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BUDAPEST-SZABADSÁGHEGY

Nr. 49—50

L. DETRE AND S. KANYÓ

FOUR COLOUR PHOTOMETRY OF VW CEP DURING THE INTERNATIONAL CAMPAIGN IN 1959

JULIA BALÁZS AND L. DETRE

PHOTOELECTRIC OBSERVATIONS OF VW CEP IN 1950, 1952 AND 1959

BUDAPEST, 1961

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PHOTOELECTRIC OBSERVATIONS OF VW CEP IN 1950, 1952 AND 1959

by

JULIA BALÁZS AND L. DETRE

Over seven hundred white, blue and yellow observations were secured on 10 nights in 1950, 1952 and 1959 by Dr. I. Ozsváth and the writers. A review of all available photoelectric data confirms the relations found by Dr. Kwee between the light-curve variations and the phase-shifts of the minima, but the phenomena seem to be not periodic.

In 1950 and 1952 Dr. *I. Ozsváth* and the writers obtained about 500 photoelectric observations of VW Cep at the Newtonian focus of our 24-inch reflector using an RCA 931 A multiplier. At the beginning of the observations no colour-filters were used, later the observations were obtained through filters Schott BG 12 and GG 11. Shortly before the beginning of the international campaign in 1959 some observations were secured by the first writer in blue and yellow through filters BG 12 + GG 13 and GG 11 respectively, using an RCA 1P21 phototube. In all these observations the comparison star used was BD + 74°877 which was supected of variability by *R. S. Dugan* [1]. But apparently this star shows slow variations only, hence the observations on one and the same night are not effected by the variability of this star. In this way exact data can be obtained for the epochs of the minima and for the relative brightnesses of the maxima. These data are especially important for the study of the Kwee-effect [2]. Table I gives a summary of our observations. The magnitudes obtained for VW Cep are inserted in Tables III—V.

Together with the observations by *K. K. Kwee* [3], *K. Kostylev* [4], *McNamara* and *Stern* [5], *A. Szczepanowska* [6], *H. Schmidt* and *K. W. Schrick* [7] we have now a continuous series of photoelectric observations from 1948 to 1953. The epochs of the minima deduced from these observations together with the epochs obtained in 1959 are collected in Table II. The numbering of the epochs and the values $O - C$ for minima I and those of $O - C - 0.5\,P$ for minima II are according to the elements used by Kwee [14]:

$$\text{Min I} = \text{hel. J.D. } 2433898.4410 + 0^{d}.27831793.\,E$$

The epochs have been newly determined by us when the individual observations were at our disposal. Some observations are of low accuracy and the epochs in Table II may differ several minutes from those given in the literature. For

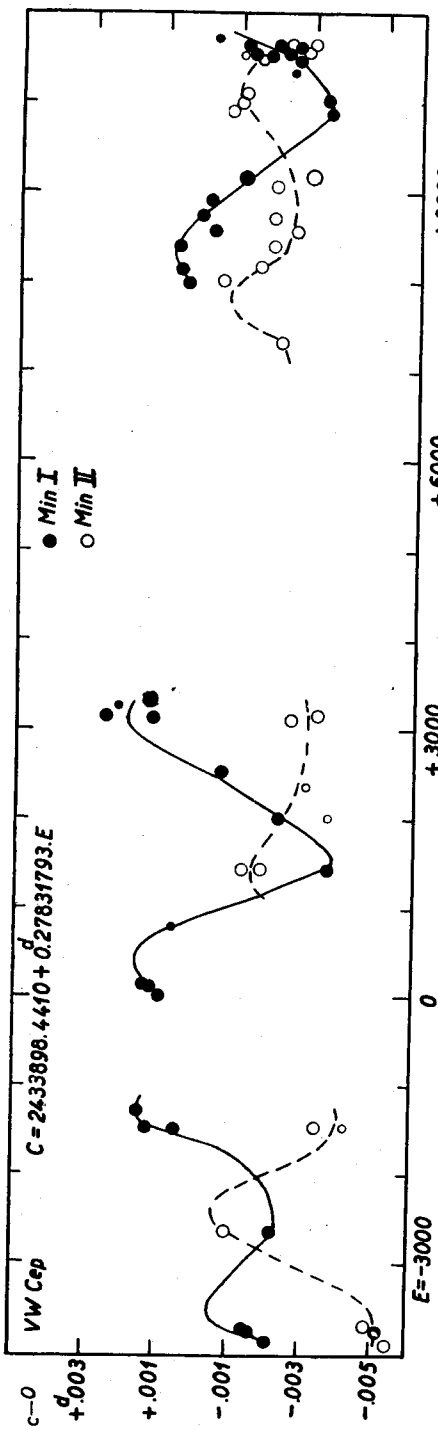

Fig. 1. O—C diagrams for the minima of VW Cep observed by photoelectric methods between 1948 and 1959

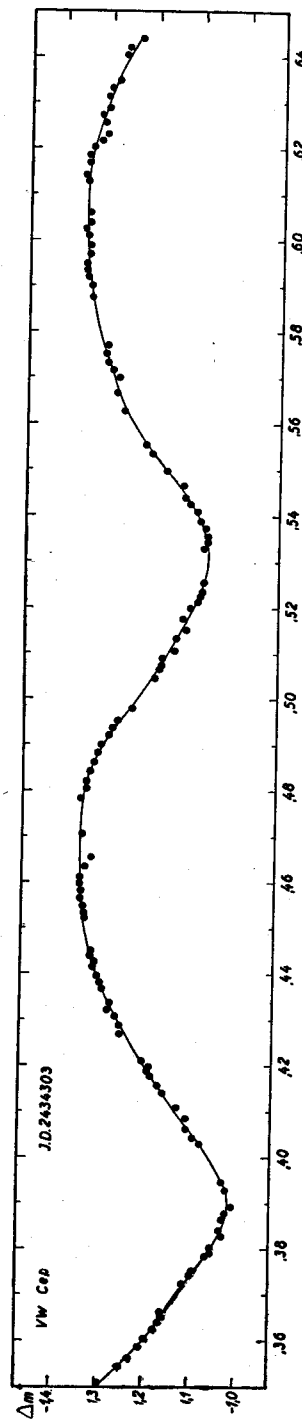

Fig. 2. Light-curve of VW Cep observed by Dr. *I. Ozsváth* in yellow light

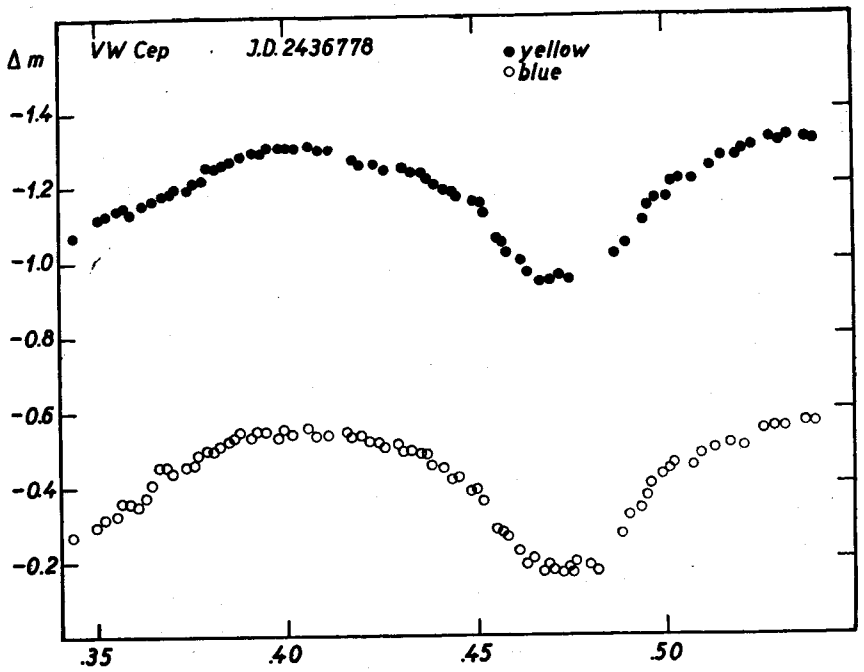

Fig. 3. Light-curves of VW Cep observed at Budapest on J. D. 2436778

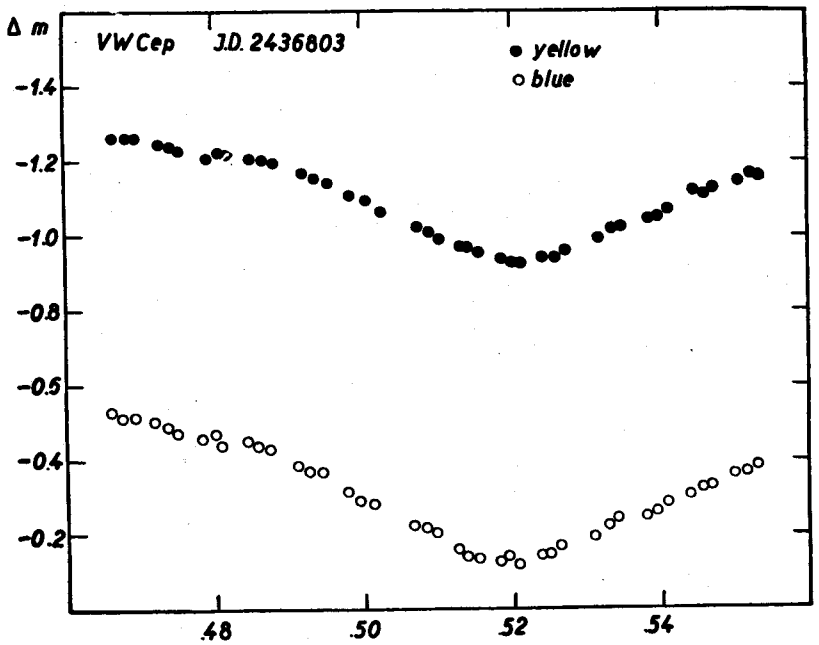

Fig. 4. Light-curves of VW Cep observed at Budapest on J.D. 2436803

Szczepanowska's observations we have deduced new epochs using the branches of the minima, whereas Szczepanowska used the moment belonging to the lowest value of the brightness as the epoch of the minimum.

Table I

Observations obtained at Budapest

Day	J. D. 243....	Time-interval	Number of observ. B	Y	W	Observer	Notes
1950 July 11/12	3474	.412—.541	—	—	73	D	1
1950 July 17/18	3480	.404—.458	—	—	28	D	2
1950 July 20/21	3483	.442—.559	—	—	46	D,O	1
1950 July 22/23	3485	.395—.562	—	—	59	B	3
1950 Sep 13/14	3538	.348—.630	—	—	35	O	4
1950 Sep 14/15	3539	.325—.465	13	12	14	B	5
1952 Oct 8/9	4294	.301—.612	88	—	—	O	6
1952 Oct 17/18	4303	.351—.644	—	124	—	O	1
1959 July 28/29	6778	.343—.561	84	78	—	B	1
1959 Aug 22/23	6803	.466—.553	42	42	—	B	1
		Total	227	256	255		

Notes : 1. Sky very good. 2. Interrupted by clouds. 3. From .449 to .498 interrupted by clouds. 4. Sky unsteady. 20 observations in yellow and 22 observations in blue disregarded. 5. Observations after .440 interfered by clouds. 6. Between .401 and .508 interrupted by clouds.

Abbreviations : B for *Balázs, D* for *Detre, O* for *Ozsváth ; B :* blue, *Y :* yellow *W :* white.

The values of $O - C$ and $O - C - 0.5\ P$ respectively from Table II. together with those given by *Kwee* in Circular No. 5. of the Coordination Programme 1959, have been plotted in Figure 1. The diagram clearly shows the variations of the epochs of the minima, first announced by *Kwee*. The epochs of minimum II showed the same variations as minimum I, however with opposite sign: when minimum I was too late, minimum II was too early. *Kwee* supposed a periodicity of about 2 years for these variations, but according to Fig. 1. different cycles are of unequal length and amplitude. Further the values of $O - C - 0.5\ P$ for minimum II are on the average smaller than the values of $O - C$ for minimum I, the difference being about $0^d.002$. Therefore the phase difference of the epochs Min II — Min I is mostly smaller than 0.5.

According to *Kwee* the variations of the epochs of the minima are correlated with the variations of the brightnesses of the maxima. When the maximum preceding Min I (Max II) is the brighter one the epoch of Min I occurs later. The reverse is true when the maximum following Min I (Max I) is the brighter one. In accordance with this we have found Max I brighter than Max II for E = +10348 (Figure 3). Max II was found brighter than Max I by *Kostylev* ($E = -3931$), *Mc Namara* ($E = -2639$), by us ($E = -1290$), by *Kwee* ($E = +122$), *Szafraniec* ($E \sim 7300$). An infrared light-curve obtained by Hardie on 24/25 and 25/26 July 1951 ($E \sim -200$) shows also Max II as the brighter one [15]. The only contradiction to *Kwee*'s relation is *Mc Namara*'s light-curve, showing Max II as the brighter one although Min I was early. The complete cycle observed by Dr. *Ozsváth* on J. D. 2434303 ($E=+1455$) shows two equal maxima in yellow light (Figure 2) at a time when Max I

Table II

Minima of VW Cephei observed photoelectrically

Min I			Min II			Ref.
J. D. hel. 243....	*E*	*O−C*	J. D. hel. 243....	E	O−C− $\frac{1}{2}$ P	
2804.3711	−3931	−d0021	2804.5069	−3931	−d0055	4
2845.2843	3784	−.0017	2845.4201	3784	−.0051	4
2856.1387	3745	−.0017	2856.2745	3745	−.0051	4
2864.2101	3716	−.0015	2864.3459	3716	−.0049	4
3163.9578	2639	−.0022	3163.8198	2638	−.0010	5
3483.4695	1491	+.0005	3474.4195:	1524	−.0042:	—
3485.4185	1484	+.0013	3485.5530:	1484	−.0034:	—
3539.4125	1290	+.0016				—
3898.4419	0	+.0009				3
3932.3970	+122	+.0012				3
3936.2936	136	+.0014				3
4122.4875:	805	+.0006:				6
			4294.3465	+1422	−.0018	—
			4303.5315	1455	−.0013	—
4303.3900	1455	−.0036				
4454.5180	1998	−.0022	4457.4390:	2008	−.0036:	6
			4458.4690:	2371	−.0030:	6
4603.4196	2533	−.0007				3
4768.464	3126	+.0012	4768.321	3125	−.0026	7
4780.433	3169	+.0025	4780.288	3168	−.0033	7
4797.410:	3230	+.0021:				6
			5925.5662	7283	−.0035	8
			5930.5805	7301	−.0011	8
			5932.5253	7308	−.0018	8
6778.4725:	10348	−.0024:				—
6803.5210	10438	−.0026				—
			6826.4838:	10520	−.0010:	9
6827.4572	10524	−.0018	6827.3181	10523	−.0017	9
6830.5191	10535	−.0013				9
6830.5180	10535	−.0024	6831.4922	10538	−.0023	10
			6840.4000	10570	−.0007	11
6841.6502	10575	−.0029	6841.5129	10574	−.0011	10
6842.4857	10578	−.0024	6842.3469	10577	−.0020	10
6843.3207	10581	−.0023	6843.4594	10581	−.0028	9
6856.4028	10628	−.0012				9
6856.4023	10628	−.0017	6857.3750	10631	−.0031	13
6857.5157	10632	−.0025	6857.3751	10631	−.0030	12
6858.3493	10635	−.0029	6858.4894	10635	−.0030	10
6858.3495	10635	−.0027	6858.4892	10635	−.0032	12
6859.4630	10639	−.0025	6859.3242	10638	−.0021	12
6877.2740	10703	−.0038	6859.3240	10638	−.0023	13
6880.3390	10714	−.0003				

should have been the brighter one. Further observations are needed to verify the relations found by *Kwee*.

The authors are indebted to *K. Gefferth* and *M. Lovas* for help at the telescope.

Table III

Photoelectric Observations in White Light

J. D. ⊙ 2433...	Δm (0m001)	J. D. ⊙ 2433...	Δm (0m001)	J. D. ⊙ 2433...	Δm (0m001)
474.4124	−689	474.4998	−966	480.4445	−782
.4152	670	.5005	977	.4462	801
.4227	641			.4483	821
.4233	657	.5015	976		
.4244	671	.5027	980	.4540	826
		.5039	974	.4556	826
.4252	681	.5059	968	.4577	823
.4296	719	.5072	970		
.4303	722			483.4421	673
.4308	724	.5081	977	.4465	623
.4314	726	.5125	946	.4495	614
		.5132	943	.4547	581
.4360	749	.5140	941	.4564	550
.4371	738	.5150	950		
.4378	760			.4616	507
.4385	763	.5152	938	.4637	509
.4417	794	.5166	927	.4690	492
		.5175	916	.4711	501
.4424	804	.5183	922	.4716	504
.4442	808	.5205	911		
.4453	820			.4754	514
.4460	835	.5252	897	.4772	522
.4467	838	.5265	876	.4785	527
		.5272	882	.4799	540
.4498	856	.5279	882	.4851	587
.4504	853	.5338	821		
.4514	853			.4858	587
.4533	881	.5352	797	.4886	638
.4540	886	.5367	793	.4901	664
		.5412	750	.4905	669
.4547	883			.4954	724
.4555	894	480.4041	554		
.4565	908	.4057	536	.4968	748
.4625	920	.4078	539	.4980	772
.4636	927	.4093	554	.4993	770
		.4148	562	.5072	838
.4678	949			.5094	847
.4738	958	.4155	560		
.4744	958	.4174	590	.5105	855
.4751	967	.4182	594	.5170	854
.4775	979	.4189	608	.5182	874
		.4196	581	.5199	878
.4782	970			.5209	888
.4790	975	.4211	625		
.4801	985	.4271	660	.5264	871
.4808	982	.4290	682	.5275	879
.4821	987	.4305	696	.5286	876
		.4314	705	.5335	895
.4864	974			.5366	884
.4876	985	.4322	735		
.4888	987	.4334	728	.5368	876
.4895	987	.4352	726	.5424	890
.4905	977	.4405	772	.5430	911
		.4420	782	.5446	921
.4915	976			.5453	928
.4924	987	.4424	773		
.4940	964	.4438	780		

J. D. ⊙ 2433...	Δm (0m001)	J. D. ⊙ 2433...	Δm (0m001)	J. D. ⊙ 2433...	Δm (0m001)
483.5486	−916	485.5008	−918	538.4278	−624
.5496	917	.5018	913	.4350	595
.5513	932	.5029	899	.4360	598
.5533	878			.4507	593
.5560	878	.5035	899	.4519	619
.5589	838	.5080	893		
		.5098	900	.4892	861
485.3952	684	.5113	877	.4902	859
.3966	683	.5137	886	.4975	901
.3976	669			.4986	904
.3989	639	.5141	880	.5110	897
.3999	655	.5177	866		
		.5183	857	.5134	900
.4036	636	.5191	860	.5212	883
.4051	620	.5201	824	.5367	789
.4060	589			.5453	771
.4070	579	.5208	812	.5600	630
.4087	560	.5368	744		
		.5375	754	.5689	594
.4147	505	.5386	716	.5847	587
.4156	502	.5397	704	.5863	614
.4168	512			.5932	654
.4179	524	.5408	695	.5944	665
.4189	511	.5446	669		
		.5456	664	.6072	806
.4232	518	.5467	632	.6083	818
.4247	511	.5478	632	.6150	832
.4263	527			.6290	871
.4267	539	.5542	642	.6299	860
.4284	546	.5555	636		
		.5607	654	539.3251	871
.4347	658	.5618	685	.3380	896
.4349	668			.3391	877
.4371	679	538.3485	806	.3560	914
.4400	720	.3493	815	.3542	889
.4406	729	.3623	852		
		.3751	842	.3824	775
.4438	748	.3820	847	.3890	723
.4447	763			.4053	559
.4456	768	.3838	844	.4114	543
.4471	780	.3985	837	.4250	630
.4479	779	.3993	846		
		.4058	801	.4316	651
.4487	782	.4067	789	.4542	856
.4997	925	.4269	599	.4593	881
				.4647	891

Table IV

Photoelectric Observations in Yellow Light

J. D. ⊙ 243....	Δm	J, D. ⊙ 243...	Δm	J, D. ⊙ 243...	Δm
3539.3347	−1.175	3539.4076	−0.878	4303.3511	−1.294
.3411	.162	.4208	.890	.3542	.247
.3485	.172	.4308	.977	.3560	.225
.3587	.109	.4493	1.132	.3584	.205
.3812	.086	.4561	.239	.3603	.195
.4002	0.948	.4611	.216	.3624	.171

J. D. ⊙ 243....	Δm	J. D. ⊙ 243....	Δm	J. D. ⊙ 243....	Δm
4303.3640	−1.164	.4893	−1.304	.6271	−1.325
.3652	.159	.4921	.292	.6288	.311
.3661	.160	.4936	.287	.6311	.311
		.4954	.267	.6330	.302
.3725	.115	.4975	.238	.6347	.284
.3742	.098				
.3755	.091	.5046	.190	.6405	.272
.3781	.063	.5062	181	.6421	.268
.3793	.053	.5072	.177	.6440	.235
.3805	.049	.5085	178		
.3827	.025	.5105	.151	6778.3441	.068
.3840	.033	.5133	.146	.3504	.119
.3866	.030	.5153	.123	.3527	.124
.3876	.020	.5175	.133		
.3890	.006	.5200	.117	.3558	.139
.3944	.030	.5213	.099	.3572	.136
		.5224	.090	.3586	.125
.4029	.083	.5236	.089		
.4041	.096	.5254	.087	.3625	.150
.4061	.110			.3640	.150
.4085	.107	.5329	.090		
.4110	.128	.5341	.080	.3678	.175
.4138	.159	.5353	.079	.3692	.177
.4153	.172	.5373	.082	.3706	.191
.4175	.183	.5385	.095		
.4190	.198	.5406	.103	.3744	.196
.4195	.190	.5437	.131	.3758	.205
.4212	.207	.5467	.133	.3772	.205
		.5498	.166		
.4268	.258	.5535	.205	.3814	.244
.4286	.260	.5552	.217	.3824	.254
.4308	.267				
.4320	.283	.5625	.268	.3855	.265
.4336	.278	.5661	.283	.3869	.265
.4366	.293	.5699	.277	.3883	.280
.4380	.298	.5715	.291		
.4395	.306	.5730	.300	.3916	.290
.4415	.316	.5750	.304	.3936	.291
.4428	.310	.5766	.302	.3952	.298
.4441	.319				
.4457	.314	.5892	.339	.3989	.302
		.5906	.335	.4005	.299
.4521	.335	.5920	.351	.4026	.301
.4533	.334	.5934	.352		
.4545	.336	.5949	.354	.4067	.302
.4565	.348	.5970	.342	.4092	.298
.4584	.345	.5984	.345	.4117	.290
.4598	.349	.5997	.332		
.4610	.345	.6010	.349	.4173	.260
.4631	.336	.6035	.345	.4186	.261
.4662	.317	.6060	.345	.4200	.257
.4706	.342				
		.6128	.353	.4235	.247
.4783	350.	.6142	.360	.4263	.239
.4805	.331	.6169	.352		
.4821	.330	.6185	.353	.4305	.246
.4824	.316	.6200	.343	.4318	.244
.4840	326	.6222	.319	.4332	.238
.4863	.319	.6229	.312		
.4880	.314	.6255	.315		

J. D. ⊙ 243....	Δm	J. D. ⊙ 243...	Δm	J. D. ⊙ 243...	Δm
6778.4367	−1.234	6778.5006	−1.166	6803.4881	−1.193
.4381	.215	.5020	.209	.4920	.163
.4395	.203	.5034	.208	.4934	.150
				.4953	.136
.4430	.185	.5068	.211	.4985	.103
.4443	.176	.5082	.209	.5004	.092
.4457	.167			.5024	.060
		.5131	.242	.5075	..020
.4499	.152	.5145	.269		
.4513	.147			.5089	.002
.4527	.127	.5193	.268	.5102	−0.983
		.5208	.292	.5134	.969
.4561	.055	.5233	.299	.5144	.966
.4575	.043			.5156	.951
.4589	.028	.5279	.312	.5187	.940
		.5303	.311	.5200	.927
.4624	−0.992	.5329	.325	.5213	.922
.4638	.990			.5243	.942
.4652	.968:	.5375	.312	.5257	.935
		.5396	.306	.5273	.959
.4686	.975:	.5610	.312	.5318	.984
.4700	.953:			.5334	−1.013
.4714	.944:	6803.4668	.258	.5348	.019
		.4684	.262	.5386	.041
.4749	.941:	.4698	.260	.5399	.048
.4763	.935:	.4728	.241	.5413	.071
.4777	.925	.4742	.238	.5446	.112
		.4756	.222	.5460	.110
.4881	−1.005:	.4791	.203	.5474	.123
.4982	.040	.4805	.218	.5507	.145
		.4818	.212	.5520	.152
.4943	.097	.4851	.203	.5534	.148
.4957	.147	.4867	.202		
.4971	.157				

Table V

Photoelectric Observations in Blue Light

J. D. ⊙ 243...	Δm	J. D. ⊙ 243....	Δm	J. D. ⊙ 243...	Δm
3539.3363	−0.524	4294.3136	−0.412	−0.3658	−0.334
.3428	.499	.3197	.391	.3693	.331
.3542	.520	.3226	.362	.3710	.377
.3611	.506	.3237	.355	.3739	.410
.3797	.380	.3263	.322	.3752	.423
.3867	.315	.3274	.308	.3854	.452
.4021	.115	.3297	.308	.3880	.457
.4094	.092	.3311	.268	.3924	.460
.4125	.059	.3319	.273	.3961	.443
.4362	.218			.3996	.469
.4519	.428	.3400	.228		
.4577	.415	.3412	.221	.5085	.399
.4629	.520	.3435	.239	.5097	.391
		.3444	.216	.5106	.396
4294.3011	.489	.3456	.232	.5115	.414
.3033	.470	.3483	.224	.5135	440
.3057	.488	.3510	.228	.5153	.469
.3075	.490	.3531	.255	.5167	.497
.3088	.455			.5193	.479
.3097	.438	.3617	.270	.5205	.483
.3116	.417	.3634	.295		

J. D. ⊙ 243...	Δm	J. D. ⊙ 243...	Δm	J. D. ⊙ 243...	Δm
4294.5258	−0.489	6778.3685	−0.454	6778.5027	−0.455
.5278	.517	.3699	.440	.5061	.450
.5303	.498	.3737	.450	.5075	.446
.5310	.490	.3751	.454	.5089	.480
.5321	.504	.3765	.484	.5131	.495
.5331	.503	.3793	.497	.5169	.502
.5343	.517	.3807	.495	.5222	.511
.5364	.525	.3821	.508	.5270	.546
.5373	.529	.3849	.519	.5292	.547
.5382	.520	.3862	.531	.5317	.545
.5393	.509	.3876	.543	.5365	.565
		.3909	.523	.5386	.537
.5470	.549	.3923	.555	.5406	.575
.5486	.533	.3944	.548	.5596	.553
.5508	.519	.3980	.527	.5610	.563
.5528	.552	.3997	.555		
.5560	.532	.4015	.536	6803.4661	.532
.5583	.551	.4056	.558	.4677	.518
.5607	.556	.4078	.528	.4691	.520
.5626	.561	.4105	.532	.4721	.506
		.4164	.547	.4735	.484
.5685	.567	.4180	.534	.4749	.479
.5702	.555	.4193	.533	.4784	.459
.5712	.548	.4228	.521	.4798	.468
.5728	.520	.4242	.513	.4811	.445
.5735	.523	.4256	.503	.4842	.456
.5754	.532	.4248	.507	.4860	.440
.5772	.503	.4311	.493	.4874	.428
.5790	.494	.4325	.495	.4913	.386
.5818	.493	.4360	.492	.4927	.368
		.4374	.474	.4943	.365
.5880	.507	.4388	.451	.4978	.317
.5894	.499	.4423	.446	.4994	.292
.5907	.436	.4436	.419	.5013	.282
.5913	.441	.4450	.419	.5066	.224
.5923	.425	.4492	.382	.5083	.212
.5937	.427	.4506	.390	.5096	.204
.5949	.434	.4520	.356	.5128	.163
.5962	.433	.4555	.279		
		.4568	.271	.5140	.139
.5976	.407	.4582	.266	.5150	.133
		.4617	.224	.5181	.124
.5992	.391	.4631	.187	.5193	.136
.6003	.354	.4645	.197	.5206	.117
.6015	.368	.4680	.173	.5236	.141
.6028	.346	.4693	.184	.5250	.150
.6038	.333	.4707	.173	.5265	.173
.6124	.305	.4742	.181	.5310	.198
		.4756	.193:	.5327	.225
6778.3434	.264	.4770	.160:	.5340	.240
.3497	.296	.4805	.172:	.5380	.247
.3517	.318	.4818	.163:	.5394	.256
.3551	.318	.4888	.269	.5407	.284
.3565	.362	.4902	.317	.5440	.305
.3579	.358	.4936	.334	.5454	.325
.3612	.354	.4950	.373	.5467	.329
.3626	.321	.4964	.407	.5500	.364
.3640	.407	.4999	.429	.5514	.364
.3671	.452	.5013	.434	.5527	.380

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