THE ULTRASHORT PERIOD VARIABLE *SZ* LYNCIS

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RIASSUNTO. — La variabile SZ Lyncis, di tipo W UMa secondo il Catalogo di Kukarkin e Parenago è invece una RR Lyr a cortissimo periodo. Da 750 osservazioni fotoelettriche nel sistema *B, V* viene ricavata una curva di luce media con: max $V = 9^m.12$ $B-V = +0^m.26$; min $V = 9^m.64$ $B-V = +0^m.41$. Le curve di luce si ripetono esattamente entro la precisione delle misure; pure gli *O—C* ricavati con l'effemeride: Max elioc. = G.G. 2437367.4419 + + 0.12053349 *E* hanno un andamento regolare. Dalla relazione *Periodo-*M_v di L. Woltjer per le cefeidi nane si ricava per SZ Lyn $M_v = +2.1$.

ABSTRACT. — From 750 photoelectric observations in the *B, V* system an ephemeris and a mean light curve are obtained for the ultrashort period variable SZ Lyncis. The light curves are repetitive and the *O—C* regular. After the relation *Period-* M_v of L. Woltjer for the dwarf cepheids we have for SZ Lyn $M_v = +2.1$.

According to the General Catalogue of Variable Stars (1958) SZ Lyncis is an eclipsing binary and therefore it was thought to obtain a light curve and to compute the elements of the system. However, from the measurements of the color and it's variation ($0^m.15$) during the first hour of observing it appeared clearly the star was not a W UMa type because these have a color excursion along a cycle of some hundredths of magnitude. Nevertheless the observations were continued to obtain the period and the light curve and to detect a possible variation, also after having successively known the papers of H. Schneller (1) and O. Eggen (2) which indipendently showed the ultrashort-period (174 minutes) RR Lyrae nature of SZ Lyncis.

All the observations, 750 in number given as $\Delta m = m_{comp} - m_{var}$ in the Tables I and II, were carried out with the 40-inch reflector of the Merate Observatory and a Lallemand photomultiplier in two colors close to *B* and *V* of Johnson and Morgan system. Since SZ Lyn changes its brightness quickly (by about $0^m.02$/min during the rise to maximum) several measures on the variable were done between two consecutive settings on the comparison. The latter was BD + 45°1544 = HD 67646 (Ptm = $9^m.32$, Ptg = $9^m.74$, F5) used also by Schneller, checked sometime on the constancy with two other nearby stars. The corrections for

(*) Ricevuta il 3 agosto 1963.

the differential extinction between variable and comparison star were practically negligible since the observations were made all at *sec z* < 1.5 and the color effects amount at the most to $0^m.002$. A comparison to 36 UMa B, from the list of Johnson and Morgan, gave for HD 67646: $V = 9^m.45$, $B\text{-}V = + 0^m.48$. For the reductions extensive use was made of a magnitude rule that give $m = 2.5 \log d$ where d is the deflection in millimeters on the Speedomax chart. The values of Δm, with the differences in gain step included, of *sec z* and helioc. J.D., were computed for each measure of the variable with the IBM 1620 of the Milano Observatory. SZ Lyn was observed in four nights extending over 700 cycles.

TABLE III. — *Observed times of maximum light.*

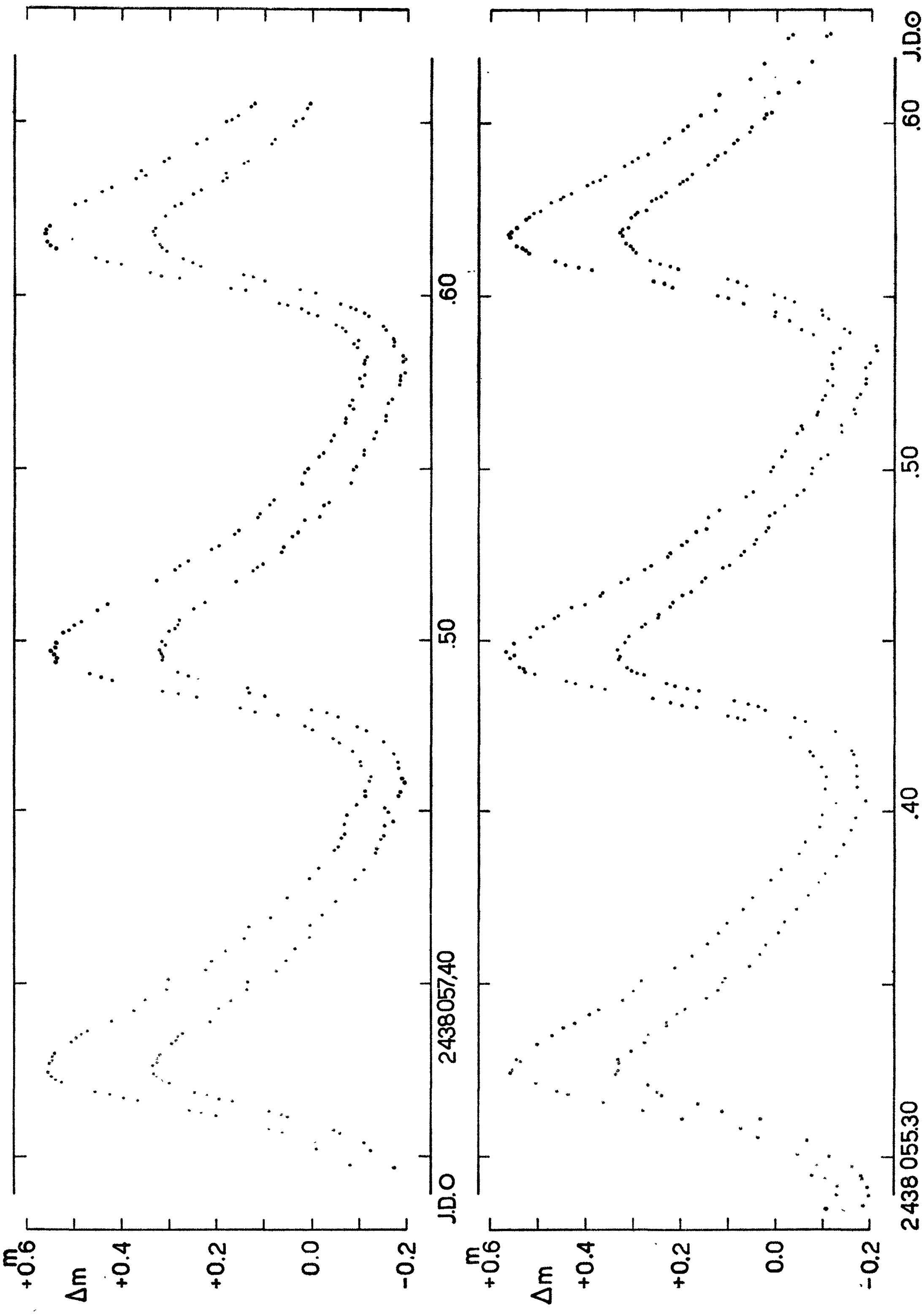
Observer	Helioc. J. D.	E	O—C
S	2437367.440	0	— 0.002
S	368.4062	8	+ .0001
E	642.0182	2278	+ .0011
B	38055.3268	5707	+ .0003
B	055.4463	5708	— .0007
B	055.5681	5709	+ .0006
B	057.3752	5724	— .0003
B	057.4964	5725	+ .0003
B	057.6172	5726	+ .0006
B	114.3880	6197	+ .0001
B	140.423	6413	.000

S = Schneller E = Eggen B = Broglia

In Table III are reported the eight epochs of maximum relative to the present measures after those I deduced from the light curves of Schneller and Eggen. The preceding observations of A. Soloviev ([3]) and W. P. Tsesevich ([4]), which classified SZ Lyn as W UMa type, are not published, so it was not possible to derive their data of maximum. Therefore I computed by least squares the following ephemeris only from the epochs quoted in Table I, all derived from photoelectric observations:

$$\text{Max helioc.} = \text{J.D. } 2437367.44186 + 0.120533486 \text{ E}$$
$$\pm 26 \qquad \pm 52 \text{ e.m.}$$

All residuals *O—C* are compatible with the precision of the corresponding instant of maximum.



Δm
+0.6
+0.4
+0.2
0.0
-0.2
J.D.⊙
2438057,40
.50
.60
2438055,30
.40

In each of the two nights G.G. 2438055, 2438057 the variable was measured during three consecutive cycles for detecting an eventual variation of the light curve. It is known that the RR Lyrae stars with a secondary variation and fundamental period P_o close to the value of SZ Lyn, like AI Vel, RV Ari, BP Peg, have a ratio P_b/P_o of the beat to the fundamental period near to 3.4 and a ratio δ between the brightness variations respectively of periods P_b and P_o ranging about from 0.2 to 1.0. As a consequence of the secondary pulsation it is also an oscillation of the residuals $O—C$ computed from a linear ephemeris with a range of about $0^d.006$ - $0^d.01$. As it appears from the Fig. 1 the light variation of SZ Lyn is quite regular and repetitive during an interval of three cycles at least and also the $O—C$ have a normal trend so it is no confirmation of the irregularities supposed by Schneller or of a short period variation. The mean light and color curves are given in Table IV. From these we have:

$$\text{max } V = 9^m.12 \qquad B\text{-}V = +\ 0^m.26$$
$$\text{min } = 9\ .64 \qquad \phantom{B\text{-}V} = +\ 0\ .41$$

The mean Ludendorff coefficient is 0.311 ± 0.004 e.m.

TABLE IV. — *Mean visual and color curves of SZ Lyncis*

Phase	V	B-V	Phase	V	B-V	Phase	V	B-V
$0^P.00$	$9^m.120$	$+\ 0^m.260$	$0^P.35$	$9^m.465$	$+\ 0^m.370$	$0^P.75$	$9^m.620$	$+\ 0^m.400$
.03	.135	.260	.40	.505	.380	.79	.580	.395
.06	.165	.270	.45	.535	.395	.82	.540	.385
.10	.210	.280	.50	.570	.395	.85	.485	.365
.15	.270	.305	.55	.595	.405	.88	.400	.335
.20	.330	.325	.60	.610	.405	.91	.300	.315
.25	.390	.340	.65	.630	.410	.94	.200	.285
.30	.435	.355	.70	.640	.410	.97	.140	.270

According to the correlations between period, spectral appearance, color and light variations from maximum to minimum shown by H. Spinrad (5) for twenty three field RR Lyrae of which eight with very short periods ($P < 0^d.2$) it appears the latter to have a rather large range in color and light amplitudes and Ludendorff coefficients. Bailey *c* class which has immediately longer periods is instead a rather compact group respect to the relations quoted above. AD CMi (6), BP Peg (7) and SZ Lyn, all with $P < 0^d.2$, which are not included in the list of Spinrad, confirm the above remarks so it can be concluded that the color and light curves do not provide a significant grouping criterion for these stars. This is due in part to the presence between the ultrashort variables of some ones presenting a beat phenomena with very different light modulations, like AI Vel, SX Phe, VZ Cnc, RV Ari, BP Peg, DQ Cep, δ Sct. The value $P_1/P_0 = 0.8$, where $1/P_1 = 1/P_0 + 1/P_b$, the same for all these stars, and the absence of beat phenomena in the RR Lyrae with P_0 ranging from $0^d.20$ to $0^d.37$ which then reappears for $P_0 > 0^d.37$, but with a constant value P_1/P_0 close to one, is an indication of some common physical properties. In other words when the conditions for the beat phenomenon exist the effects on the period but not in the light amplitude modulation are similar for the stars of the group. The more significant parameters for defining the group are however the galactic distribution, in particular the absence from the globular clusters, and the absolute magnitude from which it derive the name of dwarfs cepheids. Referring just to the relation M_V - *Period* given by L. Woltjer ([8]) we have for SZ Lyncis $M_V = + 2.1$.

REFERENCES

(1) A.N. 286 - 102 (1961).
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(3) Astron. Circ. URSS 159 - 18 (1955).
(4) Astron. Circ. URSS 170 - 16 (1956).
Astron. Circ. URSS 175 - 16 (1956).
(5) Ap. J. 130 - 359 (1959).
(6) Ap. J. 130 - 834 (1959).
(7) Merate Contr. N. 47 (1954), N. 142 (1959).
(8) B.A.N. XIII - 62 (1956).

TABLE I. — *Differential bleu magnitudes*

helioc. J.D. 2438000.+	Δm	helioc. J.D. 2438000.+	Δm	helioc. J.D. 2438000.+	Δm
55.2862	— 0.108	55.4341	+ 0.257	55.5410	— 0.054
.2900	.132	.4367	.359	.5439	— 0.029
.2927	.131	.4375	.386	.5450	+ 0.004
.2950	.106	.4382	.421	.5460	.001
.2959	.078	.4389	.439	.5489	.068
.2986	.092	.4410	.504	.5500	.099
.3020	— 0.050	.4417	.525	.5510	.124
.3064	+ 0.033	.4424	.529	.5534	.215
.3092	.069	.4431	.537	.5543	.233
.3122	.195	.4456	.558	.5552	.256
.3144	.275	.4466	.549	.5582	.387
.3166	.359	.4475	.566	.5592	.414
.3190	.434	.4498	.549	.5600	.442
.3199	.457	.4519	.516	.5609	.464
.3225	.500	.4544	.500	.5633	.518
.3253	.555	.4551	.489	.5640	.526
.3262	.552	.4574	.464	.5648	.532
.3286	.535	.4581	.458	.5657	.543
.3294	.545	.4606	.429	.5682	.558
.3335	.499	.4614	.399	.5689	.557
.3359	.469	.4641	.368	.5698	.553
.3386	.446	.4648	.363	.5706	.546
.3398	.419	.4680	.325	.5731	.526
.3422	.392	.4688	.309	.5739	.518
.3437	.370	.4718	.276	.5748	.510
.3463	.318	.4728	.262	.5756	.495
.3490	.297	.4754	.226	.5781	.474
.3521	.281	.4763	.221	.5790	.453
.3561	.211	.4790	.196	.5797	.447
.3594	.173	.4800	.184	.5805	.431
.3625	.141	.4827	.165	.5830	.396
.3658	.119	.4839	.142	.5838	.387
.3687	.100	.4872	.139	.5846	.372
.3728	.066	.4889	.117	.5857	.358
.3762	.048	.4930	.062	.5886	.318
.3812	+ 0.009	.4942	.047	.5896	.304
.3842	— 0.012	.5005	.009	.5907	.288
.3890	.051	.5016	+ 0.005	.5918	.268
.3926	.064	.5048	— 0.014	.5955	.235
.3966	.093	.5062	.021	.5964	.226
.4002	.098	.5113	.047	.5988	.194
.4038	.128	.5126	.058	.5998	.186
.4080	.106	.5132	.055	.6029	.158
.4111	.108	.5166	.088	.6046	.128
.4141	.101	.5178	.089	.6090	.119
.4173	.083	.5209	.099	.6133	.055
.4186	.074	.5221	.105	.6180	+ 0.024
.4228	— 0.034	.5252	.122	.6252	— 0.024
.4278	+ 0.064	.5264	.112	55.6262	— 0.034
.4282	.080	.5300	.121		
.4290	.099	.5311	.122	57.3466	— 0.082
.4314	.165	.5346	.123	.3516	.008
.4322	.196	.5359	.137	.3537	— 0.005
.4330	.218	.5398	.080	.3566	+ 0.061

TABLE I — (*Continued*)

helioc. J.D. 2438000.+	Δm	helioc. J.D. 2438000.+	Δm	helioc. J.D. 2438000.+	Δm
57.3575	+ 0.091	57.4798	+ 0.151	57.5911	— 0.052
.3613	.200	.4827	.242	.5938	— 0.011
.3623	.230	.4837	.280	.5948	+ 0.008
.3631	.257	.4848	.316	.5956	.024
.3659	.364	.4877	.420	.5966	.052
.3666	.394	.4886	.442	.5975	.070
.3675	.424	.4898	.468	.6007	.141
.3684	.456	.4932	.537	.6016	.172
.3710	.524	.4942	.534	.6043	.279
.3719	.539	.4952	.542	.6051	.318
.3729	.548	.4963	.544	.6059	.342
.3737	.556	.4974	.538	.6085	.400
.3763	.551	.4985	.536	.6093	.431
.3774	.546	.5015	.523	.6103	.455
.3784	.543	.5025	.511	.6128	.539
.3794	.540	.5036	.499	.6137	.550
.3828	.505	.5046	.483	.6148	.556
.3838	.494	.5082	.451	.6173	.561
.3849	.483	.5099	.428	.6184	.558
.3859	.472	.5170	.325	.6194	.552
.3890	.419	.5200	.288	.6257	.497
.3920	.374	.5211	.278	.6266	.476
.3950	.349	.5224	.258	.6293	.440
.3982	.304	.5259	.210	.6303	.421
.4007	.303	.5270	.194	.6331	.368
.4038	.221	.5305	.162	.6340	.351
.4061	.210	.5316	.154	.6354	.359
.4092	.180	.5352	.113	.6379	.312
.4126	.140	.5363	.110	.6388	.300
.4163	.132	.5392	.088	.6430	.242
,4190	.085	.5405	.082	.6442	.223
.4245	.050	.5450	.022	.6493	.179
.4304	+ 0.005	.5484	.018	.6502	.169
.4332	— 0.013	.5495	+ 0.008	.6511	.155
.4382	.050	.5529	— 0.014	.6541	.130
.4393	.056	.5540	.023	57.6550	+ 0.121
.4420	.063	.5574	.039		
.4430	.068	.5594	.047	114.3165	+ 0.022
.4461	.069	.5627	.070	.3220	+ 0.007
.4486	.076	.5638	.073	.3280	— 0.040
.4515	.097	.5670	.088	.3316	.055
.4548	.113	.5677	.080	.3342	.070
.4559	.113	.5691	.084	.3377	.090
.4586	.122	.5735	.107	.3460	.096
.4597	.124	.5754	.101	.3494	.117
.4631	.105	.5766	.108	.3534	.107
.4642	.103	.5800	.110	.3566	.095
.4671	.087	.5808	.111	.3600	.083
.4698	.059	.5817	.116	.3624	.069
.4710	.047	.5847	.096	.3633	.042
.4735	— 0.002	.5857	.089	.3658	— 0.003
.4747	+ 0.014	.5866	.095	.3683	+ 0.037
.4777	.073	.5893	.070	.3704	.092
.4788	.118	.5902	.066	.3711	.119

TABLE I — (*Continued*)

helioc. J.D. 2438000.+	Δm	helioc. J.D. 2438000.+	Δm	helioc. J.D. 2438000.+	Δm
114.3737	+ 0.190	114.4078	+ 0.338	140.3897	— 0.108
.3745	.211	.4106	.318	.3927	.115
.3769	.295	.4142	.241	.3995	.044
.3779	.328	.4229	.165	.4026	— 0.005
.3803	.437	.4257	.146	.4041	+ 0.037
.3813	.474	.4285	+ 0.113	.4068	.084
.3836	.518	.4385	0.000	.4087	.144
.3844	.539	.4433	— 0.014	.4127	.284
.3868	.532	114.4465	— 0.021	.4143	.367
.3876	.517			.4168	.459
.3902	.536	140.3467	+ 0.081	.4176	.490
.3926	.536	.3492	.058	.4190	.524
.3949	.508	.3528	.023	.4226	.542
.3973	.484	.3554	+ 0.030	.4239	.548
.4008	.434	.3593	— 0.003	.4263	.522
.4031	.397	.3822	.117	140.4289	+ 0.536
.4054	.377	.3863	.126		

TABLE II. — *Differential visual magnitudes*

helioc. J.D. 2438000.+	Δm	helioc. J.D. 2438000.+	Δm	helioc. J.D. 2438000.+	Δm
55.2868	— 0.187	55.3471	+ 0.146	55.4273	— 0.064
.2897	.198	.3494	.120	.4287	— 0.041
.2923	.195	.3521	.109	.4310	+ 0.020
.2946	.183	.3530	.107	.4318	.035
.2955	.182	.3566	.054	.4326	.056
.2981	.162	.3599	.031	.4337	.087
.3009	.115	.3631	+ 0.019	.4363	.159
.3072	— 0.067	.3663	— 0.006	.4371	.186
.3118	+ 0.030	.3692	.022	.4378	.211
.3141	.110	.3732	.047	.4386	.228
.3162	.161	.3769	.071	.4407	.275
.3186	.237	.3807	.093	.4414	.290
.3196	.247	.3837	.107	.4421	.300
.3220	.265	.3885	.129	.4427	.311
.3248	.335	.3921	.144	.4452	.329
.3258	.332	.3960	.162	.4460	.325
.3282	.329	.3995	.168	.4480	.331
.3289	.330	.4032	.198	.4502	.316
.3316	.303	.4057	.186	.4523	.309
.3339	.275	.4086	.173	.4548	.279
.3363	.267	.4116	.173	.4555	.273
.3391	.228	.4147	.172	.4577	.247
.3402	.229	.4180	.167	.4585	.246
.3428	.206	.4190	.163	.4610	.219
.3441	.189	.4243	.127	.4619	.214

TABLE II — (*Continued*)

helioc. J.D. 2438000.+	Δm	helioc. J.D. 2438000.+	Δm	helioc. J.D. 2438000.+	Δm
55.4644	+ 0.196	55.5702	+ 0.325	57.3853	+ 0.272
.4653	.176	.5710	.313	.3886	.214
.4684	.156	.5734	.304	.3925	.195
.4693	.147	.5744	.296	.3946	.170
.4723	.110	.5751	.289	.3977	.135
.4731	.097	.5760	.273	.4002	.133
.4758	.072	.5786	.260	.4034	.076
.4769	.065	.5794	.253	.4066	.056
.4795	.044	.5801	.239	.4099	.037
.4805	.039	.5810	.231	.4132	.005
.4832	.018	.5834	.202	.4168	+ 0.004
.4844	.015	.5842	.197	.4196	— 0.022
.4879	.013	.5851	.187	.4240	.051
.4888	+ 0.002	.5864	.175	.4300	.090
.4904	— 0.018	.5891	.143	.4328	.109
.4936	.047	.5902	.129	.4377	.136
.4950	.062	.5913	.123	.4387	.137
.4998	.076	.5923	.109	.4414	.146
.5011	.081	.5950	.088	.4425	.150
.5041	.097	.5960	.081	.4457	.152
.5055	.109	.5984	.056	.4467	.172
.5120	.141	.5994	.051	.4495	.160
.5139	.141	.6023	.025	.4509	.152
.5172	.169	.6034	.019	.4543	.182
.5183	.167	.6040	+ 0.011	.4553	.186
.5216	.172	.6095	— 0.006	.4581	.197
.5226	.178	.6128	.048	.4592	.190
.5259	.190	.6185	.077	.4625	.183
.5270	.192	.6257	.107	.4637	.180
.5305	.191	55.6267	— 0.114	.4666	.174
.5318	.203			.4704	.151
.5353	.216	57.3461	— 0.174	.4731	.114
.5367	.214	.3513	.123	.4741	.096
.5403	.155	.3534	.110	.4772	.055
.5414	.145	.3561	.058	.4783	— 0.032
.5444	.112	.3570	— 0.046	.4793	+ 0.003
.5455	.101	.3609	+ 0.051	.4832	.099
.5464	.099	.3617	.062	.4842	.131
.5495	.039	.3627	.091	.4854	.135
.5505	— .0.019	.3654	.166	.4882	.240
.5514	+ 0.003	.3662	.195	.4891	.258
.5539	.060	.3671	.221	.4902	.281
.5548	.081	.3680	.247	.4937	.314
.5557	.099	.3707	.300	.4947	.316
.5588	.206	.3714	.315	.4957	.317
.5596	.222	.3724	.326	.4968	.319
.5604	.242	.3733	.331	.4979	.307
.5613	.265	.3759	.335	.4991	.316
.5637	.294	.3769	.325	.5019	.302
.5644	.301	.3779	.325	.5030	.289
.5653	.307	.3789	.321	.5041	.280
.5661	.316	.3824	.296	.5052	.277
.5686	.324	.3832	.287	.5088	.246
.5694	.328	.3843	.282	.5106	.226

TABLE II — (*Continued*)

helioc. J.D. 2438000.+	Δm	helioc. J.D. 2438000.+	Δm	helioc. J.D. 2438000.+	Δm
57.5164	+ 0.158	57.6225	+ 0.311	114.4148	+ 0.072
.5195	.124	.6252	.288	.4223	.031
.5206	.117	.6261	.276	.4252	+ 0.017
.5218	.103	.6288	.248	.4281	— 0.005
.5253	.064	.6298	.233	.4362	.072
.5265	.060	.6325	.188	.4370	.084
.5300	.040	.6336	.178	.4381	.094
.5311	.030	.6349	.183	.4427	.103
.5347	+ 0.002	.6375	.144	114.4460	— 0.112
.5357	— 0.002	.6384	.137		
.5386	.024	.6436	.088	140.3462	— 0.029
.5397	.034	.6447	.080	.3488	.049
.5455	.082	.6488	.040	.3523	.073
.5491	.086	.6498	.036	.3550	.072
.5500	.093	.6508	.022	.3590	.097
.5534	.108	.6536	.013	.3827	.186
.5546	.110	57.6546	+ 0.005	.3858	.203
.5582	.131			.3891	.185
.5599	.136	114.3161	— 0.063	.3922	.183
.5634	.155	.3215	.086	.3986	.155
.5644	.156	.3276	.122	.4022	.114
.5684	.159	.3310	.135	.4036	.096
.5697	.167	.3337	.142	.4063	.035
.5738	.184	.3372	.154	.4081	— 0.014
.5749	.185	.3469	.183	.4120	+ 0.108
.5761	.187	.3498	.184	.4147	.195
.5771	.196	.3539	.186	.4171	.266
.5804	.192	.3570	.176	.4181	.289
.5812	.195	.3604	.171	.4193	.302
.5821	.191	.3629	.150	.4221	.321
.5851	.173	.3638	.137	.4235	.321
.5862	.171	.3663	.093	.4260	.303
.5871	.171	.3687	.070	.4342	.249
.5898	.155	.3707	.026	.4363	.215
.5907	.151	.3715	— 0.012	.4422	.141
.5934	.119	.3741	+ 0.041	140.4482	+ 0.003
.5943	.109	.3748	.064		
.5953	.091	.3774	.137		
.5961	.081	.3783	.170		
.5970	.058	.3808	.254		
.6002	— 0.007	.3818	.273		
.6011	+ 0.025	.3840	.305		
.6038	.099	.3848	.317		
.6046	.123	.3872	.298		
.6055	.145	.3880	.294		
.6080	.236	.3906	.315		
.6088	.250	.3929	.303		
.6098	.272	.3954	.285		
.6123	.305	.3977	.269		
.6133	.316	.4012	.231		
.6143	.321	.4035	.206		
.6168	.330	.4059	.188		
.6179	.333	.4083	.159		
.6189	.330	.4114	.143		