Photo-electric light-curves of V 366 Cygni and UZ Leonis

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for population I cepheids and in the lower part the frequency curve for the globular clusters have been given for comparison. The short periods have practically disappeared altogether and there is an excess of cepheids with long periods. It must be concluded that a large fraction of these cepheids belong to population II, which is confirmed by the available light-curves.

The final conclusion therefore is that of the 120 cepheids in the constellations around the galactic centre at least 25 belong to population I and that most of these variables are rather bright, and that at least 70, most of them faint, belong to population II.

An investigation of the spatial distribution of these variables should wait until accurate photometric data concerning magnitudes and colours have become available.

The frequency curves are given in tabular form in the accompanying table.

log *P*	Fig. 2	Fig. 3	Fig. 4	(Fig. 3)	Fig. 5	(Fig. 2)	Fig. 6	(Fig. 3)	(Fig. 4)	Fig. 7	(Fig. 2)	(Fig. 4)
.0	0	0	1	.0	0	.0	2	.0	1.7	1	.0	1.7
.1	1	1	5	.3	0	.2	2	.4	8.7	0	.4	8.5
.2	1	2	1	.5	0	.2	4	.9	1.7	0	.4	1.7
.3	3	3	2	.8	0	.7	2	1.3	3.5	0	1.2	3.4
.4	4	5	1	1.3	1	.9	2	2.2	1.7	0	1.6	1.7
.5	13	12	0	3.1	2	3.1	2	5.4	.0	1	5.2	.0
.6	21	17	1	4.4	3	4.9	0	7.6	1.7	0	8.4	1.7
.7	22	18	1	4.6	4	5.2	1	8.0	1.7	2	8.8	1.7
.8	13	17	1	4.4	8	3.1	1	7.6	1.7	1	5.2	1.7
.9	6	10	0	2.6	2	1.4	2	4.5	.0	1	2.4	.0
1.0	10	6	0	1.5	1	2.3	2	2.7	.0	4	4.0	.0
1.1	11	5	8	1.3	1	2.6	13	2.2	13.9	13	4.4	13.6
1.2	6	3	4	.8	2	1.4	8	1.3	7.0	6	2.4	6.8
1.3	2	1	0	.3	2	.5	3	.4	.0	4	.8	.0
1.4	0	1	2	.3	1	.0	2	.4	3.5	6	.0	3.4
1.5	2	2	0	.5	0	.5	1	.9	.0	5	.8	.0
1.6	0	2	0	.5	0	.0	0	.9	.0	1	.0	.0
1.7	0	0	0	.0	0	.0	0	.0	.0	1	.0	.0

PHOTOELECTRIC LIGHT-CURVES OF V366 CYGNI AND UZ LEONIS

BY C. J. VAN HOUTEN

Photoelectric light-curves were determined of the variables V366 Cygni and UZ Leonis, with the 10-inch refractor of the Leiden Observatory. For V366 Cygni BEYER's elements were confirmed and improved, but UZ Leonis, formerly classified as a c-type RR Lyrae variable, appeared to be an eclipsing variable with a period twice that found by KAHO.

During the year 1953, light-curves of the variables V366 Cygni and UZ Leonis were determined by the writer with a photoelectric photometer attached to the 10-inch refractor of the Leiden Observatory. Neither of the two light-curves could be finished completely on account of unfavourable weather conditions and the departure of the observer to the United States. The photomultiplier with which the 1953 observations were made is no longer available, so that the light-curves cannot be completed. It was thought, however, that the unfinished results might still give important information about these stars; consequently they were prepared for publication. The number of observations of V366 Cygni is 384, of UZ Leonis 143.

Equipment. The output current of the photomultiplier was amplified by a 2-tube d.c. amplifier; usually a grid-leak resistance of 20 megohms was used. The recording instrument was a galvanometer. The telescope, a visual refractor, has a sizeable secondary spectrum in the violet region, so that a rather large-size diaphragm had to be used. For that reason it was not possible to work during moonlight.

Without moonlight the night-sky was practically negligible; this means that the limit for the observations was set by the amplifier used. In order to get a sufficient deflection no colour-filter was used for this set of observations. It was necessary to refrigerate the photocell during the summer months, but in the other seasons the photometer was used without cooling.

V366 Cygni. The light-curve derived from the photoelectric observations is essentially of the same form as determined by BEYER [1]); the depths of the primary and secondary minima are $0^m.46$ and $0^m.19$, resp. The

[1]) *A.N.* **267**, 395, 1938.

star BD $+53°$ 2484 was used as a comparison star. It is situated at a distance of only 12′ from the variable and has practically the same colour, so that no corrections for differential extinction were necessary.

From the light-curve the following time of primary minimum could be derived: J.D. $2434489^d.5933$. A least-squares solution together with BEYER's minima yielded the elements:

$$\text{Prim. min.} = \text{J.D. } 2434489^d.593 + 1^d.0960183\, E.$$
$$\pm\ 2 \qquad \pm\ 11 \text{ m.e.}$$

In this solution the photoelectric minimum has been given a weight 5; this is evidently an underestimate. The residuals may be seen from the following table:

TABLE 1

J.D.– 2420000	E	O–C
d		d
5900.097	–7837	.000
7283.254	–6575	–.018
7642.796	–6247	+.030
7962.805	–5955	+.001
8391.348	–5564	+.001
8745.357	–5241	–.004
9085.114	–4931	–.012
14489.593	0	.000

Because of the irregular distribution of the individual observations over the light-curve no attempt was made to obtain normal points of equal weight. The normal points are listed in Table 2. The phases in this table were computed from the formula:

$$\text{phase} = 1/P \times (\text{J.D.} - 2430000).$$

n refers to the number of observations contributing to one normal point. All observations were given equal weight. The phase of the primary minimum is 0.2755.

TABLE 2

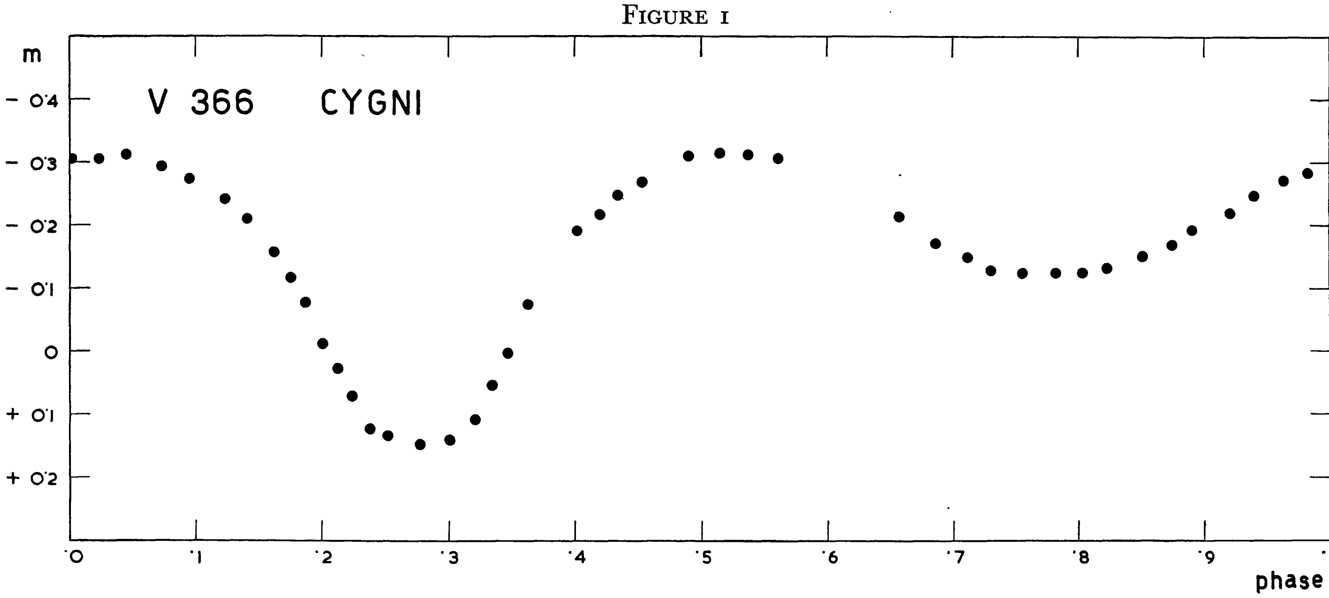
phase	n	$m_v - m_c$	phase	n	$m_v - m_c$
1/d		m	1/d		m
.0018	13	–.306	.4198	4	–.218
.0229	10	–.306	.4338	6	–.247
.0445	7	–.312	.4528	9	–.269
.0725	8	–.293	.4893	7	–.310
.0950	9	–.274	.5146	10	–.315
.1234	10	–.241	.5370	9	–.312
.1410	5	–.210	.5608	7	–.306
.1626	4	–.157	.6570	8	–.214
.1756	8	–.117	.6861	6	–.171
.1868	4	–.077	.7108	6	–.149
.2003	4	–.011	.7302	8	–.128
.2123	10	+.027	.7552	7	–.124
.2242	7	+.071	.7816	7	–.124
.2378	12	+.124	.8037	10	–.125
.2521	10	+.134	.8225	9	–.132
.2764	7	+.148	.8511	10	–.150
.3005	19	+.140	.8743	16	–.169
.3203	11	+.109	.8904	10	–.192
.3344	10	+.054	.9203	10	–.219
.3467	9	+.003	.9394	13	–.247
.3623	8	–.074	.9628	10	–.271
.4022	6	–.191	.9824	10	–.283

The light-curve (normal points) of V366 Cygni is shown in Figure 1, and the individual observations are listed in Table 4. I am indebted to Mr J. WOLTERBEEK MULLER for the observations of April 7 and April 21, 1953, and to Mr A. OLLONGREN for the observations of September 1, 1953.

UZ Leonis. Observations of this star were reported by S. KAHO [1]), J. ASHBROOK [2]), G. PRESTON [3]) and W.

[1]) *Tokyo Bull.* No. 209, 1937; second ser. No. 49, 1952.
[2]) *A.J.* **54**, 198, 1949.
[3]) *A.J.* **56**, 112, 1951.

FIGURE 1



V 366 Cygni, normal points.

DZIEWULSKI[1]). KAHO classified the star as a c-type RR Lyrae variable with a period of $0^d.309041$. However, the Leiden observations, after reduction, yielded minima that were defined more sharply than the maxima; moreover, even and odd minima showed a difference in depth of about $0^m.05$. So, evidently, the classification has to be changed; UZ Leonis is a W UMa-type eclipsing variable with a period twice as long as found by KAHO.

In order to tie in with the maxima published by former authors, the time of minimum light found from the Leiden observations was transformed into a maximum by adding half of the apparent period; then a least-squares solution was made of the ephemeris, giving equal weight to all the observations. The maxima used were: the maxima of KAHO, except those given with only two decimals; PRESTON's normal maximum, DZIEWULSKI's normal maximum and the photoelectric maximum. The result of the least-squares solution is:

$$\text{Maximum} = \text{J.D. } 2429685^d.100 + 0^d.30901727\,E,$$
$$\pm\ 3 \quad \pm\ 39 \quad \text{m.e.}$$

the individual maxima giving the residuals following in Table 3. From the Leiden observations a time of primary minimum of J.D. $2434486^d.4650$ could be derived. Together with the doubled period this gives the elements:

$$\text{Prim. min.} = \text{J.D. } 2434486^d.4650 + 0^d.6180345\,E.$$

The light-curve seems to show a small difference of about $0^m.02$ between the heights of even and odd maxima, in the sense that the maximum following the

[1]) *Torun Bull.* No. 12, 1953.

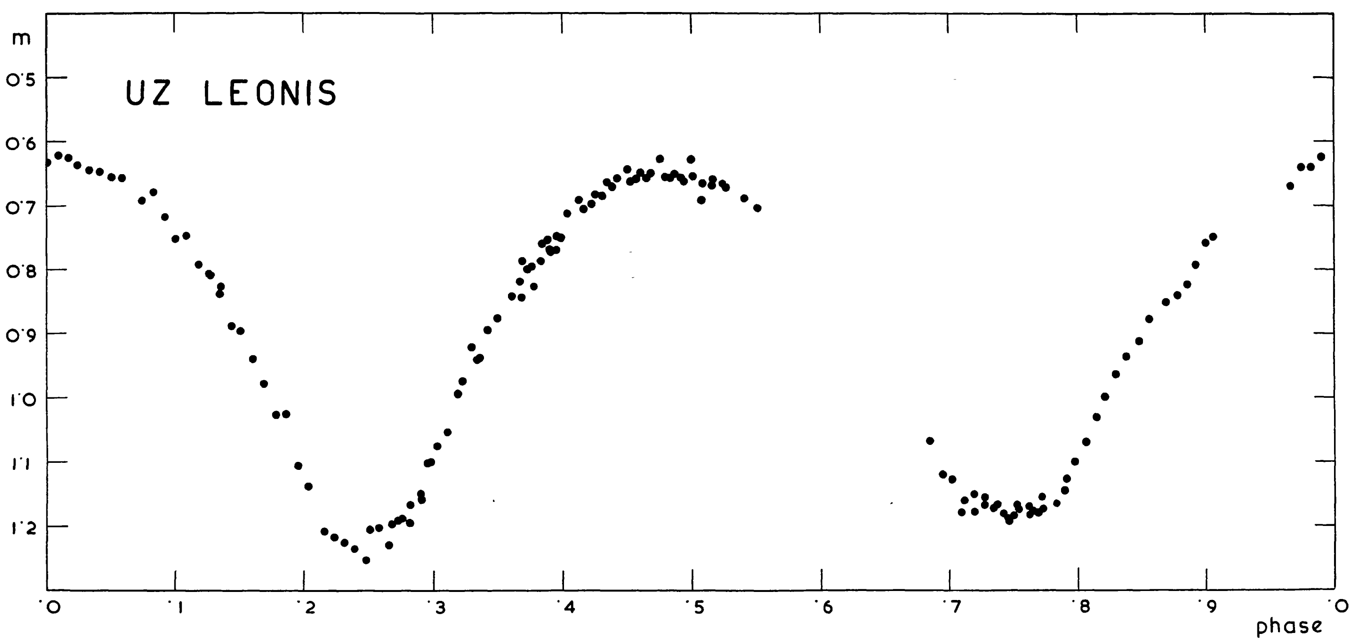
TABLE 3

J.D.— 2420000	E	$O-C$
d		
4925.019	−15404	+.021
8548.218	−3679	−.007
8572.323	−3601	−.005
8581.893	−3570	−.017
8635.063	−3398	+.004
8640.282	−3381	−.030
8657.002	−3327	+.003
8664.105	−3304	−.002
8687.283	−3229	.000
8949.022	−2382	+.002
9004.969	−2201	+.016
9685.109	0	+.009
10084.958	1294	−.010
13325.321	11780	−.002
13453.871	12196	−.003
13768.462	13214	+.008
14489.401	15547	+.010

secondary minimum is the brighter one. However, the observations are not numerous enough to state this with certainty. With respect to the average of the two maxima the depth of the primary minimum is $0^m.59$, and of the secondary minimum $0^m.54$. The star BD $+14°$ 2284 was used as a comparison star. Corrections for differential extinction have been applied. As a rule they were small.

Table 5 gives the individual observations, as the total number of observations is too small to make the formation of normal points profitable. The light-curve is illustrated in Figure 2.

FIGURE 2



UZ Leonis , individual observations.

TABLE 4
Individual observations of V366 Cygni

J.D.— 2430000	$m_v - m_c$	J.D.— 2430000	$m_v - m_c$	J.D.— 2430000	$m_v - m_c$	J.D.— 2430000	$m_v - m_c$	J.D.— 2430000	$m_v - m_c$
d	m	d	m	d	m	d	m	d	m
4486.5365	− .322	4522.4617	+ .130	4598.5152	− .215	4606.5643	− .295	4628.5877	− .265
.5420	− .310	.4853	+ .135	.5190	− .210	.5692	− .322	.5919	− .265
.5514	− .318	.4908	+ .142	.5225	− .219	.5733	− .304	.5964	− .252
.5573	− .328	.4960	+ .152	.5263	− .210	.5771	− .295	.6009	− .255
.5629	− .315	.5012	+ .145	.5315	− .203	.5813	− .300	.6096	− .245
4487.5372	− .185	.5071	+ .155	.5353	− .175	.5858	− .300	.6138	− .251
.5424	− .192	.5144	+ .103	.5402	− .175	.5941	− .315	.6190	− .242
.5476	− .208	.5203	+ .135	.5482	− .145	4622.3738	− .235	.6259	− .214
.5532	− .215	.5259	+ .112	.5527	− .180	.3801	− .249	.6294	− .230
.5580	− .195	.5339	+ .064	.5569	− .185	.3874	− .240	.6342	− .202
.5629	− .225	.5387	+ .055	.5610	− .164	.3950	− .255	4629.3596	− .110
.5677	− .248	.5446	+ .029	.5652	− .152	.4020	− .271	.3645	− .120
.5730	− .240	.5502	+ .020	.5705	− .156	.4099	− .278	.3693	− .140
.5782	− .250	.5554	− .025	.5739	− .158	.4165	− .266	.3745	− .128
.5823	− .254	.5610	− .050	.5777	− .144	.4353	− .289	.3797	− .124
.5868	− .264	.5666	− .090	.5819	− .150	.4405	− .318	.3839	− .115
.5914	− .270	4545.4427	+ .132	.5871	− .132	.4457	− .316	.3881	− .142
.5955	− .270	.4472	+ .122	.5916	− .138	.4502	− .294	.3933	− .146
.5997	− .275	.4520	+ .138	.5961	− .140	.4648	− .308	.4075	− .145
.6042	− .269	.4559	+ .142	.6003	− .142	.4690	− .315	.4124	− .139
4488.5306	+ .164	4579.5258	+ .091	4603.4097	− .256	.4731	− .318	.4176	− .152
.5358	+ .144	.5314	+ .064	.4143	− .250	.4787	− .320	.4228	− .155
.5407	+ .130	.5439	+ .005	.4184	− .235	.4839	− .299	.4283	− .150
.5452	+ .085	.5484	− .020	.4222	− .230	.4915	− .331	.4339	− .152
.5497	+ .120	.5529	− .035	.4271	− .228	.4957	− .300	.4381	− .172
.5549	+ .114	.5577	− .048	.4309	− .215	.4992	− .349	.4433	− .170
.5594	+ .075	.5619	− .080	.4347	− .200	.5033	− .299	.4485	− .174
.5643	+ .045	.5657	− .086	.4396	− .204	.5072	− .334	.4915	− .219
.5698	+ .040	.5696	− .093	.4486	− .180	.5120	− .289	.4957	− .226
.5747	+ .010	.5737	− .114	.4535	− .150	.5162	− .322	.4999	− .232
.5789	− .006	4583.4158	− .142	.4573	− .152	.5197	− .325	.5040	− .218
4489.5213	+ .028	.4203	− .160	.4618	− .145	.5238	− .300	.5085	− .240
.5262	+ .040	.4259	− .210	.4656	− .122	.5277	− .299	.5124	− .252
.5324	+ .055	.4509	− .190	.4702	− .104	.5322	− .288	.5165	− .239
.5408	+ .080	.4665	− .206	.5083	+ .005	.5367	− .319	.5221	− .254
.5498	+ .096	.4721	− .250	.5115	+ .034	4628.4391	− .268	.5263	− .255
.5581	+ .118	.4783	− .238	.5150	+ .050	.4426	− .269	.5304	− .274
.5658	+ .125	.4832	− .254	.5184	+ .070	.4460	− .268	.5346	− .270
.5727	+ .145	.4881	− .244	.5222	+ .058	.4513	− .272	.5402	− .272
.5817	+ .164	.4936	− .278	.5257	+ .090	.4554	− .280	.5450	− .295
.5887	+ .156	.5068	− .255	.5306	+ .110	.4596	− .290	4636.3450	− .136
.5956	+ .154	.5429	− .322	.5340	+ .106	.4641	− .290	.3507	− .111
.6026	+ .164	.5464	− .302	.5434	+ .160	.4683	− .290	.3565	− .090
.6095	+ .160	.5502	− .324	.5479	+ .144	.4717	− .292	.3610	− .074
4508.4864	− .315	.5544	− .316	.5521	+ .150	.4756	− .285	.3783	+ .009
.4913	− .308	.5578	− .305	4606.3952	− .144	.4794	− .295	.3842	.000
.4972	− .322	5613	− .310	.3990	− .141	.5141	− .298	.3912	+ .015
.5024	− .302	.5655	− .288	.4025	− .171	.5183	− .308	.3960	+ .035
.5076	− .285	.5693	− .282	.4063	− .141	.5221	− .315	.4020	+ .054
.5131	− .294	.5738	− .334	.4101	− .165	.5259	− .318	.4079	+ .088
.5181	− .315	.5780	− .299	.4198	− .170	.5301	− .315	.4127	+ .105
4515.4565	− .175	.5815	− .338	.4243	− .178	.5342	− .310	.4183	+ .116
.4617	− .178	4592.3981	− .289	.4403	− .164	.5384	− .312	.4224	+ .140
.4662	− .189	.4061	− .280	.4452	− .170	.5419	− .316	.4273	+ .144
.4718	− .200	.4113	− .289	.5313	− .280	.5471	− .298	.4329	+ .155
.4770	− .210	.4154	− .282	.5351	− .285	.5513	− .300	.4388	+ .124
4521.5098	− .175	.4203	− .296	.5389	− .270	.5561	− .305	.4714	+ .132
.5147	− .182	.4255	− .279	.5431	− .280	.5610	− .302	.4766	+ .150
.5192	− .204	.4425	− .258	.5504	− .271	.5648	− .298	.4818	+ .156
4522.4443	+ .120	4598.5034	− .225	.5538	− .285	.5700	− .285	.4867	+ .126
.4499	+ .106	.5076	− .220	.5578	− .292	.5752	− .285	.4912	+ .115
.4561	+ .125	.5114	− .210	.5611	− .290	.5829	− .285	.4961	+ .141

Table 4 *(continued)*

J.D.— 2430000	$m_v - m_c$	J.D.— 2430000	$m_v - m_c$	J.D.— 2430000	$m_v - m_c$	J.D.— 2430000	$m_v - m_c$	J.D.— 2430000	$m_v - m_c$
d	m	d	m	d	m	d	m	d	m
4636.5033	+ .115	4646.3716	+ .125	4662.3873	− .232	4720.2569	− .109	4720.3149	− .115
.5099	+ .091	4662.3151	− .165	.3908	− .245	.2604	− .115	.3187	− .115
.5155	+ .076	.3193	− .168	.3943	− .228	.2639	− .129	.3226	− .102
.5197	+ .065	.3241	− .162	4692.2438	− .145	.2670	− .125	.3264	− .099
.5249	+ .045	.3276	− .178	.2473	− .130	.2708	− .135	.3299	− .126
.5304	+ .010	.3318	− .177	.2511	− .099	.2743	− .109	.3333	− .135
.5342	+ .017	.3359	− .194	.2553	− .093	.2788	− .119	.3368	− .130
.5388	− .015	.3398	− .195	.2587	− .077	.2826	− .140	.3399	− .139
4646.3390	+ .140	.3439	− .191	.2650	− .065	.2865	− .120	.3455	− .125
.3426	+ .144	.3474	− .188	.2695	− .030	.2906	− .120	.3486	− .119
.3480	+ .130	.3512	− .200	.2737	− .010	.2944	− .124	.3528	− .120
.3522	+ .128	.3620	− .226	.2775	− .015	.3007	− .149	.3566	− .140
.3571	+ .118	.3654	− .210	.2823	+ .018	.3042	− .136	.3611	− .154
.3609	+ .140	.3793	− .230	.2862	+ .045	.3076	− .128	.3646	− .130
.3661	+ .105	.3831	− .236	4720.2535	− .122	.3115	− .122		

Table 5

Individual observations of UZ Leonis

J.D.— 2430000	$m_v - m_c$	phase	J.D.— 2430000	$m_v - m_c$	phase	J.D.— 2430000	$m_v - m_c$	phase
d	m		d	m		d	m	
4475.3432	+ 1.208	.2512	4486.4778	+ 1.198	.2673	4488.3943	+ 0.787	.3683
.3474	1.204	.2580	.4827	1.189	.2753	.3991	0.795	.3761
.3519	1.230	.2653	.4872	1.167	.2825	.4068	0.753	.3885
.3564	1.192	.2726	.4923	1.160	.2908	.4109	0.749	.3952
.3619	1.196	.2815	.4966	1.101	.2978	.4162	0.713	.4037
.3661	1.150	.2882	4487.3541	1.068	.6852	.4217	0.692	.4126
.3710	1.102	.2962	.3600	1.121	.6948	.4276	0.698	.4222
.3751	1.076	.3028	.3645	1.128	.7020	.4328	0.685	.4306
.3797	1.055	.3103	.3690	1.179	.7093	.4377	0.671	.4385
.3849	0.994	.3187	.3749	1.151	.7189	.4464	0.663	.4526
.3911	0.922	.3287	.3801	1.156	.7273	.4512	0.649	.4604
.3956	0.939	.3360	.3846	1.173	.7346	.4561	0.649	.4683
.5064	0.669	.5153	.3892	1.181	.7420	.4606	0.627	.4756
.5133	0.672	.5264	.3940	1.185	.7498	.4655	0.657	.4835
.5224	0.690	.5411	.4034	1.177	.7650	.4706	0.657	.4918
.5286	0.705	.5512	.4083	1.174	.7729	.4755	0.629	.4999
4478.5048	0.819	.3668	.4144	1.166	.7828	.4804	0.693	.5076
.5083	0.800	.3724	.4187	1.145	.7897	.4859	0.660	.5165
.5117	0.834	.3779	.4235	1.101	.7975	.4901	0.666	.5233
.5156	0.759	.3842	.4289	1.070	.8063	4489.3814	0.671	.9655
.5191	0.769	.3899	.4341	1.032	.8147	.3870	0.641	.9745
.5222	0.770	.3949	.4381	1.000	.8211	.3915	0.641	.9818
4486.3907	0.806	.1264	.4430	0.965	.8291	.3964	0.625	.9897
.3959	0.839	.1348	.4482	0.937	.8375	.4029	0.632	.0002
.4014	0.889	.1437	.4548	0.913	.8482	.4085	0.622	.0093
.4059	0.898	.1510	.4596	0.878	.8559	.4134	0.625	.0172
.4118	0.941	.1605	.4676	0.852	.8689	.4179	0.637	.0245
.4169	0.979	.1688	.4721	0.841	.8761	.4234	0.645	.0334
.4229	1.034	.1785	.4780	0.824	.8857	.4287	0.647	.0420
.4275	1.033	.1860	.4819	0.794	.8920	.4342	0.655	.0509
.4334	1.107	.1955	.4867	0.760	.8998	.4391	0.657	.0588
.4382	1.140	.2033	.4903	0.750	.9056	.4488	0.693	.0745
.4459	1.210	.2157	4488.3658	0.975	.3222	.4543	0.679	.0834
.4507	1.218	.2235	.3727	0.942	.3333	.4599	0.718	.0925
.4556	1.226	.2314	.3780	0.895	.3419	.4648	0.753	.1004
.4604	1.236	.2392	.3828	0.877	.3497	.4700	0.747	.1088
.4660	1.254	.2482	.3894	0.842	.3604	.4759	0.792	.1184

TABLE 5 (*continued*)

J.D.– 2430000	$m_v - m_c$	phase	J.D.– 2430000	$m_v - m_c$	phase	J.D.– 2430000	$m_v - m_c$	phase
d	m		d	m		d	m	
4489.4821	+ 0.809	.1284	4501.3918	+ 0.751	.3987	4501.4550	+ 0.655	.5009
.4863	0.827	.1352	.4029	0.706	.4166	.4595	0.666	.5082
4500.3707	1.193	.7465	.4084	0.684	.4255	4508.3836	1.161	.7116
.3752	1.174	.7538	.4140	0.663	.4346	.3885	1.179	.7196
.3801	1.170	.7617	.4189	0.658	.4425	.3934	1.168	.7275
.3846	1.180	.7690	.4237	0.644	.4503	.3993	1.168	.7370
.4029	1.127	.7986	.4282	0.659	.4576	.4045	1.189	.7455
4501.3730	0.845	.3683	.4328	0.657	.4650	.4090	1.168	.7527
.3776	0.797	.3757	.4418	0.655	.4796	.4149	1.183	.7623
.3824	0.787	.3835	.4463	0.651	.4869	.4205	1.155	.7713
.3869	0.771	.3907	.4508	0.663	.4941			