A STUDY OF THE ECLIPSING BINARY XX CAS

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Abstract. *UBV* photometry of the eclipsing binary system XX Cas has been presented. Primary eclipse appears to be a total occultation rather than a partial transit (Pierce, 1938). A slightly improved period of $3^{d}.0671708$ has been obtained, and the colour of the system discussed.

1. Introduction

The variability of the eclipsing binary system XX Cas (= BD + 60° 246 = HV 3550) was discovered photographically by Mackie (Bailey, 1921). He thought the variation to be as that of an eclipsing system. Selivanow (1923) confirmed the eclipsing nature of the light variation and presented the light elements. Gaposchkin (1935) discussed blue, yellow, and red photographic observations and found no evidence of constant light during minimum. He considered the eclipses as partial or grazing, with the secondary displaced toward the preceding primary. Pierce (1938) has reported that Leiner (1922, 1923, 1924) gave the improved light elements from visual estimates and found no constant light in the minimum while Pagaczewski's (1930, 1934) elements gave a constant light of about $0^{d}.08$ duration. His own light curve has some evidence of both reflection and ellipticity but displacement of the secondary minimum is not noticeable as suggested by Gaposchkin (1935). Pierce (1938) has derived the elements of the system and has also mentioned the observations by Gadomski (1935) giving a duration of totality of about $0^{d}.06$.

McLaughlin (1927) presented the mean densities of the components of the system. Wyse (1934) reported the spectral types of both the components as B4n and B6n and gave their provisional densities.

According to Gaposchkin (1935) visual observations of Leiner indicate that the light curve of the system is that of a non-elliptical nature, with an eclipse lasting less than half a day while Pagaczewski's observations give $D = 0^{d}.68$ and indicate that the secondary minimum must be deep. Gaposchkin concluded from his photographic observations that the light curve is that of non-elliptical components and if any ellipticity exists at all, it must be very small. He also pointed out that the existance of the secondary minimum is evident but its depth can not be greater than $0^{m}.2$. Gaposchkin further corroborated that apsidal motion may be present in the system and that the line of apsides advances. He pointed out that the secondary spectra should have been differently classified and the spectral types of the components are B4 and B8. He further pointed out that the colour excess may be present in the system.

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2. Observations

In order to remove the uncertainties regarding the nature of eclipses, totality, spectral classes, apsidal motion, ellipticity and reflection effects etc., we have observed the system XX Cas with 38-cm reflector of Uttar Pradesh State Observatory, through U, B, and V filters, using an unrefrigerated 1P21 photomultiplier with d.c. techniques.

A total of 27 nights of observations have been secured during the period December 1972 to February 1975. To begin with two stars (BD + 60° 241 and BD + 60° 255) were chosen as comparison stars. However, the former was found to be a better comparison star than the latter as seen from the nightly variations in the magnitudes, and hence all the reductions were carried out using that star only. The standard deviations of the comparison star, derived on six nights chosen randomly, in U, B, and V filters are given in Table I along with the particulars of the stars.

The instrumental magnitudes have been converted into standard ones by observing six standard stars of different spectral types.

A total of 193 observations in U, 231 in B, and 299 in V have been secured and are listed in Tables IV, V, and VI, respectively.

TABLE I
Particulars of the stars

Star	α_{1855}	δ_{1855}	m_v	Average standard deviation of an individual observation in U, B, and V filters
Variable star XX Cas = BD + 60° 246	$01^h20^m05\overset{s}{.}3$	+60°13′.2	$9\overset{m}{.}2$	–
Comparison star = BD + 60° 241	$01^h18^m46\overset{s}{.}1$	+60°07′.9	$9\overset{m}{.}5$	$\pm 0\overset{m}{.}026$ (U) $\pm 0\overset{m}{.}017$ (B) $\pm 0\overset{m}{.}027$ (V)

3. Epoch and Period

During the course of our observations one primary and two secondary minima have been observed. The times of mnima have been determined with a graphical accuracy of $0\overset{d}{.}001$ and are listed below:

Observed minima of XX Cas

Primary minima JD (Hel)	Secondary minima JD (Hel)
(1) 2441990.253	(1) 2442007.137
	(2) 2442010.166

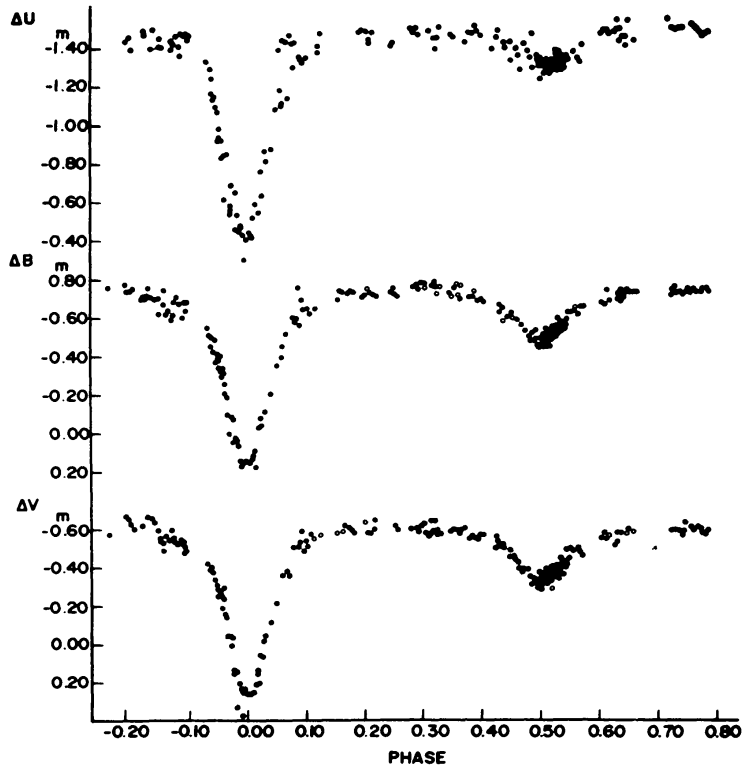

Fig. 1. Light curves of XX Cas.

Chau (1959) presented photoelectric light elements taken at λ5150 Å and confirmed Pierce's statement that there is no evidence of the period change since the discovery of the system.

Using the elements given by Chau (1959) viz:

$$\text{Pr. Min.} = \text{JD}\,2436527.619 + 3^{d}.0671773\,E,$$

the period on the basis of our observations comes out to be $3^{d}.0671708$, which is not significantly different from that given by Chau (1959).

Wood and Forbes (1963) computed the ephemeries for minimum light applying the method of least squares and presented the following elements:

$$\text{Pr. Min.} = \text{JD}\,2433282.54239 + 3^{d}.0671799\,E.$$

TABLE II
Epoch and period of XX Cas

Sl. No.	Author	Epoch and period
1.	Gaposchkin (1935)	JD 2425326.284 + $3^{d}.0671663\,E$
2.	Pierce (1938)	JD 2425326.286 + $3.0671775\,E$
3.	Chau (1959)	JD 2436527.619 + $3.0671773\,E$
4.	Wood and Forbes (1963)	JD 2433282.54239 + $3.0671799\,E$
5.	Srivastava (present observations)	JD 2441990.253 + $3.0671724\,E$

TABLE III
Tentative colour indices of XX Cas

Sl. No.	Phase	$B-V$	$U-B$	Tentative UV-excess	S_p
1.	Maximum (combined colour of both the components)	$+0^m.361$	$-0^m.597$	$0^m.597$	F2V
2.	Tip of primary minimum (colour of the secondary component)	+0.361	−0.456	0.456	F2V
3.	Primary component	+0.360	−0.716	0.716	F2V
4.	Comparison star	+0.471	+0.123	–	F6III

TABLE IV
Standard U magnitudes of XX Cas

JD (Hel)	Phase	Δm	JD (Hel)	Phase	Δm
2441 658.1366	0.7164	$-1^m.542$	010.1263	0.4803	$-1^m.384$
.1482	0.7240	−1.493	.1356	0.4835	−1.343
.1624	0.7286	−1.488	.1492	0.4878	−1.292
.1787	0.7339	−1.488	.1699	0.4946	−1.294
.1943	0.7390	−1.496	.1812	0.4982	−1.325
.2539	0.7585	−1.512	.1918	0.5017	−1.304
.2666	0.7626	−1.497	.2133	0.5087	−1.301
.2746	0.7652	−1.489	.2283	0.5136	−1.313
.2869	0.7692	−1.472	.2635	0.5251	−1.289
.2998	0.7734	−1.451	.2895	0.5336	−1.301
.3151	0.7784	−1.461	.3015	0.5375	−1.313
.3300	0.7833	−1.466	.3125	0.5411	−1.339
990.2156	−0.0112	−0.465	.3219	0.5441	−1.359
.2288	−0.0069	−0.429	016.0950	0.4263	−1.457
.2423	−0.0025	−0.403	.1100	0.4312	−1.492
.2633	+0.0043	−0.440	.1255	0.4395	−1.425
.2740	0.0078	−0.432	.1672	0.4499	−1.429
.2839	0.0111	−0.522	.1984	0.4600	−1.394
.2936	0.0142	−0.592	.2107	0.4640	−1.353
.3107	0.0198	−0.545	.2252	0.4688	−1.278
.3229	0.0238	−0.755	034.1883	0.3253	−1.456
			.2021	0.3298	−1.509
2442 007.1088	0.4965	−1.361	.2635	0.3498	−1.473
.1167	0.4991	−1.346	.2782	0.3546	−1.460
.1318	0.5037	−1.328	035.1260	0.6311	−1.488
.1393	0.5065	−1.342	.1368	0.6346	−1.430
.1546	0.5115	−1.329	.1658	0.6440	−1.451
.1627	0.5141	−1.322	.2193	0.6615	−1.432
.1720	0.5172	−1.322	036.0667	−0.0622	−1.165
.1802	0.5198	−1.336	.0798	−0.0580	−1.133
.2068	0.5285	−1.338	.0923	−0.0539	−1.096
.2194	0.5326	−1.345	.1049	−0.0498	−1.069
.2310	0.5364	−1.356	.1749	−0.0270	−0.687
.3132	0.5632	−1.345	.1866	−0.0231	−0.652
.3262	0.5674	−1.322	.1993	−0.0191	−0.534
.3349	0.5703	−1.413	.2120	−0.0149	−0.444
			.2254	−0.0105	−0.476

Table IV (continued)

JD (Hel)	Phase	Δm	JD (Hel)	Phase	Δm
040.1849	0.2814	−1.506	358.2076	−0.0340	−0.855
.2010	0.2857	−1.482	.2220	−0.0291	−0.536
.2159	0.2905	−1.508	.2512	−0.0196	−0.455
.2277	0.2944	−1.469	.2958	−0.0050	−0.300
.2888	0.3143	−1.494	372.1379	+0.5079	−1.336
.3053	0.3197	−1.450	.1499	0.5118	−1.282
.3199	0.3244	−1.393	.1614	0.5156	−1.314
041.1764	0.6037	−1.473	.1822	0.5224	−1.270
.1895	0.6080	−1.489	373.1036	−0.1772	−1.488
.2029	0.6124	−1.487	.1068	−0.1762	−1.472
.2176	0.6171	−1.469	.1428	−0.1644	−1.399
.2484	0.6272	−1.478	.1548	−0.1605	−1.499
.2612	0.6314	−1.539	.1818	−0.1517	−1.452
.2736	0.6354	−1.494	.1861	−0.1503	−1.411
.2875	0.6399	−1.452	.1984	−0.1463	−1.411
.3029	0.6450	−1.408	.2481	−0.1301	−1.393
.3143	0.6487	−1.538	.2594	−0.1264	−1.422
042.1802	−0.0691	−1.329	.2875	−0.1173	−1.410
.1928	−0.0649	−1.295	.2984	−0.1137	−1.479
.2067	−0.0604	−1.241	.3140	−0.1083	−1.464
.2188	−0.0565	−1.147	.3177	−0.1074	−1.470
.2442	−0.0482	−0.978	378.1660	+0.4733	−1.422
.2580	−0.0437	−0.925	.2021	0.4851	−1.469
.2730	−0.0388	−0.851	.2370	0.4965	−1.345
049.1195	+0.1934	−1.480	.2523	0.5014	−1.233
.1350	0.1985	−1.492	.2998	0.5169	−1.310
.1604	0.2067	−1.489	385.9882	0.0877	−1.351
.1741	0.2112	−1.444	.9908	0.0886	−1.338
.1873	0.2155	−1.485	386.0027	0.0925	−1.325
.2838	0.2470	−1.416	.0277	0.1006	−1.349
.2942	0.2504	−1.434	.0931	0.1220	−1.409
050.0752	0.5050	−1.302	.1053	0.1259	−1.376
.1453	0.5278	−1.385	392.0907	0.3748	−1.429
.1576	0.5319	−1.378	.1036	0.3790	−1.482
.1736	0.5371	−1.340	.1184	0.3838	−1.476
.1902	0.5425	−1.334	.1326	0.3884	−1.516
.2329	0.5564	−1.379	.1462	0.3929	−1.487
098.0792	0.1558	−1.388	.1642	0.3987	−1.462
.0968	0.1616	−1.440	395.1423	0.0086	−0.412
.1114	0.1663	−1.430	.1931	0.0252	−0.631
.1316	0.1729	−1.467	.2057	0.0293	−0.863
.1443	0.1771	−1.419	.2191	0.0336	−0.807
.1588	0.1818	−1.426	.2476	0.0429	−0.880
128.1153	−0.0514	−0.920	.2714	0.0507	−1.084
.1248	−0.0483	−0.927	.2851	0.0552	−1.169
.1357	−0.0446	−0.736	.3000	0.0600	−1.102
.1464	−0.0411	−0.614	.3229	0.0675	−1.108
.1570	−0.0377	−0.585	.3357	0.0717	−1.141
.1673	−0.0343	−0.562	.3727	0.0838	−1.299
339.2674	−0.2089	−1.434	428.8681	0.4191	−1.392
.2808	−0.2046	−1.452	.9401	0.4426	−1.398
.3091	−0.1953	−1.392	.9654	0.4508	−1.326

Table IV (continued)

JD (Hel)	Phase	Δm	JD (Hel)	Phase	Δm
458.0574	0.5205	$-1^m.310$	.1917	−0.1097	$-1^m.430$
.0702	0.5244	−1.373	.2051	−0.1053	−1.474
.0798	0.5278	−1.310	461.0830	+0.5069	−1.261
.0938	0.5324	−1.302	.1154	0.5175	−1.263
.1023	0.5352	−1.339	.1303	0.5223	−1.334
.1128	0.5386	−1.266	.1472	0.5279	−1.287
459.1274	−0.1306	−1.437	.1621	0.5327	−1.315
.1399	−0.1266	−1.462	.1789	0.5382	−1.288
.1742	−0.1154	−1.357	—	—	—

TABLE V
Standard *B* magnitudes of XX Cas

JD (Hel)	Phase	Δm	JD (Hel)	Phase	Δm
2441 658.1363	0.7201	$-0^m.716$	.3139	0.5634	$-0^m.616$
.1381	0.7207	−0.743	.3267	0.5678	−0.653
.1491	0.7243	−0.753	.3353	0.5704	−0.661
.1631	0.7288	−0.728	010.1267	0.4805	−0.502
.1794	0.7342	−0.728	.1362	0.4836	−0.475
.1952	0.7393	−0.714	.1498	0.4880	−0.481
.2061	0.7429	−0.736	.1599	0.4913	−0.487
.2176	0.7466	−0.745	.1705	0.4948	−0.454
.2416	0.7544	−0.727	.1923	0.5018	−0.472
.2544	0.7586	−0.745	.2033	0.5054	−0.519
.2670	0.7627	−0.737	.2289	0.5138	−0.535
.2752	0.7654	−0.736	.2399	0.5174	−0.519
.2875	0.7694	−0.731	.2520	0.5213	−0.498
.3006	0.7737	−0.747	.2639	0.5252	−0.512
.3155	0.7785	−0.748	.2766	0.5293	−0.522
.3306	0.7835	−0.735	.3020	0.5376	−0.544
990.2164	−0.0110	+0.170	.3131	0.5412	−0.582
.2296	−0.0067	0.150	.3223	0.5442	−0.593
.2427	−0.0024	0.146	016.1084	0.4307	−0.668
.2639	+0.0139	0.148	.1241	0.4358	−0.655
.2845	0.0112	0.128	.1658	0.4494	−0.625
.2942	0.0144	0.088	.1778	0.4533	−0.597
.3111	0.0199	−0.033	.1970	0.4596	−0.592
.3234	0.0239	−0.080	.2233	0.4682	−0.562
2442 007.1094	0.4967	−0.495	034.1241	0.3044	−0.781
.1172	0.4993	−0.495	.1602	0.3162	−0.767
.1324	0.5042	−0.480	.1722	0.3201	−0.784
.1400	0.5067	−0.479	.1865	0.3247	−0.721
.1469	0.5090	−0.509	.2003	0.3292	−0.758
.1551	0.5116	−0.496	.2621	0.3494	−0.709
.1632	0.5143	−0.526	.2767	0.3541	−0.755
.1726	0.5173	−0.498	.2919	0.3591	−0.713
.1809	0.5201	−0.532	.3068	0.3640	−0.695
.2074	0.5287	−0.526	035.1247	0.6306	−0.693
.2315	0.5366	−0.540	.1353	0.6341	−0.690

Table V (continued)

JD (Hel)	Phase	Δm	JD (Hel)	Phase	Δm
.1492	0.6386	$-0^m.701$	.1908	0.5427	$-0^m.563$
.2057	0.6571	−0.731	.2050	0.5472	−0.629
.2172	0.6608	−0.731	.2195	+0.5520	−0.633
036.0655	−0.0626	−0.449	.2322	0.5565	−0.655
.0785	−0.0584	−0.424	098.0797	0.1560	−0.697
.0908	−0.0544	−0.368	.0974	0.1618	−0.739
.1035	−0.0502	−0.379	.1120	0.1665	−0.734
.1737	−0.0274	−0.084	.1320	0.1731	−0.727
.1854	−0.0235	−0.070	.1448	0.1772	−0.735
.1978	−0.0195	+0.030	.1593	0.1820	−0.731
.2106	−0.0153	0.064	128.1143	−0.0517	−0.408
.2238	−0.0110	0.148	.1240	−0.0485	−0.339
040.2016	+0.2859	−0.762	.1345	−0.0450	−0.322
.2164	0.2907	−0.765	.1455	−0.0414	−0.342
.2281	0.2945	−0.748	.1560	−0.0380	−0.208
.2453	0.3001	−0.777	.1666	−0.0346	−0.092
.2609	0.3052	−0.765	339.1840	−0.2361	−0.755
.2750	0.3098	−0.760	.2681	−0.2087	−0.767
.2895	0.3145	−0.726	.2811	−0.2045	−0.740
.3059	0.3199	−0.763	.2962	−0.1995	−0.737
.3203	0.3246	−0.773	.3097	−0.1951	−0.752
041.1770	0.6039	−0.678	358.1690	−0.0464	−0.399
.1898	0.6081	−0.665	.1864	−0.0407	−0.310
.2035	0.6126	−0.739	.2083	−0.0335	−0.189
.2184	0.6174	−0.685	.2227	−0.0289	0.000
.2617	0.6315	−0.724	.2371	−0.0242	+0.043
.2741	0.6356	−0.739	.2519	−0.0193	0.032
.2879	0.6401	−0.733	372.1213	+0.5025	−0.464
.3034	0.6451	−0.741	.1370	0.5078	−0.457
.3147	0.6488	−0.734	.1488	0.5115	−0.502
042.1806	−0.0689	−0.548	.1602	0.5150	−0.451
.1933	−0.0648	−0.509	.1811	0.5171	−0.527
.2070	−0.0603	−0.500	.1927	0.5258	−0.554
.2193	−0.0563	−0.488	373.0908	−0.1814	−0.700
.2447	−0.0480	−0.383	.1028	−0.1775	−0.707
.2585	−0.0435	−0.294	.1058	−0.1765	−0.702
.2735	−0.0386	−0.255	.1175	−0.1727	−0.705
049.1356	+0.1987	−0.710	.1294	−0.1688	−0.756
.1475	0.2025	−0.718	.1416	−0.1648	−0.705
.1610	0.2069	−0.749	.1536	−0.1609	−0.698
.1746	0.2114	−0.728	.1676	−0.1563	−0.699
.1879	0.2157	−0.715	.1806	−0.1521	−0.699
.2017	0.2202	−0.712	.1848	−0.1507	−0.621
.2844	0.2472	−0.753	.2089	−0.1429	−0.748
.2946	0.2505	−0.752	.2237	−0.1380	−0.617
.3028	0.2532	−0.720	.2627	−0.1253	−0.684
.3118	0.2559	−0.712	.2747	−0.1217	−0.707
050.0758	0.5052	−0.448	.2974	−0.1140	−0.679
.1174	0.5188	−0.548	.3130	−0.1089	−0.680
.1322	0.5239	−0.517	.3161	−0.1079	−0.682
.1458	0.5280	−0.503	378.1663	+0.4734	−0.535
.1582	0.5321	−0.537	.2028	0.4853	−0.524
.1741	0.5372	−0.550	.2238	0.4910	−0.537

Table V (continued)

JD (Hel)	Phase	Δm	JD (Hel)	Phase	Δm
.2373	0.4965	$-0^m.445$	.3235	0.0677	$-0^m.515$
.2529	0.5000	−0.461	.3595	0.0794	−0.600
.2692	0.5069	−0.496	.3731	0.0839	−0.594
.2828	0.5114	−0.496	.3855	0.0879	−0.559
385.9726	0.0827	−0.586	428.9036	0.4307	−0.627
.9899	0.0883	−0.730	.9188	0.4356	−0.581
386.0015	0.0921	−0.696	.9406	0.4427	−0.599
.0134	0.0960	−0.642	458.0786	0.5274	−0.596
.0264	0.1002	−0.647	.0926	0.5320	−0.580
.0379	0.1040	−0.651	.1012	0.5348	−0.569
.0502	0.1080	−0.625	.1113	0.5381	−0.544
.0799	0.1177	−0.643	.1257	0.5418	−0.507
.1038	0.1255	−0.642	459.0991	−0.1431	−0.667
392.0626	0.3656	−0.763	.1144	−0.1349	−0.634
.1042	0.3792	−0.705	.1280	−0.1304	−0.590
.1189	0.3840	−0.706	.1405	−0.1264	−0.614
.1334	0.3887	−0.742	.1748	−0.1152	−0.673
.1467	0.3930	−0.688	.1924	−0.1094	−0.600
.1647	0.3989	−0.694	.2024	−0.1052	−0.636
.1775	0.4031	−0.678	461.0837	+0.5072	−0.542
395.1429	0.0088	+0.122	.0989	0.5121	−0.459
.1697	0.0176	0.175	.1162	+0.5178	−0.489
.1936	0.0253	−0.041	.1308	0.5225	−0.553
.2062	0.0294	−0.112	.1479	0.5281	−0.541
.2355	+0.0390	−0.205	.1627	0.5329	−0.533
.2718	0.0508	−0.351	.1797	0.5385	−0.576
.2856	0.0553	−0.392	.2097	0.5483	−0.631
.3013	0.0604	−0.452	–	–	–

Splittgerber (1972) also observed the primary minima photographically.

Some of the epochs and the corresponding periods given in the literature are listed in Table II. It can be seen from the table that except for the period given by Gaposchkin (1935), the period of the system does not show any significant change.

4. Colour of XX Cas

The colours of the comparison star have been obtained for five nights, the average colour being $B - V = +0^m.471$ and $U - B = +0^m.123$. These values indicate that the comparison star belongs fairly close to F6 III spectral-luminosity class, according to the colour-sequence given by Arp (1958). The colours of the primary and the secondary components have been derived by usual method on the assumption that the primary minimum is due to a total occultation.

If both components are Main-Sequence stars, both components seem to belong to F2 spectral class. However, in absence of spectroscopic observations, these are only tentative spectral types. A more detailed analysis of the light curve for the elements of the system with be undertaken at a later date.

TABLE VI
Standard V magnitudes of XX Cas

JD (Hel)	Phase	Δm	JD (Hel)	Phase	Δm
2441 658.1369	0.7203	−0.594	.2644	0.5244	−0.364
.1384	0.7208	−0.597	.2770	0.5295	−0.344
.1635	0.7290	−0.599	.2906	0.5339	−0.398
.1800	0.7344	−0.593	.3025	0.5378	−0.372
.1955	0.7394	−0.592	.3135	0.5414	−0.425
.2067	0.7431	−0.596	.3231	0.5445	−0.434
.2179	0.7467	−0.638	016.0942	0.4261	−0.564
.2421	0.7546	−0.614	.1093	0.4271	−0.539
.2549	0.7588	−0.597	.1249	0.4361	−0.518
.2674	0.7629	−0.608	.1664	0.4496	−0.461
.2757	0.7656	−0.610	.1785	0.4535	−0.466
.2881	0.7696	−0.609	.1865	0.4562	−0.457
.3011	0.7738	−0.583	.1978	0.4598	−0.442
.3162	0.7788	−0.590	.2101	0.4638	−0.398
.3311	0.7836	−0.574	.2243	0.4685	−0.381
990.2171	−0.0107	+0.235	034.1249	0.3046	−0.630
.2301	−0.0065	0.232	.1608	0.3164	−0.648
.2433	−0.0022	0.261	.1730	0.3203	−0.648
.2645	+0.0047	−0.258	.1875	0.3251	−0.575
.2850	0.0114	−0.247	.2013	0.3296	−0.576
.2947	0.0146	+0.205	.2629	0.3496	−0.595
.3116	0.0201	0.059	.2775	0.3544	−0.606
.3240	0.0241	−0.013	.2929	0.3594	−0.600
			.3078	0.3643	−0.580
2442 007.1099	0.4969	−0.333	035.1255	0.6309	−0.583
.1178	0.4995	−0.333	.1361	0.6344	−0.584
.1329	0.5044	−0.334	.1502	0.6390	−0.588
.1406	0.5069	−0.317	.1649	0.6438	−0.583
.1474	0.5091	−0.343	.2065	0.6573	−0.591
.1557	0.5118	−0.351	036.0661	−0.0624	−0.400
.1634	0.5144	−0.384	.0792	−0.0582	−0.372
.1732	0.5175	−0.354	.0916	−0.0541	−0.307
.1813	0.5202	−0.377	.1041	−0.0500	−0.247
.1946	0.5245	−0.390	.1743	−0.0272	+0.034
.2080	0.5289	−0.417	.1860	−0.0233	0.133
.2205	0.5330	−0.380	.1986	−0.0192	0.147
.2322	0.5368	−0.410	.2112	−0.0151	0.203
.3145	0.5636	−0.507	.2246	−0.0108	0.247
.3273	0.5678	−0.485	040.1891	+0.2808	−0.634
.3358	0.5706	−0.464	.2022	0.2861	−0.604
010.1272	0.4806	−0.395	.2167	0.2908	−0.608
.1368	0.4838	−0.353	.2287	0.2947	−0.589
.1502	0.4881	−0.343	.2459	0.3003	−0.621
.1603	0.4914	−0.331	.2615	0.3054	−0.578
.1712	0.4950	−0.319	.2756	0.3100	−0.567
.1823	0.4986	−0.378	.2901	0.3147	−0.581
.1929	0.5021	−0.311	.3064	0.3168	−0.594
.2069	0.5056	−0.370	.3207	0.3247	−0.600
.2143	0.5090	−0.398	041.1776	0.6041	−0.560
.2294	0.5140	−0.372	.1904	0.6083	−0.584
.2404	0.5174	−0.370	.2040	0.6127	−0.548
.2525	0.5215	−0.346	.2188	0.6175	−0.571

Table VI (continued)

JD (Hel)	Phase	Δm	JD (Hel)	Phase	Δm
.2496	0.6278	−0.518	.2526	−0.0191	0.277
.2622	0.6317	−0.537	.2789	−0.0105	0.309
.2746	0.6357	−0.584	372.1219	+0.5027	−0.372
.2885	0.6403	−0.575	.1376	0.5078	−0.366
.3039	0.6453	−0.580	.1494	0.5117	−0.331
.3153	0.6490	−0.603	.1608	0.5154	−0.383
042.1814	−0.0687	−0.418	.1707	0.5186	−0.377
.1940	−0.0646	−0.386	.1817	0.5222	−0.388
.2075	−0.0602	−0.372	373.0913	−0.1812	−0.617
.2198	−0.0561	−0.333	.1181	−0.1725	−0.666
.2451	−0.0479	−0.257	.1422	−0.1646	−0.658
.2591	−0.0433	−0.213	.1542	−0.1607	−0.634
.2740	−0.0385	−0.155	.1682	−0.1561	−0.596
049.1480	+0.2027	−0.639	.1812	−0.1519	−0.551
.1615	0.2071	−0.584	.1855	−0.1505	−0.536
.1752	0.2116	−0.581	.1978	−0.1465	−0.530
.1882	0.2158	−0.601	.2097	−0.1423	−0.487
.2952	0.2491	−0.650	.2591	−0.1265	−0.596
.3024	0.2530	−0.621	.2634	−0.1251	−0.532
.3125	0.2563	−0.599	.2753	−0.1212	−0.518
050.0764	0.5084	−0.355	.2869	−0.1174	−0.513
.0923	0.5106	−0.344	.2981	−0.1138	−0.522
.1054	0.5148	−0.367	.3130	−0.1087	−0.473
.1182	0.5190	−0.389	.3169	−0.1077	−0.485
.1326	0.5237	−0.369	378.1668	+0.4736	−0.396
.1464	0.5282	−0.370	.2034	0.4855	−0.311
.1588	0.5322	−0.402	.2379	0.4967	−0.289
.1746	0.5374	−0.416	.2535	0.5018	−0.280
.1913	0.5428	−0.419	.2834	0.5116	−0.318
.2056	0.5475	−0.455	.3133	0.5213	−0.287
.2201	0.5522	−0.493	385.9877	0.0876	−0.509
.2337	0.5565	−0.492	.9904	0.0885	−0.531
098.0802	0.1561	−0.581	386.0021	0.0923	−0.589
.0980	0.1620	−0.590	.0140	0.0962	−0.484
.1127	0.1668	−0.619	.0270	0.1004	−0.538
.1326	0.1733	−0.605	.0384	0.1041	−0.511
.1435	0.1775	−0.596	.0508	0.1082	−0.575
.1596	0.1821	−0.587	.0806	0.1146	−0.547
128.1149	−0.0516	−0.279	.1046	0.1257	−0.571
.1245	−0.0484	−0.277	392.0633	0.3658	−0.600
.1350	−0.0448	−0.250	.0789	0.3709	−0.603
.1459	−0.0412	−0.242	.1047	0.3793	−0.555
.1566	−0.0378	−0.144	.1194	0.3841	−0.568
.1667	−0.0344	−0.044	.1339	0.3889	−0.562
339.1845	−0.2360	−0.568	.1472	0.3932	−0.553
.2689	−0.2086	−0.666	.1652	0.3991	−0.575
.2817	−0.2043	−0.650	.1782	0.4033	−0.576
.2968	−0.1993	−0.623	395.1309	0.0049	−0.227
.3103	−0.1949	−0.597	.1434	0.0090	−0.252
358.1864	−0.0407	−0.296	.1703	0.0181	+0.201
.2089	−0.0334	−0.045	.1942	0.0255	0.063
.2234	−0.0286	+0.004	.2068	0.0909	−0.045
.2377	−0.0240	0.155	.2360	0.0392	−0.117

Table VI (continued)

JD (Hel)	Phase	Δm	JD (Hel)	Phase	Δm
.2723	0.0510	−0.215	459.0997	−0.1397	−0.566
.3020	0.0607	−0.361	.1150	−0.1347	−0.545
.3241	0.0679	−0.382	.1411	−0.1262	−0.553
.3366	0.0720	−0.355	.1756	−0.1149	−0.542
.3599	0.0796	−0.511	.1931	−0.1092	−0.535
.3737	0.0841	−0.505	.2059	−0.1050	−0.502
428.8869	0.4252	−0.504	461.0844	+0.5074	−0.374
.9041	0.4308	−0.513	.0995	0.5123	−0.334
.9195	0.4358	−0.509	.1169	0.5180	−0.353
.9967	0.4512	−0.494	.1314	0.5227	−0.368
458.0568	0.5203	−0.411	.1485	0.5283	−0.412
.0790	0.5276	−0.458	.1633	0.5331	−0.404
.0930	0.5321	−0.461	.1807	0.5388	−0.369
.1018	0.5350	−0.438	.1952	0.5435	−0.500
.1123	0.5384	−0.434	.2102	0.5484	−0.502
.1233	0.5420	−0.377	–	–	–

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References

Arp, H. C.: 1958, in S. Flügge (ed.), *Handbuch der Physik* **51,** 83.
Bailey, S. I.: 1921, *Harvard Circ.*, No. 225.
Chau, K. C.: 1959, *Astron. J.* **64,** 468.
Gadomski, J.: 1935, *Circ. Astron. Obs. Warsaw* **15,** 4.
Gaposchkin, S.: 1935, *Harvard Bull.* **900,** p. 13.
Leiner, E.: 1922, *Beob. Zirkular* **4,** 55.
Leiner, E.: 1923, *Beob. Zirkular* **5,** 33.
Leiner, E.: 1924, *Astron. Nachr.* **222,** 137.
McLaughlin, D. B.: 1927, *Astron. J.* **38,** 45.
Pagaczewski, J.: 1930, *Acta Astron.* **1** (c), 93.
Pagaczewski, J.: 1934, *Publ. Pozan* **2,** No. 3, p. 28.
Pierce, N. L.: 1938, *Princeton Contr.*, No. 18, p. 10.
Selivanov, S.: 1923, *Astron. Nachr.* **219,** 372.
Splittgerber, E.: 1972, *Mitt. Veränder. Sterne* **6,** 53.
Wood, D. B. and Forbes, J. E.: 1963, *Astron. J.* **68,** 257.
Wyse, A. B.: 1934, *Lick Obs. Bull.* **17,** (No. 464), 37.