ANALYSIS OF THE LIGHT CURVE, ORBITAL ELEMENTS AND THE PERIOD CHANGES OF U CEPHEI

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Received 20 February 1977

Abstract: From photoelectric observations in the B spectral range extending from October 1967 to July 1976 we derived the complete light curve of U Cephei. The orbital elements resulting from our solution are essentially the same as Batten's derived from the different light curves. From our observations eight epochs of minima have been determined. Combined with other photoelectric timings of middle-eclipse the variations of the period of U Cephei have been investigated. It has been shown that a departure of the residuals from a parabolic distribution is caused by two factors: One is physical resulting from the mass transfer process (Hall, 1975) and the other is observational caused by errors in deriving the epochs of middle-eclipse from the observed light curve. The magnitude of the latter effect is about 0.005 days. We also studied the long-term increase of the period and found that during the 1974 outburst the rate of change was affected by mass outflow while no similar effect was observed during the 1969 outburst.

In the concluding part of this paper we have analysed the light curves of U Cephei. From our data we have found that the overall depth of the primary eclipse changes by $0\overset{m}{.}1$ between times of active and quiet stage. Similar effects are found near secondary minima and at phases of maximum light preceding the primary minimum. The presence of hot spots on the brighter component is indicated by our observations.

Introduction

Perhaps no other star has been treated more extensively in recent years than the Algol-type binary U Cephei. The system consists of a B6 V primary star and a less massive G8 IV type secondary. The eclipse is total and its depths is about 3 magnitudes. Since the secondary star fills its Roche lobe there is a mass transfer taking place from this star to the primary. In his extensive treatment Batten (1974) presented evidence for a luminous bridge joining the two stars. On the other hand Plavec (1974) thinks that a ring or disc exists around the primary star.

There is a spectroscopic and photometric evidence for the presence of gas clouds in the system. The spectra of U Cephei taken at times of primary minima show emission lines in the Balmer series of hydrogen and in the H and K lines of calcium. The intensity of the lines appears to be related to the activity of the mass transfer process. In spite of a large number of photoelectric observations of U Cephei accurate photoelectric observations are rather few, especially those covering the whole light curve. Dugan (1920) was the first who from visual observations derived the photometric orbital elements for the system. He also observed the asymmetry of the light curve near the primary minima which in his opinion was caused by tidal distorsion of the components. More recent orbital elements based on photoelectric observations were obtained, notably, by Batten (1974) and Hall and Walter (1974). In this paper we will derive the orbital elements from our photoelectric observations and they will be compared with those given by other authors.

Since the earliest observations of U Cephei it was evident that the period of the system was increasing. The individual determinations of the epoch of minima could be represented by a quadratic formula whose coefficients were also published by Batten (1974). However, on this secular increase of the period short term variations are superimposed. It is generally accepted that a mass transfer between the components of the system is responsible for the observed change of the period. In Hall's interpretation the short period variations are due to the mass and angular momentum transfer (Hall, 1975).

Since the first visual observations it was evident that the form of the light curve is far from regular. The photoelectric observations show considerable variations of the light curve during totality. The observations of Huffer and Code, published by Batten (1974) show clearly an increase of the brightness after the second contact. Bakos and Tremko (1973) also found light changes whose slant went in the opposite direction of those of Huffer and Code. The cause of the variability has been ascribed to various effects, for instance the chromospheric activity of the G type star, or its variability or even the presence of a hot spot near one of the poles of the primary component (Walter, 1975).

An asymmetry of the primary minimum is quite obvious and results from an absorption on the descending branch of the light curve. On the other hand Olson (1976) finds evidence for the additional light due to a ring or disc around the primary component. Peculiarities are also present at phases of constant light and during secondary minima.

There is a great variety of problems connected with U Cephei and in this paper we wish to deal with some. Mainly on the basis of our photoelectric observations we shall discuss the light curve and its variations, we shall derive the photometric elements and finally we shall deal with the variations of the period and offer our own interpretation of observations.

Photoelectric Observations

Our observations were made at the Skalnaté Pleso Observatory with the photometer attached to the 60 cm reflector. The photometer is of automatized design using an E.M.I. 6256B photomultiplier tube as light detector and a set of filters matched to the UBV system has heen used. The electronic part consists of an integrating amplifier and an analog-digital converter. The output is typewritten on a paper for easy inspection and punched on a tape for reduction by an electronic computer. A detailed description of the photometer can be found in a paper published by Horák et al. (1976).

U Cephei has been on the observing programme since 1967. All phases of the light curve were adequately covered in the B spectral range, although the minima also have been observed with V and U filters. In this paper we will discuss just the B observations. Due to the proximity of the comparison star the correction for differential extinction was not applied.

The observations around the primary and secondary minima have already been published and discussed earlier by Bakos and Tremko (1973). Since that time additional observations of minima have been made. The individual observations except those already published (Bakos and Tremko, 1973) have been collected in Table 4, while normal points can be found in Table 1 and are plotted in Fig. 1. The epoch of primary minimum was taken at

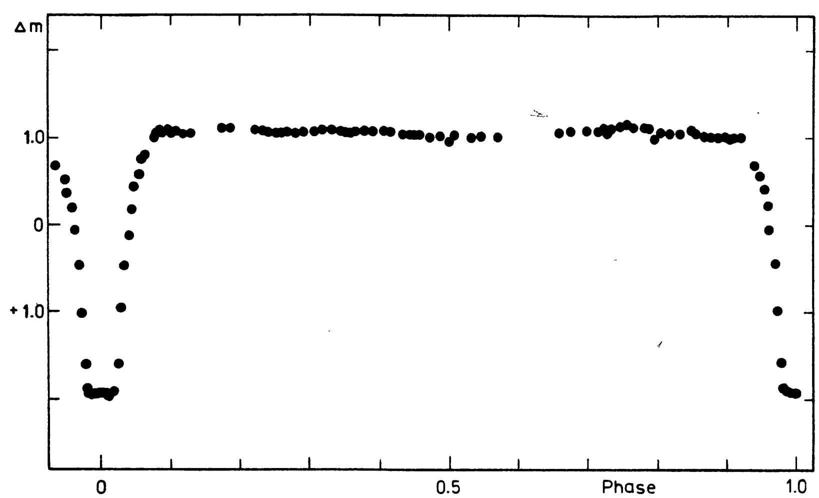

Fig. 1. Normal light curve of U Cephei.

J.D.$_{hel}$ 2439044.3978 and the period at this epoch was assumed to be P=2.49302 days. The phases of the normal points were computed by means of the instantaneous period.

Photometric Orbital Elements

Because of the large number of individual observations, extending over a time interval of many years normal points were formed which were used in our investigation of changes of the light-curve with time. However, only the points which did not appeared to be influenced by irregularities were selected for a determination of the orbital elements. These have been listed in Table 1 along with other information pertaining to the adopted solution.

The computations were performed with Minsk 22 computer of the University of Brno using the programme of Dr. Vetešník. For the rectification procedure the standard Russell—Merrill method was used (Russell and Merrill, 1952) and the orbital elements were computed by means of the

Table 1

Phase	Θ	Δm	σ	I	Θ_{rect}	I_{rect}	N
.0027	0.98	−1.942	.014	0.0621	0.99	0.0768	42
.0074	2.69	−1.934	.011	0.0625	2.70	0.0773	31
.0128	4.63	−1.931	.010	0.0627	4.66	0.0774	42
.0171	6.17	−1.915	.002	0.0636	6.20	0.0783	79
.0229	8.26	−1.618	.005	0.0844	8.30	0.0989	60
.0281	10.13	−0.984	.008	0.1518	10.18	0.1661	70
.0331	11.93	−0.487	.000	0.2390	11.99	0.2529	50
.0378	13.63	−0.137	.006	0.3283	13.70	0.3418	41
.0426	15.34	0.167	.007	0.4340	15.42	0.4470	42
.0484	17.45	0.420	.000	0.5475	17.53	0.5599	47
.0527	18.99	0.569	.007	0.6277	19.09	0.6397	25
.0583	20.99	0.728	.003	0.7257	21.10	0.7371	31
.0614	22.12	0.799	.000	0.7750	22.23	0.7859	25
.0748	26.96	1.013	.000	0.9436	27.08	0.9531	19
.0766	27.58	1.075	.012	0.9993	27.71	1.0085	27
.0830	29.89	1.078	.000	1.0018	30.02	1.0105	24
.0862	31.03	1.046	.000	0.9727	31.17	0.9813	31
.0987	35.36	1.080	.027	1.0009	35.71	1.0083	36
.1008	36.31	1.066	.000	0.9908	36.45	0.9981	10
.1096	39.46	1.060	.000	0.9854	39.61	0.9919	42
.1186	42.72	1.077	.031	1.0016	42.87	1.0072	39
.1281	46.13	1.071	.000	0.9954	46.29	1.0002	21
.1724	62.07	1.097	.000	1.0195	62.19	1.0199	30
.1847	66.50	1.086	.000	1.0093	66.61	1.0086	41
.2190	78.85	1.085	.000	1.0083	78.90	1.0051	31
.2293	82.57	1.081	.000	1.0046	82.61	1.0007	30
.2396	86.28	1.067	.000	0.9917	86.30	0.9874	31
.2494	89.79	1.067	.000	0.9917	89.78	0.9869	30
.2605	93.79	1.071	.000	0.9954	93.77	0.9901	31
.2698	97.14	1.075	.000	0.9991	97.10	0.9934	27
.2793	100.55	1.077	.000	1.0009	100.50	0.9950	35
.2894	104.19	1.085	.000	1.0083	104.12	1.0022	30
.3050	109.81	1.084	.000	1.0074	109.71	1.0011	26
.3204	115.36	1.091	.000	1.0139	115.24	1.0076	30
.3331	119.91	1.085	.000	1.0083	119.78	1.0022	30
.3431	123.52	1.085	.000	1.0083	123.38	1.0024	30
.3511	126.42	1.080	.000	1.0037	126.28	0.9980	25
.3597	129.52	1.083	.000	1.0065	129.36	1.0010	27
.3698	133.13	1.086	.007	1.0097	132.97	1.0045	92
.3783	136.21	1.083	.000	1.0063	136.05	1.0013	52
.3922	141.21	1.092	.000	1.0148	141.06	1.0103	8

Phase	Θ	Δm	σ	I	Θ_{rect}	I_{rect}	N
.4047	145.70	1.079	.000	1.0028	145.56	0.9987	39
.4176	150.34	1.077	.000	1.0009	150.20	0.9973	33
.4375	157.50	1.069	.000	0.9936	157.39	0.9906	35
.4442	159.92	1.072	.000	0.9963	159.82	0.9935	32
.4549	163.77	1.066	.000	0.9908	163.69	0.9883	20
.4625	166.51	1.064	.000	0.9890	166.44	0.9866	49
.4781	172.12	1.040	.004	0.9674	172.07	0.9653	40
.4933	177.61	1.027	.008	0.9560	177.59	0.9540	73
.5027	180.98	1.028	.000	0.9568	180.98	0.9548	23
.5117	184.24	1.054	.000	0.9799	184.26	0.9779	36
.5384	193.85	1.034	.000	0.9621	193.92	0.9597	34
.5496	197.86	1.043	.000	0.9701	197.95	0.9675	34
.5726	206.17	1.049	.000	0.9754	206.29	0.9722	37
.6589	237.23	1.077	.000	1.0009	237.25	0.9951	32
.6718	241.86	1.083	.000	1.0065	241.99	1.0003	45
.6986	251.52	1.084	.000	1.0074	251.62	1.0011	45
.7158	257.69	1.096	.000	1.0186	257.75	1.0124	25
.7251	261.05	1.098	.000	1.0205	261.10	1.0145	27
.7262	261.43	1.075	.000	0.9991	261.48	0.9933	21
.7353	264.73	1.133	.000	1.0539	264.76	1.0479	36
.7482	269.36	1.142	.000	1.0627	269.37	1.0571	37
.7590	273.23	1.140	.000	1.0607	273.22	1.0556	23
.7677	276.39	1.124	.006	1.0450	276.35	1.0406	60
.7854	282.75	1.114	.000	1.0356	282.68	1.0324	12
.7904	284.54	1.096	.000	1.0186	284.47	1.0158	28
.7955	286.37	1.034	.000	0.9621	286.29	0.9602	6
.8046	289.68	1.084	.000	1.0074	289.58	1.0058	34
.8165	293.95	1.063	.000	0.9881	293.84	0.9877	34
.8326	299.73	1.081	.000	1.0046	299.60	1.0055	34
.8461	304.60	1.093	.000	1.0158	304.45	1.0179	37
.8592	309.33	1.060	.039	0.9864	309.17	0.9900	82
.8710	313.56	1.025	.000	0.9541	313.29	0.9590	30
.8794	316.58	1.018	.000	0.9480	316.43	0.9537	21
.8880	319.70	1.015	.000	0.9454	319.55	0.9518	30
.8974	323.08	1.007	.000	0.9384	322.93	0.9457	21
.9046	325.67	1.004	.000	0.9358	325.53	0.9437	30
.9078	326.81	0.993	.000	0.9264	326.67	0.9346	10
.9138	328.98	1.001	.022	0.9333	328.84	0.9420	65
.9225	332.13	0.983	.000	0.9183	332.00	0.9277	40
.9387	337.95	0.762	.002	0.7491	337.84	0.7602	44
.9478	341.21	0.535	.007	0.6084	341.11	0.6204	38
.9526	342.95	0.375	.007	0.5250	342.97	0.5375	32
.9570	344.55	0.192	.008	0.4446	344.47	0.4575	32
.9615	346.15	−0.069	.003	0.3487	346.08	0.3621	21
.9679	348.45	−0.466	.007	0.2446	348.39	0.2584	45
.9729	350.25	−1.017	.005	0.1464	350.20	0.1607	45
.9780	352.10	−1.608	.011	0.0850	352.06	0.0996	60
.9832	353.96	−1.896	.013	0.0648	353.92	0.0794	46
.9879	355.65	−1.923	.009	0.0631	355.62	0.0779	49
.9919	357.10	−1.931	.022	0.0627	357.09	0.0775	19
.9992	359.71	−1.927	.008	0.0629	359.71	0.0777	20

method of Horák (1966). The adopted orbital elements have been collected in Table 2. In the same table we have also given the orbital elements derived by Dugan (1920), Batten (1974) and Hall and Walter (1974), respectively. The following discussion concerning this table is made. Although Dugan's solution is based on observations made by means of a visual photometer it appears to us that these results are consistent and they can be adopted as fairly close to those obtained from photoelectric

Table 2

List of orbital elements

	Dugan	Batten adopted	Hall adopted	Tremko and Bakos
R_1	0.20	0.20	0.1665	0.1995±0.0010
R_2	0.32	0.32	0.3440	0.3151±0.0005
L_1				0.9202±0.0015
i	86.4	90	83.14	89.8 ±8.2
u_1				0.56 ±0.05
u_2				0.6 adopted

observations. The slightly different inclination as compared to ours does not seem to be too significant, since this element appears to be the least accurate. Batten (1974) has made a preliminary solution based on the photoelectric light curves of Khozov and Minaev, and of Broglia. Although there are differences in the elements of these two solutions, especially in the inclination, Batten's adopted values are identical with our solution. Hall and Walter (1975) also discussed the light curves of U Cephei and performed a solution for the elements. They used three different light curves, namely that of Khozov and Minaev, Catalano and Rodono and that of Tschudowitschew. In the latter case the different coefficients for the short region rectification were used. Although the derived elements are internally consistent, the consistency was achieved by choosing a convenient rectification procedure. Their adopted values for the elements are numerically different from those of other authors and the difference can be explained as a result of their short region rectification method.

The Period and Its Variations

Recently two important papers on the period of U Cephei were published, namely by Batten (1974) and Hall (1975). Batten collected all the times of minima not contained in the paper published by Svechnikov (1955) and included many new photoelectric observations. With these data he fitted a parabola to the observed times of minima and by least squares method determined the numerical value of the quadratic term. The epoch of the primary minimum is then given by the expression:

$$\text{Min } I = \text{J.D.}_{\text{hel}}\, 2407890.3643 + 2.4928379 \times$$
$$\times E + 6.68 \times 10^{-9} \times E^2.$$

Although the parabola represents the best fit of the residuals it is obvious that large systematic deviations from the curve exist. Hall (1975) using Batten's data analysed the deviations of the normal points from the quadratic formula and found that those can be fitted with short parabolic segments, whose quasiperiod he derived as 9.1±3.8 years. Both authors agree that the long-term increase of the period is caused by mass transfer from the less massive to the more massive component. The short parabolic segments, in Hall's interpretation are explained as alternating period increases and decreases. The average period for each segment as well as their rate of change has been computed. The abrupt decrease of the period Hall explained as evidence for the transfer of angular momentum from secondary to the primary star.

Since in recent times many accurate photoelectric observations of minimum of U Cephei have been obtained we have decided to analyse the variations of the period in order to understand the nature of these changes. In Table 3 we collected all such photoelectrically derived epochs previously published by Svechnikov et al. (1972), Batten (1974), Bakos and Tremko (1973) and others.

The distribution of the residuals with respect to the quadratic formula has been plotted in Fig. 2. In a different paper we have already (Bakos and Tremko, 1976) analysed the variations of the period using linear formula and drawn our conclusions. The residuals from the linear formula in Table 3 are indicated by $(O\text{-}C)_1$, those from the quadratic formula by $(O\text{-}C)_2$. In this paper we accepted the numbering of epochs according to Batten (1974). Thus the zero point is shifted by 12497 in comparison with our preceding paper (Bakos and Tremko, 1976). However, at this place we would like to mention briefly the main results of our investigation. We are in accord with the previously accepted view that the mass transfer is responsible for the secular change of the period. Since the flow of matter is not constant as a function

Table 3

Photoelectric epochs of minima of U Cephei

J.D.$_{hel}$	E	O-C$_1$	O-C$_2$	References
2432168.7035	9739	+0.0548	−0.0427	1
2203.6030	9753	+ .0520	.0448	1
3564.7515	10299	+ .0116	.0589	1
6097.6349	11315	− .0133	.0455	1
6137.5222	11331	.0143	.0460	1
6518.9576	11484	.0110	.0381	1
8670.441	12347	− .0038	.0112	2
9044.3978	12497	.0000	.0050	3
9403.3935	12641	+ .0008	− .0021	1
9787.3243	12795	.0065	+ .0064	1
2440086.4908	12915	.0107	.0108	1
0101.4483	12921	.0101	.0103	1
0136.3542	12935	.0137	.0140	1
0141.335	12937	.0084	.0088	1
0213.6372	12966	.0131	.0137	4
0228.5925	12972	.0102	.0109	4
0233.5810	12974	.0127	.0134	4
0.243.5555	12978	.0151	.0158	5
0273.4695	12990	.0129	.0137	1
0440.5195	13057	.0305	.0319	4
0512.8046	13086	.0181	.0196	1
0809.4802	13205	.0243	.0266	1
0854.3560	13223	.0257	.0282	1
0874.3009	13231	.0265	.0289	1
1190.9261	13358	.0381	.0412	1
1198.4067	13361	.0397	.0427	1
1203.3925	13363	.0394	.0425	1
1210.8706	13366	.0385	.0416	1
1215.8567	13368	.0385	.0416	1
1218.3500	13369	.0388	.0419	1
1223.3360	13371	.0388	.0419	1
1719.4651	13570	.0569	.0604	5
1901.4641	13643	.0654	.0690	5
2267.9345	13790	.0619	.0653	6
2302.8402	13804	.0653	.0686	7
2307.8280	13806	.6671	.0704	7
2312.8095	13808	.0625	.0659	7
2317.7950	13810	.0620	.0653	7
2322.7835	13812	.0644	.0678	8
2327.7697	13814	.0646	.0679	7
2337.7362	13818	.0590	.0623	8
2342.7245	13820	.0613	.0646	8
2347.7146	13822	.0653	.0686	8
2377.6246	13834	.0591	.0624	8
2452.417	13864	.0609	.0641	9
2462.3927	13868	.0645	.0677	10
2816.4050	14010	+ .0680	+ .0706	5

Table 3 (References)

1. BATTEN, A. H. (1974): Publ. Domin. Astrophys. Obs., *XIV*, No. 10, 191.
2. SVECHNIKOV, M. A., SURKOVA, L. P., DANILOV, V. M. (1972): Var. Stars Bull., *18*, 237.
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of time the rate of the changes shows up in the O-C diagram as departure of points from a straight line. In Batten's diagram this is apparent between epochs 8000—12000. The same effect is shown in our Fig. 2. In addition to these two effects shorter quasiregular fluctuations appear which in Hall's paper were fitted by parabolic segments with previously mentioned period of 9.1 years. His explanation that they indicate sudden decrease of period as a result of transfer of angular momentum is not excluded but the effect may be masked by phenomena associated with the change of the light curve during primary minima. We have found that due to filling-in effect of the falling branch of the eclipse the time of the middle-eclipse is shifted in a sense of making the period longer and a return to undisturbed state produces a shift in the opposite direction which appears as a decrease of the period. Since it is customary to publish just the epochs of minima without reference to the shape of the light curve the danger exists, especially when few observations are available, that fictitious changes of the period are recorded. The magnitude of this effect is at least 0.005 days. Since the quantity $\Delta P/P$ is used to derive a measure of the mass transferred unrealistically large values of ΔM may thus be derived (Svechnikov et al., 1972).

During the time interval covered by our Table 3 two outbursts of U Cephei have been recorded spectroscopically. Batten (1969) observed in 1969 emission lines during the primary eclipse around the second contact. There are no photoelectric observations at the time of the event but we have a number of accurate timings of epochs of minima about 3 months earlier. We have plotted these points on an expanded scale in Fig. 3a. From the plot it is obvious that the outburst started earlier than detected spectroscopically by Batten (1969) and secondly, it appears to us that the process of mass ejection and cloud formation is taking place over a period of few months. From the scatter of points in the first diagram we conclude that sudden changes in mass ejection, cloud formation and their motion occur. In the plot of residuals there is an isolated point, nearest to the spectroscopically observed outburst, which in our opinion is rather high. Although the epoch of the minimum contains no obvious error we have no reasonable explanation for its magnitude.

A similar situation is recorded in diagram 3c which corresponds to another outburst observed in 1974. The latter outburst differs from that in 1969 inasmuch as it slowed down the secular increase of the period. The situation is reminiscent of that shown in Fig. 17 of Batten around 1940 (Batten, 1974). In contrast during a quiescent period the O-C diagram shows a minimal scatter on Fig. 3b.

Polarimetric observations also confirm the fact

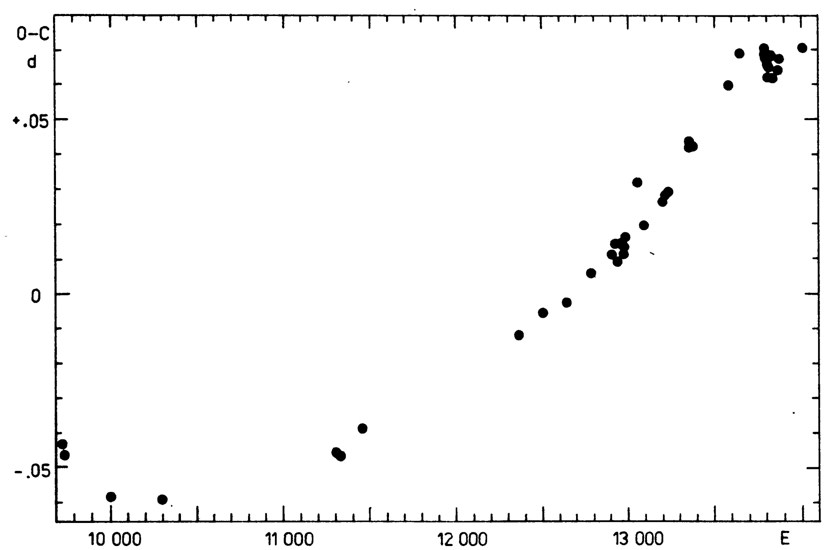

Fig. 2. O-C diagram for photoelectric epochs of minima.

that U Cephei goes through stages of quiet and disturbed periods. Coyne (1974) observed the polarization near primary minima in 1973 and found no detectable variation of polarization. A similar effect was found by Piirola (1975) in 1972 and 1973. On the other hand in 1975 the latter author found a variable polarization between the second and third contact pointing to the changing density of circumstellar matter.

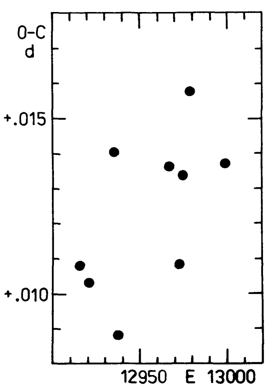

Fig. 3a. The spread of the individual epochs of minima in 1969.

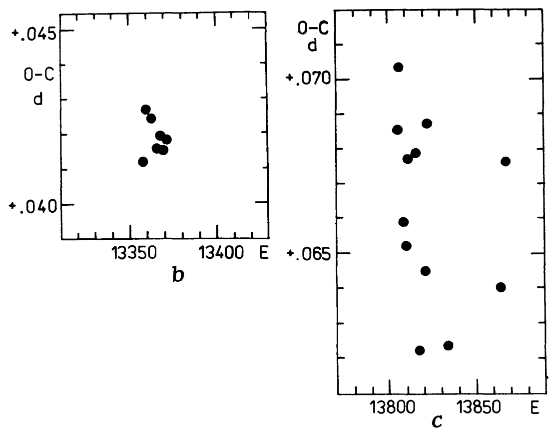

Fig. 3b. The spread of the individual epochs of minima in 1971.

Fig. 3c. The spread of the individual epochs of minima in 1974.

The Light Curve and Its Variations

As we mentioned in the introductory part the light curves of U Cephei were obtained over a period of many years. Nevertheless the observational material is homogeneous since the same equipment and the same set of filters were used. In this section we wish to discuss the light curve during the primary minima, then the secondary minima and finally the part outside the eclipses.

There exist considerable variations of the width, depth and shape of the primary minima. The overall depth can vary more than $0\overset{m}{.}1$ which was confirmed by our observations and the brightness at second and third contact differs and the brightness during the total eclipse may be variable. There are also considerable changes in the duration of the eclipse. The minimum can last more than 2 hours in the B filter but at other times it is as short as 47 minutes in V colour.

In Hall and Walter's (1974) discussion the slant during totality was defined. They have suggested that an upward slant results from an accumulation of matter around the hotter star. Walter (1975) extended the discussion to the downward slants and argued that such an effect could be caused by a stream of particles flowing towards the polar regions and producing the hot spots on the B star. Due to inclination of the B star's polar axis and its precessional motion the hot spot may affect different phases of minima during totality. The amplitude of this effect in Walter's estimate is about $0\overset{m}{.}2$ in the B light and its precessional period he estimated to be 12 years.

The slants derived from our observations during 1968 and 1969 appear to be slightly negative which does not contradict Walter's interpretation of the slants. At present time (1975—1976) mass transfer and the precession of the B star's polar axis operate in the same direction and therefore we should be observing a maximum positive slant of the minima. Thus if it is observed it would be a sensitive indicator of activity af this binary system. On the other hand a flat-bottomed minima would indicated a small mass transfer activity. However the slants by themselves do not fully explain the complicated nature of the light curve during primary minima. For instance, why some minima have a round bottom, a step shaped bottom or why the depth of minima is variable.

The shape of the primary minima is asymmetric due to the deformation of the descending branch. The distorsion is caused by absorption and/or filling-in effect by radiating clouds. The effect of the absorption is to depress the light curve about the time of the first contact while the effect of filling-in, noticeable around the second contact, changes the width of the eclipse. The ascending branch is much less affected by the phenomena except for the portion around the fourth contact which produces a brightening of about $0\overset{m}{.}05$. We believe this is an agreement with the idea of Walter, that the equatorial hot spot produces the brightening at the fourth contact. At time of low activity the brightening is very small and the light curve becomes quite flat.

The brightness of the secondary minima in the light curve is quite variable. Related to the light level $-1^{m}.10$ one of our minima is above this level while others dip below this line up to $0^{m}.15$. There may exist a relation between the level of secondary minimum and the activity of the system. However, no confirmation of such an effect has been made. The observations of 1969 (high activity) seem to correlate with the shallower primary minima and the secondary minimum in 1973 correlates with the deeper primary minimum, corresponding to a low activity of the system.

Finally commenting on the phases of maximum light, which were observed at the time of low activity, we notice just a small departure from constancy at the phase 0.25 while at phase 0.75 the brightness at maximum is variable the deviations being about $0^{m}.05$. It is worthnoticing that the light curve appears least disturbed from the time of the third contact through the phase of constant light preceding the secondary minimum.

Our final comment on the shape of the light curve is the following: Because of rather scarce observations the changes occurring over short-time intervals cannot be followed adequately and therefore are not well understood.

Conclusion

In this paper we have presented observations of the light curve of U Cephei. The data were used to derive the geometric elements for the system. The elements are consistent with those derived by Batten and are based on the standard rectification procedure. On the other hand they differ to some extent from the elements of Hall and Walter who applied the short region rectification method to their light curves.

The photoelectrically obtained epochs of primary minima confirm the well established regular increase of the period of U Cephei. We found that during period of increased mass transfer from the secondary to the primary component the secular increase of the period was affected only during the last outburst of U Cephei in 1974. At that time the period increased at a slower rate than before the outburst. On the other hand no obvious change occurred during the 1969 outburst. One important outcome of our investigation showed that the scatter of the residuals increased during period of high activity which is caused by the distorsion of the descending branch of the light curve and it can produce a spurious short-term variations of the period.

Finally we have analysed the light curve during the primary and the secondary minima as well as the constant phase. We have established a large degree of variations especially during minima,

Table 4

Blue observations

$J.D._{hel}$	Δm	$J.D._{hel}$	Δm
2440243.2882	−1.009	.3350	−0.992
.2889	−1.007	.3358	−1.001
.2896	−1.010	.3365	−0.996
.2903	−1.009	.3399	−0.998
.2910	−1.008	.3405	−1.000
.2917	−1.005	.3412	−0.999
.2924	−1.009	.3419	−0.997
.2930	−1.009	.3426	−0.999
.2938	−1.006	.3433	−0.998
.2944	−1.008	.3441	−0.998
.2951	−1.003	.3448	−0.993
.2979	−1.007	.3455	−0.996
.2988	−1.007	.3462	−0.996
.2994	−1.005	.3469	−0.993
.3001	−1.010	.3511	−0.991
.3009	−1.002	.3518	−0.991
.3016	−1.009	.3525	−0.988
.3023	−1.007	.3532	−0.992
.3030	−1.002	.3538	−0.987
.3037	−1.002	.3546	−0.987
.3044	−0.999	.3552	−0.987
.3063	−1.006	.3559	−0.988
.3070	−0.997	.3566	−0.985
.3077	−0.995	.3573	−0.988
.3085	−0.995	.3580	−0.983
.3092	−1.000	.3608	−0.981
.3100	−1.005	.3615	−0.974
.3106	−0.994	.3620	−0.975
.3113	−0.994	.3627	−0.978
.3120	−0.994	.3635	−0.973
.3127	−0.995	.3641	−0.972
.3134	−0.990	.3648	−0.968
.3155	−0.997	.3656	−0.967
.3162	−0.995	.3664	−0.964
.3169	−0.993	.3671	−0.965
.3176	−0.999	.3699	−0.959
.3183	−0.996	.3706	−0.953
.3190	−0.992	.3713	−0.952
.3197	−0.996	.3720	−0.945
.3204	−0.997	.3727	−0.943
.3210	−1.007	.3734	−0.943
.3218	−1.002	.3740	−0.936
.3225	−0.999	.3747	−0.930
.3294	−0.994	.3754	−0.925
.3301	−0.989	.3762	−0.920
.3308	−0.991	.3783	−0.912
.3315	−0.994	.3790	−0.909
.3322	−0.990	.3797	−0.903
.3329	−0.993	.3804	−0.905
.3336	−0.990	.3811	−0.894
.3343	−0.991	.3818	−0.893

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.3824	−0.895	.4454	−0.195
.3831	−0.881	.4511	−0.080
.3839	−0.887	.4520	−0.058
.3846	−0.878	.4527	−0.040
.3853	−0.872	.4537	−0.026
.3859	−0.873	.4547	−0.000
.3868	−0.863	.4557	−0.015
.3893	−0.851	.4564	−0.038
.3902	−0.844	.4571	−0.050
.3909	−0.835	.4581	−0.077
.3917	−0.830	.4590	−0.095
.3924	−0.830	.4599	−0.108
.3931	−0.825	.4624	+0.161
.3938	−0.816	.4632	+0.176
.3843	−0.809	.4641	+0.205
.3951	−0.801	.4650	+0.212
.3959	−0.799	.4658	+0.235
.3966	−0.794	.4666	+0.257
.3973	−0.787	.4678	+0.286
.4028	−0.744	.4689	+0.310
.4034	−0.740	.4697	+0.335
.4041	−0.735	.4706	+0.364
.4048	−0.733	.4710	+0.369
.4056	−0.721	.4738	+0.460
.4063	−0.710	.4745	+0.482
.4070	−0.711	.4752	+0.501
.4076	−0.700	.4759	+0.528
.4084	−0.699	.4766	+0.547
.4091	−0.689	.4773	+0.574
.4097	−0.687	.4781	+0.596
.4124	−0.656	.4788	+0.619
.4133	−0.651	.4795	+0.654
.4139	−0.633	.4802	+0.677
.4146	−0.627	.4829	+0.814
.4173	−0.604	.4836	+0.860
.4181	−0.596	.4843	+0.865
.4190	−0.597	.4851	+0.921
.4198	−0.567	.4857	+0.919
.4205	−0.560	.4864	+0.946
.4214	−0.547	.4871	+0.994
.4224	−0.532	.4878	+1.007
.4253	−0.504	.4885	+1.056
.4261	−0.495	.4893	+1.090
.4269	−0.483	.4990	+1.503
.4279	−0.465	.4997	+1.539
.4296	−0.445	.5004	+1.546
.4305	−0.432	.5011	+1.568
.4313	−0.419	.5018	+1.615
.4320	−0.415	.5025	+1.636
.4329	−0.404	.5032	+1.637
.4336	−0.389	.5039	+1.671
.4364	−0.347	.5046	+1.686
.4371	−0.338	.5053	+1.734
.4380	−0.325	.5074	+1.787
.4388	−0.310	.5081	+1.790
.4396	−0.295	.5088	+1.826
.4405	−0.282	.5094	+1.804
.4413	−0.274	.5101	+1.899
.4421	−0.242	.5108	+1.875
.4438	−0.220	.5115	+1.872
.4447	−0.213	.5122	+1.904

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.5129	+1.902	.5786	+1.914
.5151	+1.928	.5793	+1.914
.5158	+1.930	.5800	+1.946
.5165	+1.933	.5808	+1.918
.5172	+1.935	.5814	+1.918
.5178	+1.937	.5821	+1.918
.5185	+1.934	.5828	+1.918
.5192	+1.930	.5836	+1.915
.5200	+1.930	.5842	+1.918
.5206	+1.929	.5849	+1.944
.5214	+1.914	.5870	+1.938
.5220	+1.918	.5877	+1.924
.5227	+1.930	.5884	+1.918
.5234	+1.932	.5891	+1.939
.5241	+1.928	.5898	+1.936
.5249	+1.934	.5905	+1.934
.5298	+1.917	.5912	+1.932
.5304	+1.959	.5920	+1.930
.5311	+1.971	.5926	+1.934
.5318	+1.982	.5933	+1.958
.5325	+1.991	.5954	+1.926
.5339	+1.954	.5961	+1.939
.5346	+1.938	.5969	+1.959
.5423	+1.924	.5983	+1.958
.5430	+1.921	.5989	+1.995
.5437	+1.910	.5997	+1.975
.5444	+1.876	.6004	+1.924
.5451	+1.903	.6011	+1.897
.5458	+1.898	.6020	+1.917
.5465	+1.928	.6066	+1.758
.5472	+1.946	.6074	+1.807
.5479	+1.960	.6115	+1.545
.5514	+1.923	.6122	+1.504
.5521	+1.940	.6130	+1.479
.5528	+1.966	.6136	+1.457
.5535	+1.908	.6144	+1.474
.5543	+1.985	.6150	+1.433
.5549	+1.972	.6157	+1.418
.5556	+1.973	.6163	+1.373
.5562	+1.974	.6189	+1.181
.5569	+1.970	.6198	+1.150
.5578	+1.959	.6206	+1.119
.5605	+1.950	.6213	+1.087
.5612	+1.915	.6221	+1.057
.5619	+1.934	.6227	+1.026
.5626	+1.924	.6235	+0.969
.5634	+1.923	.6241	+0.940
.5641	+1.958	.6248	+0.927
.5647	+1.926	.6255	+0.937
.5654	+1.923	.6290	+0.778
.5661	+1,931	.6298	+0.729
.5668	+1.933	.6304	+0.719
.5689	+1.910	.6311	+0.706
.5696	+1.941	.6318	+0.654
.5703	+1.938	.6326	+0.660
.5710	+1.943	.6736	−0.432
.5717	+1.972	.6743	−0.450
.5724	+1.969	.6749	−0.471
.5731	+1.957	.6756	−0.470
.5737	+1.913	.6764	−0.480
.5745	+1.914	.6770	−0.493

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.6778	−0.504	.3394	−1.001
.6784	−0.511	.3400	−1.002
.6791	−0.518	.3407	−1.004
.6798	−0.530	.3414	−0.998
.6805	−0.536	.3422	−1.004
.6832	−0.569	.3430	−0.998
.6839	−0.584	.3436	−0.967
.6846	−0.593	.3464	−0.982
.6853	−0.600	.3471	−0.989
.6860	−0.613	.3478	−0.986
.6867	−0.619	.3485	−0.971
.6874	−0.634	.3492	−0.983
.6880	−0.638	.3499	−0.976
.6887	−0.649	.3506	−0.960
.6895	−0.655	.3513	−0.963
.6915	−0.678	.3523	−0.959
.6922	−0.684	.3530	−0.948
.6929	−0.695	.3560	−0.927
.6935	−0.701	.3568	−0.923
.6944	−0.717	.3603	−0.914
.6951	−0.718	.3612	−0.913
.6957	−0.723	.3621	−0.893
.6865	−0.729	.3630	−0.891
.6971	−0.740	.3636	−0.885
.7006	−0.766	.3644	−0.883
.7011	−0.772	.3714	−0.839
.7018	−0.777	.3720	−0.837
.7026	−0.787	.3728	−0.832
.7034	−0.793	.3735	−0.824
.7040	−0.799	.3741	−0.822
.7047	−0.809	.3748	−0.811
.7054	−0.810	.3755	−0.809
.7061	−0.817	.3762	−0.798
.7068	−0.824	.3769	−0.796
		.3776	−0.784
2440248.3137	−1.034	.3802	−0.745
.3145	−1.032	.3811	−0.726
.3152	−1.029	.3817	−0.745
.3158	−1.021	.3824	−0.738
.3165	−1.039	.3831	−0.730
.3173	−1.040	.3838	−0.722
.3185	−1.053	.3849	−0.719
.3197	−1.060	.3871	−0.696
.3208	−1.014	.3881	−0.691
.3214	−1.020	.3890	−0.692
.3220	−1.050	.3920	−0.667
.3227	−1.045	.3928	−0.659
.3258	−1.024	.3936	−0.659
.3280	−1.029	.3942	−0.654
.3290	−1.022	.3950	−0.648
.3298	−1.029	.3956	−0.627
.3305	−1.024	.3967	−0.636
.3310	−1.020	.3980	−0.639
.3317	−1.023	.3991	−0.603
.3324	−1.017	.4007	−0.604
.3331	−1.016	.4055	−0.557
.3339	−1.013	.4066	−0.555
.3344	−1.008	.4075	−0.557
.3373	−1.004	.4084	−0.538
.3380	−1.003	.4094	−0.507
.3387	−1.006	.4104	−0.507

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.4114	−0.450	.5361	−1.072
.4125	−0.447	.5368	−1.070
.4134	−0.447	.5375	−1.070
.4143	−0.422	.5382	−1.073
.4153	−0.420	.5389	−1.073
.4190	−0.309	.5396	−1.071
.4199	−0.386	.5403	−1.072
.4211	−0.353	.5410	−1.066
.4220	−0.353	.5452	−1.075
.4228	−0.335	.5458	−1.073
.4237	−0.296	.5466	−1.076
.4246	−0.294	.5472	−1.077
.4254	−0.247	.5479	−1.082
.4262	−0.232	.5486	−1.082
.4270	−0.275	.5494	−1.085
.4279	−0.247	.5500	−1.079
.4328	−0.162	.5507	−1.081
.4341	−0.141	.5515	−1.078
.4351	−0.132	.5556	−1.074
.4361	−0.099	.5563	−1.068
.4371	−0.076	.5570	−1.068
.4381	−0.055	.5577	−1.063
.4390	−0.013	.5584	−1.067
.4400	+0.032	.5591	−1.067
.4408	+0.015	.5598	−1.064
.4421	+0.082	.5605	−1.065
.4512	+0.284	.5613	−1.063
.4522	+0.272	.5620	−1.067
.4531	+0.298	.5626	−1.067
.4539	+0.328	.5634	−1.064
.4546	+0.335	.5675	−1.074
.4553	+0.363	.5682	−1.080
.4561	+0.368	.5689	−1.072
.4569	+0.418	.5696	−1.070
.4578	+0.437	.5703	−1.068
.4584	+0.470	.5710	−1.068
.4593	+0.484	.5717	−1.066
.4631	+0.632	.5724	−1.064
.4640	+0.664	.5731	−1.064
.4650	+0.755	.5738	−1.061
.4660	+0.792	.5772	−1.060
.4670	+0.857	.5780	−1.062
.4678	+0.923	.5786	−1.062
.4688	+0.946	.5793	−1.060
.4695	+0.984	.5801	−1.065
.4702	+1.018	.5808	−1.067
.4712	+1.018	.5814	−1.066
.4755	+1.267	.5822	−1.059
.4765	+1.353	.5829	−1.063
.4779	+1.356	.5835	−1.066
.4796	+1.421	.5871	−1.061
.4808	+1.478	.5878	−1.064
.4817	+1.499	.5884	−1.057
.4826	+1.609	.5891	−1.064
.4838	+1.653	.5898	−1.055
.4848	+1.687	.5906	−1.056
.4859	+1.731	.5913	−1.054
		.5920	−1.058
2440284.5340	−1.069	.5927	−1.057
.5348	−1.067	.5936	−1.055
.5354	−1.067	.5941	−1.059

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.5968	−1.063	.6570	−1.066
.5975	−1.069	.6578	−1.068
.5982	−1.070	.6584	−1.067
.5989	−1.068	.6590	−1.067
.5996	−1.073	.6598	−1.068
.6003	−1.073	.6606	−1.072
.6010	−1.078	.6632	−1.074
.6017	−1.075	.6638	−1.068
.6025	−1.075	.6646	−1.067
.6032	−1.068	.6653	−1.070
.6058	−1.067	.6660	−1.076
.6065	−1.066	.6666	−1.073
.6072	−1.071	.6674	−1.082
.6078	−1.079	.6681	−1.077
.6085	−1.072	.6688	−1.072
.6092	−1.079	.6695	−1.078
.6100	−1.078		
.6107	−1.078	2440318.3454	+1.987
.6114	−1.075	.3462	+1.917
.6120	−1.081	.3469	+1.963
.6128	−1.089	.3477	+1.963
.6169	−1.081	.3484	+1.978
.6176	−1.079	.3513	+1.963
.6183	−1.082	.3521	+1.956
.6199	−1.087	.3528	+1.948
.6205	−1.085	.3536	+1.970
.6212	−1.082	.3546	+1.932
.6218	−1.082	.3550	+1.932
.6225	−1.079	.3612	+1.917
.6232	−1.082	.3619	+1.932
.6239	−1.080	.3627	+1.932
.6246	−1.072	.3534	+1.924
.6253	−1.071	.3641	+1.916
.6259	−1.070	.3649	+1.909
.6287	−1.071	.3657	+1.916
.6295	−1.071	.3670	+1.916
.6302	−1.075	.3678	+1.909
.6309	−1.066	.3686	+1.916
.6315	−1.066	.3732	+1.930
.6322	−1.070	.3740	+1.915
.6329	−1.073	.3747	+1.930
.6336	−1.073	.3754	+1.930
.6343	−1.074	.3761	+1.916
.6350	−1.069	.3771	+1.930
.6356	−1.072	.3788	+1.914
.6364	−1.075	.3795	+1.924
.6398	−1.063	.3803	+1.929
.6407	−1.065	.3810	+1.936
.6412	−1.064	.3856	+1.929
.6419	−1.064	.3864	+1.907
.6425	−1.061	.3872	+1.907
.6432	−1.055	.3880	+1.899
.6438	−1.059	.3891	+1.907
.6446	−1.056	.3898	+1.907
.6453	−1.062	.3906	+1.906
.6459	−1.057	.3935	+1.883
.6466	−1.054	.3984	+1.747
.6439	−1.067	.3992	+1.704
.6550	−1.065	.3999	+1.697
.6557	−1.069	.4007	+1.656
.6563	−1.067	.4021	+1.582

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.4030	+1.559	.4960	−0.770
.4036	+1.512	.4969	−0.784
.4044	+1.471	.4975	−0.789
.4060	+1.413	.4982	−0.799
.4067	+1.363	.4989	−0.800
.4117	+1.126	.4997	−0.801
.4124	+1.087	.5004	−0.815
.4131	+1.056	.5011	−0.820
.4139	+1.019	.5019	−0.817
.4147	+0.979	.5027	−0.827
.4153	+0.957	.5767	−1.062
.4161	+0.930	.5774	−1.062
.4171	+0.900	.5781	−1.065
.4178	+0.843	.5789	−1.066
.4186	+0.828	.5796	−1.063
.4192	+0.793	.5803	−1.066
.4281	+0.457	.5812	−1.067
.4288	+0.441	.5818	−1.072
.4296	+0.426	.5826	−1.067
.4303	+0.390	.5943	−1.061
.4311	+0.369	.5950	−1.054
.4316	+0.347	.5957	−1.063
.4324	+0.317	.5965	−1.055
.4339	+0.268	.5972	−1.057
.4346	+0.247	.5980	−1.055
.4354	+0.228	.5987	−1.056
.4392	+0.130	.5995	−1.055
.4399	+0.110	.6002	−1.052
.4407	+0.091	.6025	−1.056
.4414	+0.073	.6032	−1.049
.4421	+0.052	.6039	−1.054
.4428	+0.031	.6047	−1.060
.4436	+0.022	.6054	−1.054
.4443	−0.001	.6066	−1.053
.4451	−0.008	.6074	−1.063
.4458	−0.029	.6081	−1.065
.4502	−0.128		
.4510	−0.137	2440319.4172	−1.064
.4517	−0.144	.4180	−1.070
.4525	−0.169	.4186	−1.059
.4532	−0.182	.4192	−1.066
.4539	−0.206	.4200	−1.059
.4554	−0.208	.4207	−1.061
.4687	−0.467	.4214	−1.053
.4694	−0.475	.4222	−1.065
.4702	−0.477	.4229	−1.069
.4709	−0.497	.4236	−1.072
.4716	−0.500	.4297	−1.072
.4724	−0.506	.4304	−1.073
.4819	−0.623	.4311	−1.068
.4827	−0.632	.4317	−1.069
.4834	−0.651	.4325	−1.070
.4842	−0.656	.4332	−1.073
.4849	−0.668	.4339	−1.066
.4857	−0.666	.4347	−1.072
.4864	−0.576	.4354	−1.068
.4872	−0.582	.4361	−1.073
.4879	−0.687	.4369	−1.076
.4886	−0.699	.4413	−1.070
.4894	−0.702	.4420	−1.081
.4953	−0.764	.4428	−1.071

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.4435	−1.080	.5612	−1.027
.4447	−1.066	.5620	−1.029
.4454	−1.071	.5628	−1.030
.4462	−1.060	.5635	−1.033
.4469	−1.068	.5642	−1.034
.4476	−1.063	.5650	−1.034
.4484	−1.056	.5658	−1.029
.4528	−1.074	.5666	−1.028
.4535	−1.075	.5673	−1.028
.4543	−1.078	.5681	−1.028
.4550	−1.074	.5691	−1.023
.4809	−1.061	.5741	−1.022
.4815	−1.071	.5748	−1.028
.4822	−1.062	.5763	−1.030
.4830	−1.066	.5771	−1.032
.4838	−1.063	.5779	−1.025
.4845	−1.060	.5786	−1.030
.4852	−1.064	.5794	−1.034
.4859	−1.062	.5844	−1.023
.4867	−1.063	.5851	−1.021
.4874	−1.062	.5865	−1.024
.4933	−1.064	.5874	−1.018
.4939	−1.071	.5888	−1.023
.4954	−1.064	.5909	−1.043
.4962	−1.076	.5917	−1.033
.4969	−1.074	.5931	−1.043
.4977	−1.070	.5938	−1.040
.4984	−1.072	.5981	−1.029
.5037	−1.057	.5988	−1.034
.5044	−1.062	.5995	−1.027
.5052	−1.065	.6002	−1.027
.5059	−1.064	.6011	−1.030
.5066	−1.062	.6018	−1.026
.5074	−1.058	.6026	−1.024
.5096	−1.057	.6033	−1.020
.5107	−1.066	.6044	−1.015
.5117	−1.068	.6047	−1.030
.5135	−1.059	.6055	−1.031
.5133	−1.060	.6062	−1.032
.5142	−1.060	.6068	−1.033
.5200	−1.051	.6076	−1.026
.5207	−1.053		
.5214	−1.054	2440501.5399	−1.042
.5221	−1.052	.5413	−1.054
.5229	−1.049	.5424	−1.057
.5270	−1.035	.5435	−1.056
.5280	−1.046	.5642	−1.049
.5287	−1.050	.5653	−1.041
.5318	−1.046	.5664	−1.031
.5378	−1.047	.5675	−1.044
.5385	−1.050	.5686	−1.048
.5400	−1.043	.5697	−1.046
.5483	−1.037	.5706	−1.048
.5490	−1.041	.5717	−1.039
.5497	−1.035	.5860	−1.041
.5505	−1.039	.5871	−1.032
.5519	−1.036	.5882	−1.033
.5531	−1.040	.5893	−1.031
.5554	−1.039	.5904	−1.023
.5561	−1.037	.5915	−1.029
.5605	−1.036	.5926	−1.027

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.5948	−1.015	.6120	−1.062
.5961	−1.021	.6127	−1.062
		.6134	−1.061
2440511.5272	−1.062	.6141	−1.065
.5282	−1.062	.6148	−1.060
.5323	−1.070	.6155	−1.063
.5345	−1.070	.6161	−1.062
.5355	−1.070	.6193	−1.061
.5363	−1.074	.6202	−1.063
.5371	−1.071	.6211	−1.062
.5380	−1.071	.6217	−1.062
.5417	−1.078	.6223	−1.060
.5428	−1.067	.6229	−1.053
.5437	−1.065	.6238	−1.049
.5446	−1.061	.6244	−1.049
.5453	−1.063	.6251	−1.047
.5460	−1.053	.6258	−1.045
.5468	−1.059	.6266	−1.042
.5474	−1.054	.6310	−1.040
.5480	−1.056	.6316	−1.054
.5487	−1.054	.6323	−1.052
.5523	−1.061	.6345	−1.048
.5530	−1.061	.6352	−1.049
.5537	−1.051	.6359	−1.048
.5544	−1.054	.6366	−1.049
.5550	−1.049	.6374	−1.049
.5557	−1.056	.6381	−1.053
.5565	−1.053	.6387	−1.049
.5789	−1.074	.6422	−1.059
.5796	−1.069	.6429	−1.048
.5809	−1.067	.6436	−1.048
.5816	−1.064	.6443	−1.044
.5823	−1.064	.6450	−1.054
.5829	−1.064	.6456	−1.047
.5836	−1.065	.6463	−1.047
.5843	−1.061	.6470	−1.055
.5850	−1.059	.6490	−1.061
.5857	−1.057	.6498	−1.056
.5864	−1.056		
.5894	−1.050	2440870.4813	−1.142
.5901	−1.050	.4818	−1.141
.5907	−1.052	.4826	−1.142
.5914	−1.052	.4833	−1.139
.5921	−1.055	.4839	−1.136
.5928	−1.050	.4846	−1.142
.5935	−1.052	.4853	−1.139
.5942	−1.054	.4860	−1.136
.5949	−1.049	.4867	−1.140
.5957	−1.069	.4874	−1.135
.5988	−1.049	.4996	−1.108
.5997	−1.055	.5011	−1.114
.6004	−1.056	.5021	−1.108
.6017	−1.047	.5028	−1.107
.6024	−1.042	.5035	−1.103
.6031	−1.039	.5042	−1.103
.6042	−1.053	.5049	−1.104
.6049	−1.060	.5056	−1.112
.6056	−1.054	.5063	−1.109
.6099	−1.060	.5070	−1.107
.6106	−1.062	.5160	−1.098
.6113	−1.063	.5167	−1.106

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.5174	−1.106	.6506	−1.152
.5181	−1.106		
.5188	−1.103	2441696.3481	−1.144
.5195	−1.103	.3488	−1.128
.5202	−1.100	.3495	−1.136
.5209	−1.097	.3501	−1.130
.5334	−1.085	.3508	−1.129
.5341	−1.082	.3523	−1.144
.5348	−1.078	.3530	−1.133
.5355	−1.080	.3536	−1.126
.5362	−1.083	.3543	−1.124
.5369	−1.083	.3552	−1.124
.5376	−1.081	.3557	−1.121
.5494	−1.086	.3564	−1.120
.5501	−1.096	.3598	−1.138
.5508	−1.095	.3606	−1.135
.5515	−1.100	.3613	−1.131
.5522	−1.099	.3620	−1.131
.5529	−1.095	.3627	−1.123
.5536	−1.105	.3634	−1.129
.5543	−1.103	.3641	−1.120
.5591	−1.109	.3648	−1.127
.5598	−1.105	.3655	−1.126
.5605	−1.104	.3662	−1.125
.5612	−1.108	.3668	−1.125
.5619	−1.107	.3682	−1.125
.5626	−1.107	.3718	−1.139
.5737	−1.098	.3724	−1.139
.5744	−1.106	.3732	−1.124
.5751	−1.094	.3738	−1.136
.5758	−1.094	.3746	−1.128
.5765	−1.082	.3753	−1.132
.5772	−1.103	.3759	−1.138
.5778	−1.090	.3766	−1.134
.5785	−1.086	.3773	−1.156
.5792	−1.096	.3780	−1.138
.5799	−1.101	.3787	−1.139
.5806	−1.097	.3794	−1.139
.6113	−1.137	.3815	−1.162
.6124	−1.143	.3821	−1.160
.6133	−1.143	.3829	−1.146
.6140	−1.137	.3836	−1.184
.6147	−1.139	.3843	−1.153
.6154	−1.136	.3850	−1.141
.6161	−1.143	.3857	−1.137
.6167	−1.138	.3864	−1.135
.6279	−1.132	.3870	−1.160
.6286	−1.148	.3877	−1.148
.6292	−1.152	.3884	−1.142
.6300	−1.151	.3891	−1.152
.6307	−1.141	.3898	−1.130
.6314	−1.144	.3905	−1.139
.6321	−1.148	.3932	−1.133
.6328	−1.140	.3940	−1.135
.6335	−1.137	.3946	−1.128
.6342	−1.144	.3953	−1.128
.6472	−1.138	.3960	−1.117
.6479	−1.140	.3967	−1.115
.6486	−1.143	.3973	−1.119
.6492	−1.138	.3980	−1.120
.6499	−1.152	.3987	−1.115

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.3994	−1.141	.4906	−1.103
.4022	−1.141	.4913	−1.094
.4029	−1.145	.4920	−1.085
.4036	−1.146	.4927	−1.086
.4043	−1.148	.4934	−1.084
.4050	−1.154	.4941	−1.082
.4057	−1.155	.4948	−1.087
.4064	−1.150	.4955	−1.095
.4071	−1.155	.4961	−1.087
.4078	−1.143	.4968	−1.064
.4085	−1.140	.4975	−1.090
.4092	−1.145	.4982	−1.088
.4098	−1.141	.4989	−1.091
.4125	−1.156	.4996	−1.098
.4132	−1.149	.5003	−1.091
.4139	−1.155	.5010	−1.092
.4146	−1.155	.5038	−1.116
.4160	−1.147	.5046	−1.106
.4167	−1.148	.5051	−1.107
.4174	−1.148	.5058	−1.106
.4181	−1.140	.5065	−1.105
.4188	−1.139	.5072	−1.106
.4194	−1.137	.5079	−1.102
.4206	−1.144	.5086	−1.104
.4215	−1.140	.5093	−1.101
.4244	−1.144	.5100	−1.099
.4251	−1.135	.5107	−1.102
.4258	−1.133	.5114	−1.102
.4265	−1.129	.5232	−1.101
.4272	−1.129	.5238	−1.095
.4279	−1.132	.5246	−1.093
.4286	−1.132	.5252	−1.090
.4293	−1.129	.5259	−1.091
.4299	−1.134	.5266	−1.086
.4306	−1.137	.5273	−1.092
.4313	−1.136	.5280	−1.085
.4320	−1.132	.5287	−1.090
.4347	−1.141	.5294	−1.094
.4355	−1.135	.5301	−1.090
.4362	−1.136	.5307	−1.093
.4369	−1.134	.5328	−1.101
.4377	−1.134	.5335	−1.094
.4384	−1.136	.5342	−1.093
.4393	−1.130	.5349	−1.090
.4399	−1.131	.5356	−1.090
.4404	−1.134	.5363	−1.090
.4411	−1.132	.5370	−1.076
.4419	−1.120	.5377	−1.076
.4425	−1.128	.5384	−1.078
.4432	−1.124	.5391	−1.074
.4460	−1.136	.5398	−1.070
.4467	−1.128	.5404	−1.075
.4473	−1.131	.5425	−1.082
.4480	−1.116	.5432	−1.079
.4487	−1.128	.5439	−1.073
.4494	−1.138	.5447	−1.073
.4501	−1.138	.5454	−1.068
.4508	−1.136	.5465	−1.073
.4515	−1.135	.5474	−1.072
.4522	−1.138	.5481	−1.080
.4528	−1.130	.5488	−1.075

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.5495	−1.070	.6177	−1.098
.5502	−1.075	.6184	−1.095
.5530	−1.079	.6191	−1.096
.5538	−1.082	.6198	−1.097
.5544	−1.067	.6205	−1.097
.5551	−1.072	.6211	−1.101
.5557	−1.065	.6218	−1.097
.5564	−1.061	.6224	−1.100
.5572	−1.068	.6232	−1.098
.5578	−1.053	.6239	−1.099
.5585	−1.057	.6259	−1.100
.5592	−1.058	.6266	−1.101
.5600	−1.057	.6273	−1.097
.5607	−1.058	.6279	−1.095
.5627	−1.065	.6285	−1.098
.5634	−1.076	.6292	−1.097
.5641	−1.064	.6300	−1.097
.5648	−1.071	.6306	−1.095
.5654	−1.070	.6312	−1.093
.5662	−1.067	.6320	−1.094
.5669	−1.065	.6326	−1.093
.5676	−1.063	.6333	−1.094
.5682	−1.057	.6340	−1.093
.5689	−1.071	.6361	−1.093
.5696	−1.066	.6368	−1.088
.5724	−1.060	.6375	−1.088
.5731	−1.059	.6382	−1.086
.5738	−1.064	.6389	−1.079
.5745	−1.060	.6396	−1.077
.5752	−1.059	.6402	−1.080
.5759	−1.057	.6409	−1.081
.5766	−1.058	.6416	−1.098
.5773	−1.053	.6423	−1.077
.5779	−1.058	.6430	−1.072
.5788	−1.056	.6437	−1.075
.5794	−1.054	.6444	−1.079
.5829	−1.056	.6473	−1.099
.5836	−1.055	.6479	−1.096
.5843	−1.044	.6486	−1.099
.5850	−1.046	.6493	−1.105
.5857	−1.042	.6498	−1.102
.5870	−1.058	.6506	−1.105
.5877	−1.061	.6514	−1.113
.5886	−1.054	.6520	−1.115
.5893	−1.059	.6535	−1.101
.5899	−1.055	.6541	−1.086
.5906	−1.060	.6548	−1.093
.6038	−1.090	.6575	−1.097
.6059	−1.090	.6582	−1.106
.6067	−1.090	.6590	−1.101
.6074	−1.090	.6596	−1.102
.6082	−1.084	.6603	−1.095
.6094	−1.092	.6610	−1.100
.6108	−1.092	.6616	−1.106
.6114	−1.089	.6622	−1.105
.6122	−1.092	.6630	−1.111
.6128	−1.098	.6637	−1.102
.6135	−1.090	.6644	−1.105
.6142	−1.097	.6651	−1.109
.6163	−1.096	.6672	−1.092
.6170	−1.094	.6680	−1.109

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.6687	−1.104	.5915	−0.098
.6694	−1.104	.5921	−0.114
.6700	−1.102	.5928	−0.124
.6707	−1.104	.5968	−0.196
.6714	−1.105	.5991	−0.234
.6721	−1.106	.5996	−0.247
.6728	−1.105	.6004	−0.258
.6735	−1.108	.6011	−0.279
.6755	−1.106	.6018	−0.301
.6762	−1.101	.6024	−0.307
.6768	−1.101	.6032	−0.300
.6776	−1.091	.6039	−0.341
.6818	−1.104	.6045	−0.348
.6826	−1.097	.6052	−0.366
.6855	−1.094	.6060	−0.369
.6861	−1.093	.6087	−0.409
.6868	−1.089	.6094	−0.411
.6875	−1.090	.6101	−0.420
.6882	−1.092	.6108	−0.434
.6890	−1.094	.6115	−0.433
.6897	−1.087	.6121	−0.445
.6904	−1.094	.6128	−0.460
.6911	−1.087	.6136	−0.468
.6918	−1.090	.6142	−0.468
.6925	−1.087	.6179	−0.537
.6932	−1.092	.6186	−0.548
.6945	−1.095	.6193	−0.551
		.6200	−0.561
2441709.5589	+0.885	.6207	−0.575
.5596	+0.864	.6214	−0.578
.5603	+0.842	.6220	−0.590
.5609	+0.824	.6234	−0.608
.5615	+0.792	.6244	−0.619
.5622	+0.759	.6271	−0.651
.5633	+0.718	.6278	−0.659
.5640	+0.700	.6286	−0.679
.5647	+0.662	.6293	−0.680
.5654	+0.625	.6302	−0.681
.5682	+0.532	.6309	−0.695
.5688	+0.515	.6316	−0.699
.5695	+0.496	.6323	−0.703
.5702	+0.474	.6330	−0.722
.5707	+0.452	.6337	−0.725
.5715	+0.439	.6344	−0.714
.5722	+0.401	.6371	−0.759
.5729	+0.392	.6379	−0.762
.5736	+0.371	.6386	−0.774
.5770	+0.275	.6395	−0.776
.5777	+0.260	.6403	−0.781
.5786	+0.250	.6410	−0.785
.5792	+0.223	.6417	−0.783
.5798	+0.215	.6425	−0.794
.5832	+0.112	.6432	−0.791
.5839	+0.100	.6439	−0.812
.5866	+0.027	.6470	−0.842
.5873	+0.010	.6480	−0.845
.5880	−0.007	.6487	−0.857
.5888	−0.036	.6495	−0.858
.5895	−0.050	.6507	−0.869
.5902	−0.060	.6514	−0.880
.5909	−0.085	.6520	−0.881

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.6528	−0.892	.3822	−1.103
.6535	−0.896	.3828	−1.099
.6541	−0.901	.3835	−1.102
.6582	−0.925	.3842	−1.104
.6589	−0.927	.3849	−1.104
.6596	−0.928	.3856	−1.102
.6603	−0.929	.3862	−1.102
.6610	−0.930	.3869	−1.101
.6617	−0.937	.3876	−1.110
.6624	−0.948	.3883	−1.108
.6630	−0.947	.3890	−1.108
.6637	−0.959	.3897	−1.107
.6678	−0.972	.3904	−1.108
.6686	−0.977	.3911	−1.112
.6693	−0.986	.3918	−1.106
.6698	−0.992	.3950	−1.111
.6706	−0.994	.3959	−1.112
.6713	−1.001	.3966	−1.103
.6720	−1.001	.3973	−1.103
.6727	−1.009	.3981	−1.113
.6734	−1.003	.3988	−1.112
.6767	−1.011	.3995	−1.110
.6775	−1.015	.4002	−1.113
.6782	−1.026	.4009	−1.123
.6788	−1.022	.4016	−1.118
.6795	−1.027	.4023	−1.115
.6802	−1.040	.4030	−1.114
.6809	−1.036	.4037	−1.111
.6816	−1.046	.4044	−1.117
.6823	−1.048	.4051	−1.117
.6829	−1.040	.4292	−1.100
.6868	−1.048	.4299	−1.100
.6877	−1.054	.4306	−1.100
.6884	−1.064	.4313	−1.104
.6890	−1.053	.4320	−1.118
.6897	−1.064	.4327	−1.118
.6904	−1.071	.4334	−1.124
.6911	−1.064	.4341	−1.124
.6918	−1.077	.4348	−1.118
.6925	−1.072	.4355	−1.118
.6932	−1.056	.4362	−1.121
.6938	−1.073	.4369	−1.120
.6946	−1.058	.5974	−1.019
.6972	−1.072	.5981	−1.025
.6978	−1.078	.5988	−1.019
.6985	−1.077	.5995	−1.028
.6992	−1.092	.6002	−1.014
.7000	−1.098	.6009	−1.023
.7006	−1.100	.6016	−1.021
.7013	−1.094	.6023	−1.028
.7020	−1.105	.6029	−1.022
.7026	−1.112	.6026	−1.012
.7033	−1.112	.6043	−1.024
.7040	−1.102	.6050	−1.027
		.6076	−1.021
2441716.3700	−1.104	.6083	−1.020
.3707	−1.101	.6089	−1.019
.3715	−1.097	.6096	−1.018
.3722	−1.101	.6103	−1.015
.3728	−1.099	.6110	−1.014
.3796	−1.108	.6117	−1.014

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.6124	−1.025	.6660	−1.021
.6131	−1.012	.6667	−1.024
.6138	−1.024	.6676	−1.022
.6160	−1.031	.6682	−1.018
.6166	−1.018	.6689	−1.017
.6173	−1.018	.6696	−1.019
.6180	−1.012	.6703	−1.015
.6187	−1.026	.6710	−1.016
.6216	−1.029	.6717	−1.017
.6223	−1.031	.6724	−1.011
.6230	−1.030	.6731	−1.012
.6237	−1.022	.6738	−1.007
.6244	−1.029	.6745	−1.010
.6256	−1.019	.6779	−1.007
.6264	−1.020	.6786	−1.012
.6271	−1.016	.6793	−1.004
.6278	−1.018	.6800	−1.005
.6284	−1.027	.6807	−1.011
.6291	−1.026	.6814	−1.007
.6299	−1.021	.6821	−1.007
.6305	−1.041	.6827	−1.007
.6312	−1.032	.6834	−1.008
.6319	−1.033	.6841	−1.007
.6352	−1.029	.6848	−1.004
.6359	−1.031	.6855	−1.010
.6366	−1.027	.6862	−1.013
.6373	−1.030	.6869	−1.013
.6380	−1.026	.6876	−1.014
.6388	−1.035	.6905	−1.014
.6394	−1.031	.6912	−1.011
.6401	−1.032	.6919	−1.017
.6409	−1.030	.6926	−1.016
.6416	−1.030	.6933	−1.015
.6425	−1.021	.6940	−1.016
.6431	−1.025	.6947	−1.021
.6438	−1.029	.6954	−1.019
.6445	−1.028	.6960	−1.023
.6452	−1.028	.6967	−1.024
.6479	−1.031	.6973	−1.026
.6486	−1.031	.6980	−1.024
.6493	−1.014	.6988	−1.034
.6500	−1.010	.6995	−1.030
.6507	−1.021	.7002	−1.035
.6514	−1.020		
.6521	−1.020	2441718.6342	−1.111
.6528	−1.020	.6349	−1.105
.6535	−1.020	.6356	−1.108
.6542	−1.020	.6363	−1.105
.6549	−1.015	.6370	−1.109
.6555	−1.015	.6377	−1.108
.6562	−1.015	.6384	−1.107
.6569	−1.021	.6391	−1.107
.6576	−1.026	.6398	−1.108
.6603	−1.021	.6405	−1.110
.6610	−1.024	.6412	−1.113
.6617	−1.025	.6419	−1.110
.6624	−1.018	.6426	−1.110
.6633	−1.018	.6433	−1.113
.6640	−1.020	.6439	−1.107
.6646	−1.018	.6466	−1.115
.6653	−1.026	.6473	−1.108

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.6480	−1.113	.3050	−1.099
.6487	−1.114	.3057	−1.099
.6494	−1.114	.3064	−1.100
.6501	−1.117	.3073	−1.098
.6508	−1.117	.3080	−1.100
.6515	−1.117	.3087	−1.098
.6522	−1.114	.3093	−1.098
.6529	−1.118	.3100	−1.099
.6535	−1.119	.3107	−1.095
.6542	−1.116	.3114	−1.099
.6549	−1.120	.3121	−1.099
.6556	−1.120	.3128	−1.095
.6563	−1.118	.3135	−1.098
.6592	−1.116	.3162	−1.096
.6598	−1.122	.3169	−1.092
.6605	−1.120	.3176	−1.100
.6612	−1.124	.3183	−1.096
.6619	−1.118	.3190	−1.096
.6625	−1.116	.3197	−1.096
.6633	−1.119	.3204	−1.099
.6639	−1.113	.3211	−1.092
.6646	−1.117	.3218	−1.090
.6653	−1.115	.3235	−1.094
.6660	−1.121	.3242	−1.098
.6667	−1.118	.3249	−1.090
.6674	−1.119	.3256	−1.100
.6682	−1.118	.3263	−1.095
.6688	−1.117	.3270	−1.096
.6711	−1.121	.3289	−1.105
.6716	−1.115	.3295	−1.090
.6723	−1.123	.3300	−1.099
.6730	−1.121	.3307	−1.082
.6737	−1.120	.3314	−1.090
.6744	−1.120	.3321	−1.088
.6751	−1.120	.3328	−1.090
.6758	−1.126	.3335	−1.060
.6765	−1.118	.3342	−1.074
.6772	−1.113	.3348	−1.078
.6778	−1.115	.3355	−1.068
.6786	−1.116	.3362	−1.064
.6792	−1.118	.3370	−1.084
.6799	−1.112	.3377	−1.088
.6806	−1.114	.3384	−1.089
.6833	−1.118	.3391	−1.079
.6840	−1.122	.3414	−1.091
.6846	−1.116	.3421	−1.090
.6853	−1.112	.3432	−1.087
.6861	−1.115	.3439	−1.091
.6868	−1.115	.3446	−1.091
.6875	−1.116	.3453	−1.092
.6882	−1.118	.3467	−1.023
.6889	−1.117	.3474	−1.085
.6896	−1.119	.3480	−1.091
.6903	−1.120	.3495	−1.090
.6910	−1.117	.3502	−1.097
.6917	−1.119	.3509	−1.090
.6924	−1.125	.3515	−1.092
.6931	−1.122	.3538	−1.092
		.3544	−1.085
2441747.3035	−1.102	.3550	−1.089
.3043	−1.104	.3557	−1.090

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.3564	−1.088	.4660	−1.076
.3571	−1.085	.4667	−1.078
.3578	−1.083	.4674	−1.070
.3583	−1.092	.4680	−1.068
.4196	−1.086	.4687	−1.071
.4203	−1.086	.4715	−1.074
.4210	−1.084	.4722	−1.064
.4217	−1.087	.4729	−1.064
.4224	−1.083	.4736	−1.065
.4231	−1.092	.4743	−1.067
.4238	−1.083	.4750	−1.065
.4245	−1.085	.4757	−1.065
.4252	−1.082	.4764	−1.065
.4259	−1.084	.4771	−1.063
.4266	−1.079	.4778	−1.065
.4273	−1.081	.4785	−1.066
.4280	−1.081	.4792	−1.061
.4287	−1.082	.4799	−1.063
.4294	−1.082	.4806	−1.064
.4301	−1.088	.4811	−1.063
.4325	−1.082	.4834	−1.067
.4333	−1.081	.4841	−1.066
.4340	−1.081	.4848	−1.067
.4347	−1.085	.4855	−1.070
.4355	−1.087	.4862	−1.057
.4362	−1.085	.4868	−1.063
.4369	−1.092	.4875	−1.058
.4380	−1.087	.4882	−1.063
.4390	−1.093	.4889	−1.060
.4397	−1.089	.4896	−1.062
.4404	−1.088	.4903	−1.063
.4410	−1.092	.4910	−1.058
.4417	−1.090	.4917	−1.064
.4424	−1.091	.4924	−1.063
.4431	−1.090	.4931	−1.066
.4453	−1.097	.4938	−1.065
.4460	−1.093	.4957	−1.058
.4467	−1.095	.4964	−1.056
.4474	−1.085	.4971	−1.060
.4481	−1.087	.4978	−1.057
.4488	−1.095	.4985	−1.063
.4495	−1.080	.4992	−1.064
.4500	−1.086	.4998	−1.065
.4507	−1.080	.5005	−1.065
.4515	−1.076	.5012	−1.068
.4522	−1.081	.5029	−1.068
.4529	−1.085	.5036	−1.066
.4537	−1.076	.5043	−1.065
.4542	−1.081	.5050	−1.067
.4549	−1.078	.5057	−1.069
.4556	−1.081	.5064	−1.074
.4588	−1.085	.5082	−1.073
.4595	−1.081	.5089	−1.073
.4604	−1.080	.5097	−1.070
.4611	−1.080	.5104	−1.068
.4618	−1.087	.5111	−1.069
.4625	−1.082	.5119	−1.067
.4632	−1.079	.5126	−1.069
.4639	−1.073	.5133	−1.068
.4646	−1.066	.5140	−1.067
.4653	−1.069	.5147	−1.067

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.5154	−1.066	.5663	−1.083
.5161	−1.066	.5670	−1.077
.5168	−1.067	.5690	−1.081
.5175	−1.070	.5697	−1.084
.5203	−1.073	.5704	−1.080
.5229	−1.059	.5711	−1.080
.5236	−1.068	.5718	−1.075
.5243	−1.066	.5725	−1.076
.5250	−1.067	.5732	−1.080
.5257	−1.067	.5739	−1.080
.5264	−1.068	.5746	−1.079
.5271	−1.067	.5753	−1.076
.5278	−1.072	.5760	−1.075
.5286	−1.073	.5767	−1.079
.5293	−1.069	.5774	−1.070
.5300	−1.076	.5781	−1.075
.5307	−1.073	.5788	−1.077
.5314	−1.074	.5795	−1.082
.5321	−1.074	.5814	−1.075
.5328	−1.074	.5821	−1.080
.5335	−1.070	.5828	−1.076
.5367	−1.075	.5835	−1.081
.5375	−1.075	.5841	−1.086
.5382	−1.079	.5848	−1.086
.5389	−1.074	.5854	−1.079
.5396	−1.076	.5861	−1.073
.5403	−1.074	.5868	−1.085
.5410	−1.073	.5875	−1.081
.5417	−1.075	.5882	−1.082
.5424	−1.075	.5889	−1.084
.5431	−1.075	.5896	−1.082
.5438	−1.072	.5903	−1.075
.5445	−1.072	.5910	−1.067
.5452	−1.068	.5917	−1.067
.5459	−1.071	.5924	−1.068
.5466	−1.068	.5931	−1.068
.5488	−1.074	.5938	−1.070
.5495	−1.068	.5961	−1.083
.5502	−1.071	.5967	−1.086
.5509	−1.070	.5973	−1.088
.5516	−1.070	.5980	−1.090
.5523	−1.070	.5987	−1.090
.5530	−1.074	.5994	−1.091
.5537	−1.075	.6001	−1.083
.5544	−1.074	.6008	−1.088
.5551	−1.073	.6015	−1.086
.5557	−1.075	.6022	−1.086
.5565	−1.075	.6029	−1.085
.5572	−1.075	.6036	−1.081
.5579	−1.075	.6043	−1.079
.5586	−1.073	.6050	−1.083
.5593	−1.072	.6057	−1.080
.5600	−1.080	.6079	−1.077
.5607	−1.078	.6085	−1.080
.5614	−1.078	.6092	−1.087
.5621	−1.078	.6099	−1.091
.5628	−1.079	.6106	−1.091
.5335	−1.078	.6113	−1.088
.5642	−1.085	.6120	−1.087
.5649	−1.081	.6127	−1.084
.5656	−1.077	.6134	−1.089

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.6141	−1.089	.5097	−1.072
.6148	−1.087	.5111	−1.061
.6152	−1.089	.5118	−1.071
.6159	−1.086	.5125	−1.065
.6166	−1.081	.5148	−1.081
.6173	−1.076	.5155	−1.082
.6330	−1.081	.5162	−1.072
.6348	−1.091	.5169	−1.073
.6476	−1.085	.5176	−1.075
.6383	−1.075	.5183	−1.077
.6390	−1.079	.5190	−1.077
.6397	−1.077	.5197	−1.079
.6404	−1.081	.5205	−1.074
.6411	−1.084	.5212	−1.077
.6418	−1.079	.5219	−1.070
.6425	−1.077	.5226	−1.075
.6447	−1.079	.5233	−1.071
.6454	−1.076	.5240	−1.072
.6461	−1.083	.5247	−1.070
.6467	−1.080	.5274	−1.063
.6473	−1.088	.5282	−1.066
.6480	−1.087	.5289	−1.068
.6487	−1.083	.5296	−1.077
.6494	−1.087	.5303	−1.072
.6501	−1.092	.5310	−1.075
.6508	−1.092	.5317	−1.075
.6515	−1.094	.5324	−1.075
.6522	−1.091	.5331	−1.075
.6529	−1.092	.5338	−1.078
.6536	−1.092	.5355	−1.081
.6543	−1.088	.5360	−1.081
.6550	−1.090	.5365	−1.086
		.5370	−1.085
2441758.4879	−1.078	.5375	−1.086
.4887	−1.083	.5398	−1.090
.4894	−1.080	.5404	−1.097
.4901	−1.078	.5411	−1.096
.4908	−1.072	.5418	−1.098
.4915	−1.075	.5425	−1.094
.4922	−1.077	.5432	−1.099
.4929	−1.081	.5439	−1.100
.4936	−1.079	.5446	−1.102
.4943	−1.079	.5460	−1.100
.4950	−1.077	.5469	−1.096
.4957	−1.084	.5476	−1.102
.4964	−1.079	.5483	−1.100
.4971	−1.082	.5494	−1.099
.4978	−1.079	.5503	−1.092
.5006	−1.084	.5510	−1.091
.5013	−1.077	.5545	−1.100
.5020	−1.078	.5832	−1.111
.5027	−1.078	.5842	−1.104
.5034	−1.084	.5849	−1.108
.5041	−1.082	.5856	−1.112
.5048	−1.086	.5863	−1.108
.5055	−1.084	.5870	−1.100
.5062	−1.080	.5877	−1.096
.5069	−1.091	.5884	−1.100
.5076	−1.089	.5891	−1.103
.5083	−1.066	.5898	−1.110
.5090	−1.066	.5905	−1.107

Table 4 (Continued)

J.D.hel	Δm	J.D.hel	Δm
.5912	−1.098	.5200	−0.986
.5919	−1.103	.5207	−0.987
.5924	−1.105	.5214	−0.997
.5930	−1.106	.5221	−0.998
.5943	−1.106	.5254	−1.013
.5953	−1.093	.5262	−1.015
.5958	−1.103	.5269	−1.018
.5965	−1.107	.5276	−1.021
.5972	−1.100	.5283	−1.022
.5979	−1.100	5290	−1.029
.5989	−1.105	.5297	−1.032
.6001	−1.110	.5304	−1.023
.6009	−1.105	.5310	−1.031
.6016	−1.101	.5317	−1.030
.6026	−1.102	.5345	−1.043
.6033	−1.110	.5352	−1.051
.6040	−1.103	.5360	−1.055
.6049	−1.093	.5366	−1.054
.6056	−1.099	.5372	−1.057
.6063	−1.102	.5379	−1.058
.6084	−1.113	.5386	−1.065
.6091	−1.114	.5393	−1.064
.6098	−1.101	.5400	−1.069
.6105	−1.090	.5407	−1.074
.6111	−1.097	.5435	−1.076
.6118	−1.093	.5442	−1.069
.6125	−1.099	.5449	−1.064
.6131	−1.102	.5456	−1.067
.6138	−1.105	.5463	−1.068
.6151	−1.097	.5470	−1.068
.6159	−1.098	.5477	−1.061
.6166	−1.104	.5484	−1.065
.6175	−1.106	.5491	−1.055
.6180	−1.099	.5498	−1.026
.6187	−1.098	.5524	−1.050
		.5533	−1.054
2441764.4965	−0.856	.5540	−1.055
.4979	−0.858	.5547	−1.053
.4986	−0.863	.5554	−1.050
.4993	−0.858	.5561	−1.049
.5007	−0.879	.5568	−1.050
.5014	−0.880	.5575	−1.052
.5021	−0.891	.5582	−1.053
.5028	−0.894	.5589	−1.054
.5035	−0.905	.5652	−1.056
.5069	−0.916	.5659	−1.058
.5076	−0.920	.5667	−1.060
.5083	−0.932	.5678	−1.064
.5090	−0.925	.5682	−1.065
.5097	−0.935	.5689	−1.063
.5104	−0.936	.5696	−1.064
.5111	−0.944	.5703	−1.064
.5118	−0.949	.5710	−1.068
.5125	−0.943	.5717	−1.061
.5132	−0.952	.5724	−1.063
.5159	−0.959	.5906	−1.063
.5166	−0.963	.5913	−1.049
.5173	−0.975	.5920	−1.057
.5180	−0.977	.5927	−1.062
.5187	−0.980	.5934	−1.056
.5193	−0.983	.5941	−1.059

Table 4 (Continued)

J.D.hel	Δm	J.D.hel	Δm
.5948	−1.055	.5753	−1.054
.5952	−1.058	.5760	−1.052
.5959	−1.055	.5767	−1.053
.5966	−1.062	.5795	−1.063
.5997	−1.062	.5802	−1.068
.6004	−1.062	.5809	−1.070
.6027	−1.068	.5816	−1.068
.6043	−1.056	.5823	−1.074
.6052	−1.058	.5830	−1.069
.6058	−1.063	.5838	−1.068
.6066	−1.060	.5845	−1.067
.6073	−1.063	.5852	−1.071
.6080	−1.064	.5859	−1.072
.6104	−1.068	.5866	−1.071
.6111	−1.055	.5872	−1.071
.6118	−1.056	.5879	−1.073
.6125	−1.067	.5886	−1.069
.6132	−1.064	.5911	−1.077
.6139	−1.061	.5918	−1.071
.6147	−1.059	.5925	−1.073
.6154	−1.059	.5935	−1.071
.6160	−1.063	.5942	−1.074
.6169	−1.062	.5950	−1.075
.6175	−1.058	.5955	−1.072
.6209	−1.056		
.6216	−1.061	2441833.4506	−1.097
.6222	−1.067	.4513	−1.094
.6229	−1.061	.4520	−1.089
.6236	−1.059	.4527	−1.083
.6243	−1.058	.4534	−1.075
.6250	−1.061	.4542	−1.064
.6257	−1.055	.4548	−1.063
.6264	−1.056	.4550	−1.062
.6271	−1.057	.4557	−1.072
.6278	−1.058	.4565	−1.083
.6285	−1.053	.4635	−1.063
		.4642	−1.066
2441789.5552	−1.065	.4649	−1.063
.5559	−1.065	.4656	−1.078
.5566	−1.059	.4666	−1.080
.5573	−1.052	.4675	−1.074
.5580	−1.056	.4679	−1.067
.5587	−1.054	.4685	−1.074
.5594	−1.050	.4692	−1.071
.5600	−1.011	.4699	−1.076
.5607	−1.056	.4706	−1.084
.5614	−1.054	.4748	−1.073
.5621	−1.058	.4755	−1.083
.5628	−1.054	.4761	−1.082
.5635	−1.048		
.5642	−1.058	2441847.3866	−1.096
.5676	−1.058	.3873	−1.093
.5684	−1.058	.3880	−1.091
.5690	−1.063	.3915	−1.095
.5700	−1.059	.3922	−1.090
.5705	−1.055	.3929	−1.096
.5712	−1.056	.3935	−1.092
.5719	−1.061	.3942	−1.094
.5720	−1.058	.3949	−1.094
.5733	−1.050	.3956	−1.086
.5740	−1.049	.3963	−1.095

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.3971	−1.101	.4653	−1.087
.3978	−1.102	.4660	−1.095
.3986	−1.101	.4665	−1.094
.3997	−1.098	.4671	−1.089
.4173	−1.081	.4678	−1.089
.4179	−1.082	.4684	−1.094
.4187	−1.085	.4692	−1.090
.4194	−1.091	.4697	−1.090
.4201	−1.084	.4702	−1.086
.4207	−1.090	.4707	−1.085
.4214	−1.089	.4712	−1.090
.4221	−1.090	.4718	−1.088
.4226	−1.093	.4725	−1.091
.4233	−1.085	.4730	−1.091
.4239	−1.091	.4737	−1.090
.4245	−1.087	.4753	−1.094
.4249	−1.082	.4760	−1.093
.4254	−1.090	.4764	−1.089
.4261	−1.095	.4768	−1.084
.4291	−1.080	.4772	−1.082
.4297	−1.086	.4821	−1.079
.4306	−1.082	.4828	−1.076
.4313	−1.084	.4832	−1.092
.4320	−1.083	.4837	−1.084
.4327	−1.085	.4863	−1.090
.4334	−1.099	.4869	−1.079
.4340	−1.084	.4876	−1.071
.4345	−1.083	.4880	−1.082
.4352	−1.088	.4886	−1.081
.4358	−1.083	.4892	−1.075
.4363	−1.088	.4898	−1.075
.4368	−1.079	.4914	−1.086
.4372	−1.076	.4922	−1.095
.4379	−1.087	.4928	−1.088
.4385	−1.086	.4935	−1.088
.4408	−1.087	.4960	−1.079
.4414	−1.088	.4967	−1.086
.4419	−1.094	.4978	−1.076
.4425	−1.086	.4982	−1.074
.4430	−1.090	.4989	−1.084
.4435	−1.093	.4993	−1.081
.4448	−1.093	.4999	−1.077
.4454	−1.089	.5006	−1.080
.4496	−1.095	.5011	−1.074
.4502	−1.092	.5017	−1.076
.4507	−1.095	.5024	−1.078
.4540	−1.073	.5030	−1.084
.4547	−1.085	.5033	−1.076
.4553	−1.086	.5055	−1.085
.4561	−1.055	.5060	−1.089
.4568	−1.054	.5064	−1.087
.4574	−1.057	.5071	−1.096
.4580	−1.089	.5077	−1.092
.4587	−1.089	.5082	−1.090
.4594	−1.086	.5086	−1.082
.4599	−1.088	.5093	−1.091
.4606	−1.091	.5099	−1.091
.4612	−1.087	.5121	−1.092
.4635	−1.089	.5127	−1.086
.4641	−1.090	.5134	−1.086
.4646	−1.087	.5141	−1.076

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.5148	−1.078	.5144	−1.085
.5155	−1.086	.5152	−1.090
.5161	−1.089	.5179	−1.088
		.5186	−1.082
2441917.4568	−1.127	.5193	−1.073
.4575	−1.122	.5200	−1.061
.4582	−1.120	.5207	−1.061
.4589	−1.118	.5214	−1.082
.4596	−1.114	.5221	−1.095
.4603	−1.099	.5228	−1.101
.4610	−1.104	.5235	−1.096
.4618	−1.126	.5241	−1.088
.4624	−1.125	.5249	−1.081
.4638	−1.120		
.4668	−1.124	2441942.3002	−1.107
.4673	−1.117	.3011	−1.107
.4681	−1.099	.3018	−1.112
.4708	−1.123	.3024	−1.106
.4714	−1.112	.3032	−1.105
.4722	−1.103	.3039	−1.111
.4729	−1.094	.3046	−1.107
.4736	−1.106	.3053	−1.104
.4742	−1.093	.3060	−1.112
.4749	−1.095	.3152	−1.100
.4755	−1.117	.3157	−1.098
.4763	−1.096	.3164	−1.098
.4770	−1.103	.3171	−1.085
.4777	−1.099	.3178	−1.077
.4784	−1.108	.3185	−1.074
.4813	−1.119	.3192	−1.087
.4862	−1.124	.3198	−1.088
.4869	−1.125	.3205	−1.089
.4876	−1.108	.3212	−1.090
.4882	−1.103	.3285	−1.100
.4890	−1.109	.3292	−1.094
.4918	−1.139	.3299	−1.079
.4925	−1.121	.3311	−1.085
.4933	−1.118	.3324	−1.090
.4940	−1.111	.3333	−1.089
.4946	−1.107	.3340	−1.095
.4953	−1.111	.3348	−1.083
.4961	−1.096	.3356	−1.088
.4968	−1.106	.3394	−1.109
.4977	−1.107	.3401	−1.107
.4987	−1.104	.3408	−1.103
.4998	−1.095	.3415	−1.101
.5006	−1.086	.3422	−1.105
.5045	−1.094	.3429	−1.103
.5055	−1.084	.3436	−1.106
.5061	−1.072	.3443	−1.108
.5068	−1.065	.3451	−1.108
.5075	−1.058		
.5082	−1.047	2442027.3287	−1.006
.5089	−1.050	.3294	−1.007
.5096	−1.055	.3302	−1.009
.5103	−1.059	.3309	−1.014
.5110	−1.062	.3315	−1.011
.5117	−1.058	.3322	−1.014
.5124	−1.054	.3328	−1.013
.5131	−1.053	.3336	−1.019
.5138	−1.080	.3343	−1.021

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.3350	−1.017	.3883	−1.005
.3385	−1.025	.3890	−1.004
.3392	−1.027	.3896	−1.009
.3399	−1.023	.3904	−1.011
.3406	−1.028	.3911	−1.008
.3413	−1.021	.3918	−1.011
.3421	−1.024	.3925	−1.011
.3427	−1.026	.3931	−1.011
.3434	−1.026	.3938	−1.013
.3442	−1.019	.3946	−0.999
.3449	−1.018	.3952	−1.009
.3456	−1.016	.3959	−1.013
.3485	−1.022	.3965	−1.012
.3492	−1.020	.3986	−1.010
.3499	−1.019	.3992	−1.010
.3505	−1.023	.4000	−1.007
.3513	−1.020	.4007	−1.011
.3519	−1.020	.4013	−1.005
.3526	−1.023	.4020	−1.001
.3533	−1.019	.4027	−1.002
.3541	−1.020	.4035	−0.999
.3547	−1.019	.4041	−0.996
.3554	−1.006	.4048	−0.997
.3560	−1.028	.4055	−0.994
.3581	−1.019	.4062	−0.996
.3588	−1.019	.4084	−1.001
.3595	−1.013	.4092	−1.002
.3602	−1.016	.4098	−0.998
.3609	−1.014	.4105	−0.999
.3616	−1.019	.4112	−1.002
.3623	−1.017	.4120	−0.998
.3629	−1.017	.4127	−0.999
.3636	−1.013	.4134	−1.000
.3643	−1.018	.4141	−1.000
.3650	−1.010	.4148	−0.999
.3670	−1.010	.4155	−0.999
.3677	−1.010	.4162	−0.997
.3684	−1.014	.4170	−0.998
.3690	−1.006	.4178	−0.995
.3698	−1.006	.4410	−1.021
.3705	−1.009	.4417	−1.026
.3712	−1.009	.4425	−1.026
.3719	−1.012	.4431	−1.024
.3725	−1.006	.4438	−1.029
.3732	−1.003	.4444	−1.032
.3740	−1.000	.4452	−1.035
.3747	−1.003	.4458	−1.034
.3753	−0.997	.4465	−1.038
.3759	−0.998	.4472	−1.038
.3780	−1.000	.4479	−1.041
.3787	−1.006	.4485	−1.040
.3797	−1.007	.4507	−1.034
.3807	−1.007	.4513	−1.035
.3814	−1.007	.4520	−1.037
.3821	−1.010	.4527	−1.033
.3828	−1.004	.4533	−1.041
.3835	−1.007	.4541	−1.036
.3842	−1.003	.4547	−1.036
.3849	−1.006	.4555	−1.035
.3855	−1.006	.4561	−1.034
.3862	−1.002	.4568	−1.038

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.4575	−1.036	.5090	−1.032
.4596	−1.039	.5097	−1.032
.4603	−1.038	.5103	−1.034
.4609	−1.032	.5108	−1.029
.4616	−1.032	.5118	−1.026
.4624	−1.030	.5125	−1.034
.4630	−1.032	.5131	−1.026
.4637	−1.035	.5153	−1.024
.4644	−1.030	.5158	−1.021
.4651	−1.034	.5165	−1.020
.4658	−1.031	.5172	−1.026
.4686	−1.033	.5179	−1.027
.4693	−1.035	.5186	−1.026
.4700	−1.034	.5193	−1.026
.4707	−1.034	.5200	−1.029
.4713	−1.036	.5207	−1.030
.4721	−1.034	.5214	−1.030
.4728	−1.036	.5220	−1.028
.4735	−1.039	.5245	−1.037
.4741	−1.044	.5250	−1.039
.4748	−1.041	.5256	−1.038
.4755	−1.038	.5263	−1.027
.4762	−1.039	.5270	−1.040
.4783	−1.046	.5278	−1.045
.4790	−1.043	.5285	−1.040
.4797	−1.044	.5290	−1.044
.4804	−1.041	.5297	−1.040
.4810	−1.042	.5304	−1.038
.4818	−1.036	.5311	−1.040
.4825	−1.045	.5319	−1.040
.4831	−1.043	.5326	−1.040
.4838	−1.048	.5332	−1.041
.4846	−1.047	.5339	−1.032
.4866	−1.049	.5374	−1.047
.4873	−1.047	.5380	−1.050
.4880	−1.048	.5388	−1.039
.4887	−1.050	.5391	−1.049
.4895	−1.049	.5401	−1.050
.4902	−1.045	.5408	−1.055
.4909	−1.049	.5415	−1.059
.4916	−1.042	.5422	−1.055
.4924	−1.046	.5429	−1.053
.4931	−1.048	.5435	−1.059
.4938	−1.049	.5443	−1.057
.4945	−1.042	.5450	−1.061
.4967	−1.045	.5458	−1.057
.4973	−1.043	.5479	−1.056
.4979	−1.044	.5486	−1.063
.4986	−1.044	.5498	−1.062
.4993	−1.041	.5507	−1.065
.4999	−1.040	.5518	−1.057
.5006	−1.049	.5527	−1.062
.5014	−1.051	.5539	−1.064
.5022	−1.037	.5547	−1.066
.5028	−1.029	.5555	−1.055
.5035	−1.025		
.5042	−1.042	2442044.4681	−1.104
.5063	−1.051	.4686	−1.094
.5069	−1.044	.4695	−1.102
.5076	−1.037	.4700	−1.104
.5083	−1.040	.4710	−1.095

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.4716	−1.097	.4677	−1.060
.4723	−1.105	.4684	−1.050
.4729	−1.103	.4691	−1.051
.4736	−1.095	.4699	−1.069
.4743	−1.098	.4705	−1.070
.4749	−1.105	.4712	−1.061
.4757	−1.106	.4719	−1.079
.4772	−1.102	.4726	−1.070
.4779	−1.122	.4733	−1.075
.4785	−1.116	.4740	−1.077
.4834	−1.097	.4747	−1.068
.4840	−1.083	.4769	−1.076
.4847	−1.102	.4776	−1.089
.4854	−1.101	.4782	−1.069
.4861	−1.105	.4789	−1.091
.4868	−1.085	.4796	−1.087
.4874	−1.090	.4802	−1.077
.4882	−1.091	.4809	−1.069
.4889	−1.080	.4816	−1.070
.4896	−1.068	.4823	−1.110
.4903	−1.090	.4830	−1.096
.4945	−1.095	.4837	−1.103
.4954	−1.070	.4843	−1.096
.4966	−1.083	.4850	−1.099
.4972	−1.079	.4878	−1.086
.4979	−1.092	.4886	−1.089
.4987	−1.077	.4892	−1.100
.4994	−1.086	.4899	−1.096
.5001	−1.080	.4906	−1.108
.5008	−1.065	.4913	−1.110
.5028	−1.085	.4920	−1.107
.5036	−1.082		
.5044	−1.081	2442064.4194	−1.093
.5059	−1.087	.4200	−1.101
		.4207	−1.111
2442054.4462	−1.071	.4214	−1.105
.4470	−1.074	.4221	−1.098
.4476	−1.074	.4228	−1.097
.4484	−1.080	.4235	−1.102
.4490	−1.076	.4242	−1.101
.4496	−1.076	.4249	−1.096
.4503	−1.074	.4256	−1.091
.4510	−1.072	.4263	−1.088
.4517	−1.066	.4269	−1.094
.4524	−1.079	.4276	−1.086
.4531	−1.073	.4283	−1.084
.4538	−1.073	.4304	−1.071
.4545	−1.074	.4311	−1.084
.4566	−1.076	.4318	−1.090
.4573	−1.081	.4325	−1.081
.4579	−1.081	.4332	−1.086
.4587	−1.084	.4339	−1.085
.4594	−1.075	.4346	−1.090
.4601	−1.076	.4353	−1.087
.4608	−1.072	.4360	−1.070
.4615	−1.079	.4367	−1.085
.4621	−1.076	.4374	−1.083
.4628	−1.076	.4381	−1.090
.4635	−1.077	.4388	−1.071
.4642	−1.070	.4402	−1.075
.4671	−1.059	.4409	−1.095

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.4430	−1.093	.3751	−1.076
.4437	−1.092	.3758	−1.085
.4444	−1.087	.3764	−1.093
.4451	−1.101	.3771	−1.090
.4458	−1.094	.3778	−1.093
.4465	−1.093	.3785	−1.078
.4472	−1.088	.3792	−1.083
.4479	−1.086	.3800	−1.093
		.3823	−1.077
2442079.3989	−1.077	.3828	−1.075
.3996	−1.082	.3834	−1.083
.4003	−1.078	.3841	−1.086
.4010	−1.085	.3847	−1.076
.4017	−1.091	.3855	−1.080
.4023	−1.086	.3862	−1.087
.4060	−1.080	.3868	−1.093
.4066	−1.088	.3882	−1.079
.4073	−1.092	.3889	−1.076
.4080	−1.089	.3896	−1.076
.4087	−1.089	.3902	−1.073
.4094	−1.090	.3909	−1.068
.4100	−1.085	.3958	−1.068
.4107	−1.090	.3965	−1.074
.4114	−1.092	.3972	−1.073
.4122	−1.082	.3979	−1.070
.4128	−1.075	.3984	−1.068
.4135	−1.076	.3991	−1.080
.4142	−1.081	.3998	−1.075
.4149	−1.075	.4005	−1.077
		.4074	−1.076
2442119.3469	−1.054	.4081	−1.065
.3475	−1.059	.4089	−1.069
.3482	−1.065	.4095	−1.074
.3489	−1.075	.4102	−1.058
.3496	−1.071	.4109	−1.090
.3502	−1.067	.4116	−1.079
.3509	−1.060	.4122	−1.066
.3516	−1.058	.4129	−1.078
.3572	−1.077	.4136	−1.090
.3578	−1.075		
.3585	−1.076	2442152.5413	−1.091
.3592	−1.076	.5418	−1.091
.3599	−1.078	.5424	−1.088
.3606	−1.088	.5431	−1.089
.3612	−1.092	.5438	−1.089
.3619	−1.075	.5444	−1.095
.3626	−1.088	.5451	−1.092
.3633	−1.086	.5465	−1.090
.3640	−1.091	.5472	−1.088
.3647	−1.095	.5478	−1.088
.3654	−1.082	.5485	−1.088
.3660	−1.081	.5513	−1.102
.3688	−1.070	.5519	−1.089
.3695	−1.075	.5526	−1.098
.3702	−1.083	.5534	−1.105
.3709	−1.083	.5539	−1.100
.3716	−1.079	.5547	−1.097
.3723	−1.083	.5554	−1.097
.3730	−1.084	.5560	−1.101
.3737	−1.083	.5567	−1.094
.3744	−1.084	.5574	−1.094

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.5580	−1.104	.3584	+1.794
.5587	−1.101	.3607	+1.915
.5594	−1.117	.3614	+1.919
.5601	−1.121	.3625	+1.930
.5637	−1.118	.3632	+1.888
.5642	−1.108	.3640	+1.910
.5648	−1.110	.3646	+1.942
.5655	−1.115	.3653	+2.004
.5662	−1.127	.3660	+1.947
.5670	−1.124	.3667	+1.951
.5676	−1.120	.4029	+2.030
.5683	−1.107	.4036	+2.043
.5691	−1.116	.4043	+2.010
.5697	−1.117	.4050	+2.000
.5704	−1.117	.4057	+2.014
.5710	−1.112	.4064	+2.049
.5717	−1.117	.4071	+2.031
.5723	−1.116	.4078	+1.983
.5730	−1.124	.4085	+1.992
		.4092	+2.002
2442633.3223	+0.258	.4141	+2.000
.3231	+0.301	.4148	+2.018
.3238	+0.279	.4156	+2.030
.3244	+0.336	.4166	+2.040
.3252	+0.364	.4175	+2.035
.3259	+0.382	.4182	+2.018
.3266	+0.371	.4191	+2.005
.3273	+0.412	.4198	+2.006
.3280	+0.442		
.3314	+0.571	2442816.2323	−0.877
.3321	+0.577	.2327	−0.903
.3328	+0.600	.2334	−0.895
.3335	+0.594	.2341	−0.873
.3342	+0.666	.2347	−0.845
.3349	+0.700	.2355	−0.799
.3356	+0.740	.2362	−0.818
.3363	+0.776	.2369	−0.828
.3370	+0.808	.2376	−0.832
.3377	+0.834	.2383	−0.803
.3383	+0.878	.2461	−0.734
.3414	+1.058	.2469	−0.826
.3419	+1.080	.2474	−0.740
.3427	+1.122	.2481	−0.741
.3438	+1.154	.2488	−0.709
.3446	+1.190	.2495	−0.683
.3453	+1.217	.2508	−0.714
.3459	+1.249	.2515	−0.696
.3466	+1.296	.2522	−0.676
.3473	+1.334	.2543	−0.673
.3480	+1.375	.2551	−0.662
.3510	+1.512	.2564	−0.619
.3517	+1.536	.2571	−0.632
.3523	+1.522	.2578	−0.658
.3530	+1.570	.2585	−0.648
.3536	+1.565	.2606	−0.601
.3543	+1.595	.2648	−0.595
.3551	+1.643	.2654	−0.567
.3558	+1.680	.2661	−0.531
.3565	+1.685	.2674	−0.565
.3571	+1.719	.2682	−0.545
.3577	+1.773	.2689	−0.497

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.2696	−0.452	.3367	+1.039
.2717	−0.454	.3373	+1.046
.2724	−0.471	.3381	+1.101
.2731	−0.415	.3392	+1.183
.2738	−0.431	.3392	+1.183
.2745	−0.457	.3401	+1.238
.2751	−0.423	.3408	+1.244
.2758	−0.430	.3416	+1.274
.2808	−0.351	.3422	+1.313
.2814	−0.377	.3429	+1.367
.2821	−0.351	.3435	+1.401
.2829	−0.338	.3463	+1.501
.2835	−0.314	.3470	+1.545
.2843	−0.315	.3477	+1.548
.2850	−0.313	.3485	+1.602
.2856	−0.270	.3491	+1.635
.2864	−0.271	.3498	+1.706
.2873	−0.275	.3506	+1.736
.2878	−0.269	.3541	+1.920
.2934	−0.185	.3546	+1.923
.2940	−0.161	.3554	+1.992
.2948	−0.152	.3560	+1.980
.2955	−0.175	.3566	+2.052
.2961	−0.155	.3621	+2.143
.2968	−0.131	.3628	+2.171
.2976	−0.093	.3648	+2.179
.2983	−0.114	.3655	+2.211
.2989	−0.137	.3663	+2.240
.3011	−0.018	.3677	+2.206
.3017	−0.035	.3725	+2.181
.3045	+0.048	.3731	+2.218
.3052	+0.044	.3746	+2.173
.3059	+0.024	.3760	+2.194
.3066	+0.079	.3782	+2.189
.3073	+0.095	.3787	+2.190
.3080	+0.135	.3794	+2.201
.3087	+0.121	.3801	+2.187
.3094	+0.132	.3809	+2.197
.3101	+0.151	.3822	+2.165
.3107	+0.169	.3829	+2.196
.3115	+0.219	.3858	+2.165
.3136	+0.226	.3864	+2.172
.3143	+0.236	.3871	+2.192
.3150	+0.279	.3884	+2.190
.3157	+0.288	.3898	+2.174
.3164	+0.294	.3905	+2.193
.3171	+0.338	.3919	+2.197
.3184	+0.397	.3953	+2.171
.3191	+0.401	.3960	+2.168
.3199	+0.408	.3967	+2.190
.3205	+0.419	.3974	+2.217
.3255	+0.604	.3988	+2.188
.3261	+0.619	.4001	+2.173
.3268	+0.590	.4008	+2.184
.3283	+0.693	.4065	+2.135
.3290	+0.759	.4078	+2.163
.3298	+0.783	.4092	+2.229
.3307	+0.780	.4151	+2.151
.3316	+0.792	.4157	+2.211
.3323	+0.879	.4190	+2.194
.3332	+0.938	.4197	+2.185

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.4260	+2.157	.4849	+0.604
.4266	+2.227	.4856	+0.544
.4273	+2.145	.4862	+0.452
.4280	+2.140	.4869	+0.516
.4287	+2.141	.4883	+0.542
.4295	+2.229	.4890	+0.484
.4301	+2.239	.4903	+0.392
.4308	+2.149	.4910	+0.386
.4314	+2.159	.4940	+0.292
.4322	+2.182	.4946	+0.275
.4329	+2.230	.4973	+0.181
.4335	+2.186	.4980	+0.161
.4364	+2.159		
.4371	+2.181	2442963.3691	−0.509
.4377	+2.144	.3698	−0.476
.4384	+2.188	.3712	−0.453
.4392	+2.198	.3726	−0.391
.4399	+2.210	.3733	−0.424
.4406	+2.211	.3739	−0.427
.4412	+2.168	.3746	−0.358
.4419	+2.171	.3760	−0.354
.4426	+2.204	.3768	−0.371
.4433	+2.224	.3802	−0.296
.4454	+2.181	.3809	−0.324
.4460	+2.181	.3816	−0.219
.4468	+2.216	.3830	−0.202
.4475	+2.187	.3837	−0.223
.4482	+2.138	.3844	−0.237
.4489	+2.141	.3851	−0.251
.4495	+2.140	.3865	−0.148
.4503	+2.217	.3908	−0.153
.4509	+2.173	.3915	−0.121
.4539	+1.961	.3922	−0.159
.4544	+1.939	.3929	−0.091
.4551	+1.902	.3943	−0.057
.4558	+1.865	.3950	−0.082
.4565	+1.858	.3963	−0.030
.4571	+1.864	.4019	+0.087
.4578	+1.821	.4026	+0.099
.4586	+1.703	.4033	+0.095
.4593	+1.701	.4053	+0.094
.4600	+1.678	.4060	+0.109
.4607	+1.689	.4067	+0.172
.4613	+1.581	.4074	+0.232
.4656	+1.402	.4259	+1.041
.4663	+1.394	.4266	+1.059
.4668	+1.375	.4273	+1.083
.4675	+1.395	.4358	+1.335
.4682	+1.277	.4369	+1.323
.4689	+1.204	.4376	+1.349
.4696	+1.193	.4383	+1.382
.4715	+1.171	.4390	+1.486
.4753	+0.875	.4397	+1.482
.4759	+0.850	.4404	+1.485
.4766	+0.818	.4411	+1.501
.4773	+0.805	.4418	+1.526
.4780	+0.863	.4425	+1.608
.4795	+0.662	.4432	+1.614
.4799	+0.715	.4474	+1.759
.4806	+0.712	.4481	+1.786
.4813	+0.756	.4488	+1.832

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.4495	+1.852	.5858	+1.554
.4502	+1.899	.5965	+1.573
.4508	+1.905	.5972	+1.589
.4515	+1.891	.6007	+1.734
.4522	+1.917	.6017	+1.787
.4529	+1.969	.6023	+1.825
.4578	+1.988	.6030	+1.898
.4585	+2.010	.6038	+1.893
.4592	+2.018	.6045	+1.907
.4599	+2.047	.6052	+1.938
.4620	+2.033	.6076	+2.020
.4627	+2.083	.6084	+2.056
.4634	+2.071	.6091	+2.075
.4668	+2.081	.6098	+2.071
.4675	+2.088	.6105	+2.089
.4696	+2.096	.6112	+2.083
.4703	+2.087	.6119	+2.100
.4724	+2.144	.6126	+2.131
.4731	+2.072	.6159	+2.123
.4744	+2.103	.6166	+2.146
.4771	+2.160	.6173	+2.144
.4779	+2.087	.6180	+2.140
.4808	+2.150	.6187	+2.135
.4815	+2.167	.6205	+2.151
.4822	+2.119	.6212	+2.121
.4829	+2.161	.6219	+2.138
.4835	+2.154	.6226	+2.138
.4898	+2.175	.6231	+2.151
.4912	+2.150	.6262	+2.121
.4926	+2.118	.6269	+2.135
.4933	+2.186	.6276	+2.135
.4946	+2.138	.6283	+2.125
.4954	+2.184	.6290	+2.131
.4960	+2.166	.6297	+2.161
.4967	+2.141	.6304	+2.161
		.6311	+2.161
2443085.5648	+0.216	.6318	+2.137
.5657	+0.270	.6325	+2.146
.5666	+0.294	.6332	+2.154
.5674	+0.291	.6359	+2.144
.5680	+0.317	.6365	+2.167
.5687	+0.326	.6372	+2.128
.5694	+0.378	.6379	+2.176
.5769	+0.636	.6386	+2.164
.5779	+0.652	.6393	+2.153
.5786	+0.694	.6400	+2.176
.5793	+0.732	.6407	+2.160
.5800	+0.765	.6414	+2.138
.5807	+0.766	.6421	+2.179
.5814	+0.809	.6441	+2.134
.5851	+0.973	.6448	+2.149
.5858	+0.999	.6455	+2.151
.5865	+1.033	.6462	+2.164
.5872	+1.083	.6469	+2.126
.5880	+1.134	.6476	+2.127
.5887	+1.177	.6483	+2.151
.5894	+1.216	.6490	+2.144
.5901	+1.229	.6497	+2.134
.5933	+1.391	.6504	+2.142
.5944	+1.468	.6528	+2.162
.5951	+1.518	.6534	+2.125

Table 4 (Continued)

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.6541	+2.138	.6590	+2.160
.6555	+2.144	.6618	+2.163
.6562	+2.151	.6624	+2.167
.6569	+2.170	.6630	+2.163
.6576	+2.160	.6636	+2.152
.6583	+2.168	.6642	+2.167

J.D.$_{hel}$	Δm	J.D.$_{hel}$	Δm
.6648	+2.159	.6705	+2.203
.6654	+2.155	,6712	+2.169
.6603	+2.138	.6719	+2.148
.6670	+2.146	.6732	+2.224
.6698	n2.180	.6739	+2.173

however, a lack of continuous observations prevented us from achieving a full understanding between the physical processes taking place in the binary system and their effect on the shape of the light curve.

We would like to stress that in publishing the epochs of primary minima it would be helpful to give not only the time of middle-eclipse but to publish all observations pertaining to such a minimum. Only by a consideration of both branches of the light curve the filling-in effect and its manifestation on the observed time of middle-eclipse can be established.

Acknowledgements

The authors wish to thank the staff of the Skalnaté Pleso Observatory, mainly to Mr. P. Schalling, for their effort to make and reduce the observations. One of us benefited from discussions with Drs. Batten and Scarfe and the staff at both the Dominion Astrophysical Observatory and the Department of Physics, University of Victoria. He is also grateful to the National Research Council and Czechoslovak Academy of Sciences for making it possible for him to conduct this research at the Department of Physics, University of Waterloo as an exchange Research Scientist.

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ANALÝZA SVETELNEJ KRIVKY, DRÁHOVÉ ELEMENTY A ZMENY PERIÓDY U CEPHEI

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Súhrn

Sústava U Cephei pozostáva z primárnej zložky spektrálneho typu B6 V a menej hmotnej sekundárnej zložky spektrálneho typu G8 IV. Zatmenie je úplné a jeho hĺbka je približne 3 hviezdne triedy. Interpretácia pozorovacích dát nie je jednotná. Na jednej strane prevláda názor, že žiariaci most spojuje obe zložky, na druhej strane zasa sú náznaky, že sa vytvára skutočný prstenec alebo disk okolo primárnej zložky.

Spektroskopické pozorovania dokazujú prítomnosť plynných oblakov v sústave. Spektrá U Cephei získané počas primárneho minima ukazujú emisné čiary vodíka, ako aj H a K čiary vápnika. Intenzita týchto spektrálnych čiar sa zdá byť v korelácii s veľkosťou prenosu hmoty medzi zložkami. Napriek tomu, že v poslednom čase sa získalo veľa fotoelektrických pozorovaní epôch minima, získalo sa málo pozorovaní v ostatných fázach. Naše pozorovania pokrývajú celú svetelnú krivku a umožnili odvodenie elementov. Perióda svetelných zmien vykazuje sekulárne narastanie, ktoré možno aproximovať kvadratickou formulou. Okrem sekulárneho narastania pozorujú sa aj krátkodobé variácie. Všeobecne sa prijíma názor, že zmeny periódy sú spôsobené prenosom hmoty a prenosom uhlového momentu. Tvar svetelnej krivky je premenný a najväčšie zmeny sa pozorujú v primárnom minime. Tieto zmeny potvrdzujú aj naše pozorovania a pripisujú sa rozličným efektom, ako je chromosferická aktivita sekundárnej zložky, jej premennosť alebo prítomnosť horúcej škvrny blízko pólov primárnej zložky. Zvláštnosti však existujú aj v okolí sekundárneho minima a počas konštantnej fázy. Štúdium sústavy U Cephei nastoľuje veľa problémov a niektoré z nich sa riešia v tejto práci.

Fotoelektrické pozorovania sústavy U Cephei sa získavali od roku 1967 fotoelektrickým fotometrom inštalovaným na 60 cm reflektore na Astronomickom observatóriu na Skalnatom Plese. Interpretácia pozorovaní v okolí primárneho minima sa nachádza v našej predchádzajúcej publikácii. Pretože sa získal veľký počet individuálnych pozorovaní v priebehu niekoľkých rokov, na štúdium zmien svetelnej krivky sme používali normálne body. Na výpočet dráhových elementov sme použili iba tie normálne body, ktoré neboli ovplyvnené premenlivosťou svetelných zmien. Na rektifikáciu svetelnej krivky sa použila štandardná Russellova–Merrillova metóda a elementy sa vypočítali Horákovou metódou. Hodnoty elementov, ktoré sme odvodili, sú veľmi blízke hodnotám, ktoré nedávno publikoval Batten. Hall a Walter nedávno interpretovali starší pozorovací materiál. Pri interpretácii použili rektifikáciu na krátkych úsekoch s rozličnými koeficientmi. Tak dosiahli zhodu v elementoch odvodených z rozličných sérií pozorovaní. Ich elementy sa však líšia od elementov odvodených bez aplikácie takejto rektifikácie.

Dlhodobé predlžovanie periódy svetelných zmien možno vyjadriť pomocou kvadratickej formule, avšak súčasne sa pozorujú systematické odchýlky od tohto priebehu. Odchýlky možno aproximovať parabolickými segmentami, ktoré formálne reprezentujú alternujúce predlžovanie a skracovanie periódy. Náhle skracovanie periódy vysvetľuje Hall prenosom uhlového momentu zo sekundárnej zložky na primárnu zložku. Tento problém sme študovali v tejto práci na základe fotoelektrického materiálu, ktorý je presnejší. Okrem epôch minima sme študovali tvar jednotlivých miním a objavili sme fenomenologický efekt, ktorý sa prejavuje vyplňovaním primárneho minima, a to na zostupnej vetve. V dôsledku tohto efektu dochádza k fiktívnemu predlžovaniu periódy a návrat k normálnemu tvaru minima spôsobuje zdanlivé skracovanie periódy. Fenomenologický efekt dosahuje veličinu 0.005 dní. Nie je však vylúčené, že existujú i skutočné zmeny periódy v dôsledku prenosu uhlového momentu, ale sú menej výrazné. Nie je vylúčené, že fenomenologický efekt sa môže prejavovať i pri iných sústavách, najmä preto, že sa často publikujú iba epochy minima a nie jednotlivé pozorovania, z ktorých by sa efekt distorzie dal zistiť a vylúčiť.

V priebehu posledných rokov sa zaznamenala zvýšená aktivita v podobe dvoch vzplanutí sústavy U Cephei, a to roku 1969 a 1974. Ukázali sme, že posledné vzplanutie doprevádza pokles sekulárneho predlžovania periódy a pripomína zmeny periódy v období okolo r.1940. Na O-C diagramoch sa prejaví obdobie aktivity zvýšeným rozptylom hodnôt epôch minima, ktorý je spôsobený distorziou svetelnej krivky. Rozptyl na O-C diagrame je menší v období bez vzplanutí. Aj polarimetrické pozorovania ukazujú, že v sústave U Cephei sa striedajú obdobia zvýšenej aktivity s obdobiami bez vzplanutí.

Porovnanie svetelných kriviek z rozličných období potvrdzuje značné zmeny v šírke, hĺbke a tvare primárneho minima. Celková hĺbka minima kolíše viac ako $0\overset{m}{.}1$ a v ostatnom čase sme pozorovali prehlbovanie primárneho minima. Veľké rozdiely sú i v trvaní totality. Hall a Walter študovali priebeh jasnosti počas totality a vzrast jasnosti počas totality vysvetľujú nahromadením rozptýlenej hmoty okolo primárnej zložky. Walter predložil hypotézu pre pokles jasnosti počas primárneho

minima. Vplyvom magnetického poľa prúd častíc smeruje k pólom, kde sa vytvára horúca škvrna. V dôsledku precesie primárnej zložky dochádza k premenlivej viditeľnosti škvrny a variácie priebehu jasnosti počas totality s periódou 12 rokov. Priebeh jasnosti počas totality odvodený z našich pozorovaní nie je v rozpore s Walterovou hypotézou. V tomto období efekt prenosu hmoty a poloha horúcej škvrny spôsobujú vzrast jasnosti počas totality, a preto by bol v tomto období práve vzrast jasnosti počas totality dobrým indikátorom vzrastajúcej aktivity sústavy. Primárne minimum je asymetrické a túto symetriu spôsobuje predovšetkým distorzia zostupnej vetvy. Distorziu spôsobuje absorpcia v okolí prvého kontaktu a „filling in" efektu v okolí druhého kontaktu v dôsledku svietiacich oblakov. Vzostupná vetva je menej ovplyvnená, s výnimkou časti okolo štvrtého kontaktu, kde sa pozoruje občasné zjasnenie, čo môže spôsobovať premenlivá jasnosť horúcej škvrny. Svetelné krivky získané v rozličných obdobiach ukazujú premenlivú hĺbku sekundárneho minima. Najmenej deformovaná časť svetelnej krivky je medzi štvrtým kontaktom a sekundárnym minimom.

АНАЛИЗ КРИВОЙ БЛЕСКА, ОРБИТАЛЬНЫЕ ЭЛЕМЕНТЫ И ИЗМЕНЕНИЯ ПЕРИОДА U ЦЕФЕЯ

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Резюме

Система U Цефея состоит из первичного компонента спектрального типа B6 V и менее массивного вторичного компонента спектрального типа G8 IV. Затмение полное, и его глубина составляет приблизительно 3 звездных величин. Интерпретация данных наблюдений не отличается единством. С одной стороны, преобладает мнение, что светящийся мост соединяет оба компонента, с другой стороны, опять же, есть намеки на то, что вокруг первичного компонента образуется настоящее кольцо или диск.

Спектроскопические наблюдения доказывают присутствие в системе газовых облаков. Спектры U Цефея, полученные во время первичного минимума, показывают эмиссионные линии водорода, а также H и K линии кальция. Интенсивность этих спектральных линий, кажется, находится в корреляции с количеством переноса массы между компонентами. Вопреки тому что в последнее время было получено много фотоэлектрических наблюдений эпох минимума, в остальных фазах было сделано немного наблюдений. Наши наблюдения покрывают всю кривую блеска и позволяют сделать вычисление элементов. Период изменения блеска показывает длительное возрастание, которос можно аппроксимировать квадратной формулой. Наряду с длительным нарастанием наблюдаются и кратковременные вариации. Общепринято мнение, что изменения периода вызваны переносом массы и переносом момента количества движения. Форма кривой блеска является переменной, и наибольшее изменение наблюдается в первичном минимуме. Эти изменения подтверждают и наши наблюдения. Они приписываются различным эффектам, как, например, хромосферной активности вторичного компонента, ее изменчивости, или присутствию горячего пятна вблизи полюсов первичного компонента. Однако существуют особенности и в окрестностях вторичного минимума и в период константной фазы. Изучение системы U Цефея выдвигает много проблем, некоторые из них решаются и в этой работе.

Фотоэлектрические наблюдения системы U Цефея были получены с 1967 г. при помощи фотоэлектрического фотометра, установленного на 60 см рефлекторе в Астрономической обсерватории на Скалнате Плесе. Интерпретация наблюдений для области первичного минимума приводится в нашей предыдущей публикации. Поскольку было получено большое количество индивидуальных наблюдений за несколько лет, то для изучения изменений кривой блеска мы применяли нормальные точки. Для расчета элементов орбиты мы использовали лишь те нормальные точки, на которые не оказывает влияния переменчивость изменений блеска. Для ректификации кривой блеска применялся стандартный метод Расселл–Мерилла, а элементы рассчитывались при помощи метода Горака. Величины элементов, которые мы вывели, весьма близки к величинам, опубликованным недавно Баттеном. Халл и Бальтер недавно интерпретировали старший материал наблюдений. При интерпретации они использовали ректификацию на коротких участках с различными коэффициентами. Таким образом, они достигли совпадения элементов, выведенных из различных серий наблюдений. Однако их элементы отличаются от элементов, полученных без применения такой ректификации.

Долговременное удлинение периода изменений блеска

можно выразить при помощи квадратного уравнения, однако одновременно наблюдаются систематические отклонения от этого процесса. Отклонения можно аппроксимировать параболическими сегментами, которые формально представляют чередующиеся удлинения и сокращения периода. Резкое сокращение периода Халл объясняет переносом углового момента с вторичного компонента на первичный. Эту проблему мы изучали в данной работе на основе фотоелектрического материала, который является более точным. Кроме того, наряду с эпохами минимума, мы изучали форму отдельных минимумов и обнаружили феноменологический эффект, который проявляется заполнением первичного минимума, а именно на нисходящей ветви. Вследствие этого эффекта происходит фиктивное удлинение периода, и возвращение к нормальной форме минимума вызывает кажущееся сокращение периода. Феноменологический эффект достигает величины 0,005 дня. Однако не исключено, что существует и действительное изменение периода вследствии переноса углового момента, но эти изменения менее отчетливы из-за феноменологического эффекта. Не исключено, что феноменологический эффект может проявляться и у других систем, особенно потому, что часто публикуются только эпохи минимума, а не отдельные наблюдения, по которым можно было бы обнаружить и рассчитать эффект дисторсии.

В последние годы была отмечена повышенная активность в виде двух вспышек в системе U Цефея — в 1969 г. и в 1974 г. Мы показали, что последняя вспышка сопровождалась уменьшением секулярного удлинения периода и напоминает изменения периода, наблюдаемые около 1940 г. На диаграммах O-C период активности проявляется повышенным рассеянием величин эпох минимума, что вызвано дисторсией кривой блеска. Рассеяние на диаграмме O-C меньше в период без вспышек. Поляриметрические наблюдения также показывают, что в системе U Цефея чередуются периоды повышенной активности с периодами без вспышек.

Сравнение кривых блеска различных периодов подтверждают наличие значительных изменений в ширине, глубине и форме первичного минимума. Общая глубина минимума колеблется более чем на $0^m.1$, а в последнее время мы наблюдали углубление первичного минимума. Большие различия наблюдаются и в продолжительности полного затмения. Халл и Вальтер изучали ход яркости во время полного затмения и объясняют увеличение яркости во время полного затмения скоплением материи вокруг первичного компонента. Вальтер предложил гипотезу для объяснения снижения яркости во время первичного минимума. Под влиянием магнитного поля поток частиц направляется к полюсам, где образуется горячее пятно. Вследствие прецессии первичного компонента происходит изменение видимости пятна и вариации хода яркости в период полного затмения с периодом 12 лет. Ход яркости во время полного затмения, выведенный на основании наших наблюдений, не противоречит гипотезе Вальтера. В этот период эффект переноса массы и положение горячего пятна вызывают рост яркости во время полного затмения, поэтому в этот период именно рост яркости в период полного затмения был бы хорошим индикатором возрастающей активности системы. Первичный минимум является асимметрическим, и эта асимметрия вызвана прежде всего дисторсией нисходящей ветви. Дисторсия вызвана абсорпцией в месте первого контакта и filling-in эффектом заполнения в месте второго контакта вследствие светящихся облаков. Влияние на восходящую ветвь меньше, за исключением части около четвертого контакта, где наблюдается появляющееся временами усиление яркости, что может быть вызвано переменной яркостью горячего пятна. Кривые блеска, полученные в различные периоды, показывают изменчивую глубину вторичного минимума. Наименее деформированная часть кривой блеска находится между четвертым контактом и вторичным минимумом.