Kodaikanal Observatory

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The Light Curve of the Short Period Variable SX Phoenicis*

by

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Abstract—Relative changes in the primary, secondary and beat periods of SX Phoenicis have been evaluated using photoelectric observations made on five nights It is found that the primary period P_0 is becoming longer relative to the secondary period P_1 and that the beat period P_b is becoming shorter correspondingly A typical light curve in the blue along with the colour curve is also given.

Introduction

The variation of light of SX Phoenicis was first discovered by Eggen (1952) as a result of photoelectric observations of the star made on two nights at the Mount Stromlo Observatory He established that the star was an intrinsic variable of the RR Lyrae type with a period of approximately 80 minutes, the shortest known for any variable star He had also suspected the presence of a secondary period. Eggen derived an ephemeris which gave a fairly satisfactory representation of his observational data The heliocentric elements of the maxima were given by

$$\text{Max}=\text{JD } 2433927\cdot0402+0\ 056033\text{E}$$

The range of variation was observed to be different in every cycle and varied from 0·3 to 0·8 mag. From the apparent magnitude and the trigonometric parallax of the star he computed the absolute magnitude to be +4·3 which is too small if it were the conventional RR Lyrae type with absolute magnitude zero. Jackson (1938, 1949) first drew attention to the star's large proper motion. This large proper motion of about 0″·886 per year and the high galactic latitude (—71°) also tend to show that the star is relatively nearby with a low intrinsic luminosity. Kuiper (1940) classified this star as a probable subdwarf (A3) Fundamental data in respect of this star have been given by Evans, Menzies and Stoy (1957)

SX Phoenicis has been the subject of extensive photo-electric observations by Walraven (1953, 1955) in one colour viz. blue, during July to October 1952 with a photoelectric wedge photometer on the 16″ refractor at the Leiden Southern Station He concluded that the light variations depended upon two periods, the primary P_0 and a secondary P_1 The interference of these two oscillations gave rise to a beat period P_b which is related to P_0 by the formula

$$\frac{1}{P_b} = \frac{1}{P_1} - \frac{1}{P_0}$$

The values derived by him for P_0, P_1 and P_b are 0^d 05496420, 0^d 04277268 and 0^d 192836 respectively

Simultaneous spectrographic and photoelectric observations of this star were made by O C Wilson and Walker (1956) during August 1954 at Palomar, with the 200″ reflector They found large variations in the light amplitude of the star but were unable to detect correspondingly large changes in the radial velocity curve

On three nights during 1957, Wood (1959) made two and three colour photoelectric observations at the Mount Stromlo Observatory His results suggested that the beat period has shortened He also noticed occasional rapid fluctuations within a fraction of a minute

With a view to detect possible changes with time, in the nature of the light curve of this short period variable, the star was placed on the photoelectric programme at Kodaikanal during October 1963 to January 1964

Observational data

Photoelectric observations were made on SX Phoenicis at Kodaikanal on five nights with an unrefrigerated 1P21 photomultiplier attached to the 8″ Cooke refractor. A linear D C. amplifier with an Esterline Angus recorder was used for recording the star deflections On the night of October 26, observations were made in two colours viz blue and

*SX Phoenicis, HD 223065, R.A $23^h\ 41^m$ 2 (1900), Dec—42° 07′ (1900)

yellow, and on subsequent nights in only one colour, blue The filters used were Corning 5030 plus Schott GG 13 for blue, and Corning 3384 for yellow The comparison star used was HD 223107 Taking into account the relevant extinction coefficients the photometric traces were reduced to magnitude differences, $\triangle$ mag, outside the atmosphere Table I gives the $\triangle$ mag of the variable with time in heliocentric Julian days

The period

The observational material available now is not adequate to redetermine the actual periods P_o, P_1 and P_b But the data can, however, be utilized for the study of the relative changes in the above periods using the ephemeris given by Walraven (1953) Table II gives the phase observations for this epoch The following formulae of Walraven (1953) were made use of in the analysis

$$J\,D = 2434200^d{\cdot}0389 + 0^d\ 0549642\,(E + \triangle\varphi) \qquad (1)$$

(which gives the heliocentric J D of the moments when the ascending branch reaches the median magnitude)

$$\Psi = \frac{(J\,D - 2434200\ 1039)}{5\ 18575} \qquad (2)$$

(which gives the phase of the beat period $P_b = 0^d\ 192836$)

In Table II the first column gives the times of heliocentric J.D. of the observed maxima, the second column gives the times of mean light on the ascending branch computed from (1) and the third column gives the difference (O-C) days between the first two Column four gives the phase Ψ of the beat period using (2). On a comparison of the variation of (O-C) with the curve of Figure I of Walraven's paper (1953) a satisfactory agreement is seen if the latter curve is shifted to the left by 0 25 in the phase Ψ. The fifth column gives the revised phase Ψ' which is equal to (Ψ + 0 25) Column six gives the $\triangle\varphi$ phase corresponding to Ψ' read out from the curve in Figure I of Walraven (1953) These $\triangle\varphi$ phases have been converted to $\triangle\varphi$ in days and given under column seven Finally, column eight gives the corrected (O-C) days which are the residuals obtained by subtracting the values of column seven from the corresponding ones of column three From the above table it is seen that the observed maxima in the present epoch occur $0^d{\cdot}03$ later than the moments when the ascending branches reach the median magnitude, according to the 1952 observations The corresponding value for Wood's (1957) observations was 0^d 0207 The observations, therefore, indicate that from 1952 the primary period P_o is probably becoming longer relative to the secondary period P_1, while the beat period P_b is becoming shorter correspondingly

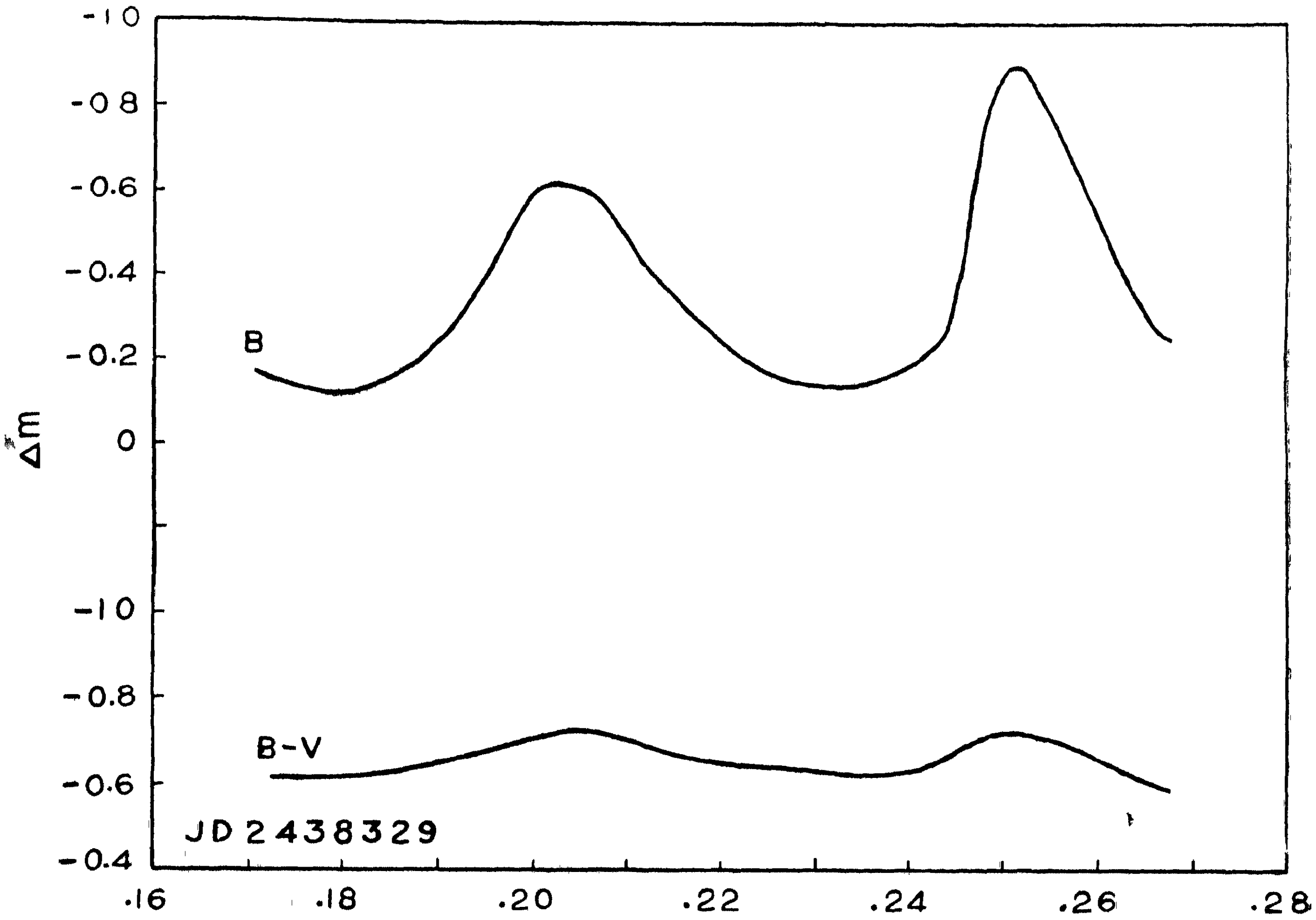

FIGURE 1.—The light and colour variation of SX Phoenicis

The light variations

Figure I shows a typical light curve of SX Phoenicis in the blue along with the corresponding colour curve (instrumental system). From our observations it is seen that the amplitude varied from 0·76 to 0·48 mag. in blue and from 0·66 to 0·37 mag. in yellow. In both blue and yellow there were fluctuations in the magnitudes of maxima from cycle to cycle, to the extent of 0·3 mag. whereas the minima remained practically at the same level in all cycles within 0·1 mag. A similar tendency was also reported by Wood (1959). A colour change of 0·12 mag. from maximum to minimum phase indicates that there is a significant alteration in spectral type during a cycle, say from A2 to F0 as pointed out by Eggen (1952). This short period variable with an absolute magnitude of +4·3 therefore, belongs to the class of dwarf cepheids.

Acknowledgement

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TABLE I

Photoelectric Observations of SX Phoenicis

J D	△ Mag	J D	△ Mag	J D	△ Mag	J D	△ Mag
2438329	*Yellow*	1417	+ 144	1582	+ 337	2028	+ 105
		1423	+ 144	1585	+ 339	•2030	+•107
1237	+ 532	1425	+ 128	1589	+ 339	2048	+•115
1240	+ 532	1428	+ 128	1591	+ 339	2051	+ 116
1242	+ 532	1430	+ 131	1593	+ 351	2061	+ 121
1245	+ 529	1433	+ 131	1599	+ 372	2063	+ 121
1248	+ 529	1435	+ 134	1602	+ 363	2074	+•141
1250	+ 529	1438	+ 134	1604	+ 365	2077	+ 139
1253	+ 522	1441	+ 131	1606	+ 373	2080	+ 151
1255	+ 517	1443	+ 136	1609	+ 369	2092	+ 139
1270	+ 522	1446	+ 144	1611	+ 377	2094	+ 193
1273	+ 522	1448	+ 138	1613	+ 386	2097	+ 198
1275	+ 517	1450	+ 144	1616	+ 386	2107	+ 203
1278	+ 512	1453	+ 144	1619	+ 388	2110	+ 219
1280	+ 505	1455	+ 154	1703	+ 446	2125	+ 252
1284	+ 498	1458	+ 158	1705	+ 418	2127	+ 252
1291	+ 482	1460	+ 151	1708	+ 475	2129	+ 258
1296	+ 471	1463	+ 151	1716	+ 446	2194	+ 367
1299	+ 460	1466	+ 151	1718	+ 418	2196	+ 367
1302	+ 456	1482	+ 189	1720	+ 461	2211	+ 374
1304	+ 451	1485	+ 196	1736	+ 461	2213	+ 408
1306	+ 447	1487	+ 196	1738	+ 475	2215	+ 415
1309	+ 442	1490	+ 203	1749	+ 461	2226	+ 395
1311	+ 433	1492	+ 221	1752	+ 468	2228	+ 415
1314	+ 433	1495	+ 221	1754	+ 475	2231	+ 421
1320	+ 424	1497	+ 221	1764	+ 495	2240	+ 421
1323	+ 420	1500	+ 207	1766	+ 502	2242	+ 424
1325	+ 414	1503	+ 221	1769	+ 502	2252	+ 424
1328	+ 407	1505	+ 225	1784	+ 502	2254	+ 428
1331	+ 403	1508	+ 225	1787	+ 509	2264	+ 424
1333	+ 381	1510	+ 225	1795	+ 509	2277	+ 428
1335	+ 362	1513	+ 225	1797	+ 495	2279	+ 468
1338	+ 360	1516	+ 228	1800	+ 495	2281	+ 475
1340	+ 358	1518	+ 228	1813	+ 475	2294	+ 475
1343	+ 356	1520	+ 228	1815	+ 500	2296	+ 478
1346	+ 339	1523	+ 243	1831	+ 481	2299	+ 482
1348	+ 329	1526	+ 261	1842	+ 468	2309	+ 461
1351	+ 321	1528	+ 261	1845	+ 468	2311	+ 482
1357	+ 317	1530	+ 251	1851	+ 461	2321	+ 482
1359	+ 309	1533	+ 261	1854	+ 457	2324	+ 489
1362	+ 290	1540	+ 280	1915	+ 391	2336	+ 489
1364	+ 290	1543	+ 280	1922	+ 371	2339	+ 489
1376	+ 233	1545	+ 300	1928	+ 353	2354	+ 482
1378	+ 215	1548	+ 303	1931	+ 329	2356	+ 479
1381	+ 207	1551	+ 303	1944	+ 294	2443	+ 405
1383	+ 206	1553	+ 319	1946	+ 288	2446	+ 398
1387	+ 190	1555	+ 319	1951	+ 262	2460	+ 366
1390	+ 177	1558	+ 303	1961	+ 240	2463	+ 347
1392	+ 176	1561	+ 300	1964	+ 229	2475	+ 295
1394	+ 174	1563	+ 303	1977	+ 187	2478	+ 281
1397	+ 168	1566	+ 303	1979	+ 176	2481	+ 275
1400	+ 161	1568	+ 309	1989	+ 151	2493	+ 263
1402	+ 131	1571	+ 309	1991	+ 146	2495	+ 121
1405	+ 138	1571	+ 309	2002	+ 107	2498	+ 114
1408	+ 138	1573	+ 335	2005	+ 105	2510	— 020
1409	+ 141	1576	+ 335	2012	+ 102	2513	— 039
1412	+ 144	1579	+ 335	2014	+ 102	2515	— 046
1415	+ 144	1581	+ 339	2025	+ 102	2530	— 124

TABLE I—*contd*

J D	△ Mag	J D	△ Mag	J D	△ Mag	J D	△Mag
2438329	*Yellow*	1921	— 329	2331	— 124	0812	— 059
		1936	— 359	2347	— 134	0826	— 059
2545	— 156	1938	— 365	2349	— 155	0888	— 119
2547	— 156	1941	— 372	2361	— 159	0892	— 128
2550	— 161	1949	— 411	2362	— 164	0895	— 116
2560	— 171	1956	— 438	2366	— 167	0899	— 160
2562	— 161	1958	— 448	2367	— 173	0902	— 111
2564	— 159	1968	— 479	2450	— 236	0905	— 128
2580	— 116	1971	— 483	2453	— 240	0923	— 167
2582	— 110	1981	— 543	2455	— 247	0926	— 179
2593	— 068	1984	— 555	2465	— 272	0930	— 192
2595	— 056	1991	— 570	2468	— 278	0933	— 199
2607	— 003	1997	— 576	2470	— 310	0937	200
2617	+ 053	2007	— 611	2473	— 329	0940	201
2621	+ 091	2009	— 615	2483	— 400	0941	215
2624	+ 103	2018	— 617	2485	— 410	·0947	— 221
2638	+ 138	2020	— 612	2489	— 425	0951	— 231
2641	+ 143	2023	— 611	2500	— 642	·0954	— 210
2644	+ 187	2035	— 609	2505	— 673	0958	— 255
2656	+ 209	2038	— 605	2529	— 805	0965	— 242
2659	+ 215	2040	— 602	2537	— 908	0968	— 256
2673	+ 253	2050	— 596	2540	— 897	0972	— 279
2676	+ 261	2055	— 596	2542	— 891	0975	— 245
2679	+ 291	2058	— 585	2553	— 883	0979	— 266
2682	+ 297	2067	— 577	2555	— 880	0982	286
2699	+ 361	2069	571	2557	— 880	0986	281
2702	+ 361	2084	— 530	2567	— 820	0993	— 343
2711	+ 368	2087	527	2570	— 788	0994	344
2713	+ 377	2089	— 521	2572	— 759	·0996	—·355
		2100	— 486	2585	— 788	0998	— 378
2438329	*Blue*	2102	— 480	2587	— 779	1095	— 500
		2104	— 470	2590	— 772	1097	— 476
1700	— 165	2117	— 469	2598	— 586	1098	— 476
1711	— 156	2119	— 462	2600	—·563	1100	— 480
1713	— 156	2122	— 446	·2603	— 563	1102	— 490
1726	— 143	2132	— 415	2612	— 672	1104	500
1728	— 143	2181	— 343	2615	— 658	·1105	— 496
1740	— 138	2188	— 306	2617	— 643	1107	— 487
1743	— 135	2189	— 286	2631	— 575	1109	— 495
1746	— 135	2205	— 267	2635	— 556	1111	— 481
1757	— 126	2208	— 254	·2647	— 457	1112	— 495
1759	— 126	2228	— 240	2649	— 429	1114	—·481
1762	— 125	2230	— 236	2652	— 437	1116	— 479
1777	— 130	2232	— 223	2664	— 369	1118	— 478
1779	— 142	2235	— 213	2665	— 319	1119	— 460
1782	— 143	2238	— 213	·2669	— 303	·1121	— 468
1789	— 135	2245	— 212	2686	— 331	1124	— 471
1792	—·136	2247	— 209	2689	— 319	1196	— 355
1805	— 149	2257	— 196	2699	— 262	1198	— 367
1807	— 145	·2259	— 196	·2701	— 262	1199	— 315
1826	— 149	2272	— 179	2708	— 253	1201	— 355
1828	— 145	2274	— 175	2721	— 258	1203	— 339
1836	— 153	2286	— 169			1204	— 332
1838	— 153	2289	— 164	2438379	*Blue*	1206	— 330
1847	— 140	2291	— 146			1208	— 320
1849	— 153	2304	— 146	0742	— 062	1210	— 311
1910	— 274	2306	— 151	0756	— 058	1211	— 317
1913	— 290	2316	— 142	0770	— 083	1213	— 321
1922	— 290	2318	— 143	0784	— 098	1215	— 322
1923	— 308	2328	— 135	0798	— 051	·1243	— 263

TABLE I—*contd*

J D	△ Mag	J D	△ Mag	J D	△ Mag	J D	△ Mag
2438379	*Blue*	1585	— 429	1972	— 040	1364	—1 031
		1587	— 452	1979	— 051	1371	—1 034
1245	— 260	1588	— 457	1986	— 058	·1378	—1 041
1246	— 258	1590	— 460	1993	— 066	·1385	—1 028
1248	— 251	1592	— 468	2000	— 061	·1392	—1 009
1250	— 250	1594	— 481			1434	— 846
1251	— 248	1595	— 488	2438381	*Blue*	1441	— 806
1253	- 245	1597	— 509			1447	— 758
1255	237	1599	— 519	0753	— 293	1454	— 730
1257	— 234	1600	— 531	0759	— 295	1510	— 478
1258	— 232	1602	— 543	0766	— 325	1517	— 451
1260	— 226	1606	— 537	0773	— 340	1524	— 424
1262	— 223	1607	— 545	0780	— 377	1531	— 403
1263	— 220	1614	— 601	0787	— 413	1538	— 375
1265	— 216	·1618	—·604	0794	— 443		
1267	— 212	1621	— 607	0801	— 494	2438398	*Blue*
1269	— 209	1625	— 604	0808	— 533		
1270	— 206	1628	— 627	0815	— 550	0636	— 529
1284	— 203	1632	— 626	0822	— 592	0643	— 600
1288	— 196	1635	— 632	0829	— 629	0650	— 640
1291	— 192	1639	— 639	0836	— 664	0657	— 688
1295	— 189	1642	— 657	0843	— 685	0664	— 738
1298	— 182	1647	— 617	0850	— 700	0674	— 792
1302	— 175	1649	— 631	0857	— 715	0678	— 752
1305	— 169	1653	— 635	0864	— 717	0685	— 778
1309	— 164	1705	— 542	0871	— 719	0688	— 800
1312	— 159	1708	— 528	0878	— 720	0692	— 788
1316	— 160	1712	— 505	0885	— 710	0695	— 784
1333	— 155	1715	— 486	0892	— 713	0699	— 780
1340	— 142	1726	— 473	0899	— 705	0706	— 770
1347	— 135	1729	— 462	0902	— 700	0713	— 774
1354	— 129	1732	— 445	0954	— 565	0719	— 752
1361	— 116	1757	— 343	0961	— 552	0726	— 703
1368	— 107	1760	— 335	0968	— 536	0730	—·737
1375	— 094	1764	— 316	0975	— 503	0733	— 727
1382	— 086	1771	— 289	0982	— 481	0740	— 701
1437	— 100	1774	— 277	0989	— 460	0789	— 521
1444	— 096	1778	— 267	0996	— 443	0796	— 484
1451	— 087	1826	— 142	1003	— 431	0803	— 466
1458	— 086	1830	— 137	1010	— 416	0810	— 443
·1500	— 145	1833	— 138	1017	— 406	0817	— 423
1503	— 150	1837	— 132	1024	— 391	0824	— 401
1507	— 153	1840	— 135	1031	— 378	0831	— 383
1510	— 160	1844	— 134	1037	— 365	0838	— 357
·1514	— 160	1847	— 115	1044	— 349	0845	— 312
1517	— 171	1851	— 095	1267	— 264	0859	— 282
1521	—·171	1854	— 081	1274	— 282	0865	— 275
1524	— 173	1875	— 085	1281	— 305	0872	— 268
1527	— 173	1882	— 078	1288	— 319	0879	— 262
·1531	— 178	1889	— 057	1295	— 340	0886	— 255
1534	— 178	1896	— 056	1302	— 369	1095	— 223
1538	— 178	1903	— 068	1309	— 411	1102	— 244
1566	— 311	1910	— 065	1316	— 457	1109	— 286
1567	—·318	1917	—·047	1322	— 507	1116	— 320
1569	— 335	1924	—·041	1329	— 573	1123	— 352
1571	— 350	1930	— 040	1336	— 624	1129	— 392
1573	— 360	1937	— 038	1347	— 771	1136	— 399
1574	— 377	1951	— 032	1350	— 969	1157	— 634
1576	— 385	1958	— 032	1354	— 974	1164	— 663
·1583	—·413	1965	— 035	1357	— 994	1171	— 797

TABLE I—*concld*

J D	△ Mag	J D	△ Mag	J D	△ Mag	J D	△ Mag
2438308	*Blue*	0795	— 055	1038	— 385	1120	— 630
		0802	— 040	1040	— 402	1122	— 625
1178	— 819	0809	— 034	1042	— 413	1123	— 622
1185	— 892	0823	+ 012	1043	— 427	1125	— 627
1199	— 912	0830	+ 003	1045	— 440	·1127	— 615
1206	— 910	0837	+ 005	1047	— 459	1128	— 608
1213	— 903	0844	+ 005	1049	— 477	1130	— 603
1220	— 889	0851	+ 016	1050	— 491	1132	— 599
1231	— 871	0857	+ 018	1052	— 508	1134	— 596
		0864	+ 015	1054	— 521	1135	— 590
2438399	*Blue*	0871	+ 020	1056	— 534	1141	— 573
		0878	+ 018	1057	— 552	1142	— 566
0628	— 613	0885	+ 023	1059	— 565	1144	— 561
0632	— 596	0899	+ 050	1061	— 580	1156	— 553
0635	— 575	0931	+ 019	1062	— 590	1148	— 553
0639	— 565	0937	+ 018	1064	— 600	1149	— 543
0649	— 510	0941	+ 010	1066	— 610	1151	537
0653	— 491	0944	+ 004	1068	— 627	1153	— 529
0656	— 473	0948	— 001	1069	— 640	1154	— 524
0659	— 459	0951	— 005	1071	— 644	1156	— 520
0663	— 439	0955	— 012	1076	— 674	1158	— 512
0666	— 423	0958	— 015	·1078	— 688	1160	— 506
0673	— 388	0962	— 017	·1080	— 690	1161	— 497
0677	— 375	0965	— 022	1082	— 688	1163	— 492
0680	— 358	0969	— 027	1083	— 686	1167	— 478
0684	— 337	0972	— 029	1085	— 683	1170	— 476
0687	— 321	0979	— 053	·1087	— 682	1174	— 450
0691	— 293	0983	— 067	1089	— 682	1177	—·427
0694	— 291	0986	— 078	1090	— 679	1181	— 415
·0698	— 268	0990	— 084	·1092	— 677	1184	— 391
0705	— 261	0993	— 095	1094	— 674	1187	— 369
0708	— 246	0997	— 105	1095	— 671	1191	— 350
0712	— 232	1000	— 114	1097	—·668	·1194	— 339
0715	— 224	1003	— 121	·1099	—·665	·1202	— 306
0719	— 209	1007	— 132	1101	— 669	1205	— 290
0722	— 206	1010	— 144	·1102	— 666	1290	— 272
0725	— 195	1021	— 222	1104	—·667	1212	— 258
0729	— 178	1024	— 258	1106	— 663	1215	— 248
0732	— 170	1026	— 275	1108	— 660	1219	— 227
0736	— 154	1028	— 290	1109	— 655	·1275	— 083
0739	— 137	1029	— 304	1111	— 651	1281	— 065
0743	— 129	1031	— 321	·1113	— 646	1288	— 056
0774	— 089	·1033	— 337	1115	—·640	·1295	— 045
0781	— 079	·1035	— 353	1116	— 635	1302	— 021
0788	— 061	·1036	— 375	·1118	— 637		

TABLE II

Phase Observations

Observed maximum J D 2438	Ascending branch computed rofm (1)	O-C days	ψ Computed	ψ′	△φ from curve	△φ in days	Corrected O-C days
1	2	3	4	5	6	7	8
329 2025	1695	+ 0330	473	723	+ 044	+ 0024	+ 0306
329 2543	2244	+ 0299	742	·992	— 002	— 0001	+ 0300
379 1645	1319	+ 0326	564	814	+ 029	+ 0016	+ 0310
381 0884	0557	+ 0327	540	790	+ 033	+ 0018	+ 0309
381 1387	1106	+ 0281	801	051	— 019	— 0010	+ 0291
398 0713	0396	+ 0317	609	859	+ 022	+ 0012	+ 0305
398 1225	0946	+ 0279	875	125	— 031	— 0017	+ 0296
399 1111	0839	+ 0272	002	252	— 040	— 0022	+ 0294

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