.4492	1.018	.5146	.036	.6045	.516	.5757	.661
.4567	.801	.5169	.049	.6240	.573	.5787	.556
.4597	.714	.5200	.061	.6272	.587	.5870	.435
.4621	.618	.5301	.099	.6305	.613	.5910	.382
.4670	.505	.5340	.140	.6391	.651	.5934	.342
.4695	.451	.5397	.185	.6427	.677	.6023	.152
.4723	.439	.5471	.212	.6460	.695	.6061	.087
.4781	.354	.5508	.243	.6527	.707	.6096	+0.037
.4808	.286	.5544	.255	.6559	.726	.6172	-0.011
.4834	.235	.5617	.323	.6586	.726	.6200	+0.003
.4896	.109	.5657	.328	.6655	.735	.6232	.006
.4924	.048	.5696	.349	.6687	.748	.6267	.019
.4953	.027	.5780	.374	.6720	.767	.6293	.053
.4980	.027	.5828	.410	.6797	.790	.6407	.104
.5032	.009	.5870	.444	.6825	.806	.6434	.129
.5061	+0.002	.5950	+0.484	.6853	+0.819	.6462	+0.148

Table 14c (cont.)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2436231		2435267		2436288		2436647	
.6557	+0.205	.5589	+0.979	.4578	+0.658	.4139	+1.020
.6587	.210	.5750	1.040	.4646	.522	.4157	1.052
.6615	.228	.5804	1.047	.4673	.464	.4178	1.048
.6694	.252	.5836	1.034	.4706	.430	.4216	1.025
.6726	.272	.5876	1.054	.4796	.277	.4232	1.040
.6757	.280	.5972	1.079	.4824	.203	.4249	1.012
.6821	.322	.6016	1.064	.4854	.128	.4289	1.045
.6849	+0.323	.6060	1.082	.4892	.090	.4305	1.028
		.6089	1.077	.4956	.050	.4334	1.045
2436264		.6166	1.087	.4982	.057	.4377	1.036
.3983	+1.122	.6204	1.068	.5011	.049	.4404	1.062
.4014	1.153	.6238	1.053	.5053	.037	.4423	1.023
.4049	1.133	.6356	1.063	.5115	.055	.4472	1.023
.4156	1.185	.6395	1.063	.5150	+0.064	.4495	1.038
.4191	1.196	.6417	1.060			.4513	1.032
.4356	1.226	.6469	+1.079	2436604		.4556	1.031
.4382	1.234			.6100	+1.186	.4573	1.030
.4410	1.209	2436272		.6124	1.187	.4592	1.012
.4474	1.197	.2925	+0.441	.6149	1.170	.4632	1.023
.4504	1.208	.2957	.414	.6204	1.164	.4649	1.024
.4538	1.180	.3025	.277	.6232	1.158	.4666	1.005
.4609	1.094	.3058	.222	.6260	1.128	.4705	1.001
.4638	1.031	.3120	.128	.6315	1.096	.4725	1.024
.4673	0.974	.3151	+0.104	.6343	1.067	.4745	1.037
.4702	.897			.6371	1.035	.4833	1.031
.4729	.830	2436278		.6426	0.937	.4852	1.024
.4757	.693	.3991	+1.182	.6447	.876	.4872	1.040
.4798	.546	.4015	1.095	.6468	.796	.4924	1.030
.4830	.479	.4043	1.041	.6520	.618	.4960	1.034
.4867	.439	.4105	0.928	.6541	.549	.4981	1.061
.4902	.433	.4133	.844	.6562	.487	.5031	1.069
.4960	.332	.4227	.600	.6603	.430	.5055	1.079
.4994	.260	.4251	.521	.6624	.413	.5075	1.071
.5027	.199	.4279	.477	.6645	.408	.5212	1.129
.5062	.134	.4348	.394	.6690	.325	.5231	1.110
.5095	.088	.4376	.328	.6711	.290	.5249	+1.106
.5129	.039	.4411	.291	.6732	.248		
.5164	.015	.4466	.168	.6784	.145	2443848	
.5202	.004	.4494	.145	.6808	.099	.5650	+1.136
.5237	.010	.4522	.109	.6829	.045	.5712	1.144
.5272	.025	.4640	.034	.6874	.031	.5729	1.172
.5308	.047	.4675	.068	.6895	.002	.5779	1.164
.5342	+0.078	.4702	.084	.6916	+0.006	.5799	1.170
		.4744	.093	.6956	−0.006	.5838	1.142
2436267		.4779	+0.096	.6975	−0.003	.5855	1.137
.5186	+0.868			.6996	+0.019	.5893	1.108
.5228	.883	2436288				.5911	1.097
.5266	.886	.4364	+1.186	2436647		.5959	1.067
.5308	.932	.4388	1.135	.4022	+1.029	.5978	1.056
.5385	.957	.4425	1.062	.4036	1.015	.6015	1.003
.5465	.965	.4449	0.979	.4069	1.025	.6031	0.965
.5550	.969	.4526	.817	.4084	1.041	.6062	.941
.5548	+0.966	.4551	+0.750	.4103	+1.001	.6080	+0.885

Table 14c (cont.)

J.D.	ΔB	J.D.	ΔB	J.D.	ΔB	J.D.	ΔB
2443848		2443954		2443954		2445471	
.6139	+0.702	.5730	+0.552	.6098	-0.012	.4020	+0.698
.6154	.659	.5747	.504	.6129	.035	.4033	.670
.6182	.612	.5776	.444	.6146	.033	.4047	.640
.6196	.530	.5790	.431	.6175	.027	.4060	.580
.6226	.466	.5818	.436	.6192	.017	.4074	.531
.6161	.429	.5832	.432	.6219	-0.003	.4174	.393
.6309	+0.409	.5857	.361	.6232	+0.006	.4188	.376
		.5869	.344	.6262	.011	.4250	.216
2443954		.5894	.295	.6279	.016	.4263	.179
.5578	+0.999	.5908	.269	.6307	.038	.4277	+0.154
.5592	.980	.5933	.230	.6325	+0.045	.4420	-0.076
.5616	.919	.5954	.206			.4651	+0.005
.5628	.887	.5997	.074	2445471		.4691	-0.012
.5653	.816	.6009	.055	.3894	+1.041	.4720	+0.031
.5665	.780	.6039	.023	.3908	1.021	.4734	0.018
.5691	.708	.6054	+0.008	.3921	0.989	.4747	+0.043
.5703	+0.657	.6084	-0.004	.3980	+0.837		

Table 14d

Photoelectric uv observations of TU UMa

J.D.	ΔU	J.D.	ΔU	J.D.	ΔU	J.D.	ΔU
2445471		2445471		2445471		2445471	
.3889	+1.027	.4051	+0.484	.4254	+0.223	.4656	-0.046
.3912	0.988	.4065	.451	.4268	.180	.4724	+0.041
.3925	.954	.4078	.413	.4281	+0.162	.4738	.050
.4024	.580	.4179	.353	.4425	-0.054	.4752	+0.069
.4038	+0.552	.4192	+0.348				

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THE LIGHT CURVE OF V 441 HERCULIS

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ABSTRACT

The light variations of the F-type supergiant V 441 Her have been followed for a period of five years in the B and V pass bands. A pulsation period of 63.9 days has been derived. The residuals show a harmonic distribution with a period of about 1500 days. Arguments are presented in favour of a circumstellar envelope around the F-type star and an infrared companion to this star.

INTRODUCTION

V 441 Her (89 Her, HD 163506) is a relatively bright star (V = 5.45) of spectral type F2eIa and an absolute visual magnitude of -7.1 (*Searle* et al., 1963). A light curve with an amplitude of 0.1 mag. and a period of about 70 days has been derived by *Worley* (1956). Variations in radial velocities have been noted by *Campbell* and *Moore* (1928). Spectroscopic orbital elements were derived by *Ferro* (1983) with a period of 286 days. During the last ten years the star has been the subject of numerous photometric observations by *Percy* et al. (1979), *Burki* et al. (1980), *Fernie* (1981) and *Percy* and *Welch* (1981). The present author has discovered the star accidentally by choosing it as a comparison star in a program of photoelectric observations of some visual binaries.

As has already been pointed out, spectroscopic observations yield a period of 286 days for the radial velocity variations. From orbital elements derived by *Ferro* (1983) it appears that a massive primary star of 20 solar masses has a companion of about 2 $M_\odot$ at a distance of nearly 3 AU. A line splitting of the H and K lines, of Hβ and of the D lines has been observed indicating a presence of a circumstellar envelope (*Gillett* et al., 1970). From IUE high resolution ultraviolet spectra *Lamb* and *Neese* (1982) have found evidence for mass loss from the star. On the other hand *Humphreys* and *Ney* (1974) concluded that 89 Her may be a binary system having an infrared star at a distance of about 9 AU.

OBSERVATIONS

The present series of photometric observations has started in the spring of 1981 and continued yearly, with the exception of one year (1985) until the summer of 1986. The observations were made with the 0.3 m reflector of the University of Waterloo equipped with a thermoelectrically cooled photometer and an EMI 9844B photomultiplier tube. The observations were made in the B and V pass bands. On each night a series of measurements of the comparison star, the variable and the check star were made. The variable was compared with the star HD 165908 of spectral type F7V and checked against the star HD 162555 of spectral type K1III. A differential extinction correction has been applied to the observations. The following magnitude difference between the comparison star and the check star has been derived:

$$B = -0\overset{\mathrm{m}}{.}974 \pm 0.003 \qquad V = -0\overset{\mathrm{m}}{.}532 \pm 0.003$$

The light curve of V 441 Her is that of a small amplitude pulsating variable with a period given by a number of authors as 63 to 72 days. From sources listed above 17 epochs of maximum brightness have been extracted and a least squares solution performed to derive corrections to the assumed zero epoch, the period and its derivative. The following elements have been obtained:

$$\text{Max.} = \text{J.D. } \underset{\pm.0027}{2444395.1723} + \underset{\pm.00012}{63\overset{\mathrm{d}}{.}93296}\cdot E + \underset{\pm.000000008}{0\overset{\mathrm{d}}{.}000067914}\cdot E^2 \quad \text{(m.e.)}$$

The photoelectric observations made at Waterloo have been listed in Table I while the epochs of maxima used in derivation of the period have been reproduced in Table II. The residuals from the above ephemeris, especially those of the last ten years exhibit an oscillation in the range of ± 20 days with a period of about 1950 days (the average separation between maxima and

Table I

Photoelectric observations of V 441 Her

J.D.	Phase	V	B-V	J.D.	Phase	V	B-V
2440000+				244000+			
4745.854	0.4661	5.336	0.531	5540.665	0.7384	5.248	0.463
4760.792	0.6989	5.289	0.495	5549.601	0.8767	5.242	0.457
4773.724	0.9004	5.240	0.499	5554.569	0.9536	5.255	0.480
4781.757	0.0255	5.268	0.484	5567.560	0.1391	5.309	0.478
4782.700	0.0402	5.256	0.496	5571.553	0.2009	5.294	0.518
4795.634	0.2418	5.302	0.511	5578.544	0.3090	5.338	0.483
4796.659	0.2577	5.308	0.508	5585.535	0.4172	5.356	0.491
4807.630	0.4287	5.368	0.534	5592.530	0.5254	5.318	0.522
4808.621	0.4441	5.355	0.539	5819.868	0.9314	5.252	0.492
4810.607	0.4750	5.350	0.534	5836.798	0.3390	5.338	0.525
4815.608	0.5530	5.338	0.534	5844.803	0.4638	5.352	0.498
4817.634	0.5845	5.317	0.531	5853.774	0.6037	5.318	0.499
4828.599	0.7554	5.244	0.474	5855.775	0.6350	5.328	0.485
4876.565	0.5003	5.351	0.551	5870.725	0.8681	5.252	0.470
4880.606	0.5632	5.344	0.550	5872.722	0.8992	5.252	0.469
4881.591	0.5786	5.308	0.550	5880.676	0.0233	5.245	0.492
4890.565	0.7184	5.276	0.500	5882.686	0.0346	5.252	0.472
4894.582	0.7809	5.238	0.526	5887.660	0.1322	5.264	0.489
5087.854	0.7720	5.246	0.497	5893.660	0.2258	5.289	0.496
5140.740	0.5943	5.328	0.532	5894.636	0.2410	5.297	0.491
5144.710	0.6560	5.290	0.519	5900.649	0.3348	5.329	0.487
5151.672	0.7642	5.258	0.543	5907.615	0.4434	5.330	0.498
5158.720	0.8738	5.246	0.506	5909.590	0.4742	5.316	0.515
5217.594	0.7819	5.223	0.479	5928.568	0.7707	5.267	0.519
5220.544	0.8278	5.217	0.479	5929.562	0.7856	5.259	0.473
5221.536	0.8432	5.240	0.482	5934.565	0.8637	5.244	0.458
5222.550	0.8589	5.242	0.484	5937.554	0.9103	5.215	0.463
5243.522	0.1766	5.311	0.497	6550.840	0.6796	5.270	0.506
5247.514	0.2386	5.322	0.502	6558.814	0.7436	5.219	0.527
5248.517	0.2542	5.365	0.489	6580.756	0.0858	5.255	0.528
5264.531	0.5029	5.320	0.531	6584.742	0.1480	5.287	0.522
5266.500	0.5335	5.323	0.509	6591.729	0.2570	5.319	0.536
5269.500	0.5800	5.316	0.540	6598.715	0.3659	5.361	0.540
5470.822	0.6570	5.277	0.506	6599.700	0.3813	5.362	0.531
5506.800	0.2140	5.311	0.503	6606.690	0.4903	5.353	0.531
5507.693	0.2278	5.314	0.481	6621.668	0.7238	5.284	0.503
5525.639	0.5057	5.308	0.513	6634.621	0.9258	5.266	0.502
5537.660	0.6918	5.265	0.452				

minima). The distribution of residuals is shown in Figure 1a. Subsequently, the residuals have been fitted to the following expression:

$$(O-C)_1 = A\cdot\sin2\pi\left(\frac{P_o}{P_1}E - \varphi\right)$$

where P_o is the pulsation period and P_1 is the period of oscillation while φ is the phase shift. By the method of least squares the following elements have

Table II

Epochs of maxima of V 441 Her and their residuals

J.D.	Δt	E	$(O-C)_1$	$(O-C)_2$	Source
2435308.72	-9087.024	-142	18.612	- 8.015	Worley, 1956
5386.63	-9009.114	-141	32.398	5.995	-"-
8894.548	-5501.196	- 86	12.937	3.274	Burki et al., 1980
2441398.675	-2997.069	- 47	16.768	4.978	-"-
1458.519	-2937.225	- 46	12.488	- 0.198	-"-
3316.74	-1079.004	- 17	11.107	5.787	Fernie, 1981
3452.487	- 943.257	- 15	18.606	11.496	-"-
3689.705	- 706.039	- 11	- 0.673	- 8.724	Percy et al., 1979
4060.656	- 335.088	- 5	-14.467	-16.511	Fernie, 1981
4395.744	0	0	0	0.572	Percy and Welch, 1981
4455.592	59.848	1	- 4.276	1.909	-"-
4522.528	126.784	2	- 1.465	5.542	Ferro, 1983
4704.899	309.155	5	-11.466	- 3.584	-"-
4773.724	377.980	6	- 6.765	0.865	present paper
4828.599	432.855	7	-16.014	- 8.887	-"-
4894.582	498.838	8	-14.156	- 7.751	-"-
5221.536	825.792	13	- 7.823	- 6.768	-"-
5549.601	1153.857	18	- 0.379	- 2.745	-"-
5877.696	1481.952	23	7.095	7.475	-"-
5937.554	1541.810	24	2.829	4.450	-"-
6558.814	2163.070	34	-17.153	- 3.645	-"-
6636.621	2240.877	35	- 3.470	10.189	-"-

been derived:

$$A = 6\overset{d}{.}532 \pm .012 \qquad \varphi = 135\overset{\circ}{.}685 \pm .012 \text{ (m.e.)}$$

The new residuals appear to have a more random distribution with a scatter of about ± 10 days. The sum of the squares of the residuals has been reduced to 1083 from 3760. Some of the large residuals may have been produced by inclusion of inadequately observed epochs of maxima.

The observations made between 1981-86 have been represented in terms of the 64-day period, including the quadratic term in Figure 2a. The light curve reached a maximum at phase 0.85 and a minimum at phase 0.40. Its amplitude is 0.12 mag. The individual points exhibit a scatter of about 0.02 mag. with respect to the mean light curve. The colour index, B-V, shows a considerable scatter. Therefore its mean value for every tenth of the phase interval has been calculated and plotted in Figure 2b. The open circles represent the mean of fewer than five points in a given phase interval. The plot shows that the colour index changes with the light curve becoming bluer at the time of maximum brightness of the light curve with, perhaps, a small phase delay as compared with the light curve itself.

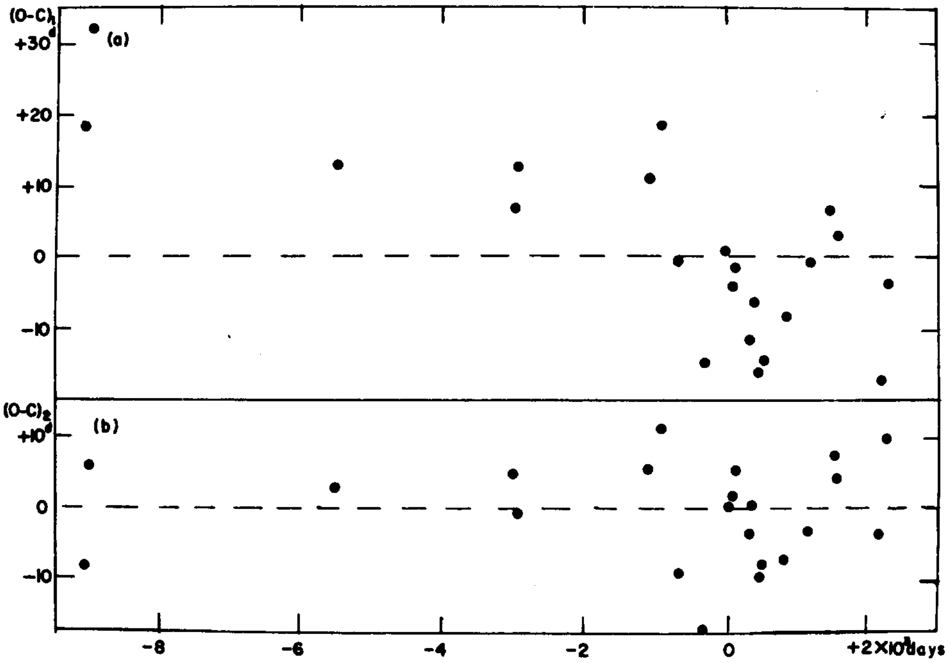

Figure 1a: The residuals $(O-C)_1$ of Table II including the quadratic term of the ephemeris

1b: The residuals $(O-C)_2$ including the harmonic term

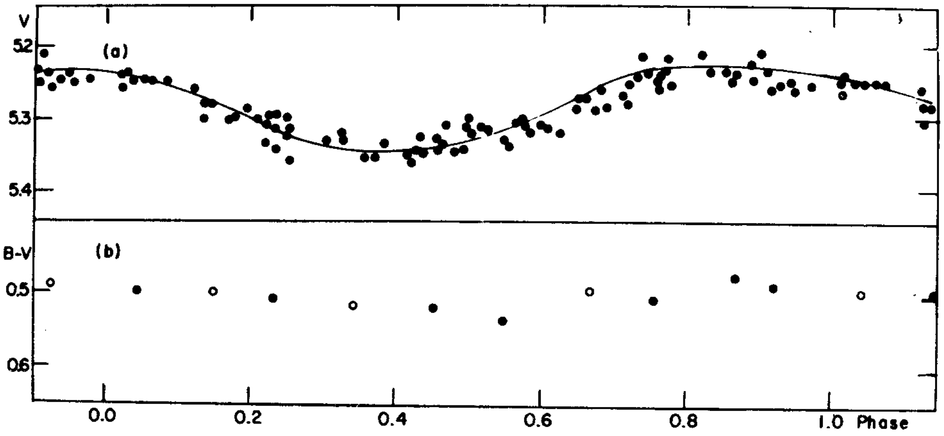

Figure 2a: The light curve of V 441 Her

2b: The colour index (B-V) of V 441 Her

DISCUSSION

In the preceding section it has been shown that the period of light variations of 89 Her is variable and a second order term is required to represent the light curve of the star over a long period of time. Coupled with the line doubling of certain spectral lines observed by *Böhm-Vitense* (1956) and more recently by *Lamb* and *Neese* (1982) an expansion velocity of about 200 kms^{-1} has been observed. This velocity may represent the escape velocity at the stellar surface. It indicates an ejection of a gaseous shell and a formation of a circumstellar envelope around the F-type supergiant. *Sargent* and *Osmer* (1969) have estimated the mass loss to the envelope at about 10^{-8} $M_{\odot}$/year. In addition, *Humphreys* and *Ney* (1974) have measured an infrared excess in the radiation of this star and concluded at the presence of a late type supergiant having an orbital period in excess of 4 years. The distribution of the residuals in Figure 1a confirms the presence of a star in the system. By assuming the mass of the F-type supergiant to be about 20 $M_{\odot}$, the mass of the infrared star as 10 $M_{\odot}$ and the orbital period as 5.3 years (1950 days) the semimajor axis of the orbit is about 9.3 AU.

Thus we conclude that the system of 89 Her is at least a triple system having a small mass component orbiting the F-type supergiant with a period of 285 days. At the same time the pulsating supergiant is loosing mass to a circumstellar envelope. In addition there is a late type supergiant orbiting the system with a period of about 5.3 years.

Most of the reduction work and preparation of the manuscript were done while the author was visiting the Konkoly Observatory in Budapest. The hospitality of Dr. Béla Szeidl is herewith acknowledged. This research was supported by a grant from the Natural Sciences and Engineering Research Council of Canada.

Budapest - Szabadsåghegy and Waterloo, 17 December, 1986

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UBV OBSERVATIONS OF THE RS CVn BINARY HK LACERTAE BETWEEN 1978-1985

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UBV OBSERVATIONS OF THE RS CVn BINARY HK LACERTAE BETWEEN 1978-1985

Abstract

We report 524 UBV observations of the RS CVn binary HK Lac made between 1978-1985. Our starspot modelling results published previously for 12 light curves (using V colour) are summarized. Three additional modelled light curves are presented which have not been published before.

Nine UBV light and colour curves obtained between 1982-85 in 16 American and 2 Hungarian observatories, are given. Light curve modelling made for the V and B light curves separately show that the resulting model parameters agree well within the error of the modelling procedure.

Introduction and Observations

We have previously published two detailed papers on HK Lac describing its light variation on the basis of starspot modelling (Olah et al., 1985, 1986, hereafter Paper I and Paper II, respectively). The observations we used were only published in part so we have compiled a complete presentation here for future use by other investigators.

The magnitudes presented here are individual values, but when performing the light curve modelling for Paper II, we formed nightly means if we had more than one value per night. The ΔV magnitudes used in Paper I are individual values and that table (Table VII in Paper I) is repeated here in full.

Observations have been secured altogether in 18 observatories in the standard UBV system, the observers and observatories are listed in Table I. No systematic differences have been found between the photometric results of the different observatories.

Table III gives UBV magnitudes of HK Lac with respect to HD 208728 (C1). The ΔV magnitudes of this table have already been published in Paper I. We repeat in Table III only those measurements which can be supplemented with the corresponding ΔB and ΔU magnitudes. In the beginning of this table UBV magnitudes observed by K.O. between 1976-1978 (Olah, 1979) are given.

The UBV magnitude differences (with respect to HD 210731 (C2) of Table IV have not been presented before. From this table the ΔV observations made between J.D. 2445195-2446068 were used in modelling the light curves of Paper II. Additional 100 observations gathered between J.D. 2446181-2446367 which have not been cited before in details, close Table IV.

To complete the lists of observations, Table V gives the rest of ΔV observations from Paper I.

Table I

Observer	Observatory	Telescope Aperture
Boyd, L.J.	Fairborn	10 inch
Burke, E.W. jr.	Kitt Peak	16 inch
Chambliss, C.R.	Kutztown	15 inch
Eaton, J.A.	Kitt Peak	16 inch
Fried, R.E.	Braeside	16 inch
Genet, R.M.	Fairborn	10 inch
Henry, G.W.	Dyer	24 inch
	Kitt Peak	16 inch
	Cloudcroft	48 inch
Landis, H.J.	Landis	8 inch
Lines, H.C.	Lines	20 inch
Lines, R.D.	Lines	20 inch
Louth, H.	Louth	11 inch
Miles, R.	Mouldsworth	11 inch
Nielsen, P.	Nielsen	4 inch
Olah, K.	Konkoly	24 inch
	Piszkesteto	20 inch
Renner, T.R.	Scuppernong	10 inch
Stelzer, H.J.	Stelzer	14 inch
Troeger, J.C.	Sky Lights	8 inch
Wasatonic, R.P.	Pulpit Rock	20 inch
Wasson, N.F.	Sunset Hills	8 inch

All magnitude tables (III-V) contain some sporadic observations which have never been used for starspot modelling since they did not form appropriate light curves.

Magnitude differences between HD 208728 (C1) and HD 210721 (C2), were published in the Inf. Bull. Var. Stars (Olah, 1979).

Results

Most of our starspot modelling results have already been published in Papers I and II. The main goal of those papers was, using solar analogies, to identify stable active longitudes on the surface of the star. Two different methods were used to determine the position of the corotating latitude situated about 30 degrees above and below the equator. We found complex but possible 7 year cyclic variations in the median brightness of the star.

In the present paper we show that spot models made in different colours of the same light curve give the same result within the error of the determination of the parameters. From UBV light curves observed between 1982-85 the V colour has already been fitted by two spots. Here we supplement by giving model results from the B data.

For spot modelling we used the equations developed by Budding (1977) combined with a grid-search method to find the proper parameters. As orbital inclination we found $i = 60^{o}$ (Paper I). Limb darkening coefficients were 0.75 (V), 0.85 (B), 0.91 (U), from Manduca et al. (1977). The time of 0 longitude was the time of maximum + 180 degrees. We took the flux ratios 0.4 (V), 0.36 (B), 0.33 (U) from Planck functions assuming that the spots were 2000 ^{o}K cooler than the surrounding photosphere. The 1.0 intensity was given by the local maximum. The overall light variation was considered to be produced by spotted belts around the star situated parallel to the equator. In most of the cases we fitted the light curves by two spots. For modelling details see Paper I.

Table II lists the J.D. intervals, epochs and the resulting spot parameters. When both V and B models are available, we give them separately in addition to their average values. The modelling results made separately for the V and B light curves agree reasonably well. Typical uncertainties in the parameters are as follows: +/- 2-3 degrees in longitude, +/- 5-8 degrees in

Table II

Resulting spot parameters

No.	J.D. (2440000+)		Period	λ_1	λ_2	β_1	β_2	γ_1	γ_2	color
	interval	epoch								
1	3355-3455	3348.3	25.042	314	80	55	- 6	22.9	23.3	V
2	3634-3721	3617.6	23.385	322	72	51	- 7.5	23.0	26.0	V
3	3722-3806	3709.8	25.203	335	63	49	26	24.0	19.7	V
4	3855-4094	3812.1	24.282	317	63	48	6	26.8	30.7	V
5	4496-4561	4445.1	24.174	296	57	38	27.5	22.5	26.6	V
6	4865-4968	4840.8	24.243	310	70	40	26.5	18.6	15.9	V
				270	50	12	46	18.2	27.9	V
				276	52	3	42	17.9	25.9	B
7	5195-5279	5180.8	23.724	273	51	8	44	18.1	26.9	mean
				318	52	57	23	24.2	28.1	V
				320	54	59	25	23.6	28.0	B
8	5471-5622	5448.0	24.397	319	53	58	24	23.9	28.1	mean
				335	60	53	17	27.0	28.0	V
				335	61	50	14	26.9	28.0	B
9	5628-5687	5618.4	24.397	335	61	52	16	27.0	28.0	mean
				339	--	45	--	37.2	----	V
				337	--	52	--	41.8	----	B
10	5697-5713	5695.1	24.429	338	--	49	--	39.5	----	mean
				304	18	7	53	26.0	19.9	V
				305	2	31	58	22.4	19.0	B
11	5820-5899	5819.3	24.461	304	10	19	56	24.2	19.5	mean
				303	8	11	63	21.3	21.3	V
				315	18	27	60	21.0	22.6	B
12	5970-6028	5965.0	24.461	309	13	19	62	21.2	22.0	mean
				345	56	48	29	23.3	19.1	V
				341	59	52	52	23.1	21.1	B
13	6030-6068	6010.9	24.461	343	58	50	41	23.2	20.1	mean
				321	51	43	34	29.2	22.1	V
				325	59	45	27	29.7	21.2	B
14	6181-6282	6159.8	24.389	323	55	44	31	29.5	21.7	mean
				308	40	36	50	27.9	22.0	V
				307	41	31	45	28.0	22.0	B
15	6283-6338	6257.7	24.501	308	41	33	48	28.0	22.0	mean

latitude and +/- 0.5 degree in radius. The latitude parameter is the most uncertain one of all the fitted parameters. In two cases (model 11 and 13) one can find larger discrepancies in one of the latitude and the corresponding radius results obtained from the V and B light curves. Except model 10 (see below) these two light curves had far the smallest number of observations: 18 (model 11) and 15 (model 13) data points were fitted. This shows, obviously, that more observational data give less uncertain parameters.

The last 9 light curves are displayed in Figures 1-9, together with the colour curves. The U measurements were not modelled, the curve is drawn with the resulted average parameters (determined by B and V light curves) and using the above mentioned limb darkening coefficient and flux ratio.

The models of No. 10, 14 and 15 from Table V have not been published before, but the model parameters were used in a recent paper (Olah et al., 1988). Model No. 10 (Figure 4), is very uncertain because of the few observational points, but is the only light curve of the star which could be fitted by one single spot.

Interesting new results about starspot proper motion on HK Lac, and also a figure of the positions of the activity centers on the star, were given in the above mentioned paper (Olah et al., 1988).

Budapest - Szabadsághegy, 1988. April 8.

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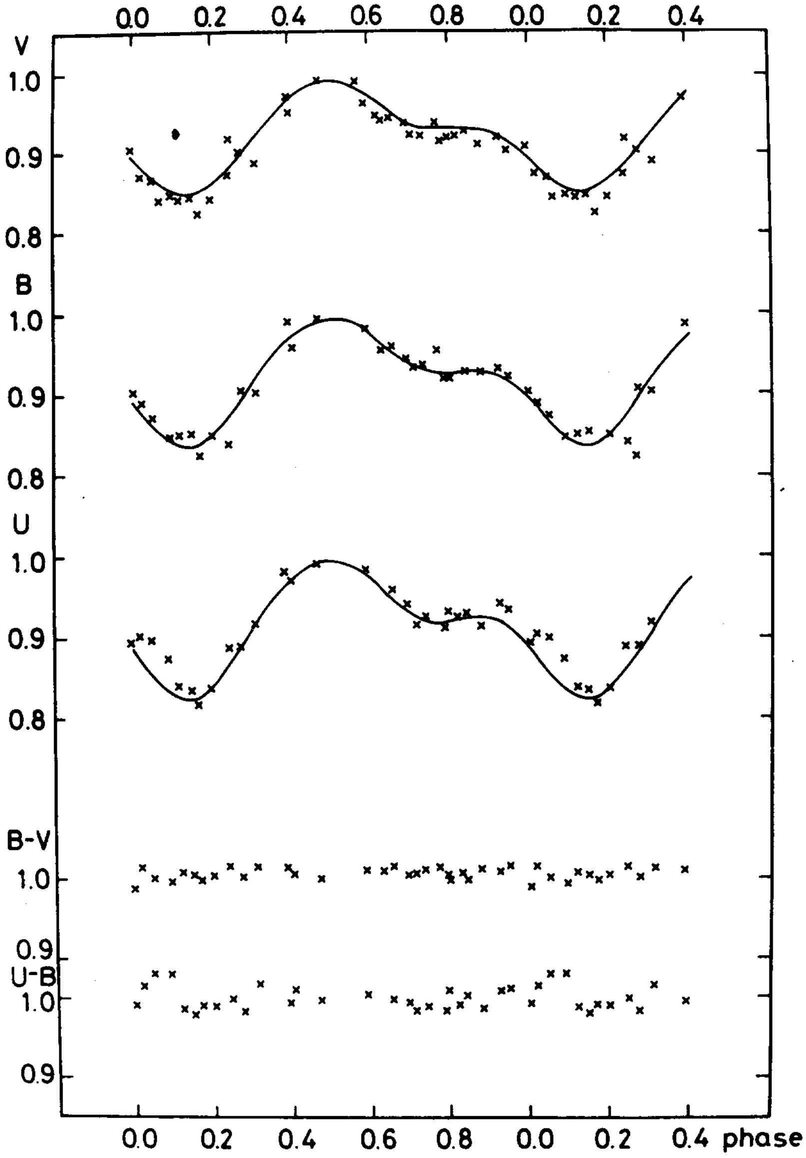

Figure 1: Light and colour curves of HK Lac (model 7)

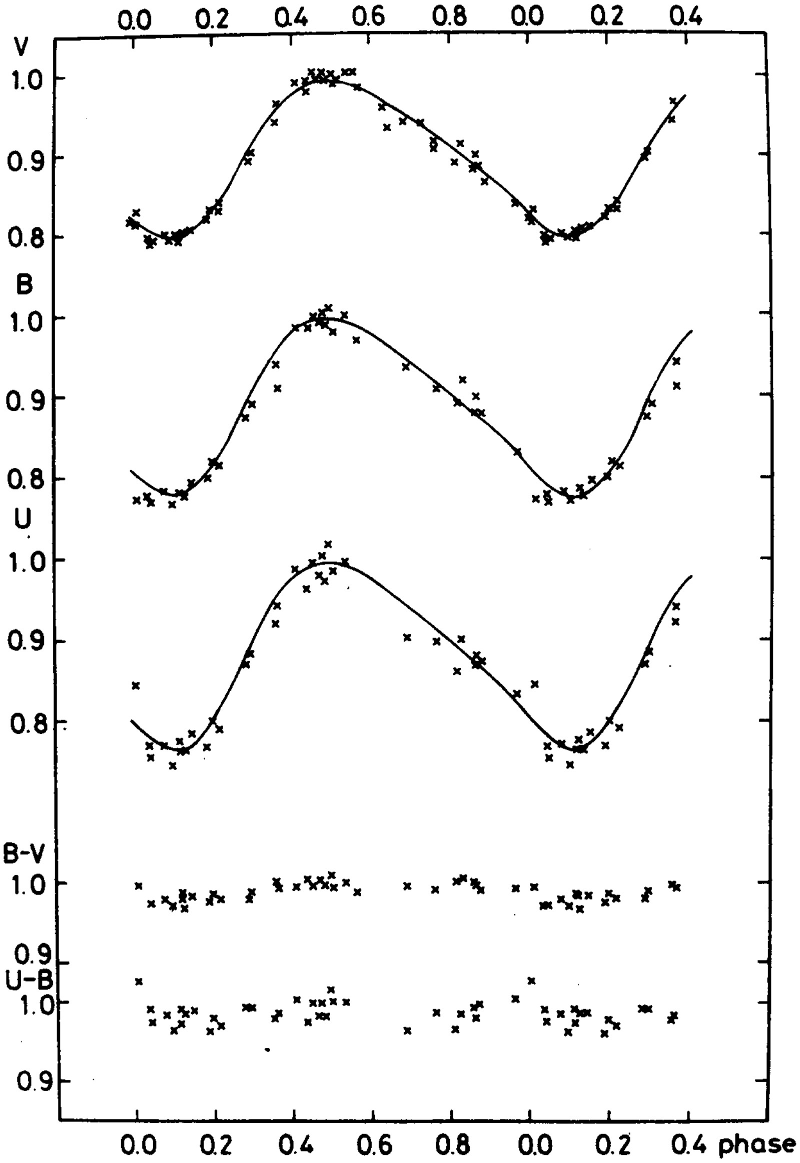

Figure 2: Light and colour curves of HK Lac (model 8)

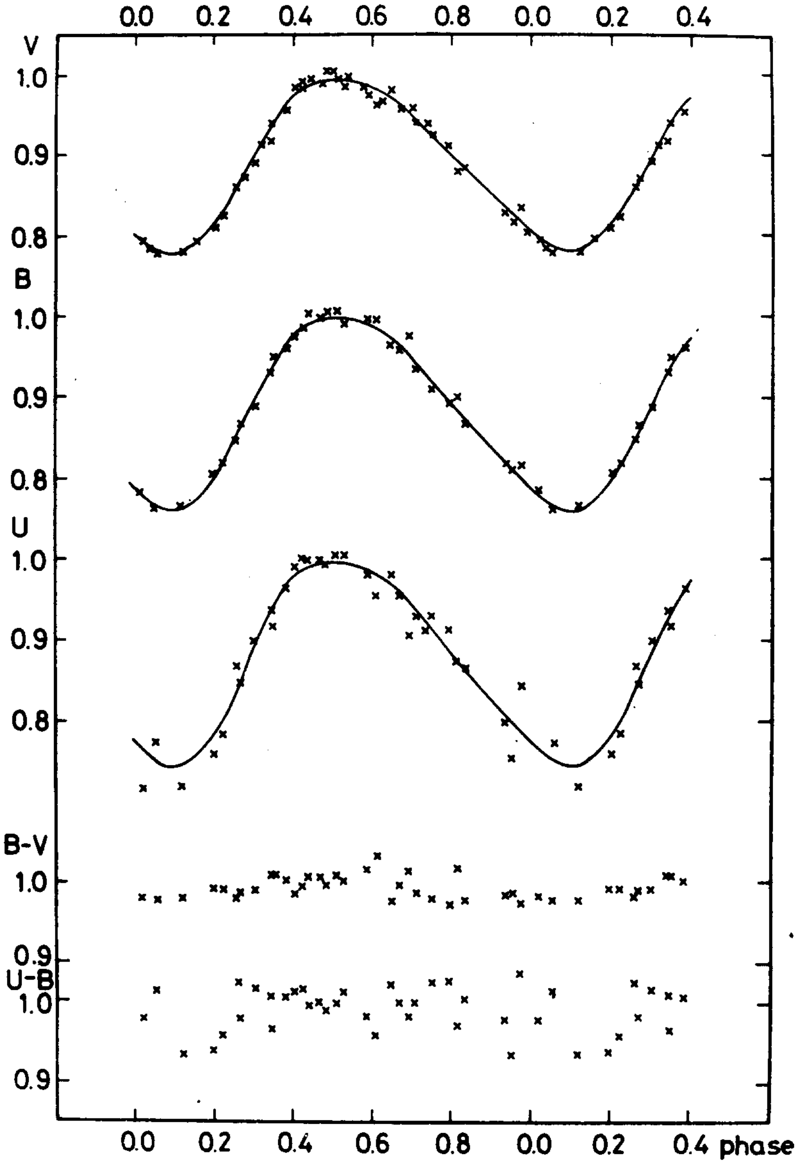

Figure 3: Light and colour curves of HK Lac (model 9)

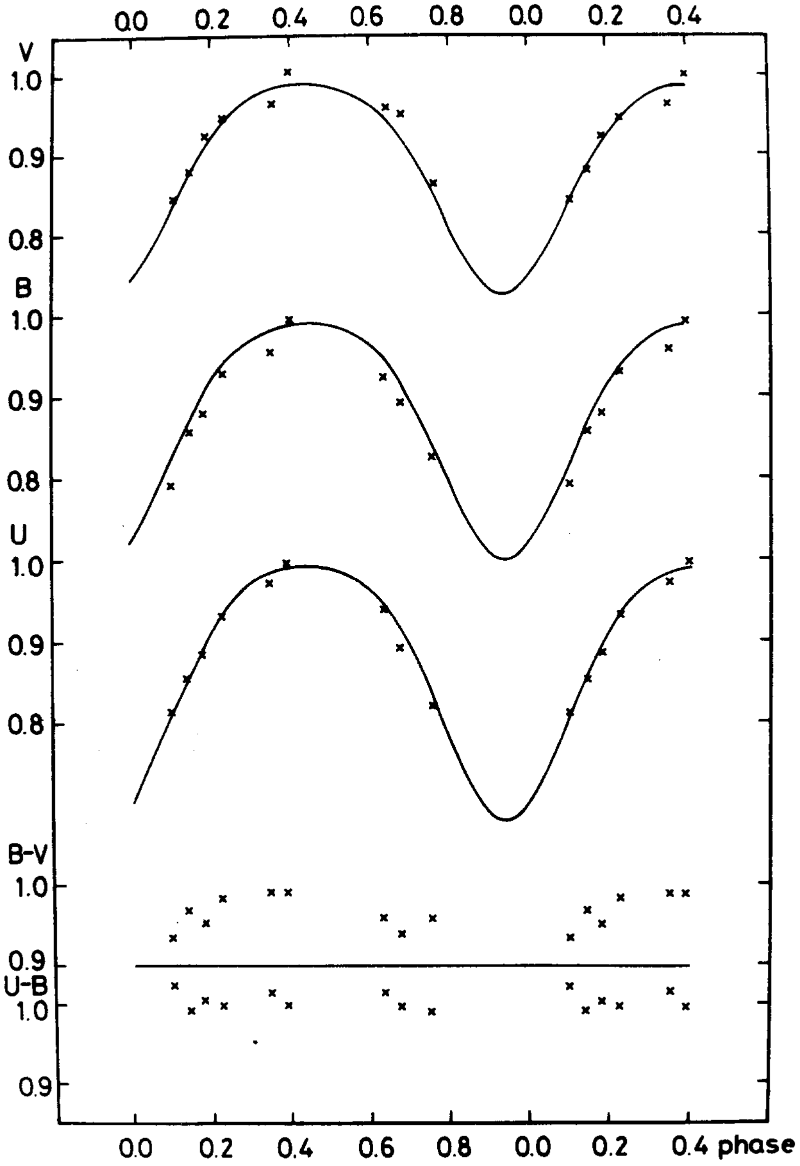

Figure 4: Light and colour curves of HK Lac (model 10)

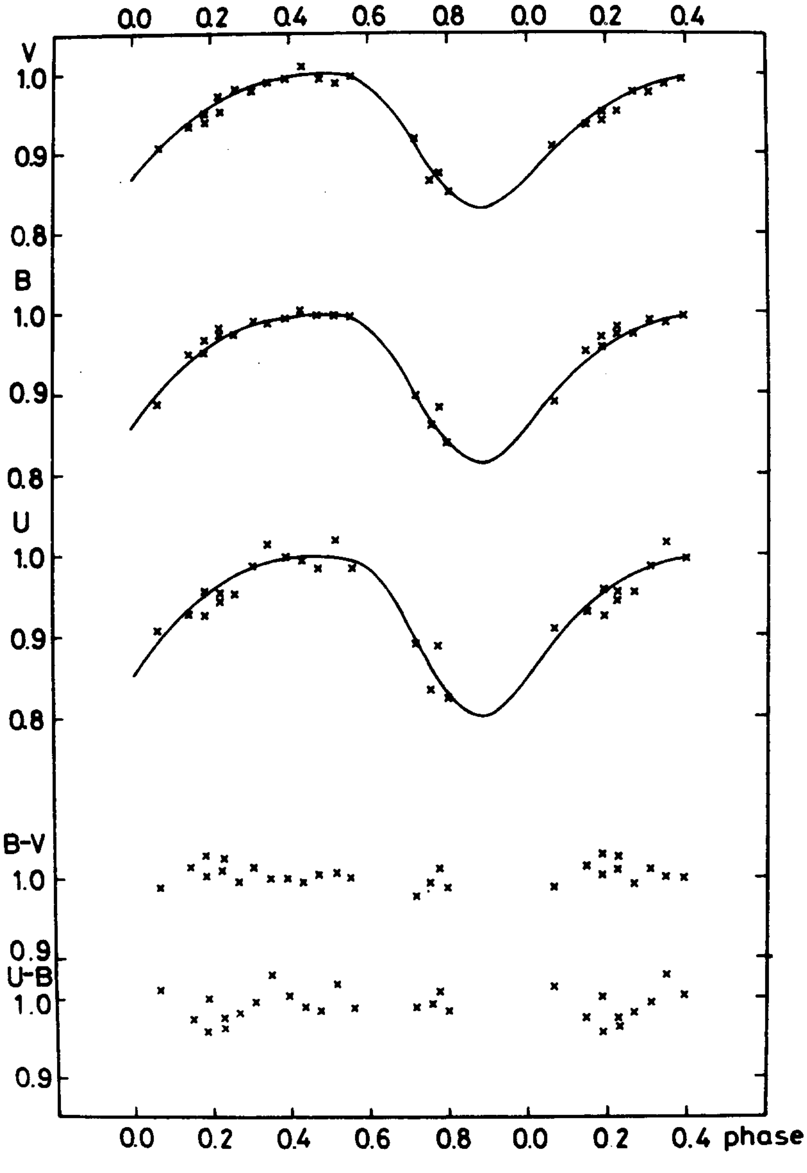

Figure 5: Light and colour curves of HK Lac (model 11)

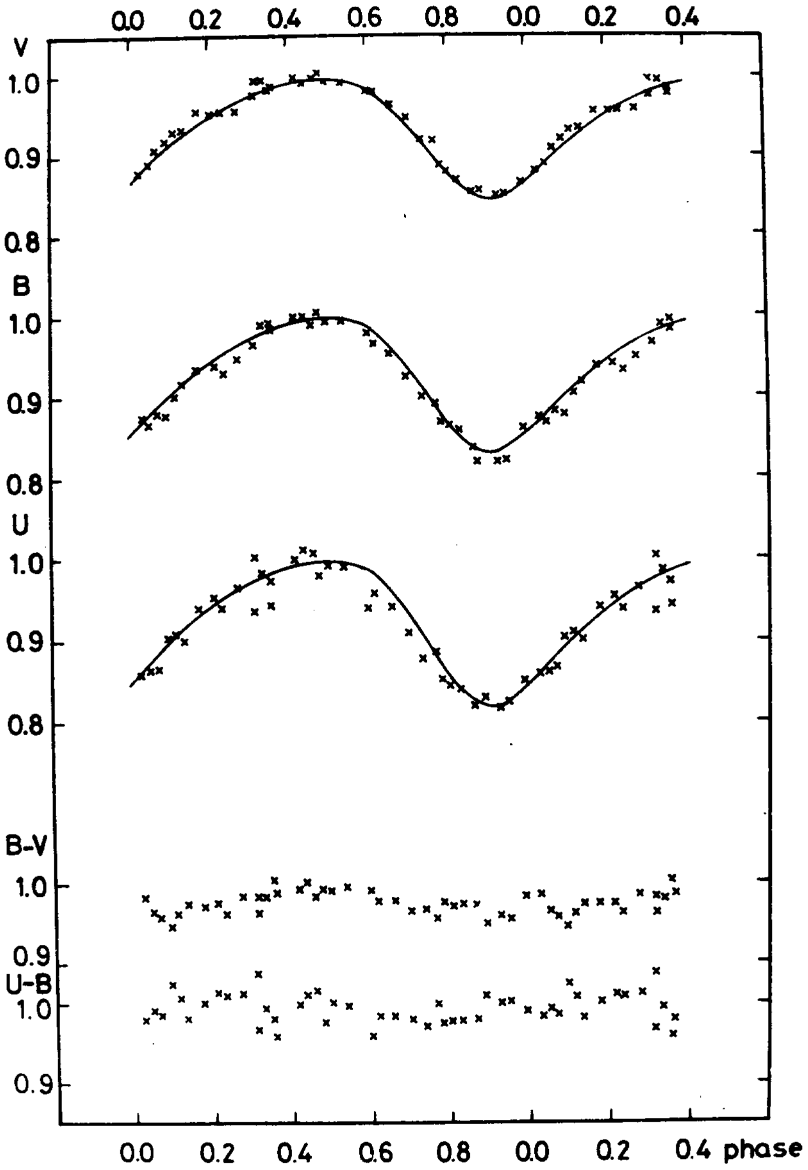

Figure 6: Light and colour curves of HK Lac (model 12)

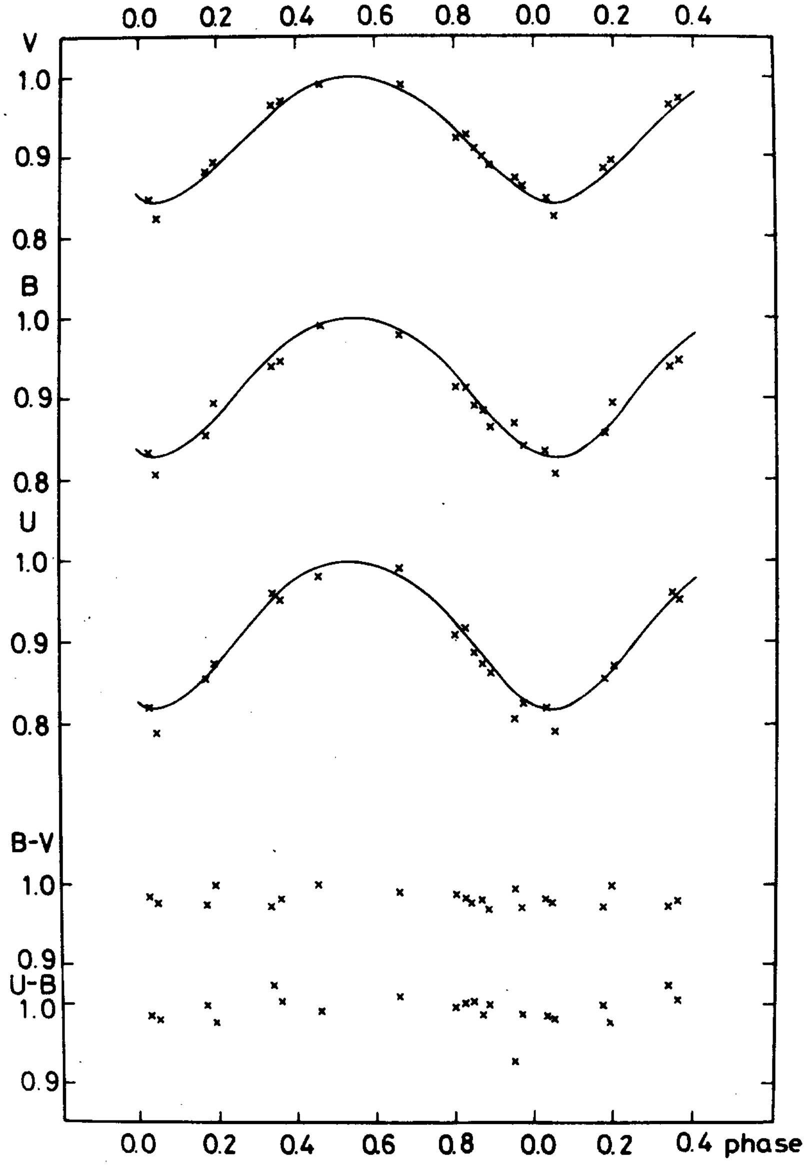

Figure 7: Light and colour curves of HK Lac (model 13)

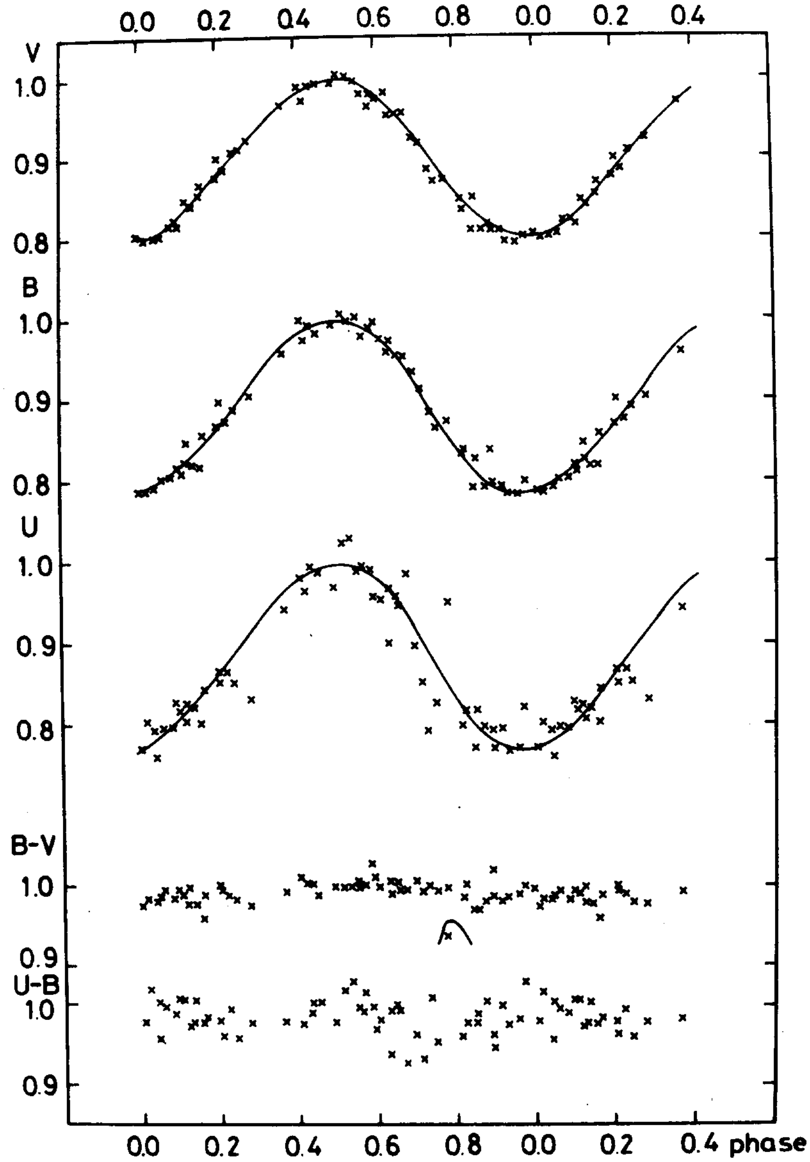

Figure 8: Light and colour curves of HK Lac (model 14)

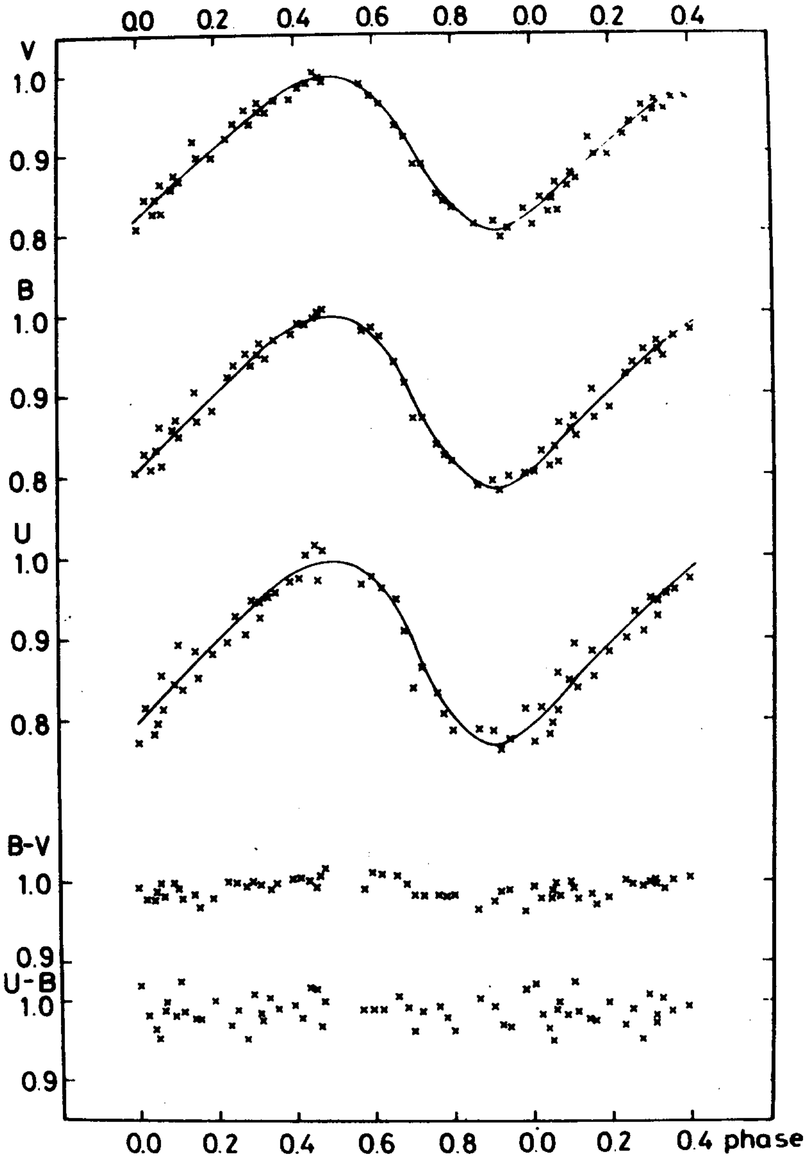

Figure 9: Light and colour curves of HK Lac (model 15)

Table III

UBV magnitudes of HK Lac with respect to HD 208728 (C1)

J.D. 2440000+	ΔU	ΔB	ΔV
3045.437	----	-.013	.100
3048.522	----	-.011	.126
3073.303	----	.002	.107
3076.286	-.095	-.002	.112
3077.230	-.053	.018	.122
3079.217	-.042	.037	.180
3108.254	-.025	.093	.192
3368.503	-.090	.024	.130
3385.525	----	-.056	.086
3432.316	-.138	-.017	.115
3434.322	-.113	-.012	.117
3438.356	-.112	-.007	.113
3455.286	-.107	.014	.152
3482.276	-.137	-.024	.124
3514.222	-.188	-.029	.088
3713.473	-.002	.096	.199
3727.547	-.167	-.034	.078
3739.464	-.025	.065	.177
3740.412	-.077	.059	.162
3742.456	-.038	.009	.111
3747.497	----	-.101	.039
3766.378	-.063	.016	.122
3777.461	-.152	-.048	.077
3797.304	-.225	-.113	.022
3879.209	----	-.011	.091
3881.232	----	.039	.157
4034.950	----	.092	.223
4035.945	----	.063	.197
4036.937	----	.018	.158
4038.954	----	-.061	.081
4043.947	----	-.121	.018
4045.942	----	-.097	.040
4048.944	----	-.073	.066
4069.878	----	-.115	.034
4086.810	----	-.019	.125
4091.849	----	-.138	-.008
4172.369	-.185	-.081	.044
4474.785	----	.058	.139
4483.688	----	-.102	-.011
4497.717	----	.061	.152
4502.390	-.259	-.122	.029
4502.708	----	-.094	.009
4511.375	-.115	-.041	.085
4514.350	-.092	-.004	.115
4533.439	-.206	-.078	.050
4541.244	-.082	.004	.109
4561.250	-.108	-.015	.082
4605.265	-.247	-.118	-.017
4613.257	-.150	-.039	.067
4621.344	----	.022	.114
4628.246	-.247	-.144	-.013
4633.242	----	-.073	.048
4635.231	-.130	-.038	.074
4638.246	-.153	-.049	.085
4783.522	-.127	-.024	.084
4787.536	-.004	.075	.169
4811.464	-.056	.069	.170
4813.422	-.042	.081	.184
4822.412	-.172	-.043	.063
4854.459	-.142	-.032	.067
4873.453	-.148	-.044	.054

Table IV

UBV magnitudes of HK Lac with respect to HD 210731 (C2)

J.D. 2440000+	ΔU	ΔB	ΔV
5195.585	----	----	-.541
5210.509	----	----	-.509
5213.855	.583	-.088	-.571
5218.451	.584	-.077	-.563
5219.479	----	-.050	-.539
5221.426	.658	-.025	-.517
5223.451	.645	-.009	-.509
5224.444	.645	-.018	-.518
5225.465	.662	-.018	-.501
5226.482	.630	-.024	-.510
5228.505	.635	.014	-.471
5228.835	.715	.040	-.445
5228.840	----	----	-.451
5229.426	.678	.047	-.449
5230.449	.710	.079	-.429
5230.672	----	----	-.417
5231.806	.760	.073	-.422
5234.810	.691	.009	-.488
5239.437	.572	-.096	-.596
5243.773	.608	-.056	-.538
5244.765	.632	-.039	-.532
5245.578	----	----	-.509
5245.743	.649	-.026	-.516
5246.499	----	-.051	-.535

Table IV (cont.)

J.D. 2440000+	ΔU	ΔB	ΔV
5247.778	.648	-.024	-.514
5250.824	.639	-.013	-.493
5253.595	----	----	-.419
5254.796	.754	.076	-.416
5256.780	.752	.077	-.418
5257.763	.690	.025	-.456
5259.415	.654	.009	-.488
5259.547	----	----	-.461
5261.361	.591	-.049	-.533
5261.824	.603	-.062	-.541
5265.563	----	----	-.590
5270.721	.667	-.014	-.507
5275.761	.684	.011	-.499
5279.717	.780	.108	-.391
5306.644	.760	.104	-.387
5310.688	----	----	-.508
5311.506	----	----	-.542
5316.674	.594	-.067	-.544
5319.668	.648	-.030	-.516
5322.673	.723	.008	-.477
5325.475	----	----	-.344
5471.557	.724	.087	-.399
5473.539	.834	.168	-.336
5475.542	.815	.158	-.353
5493.489	.663	.002	-.472
5508.471	.522	-.120	-.593
5521.510	.708	.095	-.385
5525.910	.812	.127	-.376
5526.539	.780	.109	-.388
5528.515	.659	.011	-.478
5529.930	.616	-.049	-.527
5531.944	.569	-.097	-.570
5532.517	.533	-.112	-.585
5532.902	.564	-.107	-.581
5533.487	.546	-.095	-.579
5534.750	----	----	-.592
5539.817	----	----	-.483
5541.475	.638	-.021	-.492
5542.517	.672	.027	-.458
5545.732	----	----	-.369
5546.519	.810	.158	-.346
5547.515	.807	.151	-.347
5547.721	----	----	-.349
5548.711	----	----	-.356
5560.963	----	----	-.542
5566.565	.674	.027	-.450
5572.862	.818	.149	-.343
5574.884	.765	.101	-.392
5580.741	----	----	-.581
5581.718	----	----	-.578
5581.853	.556	-.104	-.586
5582.732	----	----	-.586
5582.741	----	----	-.579
5583.726	----	----	-.574
5583.781	----	-.080	-.572
5585.716	----	----	-.514
5586.705	----	----	-.523
5586.846	.638	-.042	-.523
5587.724	----	----	-.520
5588.444	.626	-.014	-.502
5588.886	.657	-.008	-.494
5589.889	.691	.012	-.464
5591.709	----	----	-.432
5595.695	----	----	-.339
5596.699	----	----	-.337
5596.786	.849	.167	-.342
5597.364	.803	.153	-.344
5599.695	----	----	-.403
5601.372	.676	.029	-.464
5601.670	----	----	-.474
5603.328	.589	-.070	-.552
5604.334	.539	-.098	-.580
5605.462	.529	-.114	-.593
5606.494	.502	-.125	-.595
5606.710	----	----	-.587
5607.418	.529	-.114	-.591
5618.669	----	----	-.371
5619.627	----	----	-.352
5619.718	----	----	-.334
5621.629	----	----	-.347
5622.392	.788	.134	-.359
5628.615	----	----	-.599
5630.624	----	----	-.619
5631.621	----	----	-.610
5632.640	----	----	-.595
5633.622	----	----	-.576
5635.354	.537	-.096	-.575
5635.627	----	----	-.557
5636.331	.531	-.093	-.568
5636.585	----	----	-.523
5641.707	.795	.106	-.395
5642.643	----	----	-.378
5643.636	----	----	-.352
5645.736	.851	.164	-.345
5646.597	----	----	-.365
5647.746	.789	.109	-.386
5648.323	.751	.093	-.402
5649.347	.668	.033	-.460
5649.637	----	----	-.471
5650.608	----	----	-.515
5651.290	.582	-.068	-.545
5652.664	.501	-.096	-.597
5653.352	.510	-.127	-.605
5653.627	.469	-.126	-.608

Table IV (cont.)

J.D. 2440000+	ΔU	ΔB	ΔV	J.D. 2440000+	ΔU	ΔB	ΔV
5654.632	.499	-.128	-.610	5873.944	.621	-.033	-.522
5654.652	----	----	-.628	5970.752	.598	.008	-.505
5655.664	.484	-.114	-.598	5971.724	.572	-.015	-.507
5657.660	.539	-.121	-.572	5972.752	.603	-.034	-.527
5658.587	.509	-.080	-.592	5973.774	.594	-.053	-.540
5662.710	.636	-.008	-.476	5983.769	.661	.058	-.462
5665.625	.714	.104	-.405	5984.691	.712	.086	-.417
5665.682	.748	.085	-.409	5986.710	.736	.142	-.386
5666.589	.669	.095	-.417	5987.714	.748	.145	-.373
5667.606	.763	.150	-.356	5990.735	.690	.081	-.429
5667.612	----	----	-.376	5991.767	.642	.067	-.465
5667.673	.792	.132	-.358	5992.738	.644	.022	-.479
5668.583	.766	.169	-.341	5993.737	.597	-.003	-.505
5673.616	.643	.054	-.450	5994.749	.583	-.004	-.505
5674.647	.603	.008	-.489	5997.698	.549	-.058	-.550
5675.629	.560	-.045	-.521	5999.676	.530	-.071	-.553
5676.579	.527	-.080	-.564	6000.702	.522	-.064	-.555
5677.608	.490	-.105	-.597	6001.668	.538	-.064	-.549
5678.615	.492	-.123	-.603	6002.671	.540	-.068	-.546
5679.637	.484	-.131	-.607	6004.674	.580	-.037	-.534
5681.665	.513	-.121	-.587	6005.655	.598	-.020	-.518
5683.595	.539	-.076	-.566	6006.657	.635	.013	-.497
5684.571	.569	-.045	-.547	6007.656	.676	.043	-.466
5685.571	.569	-.019	-.528	6008.656	.706	.077	-.423
5686.578	.586	.000	-.515	6009.691	.722	.095	-.406
5687.581	.644	.032	-.481	6010.648	.747	.121	-.381
5697.577	.722	.124	-.402	6012.653	.738	.139	-.382
5698.574	.671	.040	-.446	6013.757	.706	.093	-.395
5699.569	.630	.011	-.496	6014.645	.693	.071	-.417
5700.610	.575	-.050	-.522	6015.711	.687	.068	-.451
5703.582	.527	-.079	-.526	6016.713	.632	.038	-.475
5704.596	.503	-.122	-.588	6021.653	.526	-.035	-.550
5710.598	.567	-.041	-.536	6022.635	.560	-.065	-.535
5711.580	.622	-.006	-.528	6024.634	.519	-.072	-.545
5713.571	.712	.079	-.422	6025.644	.551	-.077	-.560
5820.981	.662	.060	-.450	6028.662	.598	-.048	-.532
5823.972	.611	-.004	-.500	6030.626	.634	.008	-.485
5824.965	.613	-.028	-.501	6031.633	.660	.040	-.464
5825.963	.614	-.024	-.530	6032.619	.689	.070	-.442
5826.963	.576	-.045	-.532	6034.629	.737	.100	-.411
5827.956	.544	-.041	-.541	6036.626	.788	.145	-.360
5828.955	.563	-.050	-.550	6039.676	.699	.077	-.433
5829.965	.569	-.059	-.565	6043.623	.573	-.023	-.533
5830.951	.580	-.053	-.549	6046.664	.550	-.079	-.558
5831.947	.540	-.052	-.545	6051.589	.542	-.066	-.556
5832.945	.579	-.052	-.552	6055.611	.625	.009	-.486
5836.935	.687	.061	-.463	6056.619	.679	.042	-.456
5837.930	.732	.108	-.397	6058.625	.766	-.060	-.422
5838.929	.767	.134	-.380	6060.614	.745	.108	-.390
5862.907	.686	.080	-.406	6064.608	.678	.030	-.449
5871.929	.642	.001	-.481	6068.576	.584	-.032	-.535
5872.955	.643	-.020	-.489	6181.567	.741	.083	-.383

Table IV (cont.)

J.D. 2440000+	ΔU	ΔB	ΔV
6187.977	.727	.103	-.430
6190.979	.624	-.001	-.515
6197.956	.494	-.088	-.577
6198.954	.538	-.084	-.573
6199.954	.535	-.064	-.547
6204.950	.706	.096	-.426
6205.938	.773	.134	-.370
6206.929	.776	.152	-.351
6207.926	.698	.132	-.358
6208.928	.728	.149	-.359
6209.916	.734	.131	-.365
6210.915	.696	.105	-.389
6211.524	.696	.068	-.422
6211.912	.697	.102	-.413
6213.533	.645	.005	-.486
6213.904	.640	.036	-.467
6218.900	.526	-.083	-.570
6221.938	.500	-.103	-.596
6222.889	.498	-.100	-.561
6223.890	.526	-.081	-.581
6224.881	.623	-.059	-.554
6225.875	.664	-.012	-.509
6226.872	.694	.046	-.448
6228.497	.731	.087	-.420
6229.865	.736	.141	-.371
6230.862	.738	.140	-.371
6231.867	.770	.152	-.350
6233.895	.738	.143	-.363
6234.901	.734	.124	-.384
6235.846	.723	.098	-.415
6236.873	.673	.057	-.447
6237.892	.662	.041	-.454
6238.850	.662	.015	-.498
6241.874	.553	-.066	-.564
6242.873	.513	-.111	-.591
6243.878	.503	-.090	-.594
6244.931	.520	-.103	-.593
6245.872	.459	-.112	-.603
6248.840	.549	-.059	-.554
6249.916	.606	-.035	-.517
6250.845	.612	.022	-.466
6251.912	.546	.037	-.453
6252.932	.708	.083	-.403
6259.851	.705	.114	-.386
6267.829	.495	-.102	-.588
6269.848	.462	-.116	-.605
6270.828	.494	-.114	-.597
6271.827	.535	-.101	-.577
6272.793	.605	-.065	-.547
6277.948	.769	.147	-.372
6281.880	.770	.150	-.367
6282.784	.786	.139	-.367
6283.399	.736	.074	-.429
6283.784	.711	.100	-.406
6285.995	.662	.030	-.493
6286.832	.623	.015	-.493
6287.886	.605	-.036	-.523
6288.952	.595	-.067	-.563
6289.833	.568	-.067	-.560
6290.782	.533	-.087	-.575
6291.771	.520	-.095	-.579
6292.767	.481	-.110	-.598
6293.479	.519	-.125	-.607
6293.771	.479	-.129	-.603
6296.771	.514	-.105	-.581
6298.876	.592	-.026	-.522
6299.366	.675	.025	-.482
6299.810	.645	.023	-.482
6300.761	.686	.072	-.434
6301.796	.745	.093	-.412
6304.833	.782	.142	-.362
6306.780	.699	.114	-.381
6307.761	.751	.106	-.404
6308.883	.669	.044	-.447
6309.398	.679	.055	-.458
6312.753	.567	-.053	-.544
6313.753	.546	-.054	-.544
6314.744	.542	-.062	-.560
6316.737	.518	-.110	-.595
6317.747	.473	-.117	-.613
6320.743	.522	-.097	-.598
6321.784	.529	-.093	-.572
6322.737	.546	-.057	-.539
6325.752	.717	.086	-.422
6327.786	.745	.138	-.387
6328.825	.747	.128	-.387
6329.723	.763	.121	-.377
6330.729	.713	.119	-.409
6331.729	.708	.082	-.428
6332.754	.656	.036	-.453
6333.720	.611	.028	-.467
6334.784	.619	-.013	-.518
6338.736	.548	-.081	-.572
6356.327	.741	.087	-.426
6359.330	.659	.006	-.503
6364.314	.587	-.059	-.556
6365.367	.568	-.080	-.571
6366.354	.549	-.092	-.580
6367.330	.524	-.103	-.593

Table V

V observations of HK Lac with respect to HD 208728 (C1)

J.D. 2440000+	ΔV	J.D. 2440000+	ΔV	J.D. 2440000+	ΔV	J.D. 2440000+	ΔV
3633.960	.131	4177.620	.229	4536.619	.099	4881.564	.113
3650.807	.081	4182.547	.187	4536.644	.100	4883.536	.128
3659.834	.164	4194.563	.021	4537.638	.112	4884.664	.117
3662.871	.195	4196.541	.037	4539.652	.122	4889.519	.123
3676.842	.075	4209.669	.062	4540.721	.118	4891.534	.118
3714.820	.212	4210.566	.031	4541.640	.123	4893.535	.115
3718.762	.139	4217.676	.018	4542.610	.125	4893.544	.094
3721.775	.068	4227.667	.232	4543.640	.165	4897.514	.084
3722.786	.048	4451.840	.099	4544.658	.156	4898.512	.077
3723.777	.037	4453.818	.031	4545.632	.154	4900.564	.039
3726.783	.053	4454.868	-.004	4546.642	.163	4905.561	.086
3727.753	.093	4458.838	-.019	4547.640	.136	4905.644	.068
3747.719	.038	4459.823	-.004	4549.610	.068	4907.525	.104
3770.737	.052	4496.856	.159	4554.585	-.020	4914.691	.128
3790.727	.168	4498.730	.136	4554.668	-.025	4915.499	.132
3794.687	.081	4499.700	.109	4555.647	-.001	4916.496	.136
3795.719	.056	4500.861	.068	4816.806	.098	4917.503	.133
3806.698	.148	4501.707	.039	4828.678	.031	4918.682	.120
3834.629	.178	4503.721	-.014	4854.769	.062	4920.503	.106
3849.680	.039	4504.842	-.028	4865.544	.128	4921.496	.095
3855.623	.152	4505.706	-.030	4866.546	.110	4923.493	.061
3870.614	-.005	4506.717	-.017	4867.534	.114	4926.513	.059
3871.621	-.013	4509.804	.049	4868.543	.120	4927.538	.051
3872.607	-.005	4510.814	.072	4869.539	.110	4931.506	.119
3873.603	.009	4511.701	.084	4869.588	.093	4933.521	.144
3876.615	.068	4512.704	.100	4870.531	.106	4934.557	.146
3877.635	.087	4513.703	.107	4871.527	.098	4937.570	.142
3878.568	.103	4514.806	.110	4872.710	.087	4944.507	.133
3879.619	.130	4526.694	.030	4873.725	.076	4947.517	.085
3902.608	.112	4528.672	-.011	4874.681	.072	4954.603	.098
3903.635	.129	4529.638	-.016	4875.558	.062	4955.516	.106
3906.600	.179	4530.644	-.011	4876.557	.045	4956.607	.109
4078.769	.183	4531.650	.002	4877.548	.047	4959.634	.125
4094.771	.017	4532.652	.021	4877.703	.055	4960.603	.129
4136.641	.066	4534.639	.075	4878.520	.057	4967.647	.137
4160.618	.074	4535.646	.090	4880.558	.078	4968.607	.139
4169.576	.036	4535.666	.082	4880.616	.067		

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STUDY OF 54 RR LYRAE VARIABLES IN THE GLOBULAR CLUSTER M15

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STUDY OF 54 RR LYRAE VARIABLES IN THE GLOBULAR CLUSTER M15

Abstract

Brightness values and light curves are presented for 54 RR Lyrae stars and one cepheid in the globular cluster M15 (NGC 7078) from 399 photographic plates taken at the Newtonian focus of the 24" reflector of the Konkoly Observatory between 1937 and 1966.

Introduction

The *M15* = *NGC 7078* ($\alpha_{1950} = 21^h27.6^m$, $\delta_{1950} = 11°57'$) is one of the most fascinating globular clusters. Because of its star content it belongs to the five globular clusters richest in RR Lyrae variables known so far in the northern sky and apart from this it contains a planetary nebula (*Brown*, 1951, *O'Dell et al.*, 1964), an IR source (*Mac Gregor et al.*, 1973), an X–ray source (*Clark et al.*, 1975) and a pulsar (*Wolszczan et al.*, 1989), so from many points of view it is worthy of study.

In 1895 *Bailey*, (1919) started a systematic photographic study of globular clusters, among them *M15*, and on the plates thus obtained a search for variable stars began. This series of observations was continued by *Shapley, Duncan* and *Baade* at Mt. Wilson. Prior to the beginning of the Budapest observations, in the year 1937, the last photographs were taken in 1932. The plate material, the variables discovered thus far and the studies of their period changes were concisely summed up by *Izsák*, (1957) in his paper on the *O-C* diagrams of 21 RR Lyrae variables in *M15*, using the plate material obtained in Budapest until 1952.

Observations carried out with the 24" Newton telescope of the Konkoly Observatory in Budapest span almost 30 years, from 1937–1966. These observations are described in the following chapter. Since a new one meter RCC telescope was installed at our Piszkéstető mountain observatory in 1975, observations have continued there. The measurements of these new plates and the investigation of period changes of variables using the entire sets of observations published so far will be discussed in a later paper.

The considerable observational material published on *M15* has been listed in *Smith* and *Sandage*'s paper (1981) and it is complete until 1981. In addition to these I refer to the paper of *Bingham et al.*, (1984), which contains observations from the years 1974 to 1979 for 56 RR Lyrae variables.

Finally some unpublished sources of valuable material should be mentioned; e.g. the 122 plates obtained at Purple Mountain Observatory in China, on which three RR Lyrae stars were discovered by *Tsoo Yu-Hua*, (1961) and their brightness values estimated. Also some unpublished although measured plates of *Dodson, Cornwall* and *Thorndike*, (1946) is referred to. These observational data may have great importance in constructing phase diagrams to study period changes.

The Budapest observations

In 1937 *L. Detre* started a photographic programme at Konkoly Observatory in order to study variable stars in globular clusters *M3, M5, M15, M56* and *M92*. As part of this programme more than 400 plates were taken of the globular cluster *M15* at the Newtonian focus of the observatory's 24" telescope. The plate scale is 60"/mm. By 1966, the last year of this programme, city light and air pollution in the expanding capital made it impossible for photographic observations to continue in Budapest even under the best weather conditions.

All the photographic plates (399) listed in *Table I.* were good enough to provide magnitude values of the variables in the cluster either by measuring or by visual estimation. The columns are as follows: identification number of plate, heliocentric J.D. of midexposure, length of exposure in minutes, kind of plate used and observer.

From the 120 variables known so far, 55 could be measured or estimated on our plates. The limiting magnitude of the plates was about 17.0. The measurements were carried out using a Rosenberg microphotometer, and the visual estimates by blink microscope and microfilm reader device. Variables with close companions or situated in a crowded area near the centre of the cluster were not suitable for being measured by microphotometer, so estimation was the only way to get brightness values for these objects. A sequence of 16 comparison stars covering a range of magnitude 14.0 - 17.8 was selected from Bailey's list (*Bailey*, 1919). The magnitudes were determined by *Izsák* (1952) comparing them with Mount Wilson photographic magnitudes in Selected Areas 63 and 89.

These standard stars were measured on each plate against the background to construct the magnitude/density curve. (The value of the adjacent background sky has been subtracted from the density of each comparison star.) The average of the background densities has been subtracted from the density values of the measurable variables. When estimating no density curve was necessary. We tried to fit the variable in question into a sequence of several adjacent comparison stars by visual interpolation. The accuracy of the estimation is as good as the one of the measurement, in some cases can be even higher. The following variables have been completely estimated: *V7, V17, V27, V31, V36, V45, V50, V51, V54, V57, V66, V67, V74, V96, V97, V101, V103, V104, V105.*

The brightness values obtained are listed in *Table II.* The first column contains the heliocentric J.D. of the midexposure, and in the following columns each variable is identified by its number in the Third Catalogue of Globular Clusters (*Sawyer*, 1973). Instead of the magnitude, *m*, the value *m-10* is to be found.

In *Fig. 1.* the light curves of 53 RR Lyrae variables are presented from the years 1938 and 1951. In some cases obvious differences can be seen in the shape of the light curves of the same variable coming from different years due to Blazhko effect or double mode pulsation. These phenomena will be discussed below.

The stars are ordered according increasing periods. When constructing the light curves the periods determined by Bailey and by other authors were used as the starting point. Given that our final aim was to study period changes in the cluster, these periods have successively been corrected — if necessary — in the course of performing the phase diagrams (*O-C* residuals). Our periods are listed in *Table III.* Some features of the period behaviour have already been examined (*Barlai*, 1983). However the detailed study of period changes will be the subject of a forthcoming paper including the observations obtained with the one meter RCC telescope between 1976 and 1985 at our Piszkéstető mountain station.

Remarks about individual variables

V1 The only one cepheid discovered so far in *M15* (*Bailey*, 1919). Its magnitude values are listed in *Table II.* Light curves are not published for their behaviour corresponds to a typical population II cepheid, and there is no change in the light curve worth mentioning.

V3 The period (0.388714^d) found by *Mannino*, (1956a) provides light curves of less scatter than the period (0.3891547^d) determined by *Izsák*, (1957). So Mannino's period was our starting point in constructing the light curves.

V6 This star is situated near the centre, which explains the large scatter even in the case of estimated magnitudes.

V7 This star is near the centre, so only estimation of the magnitudes was possible. Estimated amplitudes — of course — cannot be compared to the amplitudes obtained from other sources. However they are suitable to determine the period.

V8 This variable has a close companion and is situated relatively near the centre, which is why the visual estimation shows rather large scatter.

V11 The period (0.3432595^d) found by *Izsák*, (1957) fits the Budapest observations best. Some of *Mannino*'s (1956a) brightness values may be erroneous, for they are contradictory even in the case of other periods. So Izsák's period was used as the starting point in constructing the light curves.

V12 This star has a changing light curve presumably due to a long beat period, although no change in the height of the maxima can be observed within one year of observational material which virtually spans an interval of 2–3 months. The highest maximum takes place in 1938 ($\approx$ 15.20 magn) and the lowest in 1951 ($\approx$ 15.50 magn). *Izsák*'s (1957) period was accepted in constructing the light curves ($P=0.5928750^d$), for it can represent all former and later observations (*Mannino*, 1956a; *Makarova* and *Akimova*, 1965; *Bailey*, 1919; *Wemple*, 1932 etc.) well.

V15 The position of this variable makes it possible to measure the brightness easily. The light curve exhibits strong Blazhko effect. The highest maximum, 15.00 magn, was observed at J.D. 2429131, and the lowest one — 15.59 magn — at J.D. 2429518. The consecutive low and high maxima suggest a Blazhko period of about 30 days.

V17 This star is one of the DM variables in the cluster (*Cox et al.*, 1983). The light variation of this star reminds us very much of the behaviour of variable 68 in the globular cluster *M3*. The amplitude of the light variation can be characterized by the fact that the difference between the highest and lowest maxima amounts to 0.6 magn. The oscillation in the position of the median points of the ascending branches is more than one hour.

V19 This star exhibits Blazhko effect. The oscillation in the phases of the median points on the ascending branches is at least as much as 0.037 *day* ≅ 1 *hour* (i.e. the phase shift between J.D. 2433872.575 and J.D. 2433884.557 in the year 1951). From these three phase shifts a short Blazhko period of about 30 days duration can be concluded. An oscillation of about 0.3 magn in the height of the maxima can be claimed with certainty. $M_{max} \approx 14.95$ magn; $M_{min} \approx 15.25$ magn. Unfortunately no well observed low maximum is available in the observational material.

V20 This variable is situated in a dense region near the centre, which led to difficulties in measuring its brightness. Due to the dark background the light curve has been distorted, and the minima has been shifted higher.

V22 Blazhko effect cannot be excluded with certainty, although the low number of well observed maxima does not enable us to settle this question.

V23 The Blazhko effect can clearly be seen in the Budapest material; $M_{max} \approx 15.35$ magn, $M_{min} \approx 15.70$ magn.

V24 This star is situated near the centre, so the scatter is considerable and the brightness values are shifted towards higher values in comparison to the light curves obtained for other variables in the cluster.

V26 An interesting DM variable of the cluster (*Cox et al.*, 1983). Due to the small amplitude no sign of any specific behaviour could be seen in the Budapest material even in spite of the broadened maximum brightness values.

V27 This star proved to be a constant on the Budapest plates. It was estimated in all cases when the plate limit made it possible. The brightness values obtained are between 16.8^m and 17^m.

V28 Although this star has a good separated position in the outer part of the cluster, still only 300 brightness values could be obtained by measurement, for the star is so dim in minimum light that it reaches the limiting magnitude of the photographic plates.

V29 This star itself has a close variable companion: *V96*. Due to this fact the brightness values have been obtained partly by measures and partly by estimates. The period 0.574978^d found by *Izsák* (1957) satisfies the Budapest observations, although the Asiago observations (*Grubissich*, 1956) show greater scatter with Izsák's period.

V30 One of the double mode pulsators in the cluster (*Cox et al.*, 1983).

V31 This star is a double mode pulsator (*Cox et al.*, 1983). The light curves obtained in Asiago (*Grubissich*, 1956) and by *Makarova* and *Akimova*, (1965) are smooth with no considerable scatter. Considering the material obtained by *Bailey*, (1919), in Babelsberg (*Bronkalla*, 1960) and in Budapest, we find a considerable scatter in the light curve. Therefore the plates were measured and afterwards visually estimated twice. The accepted brightness values are the average of the measurements and of the two series of estimation.

The scatter which remained after this procedure can be considered as real. This degree of variation in the light curve is very seldom found among RRc stars. The highest maximum observed is 15.50 magn, the lowest one is 15.90 magn. The oscillation in the maximum is presumably very high, while it is negligible in the minimum.

V32 There is a great scatter in *Bailey*'s (1919) material possibly due to Blazhko effect. The Blazhko effect can definitely be seen from *Mannino*'s (1956b) observations; there exists great difference between the slopes of the ascending branches from the years 1954 and 1955. A Blazhko period of $\approx$ 50 days can be concluded from the oscillations of the median points of the ascending branches in the year 1954, while the 15.5 magn point on the ascending branch oscillates with 0.03 day $\approx$ 3/4 hour.

The Budapest material suggests strong variation in the height of the maximum. The highest maximum observed is 14.75 magn (1941), the lowest one 15.30 magn (1951), so the difference in height can reach a value of 0.55 magn. Unfortunately the star's position is near the centre, so a slightly larger scatter than average can be taken into account.

V34 Bright star, very probably variable.

V36 This star is close to the centre, therefore its brightness was only estimated visually on the Budapest plates. The material obtained by other observers is rather scanty; only *Bailey*'s (1919) and the Babelsberg (*Fritze*, 1962) observations are available.

V38 This star has a close companion whose influence could be excluded neither in measuring nor in estimation. The scatter in the light curve is greater than usual.

V39 One of the double mode pulsators detected by *Cox et al.*, (1983). The influence of an adjacent dim companion could not be excluded either in measuring or in estimation. So the usual distortion (elevated minimum) takes place in the light curve. The light variation shows a double maximum not unusual among RRc stars. An oscillation in the height of the maxima amounting to 0.2 magn can be definitely shown.

V44 There is considerable scatter in *Bailey*'s (1919) material. The Babelsberg observations (*Fritze*, 1962) unfortunately contain descending branches only. *Nobili*'s (1957) material shows considerable scatter as well and in *Makarova* and *Akimova*'s (1965) light curves the scatter is noticeably greater in the ascending branch and in the maxima than in the descending branch. All these phenomena might be caused by the Blazhko effect. By unfortunate coincidence the Budapest observations cover descending branches and minima from 1957 on. Still it can be concluded, that considerable variation of the period is not the case.

V45 This star lies near the centre and it is difficult to obtain brightness values. A considerable scatter is to be found in the Babelsberg (*Notni* and *Oleak*, 1958) and in *Bailey*'s (1919) material as well.

V49 In a strange way the Budapest observations almost exclusively cover descending branches and minima. The Babelsberg material (*Fritze*, 1962) does not contain ascending branch either. The given period fits all observations well.

V50 The ascending branch of this star is unusually steep in comparison to the other RRc stars in the cluster. The period (0.2980583^d) is unusually short in this cluster, it much more reminds us of the periods in the cluster *M3*. The stable shape of the light curve and the conspicuously stable period relate to dwarf cepheids.

V51 This star is a double mode pulsator (*Cox et al.*, 1983). Apart from this the scatter in the Budapest material is due to the position of the variable which made its visual estimation difficult. There is large scatter in the Babelsberg material (*Fritze*, 1962) as well. The Asiago material (*Nobili*, 1957) provides incomprehensibly small amplitude and rather large scatter.

The new period (0.3969565^d) found in Budapest fits the observations considerably better than the former ones (*Bailey*, 1919; Babelsberg, Asiago). So it was accepted for constructing the light curves.

V53 The period seems to be correct. From all available observations the variation of the light curve can easily be seen. There are great differences in ascending branches in Budapest material *Bailey*'s (1919) observations from the year 1916 show large scatter, which suggests a changing light curve. Our material from the years 1938 and 1951 suggests the presence of Blazhko effect (or the star's being a double mode pulsator). This star could be measured easily, however, because of its changing light curve, visual estimations were also carried out through all of the Budapest material. In *Table II.* the average of the measured and estimated brightness values has been listed. The large scatter in the ascending branches is exclusively due to changes in the light curve. Strong changes like this occur very seldom in the light curves in this cluster and this behaviour strongly reminds us of the *V31* variable, which is also a double mode pulsator.

V54 *Bailey*'s (1919) period is incorrect and while the period obtained in Babelsberg is possible, the newly determined period, (0.3995683^d) seems to be the most appropriate. *Fritze*, (1962), *Notni* and *Oleak*, (1958) measured the star independently. The amplitude is noticeably small according to the Asiago observations (*Nobili*, 1957). Although the star is a double mode pulsator (*Cox et al.*, 1983), its behaviour is related to a typical RRc star from the Budapest material.

V57 The period determined in Budapest (0.3492988^d) fits the observations of different years better than *Bailey*'s (1919), however there is too little observational material available for this variable. The measurement of the Asiago and Babelsberg plates, and in addition the material of *Filippenko* and *Simon*, (1981) would be of great importance.

V66 This star, although not situated in the dense region of the cluster, exhibits considerable scatter due to its close companion, and both their images are blurred on most of the Budapest plates. The scatter is large in the material obtained by other observers as well.

V67 One of the most exciting variables in the cluster, a double mode pulsator, detected by *Rosino*, (1950). Neither the Babelsberg material (*Notni* and *Oleak*, 1958) nor own our observations enabled us to find an adequate period. The light curves presented in *Fig. 1.* have been prepared using the period given by *Filippenko* and *Simon*, (1981). As the variable lies near the centre in a rather dense region on our plates, difficulties arose in determining the brightness values. The magnitude values listed in *Table II.* are the mean of measure and estimate. The widening in the maxima, however, is not due to the disadvantageous position of the star.

V74 This star is near the centre and has a close companion so the scatter in the maxima is rather due to errors in visual estimation than to Blazhko effect. The steep ascending branch, unusually steep in this cluster and the conspicuously short period (0.2960107^d) would better fit RRc variables in the *M3* globular cluster (see *V50* as well).

V96 One of the most badly situated variables, with two close companions — one of them is *V29*. Due to this fact only estimates could be obtained for the brightness of the variable. Double mode pulsator.

V97 The period (0.696333^d) given by *Notni* and *Oleak*, (1958) proved to be correct. The great scatter in the maxima is probably due to Blazhko effect. Personal errors, however, during estimation cannot be excluded.

V101 Discovered by *Tsoo Yu-Hua*, (1961), this star has a good position at the remote edge of the cluster. Still estimation took place rather than measurement, because determination of the magnitudes was easier and quicker this way. The light curve is characteristic of RRc variables, although the star is a double mode pulsator.

V104 Discovered by *Tsoo Yu-Hua*, (1961). Easily measurable variable at the edge of the cluster. Its brightness was estimated. The scatter present in the maxima is due to its double mode nature (*Cox et al.*, 1983).

Acknowledgements

The author is indebted to late Prof. *L. Detre* for turning her attention to the large observational material on *M15* collected in Konkoly Observatory and for stimulating her to continue observations. Thanks are due to Dr. *B. Szeidl* for useful advice and continuous encouragement in preparing the manuscript. The valuable help of Mr. *M. Lovas* in brightness estimation is acknowledged.

Budapest, Konkoly Observatory, November 1989.

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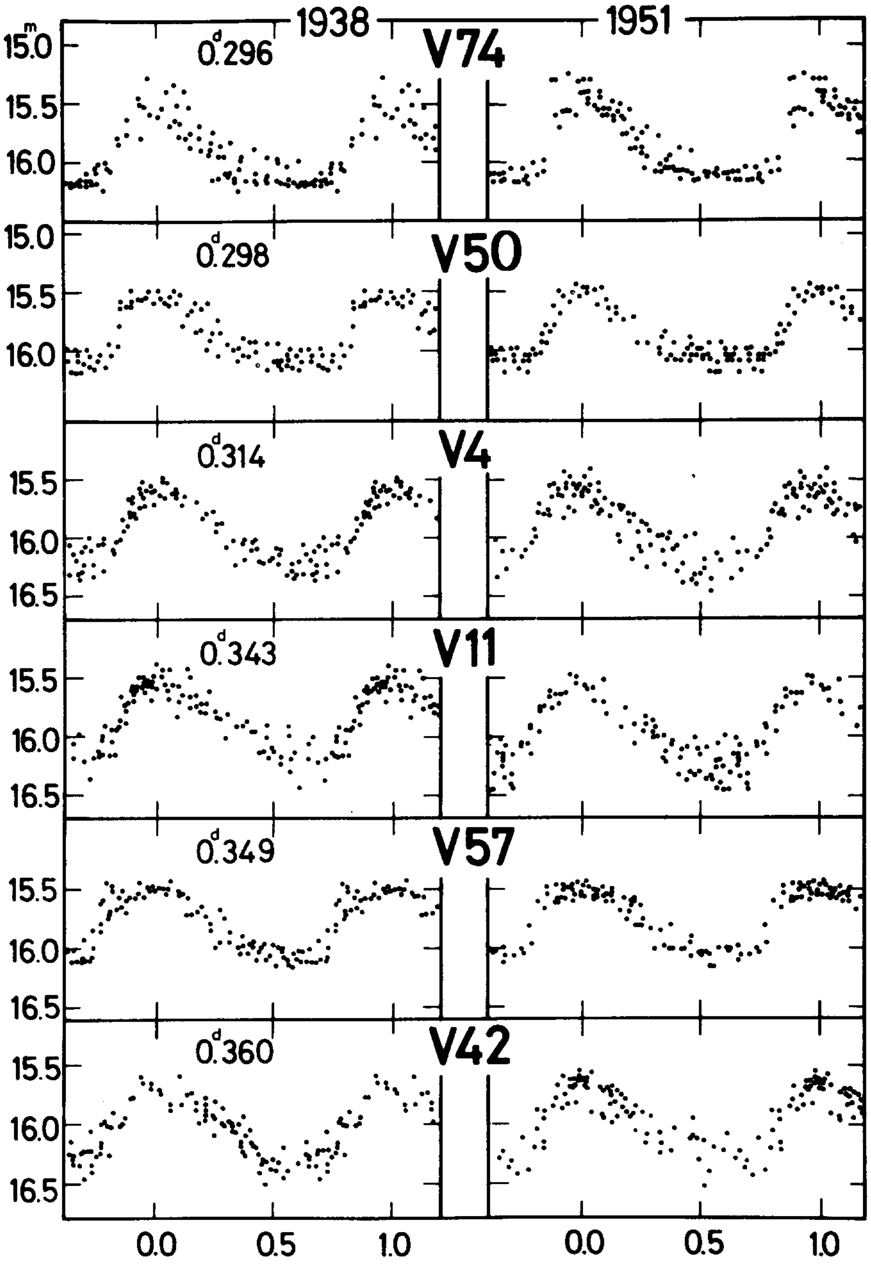

Figure 1: Light curves of RR Lyrae stars in M15 according to increasing periods.

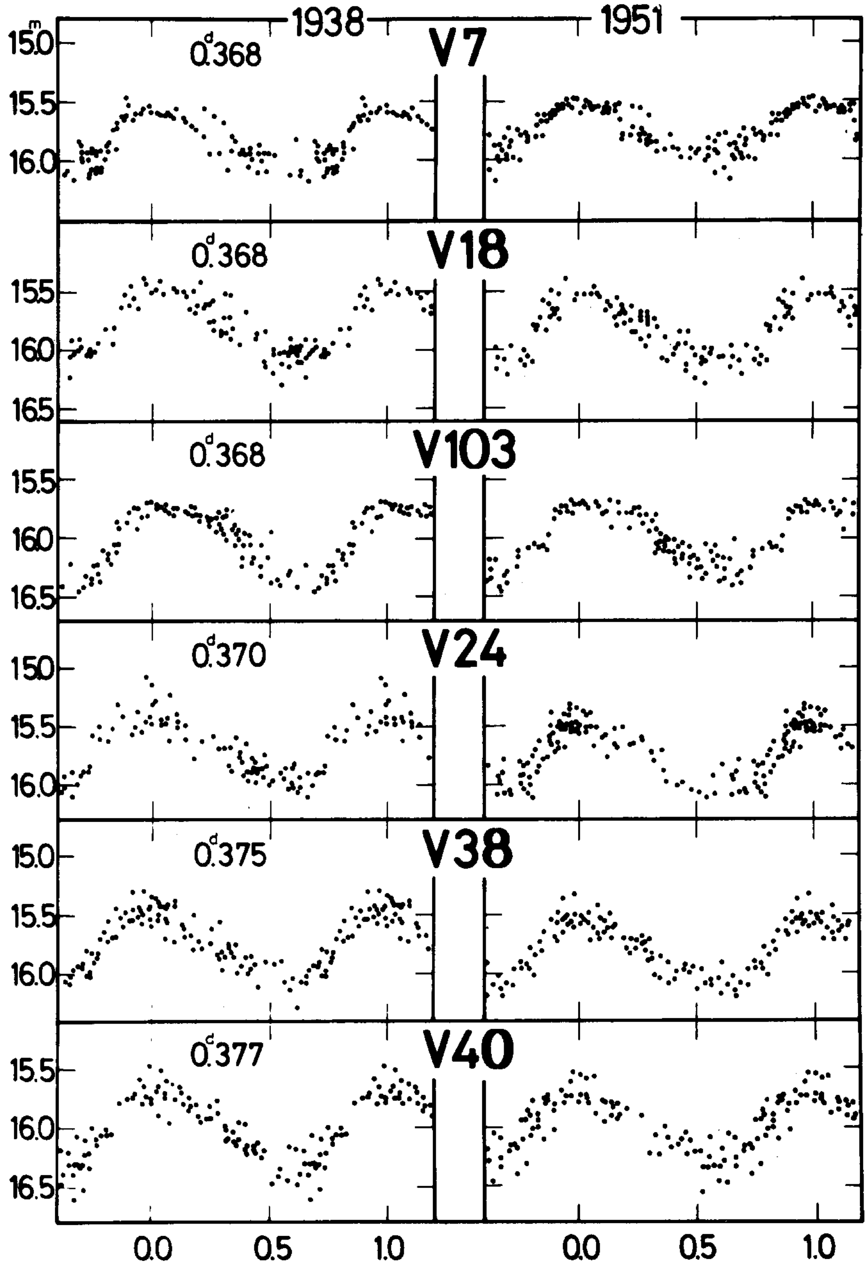

Figure 1: cont.

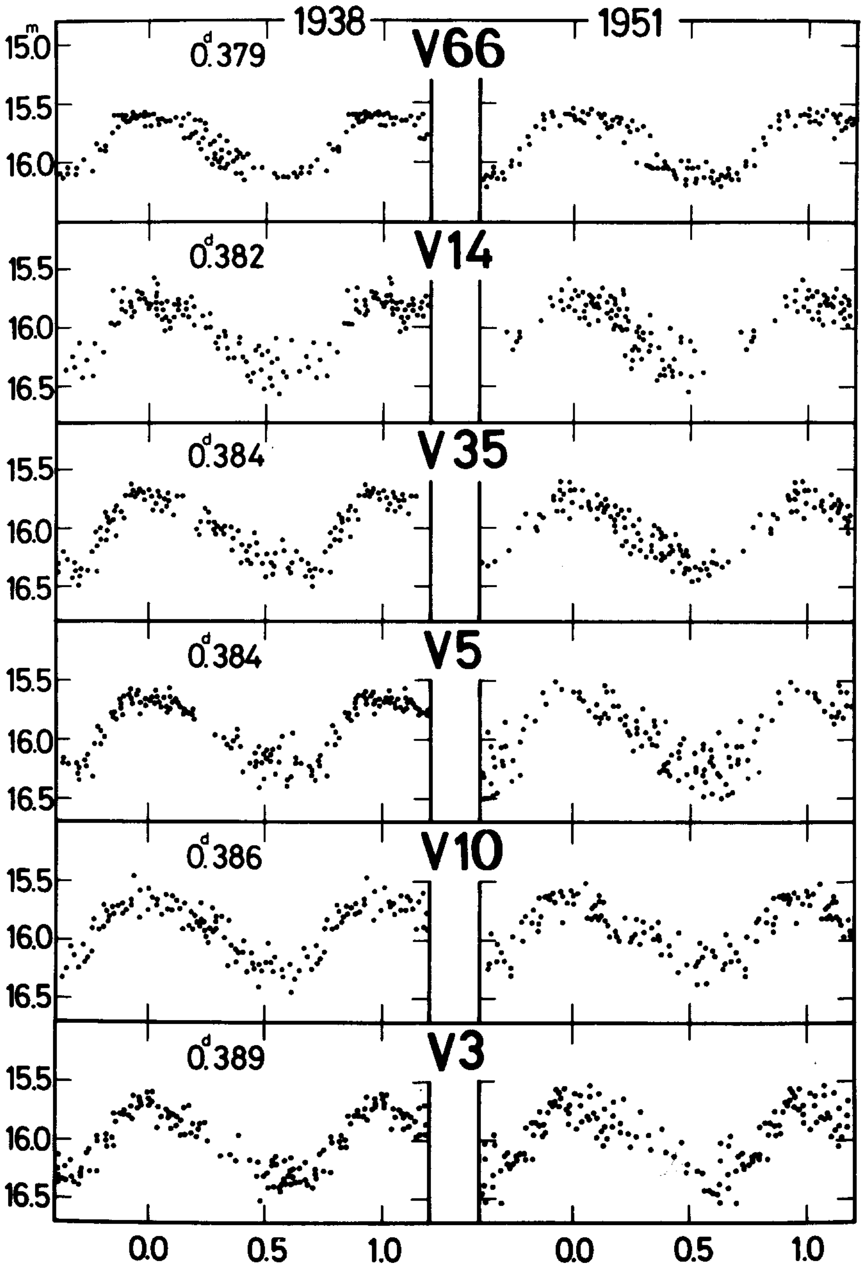

Figure 1: cont.

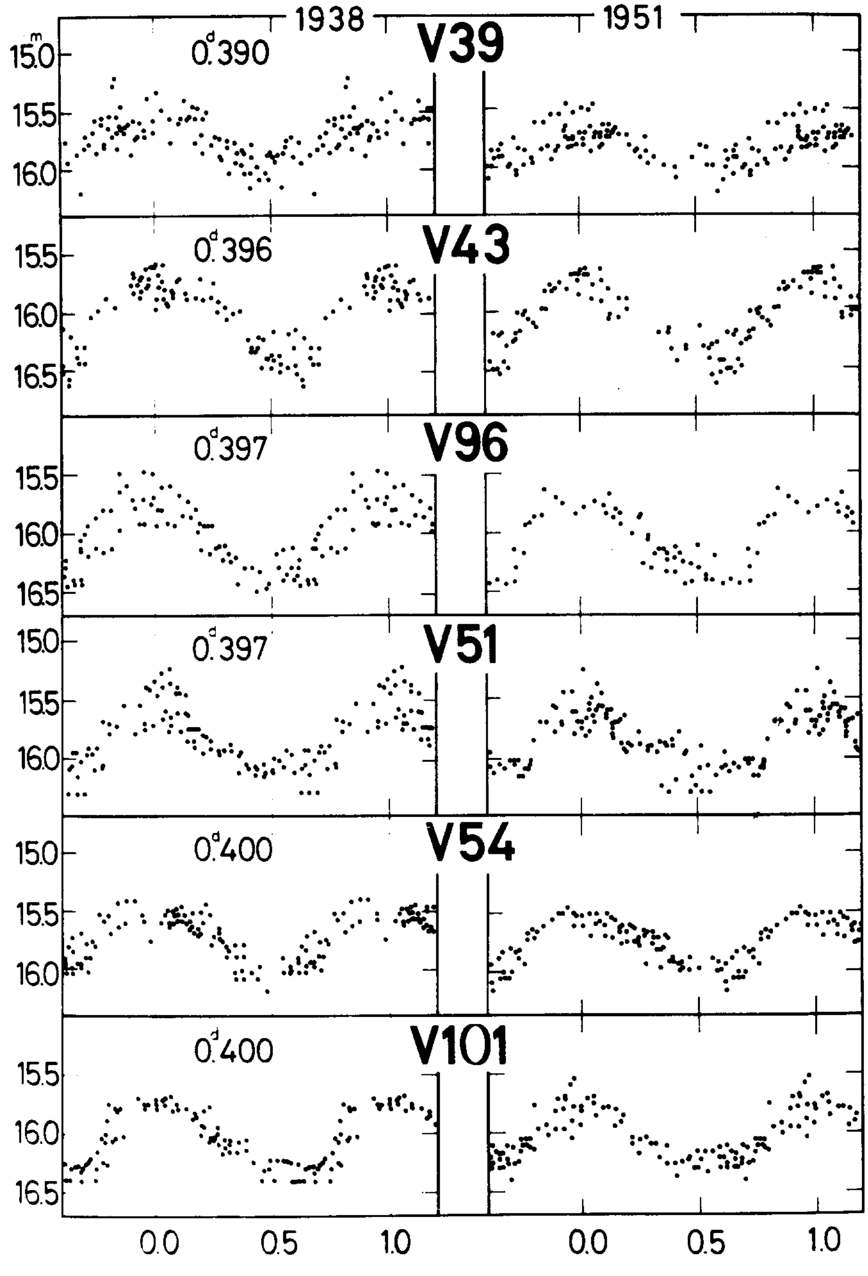

Figure 1: cont.

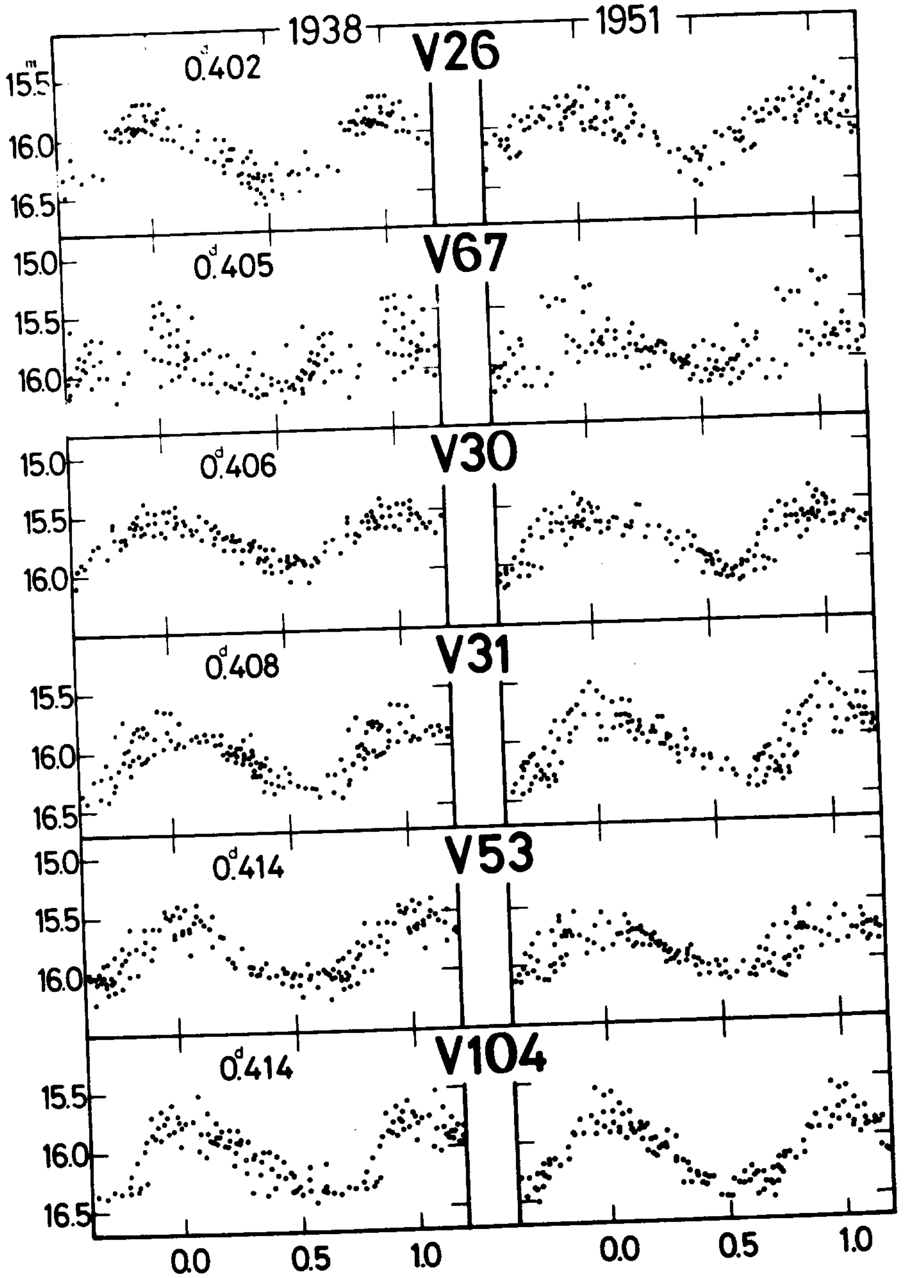

Figure 1: cont.

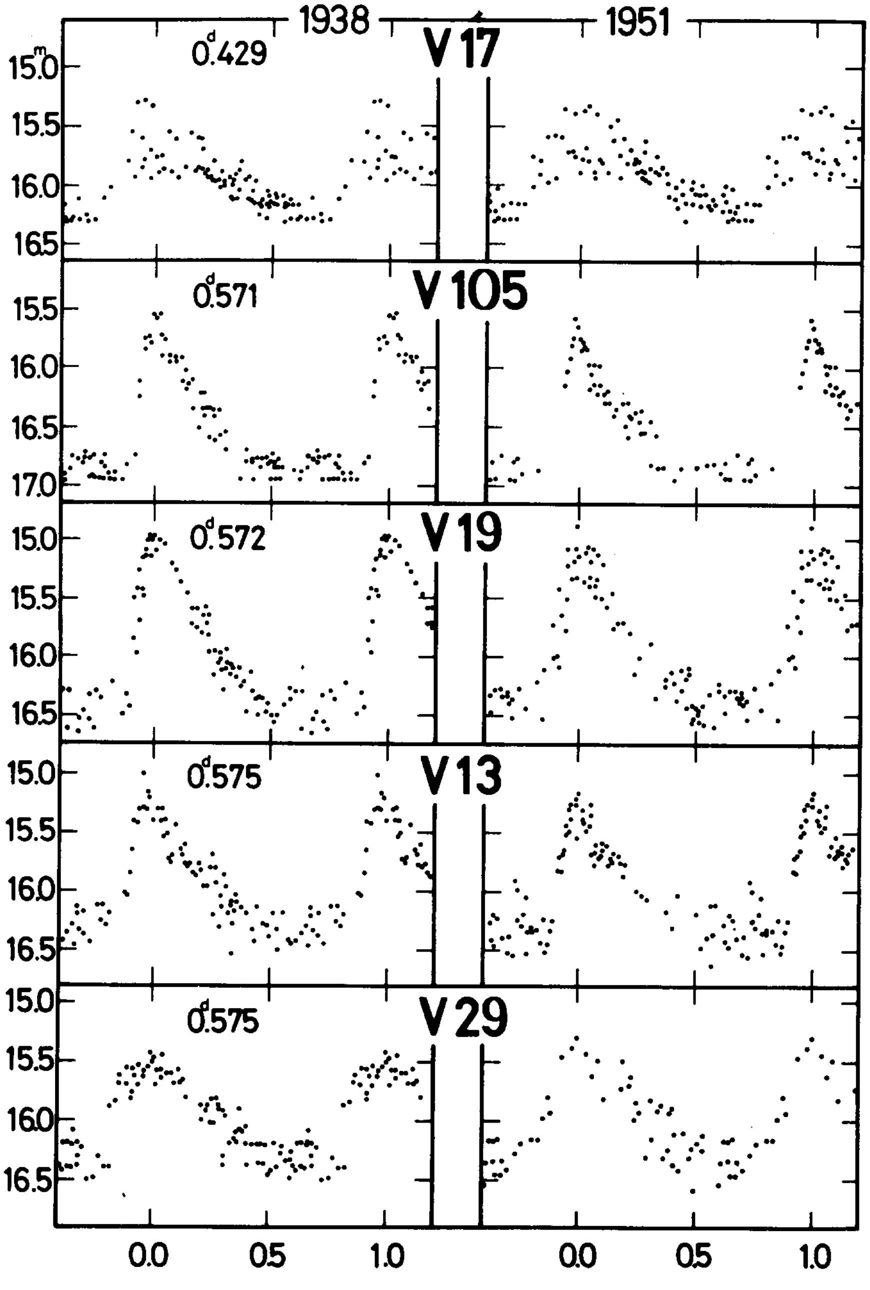

Figure 1: cont.

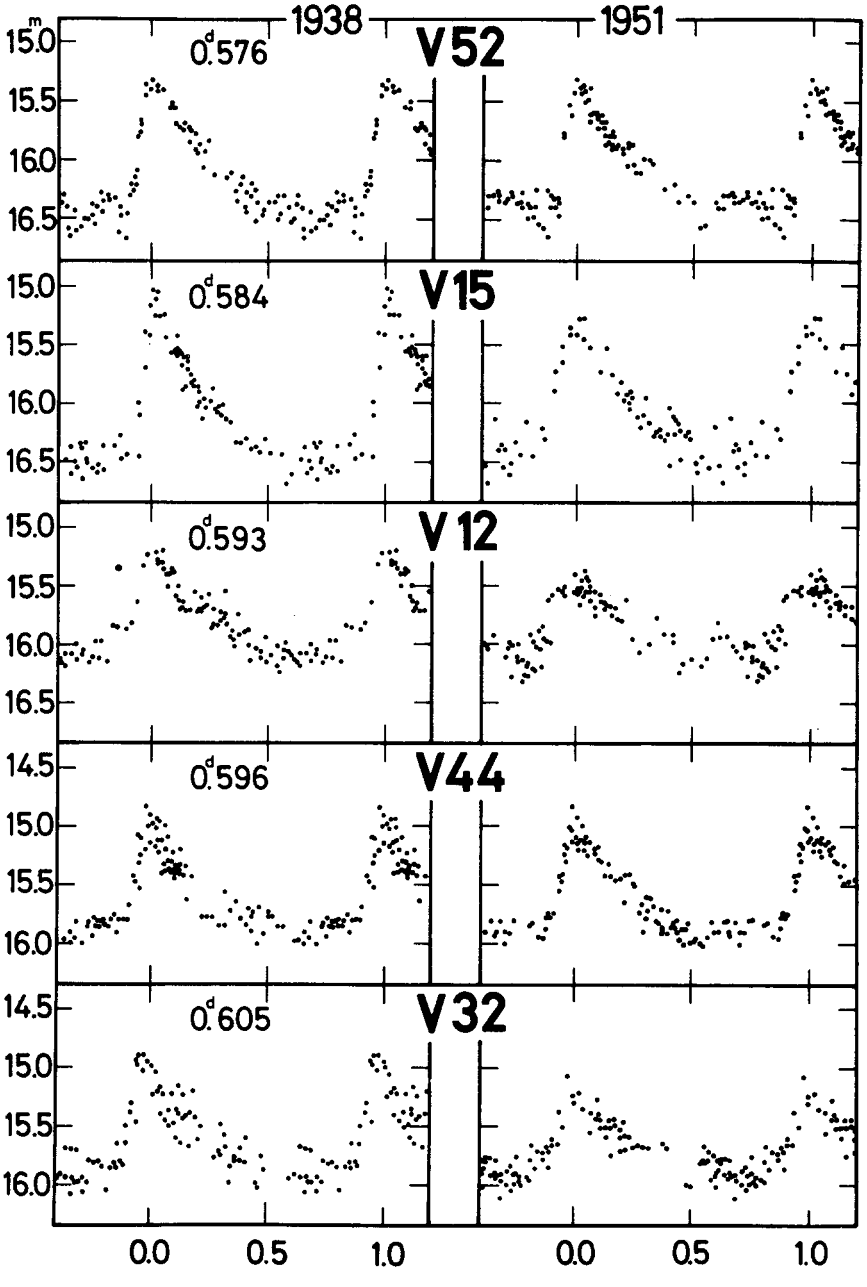

Figure 1: cont.

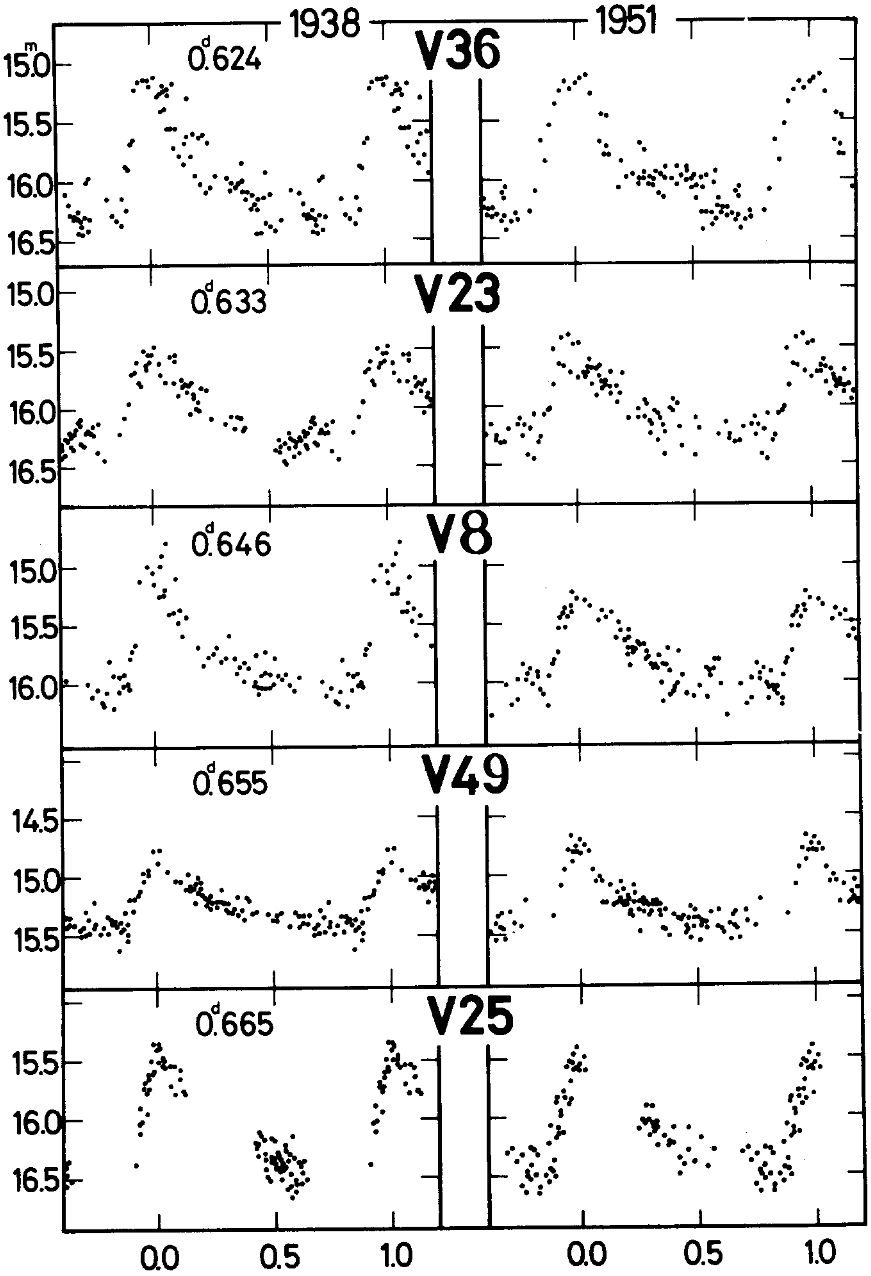

Figure 1: cont.

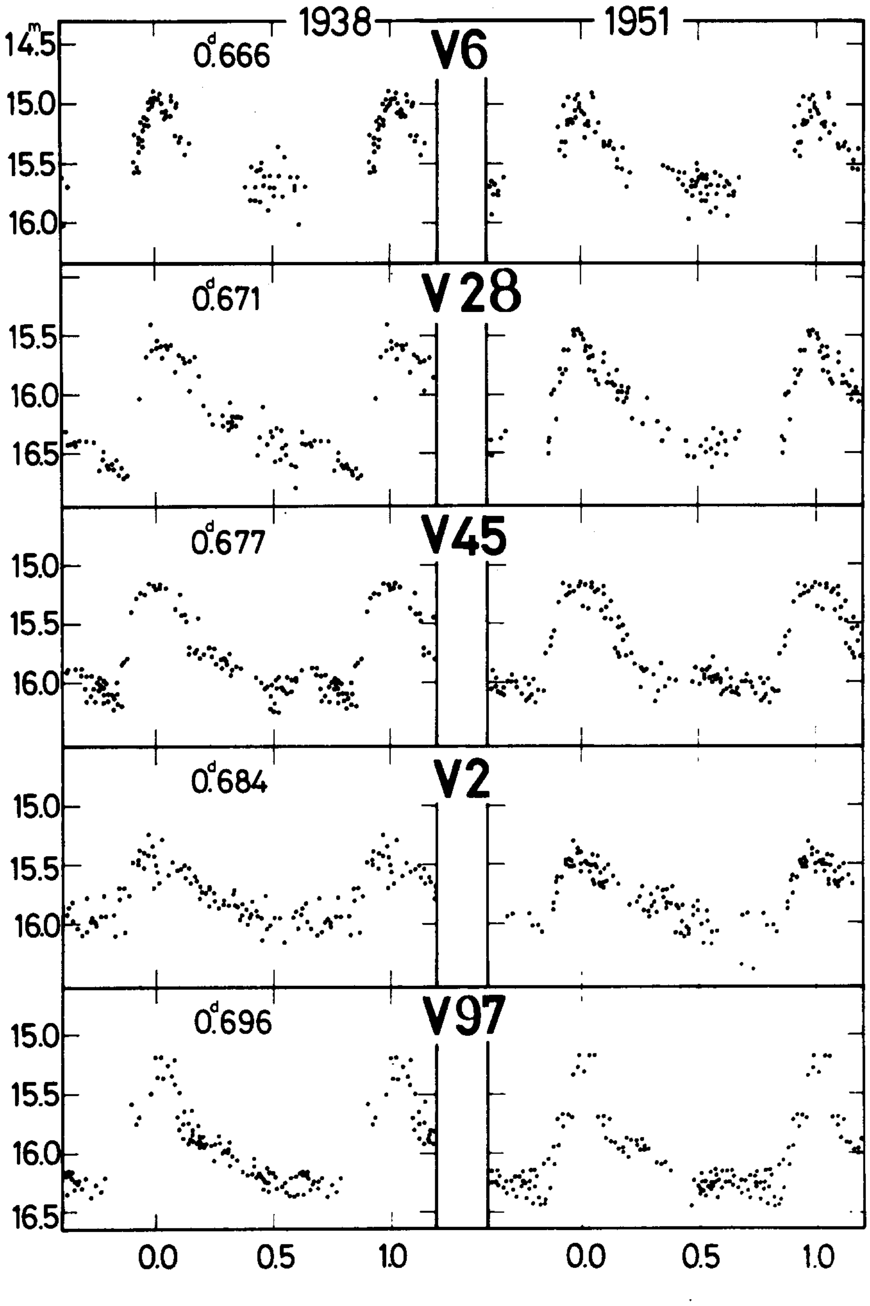

Figure 1: cont.

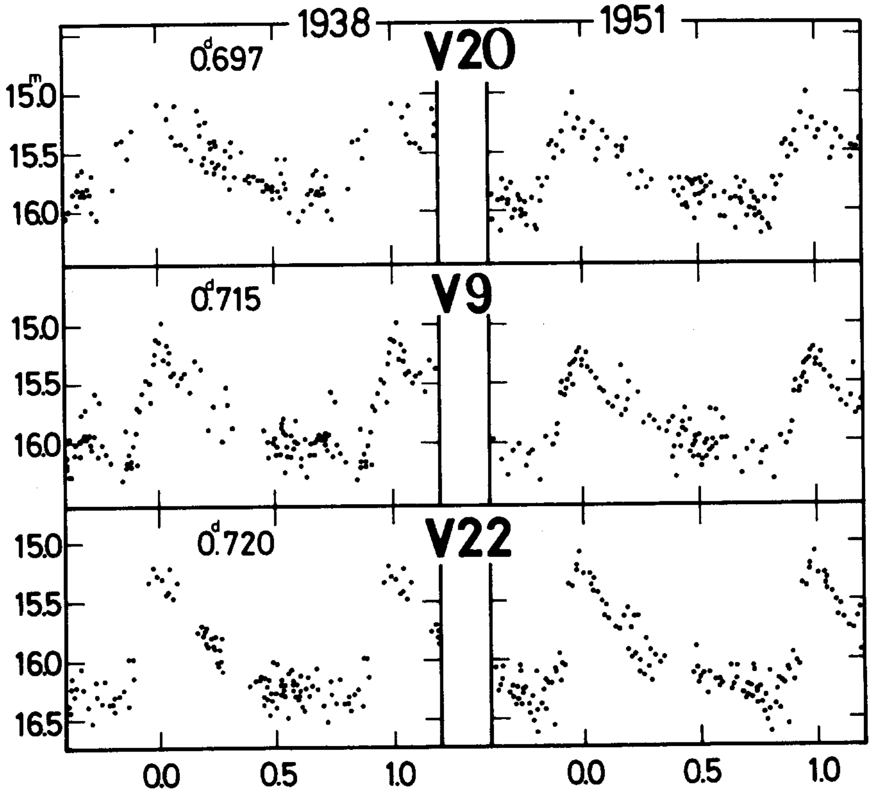

Figure 1: cont.

Table I.

List of plates

Plate R	JD 2400000+	Exp.time in minutes	Kinds of plates	Observer
1245	28752.540	15	Kodak Eastman 40	Detre
1246	28754.394	15	"	"
1247	.436	15	"	"
1248	.485	15	"	"
1249	.502	15	"	"
1250	.521	15	"	"
1256	28758.463	20	"	"
1257	.485	20	"	"
1261	28760.406	20	"	"
1262	.443	20	"	"
1264	28774.392	15	"	"
1266	28775.379	15	"	"
1267	.396	15	"	"
1268	.411	15	"	"
1269	.426	15	"	"
1270	.440	15	"	"
1271	.456	15	"	"
1272	.471	15	"	"
1278	28776.367	15	"	"
1279	.383	15	"	"
1280	.397	15	"	"
1281	.411	13	"	"
1282	.427	15	"	"
1283	.442	16	"	"
1284	.456	15	"	"
1285	.474	15	"	"
1289	28779.392	20	"	"
1290	.411	20	"	"
1291	.437	42	"	"
1297	28780.376	40	"	"
1298	.396	20	Guilleminot Superfulgur	"
1299	.422	20	Kodak Eastman 40	"
1309	28783.406	25	Guilleminot Superfulgur	"
1310	.429	20	"	"
1311	.449	20	"	"
1387	28837.251	15	"	"
1388	.265	15	"	"
1389	.279	15	"	"
1390	.293	15	"	"
1391	.307	15	"	"
1392	.325	20	"	"
1746	29107.517	15	"	Kulin
1747	.531	15	"	"
1748	.544	15	"	"
1749	.558	15	"	"
1750	.570	15	"	"
1753	29108.470	15	"	Detre
1754	.485	15	"	"
1755	.500	15	"	"

Table I. (continued)

Plate R	JD 2400000+	Exp.time in minutes	Kinds of plates	Observer
1756	29108.515	15	Guilleminot Superfulgur	Detre
1757	.530	15	"	"
1758	.544	15	"	"
1759	.558	15	"	"
1760	29109.474	15	"	Kulin
1761	.488	15	"	"
1762	.500	15	"	"
1763	.513	15	"	"
1764	.526	15	"	"
1765	.540	15	"	"
1766	.553	15	"	"
1769	29110.435	15	"	Detre
1770	.449	15	"	"
1771	29113.423	15	"	"
1772	.440	15	"	"
1773	.454	15	"	"
1774	.467	15	"	"
1775	.482	15	"	"
1776	.496	15	"	"
1777	.510	35	"	"
1779	29114.423	15	"	Kulin
1780	.438	15	"	"
1781	.452	15	"	"
1783	29130.385	15	"	"
1784	29131.347	15	"	"
1786	.379	15	"	"
1787	.393	15	"	"
1788	.408	15	"	"
1789	.449	15	"	Detre
1790	.463	15	"	"
1791	.476	15	"	"
1792	.491	17	"	"
1793	.505	15	"	"
1799	29132.371	15	"	Kulin
1800	.385	15	"	"
1801	.398	15	"	"
1802	.411	15	"	"
1803	.424	15	"	"
1804	.434	05	"	"
1806	29138.441	15	"	"
1807	.458	15	"	"
1808	.471	13	"	"
1809	.484	15	"	"
1810	.495	12	"	"
1812	29141.362	15	"	"
1813	.375	15	"	"
1814	.388	15	"	"
1815	.403	15	"	"
1816	.416	15	"	"
1817	29141.429	15	"	"

Table I. (continued)

Plate R	JD 2400000+	Exp.time in minutes	Kinds of plates	Observer
1818	29141.444	15	Guilleminot Superfulgur	Kulin
1819	.456	15	"	"
1820	.469	15	"	"
1821	.482	15	"	"
1822	.495	15	"	"
1837	29159.356	15	"	"
1838	.370	15	"	"
1839	.383	15	"	"
1840	.396	15	"	"
1849	29160.342	15	"	"
1850	.354	15	"	"
1851	.367	15	"	"
1852	.380	13	"	"
1853	.394	15	"	"
1854	.409	15	"	"
1860	29161.344	15	"	"
1861	.357	15	"	"
1862	.372	15	"	"
1863	.386	15	"	"
1864	.399	15	"	"
1878	29162.325	15	"	"
1879	.339	15	"	"
1880	.352	13	"	"
1881	.365	15	"	"
1882	.378	15	"	"
1883	.392	15	"	"
1896	29166.399	10	"	"
1901	29167.353	15	"	"
1902	.366	15	"	"
1903	.378	11	"	"
1904	.391	15	"	"
1935	29187.274	15	"	"
1936	.305	15	"	"
1937	.318	15	"	"
1938	.331	13	"	"
2265	29518.315	5	"	"
2266	.336	15	"	"
2267	.349	15	"	"
2268	.362	15	"	"
2269	.375	15	"	"
2277	29519.455	15	"	"
2279	29520.313	15	"	"
2280	.327	21	"	"
2281	.339	15	"	"
2282	.352	15	"	"
2283	.363	15	"	"
2284	.376	15	"	"
2285	29546.266	15	"	"
2286	.279	15	"	"
2491	29870.406	15	"	"

Table I. (continued)

Plate R	JD 2400000+	Exp.time in minutes	Kinds of plates	Observer
2497	29877.369	15	Guilleminot Superfulgur	Kulin
2498	.381	15	"	"
2499	.394	15	"	"
2501	.453	15	"	"
2502	.481	15	"	"
2503	.499	13	"	"
2505	29879.309	15	"	"
2506	.321	17	"	"
2507	.339	15	"	"
2508	.372	15	"	"
2510	.422	15	"	"
2511	.435	15	"	"
2512	.449	15	"	"
2712	30259.319	15	"	"
2713	.330	12	"	"
2714	.340	12	"	"
2722	30260.340	15	"	"
2723	.354	15	"	"
2724	.372	15	"	"
2725	.387	15	"	"
2726	.406	15	"	"
2727	.427	15	"	"
2733	30261.309	15	"	"
2734	.323	15	"	"
2735	.334	12	"	"
2736	.344	10	"	"
2737	.374	15	"	"
2738	.388	15	"	"
2739	.402	15	"	"
2740	.417	15	"	"
2741	.434	15	"	"
3202	33502.437	10	"	Detre,Herczeg
3205	.484	10	"	"
3206	.502	10	"	Herczeg,Ozsváth
3207	.518	10	"	"
3208	.532	10	"	"
3286	33858.435	10	"	Lovas
3287	.445	10	"	"
3290	.474	20	"	"
3291	.486	10	"	"
3309	33861.427	12	"	"
3310	.439	9	"	"
3311	.452	12	"	Herczeg
3312	.477	12	"	Herczeg,Lovas
3313	.464	12	"	"
3314	.491	12	"	"
3315	.503	12	"	"
3316	.517	12	"	
3317	.531	12	"	"
3318	.546	12	"	"

Table I. (continued)

Plate R	JD 2400000+	Exp.time in minutes	Kinds of plates	Observer
3319	33861.562	12	Guilleminot Superfulgur	Herczeg,Lovas
3331/a	33865.378	12	"	"
3332	.392	12	"	"
3333	.405	12	"	"
3334	.418	13	"	"
3335	.430	12	"	"
3336	.442	12	"	"
3337	.456	12	"	"
3338	.468	12	"	"
3340	.563	12	"	"
3341	.575	12	"	"
3348	33871.454	12	"	Lovas
3350	.483	12	"	"
3351	.496	12	"	"
3352	.507	12	"	"
3353	.518	12	"	"
3355	.542	12	"	"
3356	.555	12	"	"
3357	.570	12	"	"
3358	.584	12	"	"
3359	33872.446	37	"	"
3360	.452	10	"	"
3362	.487	12	"	"
3363	.500	12	"	"
3364	.519	12	"	"
3365	.533	12	"	"
3366	.546	12	"	"
3367	.560	22	"	"
3368	.573	12	"	"
3369	.586	12	"	"
3370	.599	10	"	"
3373	33881.401	10	"	"
3374	.413	10	"	"
3375	.425	10	"	"
3376	.439	10	"	"
3377	.451	10	"	"
3378	.470	10	"	"
3379	.483	10	"	"
3380	33884.395	12	"	"
3381	.408	12	"	"
3382	.436	11	"	"
3383	.450	12	"	"
3384	.464	12	"	"
3385	.478	12	"	"
3386	.495	12	"	"
3387	.521	15	"	"
3388	.539	15	"	"
3389	.558	15	"	"
3390	.574	15	"	"
3391	.594	14	"	"

Table I. (continued)

Plate R	JD 2400000+	Exp.time in minutes	Kinds of plates	Observer
3397	33887.457	32	Guilleminot Superfulgur	Lovas
3398	.478	12	"	"
3399	.498	12	"	"
3400	.511	12	"	"
3401	.524	12	"	"
3405	33888.400	12	"	"
3406	.412	12	"	"
3407	.425	12	"	"
3408	.437	12	"	"
3409	.461	12	"	"
3410	.474	12	"	"
3411	.485	12	"	"
3419	33889.454	12	"	"
3420	.472	12	"	"
3421	.488	2	"	"
3422	.497	12	"	"
3423	.512	12	"	"
3430	33894.380	12	"	"
3431	.393	12	"	"
3432	.408	12	"	"
3433	.420	12	"	"
3434	.439	12	"	"
3449	33895.443	12	"	"
3450	.457	12	"	"
3451	.468	12	"	"
3452	.487	12	"	"
3453	.498	12	"	"
3454	.514	12	"	"
3455	.526	15	"	"
3456	.541	15	"	"
3742	34238.526	15	"	"
3743	.539	16	"	"
3744	.553	15	"	"
3745	.565	15	"	"
3746	.580	15	"	"
3765	34241.435	15	"	"
3766	.450	15	"	"
3767	.463	15	"	"
3768	.479	15	"	"
3769	.492	15	"	"
3792	34253.410	20	"	"
3794	.446	20	"	"
3800	34254.449	20	"	"
3801	.467	20	"	"
3802	.484	20	"	"
3803	.505	10	"	"
3804	.525	22	"	"
3808	34270.492	20	"	"
3809	.514	20	"	"
3953	34573.459	15	"	"

Table I. (continued)

Plate R	JD 2400000+	Exp.time in minutes	Kinds of plates	Observer
3954	34573.473	15	Guilleminot Superfulgur	Lovas
3990	34606.527	20	"	"
3991	.541	20	"	"
3992	.556	20	"	"
3993	.571	20	"	"
3994	.586	20	"	"
4062	34945.407	15	"	"
4063	.424	15	"	"
4075	34949.463	15	"	"
4473	35371.410	15	"	"
4474	.423	15	"	"
4475	.436	15	"	"
4476	.455	15	"	"
4556	35720.298	16	"	"
4557	.315	15	"	"
4558	.328	15	"	"
4559	.344	15	"	"
4560	.356	15	"	"
4561	.369	16	"	"
4562	.381	15	"	"
4563	.394	15	"	"
4564	35725.327	16	"	"
4565	.377	15	"	"
4566	.419	16	"	"
4567	.432	15	"	"
4568	.445	15	"	"
4569	.457	15	"	"
4570	.495	15	"	"
4571	.507	15	"	"
4572	.519	15	"	"
4573	.531	15	"	"
4591	36068.496	15	"	"
4592	.514	15	"	"
4593	.528	15	"	"
4594	.543	15	"	"
4598	36073.380	15	"	"
4599	.393	15	"	"
4600	.406	15	"	"
4601	.419	15	"	"
4602	.432	15	"	"
4603	.446	15	"	"
4604	.459	15	"	"
4605	.473	15	"	"
4606	.486	15	"	"
4607	.500	15	"	"
4608	36074.381	15	"	"
4609	.394	15	"	"
4610	.406	15	"	"
4611	.420	16	"	"
4612	.434	15	"	"

Table I. (continued)

Plate R	JD 2400000+	Exp.time in minutes	Kinds of plates	Observer
4613	36074.447	15	Guilleminot Superfulgur	Lovas
4614	.460	15	"	"
4615	.473	15	"	"
4616	.486	15	"	"
4617	.500	15	"	"
4618	.513	15	"	"
4619	.526	15	"	"
4836	38259.416	15	Kodak 103a-0	Barlai,Szeidl
4838	.473	15	Gevaert	"
4839	.493	15	"	"
4847	38268.472	12	Kodak 103a-0	"
4848	.487	12	"	"
4849	.502	12	"	"
4850	.518	12	Agfa Astro Spezial	"
4851	.531	12	Kodak 103a-0	"
4852	.544	12	"	"
4853	.558	12	"	"
4854	.572	12	"	"
4855	.586	14	"	"
4856	.601	15	"	"
4857	38289.280	12	"	"
4858	.304	12	"	"
4859	.325	12	"	"
4860	.346	12	"	"
4861	.373	12	"	"
4862	.402	12	"	"
4863	.420	12	"	"
4865	.466	12	"	"
4866	.482	12	"	"
4867	.506	12	Gevaert	"
4868	.522	12	"	"
4869	.547	12	"	"
4870	.560	12	"	"
4871	.574	14	"	"
4894	39350.467	13	Kodak 0a0	Barlai
4895	.483	13	"	"
4896	.496	13	"	"
4898	.522	13	"	"
4899	.535	13	"	"
4900	39351.498	13	"	"
4901	.512	13	"	"
4902	.524	13	"	"
4903	.536	13	"	"
4908	39355.445	13	"	Lovas
4909	.460	13	"	Barlai
4910	.474	13	"	"
4911	.490	13	"	"
4912	.504	13	"	"
4913	.520	13	"	"
4914	.533	13	"	"

Table II.

Photographic Observations

J.D.				m-10				
24 00 000+	V1	V2	V3	V4	V5	V6	V7	V8
28 752.540	4.62	5.38	5.98	-	6.12	5.38	5.83	-
28 754.394	4.92	5.85	5.70	-	-	-	5.53	-
.436	5.17	-	5.83	6.11	6.14	5.77	5.48	-
.485	5.44	6.12	6.45	-	-	5.17	5.59	-
.502	5.31	5.80	6.09	-	-	5.17	5.79	-
.521	5.21	5.65	6.10	6.01	5.92	5.21	5.82	-
28 758.463	4.54	5.95	-	6.04	6.00	5.50	5.60	-
.485	4.62	5.90	-	5.98	5.68	5.34	5.49	-
28 760.406	5.21	-	6.05	-	5.72	-	5.70	-
.443	5.45	-	-	-	5.80	-	5.79	-
28 774.392	4.70	5.83	-	5.94	6.09	5.79	5.90	5.98
28 775.379	5.15	6.04	6.07	6.23	5.84	5.63	5.56	5.25
.396	5.18	5.91	5.92	6.14	5.63	5.50	5.62	5.31
.411	5.12	6.02	6.02	6.13	5.92	5.70	5.60	5.38
.426	5.16	6.01	6.11	6.21	5.60	5.71	5.67	5.30
.440	5.08	5.92	6.34	-	5.85	-	5.67	5.60
.456	4.91	5.84	6.08	6.50	5.72	5.69	5.65	5.54
.471	4.87	6.05	6.23	6.13	5.80	5.82	5.76	5.69
28 776.367	5.40	5.96	6.09	6.19	6.05	5.88	5.93	-
.383	5.46	6.06	6.22	6.39	6.20	-	5.98	6.04
.397	5.61	6.09	6.16	-	6.34	5.97	5.87	-
.411	-	-	6.20	6.37	6.25	5.48	5.92	-
.427	5.53	5.72	5.91	6.20	6.26	5.49	5.60	5.82
.442	5.67	5.67	6.06	6.48	6.26	5.45	5.60	-
.456	5.40	5.64	5.80	-	5.91	5.19	5.56	-
.474	5.50	5.40	5.56	6.16	6.10	5.04	5.60	-
28 779.392	5.47	5.76	6.27	5.67	6.00	5.69	5.64	5.72
.411	5.40	5.72	6.30	5.88	6.12	5.80	5.70	5.72
.437	5.61	5.92	6.26	5.92	6.15	5.80	5.68	5.86
28 780.376	5.22	5.99	5.77	6.00	5.71	6.00	5.99	6.11
.396	5.18	6.12	5.81	6.10	5.69	5.60	5.98	6.00
.422	5.30	5.88	5.75	6.30	5.75	5.45	5.99	-
28 783.406	5.21	5.51	6.17	5.51	6.01	5.72	5.80	5.94
.429	5.37	5.69	5.81	5.69	5.65	5.70	5.62	5.85
.449	5.21	5.70	5.77	5.59	5.77	5.71	5.53	5.99
28 837.251	5.00	6.06	5.97	6.34	5.70	5.49	6.00	5.87
.265	4.91	6.03	6.03	6.22	5.67	5.62	6.02	5.91
.279	4.94	6.05	6.01	6.25	5.62	5.50	6.02	-
.293	4.78	6.00	6.00	6.02	5.59	5.40	6.00	6.06
.307	4.70	5.85	5.90	6.04	5.72	5.72	5.98	-
.325	4.60	5.73	6.00	5.68	5.68	5.55	6.10	-
29 107.517	4.83	5.96	6.13	6.36	6.00	5.00	6.12	5.00
.531	-	6.02	6.16	6.32	6.27	-	6.17	5.05
.544	-	-	6.31	6.31	6.20	-	5.98	-
.558	-	-	-	6.00	6.40	-	6.10	4.90
.570	-	-	-	6.06	6.10	-	6.09	4.80
29 108.470	5.20	5.50	5.60	6.06	5.78	5.61	5.56	6.04
.485	5.60	5.54	5.90	6.36	5.71	5.78	5.62	6.04
.500	5.44	5.60	5.74	6.11	5.59	-	5.68	5.92
.515	5.51	5.79	5.88	6.05	5.69	5.72	5.80	-

Table II. cont.

J.D.				m-10				
24 00 000+	V1	V2	V3	V4	V5	V6	V7	V8
29 108.530	5.52	5.74	5.95	6.11	5.67	6.03	5.91	-
.544	5.39	5.84	5.86	5.94	5.64	5.70	5.99	5.82
.558	5.64	5.81	5.86	5.80	5.72	-	5.99	-
29 109.474	4.76	5.95	6.33	6.03	6.10	5.00	5.60	5.16
.488	4.97	6.04	6.13	5.90	6.12	5.11	5.53	5.26
.500	5.02	5.86	6.23	5.82	6.18	5.11	5.60	5.24
.513	4.92	5.98	6.37	5.60	6.18	5.27	5.62	5.41
.526	5.14	6.04	6.31	5.60	6.34	5.32	5.64	5.40
.540	5.11	6.10	6.27	5.66	6.20	5.43	5.63	5.49
.553	5.26	6.07	6.02	5.60	6.29	5.34	5.70	5.60
29 110.435	4.81	5.43	5.80	5.82	-	-	-	-
.449	4.71	5.66	5.80	5.61	-	-	-	-
29 113.423	4.50	5.97	6.11	6.02	6.14	5.18	5.83	5.37
.440	4.49	6.01	5.97	-	5.89	4.96	5.90	5.44
.454	4.60	5.92	6.00	-	5.98	4.95	5.91	-
.467	4.51	5.90	5.78	-	5.78	4.92	5.87	-
.482	4.58	5.96	5.78	-	5.78	5.06	5.68	-
.496	4.48	5.76	5.72	-	5.65	4.93	5.47	-
.510	4.51	-	5.68	6.08	5.68	-	-	-
29 114.423	5.73	5.93	6.13	6.19	6.04	-	5.93	-
.438	5.60	5.80	6.12	6.19	5.97	5.90	5.87	-
.452	5.50	5.70	5.95	6.30	6.13	5.71	5.94	-
29 130.385	5.15	5.66	6.17	6.10	5.66	-	-	-
29 131.347	5.14	-	5.98	6.28	5.92	-	-	-
.379	-	5.90	5.82	6.12	6.06	-	-	5.78
.393	5.31	5.92	5.70	6.23	6.16	5.15	6.12	5.68
.408	-	5.82	5.71	6.29	6.29	-	6.09	5.12
.449	-	5.78	5.78	5.72	6.20	-	6.13	-
.463	5.14	5.98	5.96	5.73	6.22	-	6.08	5.00
.476	-	5.99	5.94	5.71	6.18	-	-	-
.491	5.26	5.94	5.90	5.58	6.03	-	-	5.20
.505	5.10	5.94	6.00	5.66	6.04	-	-	5.10
29 132.371	4.67	5.59	6.51	6.01	5.72	5.53	5.94	5.99
.385	4.79	5.48	6.40	5.79	5.56	5.57	5.94	5.94
.398	4.49	5.55	6.20	5.74	5.70	5.50	6.09	5.74
.411	4.41	5.53	6.37	5.56	5.75	-	5.83	-
.424	4.54	5.61	6.37	5.64	5.75	-	5.94	5.79
.434	4.80	-	-	5.53	-	5.78	-	-
29 138.441	5.00	5.50	5.90	5.83	5.83	5.36	5.91	5.93
.458	5.17	5.53	5.83	5.88	5.64	5.45	5.99	5.94
.471	5.20	5.24	5.70	6.08	5.70	5.62	5.74	5.92
.484	5.19	5.70	5.96	6.25	5.78	5.70	5.63	6.04
.495	5.30	5.50	5.85	6.19	5.66	5.62	5.53	5.72
29 141.362	5.28	5.68	6.25	6.22	6.21	5.49	5.99	5.79
.375	5.25	5.86	6.35	6.32	6.19	5.34	6.07	5.86
.388	5.20	5.71	6.33	6.33	6.13	5.22	6.05	5.98
.403	5.49	5.74	6.29	6.13	6.06	5.18	5.92	5.87
.416	5.30	5.87	6.08	6.24	6.39	4.99	5.90	6.02
.429	5.34	5.84	6.27	6.33	6.17	4.96	5.62	6.10
.444	5.44	5.85	5.95	6.00	6.32	5.07	5.60	5.92

Table II. cont.

J.D.				m-10				
24 00 000+	V1	V2	V3	V4	V5	V6	V7	V8
29 141.456	5.36	5.75	5.77	6.13	6.25	5.10	5.56	6.04
.469	5.22	5.86	5.78	5.84	6.22	4.98	5.59	6.01
.482	5.41	5.93	5.79	5.70	6.31	5.02	5.61	5.93
.495	5.42	5.87	5.73	5.52	5.93	5.28	5.60	5.95
29 159.356	4.70	6.01	5.74	5.70	5.96	5.54	-	5.69
.370	4.60	5.95	5.62	5.65	5.98	5.36	5.94	5.85
.383	4.70	5.95	5.64	5.60	6.07	5.13	5.99	5.78
.396	4.52	6.16	5.65	5.52	6.06	5.01	6.05	5.75
29 160.342	5.52	5.38	6.16	5.58	5.81	5.82	5.91	6.00
.354	5.50	5.40	6.30	5.59	5.72	5.82	5.93	6.11
.367	5.51	5.42	6.30	5.65	5.63	5.83	6.06	6.05
.380	5.46	5.34	6.17	5.69	5.60	5.69	6.10	6.16
.394	5.48	5.56	6.44	5.80	5.71	5.71	6.09	6.08
.409	-	5.28	6.30	5.95	5.68	-	-	-
29 161.344	5.18	5.85	5.68	5.78	6.19	5.58	5.61	5.70
.357	5.22	5.80	5.72	5.88	6.33	5.57	5.56	5.82
.372	5.25	5.94	5.77	6.04	6.08	5.31	5.66	5.79
.386	5.24	6.14	5.80	6.01	5.97	5.05	5.74	5.59
.399	5.18	6.04	5.72	6.10	6.32	5.01	5.79	5.92
29 162.325	4.56	6.10	6.21	6.05	5.65	5.70	5.92	6.34
.339	-	5.70	6.38	6.04	5.80	-	-	5.81
.352	4.60	6.07	6.25	6.22	5.76	5.70	5.86	6.21
.365	4.57	5.76	6.35	6.18	5.66	5.56	5.72	6.07
.378	4.51	5.48	6.18	6.11	5.77	5.61	5.66	6.02
.392	4.63	5.46	6.39	6.23	5.78	5.61	5.66	6.01
29 166.399	5.08	5.77	5.60	-	5.94	-	-	5.32
29 167.353	5.37	5.64	6.18	6.11	5.68	5.29	5.90	5.92
.366	5.30	5.73	6.28	6.21	5.72	5.11	5.94	6.02
.378	5.34	5.74	6.40	6.20	5.77	5.02	5.94	6.06
.391	5.27	5.70	6.40	6.15	5.82	4.90	5.95	5.96
29 187.274	4.86	5.83	6.25	5.58	5.62	-	5.82	5.83
.305	5.16	5.72	6.05	5.50	5.58	-	5.87	5.76
.318	5.10	5.86	6.06	5.62	5.64	5.26	5.93	6.04
.331	5.33	5.83	5.85	5.72	5.74	5.41	5.94	-
29 518.315	5.60	5.60	5.98	6.33	6.34	5.38	5.63	6.05
.336	5.20	5.52	6.08	6.23	6.17	4.66	5.66	5.64
.349	5.39	5.54	6.14	6.16	6.22	4.70	5.68	5.79
.362	5.42	5.62	6.07	6.08	6.18	4.64	5.75	5.81
.375	5.32	5.58	6.21	5.98	6.20	4.71	5.86	5.83
29 519.455	5.01	5.95	5.87	6.08	6.20	5.51	5.92	-
29 520.313	4.49	5.43	6.31	5.46	6.24	5.14	5.99	5.86
.327	4.52	5.41	6.35	5.59	6.03	4.92	6.00	5.92
.339	4.44	5.38	6.14	5.51	5.79	4.82	5.98	5.87
.352	4.52	5.49	6.27	5.65	5.70	4.74	5.79	5.84
.363	4.55	5.54	6.25	5.77	5.65	4.71	5.95	5.88
.376	4.49	5.48	6.24	5.82	5.68	4.74	5.60	5.89
29 546.266	4.48	5.40	5.81	6.12	5.94	5.50	5.93	5.76
.279	4.44	5.37	5.89	6.10	5.90	5.19	5.96	5.52
29 870.406	5.50	6.10	5.87	6.14	5.80	-	-	-
29 877.369	5.26	5.91	5.70	5.88	5.56	5.05	5.60	5.49

Table II. cont.

J.D.				m-10				
24 00 000+	V1	V2	V3	V4	V5	V6	V7	V8
29 877.381	5.25	5.93	5.74	6.19	5.57	5.20	5.82	5.75
.394	5.34	5.83	5.67	6.11	5.65	5.22	5.90	5.73
.453	5.27	5.56	5.80	5.57	5.72	5.36	5.94	5.74
.481	5.30	5.56	5.84	5.52	5.99	5.49	5.98	6.03
.499	5.41	5.61	5.85	5.46	6.12	5.43	6.01	5.95
29 879.309	5.53	6.00	5.76	6.20	5.72	4.93	5.94	5.77
.321	5.59	6.03	5.78	5.90	5.76	4.94	5.94	5.75
.339	5.27	5.78	5.60	5.56	5.69	4.90	5.98	5.61
.372	5.13	5.91	5.83	5.48	5.90	5.00	6.01	5.81
.422	5.13	5.95	5.92	5.83	6.12	5.07	6.12	5.85
.435	4.93	5.86	5.86	5.79	6.07	5.26	5.86	5.75
.449	5.01	5.84	5.85	5.91	6.20	5.29	5.98	6.02
30 259.319	4.39	5.46	6.18	6.29	5.72	5.51	5.60	5.73
.330	4.35	5.49	6.41	6.35	5.86	5.40	5.60	5.51
.340	4.42	5.55	6.28	6.27	5.82	5.48	5.72	5.67
30 260.340	5.04	5.85	5.68	5.55	5.86	5.02	5.48	5.86
.354	4.98	5.88	5.74	5.57	5.84	4.95	5.60	5.85
.372	5.03	5.98	5.68	5.55	5.69	5.11	5.68	5.72
.387	4.92	5.91	5.82	5.56	5.60	4.89	5.73	5.43
.406	4.90	5.94	5.83	5.73	5.64	5.09	5.70	5.32
.427	4.86	5.99	5.90	5.73	5.63	5.20	5.84	5.10
30 261.309	5.21	5.62	6.34	5.60	5.97	5.51	6.10	5.73
.323	5.23	5.48	6.41	5.52	6.02	5.53	5.95	5.76
.334	5.19	5.47	6.27	5.57	6.16	5.53	6.13	5.81
.344	5.27	5.43	6.30	5.70	6.16	5.42	6.10	5.86
.374	5.31	5.38	6.39	5.82	6.27	5.40	5.85	5.76
.388	5.41	5.57	6.33	6.00	6.28	5.54	5.76	5.93
.402	5.40	5.62	6.15	5.96	6.19	5.63	5.57	5.87
.417	5.41	5.57	5.94	5.91	6.18	5.67	5.56	5.94
.434	5.32	5.65	6.02	5.98	6.18	5.62	5.62	6.03
33 502.437	4.43	5.99	5.63	5.49	5.57	5.44	6.10	5.91
.484	4.44	5.95	5.86	5.72	5.72	5.43	6.14	5.84
.502	4.48	5.96	6.07	5.66	5.75	5.55	5.91	5.88
.518	4.58	6.04	6.10	5.93	-	5.68	5.71	6.19
.532	4.57	5.88	6.09	5.95	5.77	5.49	5.66	6.05
33 858.435	5.49	5.83	5.95	6.08	6.36	5.32	5.54	6.14
.445	5.40	5.64	5.87	6.26	6.22	5.14	5.82	5.95
.474	5.55	5.49	5.57	6.01	6.15	4.92	5.79	6.03
.486	5.61	5.52	5.56	6.30	6.06	5.06	5.80	6.29
33 861.427	5.43	5.77	6.26	6.06	6.06	5.58	5.85	5.57
.439	5.35	5.89	6.43	5.72	6.26	5.58	5.93	5.65
.452	5.31	5.90	6.44	5.56	6.13	5.97	5.91	5.72
.464	5.25	5.85	6.52	5.64	6.35	5.78	5.98	5.75
.477	5.27	5.70	6.29	5.49	6.30	5.56	5.90	5.67
.491	5.13	5.75	6.53	5.55	6.25	5.60	5.99	5.69
.503	5.22	5.72	6.20	5.61	6.04	5.70	5.94	5.79
.517	5.12	5.83	6.13	5.61	6.18	5.92	6.01	5.88
.531	5.00	6.09	5.89	5.82	6.31	5.78	6.12	5.78
.546	5.12	6.09	5.85	5.75	6.47	-	6.08	6.17
.562	5.10	6.03	5.94	6.19	6.18	5.94	-	6.11

Table II. cont.

				m-10				
24 00 000+	V1	V2	V3	V4	V5	V6	V7	V8
33 865.378	5.36	5.48	6.25	6.11	6.50	5.52	5.53	5.81
.392	5.31	5.42	6.24	6.39	6.22	5.54	5.55	5.85
.405	5.45	5.51	6.17	6.37	6.19	5.56	5.60	5.87
.418	5.44	5.67	6.16	6.32	6.30	5.64	5.59	6.01
.430	5.50	5.65	6.16	6.45	6.26	5.68	5.79	5.86
.442	5.29	5.50	5.75	6.20	5.78	5.74	5.80	5.91
.456	5.56	5.60	5.76	6.35	5.84	5.70	5.84	6.05
.468	5.30	5.67	5.66	6.28	5.60	5.69	5.86	5.75
.563	5.52	5.76	5.89	5.59	5.82	5.68	5.90	5.90
.575	5.44	5.82	5.85	5.59	5.60	5.77	5.93	5.81
33 871.454	5.31	5.60	5.96	6.11	6.16	5.65	5.85	6.03
.483	5.40	5.46	6.10	5.77	6.27	5.62	5.98	6.16
.496	5.25	5.32	6.13	5.60	6.26	5.76	5.95	5.85
.507	5.22	5.41	6.01	5.58	6.16	5.68	5.98	5.98
.518	5.22	5.50	6.20	5.56	6.30	5.58	6.00	5.89
.542	5.22	5.56	6.28	5.74	6.45	5.70	5.80	5.95
.555	5.12	5.64	6.43	5.78	6.06	5.77	5.62	6.11
.570	5.12	5.43	6.38	5.72	-	5.74	5.60	5.96
.584	5.07	5.70	6.40	5.74	5.91	5.62	5.53	5.81
33 872.446	5.32	5.78	5.86	5.54	5.65	-	5.79	5.71
.452	5.31	5.88	5.84	5.75	5.67	5.06	5.84	5.72
.487	5.35	5.87	5.77	5.69	5.78	5.16	5.79	5.74
.500	5.44	5.85	5.90	5.67	5.72	4.90	5.91	-
.519	5.24	6.10	5.80	5.99	5.88	5.16	5.91	5.89
.533	5.50	5.86	5.97	5.87	6.10	5.35	5.92	5.85
.546	5.43	5.90	5.88	5.96	6.06	5.35	5.97	5.72
.560	5.45	6.18	5.79	5.94	5.99	5.39	5.94	6.08
.573	5.52	5.98	5.93	5.99	5.94	5.54	5.79	6.02
.586	5.54	6.08	5.94	5.97	5.85	5.37	6.00	5.95
.599	5.59	6.07	5.96	-	-	5.71	5.99	6.11
33 881.401	5.64	6.12	5.68	6.32	6.04	-	6.18	5.48
.413	5.45	6.05	5.71	6.19	6.28	-	5.91	5.39
.425	5.68	5.94	5.73	-	6.20	-	5.73	5.46
.439	-	5.82	5.60	-	-	-	5.75	5.41
.451	5.70	6.01	5.84	6.01	5.99	-	5.78	5.63
.470	5.60	5.90	5.77	6.12	6.12	5.76	5.61	5.66
.483	5.41	6.19	5.91	6.18	6.07	5.82	5.67	5.77
33 884.395	5.53	6.02	6.45	5.56	5.54	5.39	5.79	6.20
.408	5.42	6.08	6.03	5.54	5.79	5.44	5.70	5.98
.436	5.30	5.88	6.11	5.74	5.94	4.96	5.61	5.94
.450	5.27	5.74	6.19	5.80	5.85	5.02	5.55	6.02
.464	5.30	5.61	6.12	6.12	5.94	5.09	5.56	5.92
.478	5.34	5.47	5.85	6.07	5.87	5.18	5.60	6.10
.495	5.22	5.47	5.95	6.24	6.27	5.24	5.55	6.21
.521	5.01	5.40	5.58	6.23	6.03	5.34	5.57	5.75
.539	5.02	5.50	5.86	6.40	6.41	5.35	5.67	5.38
.558	5.10	5.68	5.62	6.36	6.30	5.47	5.73	5.36
.574	5.00	5.66	5.53	6.56	6.46	5.55	5.73	5.30
.594	4.85	5.64	6.05	6.13	6.06	5.58	5.85	5.31
33 887.457	4.93	5.95	-	5.97	5.70	5.63	5.56	-

Table II. cont.

	m-10							
J.D. 24 00 000+	V1	V2	V3	V4	V5	V6	V7	V8
33 887.478	4.91	5.91	-	5.81	6.06	5.63	5.53	6.13
.498	4.62	5.72	-	5.55	5.82	5.88	5.55	6.04
.511	4.79	5.83	6.15	5.65	5.95	5.69	5.56	-
.524	4.76	5.69	5.96	5.49	5.94	-	5.62	5.91
33 888.400	5.38	6.35	5.70	6.00	6.49	5.32	5.81	5.54
.412	5.39	5.94	5.64	5.81	6.09	5.17	5.83	5.42
.425	5.49	5.92	5.70	5.55	5.92	5.16	5.79	5.45
.437	5.54	6.40	-	5.84	6.37	5.11	5.83	5.41
.461	5.65	-	5.82	5.65	5.85	5.29	5.80	-
.474	5.40	5.92	5.60	5.42	6.17	5.15	5.62	-
.485	5.60	6.02	5.73	5.80	6.02	4.94	5.54	5.36
33 889.454	5.10	5.84	6.02	6.04	5.74	5.51	5.82	5.89
.472	5.12	5.82	-	5.82	5.84	5.60	5.80	-
.488	5.01	5.69	6.12	5.89	6.21	-	5.88	5.81
.497	5.34	-	-	-	6.30	-	5.87	-
.512	5.32	-	6.12	6.12	6.11	5.60	5.88	-
33 894.380	5.43	5.86	-	5.66	5.80	5.19	5.49	5.49
.393	5.54	5.99	6.07	5.65	5.81	5.01	5.48	-
.409	5.44	-	5.90	5.79	5.72	4.94	5.55	5.55
.420	5.79	-	-	5.63	5.80	5.17	5.56	5.74
.439	5.53	-	-	5.71	5.91	5.01	5.57	5.68
33 895.443	5.26	5.52	5.70	5.87	5.70	5.65	5.67	-
.457	5.39	5.37	5.62	5.68	5.51	5.82	5.63	6.07
.468	5.33	5.57	5.81	5.99	5.58	-	5.57	-
.487	5.27	5.48	5.98	6.08	5.60	-	5.54	-
.498	5.36	5.51	5.66	5.99	5.61	-	5.48	5.80
.514	5.41	5.52	5.64	5.98	5.76	-	5.50	5.45
.526	5.41	5.57	6.05	6.27	5.80	5.65	5.56	5.54
.541	5.47	5.53	5.75	6.14	5.59	-	5.60	5.24
34 238.526	4.63	6.00	6.33	6.21	5.80	6.02	5.85	6.03
.539	4.51	5.73	6.09	6.11	5.66	5.80	5.84	5.97
.553	4.44	5.76	6.42	6.07	5.52	5.49	5.84	-
.565	4.60	6.07	6.42	6.16	5.80	5.65	5.82	5.80
.580	4.51	5.67	6.26	-	5.60	5.80	5.91	-
34 241.435	4.52	6.12	5.59	6.14	5.93	5.10	5.54	5.84
.450	4.58	-	5.80	6.27	6.31	5.19	5.60	5.60
.463	4.72	5.84	5.90	6.09	6.07	5.34	5.62	5.84
.479	4.66	5.75	6.02	5.80	6.15	5.42	5.64	5.75
.492	4.51	-	5.68	5.79	-	5.20	-	5.87
34 253.410	5.36	5.70	6.13	5.88	6.31	-	-	-
.446	5.18	5.58	5.58	5.55	6.22	-	-	-
34 254.449	4.62	5.70	6.02	5.72	5.64	5.70	6.09	5.86
.467	4.66	5.85	6.18	5.76	6.20	5.88	5.93	5.68
.484	4.58	6.07	6.35	5.97	6.22	5.89	5.95	6.12
.505	4.76	6.15	6.40	5.92	6.36	5.68	5.97	5.87
.525	4.71	5.96	6.09	6.13	6.27	5.69	6.00	5.80
34 270.492	5.06	5.53	5.96	6.20	5.79	-	5.80	5.49
.514	5.13	5.50	5.79	5.94	-	-	5.81	5.73
34 573.459	4.47	6.08	5.86	-	6.06	-	5.80	-
.473	4.54	6.10	5.92	-	6.06	-	-	-

Table II. cont.

J.D.				m-10				
24 00 000+	V1	V2	V3	V4	V5	V6	V7	V8
34 606.527	4.53	5.60	6.05	5.50	6.04	5.48	5.75	5.59
.541	4.50	5.70	6.22	5.64	6.30	5.54	5.91	-
.556	4.64	5.98	6.16	5.63	-	-	5.67	-
.571	-	5.89	6.11	5.69	-	5.55	5.91	5.73
.586	4.59	5.71	-	5.76	5.83	-	5.86	5.71
34 945.407	5.36	6.08	5.87	6.32	-	4.86	5.83	-
.424	5.49	6.09	5.72	-	6.12	-	5.82	-
34 949.463	5.52	-	6.00	-	5.78	5.20	-	-
35 371.410	4.37	5.62	5.88	5.62	6.00	5.62	5.79	6.30
.423	4.52	5.44	5.80	5.78	6.09	-	5.75	6.12
.436	4.56	5.65	5.88	6.01	5.94	-	5.82	6.09
.455	4.60	5.60	-	5.94	-	-	5.87	-
35 720.298	5.04	5.96	5.97	5.97	6.13	5.66	5.75	-
.315	5.26	5.98	5.94	6.34	6.22	5.60	5.72	6.00
.328	5.22	6.02	6.38	6.14	6.38	-	-	6.31
.344	4.99	5.74	6.35	5.85	6.40	5.74	5.91	6.35
.356	5.00	5.50	6.15	5.66	6.14	5.58	5.97	5.80
.369	4.90	5.47	6.27	5.62	6.27	5.47	5.87	5.69
.381	4.98	5.48	6.28	5.80	6.38	5.52	5.81	5.84
.394	4.98	5.46	5.96	5.70	6.25	5.73	5.80	-
35 725.327	5.14	5.86	6.00	6.02	6.36	-	5.61	5.87
.377	5.20	5.74	6.13	5.70	6.30	5.33	5.74	5.80
.419	5.14	5.92	6.40	5.70	5.92	5.32	5.73	5.82
.432	5.24	5.84	6.16	5.78	5.90	5.20	5.86	5.84
.445	5.08	5.90	6.16	5.75	5.74	5.30	-	5.84
.457	5.22	5.82	6.44	5.88	5.82	5.50	5.78	6.00
.495	5.34	6.12	6.50	5.93	5.61	5.47	5.87	5.87
.507	5.20	5.96	-	5.88	5.52	5.42	5.85	5.82
.519	5.18	5.98	6.12	6.08	-	5.70	5.91	6.06
.531	5.22	6.01	6.04	6.32	5.74	5.34	5.89	5.82
36 068.496	4.50	6.14	5.80	5.78	6.30	-	5.98	5.97
.514	4.40	6.02	5.84	5.88	6.20	5.68	5.69	6.00
.528	-	5.66	5.90	5.84	6.02	5.73	5.57	5.80
.543	-	5.78	5.78	5.78	5.78	5.67	5.63	-
36 073.380	5.12	5.88	6.05	6.32	6.11	-	5.73	5.00
.393	5.13	5.80	6.20	6.07	6.12	5.37	5.72	5.06
.406	5.16	5.74	6.18	6.10	6.24	5.34	5.60	5.10
.419	5.24	5.74	6.36	5.96	6.24	5.30	5.65	5.14
.432	5.26	5.96	6.18	5.68	6.18	5.36	5.61	5.24
.446	5.43	5.60	5.91	5.52	6.10	5.19	5.75	5.32
.459	5.28	5.57	6.10	5.76	6.21	5.10	5.72	5.54
.473	5.24	5.53	5.92	5.56	6.26	4.74	5.83	5.50
.486	5.25	5.40	5.86	5.52	6.33	4.84	5.85	5.36
.500	5.21	5.40	5.70	5.65	6.18	4.82	5.78	5.47
36 074.381	-	5.96	6.01	5.66	5.66	-	5.83	5.66
.394	-	5.60	5.94	5.85	-	-	5.87	-
.406	4.60	5.76	6.05	5.41	5.70	5.31	5.86	5.82
.420	4.49	5.60	5.90	5.54	5.65	5.39	5.60	5.84
.434	4.48	6.00	6.06	5.74	5.74	5.54	5.71	5.98
.447	4.36	5.76	6.00	5.65	5.85	5.38	5.61	5.92

Table II. cont.

				m-10				
24 00 000+	V1	V2	V3	V4	V5	V6	V7	V8
36 074.460	4.50	5.70	6.14	5.80	5.98	5.55	5.60	5.71
.473	4.51	6.00	6.18	5.94	6.05	5.64	5.63	6.05
.486	4.53	5.72	6.20	5.98	5.85	5.64	5.74	5.82
.500	4.72	5.90	6.28	6.08	6.20	5.71	5.74	5.99
.513	4.53	5.81	6.30	5.98	5.87	5.66	5.75	5.92
.526	4.68	6.07	6.29	6.15	6.06	5.55	5.77	-
38 259.416	4.64	6.04	5.72	5.56	5.70	5.38	5.99	5.90
.473	4.30	6.16	5.68	5.88	-	-	6.06	5.93
.493	4.38	6.00	5.82	5.88	-	-	6.16	-
38 268.472	-	6.07	5.66	5.94	5.94	-	-	-
.487	4.86	6.01	5.86	5.70	6.24	4.82	5.78	5.94
.502	4.70	5.97	5.89	5.67	5.89	-	5.86	5.80
.518	4.90	6.11	5.83	5.32	5.88	4.88	5.81	5.88
.531	-	5.94	6.00	5.60	5.94	-	5.80	-
.544	4.64	5.82	6.02	5.72	6.02	4.88	5.81	5.78
.558	4.67	5.77	6.20	5.65	5.78	4.67	5.91	-
.572	4.80	5.68	6.19	5.80	5.70	4.60	5.87	5.93
.586	5.16	5.60	6.26	6.00	5.70	4.89	5.93	6.10
.601	5.10	5.45	6.24	6.02	5.70	5.08	5.98	-
38 289.280	5.30	5.70	6.34	5.88	-	5.00	6.09	5.72
.304	5.56	5.75	6.24	6.00	5.75	5.24	5.83	5.57
.325	5.38	5.83	6.16	5.90	5.58	5.32	5.74	5.24
.346	5.51	5.75	5.92	6.09	5.61	5.43	5.63	5.25
.373	5.30	5.78	5.63	6.15	5.60	5.05	5.58	5.21
.402	5.24	5.80	5.75	6.20	5.86	5.32	5.65	5.25
.420	5.23	5.90	5.76	6.24	5.87	5.09	5.65	5.45
.466	5.02	5.90	5.73	6.15	5.96	5.20	5.79	5.39
.482	4.98	5.78	5.78	5.84	6.10	5.36	5.72	5.56
.506	4.94	6.05	5.78	5.42	6.00	5.34	5.86	5.47
.522	4.84	5.92	5.90	5.56	5.90	5.28	5.80	5.60
.547	5.02	6.05	6.35	5.60	6.24	5.44	5.87	5.52
.560	4.80	-	-	5.60	6.16	5.27	-	5.54
.574	4.78	6.02	-	5.37	-	-	-	5.85
39 350.467	5.34	5.60	6.45	6.13	5.98	5.33	5.70	5.32
.483	-	5.52	6.32	6.10	5.90	-	5.70	5.27
.496	5.26	5.43	6.22	6.14	5.77	5.74	5.63	5.19
.522	5.27	5.54	6.12	6.17	5.64	5.68	5.60	5.45
.535	-	5.55	-	6.13	-	-	-	5.45
39 351.498	5.42	5.97	5.75	6.21	6.24	5.32	6.00	5.98
.512	5.42	5.89	5.79	6.53	6.25	5.38	5.85	6.05
.524	5.70	5.91	5.88	6.00	6.07	-	6.00	5.81
.536	5.51	6.00	5.92	6.20	6.40	5.38	5.95	6.16
39 355.445	5.22	5.52	6.12	5.67	6.10	5.10	6.07	5.75
.460	5.25	5.70	5.98	5.88	5.96	5.25	6.03	5.90
.474	5.23	5.89	6.25	6.21	5.76	5.41	6.05	6.05
.490	5.18	5.89	6.06	5.97	5.83	5.46	5.96	6.08
.504	5.20	6.01	6.21	6.11	5.72	5.39	6.04	5.82
.520	5.20	5.78	6.22	5.98	5.59	-	6.09	5.93
.533	5.20	5.96	6.11	-	5.77	-	-	-

Table II. cont.

J.D.				m-10				
24 00 000+	V9	V10	V11	V12	V13	V14	V15	V17
28 752.540	5.70	6.00	5.66	5.78	-	5.72	-	5.98
28 754.394	6.08	-	5.93	5.93	-	5.66	-	-
.436	6.09	-	5.90	-	-	5.80	5.83	5.76
.485	6.32	-	-	5.96	-	5.96	5.80	6.12
.502	-	-	-	-	-	5.94	5.85	6.05
.521	-	-	-	-	-	6.01	5.92	5.93
28 758.463	5.62	5.80	5.70	5.80	6.05	6.41	5.26	6.29
.485	5.89	5.84	5.90	-	5.98	-	5.54	6.25
28 760.406	5.65	5.33	-	-	-	-	-	5.60
.443	5.56	5.59	-	-	-	5.76	-	5.57
28 774.392	-	5.91	6.32	5.84	-	6.31	6.38	6.13
28 775.379	-	6.23	6.25	6.16	-	5.85	5.30	5.78
.396	6.15	5.76	6.20	6.08	-	5.71	5.35	5.60
.411	5.89	5.78	6.29	-	6.47	5.80	5.57	5.57
.426	5.75	5.96	6.11	5.77	6.35	5.77	5.62	5.60
.440	5.73	5.81	-	5.99	-	6.06	5.70	5.62
.456	5.35	5.62	6.18	5.35	6.31	5.92	5.77	5.60
.471	5.37	5.57	6.31	5.54	6.35	5.99	5.80	5.64
28 776.367	5.56	6.00	6.09	6.44	6.01	6.50	-	6.09
.383	5.81	6.08	5.92	6.10	5.94	6.60	6.59	6.12
.397	5.91	6.21	6.29	6.30	6.13	6.21	-	6.12
.411	5.83	-	6.20	-	6.00	-	-	-
.427	5.80	6.35	-	-	6.37	-	6.63	6.01
.442	6.07	-	6.48	6.06	6.34	6.60	6.72	6.10
.456	6.09	-	6.03	5.87	6.03	6.12	6.37	6.10
.474	5.81	-	6.31	-	6.53	6.10	-	6.05
28 779.392	6.00	5.85	5.69	6.06	6.27	6.32	-	5.96
.411	6.10	5.72	5.76	5.92	6.26	6.26	6.16	5.88
.437	6.26	5.99	5.92	6.08	6.30	6.27	5.61	5.82
28 780.376	6.28	6.31	5.59	5.70	6.21	5.86	6.56	6.16
.396	5.96	6.11	5.63	5.71	6.10	5.83	6.53	6.18
.422	5.67	5.80	5.70	6.07	6.20	5.90	6.66	6.10
28 783.406	5.44	-	-	-	-	5.80	6.67	6.02
.429	5.65	6.33	5.65	6.00	6.34	5.90	-	5.96
.449	5.47	6.20	5.60	6.07	6.30	5.77	6.42	5.78
28 837.251	5.90	5.62	5.99	5.58	5.64	5.80	5.20	5.56
.265	5.91	5.65	6.18	5.81	5.99	5.85	5.15	5.72
.279	6.05	5.69	6.07	5.80	5.83	5.65	5.26	5.78
.293	5.83	5.73	5.79	5.90	5.98	5.66	5.40	5.85
.307	5.92	5.76	5.72	6.00	6.17	5.85	5.44	5.90
.325	6.00	5.70	5.60	5.70	6.06	5.73	5.40	5.94
29 107.517	5.90	6.21	5.68	5.59	6.20	6.13	5.59	5.96
.531	5.69	6.07	5.83	5.70	6.30	6.41	5.89	6.05
.544	-	6.00	5.43	5.72	5.86	6.20	5.60	6.16
.558	6.00	6.20	5.74	-	6.37	6.52	5.82	6.16
.570	5.53	6.20	5.80	5.72	6.16	6.50	5.90	6.15
29 108.470	5.93	5.70	6.16	6.06	5.41	5.78	-	6.29
.485	6.13	5.71	5.78	6.15	5.30	5.78	6.60	6.30
.500	5.81	5.68	5.60	5.97	5.30	5.70	-	6.29
.515	6.20	5.69	5.53	5.97	5.40	5.80	-	6.31

Table II. cont.

J.D.				m-10				
24 00 000+	V9	V10	V11	V12	V13	V14	V15	V17
29 108.530	6.29	5.82	5.60	6.15	5.30	5.89	6.36	6.29
.544	6.01	5.74	5.60	5.84	5.53	5.78	6.27	6.12
.558	6.11	5.70	5.57	5.86	5.72	5.81	-	6.00
29 109.474	5.47	6.09	6.14	6.10	6.46	6.20	6.41	5.60
.488	5.66	6.10	5.92	5.94	6.33	6.27	6.30	5.71
.500	5.24	6.38	5.94	6.03	6.18	6.38	6.43	5.76
.513	5.14	6.18	5.89	6.11	6.44	6.11	6.11	5.86
.526	5.29	6.14	5.70	5.94	6.37	6.37	6.44	5.89
.540	5.32	6.30	5.50	-	6.25	6.34	6.69	5.94
.553	5.42	6.44	5.70	6.23	6.29	6.44	6.61	5.85
29 110.435	5.68	5.77	-	5.21	6.09	5.58	5.43	5.60
.449	5.88	5.65	-	5.20	-	5.85	-	5.88
29 113.423	-	6.32	5.84	5.40	6.50	5.96	6.04	5.56
.440	5.96	-	5.81	5.36	-	5.66	5.87	5.88
.454	6.10	-	5.92	5.63	-	5.90	6.08	5.94
.467	5.92	-	5.88	5.64	-	5.75	6.01	5.97
.482	6.12	-	-	5.71	-	5.80	-	6.00
.496	-	5.76	6.02	5.55	-	5.63	-	6.10
.510	-	5.68	5.88	5.72	-	5.92	-	5.87
29 114.423	6.17	5.88	5.65	6.11	5.93	6.17	5.99	6.10
.438	6.20	5.88	5.72	6.12	6.13	6.20	5.40	6.16
.452	6.19	5.90	5.78	-	6.19	6.10	5.17	6.15
29 130.385	5.38	6.18	6.00	6.00	5.30	6.00	6.10	6.25
29 131.347	5.84	5.64	5.90	5.72	-	6.42	6.46	5.85
.379	6.06	5.74	5.99	5.96	6.12	5.96	5.04	5.76
.393	6.00	5.73	-	5.92	6.12	5.85	5.05	5.55
.408	-	-	6.06	5.89	6.19	5.82	5.25	5.61
.449	5.76	5.72	6.06	6.06	6.04	5.78	5.55	5.59
.463	5.73	5.79	5.94	6.15	5.65	6.04	5.86	5.90
.476	5.94	5.82	5.66	6.10	5.42	5.92	5.75	5.96
.491	5.58	6.09	5.58	6.01	5.01	5.90	6.03	6.02
.505	5.66	6.26	5.58	6.12	-	5.74	6.14	-
29 132.371	5.50	6.06	6.13	5.28	6.28	6.39	6.65	5.96
.385	5.33	6.24	6.12	5.30	6.18	6.24	6.47	5.80
.398	5.12	6.15	6.18	5.40	6.32	6.43	6.56	5.94
.411	4.98	5.82	6.20	5.31	6.17	6.58	6.53	5.97
.424	5.17	5.88	6.43	5.50	6.41	6.43	6.58	6.12
.434	5.23	5.84	-	5.69	-	-	-	6.05
29 138.441	5.90	6.18	5.76	5.83	5.39	6.26	5.56	6.15
.458	6.13	-	5.79	5.80	5.76	6.09	5.60	6.10
.471	6.00	6.23	5.62	5.74	5.43	6.30	5.58	6.18
.484	6.04	6.25	5.84	5.93	5.64	6.63	5.84	6.17
.495	5.88	6.02	6.02	6.02	5.60	6.36	5.86	6.29
29 141.362	5.80	5.44	6.19	5.55	5.69	5.76	5.53	5.97
.375	5.94	5.57	6.21	5.60	5.79	5.74	5.67	6.00
.388	5.94	5.55	6.19	5.67	5.84	5.80	5.71	6.05
.403	5.99	5.67	6.04	5.86	5.76	6.01	5.81	6.12
.416	6.14	5.61	6.05	5.84	5.96	5.85	5.99	6.16
.429	5.97	5.63	5.86	5.78	5.80	5.84	5.96	6.18
.444	6.11	5.90	5.60	5.82	5.80	5.82	5.98	6.19

Table II. cont.

J.D.				m-10				
24 00 000+	V9	V10	V11	V12	V13	V14	V15	V17
29 141.456	6.00	5.88	5.50	5.88	6.04	5.90	6.05	6.08
.469	5.96	5.84	5.57	5.74	5.96	5.88	6.02	6.10
.482	5.97	5.92	5.39	5.89	6.53	6.08	6.13	6.12
.495	6.06	5.91	5.56	6.00	6.09	6.18	6.16	6.17
29 159.356	5.93	6.18	5.56	6.18	6.32	5.85	6.10	5.80
.370	5.98	6.26	5.65	6.05	6.13	5.76	5.70	5.89
.383	5.94	6.25	5.66	6.06	6.27	5.79	5.42	5.94
.396	6.12	6.19	5.72	6.14	6.38	5.99	5.26	5.91
29 160.342	5.41	5.78	5.62	5.71	5.77	6.25	6.48	6.32
.354	5.51	5.74	5.53	5.68	5.77	6.13	6.60	6.29
.367	5.44	5.65	5.49	5.57	5.87	6.28	6.56	6.30
.380	5.41	5.68	5.43	5.69	5.82	6.14	6.38	6.29
.394	5.58	5.90	5.69	5.90	5.96	6.21	6.50	6.12
.409	5.30	5.68	5.50	-	5.68	5.68	6.50	-
29 161.344	6.00	6.25	5.74	5.87	6.02	6.18	6.34	5.80
.357	6.00	6.13	5.61	5.82	5.84	6.07	6.34	5.93
.372	6.10	6.04	5.55	5.64	5.42	6.26	6.30	5.78
.386	6.26	6.09	5.49	5.32	5.30	6.26	6.39	5.94
.399	6.04	5.90	5.43	5.23	5.16	6.47	6.37	5.90
29 162.325	6.33	5.77	6.37	6.24	6.44	5.96	5.26	5.89
.339	5.89	5.82	6.16	5.98	6.42	5.87	5.44	5.70
.352	6.12	6.01	6.16	6.09	6.35	5.87	5.56	5.94
.365	6.03	5.83	5.92	6.15	6.29	5.71	5.54	5.97
.378	5.70	5.97	5.72	6.08	6.20	5.83	5.57	5.98
.392	5.58	6.05	5.58	6.08	6.37	5.84	5.63	6.12
29 166.399	-	6.18	6.14	6.14	6.14	6.30	5.11	-
29 167.353	6.21	5.78	5.91	5.28	6.12	5.74	6.37	5.55
.366	6.16	5.83	5.96	5.35	6.02	5.80	6.49	5.27
.378	5.92	5.90	6.13	5.50	6.13	5.95	6.34	5.28
.391	5.73	5.80	6.19	5.37	6.18	5.81	6.33	5.33
29 187.274	6.02	5.90	5.95	6.19	5.20	5.91	6.36	6.12
.305	6.02	5.80	6.10	6.14	5.40	6.00	-	6.13
.318	6.10	5.71	6.23	6.08	5.52	6.14	6.47	6.25
.331	6.17	5.75	6.30	-	5.70	6.04	6.44	6.29
29 518.315	6.09	6.12	6.10	5.45	6.26	6.29	5.73	5.89
.336	5.79	5.99	5.62	5.38	6.12	5.97	5.66	5.91
.349	5.86	6.15	5.59	5.52	6.08	5.96	5.72	5.94
.362	5.87	6.12	5.50	5.51	6.21	5.84	5.80	5.96
.375	5.85	6.03	5.51	5.59	6.25	5.87	5.88	6.05
29 519.455	5.26	5.87	5.50	5.22	6.29	6.36	5.59	5.80
29 520.313	5.80	5.98	6.15	6.00	5.86	5.59	6.22	5.26
.327	5.73	6.08	6.24	5.96	6.02	5.69	6.37	5.27
.339	5.70	5.99	6.23	5.87	5.92	5.70	6.49	5.36
.352	5.73	5.93	6.13	6.00	6.04	5.87	6.31	5.35
.363	5.70	5.82	6.01	5.94	5.97	5.87	6.25	5.39
.376	5.79	5.75	6.08	6.04	6.13	5.89	6.28	5.40
29 546.266	6.00	5.72	5.80	5.65	6.12	5.68	5.84	5.90
.279	6.05	5.63	5.85	5.62	6.17	5.67	5.60	5.89
29 870.406	-	6.12	-	5.54	5.76	-	-	5.91
29 877.369	5.96	5.99	5.95	6.08	6.01	6.19	5.89	6.12

Table II. cont.

J.D. 24 00 000+	m-10							
	V9	V10	V11	V12	V13	V14	V15	V17
29 877.381	5.95	5.97	6.01	6.16	5.93	6.11	5.88	6.10
.394	6.04	6.00	5.83	6.08	6.00	6.23	5.97	6.16
.453	5.95	5.60	5.55	5.90	6.13	5.79	6.27	6.00
.481	6.07	5.70	5.68	5.69	6.29	5.86	6.37	5.94
.499	6.29	5.76	5.62	5.61	6.46	5.59	6.39	5.96
29 879.309	5.64	6.07	6.14	5.56	6.23	6.26	6.56	5.76
.321	5.73	6.11	6.36	5.42	6.36	6.22	6.58	5.34
.339	5.53	5.79	6.18	5.37	6.32	5.96	6.59	5.25
.372	5.59	5.60	6.29	5.46	6.19	5.81	6.63	5.46
.422	6.10	5.75	6.08	5.77	6.34	5.85	6.63	5.55
.435	5.94	5.59	5.96	5.76	-	5.77	-	5.77
.449	5.80	5.71	5.86	5.78	6.34	5.83	6.34	5.89
30 259.319	5.85	5.78	6.07	5.34	6.28	6.35	6.43	5.28
.330	6.00	5.77	6.10	5.22	6.24	6.39	6.47	5.30
.340	5.86	5.97	6.12	5.31	6.38	6.32	6.41	5.26
30 260.340	5.81	5.51	5.98	5.98	5.96	5.96	6.35	5.90
.354	5.59	5.55	6.11	6.04	6.06	6.00	6.49	5.94
.372	5.36	5.54	6.20	6.07	6.19	6.15	6.52	5.98
.387	5.15	5.55	6.16	6.01	6.29	6.20	6.44	6.00
.406	5.13	5.60	6.19	6.07	6.29	6.28	6.45	6.00
.427	5.24	5.52	6.19	6.03	6.29	6.33	6.58	6.05
30 261.309	5.73	6.05	5.80	5.97	5.48	6.25	5.83	6.08
.323	5.62	6.04	5.82	6.00	5.47	6.18	5.88	6.12
.334	5.67	6.11	5.91	5.90	5.57	6.01	6.01	6.15
.344	5.65	6.11	5.92	5.94	5.62	5.96	5.92	6.16
.374	5.64	6.00	6.07	5.99	5.65	5.81	6.15	6.26
.388	5.78	6.22	6.06	6.09	5.80	5.87	6.01	6.24
.402	5.88	6.22	6.13	6.21	6.03	5.76	6.11	6.25
.417	5.83	6.09	6.24	6.11	5.87	5.83	6.18	6.10
.434	5.89	6.16	6.00	6.29	5.91	5.81	6.27	5.98
33 502.437	5.94	5.96	6.22	6.07	6.11	5.93	5.86	6.02
.484	6.01	5.70	6.17	5.92	6.28	6.06	6.06	6.12
.502	6.04	5.57	6.14	6.05	6.21	6.18	6.15	6.15
.518	6.06	5.70	6.28	6.21	6.47	6.33	6.28	6.11
.532	6.01	5.52	6.24	5.88	6.24	6.16	6.30	6.16
33 858.435	5.74	5.72	6.36	5.55	6.39	5.79	5.98	-
.445	5.50	5.81	6.20	5.56	6.37	5.95	6.00	6.30
.474	5.59	5.93	6.08	5.54	6.28	5.80	6.21	6.29
.486	5.85	5.78	6.41	5.75	6.47	5.69	5.95	6.29
33 861.427	5.84	5.74	5.84	5.55	6.30	5.82	6.27	-
.439	6.14	5.64	6.01	5.62	6.53	5.77	6.23	6.00
.452	6.31	5.63	6.19	5.54	6.35	5.59	6.31	6.03
.464	6.05	5.85	6.19	5.64	6.44	5.70	6.53	6.17
.477	5.91	5.63	6.07	5.64	6.50	5.85	6.14	6.15
.491	6.10	5.58	6.31	5.67	6.46	5.75	6.48	6.16
.503	6.04	5.61	6.12	5.68	6.25	5.74	6.27	6.16
.517	6.14	5.81	6.36	5.80	5.83	5.87	6.30	6.02
.531	6.17	5.80	6.44	5.62	5.65	5.90	6.51	5.91
.546	6.13	5.82	6.45	5.95	5.30	5.91	6.46	5.98
.562	6.06	5.82	6.20	6.07	-	5.90	-	-

Table II. cont.

J.D.				m-10				
24 00 000+	V9	V10	V11	V12	V13	V14	V15	V17
33 865.378	5.94	5.51	6.15	6.11	6.42	6.28	5.74	5.76
.392	5.50	5.71	5.75	6.27	6.24	6.27	5.53	5.79
.405	5.56	5.67	5.67	6.11	6.40	6.21	5.75	5.59
.418	5.35	5.97	5.73	6.31	6.53	6.45	5.92	5.58
.430	5.33	5.95	5.63	6.27	6.55	6.36	5.82	5.60
.442	5.24	5.79	5.55	6.21	6.25	6.37	5.92	5.72
.456	5.32	5.98	5.58	6.02	6.20	6.12	5.95	5.76
.468	5.25	6.04	5.60	5.84	6.35	6.56	6.12	5.78
.563	5.63	6.18	6.01	5.56	5.52	6.19	6.26	5.80
.575	5.78	6.06	6.13	5.36	5.26	6.04	6.23	5.88
33 871.454	5.80	5.85	6.02	5.50	5.78	5.74	6.59	5.72
.483	5.84	5.92	6.21	5.53	6.00	5.95	6.56	5.80
.496	5.90	5.63	6.45	5.45	6.03	6.04	6.20	5.89
.507	5.83	5.61	6.15	5.43	6.07	6.09	6.53	5.78
.518	6.14	5.59	6.34	5.53	5.85	6.05	6.68	5.90
.542	6.20	5.70	6.08	5.57	-	6.40	6.40	5.94
.555	6.01	-	5.92	5.66	6.17	6.40	6.54	5.82
.570	6.08	5.81	5.96	5.75	6.31	6.40	-	5.89
.584	6.02	5.67	5.61	5.78	6.03	6.12	6.33	5.94
33 872.446	6.10	5.98	-	6.19	-	6.12	5.91	5.96
.452	-	5.84	-	-	5.69	6.08	6.05	5.98
.487	-	-	-	-	5.21	5.94	6.10	6.10
.500	5.96	-	6.10	6.02	5.40	5.74	6.16	6.12
.519	6.03	6.01	6.40	6.14	5.36	5.68	6.24	6.15
.533	5.85	6.36	6.31	6.13	5.61	5.83	6.29	6.16
.546	5.59	6.12	6.16	6.17	5.54	5.74	6.26	6.18
.560	5.59	6.24	6.16	6.22	5.67	5.81	6.11	6.18
.573	5.44	6.18	6.06	5.88	5.73	5.81	6.17	6.16
.586	5.31	6.18	5.91	5.95	5.64	5.67	-	6.22
.599	5.21	5.97	5.79	5.62	5.87	5.85	6.24	6.22
33 881.401	5.79	6.21	-	6.00	6.19	6.00	-	5.45
.413	5.83	6.14	6.31	6.00	6.48	6.02	-	5.60
.425	5.90	-	-	-	-	6.17	-	5.70
.439	-	-	6.16	6.06	6.12	6.10	-	5.79
.451	5.92	5.95	6.00	5.97	6.12	6.15	-	5.72
.470	6.05	-	6.18	6.04	-	6.28	6.35	5.88
.483	5.96	6.30	6.32	5.97	6.20	6.35	6.61	5.85
33 884.395	6.01	5.82	5.76	6.26	6.38	5.70	6.39	5.62
.408	5.95	5.93	5.91	5.99	5.92	5.73	6.51	5.75
.436	5.99	6.12	5.96	6.19	6.05	5.88	6.44	5.78
.450	5.99	6.12	6.00	5.88	6.32	5.99	6.16	5.89
.464	6.16	6.27	6.05	5.58	6.33	6.24	6.45	5.86
.478	5.98	6.21	6.12	5.54	6.24	6.18	-	5.90
.495	5.98	6.38	6.33	5.58	6.34	6.05	6.31	5.90
.521	6.15	6.08	6.34	5.40	5.84	6.17	5.73	5.96
.539	6.28	6.20	6.26	5.51	5.51	6.01	5.65	6.03
.558	6.05	6.10	6.25	5.44	5.27	6.09	5.36	6.00
.574	6.02	6.24	6.44	5.68	5.43	6.42	5.42	-
.594	6.20	6.01	6.06	5.69	5.26	6.39	5.28	6.08
33 887.457	-	5.99	5.81	5.54	5.49	5.93	5.52	5.62

Table II. cont

J.D. 24 00 000+	V9	V10	V11	M-10 V12	V13	V14	V15	V17
33 887.478	6.07	5.99	5.93	-	5.68	5.82	5.42	5.76
.498	6.33	5.84	6.07	5.66	5.65	5.92	5.28	5.98
.511	-	5.89	5.96	5.58	5.79	5.84	5.46	6.02
.524	-	5.96	5.87	5.50	5.68	5.84	5.53	6.08
33 888.400	5.56	-	5.76	-	-	6.20	-	5.96
.412	5.58	6.03	5.64	5.95	-	-	-	6.08
.425	5.67	-	5.60	5.83	-	-	-	6.07
.437	5.71	-	5.49	-	-	-	-	6.12
.461	5.36	5.81	5.70	-	-	-	-	6.14
.474	-	5.85	5.52	5.99	5.99	6.04	-	6.29
.485	5.65	5.86	-	6.04	-	-	-	6.30
33 889.454	5.73	5.97	-	6.00	-	6.20	-	5.36
.472	5.74	6.04	5.50	5.77	-	-	6.04	5.40
.488	5.81	5.93	5.60	5.91	6.63	6.41	-	5.37
.497	-	-	-	-	-	-	-	5.33
.512	-	-	5.71	5.98	-	6.27	-	5.40
33 894.380	5.72	5.62	5.91	6.01	5.60	5.77	-	6.20
.393	-	5.86	5.92	5.92	5.70	6.02	-	6.31
.408	5.97	-	6.22	-	5.62	6.35	6.22	6.08
.420	-	-	-	-	5.75	6.00	-	-
.439	-	5.95	6.09	5.99	5.76	5.90	5.90	6.20
33 895.443	-	5.80	-	5.91	5.71	5.86	-	5.94
.457	5.48	5.64	6.33	6.24	5.44	5.76	6.13	-
.468	5.52	5.68	6.38	6.16	5.39	5.92	-	-
.487	5.21	5.69	6.16	6.11	5.16	5.98	-	5.90
.498	5.36	5.69	-	-	5.31	5.81	-	5.68
.514	5.37	-	6.06	6.18	5.45	5.79	-	5.94
.526	5.41	-	-	6.11	5.68	6.00	-	5.80
.541	5.47	5.81	6.02	5.95	5.71	5.72	-	5.50
34 238.526	6.07	6.10	5.87	5.48	6.80	-	6.51	6.06
.539	6.10	5.81	5.39	5.37	6.23	5.96	6.43	5.85
.553	5.88	5.57	-	5.30	6.16	5.81	6.48	6.04
.565	5.75	5.91	5.51	5.63	-	5.90	-	6.12
.580	-	5.85	5.57	5.57	-	6.01	-	6.00
34 241.435	6.18	6.01	6.18	-	6.41	6.25	-	6.30
.450	6.11	6.14	6.18	5.47	6.02	6.33	-	6.27
.463	5.87	6.07	6.21	5.43	-	6.07	6.35	6.31
.479	5.90	6.10	6.02	5.23	6.12	5.75	-	6.32
.492	-	-	-	5.40	6.08	5.81	-	6.31
34 253.410	6.07	-	5.86	5.58	-	5.92	5.92	-
.446	6.08	5.92	5.88	5.65	-	5.58	5.88	-
34 254.449	5.92	5.66	5.56	5.94	6.00	5.97	6.19	5.41
.467	6.20	5.70	5.90	5.94	6.03	5.85	6.07	5.52
.484	5.89	5.75	6.18	5.78	6.29	6.02	5.81	5.35
.505	5.87	5.92	-	5.50	6.74	5.55	5.31	5.39
.525	5.50	-	5.93	5.11	5.91	5.90	5.45	5.51
34 270.492	5.72	6.18	5.51	5.96	6.08	6.30	-	5.66
.514	5.73	6.04	5.34	5.40	5.90	5.90	5.96	5.90
34 573.459	-	-	-	5.60	5.78	5.75	-	6.04
.473	-	-	-	5.56	5.84	5.70	-	6.00

Table II. cont.

J.D. 24 00 000+	V9	V10	V11	V12	V13	V14	V15	V17
34 606.527	5.35	-	5.63	-	-	-	5.88	6.08
.541	5.34	-	5.54	-	-	-	6.27	6.12
.556	5.74	-	-	-	-	-	6.09	5.90
.571	5.43	5.86	5.69	6.00	-	-	-	5.75
.586	5.61	5.96	5.67	-	-	-	-	5.69
34 945.407	5.51	5.82	5.94	6.20	5.85	-	6.20	5.88
.424	-	-	-	-	5.70	-	5.67	5.87
34 949.463	-	5.96	5.62	5.62	5.75	5.87	-	5.87
35 371.410	5.62	6.08	-	5.62	5.60	5.83	6.44	5.84
.423	5.90	6.22	5.78	5.47	5.70	5.85	5.78	5.87
.436	5.97	6.05	6.00	5.44	5.60	5.88	5.30	5.94
.455	6.15	6.02	-	5.44	5.62	5.64	5.00	5.82
35 720.298	5.20	5.99	-	5.81	5.74	5.94	6.18	-
.315	5.64	-	6.30	5.92	5.53	5.85	6.58	-
.328	5.74	6.07	6.16	5.95	5.28	6.11	6.70	6.19
.344	5.77	6.05	5.77	6.10	5.36	6.00	-	5.89
.356	5.63	5.97	5.50	5.99	5.44	5.97	6.31	6.09
.369	5.65	5.82	5.62	6.14	5.58	6.32	-	5.61
.381	5.68	5.70	5.60	6.15	5.54	6.10	6.24	5.56
.394	5.40	5.82	5.48	6.04	5.54	5.90	6.00	5.64
35 725.327	5.72	6.27	5.88	5.94	6.14	6.36	6.36	5.87
.377	5.62	5.80	6.06	5.60	6.26	6.24	6.26	6.19
.419	5.76	5.66	6.26	5.32	6.26	6.26	6.58	6.01
.432	5.72	5.80	6.31	5.34	6.32	6.45	6.60	6.04
.445	5.80	5.66	6.20	5.46	6.28	6.32	6.68	6.00
.457	5.88	5.63	6.10	5.66	6.20	6.37	6.78	5.97
.495	5.77	5.57	5.62	5.53	5.34	6.26	-	6.12
.507	5.92	5.54	5.52	5.60	5.20	6.27	6.50	5.94
.519	5.86	5.60	5.52	5.60	5.22	6.12	6.30	5.99
.531	6.06	5.84	5.40	5.70	5.32	6.10	6.32	5.60
36 068.496	5.32	6.00	5.78	6.24	6.30	6.52	6.36	6.18
.514	5.22	-	5.68	6.14	6.16	6.40	6.58	6.18
.528	5.10	5.66	5.60	6.06	6.22	6.36	6.54	6.14
.543	5.00	5.40	5.67	-	5.97	6.22	6.69	6.03
36 073.380	5.75	5.92	5.72	5.64	5.40	6.21	6.47	5.91
.393	5.87	5.90	5.95	5.58	5.62	6.22	6.50	5.66
.406	5.81	6.04	5.94	5.79	5.60	6.30	6.60	5.84
.419	6.10	6.24	6.12	5.42	5.70	6.36	6.38	5.73
.432	5.78	6.44	6.01	5.26	5.72	6.30	6.01	5.86
.446	6.02	6.16	6.18	5.40	5.65	6.46	5.72	5.82
.459	5.88	6.21	6.31	5.34	5.80	6.24	5.40	5.86
.473	5.68	6.02	6.04	5.50	5.77	6.42	5.47	5.91
.486	5.36	6.03	6.15	5.50	5.90	6.44	5.44	5.84
.500	5.40	5.99	6.23	5.52	5.83	6.38	5.44	5.73
36 074.381	5.36	5.46	5.70	6.01	6.01	5.96	6.48	5.62
.394	5.15	5.41	5.60	6.12	6.04	5.80	6.80	5.55
.406	5.50	5.70	5.90	6.14	6.46	5.80	6.45	5.67
.420	5.56	5.58	6.20	6.08	6.37	5.90	6.54	5.69
.434	5.74	5.78	6.13	5.97	6.21	5.94	6.62	5.70
.447	5.60	5.71	6.04	6.04	5.95	5.95	6.42	5.82

Table II. cont.

J.D. 24 00 000+	V9	V10	V11	V12	V13	V14	V15	V17
36 074.460	5.55	5.65	6.06	5.92	5.61	6.03	6.54	5.90
.473	5.74	5.89	6.08	5.89	5.37	6.10	6.39	5.82
.486	5.74	5.88	6.20	5.90	5.41	6.14	6.48	5.88
.500	5.71	5.99	6.30	6.11	5.38	6.38	6.59	5.94
.513	5.80	6.12	6.18	6.18	5.30	6.18	6.40	5.92
.526	5.60	6.07	6.20	5.99	5.40	6.29	6.37	6.00
38 259.416	5.34	5.58	5.92	5.24	6.20	5.86	5.08	5.82
.473	5.24	5.60	5.44	5.60	6.16	5.92	5.60	-
.493	5.40	5.54	5.36	5.58	6.00	5.76	5.68	5.86
38 268.472	-	5.80	5.66	5.76	5.18	6.44	6.30	5.52
.487	6.12	5.86	5.80	5.90	5.40	6.32	6.34	5.51
.502	5.82	6.00	5.73	5.72	5.44	6.24	6.64	5.46
.518	5.95	5.90	5.85	5.88	5.40	6.23	6.65	5.70
.531	5.98	5.95	5.84	5.84	5.60	6.41	6.58	5.49
.544	5.70	5.88	5.91	5.70	5.70	6.20	6.40	5.51
.558	5.62	6.05	5.98	5.84	5.60	6.06	6.68	5.54
.572	5.86	5.88	5.96	6.06	5.82	5.98	6.66	5.68
.586	6.28	5.92	6.28	6.12	5.84	5.91	6.72	5.90
.601	6.05	5.93	6.02	5.96	5.70	5.81	6.60	5.88
38 289.280	5.78	5.62	5.84	5.78	5.66	5.62	5.92	6.02
.304	5.94	5.70	5.50	6.00	6.00	5.98	5.95	6.00
.325	6.01	5.78	5.49	5.88	6.14	5.88	5.92	5.91
.346	6.28	5.92	5.51	6.10	6.03	6.04	6.15	5.99
.373	5.72	5.82	5.59	6.00	6.00	5.98	6.23	6.03
.402	5.77	6.00	5.78	5.96	6.10	6.12	6.32	5.97
.420	5.76	5.98	5.86	6.08	6.28	6.24	6.32	5.89
.466	5.08	6.18	5.96	6.20	6.31	6.31	6.24	5.83
.482	5.10	6.10	5.91	6.10	5.91	6.22	6.65	5.86
.506	5.04	5.74	6.00	5.90	6.15	6.28	6.18	5.70
.522	5.06	5.90	6.08	6.05	6.20	6.20	6.40	5.72
.547	-	5.52	6.21	6.33	6.13	6.26	-	5.89
.560	5.30	5.46	-	5.85	6.00	6.16	6.20	5.80
.574	5.40	5.56	6.10	5.80	6.03	5.80	-	5.82
39 350.467	5.32	-	6.15	5.94	5.38	5.94	6.68	5.92
.483	5.76	5.95	6.05	5.83	5.30	5.69	6.29	6.02
.496	5.91	6.01	6.36	5.89	5.38	5.68	6.67	5.82
.522	5.76	5.83	6.07	5.82	5.67	5.78	6.58	5.79
.535	5.73	-	6.06	6.25	5.64	6.04	6.64	5.83
39 351.498	5.67	5.72	6.27	5.42	6.19	6.36	6.52	5.75
.512	5.90	5.91	6.42	5.63	6.50	6.28	6.35	5.77
.524	5.75	5.90	6.17	5.67	6.03	6.22	-	5.79
.536	6.35	5.95	6.14	5.59	6.47	6.24	-	5.79
39 355.445	5.28	6.14	5.58	6.10	6.40	5.78	5.89	5.76
.460	5.76	6.04	5.62	6.41	6.20	5.79	6.30	5.87
.474	5.70	6.25	5.93	6.07	6.28	5.81	6.34	5.87
.490	6.02	6.18	5.80	5.85	6.10	5.93	6.46	5.84
.504	5.58	-	5.86	5.92	6.65	-	6.46	5.95
.520	5.82	6.15	5.85	5.90	-	5.88	6.28	6.02
.533	5.88	6.27	6.04	5.92	6.50	-	-	-

Table II. cont.

J.D. 24 00 000+	V18	V19	V20	V22	V23	V24	V25	V26
28 752.540	5.55	-	6.08	6.27	5.54	5.96	5.70	-
28 754.394	-	6.34	5.55	5.40	5.56	-	-	-
.436	6.22	5.29	-	5.80	5.49	6.20	-	-
.485	5.97	5.24	-	5.87	5.71	-	5.70	-
.502	-	5.49	5.90	5.69	5.75	5.70	-	-
.521	-	5.43	5.61	5.78	5.54	5.59	5.36	-
28 758.463	5.91	5.16	-	-	-	-	5.99	-
.485	5.90	5.24	-	-	-	6.04	-	-
28 760.406	-	-	-	5.90	-	5.83	-	-
.443	-	-	-	-	-	5.59	-	-
28 774.392	5.94	-	6.10	-	-	6.28	-	6.00
28 775.379	6.16	6.48	5.61	5.82	5.71	5.73	6.36	6.30
.396	5.95	-	5.50	5.96	5.60	5.91	6.20	6.40
.411	6.01	-	5.58	5.89	5.80	5.94	6.13	6.41
.426	6.16	6.31	5.86	6.01	5.81	5.97	6.17	6.28
.440	6.11	-	5.90	-	6.10	6.25	6.62	-
.456	6.04	6.31	5.79	6.00	5.79	5.92	6.48	6.25
.471	6.13	6.67	5.69	6.13	6.15	6.01	6.27	6.45
28 776.367	5.60	6.00	5.91	6.17	6.44	5.40	-	5.96
.383	5.48	5.90	-	6.33	-	5.66	-	6.00
.397	5.66	6.13	6.00	6.31	6.31	5.51	-	5.90
.411	5.72	6.12	-	6.12	-	-	-	5.74
.427	5.68	6.26	5.88	6.53	6.22	5.53	6.00	5.77
.442	5.70	6.48	-	6.50	6.29	5.67	5.96	5.89
.456	5.82	-	-	-	6.45	5.80	5.64	5.80
.474	5.90	6.30	-	6.08	6.53	5.70	5.50	5.90
28 779.392	5.80	6.38	5.10	6.38	6.19	5.69	6.19	6.12
.411	5.80	6.64	5.30	6.40	6.44	5.70	6.06	6.40
.437	5.96	6.65	5.33	6.26	6.41	5.69	6.26	6.38
28 780.376	5.57	6.20	5.88	5.77	5.47	5.59	6.52	6.21
.396	5.32	6.11	5.66	5.71	5.32	5.63	6.53	6.02
.422	5.58	6.11	5.83	5.95	5.54	5.47	5.97	5.88
28 783.406	5.50	6.34	-	6.21	6.44	5.36	6.32	6.21
.429	5.65	6.53	5.85	6.33	6.38	5.74	6.34	6.30
.449	5.67	6.55	5.83	6.20	6.36	5.55	6.40	6.23
28 837.251	6.06	-	5.19	5.75	5.92	5.82	5.97	5.94
.265	6.22	6.30	5.34	5.96	5.90	6.03	6.10	6.03
.279	-	-	5.30	5.76	5.57	-	6.20	-
.293	6.02	6.20	5.25	5.77	5.55	5.73	6.20	5.98
.307	6.04	6.40	5.51	5.76	5.64	5.62	6.36	6.04
.325	6.00	6.62	5.31	5.99	5.60	5.47	6.51	6.06
29 107.517	6.00	6.49	5.81	6.30	5.71	5.90	6.60	6.00
.531	6.02	6.32	5.41	6.46	5.77	5.58	6.67	-
.544	6.03	5.85	5.40	6.00	5.55	5.60	6.56	6.07
.558	6.00	5.70	5.55	6.02	5.60	5.62	6.46	6.11
.570	6.23	5.48	5.32	6.16	-	5.32	6.52	6.02
29 108.470	5.50	6.50	5.26	6.16	6.27	-	5.60	6.56
.485	5.54	6.62	5.54	6.36	6.46	5.84	5.40	6.51
.500	5.68	6.27	5.41	6.30	6.21	5.74	5.55	6.37
.515	5.63	-	5.67	-	6.33	5.96	5.55	-

Table II. cont.

J.D. 24 00 000+	V18	V19	V20	V22	V23	V24	V25	V26
29 108.530	5.83	6.30	-	6.24	6.27	5.87	5.79	6.32
.544	5.72	-	5.71	5.97	6.32	5.84	5.58	6.32
.558	5.81	-	5.81	6.14	6.11	-	5.80	6.15
29 109.474	5.95	6.03	6.00	5.75	5.75	5.31	6.18	5.90
.488	5.64	6.10	5.85	5.70	5.86	5.48	6.29	5.70
.500	5.62	6.08	5.94	5.72	5.78	5.62	6.38	5.70
.513	5.65	6.18	5.85	5.80	6.02	5.50	6.36	5.83
.526	5.43	6.25	5.86	5.79	5.82	5.60	6.15	5.75
.540	5.49	6.47	5.85	5.90	5.85	5.77	6.62	6.01
.553	5.52	6.29	6.00	6.10	6.10	5.62	6.56	5.88
29 110.435	5.86	5.14	5.09	6.27	6.20	5.86	-	6.20
.449	6.01	5.15	-	6.29	-	-	5.95	-
29 113.423	-	5.76	5.62	6.22	6.07	6.00	6.32	6.28
.440	6.04	5.72	5.41	6.06	6.19	5.89	6.19	6.32
.454	-	5.96	5.70	-	-	-	-	5.98
.467	-	5.96	5.52	-	-	-	-	5.91
.482	6.00	5.98	-	6.17	-	5.53	6.32	5.91
.496	-	5.94	5.70	-	-	5.42	-	5.90
.510	-	-	-	-	-	5.57	-	-
29 114.423	5.85	5.42	-	5.42	5.79	5.91	6.03	-
.438	5.90	5.15	6.07	5.47	5.66	5.78	5.78	6.02
.452	5.95	4.98	-	5.33	5.60	5.86	5.50	6.03
29 130.385	6.17	6.22	-	5.86	5.89	-	6.04	5.78
29 131.347	5.52	6.50	-	6.30	6.30	-	-	6.24
.379	5.67	6.41	-	6.30	6.22	5.32	6.20	6.22
.393	5.90	6.36	5.10	6.25	6.12	5.68	6.12	6.14
.408	5.84	6.30	-	6.43	6.44	-	6.43	6.47
.449	5.97	6.53	-	6.24	6.21	-	6.47	6.53
.463	5.96	-	5.14	6.38	6.08	-	6.30	6.30
.476	5.75	6.55	-	6.52	5.96	-	6.57	6.48
.491	5.74	6.29	-	6.29	5.68	-	6.52	6.29
.505	5.86	6.36	-	6.35	5.78	-	6.40	6.35
29 132.371	5.48	6.11	5.80	5.33	6.13	5.37	6.39	5.91
.385	5.50	6.05	5.79	5.20	6.07	5.45	5.90	5.81
.398	5.50	6.09	5.55	5.28	6.18	5.28	5.74	5.93
.411	5.42	6.10	-	5.31	6.08	5.06	5.62	5.92
.424	5.61	6.22	5.55	5.43	6.18	5.23	5.58	5.93
.434	-	-	-	5.21	-	5.46	5.41	-
29 138.441	6.00	6.43	5.36	6.20	5.70	5.59	5.56	5.93
.458	6.06	5.97	5.24	6.17	5.60	5.65	5.72	5.83
.471	6.00	5.43	5.47	6.16	5.46	5.80	5.55	5.86
.484	6.04	5.00	5.40	6.37	5.63	5.93	5.66	5.99
.495	6.02	5.00	5.60	6.32	5.60	6.00	5.77	5.90
29 141.362	6.02	4.97	5.73	6.14	6.36	5.58	6.25	5.95
.375	6.14	5.01	5.75	6.21	6.34	5.68	6.15	6.18
.388	5.98	5.05	5.70	6.27	6.47	5.68	6.35	6.20
.403	5.91	5.21	5.73	6.39	6.26	5.75	6.33	6.12
.416	5.91	5.27	5.82	6.21	6.30	5.88	6.38	6.10
.429	6.04	5.37	5.79	6.21	6.26	5.86	6.45	6.33
.444	5.94	5.46	5.83	6.08	6.23	5.74	6.41	6.19

Table II. cont.

J.D. 24 00 000+	V18	V19	V20	V22	V23	V24	V25	V26
29 141.456	5.82	5.59	5.82	6.20	6.17	5.97	6.30	6.36
.469	5.81	5.59	5.88	6.30	6.13	5.90	6.33	6.38
.482	5.63	5.65	5.76	6.39	6.21	6.03	6.37	6.33
.495	5.45	5.65	6.01	6.14	6.21	6.06	6.35	6.24
29 159.356	6.10	6.50	5.60	6.15	5.50	5.50	6.50	5.94
.370	6.02	6.36	5.66	6.14	5.54	5.42	6.36	5.91
.383	6.11	6.40	5.58	6.16	5.48	5.47	6.40	5.95
.396	6.02	6.56	5.62	6.33	5.62	5.45	6.52	5.77
29 160.342	5.65	5.72	6.08	6.36	6.35	6.02	5.70	6.40
.354	5.62	5.75	6.00	6.42	6.38	6.01	5.66	6.44
.367	5.62	5.80	5.86	6.28	6.30	6.10	5.36	6.36
.380	5.74	5.82	5.82	6.24	6.35	5.91	5.37	6.34
.394	5.64	6.16	5.83	6.38	6.41	5.84	5.48	6.47
.409	5.54	5.95	-	5.98	-	5.50	-	6.50
29 161.344	5.53	5.50	5.21	5.79	5.89	5.68	6.30	6.01
.357	5.56	5.26	5.36	5.88	5.82	5.88	6.33	5.90
.372	5.39	5.09	5.43	5.88	5.80	5.80	6.33	5.90
.386	5.51	5.15	5.43	6.01	5.91	5.88	6.42	5.79
.399	5.41	5.10	5.47	6.00	5.94	5.99	6.43	5.85
29 162.325	6.30	6.62	5.73	6.48	6.35	5.54	6.12	6.31
.339	5.90	-	5.81	6.24	6.10	5.14	-	6.10
.352	6.10	6.65	5.90	6.33	6.32	5.49	5.74	6.32
.365	6.03	6.47	5.82	6.12	6.19	5.42	5.59	6.33
.378	5.97	6.33	5.67	6.23	6.15	5.39	5.51	6.33
.392	6.02	6.62	5.81	6.30	6.37	5.49	5.51	6.58
29 166.399	6.10	-	5.57	-	5.54	5.08	-	6.23
29 167.353	5.62	6.13	5.68	6.25	6.27	5.95	6.17	5.92
.366	5.73	6.36	5.65	6.11	6.39	6.00	6.42	5.98
.378	5.84	6.35	5.80	6.18	6.19	5.93	6.35	5.93
.391	5.72	6.48	5.70	6.20	6.21	5.89	6.23	6.01
29 187.274	5.82	5.58	5.44	5.75	5.78	5.88	6.22	6.20
.305	6.13	6.05	5.48	5.90	5.80	-	6.53	6.40
.318	6.20	6.29	5.54	6.04	6.05	5.85	6.32	6.45
.331	-	6.16	5.69	5.80	6.00	5.83	-	-
29 518.315	6.09	6.18	5.64	6.06	6.06	5.69	5.55	6.19
.336	5.87	6.40	-	5.70	6.02	5.26	5.42	6.15
.349	6.00	6.22	5.24	5.59	6.08	5.28	5.50	6.23
.362	5.97	6.26	5.37	5.49	6.18	5.29	5.60	6.31
.375	5.90	6.34	5.37	5.42	6.29	5.30	5.70	6.40
29 519.455	5.86	6.36	-	6.29	5.68	5.10	6.31	5.87
29 520.313	5.51	5.75	5.28	6.15	6.33	5.59	5.45	6.09
.327	5.42	5.81	5.21	6.30	6.52	5.63	5.42	6.34
.339	5.44	5.83	5.21	6.25	6.39	5.63	5.44	6.27
.352	5.51	5.95	5.27	6.33	6.32	5.63	5.46	6.22
.363	5.55	6.01	5.28	6.23	6.28	5.68	5.54	6.39
.376	5.54	6.01	5.33	6.31	6.36	5.74	5.55	6.35
29 546.266	6.01	6.43	5.47	6.27	6.27	5.74	5.39	6.04
.279	6.14	6.43	5.54	6.23	6.38	5.83	5.49	6.09
29 870.406	5.60	-	-	-	6.08	-	-	-
29 877.369	5.47	5.08	5.72	-	6.10	5.52	6.37	-

Table II. cont.

J.D. 24 00 000+	V18	V19	V20	V22	V23	V24	V25	V26
29 877.381	5.56	5.14	5.73	6.11	6.32	5.55	6.36	5.75
.394	5.57	5.24	5.70	6.11	6.38	5.61	6.25	6.03
.453	5.63	5.64	5.62	6.12	5.74	5.74	6.26	5.98
.481	5.85	5.91	5.91	6.20	5.65	6.09	6.60	6.06
.499	5.88	5.85	5.78	6.37	5.75	6.09	6.48	6.14
29 879.309	5.74	6.26	5.47	5.87	6.20	5.80	6.43	6.16
.321	5.87	6.47	5.52	5.87	5.79	5.82	6.43	5.97
.339	5.67	6.26	5.41	5.86	5.69	5.90	6.31	6.03
.372	5.89	6.48	5.43	5.77	5.71	5.93	6.40	5.88
.422	6.12	6.54	5.70	6.00	5.67	5.91	6.47	5.99
.435	5.78	6.25	5.46	6.07	5.77	5.72	-	-
.449	6.13	6.52	5.82	6.14	5.89	5.90	6.51	5.93
30 259.319	6.01	6.33	5.57	6.21	6.36	5.50	6.38	6.35
.330	5.94	6.41	-	6.04	6.49	5.42	6.24	6.34
.340	6.06	6.42	5.71	5.80	6.43	5.63	6.31	6.32
30 260.340	5.88	5.91	5.39	5.93	5.64	5.26	5.98	5.82
.354	5.79	5.94	5.28	6.03	5.71	5.25	6.03	5.94
.372	5.97	6.07	5.07	5.94	5.97	5.24	6.22	5.95
.387	5.93	6.13	4.90	6.03	5.97	5.26	6.20	6.03
.406	5.94	6.15	5.04	6.07	6.04	5.47	6.24	5.97
.427	5.95	6.21	5.07	6.14	6.09	5.50	6.14	6.07
30 261.309	5.45	5.51	5.43	6.17	6.37	5.97	6.36	6.26
.323	5.46	5.26	5.41	6.22	6.43	5.79	6.44	6.34
.334	5.45	5.23	5.57	6.12	6.34	5.81	6.36	6.31
.344	5.48	5.20	5.60	6.15	6.29	5.71	6.32	6.24
.374	5.52	5.09	5.65	6.17	6.25	5.55	6.49	6.45
.388	5.74	5.31	5.65	6.20	6.44	5.64	6.57	6.42
.402	5.82	5.42	5.76	6.17	6.28	5.42	6.40	6.36
.417	5.71	5.55	5.81	6.38	6.30	5.50	6.39	6.11
.434	5.91	5.57	5.82	6.25	6.32	5.37	6.24	6.24
33 502.437	6.06	5.62	5.61	5.90	6.06	5.77	5.83	6.25
.484	5.75	5.88	5.70	6.01	6.31	5.54	5.90	6.28
.502	5.64	5.96	5.78	5.95	6.17	5.57	5.97	6.24
.518	5.53	6.25	6.10	6.15	6.31	5.56	6.19	6.09
.532	5.49	6.16	5.83	6.03	6.37	5.32	6.09	5.98
33 858.435	6.05	6.15	5.97	6.23	5.73	5.97	6.10	6.49
.445	5.79	6.01	5.96	6.21	5.67	6.08	6.03	6.52
.474	5.50	5.89	5.75	6.26	5.75	5.84	6.08	6.09
.486	5.76	6.35	5.95	6.17	5.86	6.12	6.24	-
33 861.427	5.53	6.15	5.86	6.38	6.11	5.99	6.32	5.97
.439	5.40	6.53	6.05	6.24	6.17	5.94	6.47	5.85
.452	5.58	6.47	6.13	6.45	6.21	5.90	6.41	5.79
.464	5.53	6.58	6.22	6.52	6.08	5.78	6.49	5.85
.477	5.49	6.32	6.15	6.61	6.32	5.57	6.59	6.01
.491	5.55	6.60	5.73	-	6.08	5.48	6.50	5.79
.503	5.60	-	5.80	6.17	6.04	5.35	6.22	5.98
.517	5.80	6.48	5.72	6.20	5.83	5.50	6.36	6.05
.531	5.78	6.28	5.41	6.08	5.65	5.52	6.10	5.75
.546	5.85	6.34	5.46	5.95	5.67	5.52	5.78	5.83
.562	6.07	6.40	5.51	6.05	5.72	5.70	5.90	6.10

Table II. cont.

J.D. 24 00 000+	V18	V19	V20	V22	V23	V24	V25	V26
33 865.378	6.07	6.20	5.85	5.96	5.77	5.99	6.30	-
.392	6.21	6.13	5.89	6.01	5.73	6.06	6.26	5.91
.405	6.00	6.37	5.82	6.14	5.72	6.08	6.38	5.95
.418	6.13	6.28	5.98	6.06	5.82	6.12	6.58	5.93
.430	6.10	6.43	5.79	6.18	5.92	6.09	6.64	6.00
.442	5.73	6.56	5.88	5.97	5.80	5.84	6.53	5.75
.456	5.61	6.49	5.74	6.03	5.80	6.09	6.28	5.87
.468	5.65	6.41	5.85	5.98	5.85	5.79	6.64	5.89
.563	5.56	6.33	5.90	5.92	5.99	5.40	5.54	6.03
.575	5.74	6.53	5.82	6.20	6.24	5.52	5.41	5.92
33 871.454	5.64	5.09	5.39	6.06	6.25	5.63	6.32	5.83
.483	5.72	5.07	5.46	6.31	6.29	5.49	6.55	6.03
.496	5.77	5.08	5.50	6.23	6.32	5.35	6.45	5.75
.507	5.75	5.13	5.40	6.10	6.32	5.38	6.17	5.82
.518	6.08	5.22	5.71	6.25	6.20	5.39	5.95	5.98
.542	5.96	5.46	5.83	6.31	6.17	5.60	5.79	5.93
.555	6.19	5.72	5.68	6.43	6.26	5.61	5.47	6.08
.570	6.25	5.71	5.81	6.37	6.42	5.52	5.61	5.95
.584	5.99	5.80	5.75	6.42	6.47	5.66	5.49	6.09
33 872.446	5.72	-	-	5.36	5.98	-	6.06	6.06
.452	5.69	-	-	5.42	5.90	5.93	6.05	6.17
.487	5.53	-	-	5.63	-	5.90	6.24	6.23
.500	5.53	-	5.86	5.65	6.11	6.05	6.09	6.30
.519	5.53	6.53	5.91	5.73	5.96	5.92	6.35	6.25
.533	5.67	-	5.74	5.74	6.14	6.00	6.40	6.21
.546	5.73	6.01	5.92	5.64	6.05	5.64	6.09	-
.560	5.67	6.09	6.06	5.92	6.11	5.77	6.39	6.35
.573	5.76	5.78	5.99	5.98	6.23	5.72	-	-
.586	5.73	5.34	5.91	5.63	6.03	5.69	-	6.15
.599	5.78	4.89	5.94	-	-	5.54	-	6.26
33 881.401	5.85	6.25	5.74	6.12	6.43	6.08	6.50	-
.413	5.68	-	-	6.07	6.07	5.72	6.26	6.13
.425	5.72	6.22	5.93	6.16	6.17	-	-	-
.439	5.82	-	-	-	-	5.39	-	-
.451	5.90	6.18	5.75	6.11	6.05	5.47	-	5.99
.470	6.06	6.42	6.09	6.17	6.19	5.48	6.07	5.94
.483	5.95	6.56	5.88	6.17	6.51	5.55	6.50	6.01
33 884.395	6.10	6.23	5.94	6.06	5.68	5.65	6.06	6.04
.408	6.05	6.33	5.77	6.22	5.69	5.65	6.03	5.97
.436	5.99	6.28	6.00	6.28	5.84	5.48	6.09	5.85
.450	6.12	6.32	6.04	6.22	5.71	5.41	6.16	6.12
.464	6.03	6.37	5.90	6.33	5.84	5.60	6.22	6.15
.478	6.08	6.27	6.16	6.28	5.73	5.60	6.22	5.98
.495	5.98	6.44	5.92	6.37	6.10	5.67	6.48	6.02
.521	5.97	6.22	5.44	6.10	6.03	5.66	6.28	6.12
.539	6.00	6.11	5.56	6.26	6.20	5.62	6.39	6.25
.558	5.83	5.73	5.34	6.19	6.16	5.80	6.18	6.42
.574	5.83	5.43	5.18	6.55	6.30	5.89	6.42	6.32
.594	5.75	5.23	5.31	6.18	6.43	6.01	6.28	6.28
33 887.457	-	5.09	5.48	6.10	5.52	5.69	-	-

Table II. cont.

J.D. 24 00 000+	V18	V19	V20	V22	V23	V24	V25	V26
33 887.478	6.10	5.33	-	6.03	5.43	-	6.15	6.10
.498	5.79	5.37	-	5.36	5.40	5.63	5.84	6.23
.511	5.58	5.40	5.56	5.38	5.48	5.73	5.70	6.01
.524	5.64	5.49	5.47	5.20	5.47	5.71	5.60	5.84
33 888.400	5.92	6.28	5.79	5.56	-	6.07	-	5.81
.412	5.70	-	-	5.73	5.95	5.81	5.92	5.66
.425	5.84	-	5.76	5.63	5.99	5.83	-	5.69
.437	-	-	-	6.11	6.35	-	-	6.03
.461	5.85	-	5.78	5.82	-	5.59	-	5.82
.474	5.85	-	5.72	5.92	6.10	5.68	-	5.75
.485	6.05	-	-	-	-	5.52	-	-
33 889.454	5.63	6.11	4.83	-	5.61	-	-	-
.472	5.70	6.10	4.99	-	5.69	-	5.84	6.06
.488	5.63	6.43	5.22	6.32	5.81	5.93	6.14	6.17
.497	-	-	-	-	-	-	-	-
.512	5.88	-	-	6.05	5.90	-	5.86	6.22
33 894.380	6.08	5.33	5.40	-	6.27	5.57	5.91	5.92
.393	-	5.40	5.33	6.12	-	5.52	6.15	5.84
.408	-	5.50	5.27	6.30	6.03	5.32	6.12	5.82
.420	-	5.58	5.58	-	5.83	5.53	-	5.93
.439	6.09	5.76	5.33	-	-	5.51	-	-
33 895.443	5.99	6.00	5.81	5.24	6.20	6.04	6.44	6.21
.457	6.13	5.65	5.78	5.08	-	5.76	5.88	6.30
.468	6.32	5.52	5.90	5.27	-	5.85	5.99	6.40
.487	6.10	5.19	6.07	5.27	-	5.50	5.58	-
.498	6.00	5.15	6.07	5.32	-	5.50	5.53	-
.514	6.10	5.11	-	5.43	6.16	5.41	5.59	6.09
.526	6.10	5.19	6.17	5.50	6.25	5.54	5.55	6.15
.541	-	5.35	-	5.53	-	5.55	5.60	5.90
34 238.526	6.00	6.34	6.30	6.03	6.51	6.00	6.46	6.39
.539	5.96	6.11	6.06	5.96	6.32	5.73	6.39	6.20
.553	5.88	6.16	5.49	6.00	-	5.52	6.25	-
.565	-	6.20	5.90	6.16	6.16	5.65	6.30	6.40
.580	6.08	6.40	5.31	6.24	6.37	5.48	6.32	6.24
34 241.435	5.90	6.40	5.29	6.29	6.24	-	6.06	6.33
.450	6.04	-	5.20	6.06	6.11	5.85	5.59	6.11
.463	6.09	6.30	5.34	-	6.14	6.00	5.78	6.25
.479	5.80	-	5.14	6.26	6.30	5.93	5.64	6.12
.492	5.93	-	5.31	5.93	-	5.64	5.54	-
34 253.410	5.73	-	-	5.29	6.10	-	-	-
.446	5.61	-	-	5.43	6.18	-	5.57	-
34 254.449	5.92	5.77	5.72	6.23	5.48	5.48	-	5.74
.467	6.03	5.96	5.84	6.44	5.46	5.43	6.07	5.76
.484	5.97	-	5.97	6.32	5.36	5.65	6.69	5.97
.505	5.78	6.17	5.87	6.40	5.68	5.40	6.36	6.00
.525	5.90	6.18	-	6.20	5.52	5.26	-	5.80
34 270.492	5.83	5.90	5.74	6.26	6.11	5.57	6.62	6.10
.514	5.83	5.84	-	-	6.01	5.47	-	5.90
34 573.459	5.70	6.35	5.63	-	5.77	-	5.75	5.75
.473	5.72	-	-	6.15	5.78	-	5.50	5.75

Table II. cont.

J.D. 24 00 000+	V18	V19	V20	V22	V23	V24	V25	V26
34 606.527	5.53	-	-	5.95	-	5.62	-	5.96
.541	5.60	-	-	-	6.10	5.60	-	6.07
.556	-	-	6.25	-	-	5.87	-	-
.571	5.77	-	5.57	-	-	5.75	6.09	-
.586	5.75	-	5.43	6.05	6.16	5.73	-	6.07
34 945.407	5.90	6.60	5.20	5.85	5.66	-	5.49	-
.424	6.05	-	-	5.81	5.72	-	5.34	-
34 949.463	6.03	-	5.80	6.01	6.14	-	5.62	-
35 371.410	5.50	5.99	5.76	6.16	6.15	5.70	5.96	6.38
.423	5.52	5.62	5.64	6.31	6.10	5.70	6.17	-
.436	5.58	5.36	5.81	6.16	5.99	5.72	6.16	-
.455	5.81	5.27	5.55	-	6.04	5.94	6.07	-
35 720.298	-	6.10	-	6.04	6.06	5.26	6.23	-
.315	5.64	6.18	5.42	5.92	6.17	-	6.22	5.78
.328	5.50	6.31	5.24	6.13	6.13	5.60	6.16	5.91
.344	5.52	6.38	5.16	5.93	6.29	5.30	6.30	5.71
.356	5.50	6.12	4.84	5.60	6.17	5.08	6.30	5.85
.369	5.46	6.44	4.80	5.65	6.40	5.35	6.42	5.85
.381	5.48	6.20	4.82	5.58	6.30	5.36	6.46	5.82
.394	-	6.32	4.95	5.58	6.13	5.28	6.38	5.90
35 725.327	6.02	6.20	5.50	-	6.41	5.74	5.94	6.28
.377	5.98	6.16	5.12	5.86	6.04	5.82	6.08	6.26
.419	5.98	6.47	5.28	5.54	6.32	-	6.33	6.40
.432	5.86	6.38	5.34	5.50	6.22	5.70	6.26	6.50
.445	5.72	6.40	5.24	5.43	6.20	5.52	6.06	-
.457	5.80	6.27	5.56	5.45	6.22	5.50	6.42	6.22
.495	5.40	-	5.66	5.70	5.62	5.42	6.34	6.00
.507	5.42	-	5.27	5.58	5.52	5.32	6.28	5.84
.519	5.60	6.30	5.70	5.69	5.52	5.40	6.30	5.98
.531	5.46	-	5.68	5.80	5.78	5.14	6.26	5.94
36 068.496	5.92	6.30	5.76	6.16	5.66	5.70	5.58	6.42
.514	5.98	5.88	5.84	6.14	5.60	5.62	5.52	6.50
.528	5.86	5.40	5.52	6.16	5.90	5.24	5.73	6.22
.543	5.60	5.16	5.48	6.06	5.80	5.24	5.67	6.20
36 073.380	5.54	6.21	-	5.67	6.41	5.20	6.10	6.45
.393	5.32	6.22	5.62	5.73	6.36	5.17	6.26	6.22
.406	5.40	6.27	5.60	5.71	6.04	5.34	6.10	6.27
.419	5.52	6.50	5.60	5.84	6.04	5.36	6.26	6.28
.432	5.56	6.34	5.66	5.78	5.86	5.32	6.40	6.12
.446	5.72	6.31	5.77	5.75	5.64	5.57	6.30	6.31
.459	5.66	6.35	5.82	5.88	5.34	5.70	6.36	6.12
.473	5.60	6.48	5.98	5.92	5.42	5.60	6.40	6.00
.486	5.61	6.54	5.64	5.94	5.44	5.52	6.46	5.82
.500	5.81	6.35	5.60	5.81	5.52	5.63	6.18	5.83
36 074.381	5.89	5.66	-	6.01	6.01	-	6.70	5.91
.394	6.07	5.84	-	6.28	6.16	-	6.47	5.71
.406	5.90	5.96	4.93	6.34	6.32	5.90	6.28	6.00
.420	5.90	5.90	5.07	6.37	6.23	5.80	5.98	5.98
.434	5.56	6.10	5.00	6.41	6.24	5.50	5.67	5.90
.447	5.60	6.04	5.12	6.25	6.24	5.48	5.65	6.19

Table II. cont.

J.D. 24 00 000+	V18	V19	V20	V22	V23	V24	V25	V26
36 074.460	5.60	6.09	5.01	6.23	6.56	5.52	5.51	6.09
.473	5.42	6.26	5.28	6.39	6.18	5.52	5.70	6.16
.486	5.43	6.22	5.30	6.27	6.27	5.30	5.60	5.98
.500	5.45	6.38	5.27	6.33	6.33	5.24	5.42	6.14
.513	5.50	6.30	5.26	6.23	6.41	5.42	5.66	6.21
.526	5.28	-	5.33	6.20	6.06	5.28	5.75	-
38 259.416	6.08	5.38	5.08	6.18	5.56	5.38	5.42	6.06
.473	5.74	5.80	-	-	5.30	5.24	5.66	5.68
.493	5.64	5.82	5.14	6.36	5.36	5.16	5.90	5.70
38 268.472	-	5.20	-	5.76	5.85	-	6.36	6.08
.487	5.64	5.20	5.08	5.86	5.90	5.80	6.40	6.12
.502	5.67	5.20	5.06	5.89	5.89	5.76	6.40	6.08
.518	5.83	5.18	5.28	5.88	5.95	5.80	6.31	6.32
.531	5.63	5.30	-	5.84	6.32	-	6.50	6.44
.544	-	5.40	-	6.05	6.24	-	6.26	6.20
.558	5.70	5.46	-	6.02	6.18	-	6.26	-
.572	5.88	5.44	5.22	6.06	6.11	5.40	6.18	6.18
.586	5.88	5.56	5.20	6.12	6.40	5.50	6.40	6.54
.601	5.82	5.60	5.28	6.07	6.18	5.32	6.55	6.31
38 289.280	5.78	6.02	-	5.50	5.84	5.52	6.04	5.90
.304	5.44	5.98	5.18	5.47	5.70	5.46	5.82	5.95
.325	5.37	6.01	4.98	5.74	5.74	5.44	5.54	5.88
.346	5.51	6.38	5.05	5.79	5.85	5.43	5.36	5.95
.373	5.40	6.12	5.00	5.77	5.82	5.18	5.52	5.78
.402	5.54	6.37	4.80	5.75	6.10	5.14	5.72	5.97
.420	5.62	6.40	5.23	5.72	6.20	5.50	5.79	6.34
.466	5.73	6.15	5.30	6.10	6.06	5.47	5.94	6.31
.482	5.81	6.43	5.48	6.00	6.26	5.60	5.94	6.26
.506	5.80	6.80	5.12	6.20	6.04	5.90	5.90	6.28
.522	5.88	6.38	5.44	6.12	6.46	5.64	5.92	6.46
.547	6.02	6.21	5.40	6.20	6.13	6.06	6.21	6.05
.560	-	6.22	5.24	6.10	6.38	.	6.22	6.16
.574	-	-	5.36	6.00	6.39	-	6.10	-
39 350.467	6.09	6.27	5.76	6.25	6.24	5.84	6.72	5.78
.483	5.98	6.34	-	6.23	6.49	-	6.39	5.80
.496	6.36	6.62	5.86	6.40	6.52	5.60	6.21	5.79
.522	6.02	6.54	5.61	6.55	6.42	5.76	5.62	5.74
.535	6.12	-	-	6.27	6.39	-	5.49	6.22
39 351.498	5.56	6.20	4.90	5.36	5.32	5.41	6.26	6.36
.512	5.85	6.20	5.23	5.67	5.59	5.57	6.09	-
.524	5.73	5.99	5.20	5.48	5.48	-	6.07	6.05
.536	6.01	6.14	5.27	5.51	5.62	5.68	6.12	6.15
39 355.445	5.47	5.82	5.70	6.24	6.09	-	6.26	6.19
.460	5.51	5.90	5.52	6.22	5.97	5.75	6.28	6.21
.474	5.61	6.12	5.59	6.26	6.14	5.62	6.42	6.26
.490	5.61	-	5.72	6.05	6.06	5.50	6.08	6.37
.504	5.67	6.13	5.80	6.17	5.96	5.44	6.37	6.28
.520	5.74	6.16	5.82	6.09	6.12	5.39	6.18	6.17
.533	5.67	6.37	5.61	-	5.96	5.31	-	6.20

Table II. cont.

J.D. 24 00 000+	V27	V28	V29	V30	V31	V32	V35	V36
28752.540	-	6.20	5.69	6.04	6.12	6.07	5.95	5.43
28754.394	-	5.82	-	-	6.08	-	6.25	5.36
.436	-	5.56	-	5.72	5.96	6.00	-	5.40
.485	-	5.81	6.50	5.83	6.11	5.70	5.79	5.59
.502	-	-	6.43	5.85	6.08	5.30	-	5.75
.521	-	-	6.17	-	6.20	5.23	5.60	5.73
28758.463	-	5.70	6.42	5.70	6.08	6.10	5.71	6.40
.485	-	5.51	-	5.66	-	-	5.90	6.38
28760.406	-	-	5.70	5.48	-	-	-	6.08
.443	-	5.73	5.58	5.59	-	-	-	-
28774.392	-	-	6.10	5.90	5.98	6.10	6.38	5.36
28775.379	-	6.20	5.56	5.82	6.29	5.97	6.10	6.12
.396	-	6.21	5.60	5.63	6.46	5.86	6.14	6.10
.411	6.85	6.12	5.45	5.58	6.17	5.80	6.09	6.00
.426	-	6.35	5.60	5.43	6.13	5.97	6.10	5.98
.440	6.90	-	5.54	5.60	5.94	6.15	6.25	6.13
.456	6.90	6.40	5.68	5.40	5.74	5.90	6.25	6.22
.471	6.95	6.59	5.86	5.40	5.54	5.91	6.29	6.25
28776.367	-	6.63	6.29	-	5.89	5.40	5.95	5.90
.383	6.80	-	6.23	5.74	5.95	5.58	5.85	5.90
.397	-	-	6.20	5.81	5.98	5.55	5.83	5.65
.411	-	-	6.20	-	6.00	5.50	5.58	5.68
.427	-	-	6.05	5.82	5.98	5.42	5.61	5.98
.442	6.90	-	6.14	6.01	5.96	5.60	5.70	6.05
.456	-	-	6.02	6.02	6.11	5.71	5.61	6.12
.474	-	-	6.32	6.00	6.10	5.65	5.78	6.00
28779.392	6.85	6.01	5.61	6.00	6.33	5.34	6.38	5.42
.411	6.90	-	5.79	6.00	6.24	5.38	6.20	5.52
.437	6.85	6.19	5.63	5.86	6.41	5.73	6.02	5.59
28780.376	6.90	6.46	6.27	5.47	5.54	5.80	6.10	6.29
.396	-	6.51	-	5.52	5.55	-	6.07	6.29
.422	6.85	6.24	5.99	5.51	5.51	5.90	6.00	6.24
28783.406	6.90	6.05	5.63	6.00	6.13	5.90	5.75	6.00
.429	6.90	6.20	5.58	6.10	6.25	6.00	5.82	6.18
.449	6.90	6.15	5.56	5.98	6.10	5.79	6.00	6.17
28837.251	6.95	6.54	6.45	5.54	5.83	5.85	6.09	6.30
.265	6.80	6.28	6.42	5.78	5.96	6.00	6.19	6.31
.279	6.90	-	-	5.76	6.01	5.91	6.22	6.45
.293	6.90	6.50	6.50	5.75	6.07	5.81	6.17	6.30
.307	6.90	6.52	6.38	5.80	6.03	5.93	6.16	6.32
.325	6.80	6.75	6.23	5.70	6.06	6.06	6.30	5.82
29107.517	7.00	6.56	6.33	5.71	6.18	5.40	5.95	6.15
.531	7.00	6.46	6.42	5.55	6.13	5.45	5.95	6.29
.544	6.80	6.52	6.19	5.60	6.17	5.50	6.00	6.33
.558	6.80	-	6.20	5.46	6.23	5.60	6.05	6.38
.570	6.80	6.80	6.19	5.48	6.15	5.65	-	6.25
29108.470	6.80	6.04	6.02	5.56	6.38	5.91	6.50	6.09
.485	6.90	5.69	5.81	5.70	6.42	5.93	6.36	6.05
.500	-	5.41	6.30	5.70	6.27	5.69	6.15	5.86
.515	6.90	5.55	6.19	5.67	6.08	5.70	6.10	6.10

Table II. cont.

J.D. 24 00 000+	V27	V28	V29	V30	V31	V32	V35	V36
29108.530	-	5.70	6.15	5.91	6.06	6.06	5.83	6.12
.544	6.90	5.61	6.08	5.80	6.09	5.78	5.92	6.16
.558	6.80	-	6.19	5.91	6.06	5.81	5.68	6.15
29109.474	-	6.52	5.42	5.92	5.85	5.77	6.01	5.17
.488	6.90	6.11	5.57	5.76	5.87	5.72	5.99	5.15
.500	6.90	6.43	5.44	5.74	5.94	5.58	6.03	5.15
.513	6.95	6.36	5.60	5.85	6.06	5.98	6.20	5.13
.526	6.90	6.29	5.60	5.70	6.06	5.77	6.05	5.28
.540	6.95	6.31	5.56	5.77	6.08	5.79	6.30	5.24
.553	6.90	6.43	5.66	-	6.21	5.81	6.29	5.28
29110.435	-	-	6.08	5.45	6.22	5.64	6.02	5.93
.449	-	-	-	5.56	-	5.82	5.85	6.12
29113.423	-	6.19	5.61	5.73	6.10	5.84	6.36	5.96
.440	-	6.20	5.55	6.00	6.04	-	-	-
.454	6.80	-	5.56	6.00	6.07	5.81	6.30	5.98
.467	-	-	5.53	6.00	5.95	-	6.35	6.02
.482	6.80	-	5.58	5.96	5.97	5.50	6.20	6.02
.496	-	-	-	5.90	5.88	5.38	6.00	6.10
.510	-	-	5.70	5.94	5.93	5.46	5.92	-
29114.423	-	-	6.38	-	6.09	5.99	6.01	6.15
.438	-	-	6.19	5.56	5.91	5.76	5.84	5.90
.452	6.85	-	6.40	5.64	6.05	-	5.95	5.65
29130.385	7.00	-	6.19	5.71	6.12	6.04	6.04	6.25
29131.347	6.80	-	5.64	6.10	6.20	-	6.02	5.20
.379	6.90	-	5.68	6.10	5.98	6.04	6.10	5.42
.393	6.95	5.70	5.68	5.90	5.80	5.87	6.14	5.23
.408	7.00	5.98	5.80	5.84	5.80	-	6.29	5.18
.449	6.90	6.10	5.99	5.59	5.81	-	6.21	5.30
.463	6.80	6.17	5.87	5.70	5.97	-	6.19	5.60
.476	7.00	-	6.02	5.58	5.95	-	6.30	5.63
.491	6.85	-	5.90	5.50	5.88	5.68	6.27	5.62
.505	6.94	-	5.96	5.40	5.91	-	6.36	5.68
29132.371	6.95	6.60	5.88	5.50	6.02	5.22	5.73	6.10
.385	6.90	6.62	5.84	5.57	6.00	5.36	5.70	6.29
.398	6.89	6.32	5.62	5.65	6.03	5.24	5.74	6.30
.411	6.90	6.43	5.69	5.50	6.03	-	5.73	6.34
.424	6.85	6.43	5.76	5.55	6.14	5.20	5.71	6.30
.434	-	-	5.62	5.75	6.07	5.62	-	5.97
29138.441	6.89	6.43	5.90	5.46	5.86	5.16	6.20	6.06
.458	6.88	6.42	6.05	5.42	5.91	5.41	6.10	6.00
.471	6.85	6.40	6.20	5.55	5.94	5.38	5.94	6.16
.484	6.86	-	6.20	5.63	6.03	5.42	6.07	6.24
.495	6.90	6.40	6.19	5.62	6.03	5.51	5.72	6.20
29141.362	6.84	5.63	6.35	5.61	6.03	4.97	6.19	5.26
.375	6.90	5.62	6.36	5.64	6.12	5.03	6.30	5.40
.388	6.95	5.59	6.45	5.69	6.12	4.95	6.27	5.56
.403	6.94	5.59	6.19	5.72	6.22	5.24	6.12	5.56
.416	6.89	5.58	6.28	5.80	6.27	5.20	6.42	-
.429	6.87	5.81	6.34	5.75	6.38	5.22	6.39	5.68
.444	6.91	5.67	6.26	5.77	6.32	5.37	6.10	5.80

Table II. cont.

J.D. 24 00 000+	V27	V28	V29	V30	V31	V32	V35	V36
29141.456	6.94	5.73	6.42	5.80	6.28	5.48	6.37	5.95
.469	6.86	5.72	6.39	5.80	6.32	5.39	6.20	6.03
.482	6.87	5.69	6.19	5.80	6.34	5.43	6.41	6.10
.495	6.94	5.85	6.30	5.94	6.34	5.67	6.41	6.06
29159.356	-	6.60	6.48	5.88	6.22	5.94	6.06	-
.370	6.82	6.56	6.31	5.88	6.36	5.97	5.87	5.88
.383	6.80	6.63	6.40	5.92	6.28	5.93	6.05	5.69
.396	6.93	6.70	6.40	5.95	6.31	5.97	5.99	5.23
29160.342	6.92	6.18	6.20	5.66	6.15	5.75	6.37	6.45
.354	6.83	6.24	6.21	5.64	5.99	5.68	5.88	6.45
.367	6.97	6.28	6.42	5.55	5.88	5.84	5.93	6.36
.380	6.86	6.20	6.39	5.59	5.84	5.79	5.86	6.39
.394	6.91	6.21	6.21	5.67	5.83	5.69	5.63	6.43
.409	6.85	-	6.50	5.65	5.87	5.60	5.68	6.33
29161.344	6.83	6.50	5.87	5.91	5.86	4.90	6.29	5.19
.357	6.90	6.63	5.91	5.94	5.95	4.89	6.15	5.56
.372	6.89	6.64	5.82	6.00	5.99	4.99	6.23	5.72
.386	6.88	6.69	5.87	5.92	6.08	5.05	6.22	5.79
.399	6.82	6.72	5.92	5.93	6.11	5.17	6.32	5.86
29162.325	-	6.26	5.87	5.72	6.42	-	5.71	-
.339	-	-	5.70	5.65	6.23	5.94	5.76	-
.352	-	6.27	5.62	5.65	6.23	-	5.84	6.32
.365	-	6.31	5.54	5.56	6.09	-	5.86	6.44
.378	-	6.24	5.47	5.55	5.84	6.07	5.76	6.45
.392	-	6.28	5.57	5.67	5.74	5.97	5.73	6.43
29166.399	6.80	6.07	5.50	5.60	6.35	5.48	-	5.62
29167.353	-	6.41	6.39	5.60	5.65	5.80	5.70	6.31
.366	-	6.65	6.38	5.81	5.66	5.64	5.82	6.38
.378	6.85	6.56	6.23	5.72	5.67	5.30	5.88	6.01
.391	-	6.61	6.50	5.72	5.75	4.95	5.73	6.31
29187.274	-	6.37	6.38	5.80	6.32	5.80	5.72	6.08
.305	-	6.32	6.09	5.78	6.18	5.85	5.68	6.20
.318	-	6.58	6.09	5.90	5.80	5.85	5.80	6.29
.331	-	-	6.38	5.89	5.85	5.80	5.76	6.25
29518.315	-	5.63	5.50	6.02	6.28	5.87	5.74	5.07
.336	6.84	5.51	5.42	5.70	6.13	-	5.70	5.09
.349	6.89	5.57	5.60	5.60	6.00	5.72	5.68	5.15
.362	6.94	5.80	5.38	5.42	5.95	5.70	5.78	5.24
.375	6.87	5.89	5.55	5.40	5.97	5.67	5.76	5.36
29519.455	6.85	6.29	5.42	6.00	6.22	5.77	5.77	6.46
29520.313	6.90	5.62	6.10	5.87	6.16	5.66	5.88	5.96
.327	6.85	5.73	6.38	5.85	6.30	5.49	5.87	5.98
.339	6.89	5.59	6.40	5.88	6.08	5.29	6.04	6.10
.352	6.82	5.67	6.13	-	6.05	5.11	6.00	5.89
.363	6.86	5.65	6.35	5.97	6.00	4.97	6.08	5.88
.376	6.85	5.77	6.25	5.74	5.84	4.99	6.10	5.90
29546.266	6.90	6.51	6.44	5.90	5.93	5.85	6.01	6.30
.279	6.92	6.64	6.31	6.00	5.99	5.90	5.85	6.37
29870.406	-	-	-	5.70	-	5.56	5.80	5.58
29877.369	-	-	-	5.44	6.22	5.77	5.66	5.70

Table II. cont.

J.D. 24 00 000+	V27	V28	V29	V30	V31	V32	V35	V36
29877.381	-	6.48	6.08	5.50	6.28	5.84	5.73	5.98
.394	-	6.35	6.01	5.59	6.28	5.80	5.73	5.90
.453	-	6.45	6.21	5.79	6.22	5.74	5.94	5.89
.481	6.90	6.41	6.40	5.83	6.22	5.91	5.94	5.96
.499	-	-	-	5.91	6.20	5.56	6.07	5.98
29879.309	6.90	6.21	6.27	5.70	5.80	5.75	5.77	6.25
.321	-	6.55	6.10	5.61	5.91	5.57	5.86	-
.339	-	6.29	5.82	5.54	5.99	5.21	5.92	6.00
.372	6.90	6.42	5.55	5.42	5.94	5.17	5.91	6.06
.422	-	6.43	5.70	5.64	6.21	5.22	6.27	6.12
.435	-	-	5.53	5.65	6.10	5.32	6.30	6.20
.449	-	6.36	5.70	5.71	6.27	5.32	6.35	6.25
30259.319	6.89	5.63	6.24	5.56	5.85	5.91	6.25	5.69
.330	6.89	5.59	6.32	5.62	5.92	5.81	6.40	5.78
.340	6.88	5.41	6.21	5.56	5.99	5.89	6.14	5.87
30260.340	6.88	6.29	6.48	6.00	6.28	5.47	6.07	6.31
.354	6.86	6.44	6.57	5.85	6.18	5.41	6.25	6.36
.372	6.91	6.48	6.38	5.86	6.25	5.69	6.25	5.90
.387	6.86	6.53	6.38	5.92	6.20	5.72	6.18	5.16
.406	6.85	6.42	6.19	5.93	6.09	5.69	6.49	5.05
.427	6.90	6.41	6.62	6.00	5.99	5.70	6.33	5.05
30261.309	6.80	5.90	5.86	5.45	5.73	5.91	5.78	6.20
.323	6.92	5.81	5.94	5.39	5.82	5.81	5.75	6.29
.334	6.83	5.62	5.95	5.42	5.76	5.57	5.70	6.33
.344	6.95	5.58	6.03	5.41	5.84	5.22	5.69	6.38
.374	6.93	5.62	6.06	5.50	5.87	4.76	5.61	6.38
.388	6.88	5.69	6.30	5.58	5.98	4.87	5.80	6.42
.402	6.90	5.73	6.19	5.63	6.04	4.97	5.82	-
.417	6.87	5.71	6.46	5.50	6.00	5.08	5.77	6.08
.434	-	5.90	6.06	5.62	6.03	5.11	5.73	-
33502.437	6.89	6.35	5.63	5.85	6.15	5.77	6.01	5.88
.484	6.94	6.60	5.78	-	6.33	5.74	6.22	6.16
.502	6.90	6.46	5.68	5.86	6.27	5.89	6.14	6.16
.518	6.89	6.44	5.89	5.95	6.30	5.87	6.37	6.23
.532	6.86	6.19	5.95	5.90	6.28	5.81	6.26	6.29
33858.435	-	6.47	5.99	5.87	6.22	5.93	6.25	6.12
.445	6.95	6.51	5.93	5.81	6.16	5.86	6.22	6.07
.474	-	6.40	5.83	5.80	6.06	5.93	6.17	6.29
.486	-	-	-	6.11	5.92	5.91	6.35	-
33861.427	-	5.64	-	5.80	6.00	5.81	5.81	6.02
.439	-	5.80	-	5.69	6.00	5.81	5.94	6.08
.452	-	5.81	6.54	5.62	5.90	5.95	6.15	6.18
.464	6.90	5.92	6.19	5.53	5.79	6.02	6.22	6.29
.477	6.94	5.73	6.25	5.57	5.85	5.77	6.05	6.29
.491	-	5.91	-	5.52	6.00	-	6.25	6.29
.503	-	5.91	-	5.61	5.96	5.89	5.98	6.35
.517	-	6.05	6.54	5.69	5.94	5.96	6.09	6.30
.531	6.80	5.98	6.17	5.55	5.82	6.00	6.21	6.25
.546	6.80	6.04	6.46	5.52	5.97	6.04	6.30	6.30
.562	-	6.21	6.34	5.75	6.08	5.97	6.35	6.31

Table II. cont.

J.D. 24 00 000+	V27	V28	V29	V30	V31	V32	V35	V36
33865.378	6.90	5.79	6.16	-	6.17	5.55	6.06	6.28
.392	-	5.63	5.91	5.94	6.10	5.44	6.23	6.10
.405	-	5.63	6.31	6.01	6.24	5.44	6.46	5.68
.418	6.90	5.50	6.24	6.13	6.38	5.59	6.44	5.85
.430	-	5.46	6.37	6.15	6.33	5.51	6.35	5.54
.442	6.90	5.49	6.42	6.10	6.18	5.44	6.30	5.36
.456	7.00	5.60	6.10	6.03	6.00	5.60	6.33	5.25
.468	7.00	5.60	6.31	5.94	5.89	5.58	6.29	5.17
.563	6.90	6.07	6.17	-	5.80	5.65	5.75	5.68
.575	6.95	5.96	6.16	5.64	5.93	5.69	5.76	5.80
33871.454	6.90	5.47	5.93	5.76	6.29	5.40	6.16	6.44
.483	-	5.54	5.46	5.95	6.36	5.44	6.16	6.39
.496	6.80	5.70	-	6.05	6.30	5.50	6.01	6.24
.507	-	5.68	5.38	6.01	6.40	5.53	6.07	6.25
.518	-	5.88	5.30	6.07	6.29	5.46	6.20	6.32
.542	-	5.65	5.44	6.18	6.19	5.68	6.23	6.35
.555	6.90	5.84	5.62	6.03	5.83	5.67	6.34	6.43
.570	-	5.93	5.49	5.99	5.83	5.68	6.31	6.36
.584	-	5.99	5.82	5.99	5.74	5.69	6.20	6.34
33872.446	-	6.40	-	5.65	5.78	5.91	6.00	5.72
.452	-	-	-	5.66	5.89	5.90	5.89	5.80
.487	-	-	-	5.67	5.88	5.80	5.61	5.85
.500	-	6.50	-	5.71	5.93	5.86	5.61	5.99
.519	-	6.63	6.28	5.65	5.89	5.73	5.83	5.96
.533	-	6.43	6.19	5.71	6.03	5.67	5.80	6.00
.546	-	6.34	6.25	5.62	5.95	5.66	5.93	6.00
.560	-	6.52	6.16	5.78	6.05	5.65	5.83	6.05
.573	-	-	6.16	5.71	6.10	5.50	5.99	6.06
.586	-	6.38	5.98	5.52	6.21	-	5.85	6.12
.599	-	6.32	5.80	5.79	6.01	5.30	5.85	6.16
33881.401	-	-	5.73	5.65	5.78	-	5.91	-
.413	-	-	-	5.60	5.51	5.67	5.89	6.00
.425	-	-	5.63	5.63	5.58	5.72	6.12	6.05
.439	-	-	-	5.56	5.64	-	5.98	6.09
.451	-	6.01	-	5.54	5.68	-	6.10	5.98
.470	-	-	-	5.66	5.66	5.77	6.07	6.07
.483	-	5.83	-	5.63	5.67	5.92	6.03	6.16
33884.395	-	6.26	5.93	5.70	5.82	6.00	5.86	5.70
.408	-	6.04	6.12	5.82	5.98	6.01	5.68	5.77
.436	-	6.24	-	5.92	5.94	5.80	5.80	5.94
.450	-	6.40	6.23	5.88	6.11	5.80	5.72	5.96
.464	-	6.30	-	5.92	6.27	5.75	5.76	5.90
.478	-	-	6.12	6.02	6.18	5.79	6.04	-
.495	-	-	-	6.12	6.29	5.76	5.92	5.90
.521	-	6.53	6.35	6.14	6.33	6.11	6.20	5.94
.539	6.86	6.55	6.34	6.16	6.42	5.88	6.18	5.98
.558	6.90	6.45	6.46	6.10	6.44	5.99	6.26	6.00
.574	-	6.39	6.42	6.10	6.35	6.00	6.37	-
.594	-	6.29	-	6.02	6.29	5.97	6.38	5.94
33887.457	-	-	-	5.65	6.32	-	5.86	6.08

Table II. cont.

J.D. 24 00 000+	V27	V28	V29	V30	V31	V32	V35	V36
33887.478	-	6.39	-	5.71	5.98	5.80	5.92	-
.498	-	-	-	5.40	5.76	5.90	5.68	-
.511	-	5.91	-	5.45	5.69	5.80	5.85	6.05
.524	-	5.80	-	5.50	5.58	5.91	5.84	6.00
33888.400	-	-	5.87	5.70	5.79	5.27	6.25	6.16
.412	-	-	-	5.66	5.79	5.51	6.15	-
.425	-	-	5.90	5.53	5.85	5.51	6.15	-
.437	-	-	-	5.70	5.85	5.75	6.20	-
.461	-	-	-	-	5.91	5.72	6.35	-
.474	-	-	-	5.75	6.05	5.70	6.40	-
.485	-	-	-	6.02	6.00	5.59	6.30	-
33889.454	-	-	5.51	6.01	6.20	5.85	5.87	6.00
.472	-	-	5.70	5.77	6.12	-	5.82	6.00
.488	-	6.51	5.84	5.72	6.32	5.85	6.00	6.05
.497	-	-	-	-	-	5.60	-	5.98
.512	-	6.22	6.31	5.84	6.10	5.38	5.93	5.90
33894.380	-	5.80	-	5.72	6.20	5.07	5.70	-
.393	-	5.94	-	5.79	-	5.24	5.79	5.94
.408	-	5.99	-	5.50	6.29	5.22	-	5.98
.420	-	-	-	-	6.18	5.35	5.79	6.00
.439	-	-	-	5.65	5.94	5.38	5.80	-
33895.443	-	-	-	5.95	6.14	5.84	6.20	5.24
.457	-	-	-	5.95	6.10	5.76	6.00	5.19
.468	-	-	-	6.10	6.15	5.92	5.88	5.16
.487	-	-	-	6.08	6.16	5.94	6.03	5.12
.498	-	-	-	6.05	6.16	5.66	5.92	5.28
.514	-	-	-	-	-	5.71	5.74	-
.526	-	6.40	-	5.88	6.20	5.78	5.68	5.45
.541	-	5.97	-	5.75	-	5.71	5.68	5.47
34238.526	-	6.49	6.20	6.07	6.02	6.17	5.97	6.23
.539	-	6.10	6.28	6.00	5.98	5.90	5.85	6.29
.553	-	-	6.28	6.00	5.85	5.97	6.10	6.33
.565	-	6.32	6.20	5.87	5.90	5.93	6.05	6.40
.580	-	-	6.35	5.75	5.94	6.01	6.09	6.39
34241.435	-	-	6.37	5.95	5.76	5.80	6.06	5.77
.450	-	-	6.22	-	5.55	5.60	5.94	5.88
.463	-	-	6.47	5.58	5.62	5.52	5.94	5.94
.479	-	6.36	6.00	5.55	5.74	5.90	5.81	5.90
.492	-	-	6.18	5.49	5.83	5.90	5.77	5.91
34253.410	-	-	5.82	5.79	-	5.06	5.80	6.00
.446	-	-	5.84	5.75	6.22	5.35	5.58	6.00
34254.449	-	5.70	5.50	5.63	5.95	5.68	6.23	5.88
.467	7.00	5.94	5.42	5.72	5.88	5.96	6.28	5.65
.484	7.00	-	5.53	5.62	5.89	6.12	6.32	5.76
.505	-	-	5.81	5.50	5.74	5.87	6.32	5.94
.525	-	6.17	5.62	5.50	5.73	5.75	-	5.96
34270.492	-	5.44	5.52	5.95	5.77	5.42	6.18	-
.514	-	5.69	5.27	5.74	5.90	5.47	-	-
34573.459	-	6.30	6.01	5.95	6.18	-	6.10	5.67
.473	-	-	6.18	6.05	6.15	-	6.20	6.15

Table II. cont.

J.D. 24 00 000+	V27	V28	V29	V30	V31	V32	V35	V36
34606.527	-	5.65	6.32	5.48	6.10	5.78	-	6.02
.541	-	5.70	6.21	5.56	6.22	5.64	6.15	6.25
,556	-	-	6.10	-	6.30	6.04	-	6.00
.571	-	5.81	6.22	5.61	6.18	6.10	6.40	6.22
.586	-	5.91	6.45	5.76	6.32	-	6.30	6.13
34945.407	6.90	6.28	6.20	-	6.25	5.10	5.80	5.73
.424	-	6.22	-	-	-	5.20	5.69	-
34949.463	-	-	6.02	-	6.27	5.74	6.25	-
35371.410	-	6.28	6.55	5.88	5.92	6.00	6.20	6.27
.423	-	-	-	5.82	6.05	6.19	-	6.18
.436	-	-	6.14	5.90	6.02	6.12	6.25	-
.455	-	-	6.40	5.96	6.10	-	6.40	6.00
35720.298	6.85	6.54	6.18	5.80	5.97	4.87	5.78	-
.315	6.90	6.24	6.40	5.84	5.80	5.32	5.74	6.22
.328	7.00	6.40	6.50	5.95	5.90	5.24	5.91	6.10
.344	7.00	6.30	6.45	5.95	5.99	5.25	5.93	6.17
.356	-	5.92	6.37	6.10	5.93	5.36	5.65	6.17
.369	-	5.90	6.55	6.10	6.00	5.20	6.00	5.70
.381	-	5.79	6.50	6.00	-	5.20	5.89	5.42
.394	-	5.92	6.32	6.00	6.00	5.24	5.90	5.10
35725.327	6.80	-	5.60	5.72	6.10	5.84	5.84	-
.377	-	6.25	6.20	5.62	6.27	5.70	5.96	5.35
.419	6.86	-	6.50	5.62	6.28	5.86	5.92	5.15
.432	6.89	6.38	6.18	5.70	6.26	5.86	6.29	5.03
.445	6.95	6.34	6.45	5.64	6.27	5.71	6.16	5.18
.457	6.91	6.20	6.32	5.56	6.07	6.02	6.28	5.42
.495	6.90	6.38	6.38	5.68	5.70	5.80	6.40	5.63
.507	-	-	6.40	5.62	5.62	5.70	6.18	5.65
.519	6.90	6.40	6.55	5.84	5.63	6.00	6.38	5.70
.531	-	-	6.50	5.74	5.67	5.66	6.32	5.80
36068.496	6.82	5.48	5.50	5.58	5.90	5.78	6.30	6.17
.514	6.90	5.52	5.52	5.64	5.86	5.56	6.02	6.13
.528	6.90	5.74	5.55	5.54	5.94	5.58	5.90	6.18
.543	6.86	5.44	5.30	5.60	5.81	5.70	5.78	6.03
36073.380	6.90	6.18	6.55	5.54	5.90	5.43	6.37	5.97
.393	6.88	6.10	6.40	5.62	5.96	5.47	6.36	6.00
.406	6.90	6.13	6.38	5.56	5.96	5.53	6.24	6.05
.419	6.90	6.38	6.50	5.64	5.79	5.62	6.40	5.92
.432	6.90	6.18	6.40	5.64	6.02	5.68	6.26	6.13
.446	6.95	6.44	6.50	5.80	5.97	5.80	6.22	-
.459	6.80	6.23	6.55	5.88	6.02	5.66	6.27	6.07
.473	6.70	6.29	6.22	5.80	5.93	5.70	6.29	-
.486	6.96	6.27	6.55	5.82	6.10	5.65	6.12	6.15
.500	6.90	6.32	6.38	5.81	5.96	5.83	6.06	-
36074.381	6.90	6.48	6.12	5.96	6.07	5.70	5.65	-
.394	7.00	6.28	5.83	6.05	6.27	5.50	5.60	5.72
.406	6.95	6.24	6.29	5.86	6.28	5.16	5.61	-
.420	6.87	6.47	5.92	5.90	6.30	5.07	5.65	5.77
.434	6.95	-	6.32	5.62	6.27	5.11	5.80	5.90
.447	6.90	6.42	6.50	5.65	6.27	5.20	6.12	5.88

Table II. cont.

J.D. 24 00 000+	V27	V28	V29	V30	V31	V32	V35	V36
36074.460	6.90	-	6.32	5.70	6.26	5.18	6.00	6.00
.473	6.88	5.85	6.37	5.58	6.27	5.31	6.05	6.17
.486	6.87	5.82	6.55	5.47	6.16	5.30	6.03	6.12
.500	6.90	5.68	6.50	5.53	5.97	5.09	6.22	5.87
.513	6.85	5.66	6.38	5.62	5.74	5.30	6.43	5.93
.526	6.82	5.40	6.38	5.55	5.63	5.16	6.42	6.08
38259.416	6.91	6.34	6.60	5.97	6.33	5.15	5.92	5.30
.473	-	5.58	-	5.45	5.90	5.51	6.20	-
.493	6.81	5.58	6.40	5.51	5.78	5.36	6.16	-
38268.472	6.90	6.40	5.95	-	5.61	5.10	5.70	6.33
.487	6.94	6.30	6.15	5.47	5.71	5.42	5.78	6.25
.502	6.84	6.32	6.30	5.65	5.68	5.24	5.70	6.32
.518	6.80	-	6.19	5.77	5.73	5.50	5.68	6.33
.531	6.89	6.50	6.50	5.55	5.83	5.60	5.68	6.37
.544	6.88	6.40	6.30	5.66	5.77	5.60	5.70	6.30
.558	6.88	6.32	6.45	5.65	5.81	5.60	5.84	-
.572	6.85	6.33	6.37	5.80	5.89	5.86	5.65	6.27
.586	6.95	6.72	6.70	5.72	6.02	5.62	5.91	6.03
.601	7.00	6.33	6.60	5.92	6.01	5.52	5.87	-
38289.280	6.83	6.28	6.40	5.80	5.78	5.72	5.78	6.35
.304	6.88	6.47	6.50	5.91	5.71	5.98	5.75	6.20
.325	6.85	-	6.67	5.84	5.80	5.80	5.85	6.00
.346	6.94	6.34	6.46	6.00	5.90	6.13	5.82	5.55
.373	-	6.40	-	5.85	5.87	5.70	5.94	5.13
.402	6.90	6.37	6.40	5.95	5.81	5.66	6.06	-
.420	7.00	6.70	6.40	6.05	5.91	5.92	6.13	5.35
.466	6.87	6.35	6.45	5.76	5.99	5.95	6.15	5.62
.482	6.83	6.43	6.37	5.65	6.10	5.90	6.37	5.60
.506	6.85	6.48	6.46	5.50	6.23	5.82	6.14	-
.522	6.88	6.46	6.50	5.59	6.28	5.76	6.12	5.67
.547	6.80	6.28	5.86	5.67	6.32	5.98	6.30	5.83
.560	6.85	6.59	5.69	5.60	6.22	5.54	-	5.72
.574	6.90	-	5.52	5.50	6.40	5.21	-	5.97
39350.467	6.82	6.66	5.40	5.82	6.30	5.65	6.45	5.58
.483	6.80	6.41	5.48	5.73	6.25	5.50	6.53	5.65
.496	6.78	6.62	5.66	5.68	6.38	5.65	6.40	5.63
.522	6.82	6.40	5.65	5.65	6.23	5.73	-	5.67
.535	-	6.70	5.78	5.77	6.30	5.57	-	-
39351.498	-	5.94	6.20	5.75	5.86	5.06	5.80	6.20
.512	6.90	5.99	6.05	5.80	5.98	5.26	6.03	6.10
.524	-	6.13	5.78	5.78	5.96	5.53	6.26	-
.536	6.92	-	5.60	5.63	5.93	5.35	6.10	-
39355.445	7.00	5.97	6.43	5.84	6.07	-	6.40	5.45
.460	6.85	6.02	6.34	5.95	5.97	5.82	6.34	5.47
.474	6.95	6.00	6.48	6.02	5.86	5.75	6.37	5.58
.490	6.83	6.12	6.10	-	5.84	5.69	6.20	5.52
.504	-	5.94	6.21	6.08	5.80	5.90	6.38	5.57
.520	6.90	6.08	6.05	5.91	5.66	5.84	6.24	5.68
.533	-	-	-	5.98	5.84	5.86	-	-

Table II. cont.

J.D. 24 00 000+	V38	V39	V40	V42	V43	V44	V45	V49
28 752.540	6.09	5.98	5.79	-	-	5.33	6.18	5.40
28 754.394	-	-	5.76	-	-	5.62	6.14	5.18
.436	-	5.89	5.80	5.79	-	5.61	5.98	5.19
.485	5.68	-	5.66	5.58	5.77	5.87	6.14	5.35
.502	-	-	5.67	5.75	5.59	5.77	5.94	5.35
.521	5.37	-	5.73	5.46	5.66	5.62	5.98	5.34
28 758.463	-	6.12	6.40	5.38	5.70	5.28	6.00	5.26
.485	5.92	5.82	5.97	-	5.70	5.40	5.94	5.43
28 760.406	-	-	-	-	5.59	5.70	5.99	5.22
.443	-	-	5.66	-	5.70	5.80	5.90	5.45
28 774.392	5.64	6.30	5.83	6.10	6.10	5.88	5.15	5.39
28 775.379	6.10	5.65	6.30	5.85	6.45	5.89	5.98	5.29
.396	6.20	5.85	6.54	5.60	6.00	5.92	5.96	5.18
.411	6.00	5.82	6.23	5.84	5.78	5.80	6.12	5.31
.426	6.24	5.87	6.33	5.86	5.86	5.87	6.14	5.27
.440	-	6.09	-	5.70	5.83	5.90	6.10	5.44
.456	5.90	6.08	6.25	6.01	5.73	5.79	6.05	5.25
.471	6.02	6.11	6.22	6.02	5.84	5.91	5.88	5.34
28 776.367	5.70	6.10	5.73	6.55	6.24	5.28	5.16	5.38
.383	5.67	5.99	-	6.00	-	5.35	5.15	5.28
.397	5.90	5.83	5.79	5.93	6.30	5.47	5.06	5.42
.411	5.95	5.83	5.68	5.83	-	5.45	5.08	5.39
.427	5.97	5.70	6.10	5.77	6.48	5.58	5.14	5.42
.442	6.03	5.75	6.06	5.78	6.32	5.45	5.23	5.55
.456	6.00	5.87	5.93	5.69	-	5.69	5.23	5.45
.474	-	5.76	-	5.70	-	5.70	5.25	5.39
28 779.392	5.69	5.81	5.86	6.01	5.80	5.44	5.98	5.32
.411	5.75	5.79	5.83	5.92	5.79	5.55	6.05	5.38
.437	6.00	6.13	5.71	6.19	5.78	5.65	6.10	5.36
28 780.376	5.64	5.54	6.46	5.83	6.28	5.90	6.10	5.48
.396	5.63	5.41	6.10	5.69	6.20	5.85	6.08	5.30
.422	5.47	5.51	5.92	5.75	6.42	5.67	5.24	5.25
28 783.406	5.44	5.78	6.49	6.06	5.72	5.70	5.86	5.30
.429	5.46	5.83	5.85	6.33	5.88	5.37	5.84	5.48
.449	5.42	5.51	5.99	6.22	5.88	5.10	5.97	-
28 837.251	6.12	5.49	6.01	5.99	5.60	5.70	6.12	5.43
.265	6.03	5.50	6.30	5.85	5.81	5.65	6.16	5.41
.279	6.10	5.55	-	5.81	5.90	5.62	6.16	5.35
.293	5.91	5.53	6.20	5.77	5.73	5.66	6.05	5.37
.307	5.97	5.52	6.43	5.74	5.93	5.85	6.13	5.34
.325	6.03	5.47	6.40	5.60	5.91	5.80	5.55	5.36
29 107.517	5.92	6.21	6.31	5.96	6.50	5.22	6.18	5.10
.531	5.89	5.80	6.52	6.10	6.53	5.32	6.10	5.05
.544	6.15	-	6.00	6.00	6.20	5.37	6.23	5.05
.558	6.33	5.81	6.06	6.02	6.47	5.37	6.19	5.24
.570	6.02	5.32	6.06	6.00	6.59	5.38	6.20	5.26
29 108.470	5.70	5.43	5.91	6.01	5.70	5.97	5.45	5.33
.485	5.73	5.48	5.93	5.78	5.73	5.90	5.76	5.33
.500	5.61	5.87	5.77	5.60	5.64	5.81	5.70	5.40
.515	5.79	5.80	6.01	5.70	5.82	6.00	5.72	5.44

Table II. cont.

J.D. 24 00 000+	V38	V39	V40	V42	V43	V44	V45	V49
29 108.530	5.79	5.93	6.13	5.74	5.97	5.82	5.80	5.28
.544	5.74	6.05	5.97	5.84	5.76	5.78	5.80	5.47
.558	5.87	5.87	6.19	5.60	5.86	5.86	5.76	5.42
29 109.474	6.01	5.73	5.79	6.25	6.33	5.56	5.88	4.97
.488	5.86	5.60	5.76	6.36	6.40	5.72	5.94	5.10
.500	5.64	5.58	5.72	6.22	6.18	5.64	6.16	5.00
.513	5.69	5.56	5.65	6.27	6.46	5.79	6.12	5.14
.526	5.52	5.70	5.79	5.97	6.20	5.84	6.16	5.20
.540	5.54	5.66	5.75	5.90	6.54	5.77	6.02	5.22
.553	5.52	5.60	5.80	6.00	6.23	6.00	5.98	5.26
29 110.435	5.98	5.58	6.16	5.98	-	5.47	5.37	5.34
.449	5.78	5.59	6.14	-	-	5.10	-	5.40
29 113.423	5.62	5.84	6.10	6.33	6.32	5.09	6.02	5.05
.440	5.81	5.64	5.96	6.29	6.49	4.83	5.96	5.10
.454	5.82	5.75	6.16	-	-	4.90	6.05	5.18
.467	5.98	5.69	-	6.06	-	4.94	6.10	5.25
.482	6.00	5.60	-	-	-	5.01	6.08	5.21
.496	-	5.51	-	6.02	-	5.09	5.98	5.21
.510	5.90	5.79	-	-	-	5.22	5.90	5.28
29 114.423	5.53	6.17	5.74	6.10	5.74	5.97	5.16	5.42
.438	5.57	6.09	5.69	6.20	5.74	6.00	5.18	5.35
.452	5.53	6.10	5.75	6.51	5.71	5.95	5.19	5.21
29 130.385	6.12	6.04	5.78	6.46	5.78	5.90	6.05	4.95
29 131.347	5.36	5.48	6.06	6.24	6.46	5.40	5.25	5.32
.379	5.38	5.62	5.76	6.52	6.02	5.40	5.20	5.42
.393	5.68	5.42	5.58	6.30	5.92	5.20	5.16	5.30
.408	5.50	5.36	5.48	6.20	5.98	5.63	5.19	5.42
.449	5.55	5.59	5.76	6.27	5.89	5.77	5.24	5.49
.463	5.76	5.56	5.80	6.23	5.80	5.77	5.42	5.48
.476	5.75	5.50	5.82	6.40	6.00	5.77	5.70	5.46
.491	5.86	5.54	5.96	6.16	5.92	5.85	5.75	5.40
.505	5.92	5.74	5.82	6.02	5.90	5.85	5.80	5.49
29 132.371	5.82	5.89	6.42	5.91	6.01	5.85	6.06	5.03
.385	5.70	5.94	6.45	5.81	5.99	5.81	6.23	5.04
.398	5.55	5.87	6.18	5.87	6.03	5.85	6.25	5.10
.411	5.44	5.73	6.20	6.00	6.01	5.80	6.26	5.08
.424	5.47	5.78	6.07	6.18	6.26	5.90	6.06	5.22
.434	-	-	-	-	-	-	-	5.13
29 138.441	5.30	5.59	6.40	5.88	6.32	5.25	5.96	5.16
.458	5.30	5.62	6.61	5.84	6.64	5.00	6.00	5.36
.471	5.34	5.58	6.32	5.74	6.40	4.98	6.05	5.20
.484	5.42	5.78	6.22	5.99	6.46	4.94	6.12	5.31
.495	5.56	5.72	6.10	5.88	6.07	5.12	6.18	5.30
29 141.362	5.94	5.77	6.11	5.82	5.64	5.79	6.04	5.34
.375	5.98	5.90	6.23	5.84	5.63	5.79	6.06	5.37
.388	5.82	5.96	6.21	5.95	5.63	5.67	6.10	5.37
.403	5.72	5.89	6.20	6.01	5.85	5.42	6.16	5.29
.416	5.68	5.84	6.48	6.06	5.75	5.31	6.14	5.18
.429	5.60	5.71	6.35	6.16	5.92	5.20	6.10	5.17
.444	5.45	5.64	6.17	6.05	5.90	5.14	5.84	5.11

Table II. cont.

J.D. 24 00 000+	V38	V39	V40	V42	V43	V44	V45	V49
29 141.456	5.46	5.67	6.49	6.25	5.91	5.17	5.80	5.03
.469	5.43	5.57	6.31	6.32	5.90	5.12	5.40	4.97
.482	5.39	5.71	6.31	6.39	5.93	5.20	5.28	4.77
.495	5.43	5.89	6.23	6.45	6.09	5.38	5.24	4.88
29 159.356	6.08	5.88	5.71	5.76	6.36	5.30	5.82	5.10
.370	5.93	5.83	5.63	5.88	6.24	5.44	5.90	5.22
.383	5.80	5.73	5.70	5.78	6.42	5.40	5.87	5.22
.396	5.90	5.65	5.86	5.93	6.42	5.42	5.88	5.28
29 160.342	5.83	5.90	6.40	5.85	5.80	5.85	6.02	5.42
.354	5.86	5.82	6.34	5.78	5.79	5.94	6.05	5.33
.367	5.86	5.96	6.34	5.65	5.66	5.81	6.10	5.38
.380	5.94	5.88	6.14	5.66	5.65	5.80	6.10	5.40
.394	5.96	5.91	6.01	5.71	5.76	5.85	6.00	5.45
.409	-	-	-	-	-	5.75	5.85	5.54
29 161.344	5.43	5.67	6.11	6.35	6.35	5.70	5.78	5.29
.357	5.44	5.63	6.15	6.24	6.25	5.74	5.84	5.30
.372	5.54	5.74	6.20	6.34	6.39	5.69	5.88	5.32
.386	5.53	5.73	6.17	6.19	6.39	5.91	5.85	5.28
.399	5.42	5.70	6.26	6.26	6.50	5.77	5.94	5.18
29 162.325	6.07	5.98	5.74	6.27	5.86	5.38	5.89	5.47
.339	6.04	6.04	5.80	6.18	5.84	5.30	5.95	5.36
.352	6.09	6.00	5.76	6.34	5.82	5.33	5.94	5.62
.365	5.97	6.04	5.65	6.38	5.91	5.32	6.00	5.44
.378	5.91	5.91	5.60	6.32	5.83	5.34	5.96	5.48
.392	6.02	6.16	5.75	6.40	5.87	5.43	6.00	5.28
29 166.399	5.85	5.25	6.10	6.60	5.74	5.80	6.05	4.76
29 167.353	5.49	5.75	5.93	6.07	6.17	5.73	5.42	5.31
.366	5.59	5.77	5.88	5.94	6.23	5.77	5.48	5.37
.378	5.50	5.78	6.00	6.16	6.32	5.85	5.76	5.37
.391	5.41	5.85	6.04	6.41	6.33	5.85	5.76	5.31
29 187.274	5.42	5.80	5.51	6.15	5.72	5.53	5.98	5.39
.305	5.58	5.88	5.66	6.22	5.64	5.04	5.96	5.14
.318	5.68	5.89	5.75	6.24	5.82	5.02	5.98	4.96
.331	5.72	5.83	5.81	6.01	5.94	5.28	5.96	4.95
29 518.315	5.75	5.78	6.12	6.32	5.98	5.95	5.48	5.00
.336	5.46	5.56	5.97	5.96	5.56	5.90	5.84	4.98
.349	5.55	5.70	6.12	5.92	5.82	5.85	5.96	5.05
.362	5.67	5.71	5.93	5.80	5.73	5.95	6.03	5.10
.375	5.78	5.77	6.22	5.77	5.83	5.90	6.00	5.18
29 519.455	5.47	5.34	6.03	5.68	6.10	5.83	5.78	5.26
29 520.313	5.97	5.87	6.17	6.01	5.84	5.23	5.40	5.15
.327	6.04	5.88	6.41	6.13	5.80	5.20	5.47	5.14
.339	5.92	5.80	6.21	6.11	5.68	5.27	5.52	5.16
.352	6.01	5.83	6.11	6.11	5.62	5.29	5.72	5.23
.363	6.09	5.86	6.15	6.28	5.69	5.34	5.80	5.15
.376	6.03	5.82	6.00	6.23	5.74	5.34	5.84	5.15
29 546.266	5.97	5.65	6.03	6.07	6.27	6.00	5.95	5.31
.279	5.97	5.67	6.07	6.28	6.38	6.00	6.00	5.30
29 870.406	6.06	5.60	6.02	-	5.94	4.95	5.15	5.35
29 877.369	5.52	5.67	5.77	6.31	6.34	5.93	5.65	5.15

Table II. cont.

J.D. 24 00 000+	V38	V39	V40	V42	V43	V44	V45	V49
29 877.381	5.41	5.67	5.66	6.34	6.52	5.82	6.03	5.20
.394	5.62	5.76	5.69	6.32	6.39	5.84	5.70	5.20
.453	5.45	5.60	5.74	5.80	6.17	5.80	5.82	5.36
.481	5.75	5.96	5.77	5.78	6.02	5.80	5.94	5.26
.499	5.73	5.75	5.94	5.73	5.79	5.83	5.89	5.43
29 879.309	5.64	5.64	5.70	5.88	6.35	5.84	5.48	5.14
.321	5.57	5.62	5.68	5.75	6.32	5.48	5.50	5.15
.339	5.68	5.70	5.65	5.69	6.31	4.96	5.40	5.06
.372	5.63	5.75	5.78	5.83	6.42	4.76	5.62	5.10
.422	5.95	5.91	5.91	5.98	6.38	4.89	5.78	5.29
.435	5.97	5.76	6.04	5.92	6.22	5.03	5.80	5.46
.449	5.95	5.70	6.17	6.13	6.16	5.32	5.94	5.45
30 259.319	5.85	5.80	5.64	5.63	5.74	4.91	5.19	5.15
.330	5.62	5.74	5.76	5.65	5.71	5.08	5.32	5.08
.340	5.73	5.92	5.77	5.86	5.70	4.98	5.30	5.16
30 260.340	5.99	5.32	5.85	5.68	6.22	6.00	6.29	5.28
.354	6.18	5.35	5.65	5.58	6.22	5.90	6.29	5.35
.372	6.27	5.45	5.72	5.65	6.29	6.00	6.25	5.36
.387	5.94	5.49	5.62	5.70	6.16	6.00	6.27	5.37
.406	6.09	5.79	5.69	5.80	5.99	6.00	6.24	5.49
.427	5.92	5.64	5.66	5.80	5.92	6.00	6.22	5.50
30 261.309	5.49	5.89	6.24	6.45	5.72	5.57	5.30	5.13
.323	5.39	5.93	6.15	6.42	5.80	5.57	5.47	5.10
.334	5.48	5.93	6.24	6.34	5.81	5.63	5.56	5.19
.344	5.55	5.96	6.28	6.38	5.96	5.68	5.56	5.20
.374	5.62	5.83	6.43	6.25	6.08	5.74	5.58	5.21
.388	5.88	5.82	6.36	6.17	6.02	5.80	5.70	5.33
.402	5.83	5.79	6.19	5.99	6.15	5.96	5.86	5.24
.417	5.84	5.57	6.35	5.73	6.18	5.85	5.82	5.39
.434	5.93	5.52	6.23	5.72	6.38	5.87	5.89	5.22
33 502.437	6.04	5.53	5.58	6.04	5.61	5.81	6.06	5.17
.484	5.87	5.75	5.74	6.24	5.72	5.80	6.04	5.23
.502	5.58	5.82	5.91	6.29	5.70	5.85	6.12	5.31
.518	5.59	6.06	6.10	6.33	5.80	5.86	6.15	5.26
.532	5.51	5.84	5.99	6.26	5.95	5.80	6.14	5.31
33 858.435	5.75	5.81	6.34	6.31	5.70	5.66	6.05	5.44
.445	5.89	5.75	6.25	6.43	5.69	5.78	5.91	5.47
.474	5.92	5.73	6.05	5.88	5.75	5.81	5.94	5.34
.486	6.07	5.74	6.33	6.16	6.06	5.89	6.08	5.45
33 861.427	5.73	5.90	6.22	5.62	6.32	5.60	6.05	5.24
.439	5.75	-	6.20	5.57	6.61	5.61	6.00	5.06
.452	5.84	6.06	6.55	5.69	6.54	5.82	5.94	5.24
.464	6.05	5.98	6.08	5.70	6.50	5.87	6.05	5.32
.477	6.10	5.92	6.46	5.82	6.42	5.91	6.10	5.15
.491	6.00	-	6.46	5.79	6.25	5.85	6.16	5.22
.503	5.98	5.82	6.09	5.94	6.17	5.80	6.13	5.32
.517	5.95	5.86	6.20	5.90	6.07	5.87	6.18	5.26
.531	5.98	5.68	6.40	5.93	6.14	5.82	6.08	5.25
.546	6.09	5.73	6.31	6.16	5.83	5.97	5.76	5.25
.562	6.19	5.81	-	6.23	5.81	6.00	5.70	5.30

Table II. cont.

J.D. 24 00 000+	V38	V39	V40	V42	V43	V44	V45	V49
33 865.378	5.93	5.62	5.79	5.82	6.31	5.46	6.02	5.12
.392	5.85	5.61	5.73	5.69	6.55	5.18	5.98	5.17
.405	5.65	5.55	5.72	5.67	6.42	4.83	5.88	5.23
.418	5.55	5.55	5.75	5.93	6.56	4.92	6.00	5.30
.430	5.49	5.47	5.88	5.74	6.52	5.00	5.95	5.20
.442	5.53	5.53	5.85	5.94	6.28	5.09	6.00	5.22
.456	5.61	5.50	5.90	5.90	6.23	5.12	6.06	5.30
.468	5.52	5.52	5.92	5.85	6.02	5.17	6.04	5.22
.563	5.68	5.85	6.14	6.12	5.87	5.50	6.02	5.27
.575	5.71	5.90	6.04	6.52	5.64	5.73	5.98	5.37
33 871.454	5.58	5.99	5.58	5.89	5.77	5.32	6.00	5.37
.483	5.49	5.90	5.78	5.62	5.81	5.44	5.90	5.36
.496	5.43	5.81	5.82	5.70	5.70	5.41	5.90	5.40
.507	5.56	5.97	5.89	5.55	5.66	5.41	-	5.40
.518	5.71	5.97	5.84	5.70	5.69	5.49	5.96	5.32
.542	5.80	5.92	5.90	5.95	5.91	5.90	6.08	5.30
.555	5.80	5.80	6.21	5.99	6.04	5.71	5.90	5.49
.570	5.74	5.97	6.23	5.75	5.90	5.68	6.08	5.41
.584	5.88	5.84	6.09	5.94	6.01	5.75	6.11	5.44
33 872.446	-	5.83	-	-	6.15	5.83	5.26	4.80
.452	-	5.82	-	6.07	-	5.82	5.24	4.75
.487	-	5.47	5.93	-	-	5.77	5.15	4.80
.500	5.91	5.70	5.77	6.12	6.14	5.70	5.17	4.95
.519	6.03	5.68	5.75	6.20	6.28	5.42	5.19	5.02
.533	5.81	-	5.80	5.96	6.53	5.24	5.23	5.24
.546	5.67	5.81	5.68	5.85	6.33	5.01	5.39	5.09
.560	5.58	5.84	5.61	5.87	6.18	5.10	5.46	5.25
.573	5.52	5.73	5.78	5.69	-	5.11	5.68	5.20
.586	5.61	5.91	5.74	5.64	6.02	5.13	5.72	5.25
.599	5.54	-	5.56	5.61	-	5.14	5.79	5.34
33 881.401	5.99	5.73	6.17	6.12	5.74	5.94	5.56	5.55
.413	6.14	5.76	6.14	6.30	5.66	5.95	5.65	5.32
.425	6.09	5.71	-	-	5.90	5.73	5.78	5.54
.439	-	-	-	-	-	-	5.76	5.31
.451	5.92	5.71	-	6.22	5.81	5.54	5.85	5.40
.470	6.03	5.68	6.34	6.29	6.05	5.30	5.89	5.43
.483	6.09	5.67	6.28	6.37	5.90	5.03	5.90	5.21
33 884.395	5.94	5.86	6.06	6.39	6.41	5.87	5.98	5.21
.408	5.96	5.91	5.99	6.11	6.27	5.77	5.98	5.09
.436	6.07	6.02	6.10	5.84	6.21	5.41	5.97	5.25
.450	6.05	5.85	6.11	5.77	6.40	5.19	6.10	5.34
.464	6.11	5.95	6.20	5.69	6.29	5.13	-	5.22
.478	6.20	5.84	6.34	5.63	6.04	5.14	6.00	5.31
.495	6.11	5.92	6.34	5.85	6.10	5.20	6.00	5.47
.521	5.97	5.76	6.26	5.80	-	5.19	5.97	5.34
.539	5.74	5.81	6.16	5.86	5.76	5.30	6.12	5.38
.558	5.70	5.65	6.10	6.06	5.69	5.48	6.07	5.47
.574	5.54	5.82	6.01	6.16	5.66	5.46	6.08	5.44
.594	5.50	5.70	5.79	6.08	5.77	5.64	5.62	5.44
33 887.457	-	-	6.35	6.09	-	5.20	5.18	5.34

Table II. cont.

J.D. 24 00 000+	V38	V39	V40	V42	V43	V44	V45	V49
33 887.478	6.14	5.83	6.34	6.24	6.19	5.25	5.31	5.09
.498	5.97	6.19	-	6.03	6.33	5.23	5.45	4.79
.511	5.96	5.99	-	-	-	5.29	5.52	4.88
.524	5.79	5.86	-	5.97	6.32	5.42	5.60	4.80
33 888.400	5.62	5.82	5.73	5.60	-	5.90	5.88	5.25
.412	5.58	5.66	5.53	5.62	-	5.89	-	5.35
.425	5.71	5.53	5.55	5.60	-	5.80	5.95	5.45
.437	5.71	5.71	5.80	5.65	-	5.92	5.97	5.52
.461	5.81	5.74	5.77	5.72	-	6.00	5.95	5.37
.474	6.03	5.80	5.78	5.84	5.99	5.90	6.10	5.35
.485	5.86	5.63	5.80	5.73	5.83	5.80	6.06	5.44
33 889.454	5.66	6.03	6.17	6.21	-	5.91	5.17	4.95
.472	5.33	6.05	5.86	5.68	6.18	5.72	5.23	4.66
.488	5.54	5.99	6.00	5.84	6.43	5.86	5.25	4.80
.497	5.73	5.76	6.10	-	-	5.90	5.37	4.70
.512	5.71	-	5.86	-	-	5.86	5.47	4.75
33 894.380	5.62	5.90	5.90	6.14	6.00	5.80	6.16	5.49
.393	5.54	5.96	5.89	-	-	5.90	5.84	5.54
.408	5.50	-	5.73	-	5.99	5.81	6.04	5.30
.420	-	5.98	6.02	-	-	5.89	5.97	5.56
.439	5.84	6.08	5.74	-	-	5.80	5.99	5.46
33 895.443	-	5.81	6.18	6.10	6.30	5.81	5.56	5.06
.457	5.37	5.71	-	-	-	5.96	5.32	5.05
.468	5.58	5.85	-	6.40	-	6.00	5.16	5.24
.487	5.58	5.63	6.15	6.18	-	5.98	5.18	-
.498	5.57	5.73	5.94	-	-	5.95	5.23	5.15
.514	5.67	5.72	6.07	-	-	6.02	5.18	5.23
.526	5.65	5.72	5.94	6.25	-	5.94	5.36	5.25
.541	5.60	5.86	5.77	-	-	5.81	5.38	5.35
34 238.526	5.62	6.24	5.60	5.95	5.98	6.00	6.02	5.38
.539	5.80	5.82	5.61	5.61	5.59	6.08	5.96	5.48
.553	5.52	6.10	-	5.58	5.52	6.05	6.10	5.26
.565	5.64	5.87	5.64	5.78	5.87	6.04	5.99	5.38
.580	5.88	6.07	5.69	5.84	5.71	5.95	6.03	5.71
34 241.435	5.80	5.57	6.27	5.70	6.04	5.98	6.18	5.26
.450	5.46	5.65	6.34	5.60	5.99	5.88	6.05	5.19
.463	5.48	5.66	6.25	5.81	6.20	5.84	6.12	5.08
.479	5.32	5.63	-	6.00	6.12	5.85	6.08	5.29
.492	5.60	5.57	5.96	5.79	-	5.90	6.08	5.34
34 253.410	5.85	5.61	6.06	6.08	-	5.97	5.80	5.50
.446	5.61	5.45	6.12	6.11	-	6.00	5.90	5.40
34 254.449	6.21	5.84	5.54	5.81	5.84	5.60	6.09	4.90
.467	6.00	6.18	5.79	5.96	5.68	5.79	5.70	4.95
.484	6.25	6.00	6.02	5.97	6.00	5.89	5.40	5.04
.505	6.11	6.15	6.02	6.36	6.02	5.87	5.28	5.10
.525	5.91	5.78	5.86	6.18	6.19	5.95	5.19	5.29
34 270.492	5.81	6.00	-	6.30	6.30	5.56	6.00	5.46
.514	5.83	5.85	-	6.02	-	-	6.04	5.43
34 573.459	6.05	-	-	5.80	6.24	5.20	6.10	5.09
.473	5.96	5.78	-	5.72	-	5.11	6.00	4.91

Table II. cont.

J.D. 24 00 000+	V38	V39	V40	V42	V43	V44	V45	V49
34 606.527	-	5.64	5.60	-	5.88	5.77	6.00	5.35
.541	5.98	5.93	5.82	-	6.10	5.90	6.05	5.31
.556	-	-	-	-	-	5.95	6.05	5.35
.571	5.71	5.91	5.99	-	-	5.85	6.00	5.43
.586	5.49	-	5.99	5.93	5.98	5.90	6.08	5.53
34 945.407	6.04	5.65	5.91	6.28	5.90	6.00	5.81	5.40
.424	5.75	-	5.87	-	-	5.90	5.59	5.38
34 949.463	6.01	5.92	5.75	6.14	5.94	5.64	6.02	5.62
35 371.410	5.50	5.92	5.83	5.80	5.70	6.08	6.05	5.35
.423	5.42	5.82	5.82	-	5.87	5.78	6.12	5.35
.436	5.56	5.83	6.08	-	5.84	5.81	6.15	5.30
.455	5.72	5.66	-	6.08	5.79	5.83	6.08	5.14
35 720.298	6.15	5.44	5.68	5.72	5.71	6.04	6.15	5.40
.315	5.90	5.78	5.46	5.74	5.71	5.95	6.13	5.42
.328	6.13	5.67	5.57	5.64	5.70	5.92	6.22	5.47
.344	6.08	5.90	5.62	5.85	5.93	5.90	5.80	5.50
.356	5.99	5.99	5.69	5.70	5.88	5.95	5.75	5.36
.369	5.76	5.92	5.56	5.82	5.96	5.85	5.62	5.42
.381	5.74	5.94	5.48	5.82	5.73	5.95	5.40	5.46
.394	5.62	5.86	5.62	5.84	5.84	5.97	5.18	5.32
35 725.327	5.36	5.84	5.80	5.77	6.14	5.36	-	4.90
.377	5.58	5.84	6.04	5.60	6.06	5.28	5.80	5.02
.419	5.78	5.86	6.26	5.60	5.90	5.27	5.95	5.22
.432	5.84	5.84	6.36	5.92	5.96	5.37	6.02	5.18
.445	5.80	5.86	6.04	5.93	5.84	5.43	6.03	5.16
.457	5.84	5.94	6.33	5.86	5.73	5.50	6.00	5.28
.495	6.10	6.22	6.62	6.06	5.68	5.65	6.13	5.20
.507	5.96	5.90	6.28	6.04	5.70	5.71	6.10	5.22
.519	6.08	6.12	6.12	6.10	5.76	5.76	6.20	5.18
.531	6.03	5.94	6.40	6.32	5.94	5.70	6.20	5.20
36 068.496	6.00	5.72	6.24	6.30	5.90	5.56	6.20	5.48
.514	6.16	5.64	6.52	6.54	6.10	5.73	6.13	5.60
.528	5.96	5.60	6.16	6.48	6.36	5.75	6.05	5.60
.543	6.00	5.53	5.80	5.97	6.22	5.68	5.72	5.53
36 073.380	5.80	5.84	6.23	5.88	6.44	5.66	5.21	5.20
.393	5.90	5.84	6.07	5.90	6.42	5.72	5.23	5.22
.406	5.98	5.84	6.16	5.96	6.37	5.84	5.30	5.30
.419	6.10	5.89	6.22	6.20	6.16	5.90	5.35	5.34
.432	6.20	5.83	6.16	6.08	6.35	5.83	5.51	5.26
.446	5.91	5.82	-	6.12	6.14	5.85	5.59	5.38
.459	6.00	5.76	6.04	6.39	6.12	5.91	5.74	5.28
.473	5.95	5.63	5.90	6.13	5.92	5.90	5.66	5.40
.486	5.74	5.57	5.64	6.30	5.82	6.00	5.70	5.30
.500	5.77	5.70	5.65	6.30	5.90	6.00	5.81	5.33
36 074.381	5.46	5.32	5.61	5.71	5.91	5.14	6.05	5.40
.394	5.45	5.26	6.00	5.66	5.61	5.07	6.08	5.57
.406	5.61	5.65	5.84	5.90	6.02	5.05	6.10	5.43
.420	5.60	5.57	5.92	5.73	6.14	5.15	6.11	5.50
.434	5.74	5.57	6.15	5.77	6.06	5.35	6.12	5.56
.447	5.68	5.68	6.10	5.76	6.12	5.24	6.05	5.35

Table II. cont.

J.D. 24 00 000+	V38	V39	V40	V42	V43	V44	V45	V49
36 074.460	5.78	5.71	6.09	5.86	6.12	5.46	6.03	5.28
.473	5.97	5.80	6.23	5.85	6.08	5.55	6.03	5.18
.486	5.88	5.82	6.27	6.03	6.07	5.56	6.05	4.88
.500	6.08	5.96	6.43	6.14	6.28	5.59	6.15	4.75
.513	5.98	5.98	6.30	6.20	6.43	5.76	6.13	4.70
.526	5.83	6.06	6.45	6.37	6.37	5.80	6.20	4.68
38 259.416	6.08	5.38	5.67	6.42	5.66	-	-	5.30
.473	5.88	5.68	6.00	6.44	5.83	-	-	5.46
.493	5.54	5.48	5.74	6.04	6.26	-	-	5.20
38 268.472	6.00	5.30	5.58	6.32	5.70	5.55	6.20	5.40
.487	5.70	5.62	5.60	6.10	5.80	5.60	6.16	5.30
.502	5.56	5.60	5.67	6.18	5.67	5.60	6.13	5.48
.518	5.50	5.68	5.80	5.98	5.65	5.74	6.22	5.50
.531	5.52	5.50	5.62	5.96	5.72	5.75	6.23	5.40
.544	5.30	5.60	5.72	5.84	5.87	5.76	6.00	5.30
.558	5.46	5.82	5.82	5.60	5.96	5.82	6.20	5.34
.572	5.38	5.86	5.80	5.50	5.88	5.64	6.08	5.24
.586	5.54	5.88	6.10	5.76	6.12	5.73	6.20	5.30
.601	5.60	6.04	6.27	5.62	6.02	5.73	6.21	5.52
38 289.280	5.54	5.95	5.64	6.18	6.40	5.37	5.90	5.19
.304	5.79	5.95	5.82	6.22	6.36	5.30	5.95	5.28
.325	5.78	5.88	5.92	6.32	6.46	5.52	5.93	5.30
.346	5.96	5.92	5.94	6.07	6.27	5.59	5.98	5.35
.373	6.12	5.72	6.23	6.12	6.05	5.64	-	5.40
.402	5.91	5.60	6.10	6.06	5.78	5.68	6.05	5.40
.420	6.32	5.84	6.10	5.92	5.94	5.75	6.15	5.50
.466	5.94	5.80	6.24	5.76	5.65	5.80	6.05	5.30
.482	5.80	5.64	6.06	5.60	5.90	5.83	6.13	5.42
.506	5.52	5.42	5.90	-	5.64	5.90	6.25	-
.522	5.52	5.70	5.70	5.70	5.80	5.81	6.23	5.32
.547	5.70	5.94	5.70	5.94	5.80	5.86	6.25	5.22
.560	5.26	5.64	5.56	5.82	5.99	5.88	6.20	5.43
.574	5.34	5.56	5.52	5.90	6.38	-	6.15	5.34
39 350.467	5.49	5.92	6.23	6.37	-	-	6.18	4.90
.483	5.46	5.99	6.35	6.21	6.33	5.27	6.20	4.89
.496	5.44	5.95	6.26	6.25	6.20	5.21	6.05	5.10
.522	5.51	5.90	6.40	5.79	-	5.22	5.97	5.21
.535	5.61	5.82	-	5.70	-	-	-	5.22
39 351.498	6.00	5.66	5.92	6.10	5.68	6.03	5.73	5.37
.512	6.12	5.65	6.21	6.29	5.82	5.98	5.85	5.47
.524	6.27	5.91	6.01	6.53	5.67	5.90	5.85	5.32
.536	5.94	5.90	6.06	6.39	5.87	5.95	5.95	5.39
39 355.445	5.59	5.76	6.29	6.25	5.91	5.80	5.65	5.37
.460	5.70	5.81	6.06	6.32	5.84	5.86	5.70	5.28
.474	5.73	5.83	6.20	6.59	5.77	-	5.65	5.32
.490	5.74	5.82	5.82	6.22	5.92	5.85	5.77	5.40
.504	5.79	6.00	5.92	6.32	5.81	5.87	5.80	5.40
.520	5.86	5.86	5.53	6.39	5.83	5.81	5.80	5.26
.533	6.20	-	5.70	6.11	5.80	5.80	5.67	5.30

Table II. cont.

J.D. 24 00 000+	V50	V51	V52	V53	V54	V57	V66	V67
28 752.540	5.80	6.16	6.35	5.70	5.68	5.67	5.77	6.11
28 754.394	-	6.00	-	-	-	6.00	-	5.50
.436	-	5.98	6.40	-	5.80	-	5.65	5.50
.485	6.12	5.94	6.45	6.00	5.57	5.48	5.67	5.78
.502	6.07	6.14	6.45	-	5.50	5.47	5.70	5.75
.521	6.07	5.88	6.45	-	5.55	5.55	5.68	5.84
28 758.463	6.18	5.97	6.45	5.67	5.70	5.68	6.15	5.62
.485	6.08	6.03	6.40	5.86	5.48	-	6.18	5.99
28 760.406	5.90	5.98	-	5.72	5.95	5.67	-	5.82
.443	6.08	5.95	5.73	5.60	-	5.47	6.20	5.56
28 774.392	5.85	5.94	6.25	6.10	6.00	5.52	6.18	5.91
28 775.379	6.10	5.98	5.80	5.61	5.65	6.05	5.62	6.04
.396	6.08	6.09	5.86	5.60	5.60	5.98	5.72	5.82
.411	6.03	6.12	6.01	5.58	5.72	6.08	5.75	5.50
.426	6.20	6.15	5.97	5.60	5.70	5.70	5.85	5.53
.440	6.17	6.22	5.98	5.77	5.60	5.58	6.02	5.34
.456	6.18	6.11	6.20	5.66	5.85	5.48	5.80	5.36
.471	6.10	6.10	6.01	5.79	6.00	5.48	6.20	5.42
28 776.367	6.16	5.72	6.35	5.83	6.10	6.05	6.15	6.03
.383	6.02	5.75	6.40	6.16	6.00	6.08	5.88	5.99
.397	5.72	5.68	6.40	6.11	6.15	5.92	5.90	6.00
.411	-	5.40	6.18	6.28	6.05	6.00	5.77	6.14
.427	5.55	5.69	5.90	6.30	5.78	6.05	5.62	6.02
.442	5.70	5.76	5.62	6.29	5.77	6.17	5.75	6.13
.456	5.72	5.76	5.32	6.03	5.67	5.97	5.65	6.03
.474	5.79	5.79	5.42	6.10	5.50	5.72	5.60	6.15
28 779.392	5.65	5.98	5.61	5.98	5.62	5.59	6.10	6.08
.411	-	5.95	5.79	5.92	5.72	5.75	6.00	5.96
.437	5.77	6.05	5.90	5.99	5.75	5.90	6.03	-
28 780.376	6.00	5.56	6.29	5.59	6.17	5.47	5.90	5.58
.396	5.97	5.65	6.30	5.52	5.98	5.52	6.00	5.80
.422	5.98	5.60	6.38	5.61	5.90	5.57	6.15	5.83
28 783.406	6.10	6.07	5.50	6.10	5.75	6.13	5.88	6.14
.429	6.13	6.10	5.70	6.02	5.90	6.17	6.12	6.13
.449	6.13	6.15	5.77	6.00	5.90	5.97	6.10	6.05
28 837.251	5.72	5.68	6.55	6.09	5.72	5.60	5.92	6.03
.265	5.77	5.94	6.38	5.93	5.72	5.78	5.88	6.20
.279	5.83	5.90	6.55	6.15	5.75	5.70	5.95	5.78
.293	-	6.02	6.40	6.00	5.68	5.55	5.85	5.60
.307	6.05	6.06	6.57	6.14	5.70	5.62	5.85	5.50
.325	5.97	5.94	6.47	6.06	5.83	5.57	5.95	5.35
29 107.517	6.15	5.40	5.74	5.51	5.80	5.97	6.10	5.99
.531	5.97	5.36	5.85	5.41	5.90	5.98	6.10	6.03
.544	5.63	5.45	5.90	5.43	6.05	6.02	5.98	5.94
.558	5.57	5.62	5.86	5.55	6.00	6.17	6.08	5.90
.570	5.50	5.85	5.92	5.53	6.20	6.12	5.90	5.85
29 108.470	5.60	6.10	6.35	5.78	5.77	5.65	5.80	5.39
.485	5.60	6.12	6.33	6.00	5.55	5.80	5.75	5.37
.500	5.60	6.00	6.32	6.00	5.55	5.68	5.67	5.53
.515	5.70	6.07	6.47	6.03	5.45	5.87	5.97	5.62

Table II. cont.

J.D. 24 00 000+	V50	V51	V52	V53	V54	V57	V66	V67
29 108.530	5.83	5.98	6.45	6.02	5.43	6.05	6.05	5.72
.544	5.92	-	6.25	6.00	5.43	5.97	6.00	5.85
.558	5.85	5.94	5.80	6.03	5.55	6.03	6.10	5.80
29 109.474	5.98	5.39	6.50	6.07	5.80	5.43	5.88	6.17
.488	6.05	5.35	6.30	6.12	5.75	5.55	5.75	6.04
.500	6.13	5.28	6.40	6.10	5.82	5.57	-	6.08
.513	6.20	5.24	6.50	6.00	6.05	5.70	5.65	6.08
.526	6.13	5.45	6.29	5.99	6.03	5.73	5.62	6.14
.540	6.20	5.46	6.65	5.80	-	6.00	5.70	6.18
.553	6.17	5.76	6.60	5.85	6.10	5.75	5.60	6.05
29 110.435	6.00	-	5.85	5.64	5.73	5.48	-	5.78
.449	6.00	-	-	5.82	5.70	5.65	6.10	5.95
29 113.423	6.05	5.78	6.39	5.90	5.60	5.90	5.90	5.79
.440	6.00	5.76	6.19	5.78	5.70	5.95	5.85	5.85
.454	-	5.72	6.35	5.94	5.62	-	5.77	5.83
.467	-	-	6.42	6.00	5.55	-	5.82	6.09
.482	-	5.77	6.35	5.91	5.67	6.00	5.90	5.92
.496	-	5.61	6.35	-	-	-	6.15	6.01
.510	5.50	5.62	6.45	6.08	5.80	-	-	5.82
29 114.423	5.55	6.07	5.74	6.23	5.83	5.85	5.60	5.93
.438	5.50	6.16	5.72	6.00	5.95	5.95	5.63	5.78
.452	5.55	6.12	5.78	6.05	5.90	5.95	5.62	5.68
29 130.385	6.10	6.05	6.40	5.68	6.05	5.45	5.62	5.99
29 131.347	-	5.65	6.30	6.10	5.77	-	-	6.17
.379	5.60	5.75	6.52	6.00	5.65	5.60	6.13	6.25
.393	5.62	5.76	6.36	6.00	5.60	5.52	6.13	6.11
.408	5.57	5.82	6.40	5.97	5.62	5.52	6.13	6.05
.449	5.50	5.88	6.50	5.88	5.80	5.52	-	6.09
.463	5.80	6.12	6.37	5.78	5.70	5.50	5.85	6.00
.476	5.60	6.05	6.54	5.75	5.90	5.50	5.90	6.00
.491	5.60	6.15	6.27	5.70	6.10	5.53	-	6.23
.505	5.75	6.15	6.30	5.75	6.10	5.72	5.60	6.06
29 132.371	5.85	5.94	6.14	5.65	-	6.03	5.68	5.50
.385	6.00	6.02	6.10	5.62	-	6.02	-	5.48
.398	6.05	5.90	6.34	5.61	6.05	5.93	5.73	5.65
.411	5.95	5.90	6.14	5.40	6.00	5.85	5.83	5.40
.424	6.10	5.68	6.26	5.58	6.00	5.62	5.90	5.83
.434	5.93	5.70	-	5.60	5.78	5.45	6.02	5.50
29 138.441	6.17	5.55	6.61	6.02	5.80	5.52	5.80	5.60
.458	6.20	5.41	6.66	5.90	5.60	5.55	5.85	5.66
.471	6.20	5.46	6.20	6.00	5.70	-	5.97	5.75
.484	6.20	5.60	6.20	5.96	5.65	5.55	5.93	5.75
.495	6.15	5.72	5.66	5.86	5.62	5.72	6.05	5.93
29 141.362	6.00	5.94	6.09	5.88	5.55	6.00	5.70	6.05
.375	5.93	5.94	5.69	5.83	5.52	6.05	5.65	5.98
.388	6.02	5.98	5.36	5.75	5.48	6.10	5.60	6.15
.403	6.17	6.10	5.32	5.59	5.60	6.10	5.60	6.08
.416	6.18	-	5.37	5.75	5.67	6.15	5.70	6.11
.429	6.13	6.06	5.41	5.60	5.47	6.08	5.68	6.07
.444	6.08	6.11	5.55	5.60	5.73	6.05	5.65	5.95

Table II. cont.

J.D. 24 00 000+	V50	V51	V52	V53	V54	V57	V66	V67
29 141.456	6.20	6.03	5.56	5.60	5.77	6.03	5.62	6.13
.469	6.13	5.94	5.72	5.49	5.85	6.12	5.63	6.00
.482	6.17	6.12	5.68	5.68	5.90	6.10	5.77	6.09
.495	6.15	6.09	5.74	5.65	5.80	6.00	5.65	6.08
29 159.356	6.00	6.29	5.94	5.76	5.62	5.70	6.00	6.14
.370	6.10	6.30	6.06	5.67	5.60	5.57	5.93	5.90
.383	5.95	6.29	5.82	5.86	5.67	5.57	5.97	5.86
.396	5.80	5.96	6.12	5.94	5.72	5.48	5.95	5.68
29 160.342	5.55	5.77	6.30	6.20	6.05	6.10	5.60	6.02
.354	5.62	5.85	6.14	6.06	6.00	5.98	5.58	5.88
.367	5.53	5.90	5.76	6.12	5.92	5.85	5.60	5.81
.380	5.67	5.80	5.46	5.98	5.85	5.70	5.60	6.03
.394	5.65	5.86	5.40	6.06	6.00	5.57	5.63	6.05
.409	5.87	5.97	5.42	6.05	5.90	-	5.65	6.05
29 161.344	6.05	6.08	6.58	5.45	5.52	6.15	6.10	6.14
.357	5.93	6.15	6.43	5.48	5.55	6.10	6.13	6.13
.372	6.12	5.96	6.57	5.50	5.55	6.12	6.10	6.04
.386	6.10	6.10	6.50	5.62	5.53	6.12	6.05	6.01
.399	6.05	6.06	6.47	5.50	5.53	6.10	6.05	6.00
29 162.325	6.05	-	6.26	5.95	-	5.98	-	5.78
.339	6.05	5.63	6.20	5.96	5.92	6.00	5.60	5.85
.352	6.05	5.76	6.45	6.02	6.02	6.00	5.65	5.87
.365	6.05	5.95	6.35	6.03	5.95	6.07	5.80	5.88
.378	5.65	5.92	6.44	5.96	6.05	6.00	6.02	5.89
.392	5.60	5.94	6.45	6.11	5.95	6.12	5.97	5.86
29 166.399	6.00	5.95	6.26	5.50	6.02	5.50	5.60	6.09
29 167.353	6.10	6.08	5.51	6.00	5.55	5.80	5.93	6.14
.366	6.15	5.78	5.71	6.01	5.62	5.72	5.95	6.17
.378	6.10	5.72	5.75	6.02	5.65	5.67	6.05	6.19
.391	6.10	5.55	5.76	5.92	5.70	5.60	6.05	6.18
29 187.274	5.90	5.70	6.34	6.03	5.60	5.75	5.60	5.77
.305	5.95	5.66	6.40	6.03	5.62	5.58	5.58	5.61
.318	5.95	5.72	6.41	6.04	5.62	5.55	5.70	5.83
.331	6.10	5.40	6.34	6.14	5.50	5.50	5.63	5.71
29 518.315	5.53	5.36	6.36	5.80	5.95	5.90	6.20	5.78
.336	5.75	5.19	6.23	5.66	5.97	6.00	6.15	5.90
.349	5.90	5.26	6.30	5.63	-	6.00	6.08	5.92
.362	5.90	5.40	6.41	5.63	5.90	-	6.13	5.91
.375	6.00	5.47	6.39	5.64	6.05	-	6.00	5.96
29 519.455	-	5.52	6.35	5.95	-	-	6.13	5.98
29 520.313	-	5.46	6.01	5.83	5.98	5.70	5.83	5.91
.327	5.95	5.33	6.07	5.73	6.00	5.80	5.80	5.88
.339	5.93	5.55	6.14	5.66	-	5.75	5.75	5.78
.352	5.67	5.32	6.14	5.62	6.00	6.00	5.70	5.62
.363	5.67	5.28	6.12	5.66	5.93	6.02	5.60	5.68
.376	5.60	5.25	6.13	5.72	6.03	6.07	5.68	5.88
29 546.266	5.77	5.94	6.25	5.91	6.00	5.95	5.83	5.85
.279	5.70	5.96	6.30	5.87	6.10	6.05	5.92	5.78
29 870.406	6.10	5.80	6.50	5.83	6.00	6.15	-	6.10
29 877.369	6.05	6.12	6.35	5.45	5.50	6.05	5.62	5.99

Table II. cont.

J.D. 24 00 000+	V50	V51	V52	V53	V54	V57	V66	V67
29 877.381	6.05	6.16	6.34	5.43	5.60	5.95	5.60	6.11
.394	6.17	6.16	6.37	5.57	5.70	6.05	5.72	5.94
.453	5.58	6.19	6.39	5.78	5.65	5.85	5.85	5.99
.481	5.70	6.07	6.50	5.85	5.80	5.77	5.95	6.12
.499	5.72	5.86	6.31	5.89	5.87	5.45	6.05	6.08
29 879.309	5.87	5.98	6.01	6.21	5.50	5.45	5.78	5.90
.321	5.80	5.88	5.61	6.20	5.50	5.65	5.68	5.73
.339	6.05	6.00	5.28	5.92	5.48	5.60	5.70	5.83
.372	5.93	6.12	5.49	5.74	5.58	5.77	5.95	5.83
.422	6.10	6.15	5.86	5.54	5.55	5.95	6.05	5.96
.435	6.15	6.18	5.80	5.51	5.68	-	-	5.95
.449	6.05	6.13	5.90	5.49	5.77	5.88	6.03	6.00
30 259.319	5.67	-	5.69	5.78	5.65	5.60	5.62	6.00
.330	5.70	5.96	5.67	5.87	5.50	5.62	5.65	6.00
.340	5.70	6.02	5.78	5.93	5.50	5.55	5.60	6.00
30 260.340	6.08	5.78	6.58	5.86	6.07	5.47	6.10	5.90
.354	6.20	5.82	6.36	5.83	6.05	5.47	6.08	5.89
.372	6.15	5.94	5.81	5.73	6.10	5.45	5.93	5.87
.387	6.15	5.96	5.52	5.58	6.15	5.50	5.78	5.93
.406	5.97	6.05	5.46	5.57	6.00	-	5.77	5.88
.427	5.75	6.11	5.44	5.59	5.87	5.60	5.60	5.94
30 261.309	6.00	6.08	6.54	5.69	5.57	5.85	5.95	6.03
.323	5.88	6.12	6.35	5.57	5.57	5.73	5.83	6.04
.334	5.75	6.14	6.45	5.70	5.55	5.78	5.95	6.06
.344	5.65	6.06	6.39	5.70	5.50	5.65	5.88	6.18
.374	5.60	5.50	6.42	5.77	5.52	5.48	6.12	6.12
.388	5.70	5.62	6.35	5.93	5.70	5.45	6.13	6.17
.402	5.65	5.54	6.47	5.94	5.70	5.45	6.13	6.18
.417	5.85	5.45	6.29	6.04	5.90	5.47	6.03	6.17
.434	5.90	5.47	6.47	6.12	5.80	5.48	6.15	6.16
33 502.437	5.55	5.96	5.93	5.95	6.00	-	5.75	5.66
.484	5.60	6.03	6.16	5.76	5.78	5.57	5.82	5.79
.502	5.77	5.85	6.26	5.64	5.87	5.62	5.88	5.85
.518	5.95	5.64	6.31	5.65	5.70	5.67	5.90	5.89
.532	5.95	5.56	6.28	5.58	5.65	5.67	6.02	5.94
33 858.435	6.00	6.24	6.33	5.92	6.00	5.60	6.00	6.18
.445	-	5.90	6.27	5.96	6.07	5.50	6.17	6.08
.474	-	-	6.27	5.86	6.05	5.60	6.15	5.91
.486	-	6.08	6.37	5.98	5.82	5.62	6.15	5.80
33 861.427	6.10	5.82	6.32	6.11	5.57	6.05	6.00	5.85
.439	-	5.65	6.33	6.15	5.50	-	6.05	5.79
.452	6.00	5.46	5.80	6.10	5.55	6.00	6.15	5.91
.464	6.05	5.60	5.53	6.02	5.60	5.80	6.13	5.87
.477	6.05	5.70	5.43	6.12	5.60	5.60	6.13	5.85
.491	6.20	5.94	5.39	6.01	5.72	5.47	6.22	5.95
.503	6.05	5.90	5.42	5.92	5.68	5.57	6.10	5.99
.517	6.10	5.88	5.61	5.96	5.78	5.57	-	6.03
.531	6.05	5.90	5.60	6.13	5.95	5.53	6.03	6.05
.546	6.20	5.96	5.67	5.98	5.90	5.55	6.03	6.09
.562	6.03	5.90	5.84	5.99	5.92	5.55	5.85	5.89

Table II. cont.

J.D. 24 00 000+	V50	V51	V52	V53	V54	V57	V66	V67
33 865.378	6.10	5.62	6.40	5.84	5.50	5.43	5.60	5.99
.392	6.10	5.26	6.49	5.75	5.52	5.42	5.60	5.90
.405	6.10	5.49	6.48	5.73	5.50	5.55	5.70	5.73
.418	6.10	5.56	6.54	5.83	5.50	5.55	5.60	5.79
.430	6.00	5.64	6.57	5.74	5.60	5.60	5.65	5.73
.442	5.95	5.72	6.65	5.85	5.53	5.67	5.67	5.94
.456	5.80	5.88	6.32	5.85	5.65	5.68	-	5.89
.468	5.55	5.89	6.47	5.90	5.73	5.80	5.80	5.86
.563	5.95	5.97	5.63	6.04	5.95	6.05	6.05	6.01
.575	5.95	6.16	5.61	6.11	5.97	6.15	6.03	6.12
33 871.454	5.48	5.94	6.02	6.10	5.75	5.80	5.72	5.85
.483	5.57	5.88	6.24	6.05	5.77	6.07	5.60	5.91
.496	5.70	5.90	-	5.93	5.65	6.03	5.62	5.84
.507	5.75	5.78	6.20	5.91	5.65	6.03	5.65	5.63
.518	5.73	5.96	6.35	5.75	5.80	6.15	5.60	5.74
.542	-	6.10	6.30	5.90	5.87	6.00	-	5.75
.555	5.90	6.08	6.35	5.82	5.90	6.10	5.70	5.91
.570	5.95	6.16	6.57	5.87	5.88	6.05	5.63	5.89
.584	6.05	5.95	6.55	5.65	5.95	6.03	5.70	5.92
33 872.446	6.05	6.02	5.49	5.66	6.05	5.60	6.05	6.03
.452	5.85	5.85	5.39	5.85	6.00	5.80	6.17	5.97
.487	5.97	5.79	5.67	5.79	5.92	5.85	6.15	6.00
.500	6.07	5.70	5.79	5.81	5.63	6.00	6.12	6.02
.519	6.12	5.62	5.77	5.97	5.60	6.00	6.10	6.04
.533	6.05	5.76	5.94	5.92	5.55	5.90	6.00	6.01
.546	6.20	5.78	5.89	5.99	5.50	6.00	5.90	6.13
.560	6.00	-	6.04	5.97	5.45	6.05	5.79	6.06
.573	6.05	-	6.10	6.01	5.52	-	5.70	6.02
.586	6.05	5.80	5.99	6.10	5.60	6.00	5.65	6.18
.599	5.95	5.68	6.00	6.00	5.68	-	5.58	6.02
33 881.401	6.05	6.25	6.40	-	-	5.53	5.60	6.13
.413	-	6.29	6.30	-	5.68	5.60	-	6.10
.425	5.90	6.20	6.30	5.82	5.70	5.50	-	6.11
.439	6.00	-	6.35	5.74	5.62	5.50	-	6.10
.451	6.10	6.30	-	5.71	5.65	5.55	-	6.19
.470	6.00	6.29	6.30	5.75	5.73	5.57	5.70	5.90
.483	6.00	6.29	6.36	5.79	5.92	5.55	5.78	5.78
33 884.395	6.10	5.56	6.40	5.67	5.88	6.00	5.55	5.78
.408	6.05	5.72	6.25	5.57	5.97	5.95	5.58	-
.436	-	5.70	6.25	5.75	5.82	-	5.62	5.84
.450	6.05	5.66	6.30	5.59	5.78	6.00	5.72	5.82
.464	6.00	5.70	6.35	5.71	5.88	6.02	5.63	5.94
.478	-	5.56	5.77	5.69	5.67	5.98	-	5.80
.495	-	5.76	5.62	5.77	5.65	-	5.73	5.95
.521	5.80	5.88	5.43	5.99	5.55	5.95	-	6.06
.539	5.70	5.79	5.52	5.94	5.50	5.65	6.05	5.89
.558	5.52	5.90	5.62	5.90	5.60	5.60	6.13	5.83
.574	5.52	5.87	5.72	6.03	5.60	5.48	6.20	5.99
.594	5.48	5.86	5.75	6.03	5.58	5.52	6.05	-
33 887.457	6.00	6.10	5.87	5.93	5.73	5.75	5.55	6.19

Table II. cont.

J.D. 24 00 000+	V50	V51	V52	V53	V54	V57	V66	V67
33 887.478	6.10	6.06	5.79	6.12	5.92	5.80	5.67	6.13
.498	5.87	6.02	5.90	-	5.70	6.00	-	5.93
.511	5.63	6.02	5.90	6.03	5.68	5.98	5.85	6.00
.524	5.55	6.10	5.87	6.00	5.87	6.00	5.65	5.98
33 888.400	5.85	5.80	6.35	6.07	5.90	5.45	-	5.42
.412	5.50	5.70	-	5.90	5.92	5.45	6.08	5.52
.425	5.60	5.55	-	5.81	5.88	5.45	6.12	5.45
.437	5.55	5.60	6.40	5.72	6.05	5.52	6.05	5.46
.461	5.62	5.60	-	5.70	5.80	5.53	-	5.28
.474	5.65	5.70	6.40	5.58	5.72	5.60	-	5.56
.485	5.65	5.65	6.40	5.72	5.70	5.60	-	5.34
33 889.454	6.10	6.12	6.35	5.75	5.62	5.57	6.05	6.00
.472	6.10	6.10	6.40	5.83	5.65	5.60	6.00	5.90
.488	6.08	6.05	6.30	5.85	5.70	5.45	6.10	5.84
.497	5.95	6.16	6.30	5.90	5.70	5.47	-	6.18
.512	5.95	6.10	6.35	6.01	5.70	5.50	6.00	6.09
33 894.380	5.57	5.60	5.90	5.76	-	5.45	-	6.15
.393	5.45	5.38	5.87	5.80	5.98	5.50	5.93	6.21
.408	5.48	5.66	-	5.71	6.15	5.48	6.05	5.72
.420	5.50	5.84	6.05	5.85	6.05	5.52	6.08	5.85
.439	5.75	5.96	6.10	5.75	6.00	5.57	6.15	5.83
33 895.443	6.00	6.03	5.31	6.13	5.60	5.57	5.60	5.68
.457	6.20	6.16	5.39	6.06	5.70	5.55	5.65	5.90
.468	6.20	6.06	5.50	6.04	5.92	5.55	5.67	6.04
.487	6.10	5.70	5.60	6.12	5.80	-	5.75	5.84
.498	-	5.70	5.73	6.00	5.78	5.63	6.02	5.92
.514	6.17	5.58	5.79	5.62	5.90	5.75	6.03	6.00
.526	6.05	5.45	5.85	5.74	5.97	5.83	6.12	6.05
.541	-	5.45	5.89	5.55	5.98	-	-	6.16
34 238.526	6.13	5.40	5.42	6.01	5.70	5.83	6.12	5.78
.539	6.20	5.34	5.44	5.73	5.67	5.65	6.20	5.98
.553	-	5.60	5.40	5.60	5.62	5.87	6.05	5.79
.565	6.10	5.77	5.60	5.84	5.62	5.85	6.13	5.93
.580	-	5.76	5.78	5.90	5.55	-	6.20	5.99
34 241.435	5.98	5.83	5.70	5.70	5.55	6.00	5.80	6.00
.450	6.00	5.94	5.60	5.77	5.72	6.00	5.85	5.96
.463	6.00	5.96	5.68	5.75	5.82	6.10	5.87	5.91
.479	6.05	6.10	5.74	5.64	5.78	5.95	5.95	6.10
.492	6.05	6.12	5.69	5.78	5.63	6.00	-	6.11
34 253.410	6.00	5.90	6.40	5.68	5.65	5.55	5.95	5.52
.446	6.00	5.93	5.96	5.61	5.70	5.45	5.70	5.53
34 254.449	5.60	5.56	6.37	6.07	5.90	5.45	6.15	6.08
.467	5.48	5.60	6.56	6.04	5.80	5.40	6.10	5.91
.484	5.52	5.72	6.52	5.95	5.80	5.50	6.10	6.11
.505	5.65	5.71	6.35	6.05	5.70	5.45	6.08	6.13
.525	5.65	5.85	6.40	5.75	5.50	5.57	-	6.03
34 270.492	6.00	6.08	6.30	5.90	5.55	5.52	-	5.92
.514	-	6.05	6.35	5.90	5.48	5.45	5.70	6.06
34 573.459	6.10	5.70	6.33	5.71	5.55	5.50	-	5.38
.473	6.05	-	6.40	5.60	5.75	5.65	6.10	5.62

Table II. cont.

J.D. 24 00 000+	V50	V51	V52	V53	V54	V57	V66	V67
34 606.527	5.90	5.60	-	5.83	5.57	5.63	6.20	6.05
.541	6.00	5.60	6.23	5.87	5.57	5.52	6.03	5.90
.556	6.17	5.55	6.25	5.83	5.57	5.65	6.08	5.78
.571	6.13	5.55	6.35	5.73	5.55	5.58	6.08	5.85
.586	6.05	5.65	6.33	5.57	5.65	5.60	5.85	5.42
34 945.407	-	6.00	5.46	5.55	5.60	5.65	5.53	6.07
.424	-	5.77	-	5.60	-	-	5.60	5.75
34 949.463	6.12	5.55	5.70	5.72	5.50	5.98	6.10	5.62
35 371.410	6.20	5.63	5.62	5.90	5.65	-	5.65	5.64
.423	6.20	5.70	5.80	5.89	5.70	6.00	-	5.76
.436	6.20	5.63	5.92	5.94	5.72	-	5.60	5.76
.455	6.10	5.65	6.07	5.80	5.62	-	5.60	5.77
35 720.298	5.53	5.70	5.83	5.55	5.72	5.75	6.10	6.08
.315	5.58	5.68	5.92	5.62	5.87	-	-	6.17
.328	5.75	5.55	6.13	5.73	-	6.00	6.08	6.25
.344	5.78	5.50	6.05	5.81	5.95	5.98	6.05	6.18
.356	-	5.50	6.03	5.60	-	6.10	6.00	6.20
.369	5.70	5.62	6.27	5.81	6.00	6.05	5.78	6.09
.381	5.85	5.55	6.27	5.67	6.05	-	5.80	6.08
.394	6.07	5.70	6.20	5.90	6.10	6.05	5.65	6.26
35 725.327	5.55	-	5.70	5.77	5.63	5.85	5.60	5.70
.377	5.50	6.05	5.48	5.91	5.67	5.47	-	5.58
.419	5.87	5.95	5.72	6.05	5.70	5.50	-	5.45
.432	5.87	5.97	5.74	6.12	-	5.70	5.85	5.72
.445	5.88	5.68	5.77	6.01	5.57	-	5.80	5.67
.457	5.85	5.80	5.92	6.01	-	5.52	5.90	5.81
.495	6.00	5.80	6.00	6.22	5.80	5.63	5.95	6.00
.507	6.05	5.65	6.14	5.92	-	5.68	-	5.94
.519	6.20	5.58	6.12	5.94	-	5.89	6.08	5.80
.531	6.10	5.57	6.22	5.91	5.80	5.78	6.05	5.89
36 068.496	5.75	5.75	5.90	5.72	6.08	-	6.10	6.05
.514	5.80	5.80	5.96	5.67	5.92	5.70	6.15	6.12
.528	5.90	-	5.90	5.66	5.95	5.65	-	6.10
.543	-	5.90	5.95	5.71	5.80	5.85	6.10	6.20
36 073.380	6.10	5.93	6.40	5.84	5.65	5.70	6.10	5.94
.393	6.17	6.00	6.42	5.74	5.65	5.68	6.08	5.98
.406	6.00	6.05	6.45	5.73	5.62	5.70	-	5.88
.419	-	6.15	6.58	5.58	5.55	5.73	6.00	5.88
.432	6.00	6.15	6.54	5.60	5.57	5.65	6.05	5.90
.446	5.90	6.20	6.40	5.70	5.55	5.75	6.10	6.02
.459	5.85	6.10	6.55	5.62	5.55	5.95	6.12	-
.473	5.55	6.20	6.42	5.59	5.60	5.95	6.10	6.11
.486	5.45	6.15	6.40	5.70	5.70	5.90	6.10	6.05
.500	5.50	6.15	6.52	5.48	5.75	-	6.10	6.20
36 074.381	-	5.58	6.06	5.43	5.90	5.62	5.67	6.15
.394	5.55	5.62	6.24	5.45	5.90	5.50	5.70	-
.406	5.60	5.55	6.34	5.62	6.00	5.45	5.70	6.10
.420	5.65	5.57	6.35	5.69	6.00	5.48	5.70	6.08
.434	-	5.52	6.19	5.70	6.10	-	5.68	6.16
.447	5.90	5.62	6.21	5.76	6.00	5.70	5.80	6.06

Table 11. cont.

J.D. 24 00 000+	V50	V51	V52	V53	V54	V57	V66	V67
36 074.460	5.90	5.75	6.42	5.78	6.10	5.75	5.85	5.98
.473	6.00	5.60	6.45	5.89	6.00	5.73	5.88	5.92
.486	5.95	5.65	6.38	5.89	6.05	5.85	5.97	5.92
.500	6.03	5.85	6.48	5.95	6.05	5.88	6.05	5.91
.513	6.03	5.75	6.46	5.92	6.00	5.93	6.13	5.82
.526	6.15	6.00	6.58	6.06	5.88	6.10	6.10	5.91
38 259.416	5.90	6.00	6.03	5.96	5.77	-	5.60	5.55
.473	5.45	-	6.18	5.99	-	-	5.75	5.95
.493	5.45	-	6.27	6.10	-	-	-	5.95
38 268.472	5.85	5.70	5.30	5.70	6.10	6.12	5.62	-
.487	5.90	-	5.40	5.70	6.10	6.03	5.60	6.25
.502	6.02	5.60	5.44	5.80	6.08	6.10	5.60	6.08
.518	6.07	5.65	5.58	5.95	6.10	6.12	5.70	6.25
.531	-	5.80	5.60	5.90	6.10	6.08	5.72	6.13
.544	6.12	5.68	5.72	5.92	6.10	6.12	5.70	6.05
.558	6.10	5.85	5.60	5.98	5.85	6.08	5.75	6.16
.572	6.20	5.75	5.80	6.08	5.90	6.07	5.63	6.06
.586	5.98	5.80	5.88	6.00	5.80	6.03	5.87	6.09
.601	6.00	6.10	5.87	5.90	5.70	6.00	5.90	6.13
38 289.280	5.60	6.00	5.66	6.01	6.15	5.65	6.02	5.63
.304	5.72	5.90	5.82	6.09	6.20	5.50	5.90	5.50
.325	5.93	5.95	6.06	6.16	5.90	5.48	5.67	5.52
.346	6.00	6.05	6.10	6.06	5.95	5.50	5.60	5.63
.373	-	6.00	-	5.81	5.63	5.53	5.65	5.65
.402	6.00	6.00	6.16	5.68	5.60	6.00	5.62	5.74
.420	6.00	6.00	6.28	5.57	5.60	5.97	5.70	5.97
.466	6.05	5.65	6.46	5.46	5.60	6.00	5.92	6.00
.482	6.10	5.60	6.53	5.54	5.68	6.05	5.78	6.22
.506	6.05	5.55	6.36	5.43	5.60	6.05	5.82	6.06
.522	5.85	5.62	6.40	5.57	5.70	6.10	5.90	6.17
.547	5.55	5.60	6.44	5.80	5.80	6.10	6.00	6.25
.560	5.43	5.62	6.62	5.77	5.90	5.80	6.17	6.15
.574	5.40	5.72	6.44	5.70	5.77	-	6.03	6.25
39 350.467	6.00	6.10	6.45	5.66	-	6.05	5.63	6.25
.483	5.95	-	6.40	5.67	-	5.80	-	6.22
.496	6.00	5.75	6.55	5.83	6.10	5.85	-	6.12
.522	-	5.70	6.39	5.70	6.10	5.72	-	6.09
.535	-	-	6.39	-	-	5.45	5.85	6.10
39 351.498	6.00	-	6.36	6.07	-	6.10	5.60	5.90
.512	5.80	5.90	6.49	6.04	5.73	6.00	5.72	6.00
.524	5.65	-	6.26	6.00	-	5.95	5.60	6.20
.536	5.53	5.90	6.42	6.09	5.55	6.00	5.65	6.00
39 355.445	-	5.70	6.31	-	5.55	5.70	-	-
.460	5.50	5.90	6.45	5.78	-	5.60	5.81	5.88
.474	5.48	5.85	6.49	5.68	5.50	5.55	-	5.65
.490	5.60	6.15	6.25	5.72	5.60	5.57	5.92	5.57
.504	5.70	6.20	6.48	5.84	5.50	5.55	6.05	5.83
.520	5.75	6.15	6.27	5.87	5.70	5.70	6.00	5.58
.533	-	-	-	5.89	5.60	-	-	-

Table II. cont.

J.D. 24 00 000+	V74	V96	V97	V101	V103	V104	V105
28 752.540	5.45	5.87	5.68	5.84	5.82	6.55	6.47
28 754.394	-	-	-	6.22	5.91	-	-
.436	6.12	5.86	6.15	6.22	5.97	-	-
.485	6.10	5.96	6.20	6.08	6.15	6.30	-
.502	6.16	-	6.15	-	6.45	6.40	-
.521	6.15	5.94	6.25	5.84	6.18	6.34	6.90
28 758.463	5.18	5.99	6.15	6.04	6.36	5.58	-
.485	5.26	-	6.20	-	6.45	5.75	-
28 760.406	6.18	-	6.08	6.32	6.40	-	5.75
.443	6.16	-	5.98	6.19	6.02	-	5.65
28 774.392	6.13	5.62	6.10	6.30	6.34	6.38	6.85
28 775.379	5.50	6.20	6.10	5.79	5.84	6.50	-
.396	5.52	6.18	6.11	5.95	5.91	6.30	6.50
.411	5.68	6.30	6.23	6.08	6.08	6.25	6.58
.426	5.85	6.33	6.29	6.09	6.22	5.92	6.82
.440	5.90	6.29	6.30	5.94	6.16	6.05	6.70
.456	5.98	6.14	5.99	6.13	6.42	6.05	6.85
.471	6.10	5.87	5.87	6.10	6.34	6.05	-
28 776.367	6.09	5.87	5.88	6.30	5.81	5.97	6.75
.383	6.00	5.92	5.72	6.33	5.72	5.97	6.20
.397	6.04	5.85	5.90	6.40	5.80	5.98	5.90
.411	6.10	5.98	6.02	6.33	5.78	6.35	5.81
.427	6.08	5.84	6.01	6.24	5.77	6.20	5.92
.442	6.16	6.02	6.01	6.26	5.81	6.05	5.73
.456	6.09	6.12	6.02	6.26	5.82	6.28	6.18
.474	6.10	6.13	6.12	6.22	6.09	6.28	6.12
28 779.392	6.20	6.22	6.16	6.00	5.88	6.38	6.47
.411	6.00	6.35	6.34	5.72	6.05	6.39	6.60
.437	6.16	-	6.40	5.82	-	6.45	6.55
28 780.376	5.50	5.63	5.78	6.40	5.93	6.15	6.37
.396	5.25	5.79	5.76	6.32	5.92	6.05	5.62
.422	5.40	5.93	5.69	6.36	5.79	6.05	5.85
28 783.406	5.86	5.84	5.96	6.02	5.75	6.00	6.64
.429	5.85	5.87	5.99	6.01	5.76	5.89	6.55
.449	5.96	5.86	6.07	6.08	5.75	5.91	6.70
28 837.251	5.65	6.50	6.46	6.27	6.08	5.95	6.72
.265	5.90	6.49	6.45	6.24	6.02	5.97	6.78
.279	5.86	6.49	6.43	6.31	-	5.90	6.95
.293	6.10	6.15	6.32	6.22	6.05	6.10	6.75
.307	6.06	6.14	6.32	6.29	6.24	6.08	6.95
.325	5.94	-	6.22	6.08	6.35	6.02	6.95
29 107.517	5.52	6.40	6.20	-	5.81	6.35	6.82
.531	5.54	6.12	6.36	6.30	5.81	-	6.95
.544	5.80	6.22	6.26	6.07	5.92	6.35	6.95
.558	5.94	6.43	6.32	6.06	6.24	-	6.95
.570	5.96	6.06	6.20	5.78	5.96	6.33	6.95
29 108.470	6.10	5.47	5.21	5.78	6.05	6.20	-
.485	5.96	5.49	5.49	5.78	5.78	6.30	6.80
.500	5.89	5.62	5.65	5.85	5.74	5.90	6.78
.515	6.05	5.60	5.74	5.94	5.69	5.87	6.79

Table II. cont.

J.D. 24 00 000+	V74	V96	V97	V101	V103	V104	V105
29 108.530	5.98	5.68	5.81	6.06	5.72	5.75	6.80
.544	6.04	5.73	5.90	-	5.76	5.60	6.80
.558	6.00	5.80	5.93	6.08	5.74	5.74	6.58
29 109.474	6.16	-	6.29	-	6.29	5.91	6.12
.488	6.10	6.18	6.27	6.29	6.41	5.82	6.14
.500	6.02	6.14	6.33	6.27	6.22	-	6.35
.513	5.80	6.29	6.20	6.26	6.45	6.35	6.52
.526	5.65	6.30	6.19	-	6.32	6.20	6.42
.540	5.46	6.39	6.16	6.04	6.23	6.38	6.60
.553	5.30	6.40	6.18	5.75	6.10	6.32	6.62
29 110.435	5.53	5.72	5.58	5.69	5.76	-	6.90
.449	-	-	5.75	-	-	-	-
29 113.423	5.40	6.49	5.86	6.31	5.80	6.34	5.90
.440	5.79	6.47	5.92	6.40	5.90	6.34	5.95
.454	5.76	-	5.93	-	5.95	6.32	5.92
.467	5.90	-	5.92	6.24	6.05	6.25	-
.482	5.75	-	5.91	6.40	6.06	5.85	6.18
.496	5.96	-	5.98	-	-	5.65	-
.510	6.17	-	5.90	6.40	-	5.84	-
29 114.423	6.16	5.92	6.34	5.75	5.73	5.93	6.75
.438	5.96	5.70	6.21	5.72	5.72	5.96	6.95
.452	6.00	5.80	6.24	5.70	5.74	6.12	6.90
29 130.385	6.25	-	6.25	5.80	5.99	6.35	6.95
29 131.347	-	6.36	5.70	6.04	5.80	5.82	6.72
.379	6.20	6.42	5.50	6.16	5.69	5.52	6.95
.393	6.02	-	5.19	6.16	5.74	5.67	6.95
.408	6.08	-	5.19	6.14	5.77	5.75	6.85
.449	5.80	-	5.42	6.22	5.82	5.93	6.87
.463	-	-	5.80	-	5.92	5.92	6.95
.476	-	5.91	5.87	6.22	6.02	6.04	6.90
.491	5.65	-	5.92	6.40	5.94	6.02	6.86
.505	5.80	5.94	5.90	6.40	6.06	6.15	6.70
29 132.371	5.70	5.91	6.12	6.26	6.23	6.35	6.22
.385	5.68	5.94	6.04	6.03	6.10	6.38	6.35
.398	5.88	6.12	6.17	6.02	6.22	6.25	6.42
.411	5.70	6.23	6.22	-	5.91	6.45	6.58
.424	5.84	6.24	6.24	-	5.78	6.35	6.70
.434	5.95	-	6.15	5.74	5.91	-	-
29 138.441	6.20	6.43	5.75	5.79	5.89	5.90	6.95
.458	6.18	6.30	5.56	5.74	5.77	5.87	6.95
.471	6.18	6.35	5.84	5.71	5.74	5.95	6.82
.484	6.20	6.40	5.81	5.68	5.96	6.01	6.75
.495	6.18	6.44	5.86	5.75	6.16	5.90	6.25
29 141.362	6.10	5.49	6.10	6.03	5.81	5.82	5.76
.375	6.12	5.60	6.02	6.18	5.80	5.82	5.72
.388	6.16	5.79	6.06	6.06	5.84	5.92	5.56
.403	6.15	5.71	6.15	6.07	5.87	6.07	5.55
.416	6.20	5.75	6.18	6.05	6.01	6.05	5.76
.429	6.19	5.80	6.17	6.24	6.05	6.10	5.90
.444	6.10	5.91	6.20	6.40	5.95	6.01	5.95

Table II. cont.

J.D. 24 00 000+	V74	V96	V97	V101	V103	V104	V105
29 141.456	6.05	5.93	6.19	6.29	6.20	6.05	5.92
.469	6.06	5.85	6.24	6.23	6.32	6.10	6.03
.482	5.86	5.87	6.32	6.22	6.16	6.20	6.12
.495	5.78	5.99	6.16	6.40	6.35	6.32	-
29 159.356	-	6.14	5.88	5.91	5.72	6.36	6.85
.370	6.14	6.18	5.91	5.77	5.78	6.37	6.78
.383	6.12	6.12	5.94	5.95	5.74	6.38	6.73
.396	6.08	6.11	5.93	6.06	5.76	6.33	6.85
29 160.342	6.20	6.12	6.35	6.28	6.42	5.70	-
.354	6.18	5.94	6.38	6.30	6.38	5.75	6.22
.367	6.18	5.87	6.34	6.21	6.29	5.74	6.35
.380	6.20	5.80	6.15	6.15	6.17	5.85	6.36
.394	6.16	5.80	6.15	5.88	6.12	5.84	6.37
.409	6.25	5.65	6.25	5.78	5.86	5.87	6.55
29 161.344	5.52	5.94	5.36	5.87	6.17	6.22	6.12
.357	5.60	5.94	5.37	6.00	6.24	6.23	5.85
.372	5.55	6.10	5.26	6.07	6.37	6.22	5.80
.386	5.35	6.18	5.35	6.08	6.40	-	5.59
.399	5.40	6.20	5.70	6.12	6.30	6.15	5.73
29 162.325	6.16	6.14	6.10	6.25	5.80	6.28	6.75
.339	6.10	6.19	-	6.30	5.76	6.08	6.78
.352	6.14	6.13	6.30	6.32	5.72	5.98	6.77
.365	6.16	6.15	6.12	6.24	5.85	5.70	6.77
.378	6.18	6.12	6.16	6.39	5.82	5.78	6.75
.392	6.18	5.97	6.20	6.24	5.94	5.85	6.82
29 166.399	5.62	5.93	5.85	6.01	5.71	6.13	6.85
29 167.353	5.90	6.42	6.18	5.81	6.35	5.89	6.80
.366	5.87	6.30	6.30	5.80	6.36	5.70	6.70
.378	5.84	6.29	6.24	6.04	6.14	5.82	6.80
.391	5.94	6.33	6.29	6.00	5.86	5.79	6.95
29 187.274	6.18	-	6.06	5.69	6.05	5.95	-
.305	6.20	-	6.00	5.78	5.74	6.00	6.70
.318	6.16	-	5.98	5.74	5.82	6.04	6.79
.331	6.18	6.00	5.96	5.80	5.69	5.91	6.80
29 518.315	5.52	5.49	6.20	6.06	6.01	5.98	6.17
.336	5.45	5.55	6.20	5.92	5.98	5.95	5.90
.349	5.34	5.60	6.18	5.84	5.87	5.92	5.63
.362	5.25	5.63	6.30	5.76	5.88	5.89	5.81
.375	5.40	5.67	6.43	5.78	5.77	6.05	6.05
29 519.455	6.15	5.79	6.10	6.18	5.73	6.00	6.18
29 520.313	6.16	5.80	6.30	6.05	5.94	5.82	6.90
.327	6.18	5.75	6.29	5.84	5.96	5.80	6.88
.339	6.17	5.86	6.31	6.06	6.00	5.71	6.87
.352	6.05	5.85	6.10	5.84	6.14	5.74	6.86
.363	5.96	5.90	6.20	5.84	6.15	5.82	6.87
.376	5.88	5.94	6.29	5.82	6.14	5.90	6.85
29 546.266	6.02	6.05	6.33	6.20	6.36	6.27	6.87
.279	6.00	6.14	6.39	6.10	6.35	6.35	6.65
29 870.406	6.05	-	6.15	6.30	5.68	5.64	6.65
29 877.369	5.80	6.14	6.25	5.91	5.83	6.12	-

Table II. cont.

J.D. 24 00 000+	V74	V96	V97	V101	V103	V104	V105
29 877.381	5.70	6.12	6.24	5.78	5.72	6.00	-
.394	5.56	6.02	6.32	5.88	5.69	5.99	-
.453	5.54	5.88	6.30	5.88	5.73	5.90	6.90
.481	5.74	5.85	6.10	5.79	5.79	5.89	6.88
.499	5.80	5.91	6.05	5.84	5.92	5.99	6.75
29 879.309	6.05	6.22	5.79	6.26	5.79	6.20	5.73
.321	6.10	6.15	5.76	6.06	5.83	6.12	5.80
.339	6.08	5.95	5.90	5.96	5.96	6.22	5.83
.372	6.16	5.87	5.85	5.84	5.96	6.10	5.81
.422	6.17	5.85	5.95	5.83	6.29	5.93	6.18
.435	6.04	5.63	6.01	5.80	6.09	5.92	-
.449	5.90	5.60	6.06	5.77	6.12	5.85	6.25
30 259.319	5.65	6.47	6.43	5.54	5.81	6.32	6.53
.330	5.72	6.47	6.29	5.57	5.79	6.22	6.57
.340	5.90	6.43	6.30	5.73	5.84	6.15	6.50
30 260.340	6.02	5.87	5.89	6.36	5.75	5.96	5.93
.354	6.10	5.94	5.94	6.28	5.73	5.92	6.18
.372	6.10	5.98	5.96	6.22	5.72	6.05	6.28
.387	-	5.93	6.18	6.22	5.70	6.17	6.03
.406	6.04	5.91	6.21	6.08	5.72	6.21	6.36
.427	-	5.87	6.30	6.00	5.69	6.33	6.38
30 261.309	5.54	6.47	6.18	5.89	6.38	-	6.85
.323	5.50	6.35	6.29	5.78	6.36	6.50	6.91
.334	5.56	6.18	6.38	-	6.40	6.30	6.84
.344	5.40	6.29	6.39	5.78	6.35	6.31	6.85
.374	5.46	6.31	6.43	5.88	6.42	6.20	6.95
.388	5.76	6.29	6.43	5.78	6.42	6.30	6.35
.402	5.90	-	6.43	5.88	6.43	6.30	5.87
.417	5.88	6.00	6.37	6.08	6.10	6.12	5.74
.434	5.97	5.98	6.38	6.02	5.88	6.13	5.75
33 502.437	5.68	6.22	5.86	6.06	5.83	5.93	6.95
.484	5.98	5.91	6.04	5.71	6.00	5.88	6.95
.502	5.96	5.82	6.08	5.82	5.96	5.92	-
.518	6.08	5.70	6.10	5.75	6.24	5.82	6.95
.532	6.16	5.70	6.10	5.76	6.26	5.95	6.95
33 858.435	5.70	-	6.29	5.78	5.71	6.13	6.77
.445	5.55	-	6.18	5.93	5.72	6.08	-
.474	5.30	-	6.25	6.03	5.74	6.17	-
.486	5.45	-	6.25	6.18	5.78	6.38	6.87
33 861.427	5.40	-	6.43	6.21	5.80	6.39	5.75
.439	5.52	-	6.20	6.26	5.68	6.34	5.65
.452	5.54	6.43	6.44	6.29	5.80	6.50	5.78
.464	5.60	6.41	6.40	6.22	5.80	6.50	5.97
.477	5.63	-	6.30	6.25	5.74	6.35	5.98
.491	-	-	6.10	6.11	5.89	6.39	5.98
.503	6.05	-	5.94	6.12	5.86	6.37	6.30
.517	6.08	6.42	5.78	5.95	5.96	6.30	6.30
.531	5.97	6.40	5.68	5.92	6.12	6.38	6.35
.546	5.88	6.43	5.34	5.80	6.08	6.50	-
.562	5.90	6.41	5.18	5.86	6.22	6.30	6.58

Table II. cont.

J.D. 24 00 000+	V74	V96	V97	V101	V103	V104	V105
33 865.378	6.05	-	6.45	6.20	6.08	5.94	-
.392	6.08	6.23	6.30	6.15	5.98	5.88	-
.405	6.08	6.13	6.35	6.15	5.77	-	6.15
.418	6.15	-	6.25	6.15	5.74	5.93	5.92
.430	6.10	6.25	6.29	6.13	5.79	5.98	5.57
.442	6.07	6.30	6.29	6.10	5.72	5.92	5.75
.456	6.16	6.36	6.38	6.18	-	5.91	5.83
.468	6.16	6.40	6.16	6.10	5.70	6.10	6.05
.563	-	5.87	6.20	5.78	5.81	6.38	6.41
.575	5.45	5.85	6.16	5.58	6.08	6.33	6.38
33 871.454	5.60	-	5.88	6.15	5.93	6.32	-
.483	5.30	6.30	5.90	6.12	6.19	6.39	6.82
.496	5.50	6.18	5.89	6.15	6.16	6.38	6.90
.507	5.55	5.91	5.96	6.10	6.34	6.15	6.95
.518	5.60	-	5.97	6.14	6.26	6.14	6.95
.542	5.76	-	6.09	6.00	-	6.05	-
.555	5.88	-	6.10	5.95	6.38	5.94	6.95
.570	5.70	-	6.08	5.95	6.19	5.93	6.95
.584	5.78	5.84	6.16	6.03	6.32	5.79	6.90
33 872.446	5.80	5.80	6.25	-	5.72	5.93	6.37
.452	5.88	5.83	6.25	-	5.75	5.85	6.55
.487	5.94	5.85	6.24	6.08	5.92	-	6.85
.500	6.08	6.05	6.24	6.06	5.71	5.87	6.85
.519	6.16	6.14	6.20	6.09	5.79	6.00	-
.533	6.12	6.18	6.29	6.21	5.81	6.07	-
.546	6.12	6.20	6.26	6.10	5.81	5.93	-
.560	6.10	6.24	6.31	6.26	6.05	5.98	-
.573	6.08	6.25	6.29	6.24	6.04	6.19	-
.586	6.16	6.29	6.38	-	6.12	6.38	-
.599	6.14	6.40	6.43	6.30	6.15	6.32	-
33 881.401	-	-	6.24	6.30	6.09	6.50	6.03
.413	6.09	-	6.28	6.23	6.01	6.30	5.81
.425	6.10	-	6.31	6.32	6.02	-	-
.439	-	-	6.37	-	6.17	6.26	5.85
.451	6.16	5.63	6.32	6.21	6.17	6.18	5.85
.470	6.16	5.70	6.24	6.22	6.35	6.20	6.14
.483	6.18	5.75	6.30	6.26	6.12	6.15	6.15
33 884.395	6.10	6.25	6.25	5.89	6.17	5.93	6.30
.408	6.10	6.30	6.15	5.92	6.26	5.82	6.30
.436	6.06	6.33	6.10	5.85	6.25	5.55	6.45
.450	6.00	6.32	6.06	5.79	6.35	5.76	-
.464	5.98	-	5.96	-	6.08	5.58	6.82
.478	5.40	-	5.72	5.90	6.39	5.69	-
.495	5.25	-	5.68	-	6.15	5.76	-
.521	5.40	-	5.70	6.04	6.05	5.90	6.95
.539	5.60	-	5.28	6.09	6.11	6.14	6.85
.558	5.56	-	5.32	6.25	5.78	6.05	-
.574	5.88	6.14	5.18	6.36	5.78	6.19	6.85
.594	5.96	5.93	5.18	6.22	5.70	6.22	-
33 887.457	5.56	-	5.96	6.22	6.09	6.07	6.82

Table II. cont.

J.D. 24 00 000+	V74	V96	V97	V101	V103	V104	V105
33 887.478	5.40	-	5.90	6.18	6.08	-	-
.498	-	-	5.94	6.16	5.84	6.28	-
.511	5.48	-	5.98	-	5.73	6.30	-
.524	5.76	-	5.97	6.05	5.68	6.32	-
33 888.400	5.64	-	6.25	5.76	6.04	-	6.50
.412	5.62	-	6.17	5.77	6.02	-	6.43
.425	5.72	6.18	6.15	5.69	6.23	6.30	-
.437	5.92	-	6.20	5.75	6.05	6.25	6.55
.461	6.08	-	6.16	5.79	-	-	6.45
.474	6.05	-	6.15	5.80	6.31	6.27	6.58
.485	6.14	6.19	6.20	5.85	6.20	6.28	-
33 889.454	6.05	5.79	5.70	-	5.91	5.78	6.18
.472	6.12	5.73	5.70	-	5.75	5.93	6.22
.488	6.10	5.76	5.77	6.26	5.95	6.00	6.22
.497	6.08	5.67	5.88	6.39	6.13	5.87	6.20
.512	5.40	-	5.91	6.06	6.11	5.99	6.40
33 894.380	6.02	-	5.72	5.70	6.06	5.85	6.75
.393	6.05	-	5.95	5.69	6.27	5.61	-
.408	6.08	6.10	5.97	5.53	6.42	5.75	6.80
.420	6.10	-	6.00	5.80	-	5.90	-
.439	6.08	-	6.05	5.68	6.12	5.87	-
33 895.443	5.56	5.84	6.28	-	6.08	6.50	-
.457	5.60	5.87	6.30	6.29	6.19	6.38	-
.468	5.30	5.91	6.35	6.30	6.06	-	-
.487	5.40	6.00	6.32	6.30	6.16	6.50	-
.498	5.55	5.87	6.38	-	6.18	6.45	6.80
.514	5.50	6.02	6.25	6.24	-	6.40	-
.526	5.55	6.18	6.39	6.05	6.29	6.18	-
.541	5.75	6.14	6.15	-	6.25	-	-
34 238.526	5.80	6.31	6.02	6.25	5.73	6.11	6.65
.539	5.53	6.25	6.00	6.32	5.74	6.03	6.58
.553	5.45	6.38	6.08	6.25	5.94	6.10	6.71
.565	-	-	6.10	6.05	5.95	5.92	-
.580	5.65	-	6.16	6.11	6.14	5.97	6.60
34 241.435	6.00	5.75	6.19	5.80	5.74	6.22	6.60
.450	5.88	5.79	-	5.90	5.84	6.12	-
.463	5.77	5.91	-	5.78	5.72	6.08	-
.479	5.40	5.87	-	5.95	5.80	6.08	-
.492	5.40	5.86	6.10	-	5.86	-	-
34 253.410	5.83	-	6.30	5.80	6.15	6.40	-
.446	6.00	-	6.30	5.69	6.40	6.12	6.60
34 254.449	6.12	5.82	5.97	6.40	6.10	-	6.20
.467	6.12	5.91	5.96	6.29	6.39	5.96	6.30
.484	5.90	5.98	6.05	6.39	6.40	5.96	6.29
.505	5.45	6.00	6.16	6.23	6.28	6.15	-
.525	5.45	-	6.13	6.22	6.30	6.20	-
34 270.492	5.50	-	6.02	6.26	5.74	-	6.25
.514	-	-	5.98	-	5.76	-	-
34 573.459	6.13	-	5.98	6.00	6.42	5.81	-
.473	6.20	6.02	6.01	6.06	6.24	6.00	-

Table II. cont.

J.D. 24 00 000+	V74	V96	V97	V101	V103	V104	V105
34 606.527	5.90	5.96	6.15	-	6.21	5.92	-
.541	5.85	5.88	6.22	5.81	6.19	5.87	-
.556	6.12	6.14	6.15	-	6.08	-	-
.571	6.10	6.20	6.25	5.80	6.22	-	-
.586	6.12	6.20	5.80	5.82	6.38	5.78	-
34 945.407	-	5.94	6.20	6.24	6.11	5.82	-
.424	5.60	5.90	6.15	6.28	6.06	5.45	-
34 949.463	-	-	6.07	-	6.40	6.15	-
35 371.410	5.63	-	-	6.30	6.43	6.20	-
.423	5.70	5.80	-	6.06	6.21	6.17	-
.436	5.70	5.85	-	-	6.10	6.25	-
.455	5.92	5.92	-	5.88	-	-	-
35 720.298	6.17	6.06	6.20	6.12	5.74	6.35	6.87
.315	5.95	6.01	6.00	6.10	5.83	6.29	-
.328	5.92	6.13	6.25	6.17	5.67	6.50	6.78
.344	5.65	6.25	6.30	6.14	5.87	6.28	-
.356	5.65	6.42	6.30	6.24	5.95	6.36	-
.369	5.55	6.34	6.25	6.28	5.87	6.29	-
.381	5.60	6.04	6.25	6.27	6.07	6.30	-
.394	5.72	6.20	6.30	6.27	6.12	6.25	-
35 725.327	-	5.58	6.30	6.01	6.37	-	6.60
.377	5.55	5.84	6.25	5.86	5.90	6.28	-
.419	5.80	-	6.30	5.75	5.71	6.50	6.95
.432	5.75	-	6.30	5.77	5.72	-	6.95
.445	5.95	5.95	6.20	5.92	5.71	6.23	6.95
.457	6.07	-	6.25	5.81	5.74	6.06	-
.495	6.25	-	6.30	6.02	5.79	-	6.85
.507	6.20	6.36	6.30	6.04	5.84	5.85	-
.519	6.10	6.22	6.30	6.10	5.93	5.84	6.95
.531	6.25	-	6.30	6.08	5.96	5.82	-
36 068.496	-	6.38	6.30	5.71	6.28	5.86	6.22
.514	5.90	6.38	6.25	5.66	6.24	5.93	6.55
.528	-	6.00	6.25	5.82	6.38	5.82	6.54
.543	6.00	6.19	6.30	5.82	6.29	5.75	6.60
36 073.380	6.20	5.96	6.25	6.03	5.92	6.50	6.75
.393	6.27	5.97	6.20	6.02	5.82	6.32	6.75
.406	6.13	5.88	6.25	6.21	5.77	6.18	6.70
.419	6.27	5.86	6.15	6.20	5.74	6.23	6.71
.432	6.30	5.94	6.20	6.25	5.73	5.94	6.85
.446	6.20	-	6.20	-	5.86	5.94	6.60
.459	-	6.09	6.15	6.27	5.69	5.86	6.88
.473	-	5.91	6.20	6.25	5.69	5.68	6.52
.486	5.73	6.07	6.30	6.13	5.73	5.60	6.09
.500	5.50	5.95	6.30	6.20	5.82	5.83	5.93
36 074.381	-	6.20	6.30	5.70	6.41	-	6.90
.394	-	6.45	6.20	5.74	6.25	5.86	6.80
.406	5.65	6.37	6.25	5.69	6.35	6.09	6.87
.420	-	6.31	6.10	5.68	6.36	5.95	6.80
.434	5.82	6.45	5.72	5.74	6.34	5.95	6.92
.447	5.95	6.48	5.45	5.69	6.15	5.96	6.85

Table II. cont.

J.D. 24 00 000+	V74	V96	V97	V101	V103	V104	V105
36 074.460	6.00	6.30	5.50	5.68	6.14	6.13	6.95
.473	6.22	6.27	5.55	5.70	5.95	6.12	6.78
.486	6.27	6.22	5.52	5.69	5.81	6.21	6.80
.500	6.25	6.15	5.55	5.70	5.74	6.18	6.80
.513	6.25	6.22	5.45	5.74	5.72	6.28	6.88
.526	6.20	5.88	5.50	5.66	5.72	6.17	-
38 259.416	6.30	6.18	6.30	5.96	5.96	5.99	6.35
.473	6.30	6.30	6.30	6.05	-	6.29	6.50
.493	6.20	6.04	6.30	6.14	6.21	6.19	6.57
38 268.472	5.70	6.21	6.25	5.78	6.14	5.78	5.63
.487	5.88	6.11	6.30	5.76	5.74	5.87	5.75
.502	5.95	6.31	6.30	5.79	5.72	5.97	5.95
.518	6.05	6.30	6.30	5.73	5.74	6.02	6.10
.531	6.08	6.23	6.30	5.76	5.72	5.92	6.10
.544	6.17	6.36	6.25	5.73	5.72	5.95	6.36
.558	6.00	6.21	6.25	5.82	5.77	6.21	6.52
.572	6.27	6.31	6.15	5.85	5.77	6.14	6.29
.586	6.25	6.21	6.05	5.90	5.92	6.03	6.35
.601	6.30	6.21	6.00	5.88	5.98	6.17	6.37
38 289.280	6.18	6.07	6.20	5.84	6.18	6.20	-
.304	6.30	5.86	6.20	5.79	6.42	6.19	6.85
.325	6.30	5.92	6.10	5.74	6.39	6.25	6.90
.346	6.27	5.85	6.15	5.78	6.16	6.29	-
.373	6.20	5.87	6.30	-	6.45	6.42	-
.402	5.65	5.84	6.15	5.82	6.22	6.48	6.85
.420	5.60	5.92	6.30	6.04	6.18	6.47	-
.466	5.70	5.87	6.10	6.13	5.96	6.30	6.95
.482	5.70	6.06	6.00	6.05	5.74	6.07	6.95
.506	5.90	6.17	5.70	-	5.76	5.96	6.75
.522	5.95	6.12	5.50	6.06	5.76	5.82	6.88
.547	6.25	6.29	5.50	6.12	5.73	-	6.75
.560	6.20	-	5.45	-	5.74	5.77	6.13
.574	-	6.20	5.60	6.27	5.88	5.75	5.94
39 350.467	6.30	5.80	6.28	5.80	5.74	6.22	6.85
.483	6.30	5.84	6.21	5.80	5.82	6.03	6.75
.496	6.30	-	6.32	5.79	5.96	6.19	-
.522	6.30	5.98	6.25	5.79	6.12	5.82	6.95
.535	-	6.00	6.25	5.81	6.09	5.87	-
39 351.498	5.50	-	5.65	6.24	5.69	6.11	6.38
.512	-	-	5.85	6.25	5.72	6.15	6.58
.524	-	6.18	5.75	-	5.79	6.02	6.75
.536	5.55	-	-	6.24	5.80	6.15	-
39 355.445	-	6.23	6.20	6.23	6.36	6.31	6.26
.460	-	6.20	6.28	6.12	6.44	6.20	6.30
.474	-	6.25	6.30	-	6.34	5.93	6.40
.490	-	6.35	6.30	6.16	6.07	5.92	6.75
.504	6.25	6.26	6.25	-	5.94	5.87	-
.520	6.30	5.98	6.23	6.28	5.98	5.65	6.80
.533	-	5.80	6.30	6.20	5.77	5.68	6.70

Table III.

Periods used in constructing the light curves

V 1	$1^{\mathrm{d}}.437523$	V 31	$0^{\mathrm{d}}.4081781$
V 2	0.6842736	V 32	0.6054003
V 3	0.3887407	V 35	0.3839986
V 4	0.3135758	V 36	0.6241424
V 5	0.3842142	V 38	0.3752769
V 6	0.6659671	V 39	0.3895696
V 7	0.3675643	V 40	0.3773302
V 8	0.6462446	V 42	0.3601745
V 9	0.7152819	V 43	0.3959928
V10	0.3863931	V 44	0.5955580
V11	0.3432527	V 45	0.6773974
V12	0.5928844	V 49	0.6552015
V13	0.5749536	V 50	0.2980583
V14	0.3820024	V 51	0.3969565
V15	0.5835687	V 52	0.5756132
V17	0.4288927	V 53	0.4141270
V18	0.3677379	V 54	0.3995683
V19	0.5723030	V 57	0.3492988
V20	0.6969598	V 66	0.3793488
V22	0.7201510	V 67	0.404613
V23	0.6326959	V 74	0.2960107
V24	0.3696955	V 96	0.3967902
V25	0.6653286	V 97	0.6963337
V26	0.4022695	V101	0.4003600
V28	0.6706464	V103	0.3682720
V29	0.5749761	V104	0.4142840
V30	0.4059796	V105	0.5711550

COMMUNICATIONS
FROM THE
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HUNGARIAN ACADEMY OF SCIENCES

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STERNWARTE
DER UNGARISCHEN AKADEMIE
DER WISSENSCHAFTEN

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PREFACE

The Symposium "Variable Phenomena in Close Binary Stars" was held in Budapest, Hungary, between 7 and 10 March 1988 at Konkoly Observatory, as part of the biennial conference series of the multilateral cooperation "Stellar Physics and Evolution" subproject "Binary Stars".

Binary systems represent one of the most interesting, exciting and puzzling objects in modern astrophysics. In particular, interacting binaries have become very important in recent years. Very many phenomena to be explained in connection with dwarf novae, novae, Wolf-Rayet stars, symbiotic stars, etc. need the assumption of interactions between binary star components. Over the past decades the concept of mass exchange and mass loss has become one of the most fruitful ideas in astronomy.

Besides these very fruitful theoretical developments we can recognize enormous progress in observational methods too. Unfortunately not all of these new techniques are available to us. Nevertheless, especially in X-ray astronomy, in the extension of classical photometry to longer wavelengths and in high time-resolution photometry our development is significant. In recent years we have also seen some progress in computer technique both with regard to observations and to the reduction of data.

We now present the proceedings of the conference. I should like to thank all those who assisted in organizing the conference and in producing this volume. Finally our thanks go to the Hungarian Academy of Sciences for their financial support of the conference.

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THE ACCRETION DISC IN OY Car DURING RISE TO OUTBURST

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The eclipsing binary OY Carinae with the orbital period of 91 minutes belongs to the class of ultra-short period dwarf novae of SU UMa type. The eclipses of the accretion disc permit one to determine its dimensions and surface brightness distribution. The observations of OY Car obtained by *Vogt (1983)* were used. These unique observations contain two highly symmetric eclipses recorded during rise to a normal outburst (E=2) and shortly after maximum light was reached (E=15). These two eclipses differ strongly in their shapes. This is connected with the changes of disc brightness distribution at the beginning of an outburst. The highly symmetric eclipses indicate that the surface brightness distribution of the disc is axisymmetric, so we can describe it by a simple function f(r). Other unknown parameters are the disc's outer radius r_d and the fractional luminosity of the white dwarf l_1. The principal geometric parameters, namely the mass ratio q, the inclination angle i and the radius of the white dwarf r_1 are also unknown. To perform the solution of the two eclipses a new numerical code, described in detail in a previous paper *(Wlodarczyk 1986)*, was used.

This code - applicable to the case of symmetric eclipses - is based on the conventional model of dwarf novae, containing a Roche lobe filling cool star and a mass-gaining white dwarf, surrounded by an accretion disc. The disc is stretched in the orbital plane from r_1 to r_d. In the simplest model (d_1) the disc is assumed to be flat with the thickness h=0. We first estimate the geometric parameters q and i. To do this the second eclipse (E=15) was analysed and the distribution of σ (q,i) was found, where σ is the mean square deviation from observations. The function σ (q,i) presented in Fig. 1 has two minima but only one of them lies on the line i(q) established for OY Car by *Cook (1985)*. We adopt the values of q and i corre-

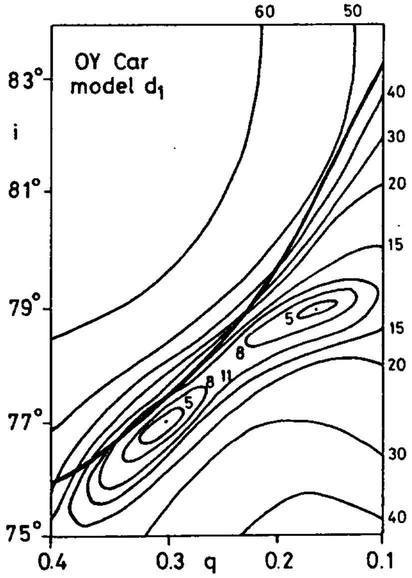

Figure 1.

sponding to this minimum ($q=0.30$, $i=76\overset{\circ}{.}9$). Such parameters are very close to those inferred by *Bailey and Ward (1981).*

For our value of q the relation $r_1(q)$ *(Cook 1985)* gives $r_1=0.013$. The further calculations were made in two steps. The final solution of the two eclipses is presented in Fig. 2. It is clearly seen that during rise to a normal outburst ($E=2$) the outer parts of the accretion disc became the dominant source of light in the system. Such photometric behaviour is consistent with the model of dwarf nova eruption presented by *Smak (1984)* in case A. Shortly after maximum the distribution $f(r)$ roughly resembles that known from the stationary accretion disc model but could not be interpreted as a model with a constant accretion rate $\dot{m}$. A more detailed analysis of OY Car is due to be published in Acta Astronomica. This work was supported in part by the Polish Academy of Sciences (grant CPBP - 01.11).

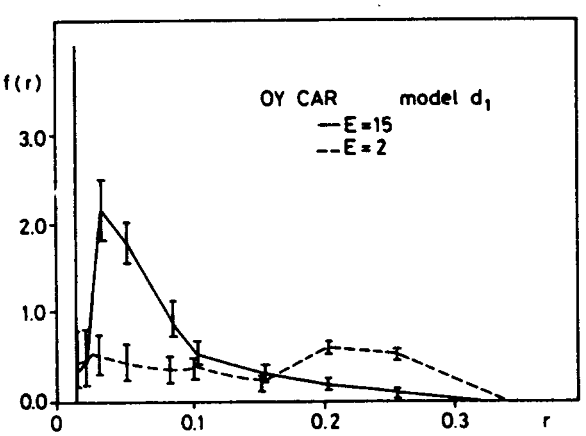

Figure 2.

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DIP FEATURES IN THE LIGHT CURVE OF TT ARIETIS

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Information on dip features in the optical light curve of TT Arietis, observed both in optical and X-ray wavelengths, is presented. These features are probably related to mass exchange in the system. A coordinated program for detailed observations and analysis of light drops is proposed to better understand the nature of the source.

TT Ari is thought to be an accreting (magnetic?) white dwarf in a close low-mass "nova-like" binary, the orbital period of which amounts to about 3.3 hours. In 1985, a complex coordinated observation program was run in the Intercosmos cooperation involving ground-based instruments as well as the EXOSAT X-ray satellite *(Wenzel et al., 1986, Hudec et al.,1987).*

TT Ari AS DIPPING SOURCE

The existence of narrow X-ray and related optical drops in the orbital light-curve of TT Arietis was first mentioned by *Jensen et al. (1983)* as a result of coordinated X-ray (Einstein) and optical observations. The observed wavelength-dependence of the decrease in X-rays has indicated that photoelectric absorption was probably responsible for the observed decrease. However, only one such event was detected.

More details were obtained during the coordinated program of EXOSAT X-ray and optical observations in 1985 *(Wenzel et al. 1986 and Hudec et al. 1987)*. Two well pronounced X-ray drops were revealed within the 11^h monitoring interval. For one of the dips simultaneous optical data were obtained showing an analogous feature. Similar dips were also revealed in some parts of the additional optical data (e.g. *Rössiger, 1987, Kraicheva et al. 1987)*.

Until now, more than 10 well pronounced dips have been revealed at optical wavelengths with typical durations between 1 and 10 minutes and amplitudes between >0.3 and ~ 2 mag. In X-rays, 3 well pronounced dips have been observed lasting ~ 15 min. and representing more than 90% decrease of the total X-ray flux of the source. Thus the central X-ray source in the system was almost fully obscured during these intervals. The reality of the presence of these narrow absorption features seen both in X-rays and optical light is now supported by the detection of more than 10 such events and also by the simultaneous detecting of dips in both spectral ranges. The duration of X-ray dips is longer than that of those simultaneously observed in the optical region (Einstein satellite X-ray/optical: 17/7 min EXOSAT: 15/8 min.). Analysis of the X-ray light curve based on EXOSAT observations has revealed a possible dip recurrence period of $3^h\ 33^m$, however, the third dip is less pronounced. No dip recurrence could be found in the Einstein X-ray data because of many gaps in the data set.

In the optical region, the dips seem to occur randomly with no clear relation to the phase of photometric or spectroscopic period. Some of the decreases exhibit double, triple or even more complex nature.

The dips are probably caused by photoelectric light absorption of the main light source in the TT Ari system (disc component) by structures related to mass exchange in the system. The second light source in the system (the secondary star component) is relatively faint, below 16.5 mag. in B. This upper limit was derived from faintness of the whole system during the very low state (superminimum) observed before 1985 when accretion probably stopped. Thus the strong drops exceeding 1 mag. may also be caused by this.

Need of more data

Although the reality of dips in the curve of TT Ari seems to be proved, more observational data are needed for a better understanding of this phenomenon. We thus suggest that another stage of coordinated ground-based optical observations of TT Ari be carried out in the near future, e.g. during the observing seasons Summer/Autumn 1988 or 1989. The second main aim of this program should be a more detailed monitoring of changes between the different shapes of orbital light curves of TT Ari as mentioned by *Wenzel et al. (1986)*.

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PHOTOMETRIC BEHAVIOR OF THE X-RAY SOURCE TT ARIETIS
DURING 1985 - 1986

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The belonging of TT Arietis to VY Scl objects included in our investigation programme, prompted us to initiate observations of this system in August 1985 when the extended programme of coordinated X-ray and optical observations of TT Arietis began. During the past three seasons, besides estimates of the brightness of the star in the standard UBV system, the behavior of the object for 3 hours during the night of August 22/23 1985 was followed and seven observational runs were carried out in the "u" region for the period 1986-1987. The observations were performed using a photoelectric photometer attached to the 60 cm Cassegrain telescope of the National Astronomical Observatory employing a photon counting technique. Star "c" *(see Wenzel et al. 1986)* served as the comparison star. For transformation of the instrumental u,b,v stellar magnitudes to the standard UBV magnitudes during 1987 the relations

$$\Delta V = \Delta v + 0.1 \ \Delta (B-V)$$

$$\Delta (B-V) = 0.89 \ \Delta (b-v) + 0.034 \ \Delta(b-v) \ \bar{X}$$

$$\Delta (U-B) = 0.89 \ \Delta (u-b) + 0.062 \ \Delta(u-b) \ \bar{X}$$

were used. The integration time was 10 sec. The results of these observations are the following:

1. During all the nights of the observations TT Ari was near maximum

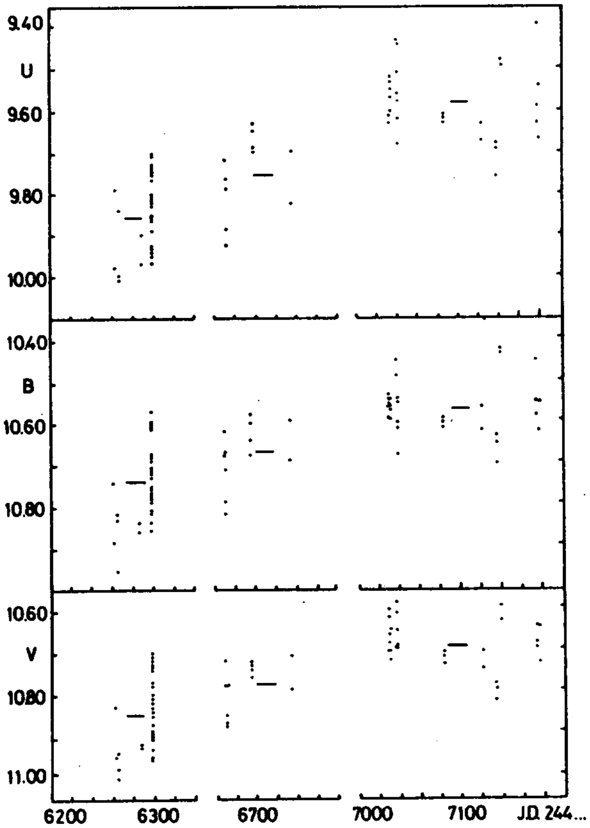

Figure 1.

light: this may be seen from Fig. 1. where all our estimates of the brightness of the star are plotted. From this figure it is seen too, that the brightness of the star fluctuates around an increased maximum mean value from 1985 to 1987. The mean of the resulting points yields the following magnitudes for TT Ari in 1985: V = 10.85, B = 10.75, U = 9.86. For 1987 the mean magnitudes are V = 10.69, B = 10.57, U = 9.58. An increase of average brightness in 1987 by 0.16 mag in V, 0.18 mag in B and 0.28 mag in U in comparison to 1985 can be suspected. The difference from average UBV magnitudes for 1985 given in a previous paper *(Kraicheva et al. 1987)* and this present paper is due to the inclusion of an additional 24 estimates of brightness from 22/23. 08. 1985. In our opinion this gives a clearer idea for the interval of variations of the brightness.

Table 1.

Magnitude estimates of TT Arietis during 1987

J.D. 244...	V	B-V	U-B
7032.4803	10.70 ±0.01	-0.14 ±0.02	-0.99 ±0.01
.4908	10.68 ±0.01	-0.09 ±0.01	-0.96 ±0.01
.5024	10.60 ±0.02	-0.04 ±0.02	-0.95 ±0.01
.5181	10.62 ±0.01	-0.09 ±0.02	-1.00 ±0.02
7033.4502	10.66 ±0.02	-0.12 ±0.03	-0.99 ±0.01
.5786	10.70 ±0.01	-0.11 ±0.01	-0.99 ±0.02
.5852	10.72 ±0.01	-0.15 ±0.02	-1.05 ±0.01
.5887	10.65 ±0.01	-0.09 ±0.01	-0.99 ±0.01
7039.4425	10.58 ±0.01	-0.13 ±0.01	-1.02 ±0.01
.5610	10.61 ±0.01	-0.12 ±0.02	-0.98 ±0.03
.5664	10.69 ±0.02	-0.14 ±0.03	-0.99 ±0.02
7040.3920	10.65 ±0.01	-0.11 ±0.02	-1.10 ±0.05
.5470	10.79 ±0.01	-0.11 ±0.01	-1.00 ±0.01
.5549	10.69 ±0.01	-0.08 ±0.02	-0.99 ±0.01
.5608	10.69 +0.01	-0.09 ±0.02	-1.03 ±0.01
7085.4282	10.71 ±0.02	-0.12 ±0.02	-0.96 ±0.02
.4339	10.73 ±0.02	-0.11 ±0.02	-1.00 ±0.02
.4394	10.71 ±0.01	-0.12 ±0.02	-0.98 ±0.02
7123.3657	10.74 ±0.02	-0.12 ±0.02	-0.99 ±0.03
.3706	10.70 ±0.01	-0.14 ±0.01	-0.89 ±0.03
7137.2016	10.78 ±0.01	-0.16 ±0.02	-0.94 ±0.01
.2071	10.82 ±0.01	-0.12 ±0.01	-0.94 ±0.01
.2123	10.79 ±0.01	-0.16 ±0.01	-0.95 ±0.01
7142.3450	10.59 ±0.01	-0.17 ±0.02	-0.95 ±0.02
.3497	10.63 ±0.01	-0.20 ±0.02	-0.94 ±0.04
7177.2586	10.68 ±0.01	-0.13 ±0.01	-0.96 ±0.02
.2662	10.64 ±0.02	-0.19 ±0.03	-1.06 ±0.01
.2726	10.69 ±0.02	-0.11 ±0.02	-0.95 ±0.01
7179.2072	10.64 ±0.01	-0.09 ±0.02	-1.01 ±0.02
.2131	10.73 ±0.01	-0.11 ±0.01	-0.95 ±0.02

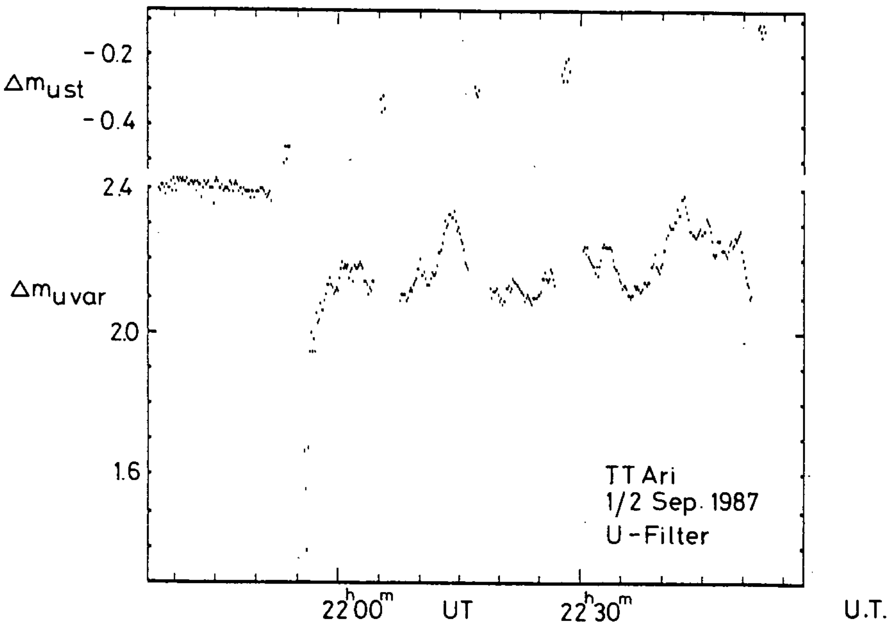

Figure 2.

2. The colour indexes on the individual nights during these 3 observing seasons were in the intervals -0.04 to -0.2 for (B-V) and -0.84 to -1.0 for (U-B), but in 1987 a few (U-B) values exceeding -1.0 were observed (Table 1 in *Kraicheva et al. 1987* and Table 1 in this paper).

3. The three-colour measurements from August 22/23 1985 show a well-expressed maximum. The start and the end of the observations are in the neighborhood of brightness minima (Figure 1 in *Kraicheva et al. 1987)*. The wave shaped variations are 0.25 mag in V and 0.32 mag in B and U. This is in agreement with the results of coordinated observations *(see Hudec et al. 1987)*.

4. The observing run during the night of November 2/3 1986, besides rapid variations with an amplitude up to 0.25 mag, showed an unusually deep dip in the brightness ($\Delta u \sim 2.3$ mag) of about 10 minutes long. Seven minutes later a new dip of the of the brightness with an amplitude up to 0.8 mag and a duration of about 10 minutes occurred (see Kraicheva et al.1987). One of the purposes of our observations during 1987 was to test the reality of these "anti flares". Details concerning the observations can be found in Table 2.

TABLE 2 Observing runs of TT Arietis during 1986 - 1987

Date	Start time (UT)	Length	Integration time (s)	A max (mag)	t (min)
1986 Nov 2	$21^h\ 31^m$	$1^h\ 00^m$	10	0.28	3
1987 Aug 25	23 30	2 05	10	0.25	5
1987 Aug 31	23 10	1 50	10	0.30	5
1987 Sep 1	21 55	2 50	10	0.28	7
1987 Dec 7	21 15	1 20	10	0.25	3
1987 Dec 12	20 35	1 15	10	0.45	6
1988 Jan 18	17 35	2 25	10	0.32	5

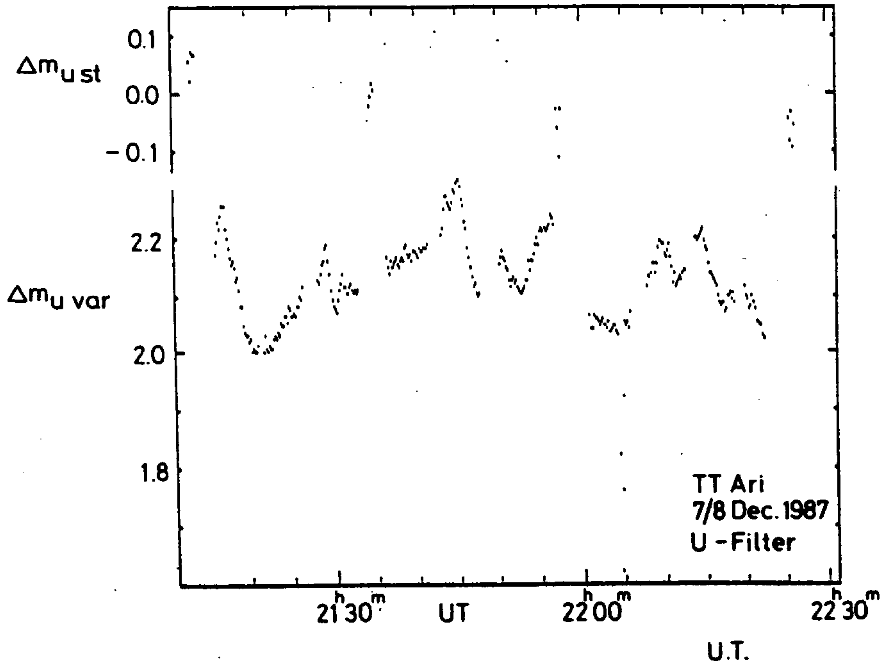

Figure 3.

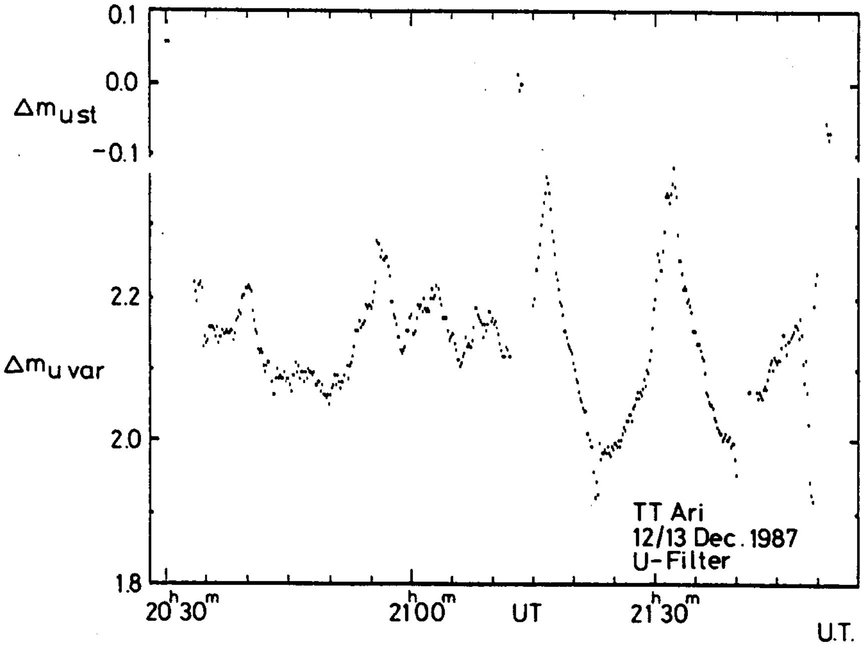

Figure 4.

Generally for the six 1987 nights the star was observed for 11^h 40^m. For this time only twice did we observe a decrease of brightness larger than 0.4 mag. The observations during the night of Sep 1/2 1987 began with a dip in the brightness up to 0.8 mag, that can be seen in Fig. 2 where a portion of the light curve of TT Ari on this night is shown. The star reached the maximum light for 3 - 4 minutes. The second dip of the brightness, with an amplitude 0.6 mag, was observed during the night of December 7/8 1987 (Fig. 3). For the first 6 - 7 minutes the star decreased in brightness by 0.2 mag and in the following 2 minutes it decreased further by 0.4 mag. For the next 3 minutes the star reached the maximum light again. *Rössiger (1987)* also observed a deep dip in brightness up to 0.9 mag in the "b" region.

5. All our observing runs during 1987 show rapid variations of the brightness with maximum amplitude for separate runs from 0.25 to 0.45 mag. Figure 4 shows the run on December 12. During this night the maximum amplitude reached 0.45 mag. The maximum amplitudes for the other runs are given in column 5 of Table 2. In column 6 of the same table the time scales of those changes are presented. It can be seen that the brightness

of the star varies by several tenths of the magnitude for time scales of 3 - 7 minutes.

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NEW STATISTICS ON DWARF NOVAE

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By processing the data of the 4th edition of *Ritter's (1987)* Catalogue of Cataclysmic Binaries... (and a few additional items of information) I rederived some statistical relations. Let P be the orbital period: M_2 and R_2, secondary mass and radius: and C, the cycle length.

Owing the Roche conditions, P is closely connected with R_2, and the rather well defined log P - M_2 curve (Fig. 1) shows that the secondary component comes very near to the mass-radius relation of the main sequence stars. The white dwarf's masses affect this relation only slightly. The deviations occurring with GK Per (and perhaps AE Aqr and BV Cen) indicate that their secondaries are in a process of evolution.

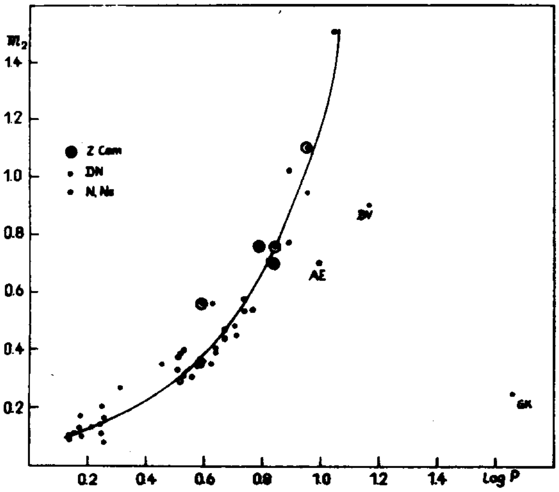

Figure 1.

Much less pronounced however is the Kukarkin-Parenago relation, which using only the Ritter data, turns out to have the form of

$$A = 0.5 + 1.85 \log C$$

(see Fig. 2 top). The large dispersion of the dots cannot simply be put down to the inaccuracy of A and C. In point of fact, it is interesting to observe that the dots lying below the regression line mainly correspond to either large or small values of P, while those lying above the line correspond to values of P that are near the much discussed period gap between about 2^h and 3^h. In a word, we are being confronted with an A - log P - log C relation. Thorough analysis led, by means of linear regression and neglecting EX Hya, to these results (Fig. 2 bottom):

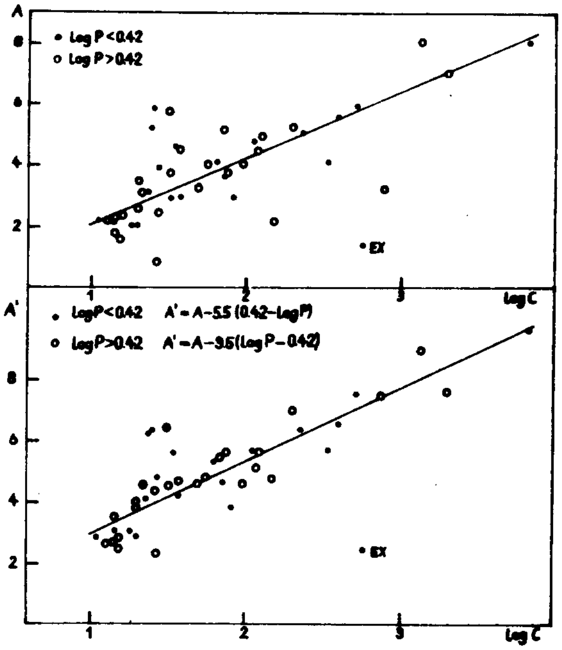

Figure 2.

$$A = -1.4 + 5.5 \log P + 2.25 \log C \qquad (P \leq 2^h)$$

$$A = 2.4 - 3.5 \log P + 2.25 \log C \qquad (P \geq 3^h)$$

By plotting log P against log C and taking the brightness amplitude A as the parameter the correlations become even more obvious (Fig. 3). It

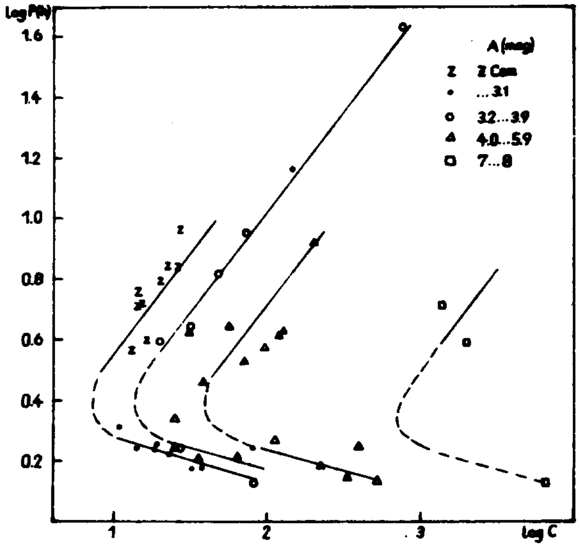

Figure 3.

is remarkable that for each A interval, C has a minimum near the period gap. (The dotted lines through the period gap are drawn only for clarity's sake). The results can be represented in the following form (Fig. 4.):

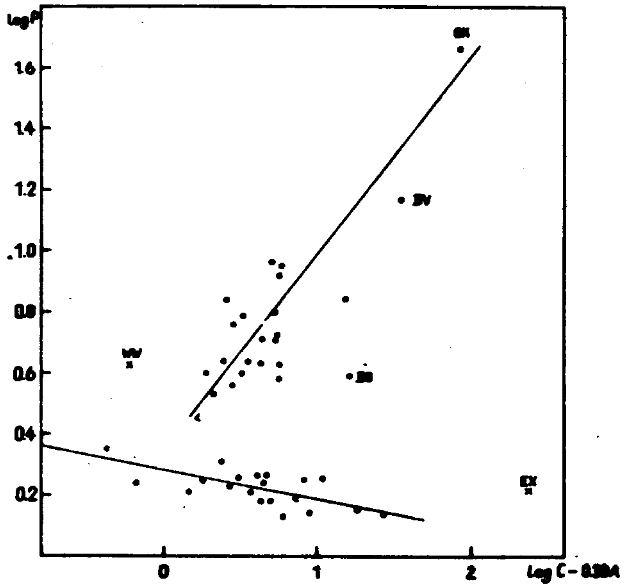

Figure 4.

$$\log P = 0.28 - 0.10\,(\log C - 0.30\,A) \qquad (P \leq 2^h)$$

$$\log P = 0.35 + 0.64\,(\log C - 0.30\,A) \qquad (P \geq 3^h)$$

EX Hya largely deviates from this relation. It is an extreme intermediate polar, surely having a disturbed accretion disk. Figure 3 shows that for fixed P, there are objects of very different values of A and C. They differ in their mass transfer rates, $\dot{m}$, a factor of more than 100. This effect was already discussed in detail by *Patterson (1984)*. The point is: What is the reason for objects of similar physical and geometrical properties differing so largely in $\dot{m}$? Perhaps this phenomenon is due to the varied efficiency of magnetic braking - or the objects are living in different states of the "hibernation cycle" of novae (if the hibernation theory is taken to be correct, see for example *Shara et al. (1986)*. Another question is: Why do objects of the same amplitude show a minimum of the cycle length near the period gap? The answer depends on the position you argue from. According to the disk instability hypothesis of dwarf nova eruptions, near the accretion disc must have a minimum in its capability for storing matter. According to the fluctuating mass transfer hypothesis, however, the secondary in systems near the period gap must become dynamically unstable in shorter intervals, but smaller in quantity. One day, perhaps, a theoretical interpretation of our findings will help to decide which of the two hypotheses is in accordance with fact, and which is the real cause for the existence of the period gap.

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ON THE ECLIPSES OF WHITE DWARFS IN DWARF NOVAE

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There are three ultra-short period dwarf novae - HT Cas, OY Car and Z Cha - in which the wite dwarf is totally eclipsed. This effect is clearly seen only during quiescence when the fractional luminosity of the white dwarf is biggest. Unfortunately, the total occultation of the white dwarf is superimposed on the eclipses of an accretion disc with a bright spot. Consequently, it is very difficult to reconstruct and to select the detailed shape of the eclipse of the primary star. The eclipse of the white dwarf contains information on the nature of the central object at the accretion disc. Due to disc accretion we might expect that the central star has a bright equatorial zone. Such a white dwarf was found in Z Cha by Smak in 1986. In general, the central object could be the typical white dwarf or a white dwarf with its lower hemisphere occulted by an optically thick disc. It could also be a white dwarf surrounded by a boundary layer or it could be a star with bright polar caps due to a strong magnetic field. A combination of these cases could also be considered.

In this paper theoretical eclipse profiles and their derivatives are calculated for the following different configurations of the central object (Fig. 1):

a_1) a white dwarf with the limb darkening coefficient $x = 0$

a_2) a white dwarf as above but its lower hemisphere is occulted by a dark disc

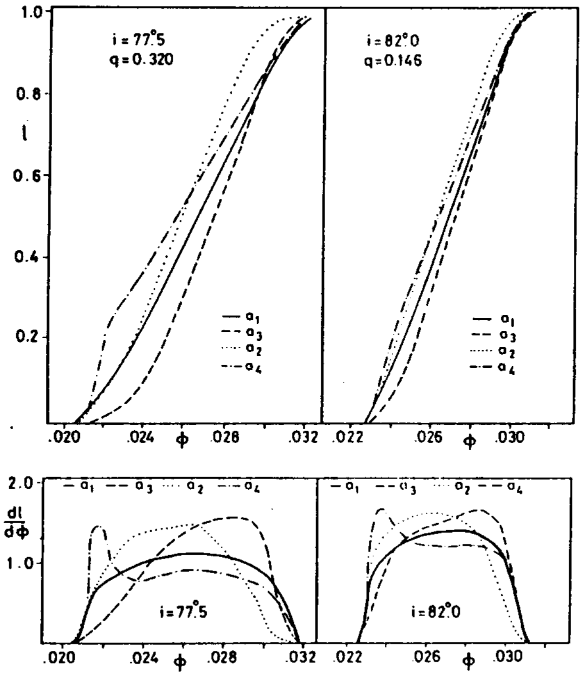

Figure 1.

a_3) a white dwarf with a bright equatorial boundary layer: in this case the surface brightness distribution was adopted in the form $I \sim \cos^n \Theta$ where Θ is the latitude measured from the equator of the white dwarf, and the width of the bright belt is then defined by the exponent n

a_4) a white dwarf with bright polar caps: in this case $I \sim \sin^n \Theta$

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STARLIGHT RE-EMISSION AND SCATTERING BY A PRECESSING ACCRETION DISC RELEVANT TO THE PARAMETERS OF THE Cyg X-1 = V1357 Cyg X-RAY BINARY

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Photometric and polarimetric variations resulting from re-emission and scattering starlight by an oblique precessing accretion disc are considered. From analysis of observational data of Cyg X-1 it follows that the disc is optically thick and precesses towards orbital motion.The scattering is not important ($\leq$10% in B band) for intensity variations but it produces some polarimetric effects. The disc radius is r_d = 0.12-0.15 a (where a is the distance between the component centres-of-mass), i.e. the disc fills as little as 40-50% of the entire Roche lobe. The precession angle is $j = 15^o-20^o$, the system inclination angle $i = 55^o-65^o$. The direct disc precession is probably due to the moment of the forces transferred to the disc by the gas stream outflowing from the star.

The optical components of high-mass X-ray binaries are high-luminosity hot stars. In the case of moderate or low X-ray luminosity of such a system, the re-emission and scattering of the optical-component light by the accretion disc form the main mechanism of disc radiation. According to the present-day concepts, the disc may either lie in the binary-system plane or be oblique and precessing. In many cases, the long-term variability found or suspected in numerous X-ray binaries *(Priedhorsky, 1987)* is probably due to disc precession. In particular, the long-term photometric and polarimetric variability of Cyg X-1 may well be explained in terms of such a model *(Karitskaya, 1979, Kemp et al., 1983, 1987).*

In the case of precessing discs tilted out of the orbital plane, re-emitting and scattering the light of the second component, the character of the variations in the radiation field parameters (the intensity I, the Stokes parameters Q and U describing the linear polarization) is defined first of all by the variations of the disc illumination by the star *(Karitskaya 1981a,b)* which varies with both the orbital phase Φ and with precession phase δ, more accurately, with $\varphi=\Phi+\delta$. The "-" sign means that the precession is in the direction of the orbital motion, the "+" sign corresponding to the reverse direction. Moreover, the conditions vary for the disc visibility which is a function of δ. Thus, the Stokes parameters $I(\Phi)$ $Q(\Phi)$ and $U(\Phi)$ are strong functions of the angle j of disc inclination to the binary-system plane and of the precession phase δ.

The intensity and the linear polarization of star radiation scattered by a precessing accretion disc have been calculated by *Karitskaya (1981a, b)* and *Bochkarev and Karitskaya (1988a)*. In the case of pure electron scattering the linear polarization variation amplitude may reach 3% and the intensity and the polarization vary both with the precession phase δ and with the orbital phase Φ of a binary system due to changes in the mutual position of the scattering disc, the star and the observer's line of sight. Contrary to the case of discs in the orbital plane, at $j \neq 0$, the third and higher harmonics appear in the Fourier spectra of I, Q and U.

The accretion discs atmospheres are not pure electron scattering. The true absorption is of great importance in them. Therefore, the field parameters of the emission scattered by the disc and their dependence on phase Φ are determined by the single-scattering albedo

$$\Omega = \varkappa_s / (\varkappa_s+\varkappa_a) \qquad (1)$$

where $\varkappa_s$ and $\varkappa_a$ are respectively the coefficients of scattering and true absorption. The single-scattering albedo Ω is generally a function of depth in the disc atmosphere and of coordinates on the disc surface. Any detailed models for accretion disc atmospheres have not been constructed yet, so the dependences are unknown. Therefore, we limited ourselves to calculating the field of disc-scattered radiation in terms of the approximation Ω = const. *(Bochkarev and Karitskaya 1988a)*. In the case of starlight scattering by disc the intensity I is a strong function of Ω at $0.7 \leq \Omega$ and varies at $\Omega \leq 0.7$ a bit more rapidly than according to the Ω^1 law. The dependence of the Stokes parameters Q and U on Ω is slightly stronger than in accordance with the linear law. The dependences of I, Q, U on the phases Φ and $\delta$and on the angle j remain, generally, the same as for $\Omega = 1$.

The first candidate for black holes, the high-mass X-ray binary Cyg X-1, has been studied in great detail both photometrically *(Kemp et al. 1987)* and polarimetrically *(Kemp 1980a, 1984)*. The linear polarization of the emission from Cyg X-1 varies by 0.25%. The second harmonic of orbital period $P_o = 5\overset{d}{.}6$ is fundamental with full variation $2A_2 = 0.18\%$ (A is amplitude). Furthermore, the first $(A_1 = 0.02\%)$ and higher (up to fifth) harmonics of P_o are observed to be much weaker *(Kemp 1980a)*. In addition, there are variations with period $P_p = 294^d$ *(Kemp et al. 1983)*.

The optical component is the main source of accretion disc heating in Cyg X-1 *(Karitskaya, 1981a)* In this case the disc surface temperature is 12000 K. The contribution of the intrinsic emission of such a disc to the system brightness does not exceed 3% *(Bruevich et al., 1978, Karitskaya 1981a)*. According to *Bochkarev and Karitskaya (1983)*, the variable polarization component of the intrinsic emission from a precessing disc inclined at $j \sim 10^o$ does not exceed 1% of the emission from the disc. Therefore, the contribution of this mechanism to the Cyg X-1 polarization variability is $\lesssim$ 0.03%. The intrinsic polarization of the emission from the Cyg X-1 optical component due to its tidal distortion is expected to be $\lesssim 0.025\%$ *(Bochkarev et al. 1985)*.

Now consider the polarization variability due to starlight scattering by the disc of Cyg X-1. The surface-normal component of gravitational acceleration g corresponds to log g = 1.5 - 2. Thus, according to *Bochkarev et al.(1985)*, we get $\Omega = 0.4$ at T=12000 K. In this case at the angle $i = 45^o \pm 20^o$ expected for Cyg X-1 *(Bochkarev et al. 1975)*, even a disc in the orbital plane which fills the Roche lobe $(r_d = 0.3a)$ may give rise to 0.25% polarization variability *(Bochkarev, Karitskaya, 1988a)*. The disc inclination to the orbital plane will lead to a larger amplitude of polarization variability.

However the observed ratio between the first and the second harmonics of polarization variability contradicts the considered mechanism. As shown by *Karitskaya (1981a)*, amplitude A_2 of the second harmonic P_o of the oblique disc polarization is in practice independent of the angle j up to $j = 20 - 30^o$. At $\Omega = 0.4$ and $r_d = 0.3a$, we get $A_2 = 0.11\%$ which is close to the observed value of 0.09%. However, the polarization of radiation from the disc comprises a strong first harmonic A_1 which rises with j, namely,

$0.8\ A_2 \leq A_1$ at $0 \leq j$. The observed A_1/A_2 ratio is 0.2 *(Kemp 1980a, 1984)*. In the absence of an additional polarization source compensating for the variations with A_1, the scattering of the emission from the star by the accretion disc accounts for not more than 25% of the polarization observed in Cyg X-1. Besides, the dependence of A_2 on the δ phase found by *Kemp (1984)* (the A_2 value reaches its maxima at $\delta = 0.25$ and 0.75) does not fit the oblique precessing disc for which the A_2 value is peaking at $\delta = 0$. It may be concluded from the dependence $A_2(\delta)$ that, probably, less than half of the A_2 value is due to the precessing accretion disc.

The high A_2/A_1 value most probably means that the main contribution to the variable polarization of the emission from Cyg X-1 is from the optically thin gas located asymmetrically with respect to the optical star. In confirmity with the assumptions made by *Kemp (1980b)* the variable polarization may be related to the hot spot at the accretion disc rim.

Thus, the above analysis shows that the starlight scattering by the disc is not the main mechanism of polarimetric variability of Cyg X-1. The contribution of the mechanism to the observed polarization variability does not seem to exceed 25-50%. From this, concerning the Ω value of ~ 0.4 expected for the disc, it follows that the accretion disc dimension does not exceed 0.2a, that is 60% of the X-ray source Roche lobe dimension.

Now let us examine the radiation intensity of an oblique precessing disc re-emitting the optical-component light as applied to Cyg X-1. As in the case of starlight scattering, the oblique processing accretion disc gives rise to photometric variability with precession period P_p (the δ phase) (due to the variation of disc visibility conditions) and with a period defined by the sum of, or the difference between, the frequencies of the precessional and orbital rotations (the phase φ) (due to the variations of the disc heating conditions). The intensity of radiation can be expanded to a Fourier series with these frequencies (the corresponding φ and δ) *(Bochkarev, Karitskaya, 1988b)*. The harmonic amplitudes of the expansion are functions of the angles of precessing j and of system inclination i, the relative radii of the disc r_d and the star r_*, the angular distribution of disc radiation intensity (generalization of the limb darkening coefficient U), the dependence of the radiation flux spectral density on the temperature ($\beta = d \ln F/d \ln T$) and the disc to star brightness ratio (γ). So one can determine these parameters by comparing the harmonic amplitudes with the observational ones, the coefficients u, β, γ, being derived from the model atmosphere. For Cyg X-1 in the B band:

$\beta=2.0$, $\gamma=0.13$, $u=-0.06$. In the case of the Cyg X-1 disc the star radiation is absorbed in the outer layer of the atmosphere. This leads to a weak outward gradient of temperature and the limb darkening coefficient turns out to be slightly negative. The reflection albedo is $A \sim 0.2$. The light scattering contribution to the photometric variability (B band) is $\leq 10\%$.

The data of the detailed analysis *(Kemp et al., 1987)* of the V 1357 Cyg photometric variability in B band have been used to find the amplitudes A_δ, A_φ, $A_{\delta\varphi}$, $A_{2\varphi}$ and $A_{2\delta}$ at a $(1.2-2.5)\sigma$ significance level for each of the amplitudes. In the fractions of 10^{-4} of the system brightness, we get $2A_\delta = 70 \pm 35$, $2A_{2\delta} = -43 \pm 35$, assuming that the precession is towards orbital motion we get $2A_\varphi = 71 \pm 27$, $2A_{\delta\varphi} = 39 \pm 35$, $2A_\varphi = 39 \pm 17.5$, assuming that the precession is opposite, which corresponds to the case of slaved disc we get $2A_\varphi = -5 \pm 29$, $2A_{\delta\varphi} = 42 \pm 37$, $2A_\varphi = 84 \pm 19$.

Qualitative analysis has shown that the amplitudes found cannot be fitted to the slaved-disc model with precession opposite to orbital motion The assumption of precession opposite to orbital motion is in better agreement with the optically-thin disc model: in the latter case, however, the amplitudes A_φ and A_δ cannot be fitted to each other at a level better than $\chi^2 \simeq 3$. At the same time, all the amplitudes (except $A_{2\delta}$) and the first harmonic of the orbital period of linear polarization of optical emission from Cyg X-1 are in agreement, at the level of a 5-value total $\chi^2 < 1$ (up to $\chi^2 = 0.5$), with the model of an optically-thick disc precessing towards the orbital motion of the system with the parameters

$$r_\star = 0.4-0.45, \quad r_d = 0.12-0.15, \quad i = 55-65^\circ, \quad j = 15-20^\circ$$

(in agreement with *Kemp et al. (1987)*). The second (main) harmonic of linear polarization was not examined because, on the basis of what has already been said, it is irrevelant to the accretion disc.

The direct precession of the disc may be due to the moment of the forces transferred to the oblique disc by gas stream out-flowing from the optical star *(Bochkarev, Karitskaya, 1988b)*. In this case the precession period is

$$P_p = 2\pi \, (v_{Kepl}/v) \, t/\tau_d \cos j$$

where v_{Kepl} and v are respectively the Kepler velocity of motion at the disc rim and the velocity of gas stream impact against the disc, t is the time within which the matter "leaks" from the rim to the interior of the disc. The observed P_p value of 294^d at $j = 15-20^o$ arises if $t \approx 10^d$, which agrees with the absence of delay of the X-ray variations with P_p relative to the optical emission variations with P_p. To the direct precession lead also the forces exerted on the disc by stellar wind and radiation pressure *(Kemp, 1988)*. The small value of t is probably due to the disturbance produced in the outer regions of the disc by the gas stream.

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OBSERVATIONAL EVIDENCE ON THE ASYMMETRY OF THE ACCRETION COLUMNS IN CLOSE BINARY SYSTEMS

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The magnetic field in AM Herculis-type binary stars is sufficiently large to cause the accretion flow to be channelled along field lines, and above the magnetic pole of the white dwarf an accretion column forms, which is the main source of the X-ray, UV, optical and near-IR emission *(Chanmugam and Wagner 1977, Stockman et al. 1977,* see also the recent reviews of *Lamb (1985)* and *Liebert and Stockman (1985))*. However, the angle θ between the magnetic axis and the column's axis deviates from zero, thus the column's axis is inclined with respect to the surface of the white dwarf (see *Andronov 1986a,b,* for details). In this case, the orbital changes of flux, radial velocities and polarization may be sufficently asymmetric.

The statistical dependence of the photovisual light curve of AM Her on its luminosity in the "active" state was derived by *Andronov (1985)*. It is highly asymmetric and, with increasing luminosity, the main maximum (hump) tends to be more prominent. The second maximum was not a constant feature of the light curve, contrary to the earlier observations of *Szkody and Brownlee (1977)* and *Gilmozzi et al. (1978)*. Thus the position and structure of the accretion column may have undergone long-term changes, as was originally pointed out by *Bailey and Axon (1981)* on the basis of photometric and polarimetric data.

Such changes may occur due to the cyclic variations of the orientation of the magnetic axis of the white dwarf in relation to the rotating binary stellar system, which are excited thereby making the accretion possible *(Andronov 1983, 1987a)*. This model of "swinging dipole" may be able to interpret the following phenomena observed in AM Herculis itself and in some other object of the same class:

a) cyclic variations of luminosity, which may be caused by the dependence of the "magnetic valve" conductivity on angle Θ.

b) cyclic variations of the phases of minima detected in AM Her (Andronov et al. 1982) and QQ Vul *(Andronov and Fuhrmann 1987)*.

c) correlation between the above mentioned phenomena *(Smykov and Shakun 1985)*.

Another source of the column's asymmetry is connected with the heterogenity of the accretion flow (see *Andronov 1987b* for a review). The initial plasma "blobs", while moving along field lines are transferred to long plasma "strips", so called "spaghettis", which bombard the shock at the top of the accretion column. In each "spaghetti" the cyclic variations of the structure existing during the penetration of such a "strip" through the shock may appear. Such a quasi-periodic oscillations usually interfer, and one may observe the sum of practically independent variations. The possible "global" oscillations of the column predicted by *Langer et al. (1982)* may be strongly affected by such "spaghetti".

However one may provide an observational test for choosing the more realistic model. In the "active" state, the number of "spaghetti" is larger than in the case of the "intermediate state". At smaller luminosity one may study the single flares ("spaghetti") or, at least, the smaller number of them, and thus may estimate their physical parameters. Because the structure of the column (and thus the characteristic "Noisar" frequency) depends on the value $\dot{m}/A$ (accretion rate per unit surface of the column's base), one may predict the increase of the "Noisar" cycle duration with decreasing luminosity in the "global" model. In the case of the "spaghetti" model the "coherence duration" is considered to increase as well, because of the increasing length of a single strip.

Thus, observations of the ultrashort-time variability of AM Her-type stars are very much needed to obtain the statistical dependence of the "Noisar" characteristics (intensity, frequency and coherence duration") on luminosity and orbital phase (presumably in the "active" state, to study the asymmetry of the column). This observational task needs time, but the results may be really important for investigating the exotic objects known as "AM Her-type stars".

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CLOSE BINARY SYSTEMS IN LATE EVOLUTIONARY STATE

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A lot of new observational and theoretical data have been published during the last decade concerning the close binary systems at a late stage of evolution. In this connection the Catalogue of Close Binary Systems at Late Stage of Evolution (editor: A.M. Cherepashchuk) has recently been prepared at Sternberg State Astronomical Institute Moscow. The authors of this catalogue are: A.A. Aslanov, D.E. Kolosov, N.A. Lipunova, T.S. Khrusina and A.M. Cherepashchuk. The catalogue is due to be published at the end of 1988 by Moscow University Press. The catalogue contains about 300 objects of different kinds: β Lyr and W Ser type systems, WR+OB binaries, run-away OB stars, X-ray binaries of different types (massive and low-mass X-ray binaries, X-ray transients, bursters, QPO, etc.), the SS 433 object, single line WR stars with probable relativistic companions, pre-cataclysmic variables, cataclysmic variables, symbiotic stars, intermediate polars, polars and binary radio-pulsars.

For the majority of the systems, the finding charts and reference stars are presented in the catalogue. The catalogue is likely to be of use both for theoreticians and for observers because it contains basic parameters of close binary systems: masses, radii, luminosities of the stars, magnitudes, spectral types, periods, etc.

Many properties of close binary systems at the late evolutionary state are well explained by the modern theory of evolution of close binaries with mass exchange. Our investigations of WR stars in eclipsing binary systems allow us to estimate the correct values of radii and temperatures of these stars. Based on our results the WR stars are helium-rich remnants formed as a result of the first mass exchange in massive close binaries.

The discovery of optical eclipses in the unique object SS 433 allows us to estimate the basic parameters of this massive X-ray binary. Judging from our interpretation of optical eclipses in the SS 433 system, this object is a massive X-ray binary system (similar to Cyg X-1 or Cen X-3) in an advanced stage of evolution: at this stage the star is overfilling its Roche lobe. Due to very high mass transfer in this system an optically bright accretion disk is formed around the relativistic companion. Thus, SS 433 is a massive X-ray binary system at the supercritical accretion regime.

A number of single-line WR stars have recently been discovered as close binary systems containing low-mass companions which may be neutron stars accreting in a strong stellar wind of WR star.

Mass determinations of X-ray pulsars in X-ray binary systems have been made as well as of black hole candidates. The masses of X-ray pulsars do not exceed 3 M_o - this being the theoretical upper limit for neutron stars predicted by Einstein's theory of general relativity. The mean value of the mass of X-ray pulsars (neutron stars) obtained from analysis of 7 X-ray binary systems is 1.4 M_o. All black hole candidates have a mass that exceeds 3 M_o and none of the 4 black hole candidates shows periodic pulsations of the X-ray radiation characteristic for the magnetic rapidly rotating neutron stars.

The search for relativistic companions for OB run-away stars by spectroscopic and photometric methods is now in progress at Moscow's Sternberg State Astronomical Institute.

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RESULTS OF PHOTOELECTRIC OBSERVATIONS OF V 533 HERCULIS

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At the Workshop of the head of Project I "Complex Investigations of Stars and Stellar Systems" of the Problem Commission "Physics and Evolution of Stars" of the multilateral cooperation of the Academies of the Socialist Countries, held in Suzdal in 1985, the star V 533 Herculis was included in the program of cooperative investigations for the coming two years within a new structure of the Commission. Additionally, it had earlier been suggested that we observe this star photoelectrically at Abastumani Astrophysical Observatory of the Georgian Academy of Sciences using the AZT-11 telescope.

The nova V 533 Her is of significance in the sense that light variations were observed with the period 63.6 sec, though no such variations were observed later *(Robinson and Nather 1983)*. Moreover, the orbital period of the star is believed to be equal to 0.28 day *(Ritter 1984)*. However this value needs to be confirmed. The fact that some long-period light variations with an amplitude of more than 1.0 mag. as well as the light variations during the night with the amplitude of about 0.2 mag. were observed at Peking Observatory, attracts one's attention.

The star V 533 Her was observed at Abastumani Astrophysical Observatory from April - June, 1986 with a two channel electrophotometer attached to the AZT-11 telescope. The electrophotometer was designed and manufactured at the observatory. The primary mirror of the telescope is 1.25 m, the equivalent focal length being 16 m. The photometer offers the possibility of simultaneously measuring the stars removed from each other at an angular distance of up to 22'.

Within 7 nights the light of the star was measured in B filter during

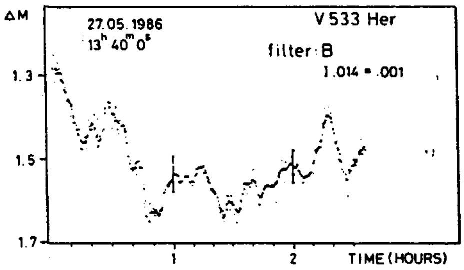

Figure 1.

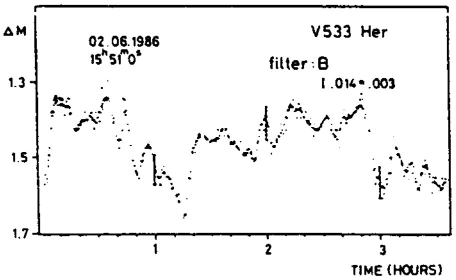

Figure 2.

a few hours at night. The longest observation lasted 3.5 hours. The star "E" from *Löchel*'s paper *(1966)* served as the comparison. The integration time was 10 sec. Due to the fact that at a distance of 12'' from V 533 Her there is a star fainter than that under investigation by 2 magnitudes, we used a 16'' diaphragm in our observations. The results are given in Figs. 1-4. The time is plotted along the X-axis and the magnitude difference between the comparison star and the variable along the Y-axis. Each point is obtained by averaging two observations. On average, the error of a measurement is 0.016 mag. The slipping mean values are plotted as well. Their measurement error is, on average, 0.005 mag. It is seen that within a

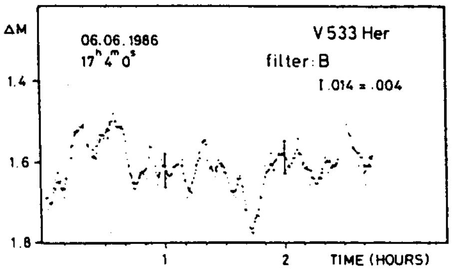

Figure 3.

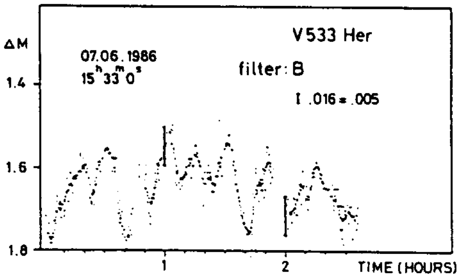

Figure 4.

night there are some irregular variations with an amplitude of 0.3 - 0.4 mag. confirming *Hao Xiang-Liang*'s and *Mei Bao*'s results *(1984)*. Comparison of observations performed on different nights shows certain differences in the character of the light variation. Single observations were averaged merging every 30 points into one. Then using the elements:

$$\mathrm{Min}_{\ominus} = 2446565.4579 + 0\overset{d}{.}28\ E$$

we reduced them to the same period.

Figure 5 shows a corresponding curve. As can be seen not all the

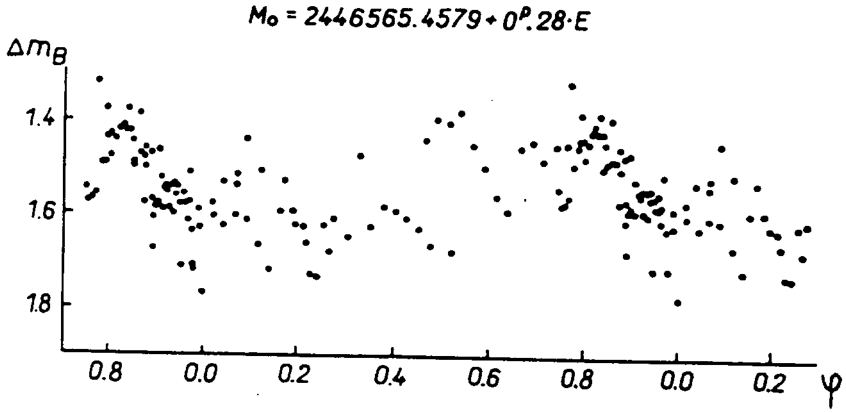

Figure 5.

phases overlap equally well. But judging by our results it can be concluded that the light curve does not show any pronounced light variations with the period of 0.28 day suggested earlier. It might be that apart from the 6 hours period in this case we are dealing with some more harmonics with

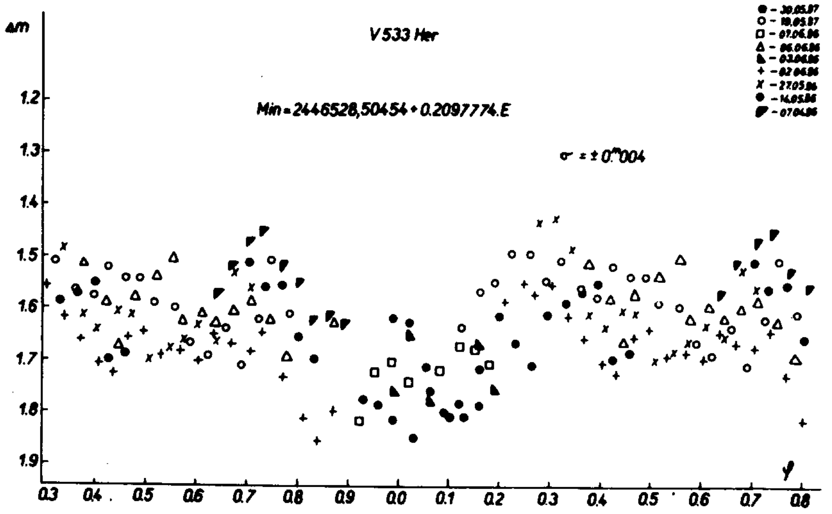

Figure 6.

shorter periods superimposed on this particular period. In order to solve the problem once and for all further observations are needed - and it is just that is envisaged by our program.

In addition, it should be noted that in *Hutching's paper (1987)*, the author gives a new spectroscopic period of the star : $0\overset{d}{.}209774$. Using this new period and selecting the epoch according to our observations a mean curve is plotted in B by averaging the observational data with 30 points into one.

Figure 6 shows that our photoelectric observations confirm Hutching's spectroscopic data through in our observations there occur certain irregular light variations during the night.

Consequently, to finally establish the nature of the light variations for the star under study, more detailed analysis of the data obtained must be carried out.

The results obtained for two pairs of parameters q,i ($q=0.320$, $i=77\overset{o}{.}5$ and $q=0.146$, $i=82\overset{o}{.}$) are presented in Figure 1. Only the egress branches of the eclipses are reproduced here.

The phase $\Phi_{1/2}$ at which half the flux is eclipsed occurs nearest phase zero for case a_1 and furthest for case a_3. Such large differences in the half width of the eclipse, especially for $q=0.320$, produce only slight differences in the relation i(q). A detailed analysis is due to published in Acta Astronomica.

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PREVIOUS OPTICAL FLARE IN THE SHORT PERIOD RS CVn SYSTEM SV Cam

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Short period RS CVn stars are active stars showing "solar-like" activities. They display all the surface phenomena of our Sun, viz. spots flares, chromospheric activity, etc. In the case of the RS CVn systems however, all these activities are much more pronounced, sometimes even by orders of magnitude. This situation is somewhat different in the case of observed optical flares. There have been only two reported unquestionable optical flare events in RS CVn systems. Both of them occurred in a short period RS CVn system: in SV Cam *(Patkós 1981)* and in XY UMa *(Zeilik et al. 1983)*. Although *Srivastava (1983)* reported some "flare-like activity" in AR Lacertae, no other observed optical flare is known in RS CVn systems.

Therefore the question remains: Why do we not observe optical flares in long period or regular RS CVn systems? These systems are very well observed and show flare activities in other wavelengths. In view of this, it is very important to study RS CVn systems showing optical flares. Table 1 contains the main characteristics of SV Cam and XY UMa.

Table 1.

	SV Cam	XY UMa
(eclipse) period	0.59	0.48
brightness	8.40 - 9.11	9.50 - 10.17

distortion wave ampl.	0.1	0.11
mass ratio (hotter/cooler) (solar units)	1.0/0.7	0.95/0.70
radius (hotter/cooler) (solar units)	1.2/0.7	0.98/0.73
spectra	G2-3 V / K4 V	G2-5 V / K5 V

The two systems are very alike. In both cases it is questionable which component is the active one. According to *Geyer (1976)* in the case of XY UMa the primary component is: - in the case of SV Cam the migrating distortion wave goes through both the primary and the secondary minima. Therefore, we have to assume that the spot activity of the system originates from both the hotter and cooler component. The flare activity itself originates with greater probability from the secondary component because two of the reported flares occurred at the bottom of the primary minimum when the hotter component is eclipsed.

Table 2 contains the main characteristics of the observed flares:

Table 2

		SV Cam		XY UMa
orb. phase	0.61	0.97	0.99	0.57
duration (min)	43	18	9	30
ΔU (mag)	0.12	0.15	0.05	0.33
ΔB (mag)	0.05	0.06	0.03	0.13
ΔV (mag)	0.03	0.03	-	0.09

Because optical flares are so limited in these systems, it might be important to mention, that I have observed a previous optical flare in

SV Cam at J.D. 2441960.4585 . The observation material was published *(Patkós 1982, page 86.)* without mentioning the three point flare event observed only in the U light curve. The main characteristics of this previous optical flare were the following:

orbital phase	0.71
duration (min)	38
ΔU (mag)	0.8

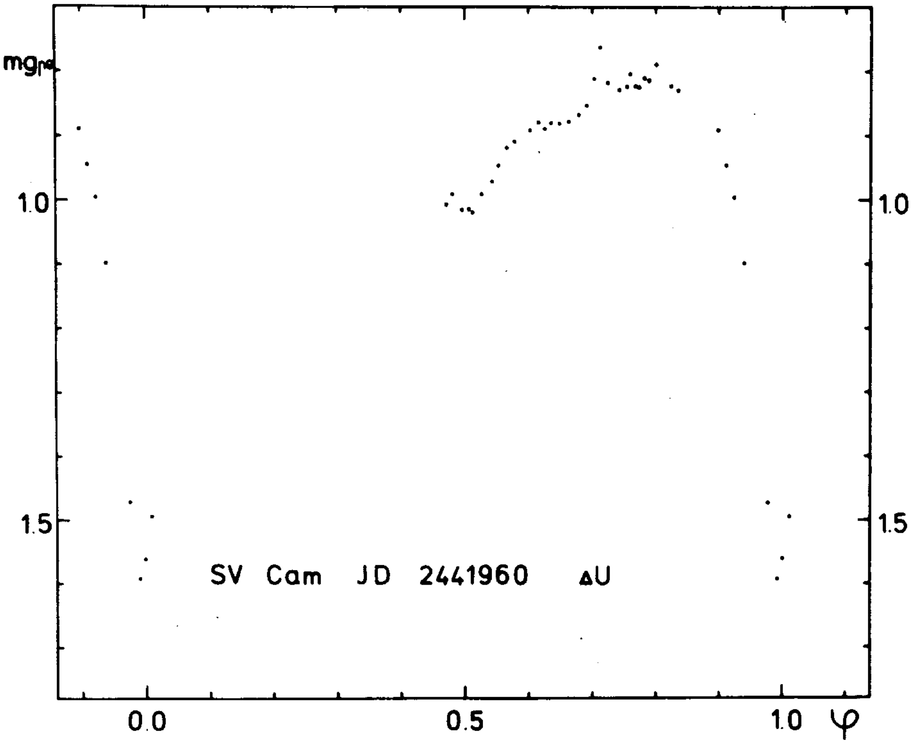

Figure 1.

As the observed light curve (Fig. 1.) shows, in the time interval following the flare there were also some flare-like spikes in the observed

U light curve of SV Camelopardalis.

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PERIOD CHANGES IN THE CLOSE BINARY SYSTEM QQ CASSIOPEIAE

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New photoelectric observations of QQ Cas were obtained and the epochs of minima were derived. The secular variations of the period have been found and an explanation for their causes is suggested.

The variable star QQ Cas (BD +59°2765 = BV 73) was discovered by *Kippenhahn (1955)*. The complete list of the photographic epochs of minima was published by *Busch (1975)*. Three new epochs of minima are included in the paper of *Braune and Lichtenknecker (1986)*.

The light curve given by *Busch (1975)* is clearly of β Lyrae-type. The spectral type of one component is B2, the spectrum of the second component is not known.

As the star has very rarely been observed in the last two decades, we put it into the observational program at Skalnate Pleso Observatory. The observations were obtained with the photoelectric photometer installed in the 0.6/7.5 m reflecting telescope in the years 1985-1987. During seven nights, over 1400 observations (in B region) were obtained. The observations are due to be published elsewhere. The derived epochs of minima are in Tab. 1.

Table 1.

J.D. hel.	m. e.	type of min.
2446743.3985:	±0.0025	pri
6756.2465	±0.0025	pri
7060.4305	±0.0015	pri
7061.5030	±0.0010	sec

The spread of the individual epochs of minima in the O - C diagram published by *Busch (1975)* is very wide. Many published epochs are actually the epochs when the star has been found to be fainter. Therefore we decided to divide the whole observational period into 18 intervals. The limits of the intervals as a rule coincide with the season in which no observation was obtained. As the shift of the secondary minimum was not observed we grouped together the primary and the secondary minima. The number of observed minima in one interval varies from 9 to 23. Thus we obtained 18 mean epochs of minima. Due to their large deviation, one mean epoch of minimum and the visual epoch of minimum from the table published by *Braune and Lichtenknecker (1986)* were omitted. Two epochs of minima obtained by *Zonn and Semeniuk (1959)* included in the list of *Busch (1975)* were not used for the calculation of mean epochs of minima but were used directly for the ephemerides calculation.

The recent calculation of elements published by *Braune and Lichtenknecker (1986)* has shown that the period is longer when the observations obtained only in recent years are used. The ephemeris with the secular term derived by us is as follows:

$$\text{Min. I.} = \text{J.D. } \underset{\pm 38}{2434330.1918} + \underset{\pm 43}{2.14204474}E + \underset{\pm 11}{1.71} * 10^{-9}E^{2}$$

The mean error of the secular term is relatively low and thus the increase of the period is a real effect. The observational period was divided into two parts for which linear ephemerides were computed. The linear ephemeris before J.D. 2435000 is:

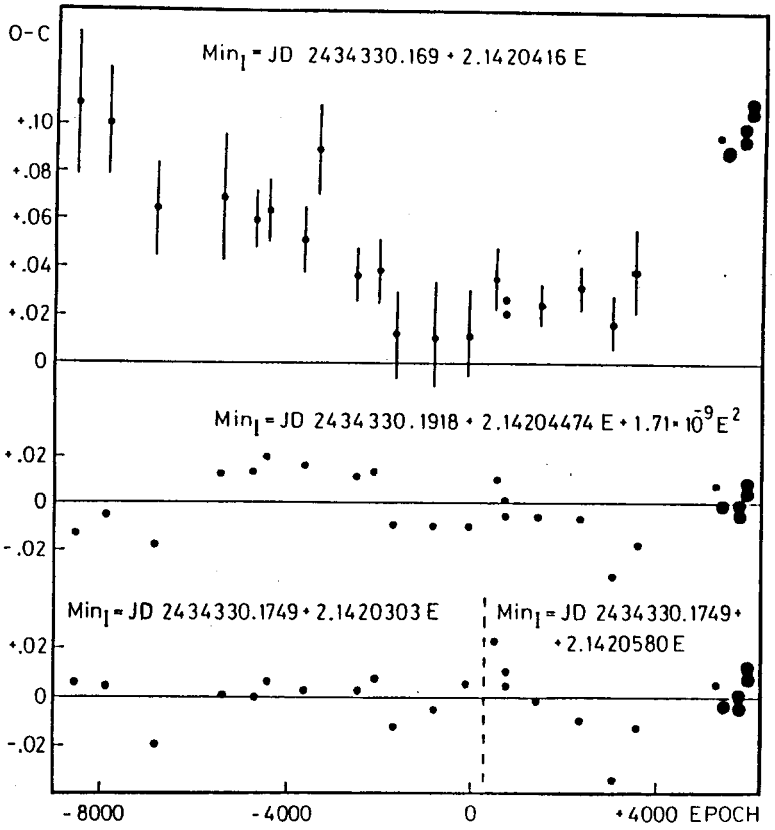

Figure 1.

$$\text{Min. I.} = \text{J.D. } 2434330.1749 + 2.14203027E$$
$$\pm 47 \qquad \pm 96$$

The linear ephemeris for the time interval after that date is:

$$\text{Min. I.} = \text{J.D. } 2434330.1726 + 2.14203027E$$
$$\pm 47 \qquad \pm 14$$

The sum of $(O - C)^2$ values is very close being by 3.5 percent lower for linear ephemerides.

The secular increase of the period can be explained within the scope of the mass transfer theory or by the light-time effect. For the mass loss we obtain the value of $\Delta m/m = 5.8 * 10^{-7}$ per year. After removing the quadratic term the rest of the deviations could be explained by a non-uniform mass transfer if these deviations are real.

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OPTICAL BEHAVIOUR OF THE POLAR AM HERCULIS

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AM Herculis is the prototype star of a subgroup of cataclysmic binaries consisting of a white dwarf as primary, and a low-mass main sequence star as the secondary component. This type of close binary is characterized, on the one side, by a strong magnetic field of the white dwarf of about $B \approx 10^7 - 10^8$ Gauss and, on the other side, by a gas stream originating from the main sequence star. This gas stream spills over to the primary and is conducted by the magnetic field. This process causes an accretion column on the magnetic pole of the white dwarf which is facing the secondary. The existence of an accretion disc around the primary can also be expected.

The orbital periods of this group of stars are very short. The period of AM Herculis amounts to $p = 0\overset{d}{.}12892737$, and the corresponding occultation-light-changes of about 0.5 magnitudes are superimposed upon the overall light curve.

This report deals with the long-term behavior of AM Herculis as it appears from observations given by *Hudec and Meinunger (1977)* and by *myself (1982, 1984a, 1984b, 1986a, 1986b, 1987)*. My observations were obtained between 1982 and 1987 on 643 blue-sensitive and 40 photovisual plates of the Schmidt camera (50/70/172 cm) of Sonneberg Observatory from more than 230 nights. Visual observations given by the French Association of Variable Star Observers published in the *AFOEV Bulletin (1982 - 1987)* are included.

The optical, the polarimetric and the X-ray behavior of AM Herculis type stars are mainly determined by the characteristics of their accretion columns. Generally we distinguish two photometric states in this group of stars: The low state, which is given by inactivities in the minimum brightness and the high state, which is caused by X-ray heating.

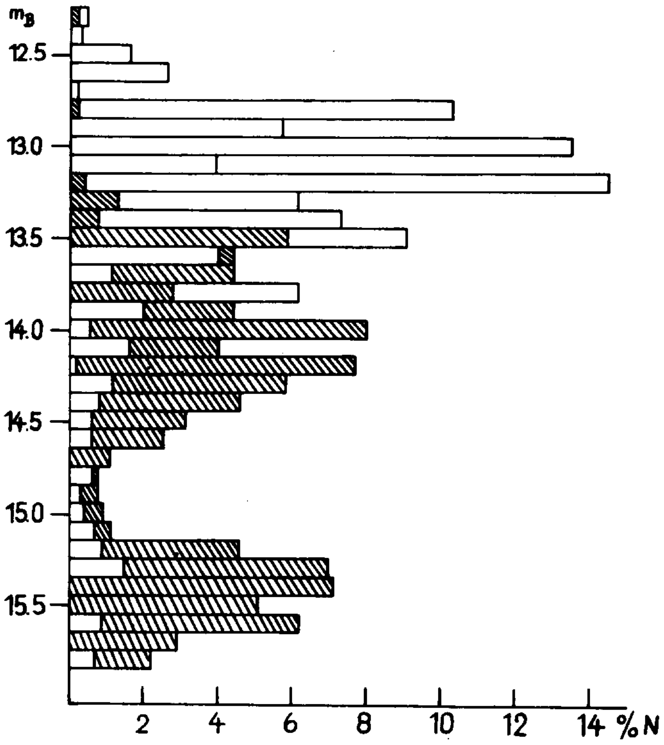

Figure 1.

In the case of AM Herculis the mean levels of the two states can be shown by the brightness distribution of the observations in B and V. In Fig. 1 the brightness distribution in B is given. The hatched areas represent observations obtained from Schmidt plates. The other ones belong to series of observations given by Meinunger and Hudec obtained on sky patrol and astrograph plates of Sonneberg Observatory.

From the brightness distribution in B it can be seen that the low state is characterized by observations between $m_B = 14^m.8$ and $m_B = 15^m.8$ with a mean level of m_B _ $15^m.3$. On the other hand all observations between $m_B = 12^m.3$ and $m_B = 14^m.8$ belong to the high state. The mean level in this latter state varies with time as can be seen in the following. But this fact is also illustrated in Fig. 1 if one compares the mean level of the observations given by Meinunger and Hudec at $m_B \approx 13^m.0$ with that obtained from my observations at $m_B \approx 14^m.0$.

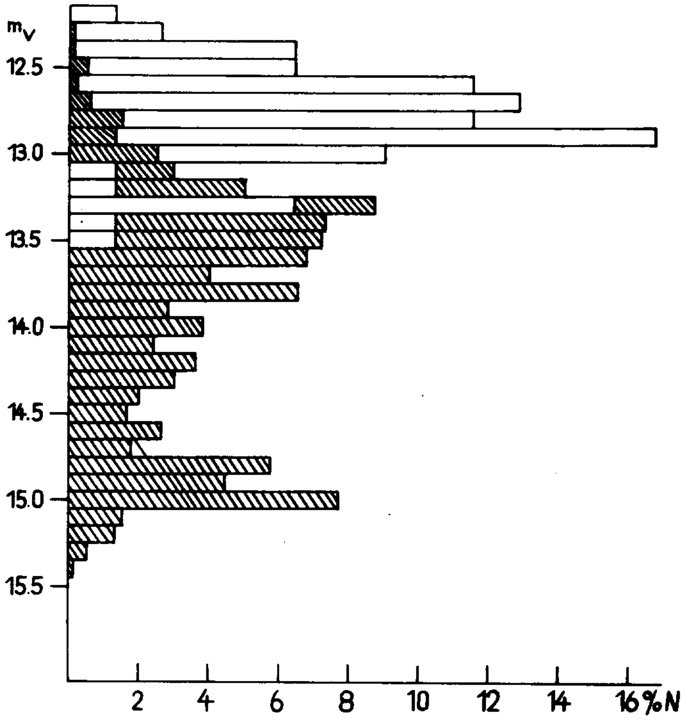

Figure 2.

The brightness distribution obtained from the visual range, shown in Fig. 2, confirms the results obtained from the blue range. Observations of the low state are situated between $m_V = 14^m.5$ and $m_V = 15^m.4$. The mean level there amounts to $m_V = 14^m.83$ taking into account the observations given by Verdenet (AFOEV). In the high state we find observations between $m_V = 12^m.2$ and $m_V = 14^m.5$. The mean levels in the high state vary with time in a similar way to those in the blue range.

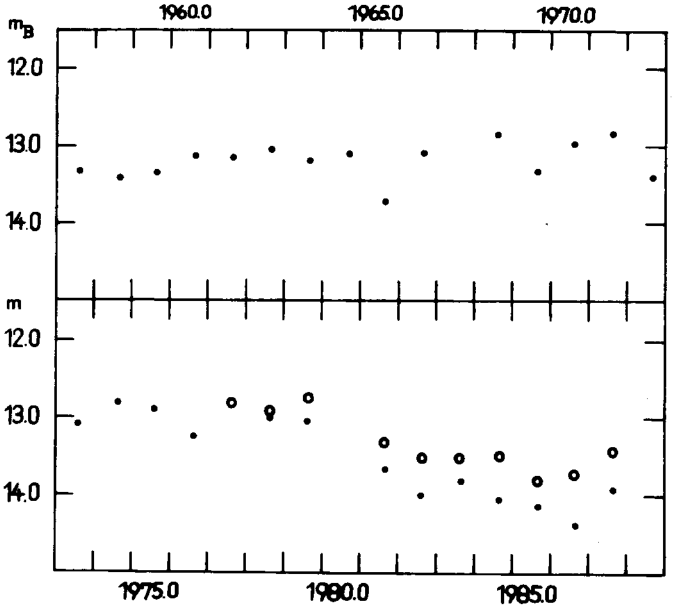

Figure 3.

In Fig. 3 the mean values of the brightness of AM Herculis obtained from all observations of the high state of each season, which represent the seasonal mean levels, are plotted against time, beginning with the year 1957. In this diagram dots characterize the behavior of the mean high state brightness in the blue range: circles characterize the behavior in the visual range.

Figure 3 illustrates the continuous increase in mean brightness between 1957 and 1970 from $m_B = 13^m.4$ to $m_B = 13^m.0$. After a period of 10 years of nearly constant mean brightness, in 1980 the star started a decrease from $m_B = 13^m.0$ to $m_B = 14^m.4$ within the following 6 years. The lowest mean brightness was observed in 1986, that is, just in that year in which the low state had its longest duration - as we can see below. The decrease in mean brightness of the high state between 1980 and 1986 is confirmed by the visual observations.

The long-term behavior of AM Herculis between 1982 and 1987 can be seen from the light curves given in Fig. 4. There, my observations in B are drawn in the upper light curve: the visual ones obtained and published by the AFOEV are grouped in the lower one.

As we can see from the two light curves, there are phases of the low and the high state which vary in an irregular manner. From the curves shown the following general conclusions can be drawn:

1). The durations of the minimum phases, or better of the low state phases, are very different. One of the shortest minima was observed in 1982 between April 15 and September 24. The longest one, on the other hand, amounts to about 290^{d} crossing the observation seasons 1985/86 if we assume that the long-lasting minimum of 104^{d} at the beginning of the series of 1986 is the continuation of the 120^{d} low state at the end of the year 1985.

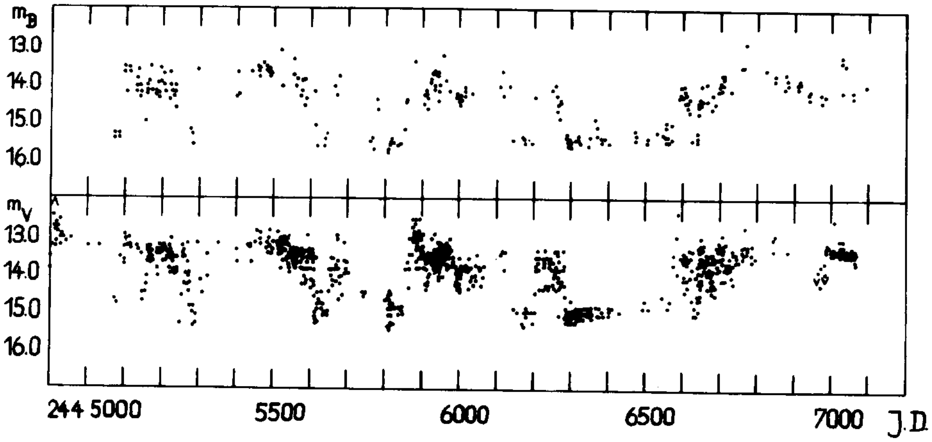

Figure 4.

2). In the high state a flare was observed on July 12, 1983. During this flare the brightness of AM Herculis increased from $m_B = 13^{m}.74$ to $m_B = 12^{m}.33$, which is an increase of 1.41 magnitudes within $0^{d}.024$ This flare proved to be unique: in the series of nights of the following years nothing of this kind was ever observed again.

3). In each case the high state of AM Herculis starts from the and is caused by X-ray heating. Therefore it seems to be especially necessary to investigate the low state, including the influences of the orbital light changes. At Sonneberg Observatory investigations on this subject have started.

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SPECTRAL PECULIARITIES OF V 367 CYGNI - A CLOSE BINARY SYSTEM AT THE STAGE OF RAPID MASS EXCHANGE

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Of greater actual importance has become the investigation of close binary systems with nonstationary phenomena as objects at the critical stage of their evolution. The system of V 367 Cygni is one of the most interesting objects of this type. This system is at the short-term stage of fast mass exchange as is manifested by the numerous effects observed: light curve deformation, variation in period, emission in lines of Balmer series. The spectrum of V 367 Cygni is a bright example of a "shell"-spectrum and our investigations *(Karetnikov and Menchenkova 1987)* have shown, in the atmosphere of the primary star there are formed only wings of hydrogen lines and lines of Mg II (λ = 448.1 nm). A complete bibliography of papers devoted to the investigation of V 367 Cygni is given in *Karetnikov and Menchenkova (1985)*.

Our research work is based upon spectrograms obtained with the 6 m telescope at SAO of the Soviet Academy of Sciences, the dispersion being 9 and 14 A/mm as well as with the 122 cm telescope of CrAO of the Soviet Academy of Sciences, the dispersion being 37 A/mm. The spectral region investigated ranges from λ= 360 to 490 nm.

The presence of emission in the first terms of Balmer series including the H_γ line is a characteristic peculiarity of V 367 Cyg spectrum throughout the whole period.

The emission intensity in line H_α varies with the phase - amounting to 2.4 at the primary minimum and to 1.1 at the maximum *(Karetnikov and Prekrestnyi 1973)*, in units of a continuous spectrum. Line H_β has a complex structure, the Be profile is of particular interest. Whereas in 1981 the blue and red emission component lines of H_β had different intensity, in

1982 the intensity of the components became similar. This resulted in a central absorption shift as shown by radial velocity measurements: in 1981 the velocity of the latter was -41 km/sec whereas in 1982 it increased to -4 km/sec. Another characteristic peculiarity of V 367 Cygni is the presence of numerous lines of neutral and ionized metals in the spectrum which lines show a practically constant radial velocity and a marked asymmetry. The asymmetry observed seems to be caused by a velocity gradient in the aggregate envelope of the system wherein the line spectrum observed is formed. The most intensive lines of FeII have emission companions. From metal lines using the criteria of spectral classification by Kopylov, we determined the envelope temperature which proved to be equal to 9500° *(Karetnikov and Menchenkova, 1985)*. From the number of the last line observed of the Balmer series of hydrogen we estimated the concentration of free electrons in the envelope $\lg n_e = 11.96$ ($m = 30$).

The physical conditions in the envelope of V 367 Cygni were determined by the curve-of-growth method. The curves of growth have been constructed from lines FeI, FeII, TiII, CrII separately for the most interesting phases of the light curve 0.0, 0.2, 0.5, 0.7 when one can expect a change of conditions in the envelope. A mean curve of growth has been constructed as well using mean values of equivalent widths of lines. The results of the determination are given in Table I.

Table I.

	FeI $\Theta_{ex}=0.82$		FeII $\Theta_{ex}=0.65$		TiII $\Theta_{ex}=0.56$		CrII $\Theta_{ex}=0.61$	
	v_t	$\lg N_\tau$	v_t	$\lg N_\tau$	v_t	$\lg N_\tau$	v_t	$\lg N_\tau$
$0^{d}.0$	-	-	33±9	6.11	18±4	6.41	19±9	-
$0^{d}.2$	-	-	31±3	5.97	22±7	6.88	18±6	5.36
$0^{d}.5$	15±1	5.88	26±6	5.85	30±7	6.92	22±7	5.44
$0^{d}.7$	13±1	5.61	26±5	5.93	23±7	6.68	18±5	5.40
	12±2	5.80	27±5	5.85	25±8	6.65	20±5	5.39

The complete absence of stellar origin details in the spectrum is a characteristic peculiarity of the V 367 spectrum, and this markedly impedes investigations into the nature of stellar components. Due to careful position measurements we could detect a single stellar line MgII at λ=448.1 nm whereas investigation of the contours of hydrogen lines H_γ and H_δ has shown that they are of complicated structure, a narrow envelope core being superimposed upon the wide line of atmospheric origin. The radial velocities of the cores of these lines are constant in time and space being equal to -4 km/sec whereas the wings show great shifts with the amplitude up to 160 km/sec and coincidence with the phase of orbital motion of the primary star's system. The wings of these lines appear to be described equally well by three models: $T_{eff} = 12000_{o}$, lg g = 2.5, - $T_{eff} = 16000^{o}$, lg g = 3.0, - $T_{eff} = 20000^{o}$, lg g = 3.5. The consideration of higher terms of Balmer series $H_8 - H_{14}$ with the use of synthetic hydrogen spectra calculated by Pavlenko (Main Astronomical Observatory of the Ukrainian Academy of Sciences) made it possible to limit the temperature range to $T_{eff} = 12000^{o} - 16000^{o}$, lg g = 2.5 - 3.0.

The line MgII (λ = 448.1 nm) is not sensitive to the magnitude of lg g but the equivalent width of the line decrease with the temperature increase. It enabled us to obtain additional information on the physical parameters of the primary star atmosphere of the V 367 Cyg system. It appeared that $T_{eff} = 12000^{o} - 14000^{o}$, lg g = 2.5 - 3.0 (assuming that lg N (Mg) = lg N_o (Mg). We failed to elicit any detail which could be identified with the spectrum of the second component. There came as no surprise as the difference of stellar magnitudes of the bright star and a companion according to *Fresa (1966)* is not less than 1.5 mag.

The absence of helium lines is a characteristic peculiarity of V 367 Cyg spectrum though the lines of helium should be observed at the temperature of 12000^{o} which we determined for the primary star. It should be noted that these lines are confidently observed in the spectrum of the primary star of the β Lyr system having close values of T_{eff} and lg g. The difference between the spectra of these two systems testifies to the fact that V 367 Cygni is at an earlier stage of evolution than β Lyr in which the stage of a fast mass exchange is completed resulting in an enhanced helium abundance: N(He)/N(H) = 1.55 *(Leushin et al. 1979)*. Possibly in the case of V367 Cyg the helium lines are blended to a greater extent by spectral lines of other elements which formation proceeds in a more powerful and more extended envelope.

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SOME REMARKS ON ECLIPSING BINARIES SEEMING TO BE INCONSISTENT WITH GENERAL RELATIVITY

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At the present time the eclipsing binary systems are very important objects of quite different parts of astrophysics due to their numerous advantageous observational and theoretical features. Two of these properties are the possibility of checking different models of the internal structure of stars and the testing of General Relativity (GR) by studying apsidal motion.

There exist a lot of eclipsing systems having well-observable periastron motion. Many of them have reasonable theoretical representation based on several model computations of polytropic stars. The theoretical rates of apsidal motion obtained by predicted internal structure constants are in fair agreement with the observed ones in most cases of the given binary systems. Besides them, we know some binaries showing considerable periastron advance in consequence of GR, due to their special physical parameters. Koch turned attention to such systems in which the relativistic contribution to the net rotation of the line of apsid is comparable with the classical (CL) effect *(Koch, 1973)*. These binaries are EK Cep, α CrB, V1143 Cyg, DI Her and RR Lyn. This list has, since, been supplemented: Giménez proposed 23 candidates and 13 additional eclipsing variables for the study of relativistic apsidal advance *(Giménez, 1985)*. In the last decade some of these systems have gained great importance because these binaries seem to show much slower apsidal rotation than expected from the combined classical and relativistic (CL+GR) effects. We would like to make some additional remarks on this problem.

The above mentioned discrepancies have been discussed by several authors. Except for the attempts to remove the observed differences within

TABLE 1.

ACCEPTED PHYSICAL PARAMETERS OF THE PROBLEMATICAL BINARIES

SYSTEM:	REFERENCES:	M_1	M_2	P_{SID}	e	l(x10^9cm)	
		($M_\odot$)	($M_\odot$)	(days)		M.w.	P.w.
Y Cyg	*Giménez et al.,1987*	16.7	16.7	2.9963310	0.1456	6.5	6.76
		±4	±4	±37	±10		±16
DI Her	a)*Popper,1982*	5.15	4.52	10.5501585*	0.4883	2.0	2.014
	b)*Guinan & Maloney,1985*	±10	±6	±25	±10		±32
	c)*Martynov & Lavrov,1987*	(a)	(a)	(b)	(c)		
AG Per	a)*Popper,1974*	4.53	4.12	2.0287298	0.068	1.8	1.810
	b)*Giménez et al.,1987*	±7	±6	±91	±1		±26
	c)*Güdür,1978*	(a)	(a)	(b)	(c)		
AS Cam	*Khaliullin & Kozyreva,1983*	3.3	2.5	3.4309475*	0.1695	1.3	1.24
		±1	±1	±16	±14		±4
V889 Aql	a)taken from *Moffat,1984*	2.5	2.5	11.1208715*	0.35	1.0	1.08
	b)*Giménez & Scaltriti,1982*	±5	±5	±111	±3		±20
		(a)	(a)	(b)	(b)		
EK Cep	a)*Popper,1987*	2.02	1.12	4.4277938	0.120	0.66	0.708
	b)*Giménez & Margrave,1985*	±1	±1	±74	±3		±4
	c)*Khaliullin,1983*	(a)	(a)	(b)	(c)		
V1143 Cyg	*Giménez & Margrave,1985*	1.33	1.29	7.6407418	0.540	-	0.604
		±3	±3	±15	±5		±12

M_1 and M_2: masses of the components

e : orbital eccentricity,

M.w.: values of "l", taken from Moffat's work (*Moffat, 1984*),

P.w.: values of "l", resulted from present work.

the range of Newtonian Mechanics, Moffat proposed to interchange GR with a Nonsymmetric Gravitational Theory (NGT) elaborated by himself. From this new theory another formula follows for the yearly rate of apsidal motion, instead of the standard Einsteinian one *(Moffat, 1984)*. This new expression involves a factor, "λ". This "λ" not only reduces the rate but it may also yield a negative sign for it, depending on the value of a constant of integration "l" appearing in the formula of "λ" *(Moffat, 1984)*. With his new theory Moffat could explain the observed behaviour of these peculiar systems. In his article he presented the results of his calculations for μ^1 Sco, Y Cyg, DI Her, AG Per, AS Cam, V889 Aql, EK Cep and PSR 1913+16 *(Moffat, 1984)*. He compared the CL+GR and the CL+NGT combined effects with the observed values of the apsidal motion rates and concluded that NGT can provide a satisfactory explanation for these binary systems.

COMPARISON OF THEORY WITH OBSERVATIONS

As a first step, we repeated the computation of $\dot{\omega}_{GR}$ and $\dot{\omega}_{NGT}$ (contributions of GR and NGT to the total effects) together with the calculation of their mean errors, using the recently published or/and the best known physical parameters of the above mentioned systems (with the exception of μ^1 Sco and PSR 1913+16, but with an additional binary V1143 Cyg).

The accepted parameters and their mean errors are shown in Table 1, with the source references. In the fifth column of this table the sidereal orbital periods can be found with their approximate errors. P_{SID} values are sometimes calculated (indicated with "*"), and in the other cases they are taken from the authors directly (if they were calculated by the author himself). In the last two columns we show the values of the parameter "l" given by *Moffat (1984)* and those resulting from our calculations, using the expression which is valid only for non-degenerated stars (taken from *Guinan and Maloney, 1985*).

In Table 2 we present the theoretical values of $\dot{\omega}_{GR}$ and $\dot{\omega}_{NGT}$ resulting from our calculations (with their errors), and Moffat's $\dot{\omega}_{NGT}$ (Moffat has not published the errors). In the third column, one can see the least erroneous (or in some cases the recently published) observed rates of apsidal motion ($\dot{\omega}_{OBS}$). The results of computations of the Newtonian contributions are taken from several authors, and presented in the last column of Table 2. Their sources with the references are also shown.

Taking into account the data in Table 2, one can establish:

i) The errors of the observed physical parameters of binary systems cause

TABLE 2.

COMPARISON OF THE THEORETICAL AND OBSERVATIONAL APSIDAL MOTION RATES

SYSTEM:	$\dot{\omega}_{OBS}$	$\dot{\omega}^{THEOR}_{CL+NGT}$ (Δ_1)	$\dot{\omega}^{THEOR}_{CL+GR}$ (Δ_2)	$\dot{\omega}^{THEOR}_{GR}$ (this	$\dot{\omega}^{THEOR}_{NGT}$ work)	$\dot{\omega}^{THEOR}_{NGT}$ M. W.	$\dot{\omega}^{THEOR}_{CL}$
Y Cyg	7.569	5.588	13.538	0.338	-7.612	-6.55	13.2
	±24			±5	±28.623		
	(a)	(+1.981)	(-5.969)				(b)
DI Her	0.00770	0.0043	0.0426	0.0233	-0.0150	-0.0141	0.0193
	±7	±55	±29	±3	±29		±26
	(c)	(+0.0034)	(-0.0349)				(d)
AG Per	4.735	5.330	7.189	0.259	-1.600	-1.57	6.93
	±36			±3	±1.141		
	(a)	(-0.595)	(-2.454)				(b)
AS Cam	0.136	0.238	0.442	0.085	-0.119	-0.185	0.357
	±15	±98	±33	±2	±67		±31
	(e)	(-0.102)	(-0.306)				(f)
V889 Aql	0.0151	0.0141	0.0205	0.0119	+0.0055	+0.0072	0.0086
	±49			±19	±48		
	(g)	(+0.0010)	(-0.0054)				(b)
EK Cep	0.0823	0.0324	0.0652	0.0362	+0.0034	+0.0117	0.029
	±75	±102	±102	±2	±2		±10
	(h)	(+0.0499)	(+0.0171)				(i)
V1143 Cyg	0.0337	0.0279	0.0419	0.0180	+0.0040	-	0.0239
	±20	±141	±139	±4	±6		±135
	(j)	(+0.0058)	(-0.0082)				(j)

References:
a: *Giménez et al.,1987*
b: *Moffat,1984*
c: *Martynov and Lavrov,1987*
d: *Guinan and Maloney,1985*
e: *Maloney et al.,1986*
f: *Khaliullin and Kozyreva,1983*
g: *Giménez and Scaltriti,1982*
h: *Hill and Ebbinghausen,1984*
i: *Khaliullin,1983*
j: *Giménez and Margrave,1985*

M.W.: Data are taken from *Moffat (1984)*. All rates are in (deg/years).

$\Delta_1=\dot{\omega}_{OBS}-\dot{\omega}^{THEOR}_{CL+NGT}$; $\Delta_2=\dot{\omega}_{OBS}-\dot{\omega}^{THEOR}_{CL+GR}$.

very large uncertainties in the output $\dot{\omega}_{NGT}$ values.

ii) The above mentioned input errors give a possibility to determine the general relativistic part with much better accuracy.

iii) The classical effect generally has a large error due to two very uncertain factors, viz. the internal structure constants and the ratio of rotational and orbital velocities (ω_r / ω_K).

iv) With the up-dated physical parameters of these systems the CL+NGT combined effects cannot approximate the observations so well as in Moffat's paper *(Moffat, 1984)*, but it can be done better than by CL+GR.

v) The traditional CL+GR rates are in agreement with the observed ones within the limits of error for V889 Aql, EK Cep and V1143 Cyg. They are considered as nonproblematic systems. Thus, only Y Cyg, DI Her, AG Per and AS Cam show some discrepancies from General Relativity.

vi) The NGT (with classical mechanics) gives an apsidal motion rate (for EK Cep) which deviates from the observed value by almost 5σ! Although the relative error of $\dot{\omega}_{CL}$ is about 34% in this case.

It seems that neither General Relativity nor the Nonsymmetric Gravitational Theory can be retained or rejected without further detailed study of this problem.

NODAL REGRESSION

As a second step, let us consider what follows if we want to keep the GR at any cost.

In this case, obviously, we have to dissect the Newtonian contribution. We have two very uncertain quantities in it, viz. the k_2, k_3, etc. parameters of the internal structure of stars and the ω_r/ω_K ratio. For the former, one can make only rough estimates based upon stellar model calculations: for the latter there is a confusion in the literature. Some authors take for the above mentioned binaries the preliminary (but not confirmed) assumption of $\omega_r / \omega_K = 1$, while some others take the well-known formula of the synchronized rotational velocity of the components of an eccentric binary system:

$$\frac{\omega_r}{\omega_K} = 1 + \frac{(12e^2)^{3/8}}{2} \qquad (1)$$

to the lowest order in eccentricity *(Zahn, 1977* and *Giuricin et al., 1984)*. The theoretical values of this ratio are 1.30, 1.74, 1.17, 1.34, 1.50, 1.26, 1.80 for Y Cyg, DI Her, AG Per, AS Cam, V889 Aql, EK Cep and V1143

Cyg, respectively.

For DI Her, *Guinan and Maloney (1985)* accepted 3.50 and 3.78 (for the primary and secondary components, respectively). Other authors took equal values for the two components: 3.6 *(Moffat, 1984)*, 3 *(Martynov and Khaliullin, 1980)*, 7 *(Koch, 1973)*. In the cases of EK Cep and AG Per one can find values from 0.8 to 1.4, and from 1 to 2.5, respectively. The ratio is usually taken as 1 for AS Cam and V1143 Cyg, or V889 Aql and Y Cyg. Moffat took 4.7 and 2.4 for the latters, respectively *(Moffat, 1984)*.

Shakura has shown *(Shakura, 1985)*, that if we omit the generally supposed circumstances, namely that the rotational axes of both components are perpendicular to the orbital plane, then we shall be able to rectify the observed discrepancies even under reasonable conditions. He presented two examples supporting this conception. If one takes the rotational axes into the orbital plane ($\alpha_1=\alpha_2=90^\circ$), one will recover the observed $\dot{\omega}_{OBS}$ rates by taking about 3, and 9-10 for the values ω_r/ω_K in the case of AS Cam and DI Her, respectively *(Shakura, 1985)*. This latter fact demands somewhat faster axial rotations but, as Shakura mentioned, it can be compensated by a suitable choice of β_1, β_2 (angles between the rotational axes and the line from the observer to the center of the system). With the appearance of the new part with negative sign in the generalized expression of $\dot{\omega}_{CL}$, the nodal line and the orbital inclination must be affected by secular variations *(Barker and O'Connell, 1978)*.

Nodal regression may also be caused by the perturbations of a third body. This assumption has also been taken into consideration in the case of DI Her *(Martynov and Khaliullin, 1980)*, but at present there exists no observational evidence of its existence. In the case of AS Cam, Al-Naimiy called attention to the existence of an L_3=0.047 (at 525 nm) intensity, which can be cancelled out from the solution of the light curve. This may be observational evidence of an about 12 mag faint third member of the system *(Al-Naimiy, 1978)*. V889 Aql also has a possible third body, corresponding to the existence of an L_3=0.185 (in V band, *Khaliullin and Khaliullina, 1987)*.

There are some other likely items of observational evidence for the existence of nodal regression in the case of OO Aql *(Demircan and Güdür, 1981)*, IU Aur, AY Mus *(Schaefer, 1981)* and AH Cep *(Mayer, 1987)*. Another possible candidate is α CrB *(Alexander, 1976)*. But for any other eclipsing binaries exact evidence has not been found yet.

The fact that we suppose inclined rotational axes gives rise to some questions about the origin of binary stars and their evolution. Discussion of this problem is not our aim. However, one has to keep in mind that all of the problematical systems are young, with massive components being before or in the main-sequence evolutionary status. The logarithms of their approximate ages are 7.396 for AG Per *(Shibata and Mimura, 1976)* and 7.699 for DI Her *(Popper, 1982)*. The primary of EK Cep is a zero-age main sequence star while its secondary is a pre-main-sequence one *(Popper, 1987)*. V1143 Cyg, which was concluded as a non-problematical system, has a log(t)= 9.2 *(Giménez and Margrave, 1985)*. With respect to the other problematical binaries we had no available data for their age.

For such young systems the characteristic time scale of vanishing of the inclination of the components' rotational axes can easily be much longer than the present age of the systems itself. This question needs further detailed study.

If the rotational axes are not perpendicular to the orbital plane (or owing to any other reason) a nodal regression occurs, then it must be reflected on the light curve as complicated variations of the depth of minima *(Shakura, 1985, Hegedüs and Nuspl, 1986)*. The general view of such kind of variations has shown (under some simplified conditions) for the concrete example of DI Her *(Hegedüs and Nuspl, 1986)*.

DEPTHS OF LIGHT MINIMA

Our third purpose was to search for the existence of such behaviour of depth of light minima among the above listed stars.

Unfortunately, photometric data in the standard UBV system available to us at the present time, were limited. Numerous visual or/and photographic estimates are not of use because of their inaccuracy and incompatibility with the recently used photometric systems. Some otherwise very good and numerous measurements were also not adopted here since they were given in an instrumental, or in another standard photometric system. We have accepted the measurements published transformed into the Johnsonian standard UBV system. The time variations of minima depth are expected to have about some hundredths of stellar magnitude as their amplitudes, and are expected to have from 60 to 1000 years as their periods.

This work is in progress: published or unpublished UBV data from individual authors and from databases are continuously collected. In view of this, the following remarks represent only a short preliminary report.

All the values of minima depths currently available are shown in Table 3, with the time intervals covered by the individual data series and

TABLE 3: DEPTHS OF MINIMA OF THE PROBLEMATIC BINARIES

SYSTEM:	J.D.	R	Depth of primary minima			Depth of second. minima		
	(-2400000)		(V)	(B)	(U)	(V)	(B)	(U)
Y Cyg	39712-42577	a	0.601	0.602	0.587			
	39712-40528	a	(0.593)	(0.596)	(0.573)			
			±7	±5	±21			
	41127-41229	b	(0.574)	(0.569)	(0.585)			
			±7	±15	±16			
	44081-44083	s					(0.585)	
							±6	
DI Her	38245-38308	c	(0.716)?	(0.719)?		(0.547)?		
			±16 ?	±21 ?		±18 ?		
	(1950-1978)	d	0.715	0.727	0.785	0.577	0.563	0.530
	40016-43718	e	(0.707)	(0.723)	(0.773)	(0.549)	(0.548)	(0.516)
			±5	±6	±6	±6	±6	±7
AG Per	37963-38020	t	(0.273)	(0.276)	(0.286)	(0.253)	(0.261)	(0.241)
			±9	±13	±17	±14	±17	±20
	38351-38363	c	(0.289)?			(0.296)?		
			±10 ?			±12 ?		
	42330	u	(0.266)	(0.267)	(0.284)	(0.263)	(0.267)	(0.275)
			±9	±9	±11	±12	±10	±10
	42384-42757	f	0.282	0.285		0.281	0.277	
			(0.277)	(0.284)		(0.281)	(0.277)	
			±3	±4		±3	±3	
	44897-44915	v	(0.272)	(0.274)		(0.278)	(0.278)	
			±10	±11		±9	±11	
	47118.4458	g	0.285	0.295				
			±13	±18				
AS Cam	(1968-1969)	h		0.61 ?			0.34 ?	
	40556-41011	i	0.620	0.655	0.735	0.395	0.395	0.335
			±11	±9	±19	±11	±9	±19
	41547-42580	j	0.595	0.625		0.390	0.385	
	44937-44971	k	0.593	0.630		0.363	0.355	
			±3	±3		±4	±5	

TABLE 3: (continuation)

SYSTEM:	J.D.	R	Depth of primary minima			Depth of second. minima		
	(-2400000)		(V)	(B)	(U)	(V)	(B)	(U)
AS Cam	44937-44971	k	(0.601)			(0.365)		
			±3			±4		
	46771	l	0.590					
V889 Aql	38932-39655	c	(0.552)?			(0.443)?		
			±19 ?			±21 ?		
	41812-43399	m	(0.546)?			(0.419)		
			±20 ?			±4		
EK Cep	38971-39023	n	1.246	1.326		0.130	0.070	
				(1.327)			(0.070)	
				±6			±2	
	40882-40891	o				(0.106)	(0.074)	
						±4	±6	
	43144-43874	p	(1.20) ?			(0.10) ?		
	43902-44630	q	1.204	1.326		0.115	0.075	
			±3	±3		±4	±6	
			(1.217)			(0.117)		
			±5			±3		
V1143 Cyg	38932-39655	r	0.525	0.533	0.535	0.214	0.213	0.215
			(0.520)	(0.527)	(0.527)	(0.211)	(0.210)	(0.214)
			±4	±4	±4	±2	±2	±3
	40835-41173	o	(0.525)	(0.536)				
			±7	±6				

Remarks:
a: *O'Connell, 1977*
b: *Zaitseva et al., 1971*
c: *Semeniuk, 1968*
d: *Martynov and Khaliullin, 1978*
e: *Martynov and Khaliullin, 1980*
f: *Güdür, 1978*
g: this paper
h: *Hilditch, 1969*
i: *Padalia and Srivastava, 1975*
j: *Gülmen et al., 1976*
k: *Khaliullin and Kozyreva, 1983*
l: *Guinan et al., 1987*
m: *Bernardi and Scaltriti, 1978*
n: *Ebbinghausen, 1966*
o: *Guarnieri et al., 1975*
p: *Hill and Ebbinghausen, 1984*
q: *Khaliullin, 1983*
r: *Snowden and Koch, 1969*
s: *Giménez and Costa, 1980*
t: *Jones, 1969*
u: *Woodward and Koch, 1987*
v: *Giménez et al., 1987*

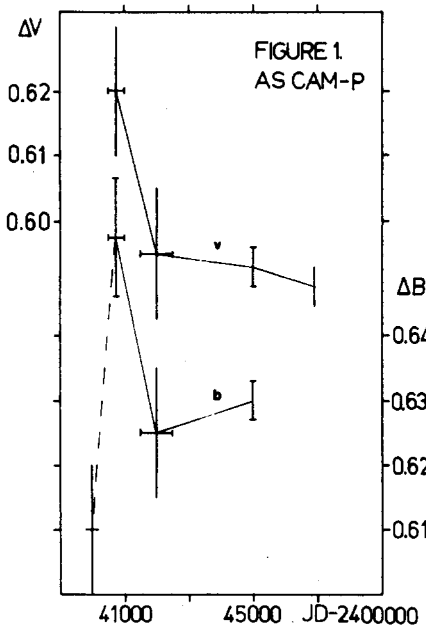

Figure 1.
Depth of pri. min. of AS Cam

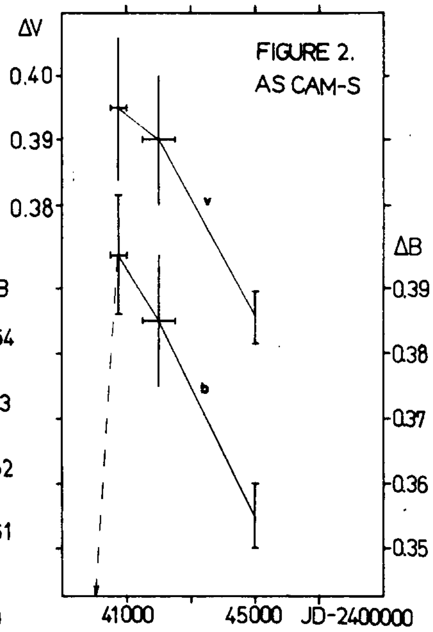

Figure 2.
Depth of sec. min. of AS Cam

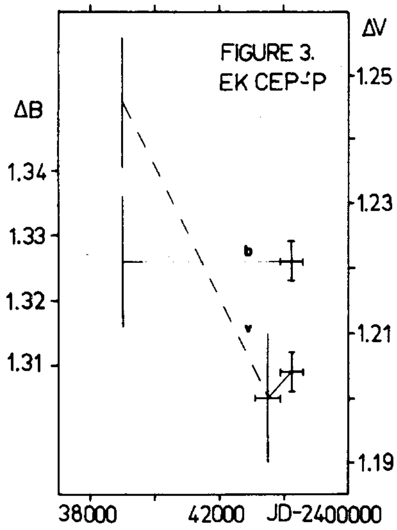

Figure 3.
Depth of pri. min. of EK Cep

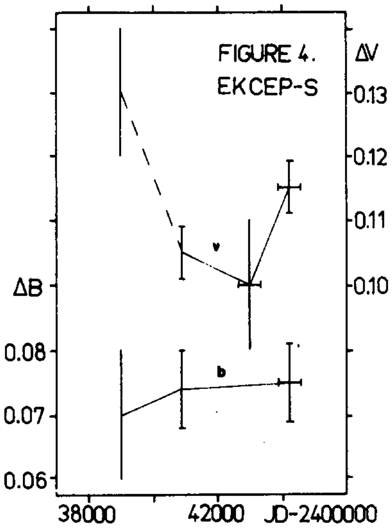

Figure 4.
Depth of sec. min. of EK Cep

(Error bars are closed opened if they were unpublished published in the source literatures).

with their sources. The data in parentheses are resulted from our least-squares parabolic fitting to the measured points (very near the center of minima). This was done for lack of published values of the depth of minima, but for some other cases also, in order to check our method and the methods of other authors. The mean value of brightness measurements outside of eclipses was taken as the maximum light level. In some cases, due to the lack of these kinds of measurements we took data from other authors. Establishing the maximum light of the system was sometimes quite difficult because of slight proximity effects or intrinsic variations.

At the moment we cannot say anything about the existence or absence of secular variations of the depth of minima among the problematic systems, and of the constancy among non-problematic ones. The data at our disposal are very few, and are extended to only a short time interval in relation to the time scale of the expected variations.

Two interesting cases having many data are shown in Figs. 1-4. AS Cam is a problematic system. In Figs. 1 and 2 we present the changes of depths of minima, observed in V and B light. The measurements in these two bands can be considered as the check of each other. The error bars of stellar magnitudes are closed in the case of known values, and are open in the case of suspected ones. The first value is very uncertain. Probably it was not made in the standard B band, rather in an instrumental one. AS Cam seems to show a predicted kind of variation.

EK Cep was concluded as a non-problematic system, so it was not expected to show secular variations of minima depths referring to a nodal regression. As one can see from Figs. 3 and 4, the B measurements demonstrate the constancy well, while in the V measurements one can find much deeper minima at the earlier epoch. This latter fact makes it questionable whether those values are really correct.

FINAL REMARKS

It would be advisable to measure the depth of minima from time to time with greater accuracy, with the same (UBV) measuring system and using the same procedure in the standardization and data reduction (making the available data set homogeneous). For the sake of safe verification of the existence (in the cases of Y Cyg, DI Her, AG Per and AS Cam) or absence (in the cases of V889 Aql, EK Cep and V1143 Cyg) of nodal regression we should have high-quality, homogeneous UBV photometric data on the depth of minima, distributed over wide time intervals.

Finally, we would like to call attention to the possibility of independent determination of spatial orientation of the orbit (by polarimetric measurements, see *Rudy, 1979*), and of the true position of rotational axes of the components of a close binary system (by spectroscopic method, see *Rossitter, 1924)*. It would be very important to apply these techniques to the problematic eclipsing binaries.

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