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OBSERVATIONS AND PERIOD VARIATION ANALYSIS OF THE W UMA TYPE STAR SW LAC[1]

J.H. Peña

Instituto de Astronomía
Universidad Nacional Autónoma de México

M.A. Hobart

Facultad de Física, Universidad Veracruzana, México

and

E. Rodríguez

Instituto de Astrofísica de Andalucía, Spain

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RESUMEN

Se reportan observaciones fotométricas recientes del sistema tipo W UMa, SW Lacertae. De los tiempos de mínimos obtenidos de las presentes observaciones junto con los encontrados en la literatura se determinan efemérides lineales, cuadráticas y armónicas cuyos residuos muestran en conjunto que la variación del período de este sistema no es periódica.

ABSTRACT

Recent photoelectric-photometric data of the W UMa system SW Lacertae are reported. From the times of minima obtained in the present paper and those found in the literature, linear, quadratic and harmonic ephemeris are derived; the residuals show that the period variation of this system is not strictly periodic.

Key words: **STARS–ECLIPSING BINARIES — STARS–VARIABLES**

1. INTRODUCTION

The W UMa contact binary system SW Lacertae (HD 216598, BD+37° 4717) has been extensively studied since its discovery by Ashall (Leavitt 1918). Its variation in period has made it the target of numerous observations. It has been observed photoelectrically by Brownlee (1957), Hinderer (1960), Broglia (1962), Widorn (1962), Chou (1963), Bookmyer (1965), Rucinski (1968), Faulkner & Bookmyer (1978), Stepien (1980), Leung, Zhai, & Zhang (1984) and Niarchos (1987). Purgathofer & Prochazka (1966), Van't Veer (1972), Faulkner & Bookmyer (1980), Panchatsaram & Abhyankar (1981), and Hopp, Hoffmann, & Witzigmann (1982) have written on the period changes of this system.

Spectroscopically, SW Lac has been observed by Adams, Joy, & Sanford (1924), Wyse (1934), Adams et al. (1935) and Roman (1956) who assigned the binary a spectral type K0V in the Yerkes system. Wyse had previously assigned the spectral type G3p+G3p in the Lick system. A mass ratio of the components equal to 0.877 was determined from radial velocity curves (Struve 1949, 1950), and Bookmyer (1965) calculated masses of 1.22 $M_\odot$ and 1.07 $M_\odot$ from its orbital solution. From the times of minima recently obtained by the authors of this paper and those found in the literature, an analysis of the period variation of this close binary is being done.

2. OBSERVATIONS

The observations were carried out at the Observatorio Astronómico Nacional at San Pedro Mártir with the 84-cm reflecting telescope. The same

[1] Based on observations collected at the Observatorio Astronómico Nacional, San Pedro Mártir, B.C., México.

equipment (a dry-ice cooled RCA 31034A photocell with a pulse counting system and Johnson's *V* filter) was used throughout the season. Two comparison stars were chosen with approximately the same magnitude as the problem star and within two degrees of it. The stars used were BD+37°4716 and BD+38°4714. The magnitudes and coordinates of the observed stars are presented in Table 1. Figure 1 shows the light curve of SW Lac for the night of November 1–2, 1989, while Figure 2 shows the light curve of this binary for the night of November 5–6, 1989. Figure 3 shows the light curves for the two nights in phase for the period 0.3207220 d. The photoelectric data obtained are shown in Table 2. In all cases each observation consisted of 30 s integrations on each star. The sequence of observations followed was C1,C2,V, C1,C2,V,..., with a 10 s integration of the sky every 40 minutes. The photometric values plotted are the instrumental magnitude differences between the variable star and one of the comparison stars, interpolated to the time of the observation of the variable. An average of the differences was subtracted from each run to establish the zero baseline. The data points are accurate to 0.005 mag; the average time interval between successive points is 0.005 d, while the accuracy in time for each point is 0.0007 d.

TABLE 1

COORDINATES AND MAGNITUDES OF THE OBSERVED STARS

Star	BD	α (1950)	δ	V	Type
SW Lac	+37°4717	$22^h49^m04^s$	+37°24′24″	9.6	W UMa
C_1	+37 4716	22 48 54	+37 55	8.1	Ref.
C_2	+38 4714	22 48 24	+38 05	8.5	Ref.

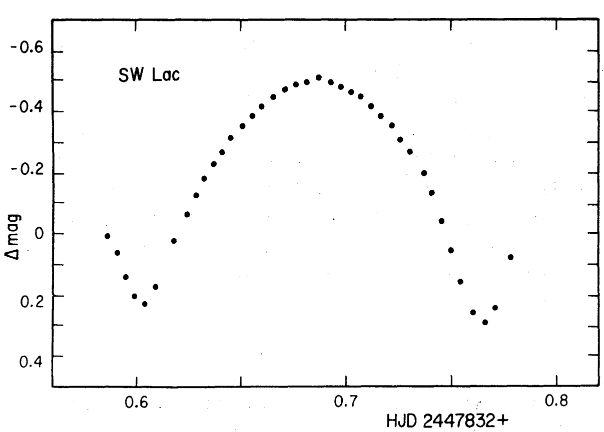

Fig. 1. Light curve of SW Lac for HJD 2447832.

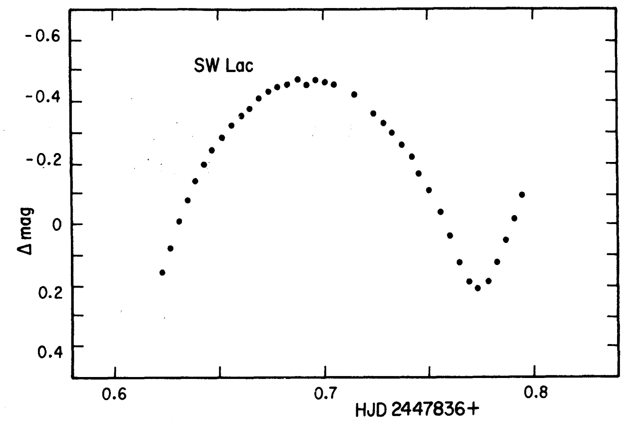

Fig. 2. Light curve of SW Lac for HJD 2447836.

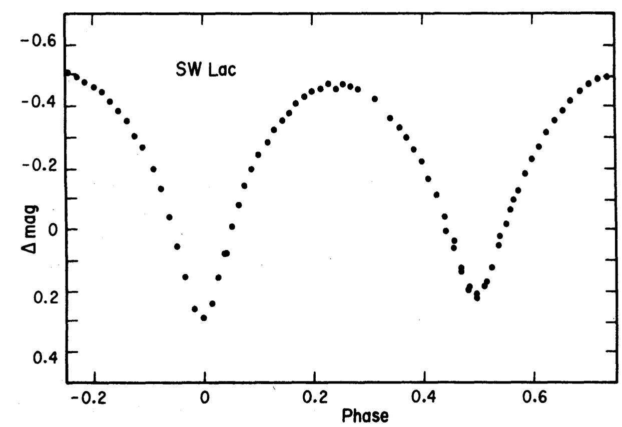

Fig. 3. Light curves in phase for HJD 2447832 and HJD 2447836. The period used was P = 0.3207220 d found in the present paper.

The times of minimum light obtained from these observations were estimated from the minima of the second order polynomial mean squares fit obtained from the light points in the vicinity of the apparent minimum values of the light curves.

3. RESULTS

Although SW Lac is one of the ten best observed eclipsing contact binaries that has been observed for more than 50 years (Van't Veer 1972) and is well known from the variable light curve and its period changes (Niarchos 1987), doubts still remain about the nature of those changes and their interpretation.

Emphasis has been given (Van't Veer 1972; Leung et al. 1984) to the necessity of extending the time span and quality of the observations in order to discriminate among the multiple models proposed to explain the period variations.

TABLE 2

PHOTOELECTRIC OBSERVATIONS OF SW LACERTAE

HJD 2447830+	Mag	HJD 2447830+	Mag	HJD 2447830+	Mag
2.5861	0.0030	2.7167	-0.3840	6.6741	-0.4300
2.5910	0.0630	2.7215	-0.3530	6.6783	-0.4460
2.5951	0.1410	2.7257	-0.3090	6.6831	-0.4590
2.5993	0.2010	2.7305	-0.2680	6.6880	-0.4690
2.6042	0.2240	2.7368	-0.1970	6.6922	-0.4540
2.6097	0.1730	2.7410	-0.1320	6.6963	-0.4710
2.6181	0.0180	2.7458	-0.0440	6.7012	-0.4680
2.6243	-0.0650	2.7500	0.0550	6.7054	-0.4540
2.6285	-0.1300	2.7548	0.1550	6.7151	-0.4260
2.6326	-0.1840	2.7604	0.2580	6.7241	-0.3660
2.6368	-0.2320	2.7660	0.2920	6.7290	-0.3350
2.6410	-0.2700	2.7708	0.2380	6.7331	-0.3000
2.6451	-0.3120	2.7785	0.0770	6.7373	-0.2600
2.6507	-0.3570	...	...	6.7422	-0.2180
2.6555	-0.3890	6.6227	0.1560	6.745	-0.1690
2.6597	-0.4160	6.6269	0.0730	6.7505	-0.1090
2.6653	-0.4480	6.6311	-0.0090	6.7554	-0.0390
2.6708	-0.4710	6.6352	-0.0810	6.7602	0.0390
2.6757	-0.4900	6.6387	-0.1460	6.7644	0.1260
2.6812	-0.4970	6.6429	-0.1990	6.7692	0.1890
2.6868	-0.5080	6.6470	-0.2460	6.7734	0.2090
2.6924	-0.4960	6.6519	-0.2880	6.7783	0.1850
2.6972	-0.4800	6.6561	-0.3200	6.7824	0.1210
2.7021	-0.4670	6.6609	-0.3550	6.7866	0.0510
2.7069	-0.4470	6.6651	-0.3790	6.7908	-0.0190
2.7118	-0.4180	6.6692	-0.4100	6.7949	-0.0930

With the data presented in the present paper, the time span of the published observations after its discovery by Ashall (Leavitt 1918) allows the number of cycles to reach 43381 if the most commonly accepted period value of 0.32072 d is assumed. For a typical photometric uncertainty in the determination of the time of minimum light of 0.0035 d and the previously mentioned E value the accuracy attainable in the period would be of 1×10^{-7} d and in the quadratic coefficient of 3×10^{-12} d if a second order equation is considered.

The complete set of times of minima compiled from the literature and shown in Table 3 was used to analyze the period behaviour of SW Lac. First, the residuals O-C were calculated by means of the linear ephemeris

$$HJD_{min} = 2443459.7476\ (\pm 0.0035) + 0.3207220\ (\pm 1 \times 10^{-7})\ E$$

which was determined through the use of a computer program already described by Hobart et al. (1989) The residuals from this linear ephemeris are tabulated in the third column of Table 3. The standard deviation for these residuals is 0.020 d. In Figure 4*a*, a plot of the residuals versus HJD shows the well-known period variation.

The interpretation of this O-C linear diagram has led to many models that try to describe the behaviour of the SW Lac system: *i)* a period increased by "jumps" alternated with constant intervals (Van't Veer 1972) (although he also states that after 1967 one gets the impression that the period, for the first time, is regularly decreasing); *ii)* no "monotonic" change in the period, only discontinuous changes (Lang & Vetešnik 1966); *iii)* a continuous variation or even *iv)* a quadruple system (Panchatsaram & Abhyankar 1981) and, *v)* a proposal by Leung et al. (1984) of decoupling the observations into a stable binary light curve and a periodic modulation light curve.

In view of the large number of possibilities, the next step we followed was a canonical continuous variation interpretation as a first approach, i.e., to fit the residuals into a quadratic equation which yield

$$HJD_{min} = 2443459.7476\ (\pm 0.0035) + 0.3207195\ (\pm 1 \times 10^{-7})\ E - (2.45 \pm 0.03) \times 10^{-10}\ E^2\ .$$

The residuals for this quadratic ephemeris are tabulated in the fourth column of Table 3. The standard deviation of these residuals is 0.014 d, numerically smaller than the residuals derived from the linear fit and hence, sustaining the interpretation of a continuous variation of the period at 4.82 s/century. The plots of the corresponding O-C residuals shown in Figure 4*b* suggest that the period changes harmonically. Since in the past, the existence of a third star (Schilt 1923), or even a fourth star in the system (Panchatsaram & Abhyankar 1981) has been proposed as an explanation of the variation of the period, a further analysis of the period behaviour, a search for harmonic periodic variation, was pursued.

This analysis consisted of the application of a standard Fast Fourier Transform method (Deeming 1975) to the linear O-C residuals to obtain a first estimate of the frequency of the period change. This frequency was then refined by the Multiple Frequency Fitting Method (MFF) described by Hobart, Peña, & Peniche (1991). The frequency found from this analysis was 9.295×10^{-5} c d^{-1} consistent with an eyeball free-hand sinusoidal curve fitted to the residuals shown in Figure 4*b*. The residuals O-C from this ephemeris are tabulated in the fifth column of Table 3. In Figure 4*c*, the plot of the residuals after this harmonic ephemeris has been subtracted still shows low amplitude anharmonic variations.

How can we interpret such results? The smaller residuals after the quadratic fit was carried out unequivocally show that the period is changing at a

TABLE 3

SW LACERTAE TIMES OF MINIMA AND O-C LINEAR, QUADRATIC AND HARMONIC

HJD	Min.	$(O\text{-}C)^a_L$	$(O\text{-}C)^b_Q$	$(O\text{-}C)^c_H$	Ref.[d]
2433923.5446	II	-0.01479	0.01802	-0.00847	3
2433928.5175	I	-0.01310	0.01964	-0.00675	3
2433931.4038	I	-0.01327	0.01943	-0.00690	3
2433993.3042	I	-0.01227	0.01952	-0.00552	3
2434271.3710	I	-0.01147	0.01635	-0.00303	3
2434600.5899	II	-0.01362	0.00973	-0.00316	3
2434637.7950	II	-0.01233	0.01054	-0.00163	20
2434658.8024	I	-0.01222	0.01037	-0.00139	20
2434660.7272	I	-0.01175	0.01081	-0.00091	20
2434663.7730	II	-0.01281	0.00971	-0.00195	20
2434664.5766	I	-0.01102	0.01150	-0.00015	20
2434664.7367	II	-0.01128	0.01124	-0.00041	20
2434665.6976	II	-0.01255	0.00996	-0.00167	20
2434665.8575	I	-0.01301	0.00949	-0.00213	20
2434666.8216	I	-0.01107	0.01142	-0.00019	20
2434667.7833	I	-0.01154	0.01094	-0.00065	20
2434680.6115	I	-0.01222	0.01009	-0.00125	20
2434681.5737	I	-0.01219	0.01011	-0.00121	20
2434681.7348	II	-0.01145	0.01085	-0.00047	20
2435036.6130	I	-0.01216	0.00568	0.00106	20
2435037.5748	I	-0.01253	0.00530	0.00070	20
2435037.7350	II	-0.01269	0.00514	0.00054	20
2435040.6182	II	-0.01599	0.00180	-0.00275	20
2435055.5357	I	-0.01206	0.00555	0.00127	20
2435055.6945	II	-0.01362	0.00399	-0.00029	20
2435057.6190	II	-0.01345	0.00413	-0.00011	20
2435374.4900	II	-0.01581	-0.00193	-0.00059	21
2435379.4638	I	-0.01320	0.00062	0.00205	21
2435390.3683	I	-0.01325	0.00045	0.00206	21
2435390.5266	II	-0.01531	-0.00162	-0.00000	21
2436037.5829	I	-0.01569	-0.00880	0.00201	22
2436045.4384	II	-0.01788	-0.01107	-0.00017	22
2436045.6005	I	-0.01614	-0.00933	0.00156	22
2436046.4020	II	-0.01645	-0.00964	0.00126	22
2436046.5634	I	-0.01541	-0.00860	0.00230	22
2436048.4870	I	-0.01614	-0.00935	0.00157	22
2436048.6470	II	-0.01650	-0.00972	0.00121	22
2436049.4490	I	-0.01630	-0.00953	0.00141	22
2436049.4493	I	-0.01600	-0.00923	0.00171	22
2436049.6091	II	-0.01657	-0.00979	0.00114	22
2436050.4115	I	-0.01597	-0.00921	0.00174	22
2436050.5709	II	-0.01693	-0.01017	0.00078	22
2436461.4147	II	-0.01804	-0.01507	-0.00078	23
2436462.3761	II	-0.01881	-0.01584	-0.00155	23
2436463.3391	II	-0.01797	-0.01502	-0.00072	23
2436480.3361	II	-0.01924	-0.01643	-0.00205	23
2436843.3967	II	-0.01597	-0.01616	-0.00108	23
2436844.3593	II	-0.01553	0.01574	-0.00065	23
2436847.4066	I	-0.01509	-0.01532	-0.00024	23
2436848.3695	I	-0.01436	-0.01459	0.00049	23
2437173.7460	II	-0.01035	-0.01300	0.00078	24
2437191.7065	II	-0.01028	-0.01306	0.00060	24
2437192.8301	I	-0.00921	-0.01200	0.00165	4
2437194.7552	I	-0.00844	-0.01124	0.00239	4
2437194.9139	II	-0.01010	-0.01290	0.00073	4
2437201.6485	II	-0.01067	-0.01351	0.00007	4
2437202.7726	I	-0.00909	-0.01195	0.00163	4
2437220.5720	II	-0.00976	-0.01274	0.00070	24
2437220.7335	I	-0.00863	-0.01161	0.00184	24
2437225.5445	I	-0.00846	-0.01147	0.00194	24
2437225.7039	II	-0.00942	-0.01243	0.00097	24
2437233.5629	I	-0.00811	-0.01118	0.00217	24
2437258.5795	I	-0.00782	-0.01107	0.00208	24
2437262.5873	II	-0.00905	-0.01232	0.00079	24
2437556.6958	II	-0.00264	-0.00782	0.00215	24
2437572.5719	I	-0.00228	-0.00756	0.00221	24
2437572.7328	II	-0.00174	-0.00702	0.00274	24
2437573.6952	II	-0.00151	-0.00679	0.00296	24
2437577.7038	I	-0.00193	-0.00724	0.00245	24
2437578.6660	I	-0.00190	-0.00721	0.00247	24
2437611.7012	I	-0.00107	-0.00658	0.00265	24
2437614.5879	I	-0.00087	-0.00640	0.00280	24
2437615.5502	I	-0.00073	-0.00627	0.00291	24
2437619.5582	II	-0.00176	-0.00732	0.00181	24
2437845.5115	I	0.00288	-0.00397	0.00166	25
2437846.4740	I	0.00321	-0.00365	0.00198	25
2437869.4062	II	0.00379	-0.00319	0.00204	25
2437871.4904	I	0.00329	-0.00370	0.00150	25
2437875.3397	I	0.00393	-0.00308	0.00205	1
2437875.4994	II	0.00327	-0.00375	0.00138	25
2437876.3014	I	0.00346	-0.00356	0.00156	1
2437876.4683	II	0.01000	0.00298	0.00809	1
2437877.4234	II	0.00294	-0.00409	0.00101	1
2437878.3846	II	0.00197	-0.00506	0.00002	1
2437879.3476	II	0.00280	-0.00423	0.00083	1
2437879.5097	I	0.00454	-0.00249	0.00257	25
2437879.6669	II	0.00138	-0.00565	-0.00060	1
2437881.2744	II	0.00527	-0.00177	0.00325	1
2437881.4339	I	0.00441	-0.00263	0.00239	1
2437883.3590	I	0.00518	-0.00188	0.00311	1
2437885.4419	II	0.00339	-0.00368	0.00127	1
2437886.4045	II	0.00382	-0.00325	0.00169	25
2437887.3671	II	0.00425	-0.00282	0.00210	25
2437887.5276	I	0.00439	-0.00269	0.00223	25
2437890.4144	I	0.00469	-0.00240	0.00247	25
2437897.4698	I	0.00421	-0.00292	0.00182	25
2437903.4034	II	0.00445	-0.00271	0.00193	25
2437916.7153	I	0.00639	-0.00085	0.00356	19
2437919.7603	II	0.00453	-0.00272	0.00163	19
2437926.6559	I	0.00461	-0.00268	0.00155	19
2437926.8139	II	0.00225	-0.00504	-0.00081	19
2437929.7008	II	0.00265	-0.00466	-0.00048	19
2437929.8627	I	0.00419	-0.00312	0.00106	19
2437940.6019	II	-0.00080	-0.00816	-0.00418	19
2437941.4091	I	0.00459	-0.00277	0.00120	25
2437959.3705	I	0.00556	-0.00190	0.00175	25
2437961.2945	I	0.00523	-0.00224	0.00137	25
2438235.5180	I	0.01140	0.00260	0.00088	13
2438670.4214	I	0.01574	0.00520	-0.00581	25
2438670.4252	I	0.01954	0.00900	-0.00201	25
2438708.2710	I	0.02014	0.00947	-0.00236	13
2438709.3930	II	0.01961	0.00894	-0.00292	13
2439039.4207	II	0.02435	0.01269	-0.00611	26
2439040.3839	II	0.02539	0.01372	-0.00510	26
2439041.3458	II	0.02512	0.01345	-0.00538	26
2439041.5075	I	0.02646	0.01479	-0.00405	26
2439059.4680	I	0.02653	0.01481	-0.00439	13
2439393.1856	II	0.03287	0.02042	-0.00492	26
2439393.3472	I	0.03410	0.02166	-0.00369	26
2439443.3810	I	0.03527	0.02274	-0.00342	13

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TABLE 3 (CONTINUED)

HJD	Min.	$(O-C)_L^a$	$(O-C)_Q^b$	$(O-C)_H^c$	Ref.[d]
2440110.4925	I	0.04497	0.03186	-0.00159	27
2440128.4540	I	0.04603	0.03293	-0.00061	7
2440202.2197	I	0.04567	0.03257	-0.00130	7
2440373.4866	I	0.04701	0.03397	-0.00028	7
2440419.3502	I	0.04736	0.03435	0.00009	7
2440441.4807	I	0.04804	0.03504	0.00079	27
2440467.4592	I	0.04806	0.03508	0.00084	27
2440497.2869	I	0.04861	0.03566	0.00145	7
2440515.2460	I	0.04727	0.03434	0.00016	7
2440542.3457	II	0.04596	0.03305	-0.00107	12
2440836.4479	II	0.04607	0.03354	0.00075	8
2440842.3820	I	0.04681	0.03430	0.00154	8
2440843.5030	II	0.04529	0.03277	0.00002	8
2440848.4758	I	0.04689	0.03439	0.00167	8
2441167.4277	II	0.04075	0.02890	-0.00095	2
2441172.4009	I	0.04275	0.03092	0.00113	2
2441172.4013	I	0.04315	0.03132	0.00153	2
2441192.7654	II	0.04141	0.02962	0.00005	2
2441192.9264	I	0.04204	0.03026	0.00069	2
2441249.3737	I	0.04227	0.03063	0.00171	2
2441583.4060	II	0.04258	0.03196	0.00738	9
2441598.3161	I	0.03911	0.02854	0.00417	9
2441598.3154	I	0.03841	0.02784	0.00347	9
2441683.3055	I	0.03717	0.02690	0.00375	9
2441900.4293	I	0.03217	0.02275	0.00278	28
2442361.7776	II	0.02184	0.01461	0.00125	29
2442369.7962	II	0.02239	0.01520	0.00195	29
2442630.3750	I	0.01455	0.00882	-0.00117	6
2442697.4039	I	0.01254	0.00722	-0.00201	6
2442768.2821	I	0.01118	0.00629	-0.00218	30
2443049.8707	I	0.00584	0.00281	-0.00310	29
2443398.4899	I	0.00021	-0.00027	-0.00410	5
2443411.4804	II	0.00146	0.00109	-0.00269	17
2443411.6343	I	-0.00500	-0.00537	-0.00915	17
2443459.7476	I	0.00000	0.00000	-0.00359	18
2443460.5490	II	-0.00041	-0.00040	-0.00399	18
2443487.6504	I	-0.00002	0.00021	-0.00329	18
2443488.6128	I	0.00022	0.00045	-0.00304	18
2443756.4151	I	-0.00037	0.00208	-0.00086	31
2443780.1487	I	-0.00017	0.00248	-0.00044	39
2443780.3090	II	-0.00026	0.00239	-0.00053	39
2443802.5987	I	-0.00074	0.00211	-0.00080	40
2444069.4412	I	0.00104	0.00629	0.00322	31
2444201.2556	I	-0.00131	0.00519	0.00185	32
2444202.2177	I	-0.00138	0.00514	0.00179	32
2444444.5213	II	-0.00327	0.00566	0.00156	33
2444461.3600	I	-0.00247	0.00663	0.00246	32
2444480.2822	I	-0.00287	0.00642	0.00219	32
2444493.7540	I	-0.00140	0.00804	0.00375	34
2444816.5570	II	-0.00511	0.00779	0.00203	33
2444852.4793	II	-0.00368	0.00962	0.00368	33
2444852.4784	II	-0.00458	0.00872	0.00278	33
2444853.4400	II	-0.00514	0.00817	0.00222	33
2444853.4414	II	-0.00374	0.00957	0.00362	33
2444854.4045	II	-0.00281	0.01051	0.00456	33
2444854.8834	I	-0.00499	0.00833	0.00238	35
2444856.8064	I	-0.00632	0.00702	0.00106	35
2444860.8188	II	-0.00295	0.01044	0.00446	35
2444914.8574	I	-0.00601	0.00799	0.00173	35
2444925.2840	II	-0.00287	0.01125	0.00493	36
2445160.5296	I	-0.00688	0.00999	0.00236	37
2445192.4399	II	-0.00842	0.00883	0.00101	37
2445201.7407	II	-0.00856	0.00880	0.00093	38
2445203.8264	I	-0.00755	0.00983	0.00195	38
2445204.7892	I	-0.00692	0.01048	0.00259	38
2445608.4174	II	-0.00738	0.01507	0.00466	16
2445608.4174	II	-0.00738	0.01507	0.00466	11
2445609.3794	II	-0.00755	0.01491	0.00450	11
2445611.3038	II	-0.00748	0.01501	0.00458	11
2445611.4638	I	-0.00784	0.01465	0.00422	11
2445612.2660	II	-0.00744	0.01505	0.00462	11
2445612.4259	I	-0.00790	0.01459	0.00416	11
2445932.8239	I	-0.01120	0.01559	0.00286	10
2445935.8710	II	-0.01096	0.01587	0.00312	10
2445951.5860	II	-0.01134	0.01571	0.00283	10
2446262.3633	II	-0.01368	0.01778	0.00222	15
2446264.4467	I	-0.01497	0.01651	0.00094	15
2446270.3797	II	-0.01533	0.01624	0.00061	15
2446270.5408	I	-0.01459	0.01698	0.00135	15
2446271.5030	I	-0.01456	0.01703	0.00139	15
2446272.4655	I	-0.01422	0.01738	0.00173	15
2446273.4268	I	-0.01509	0.01653	0.00087	15
2446274.3891	I	-0.01496	0.01668	0.00101	15
2446345.5903	I	-0.01404	0.01863	0.00226	10
2446613.5361	II	-0.03149	0.00522	-0.01418	14
2446614.4973	II	-0.03246	0.00427	-0.01514	14
2446619.4704	I	-0.03055	0.00626	-0.01322	14
2446620.4321	I	-0.03102	0.00580	-0.01368	14
2446624.4404	II	-0.03174	0.00514	-0.01439	14
2447832.6037	II	-0.02780	0.02945	-0.01536	41
2447832.7646	I	-0.02636	0.03089	-0.01393	41
2447836.7733	II	-0.02798	0.02934	-0.01560	41

[a] $\sigma_L = 0.020$ (Linear fit); [b] $\sigma_Q = 0.014$ (Quadratic fit); [c] $\sigma_H =$ (Harmonic fit).

[d] References. (1) Kalchaev, Layteschev, & Trutse 1968; (2) Pohl, & Kizilirmak 1972; (3) Kwee 1958; (4) Muthsam, & Rakos 1974; (5) Ebersberger et al. 1978; (6) Kizilirmak, & Pohl 1976; (7) Kizilirmak, & Pohl 1970; (8) Pohl, & Kizilirmak 1971; (9) Pohl, & Kizilirmak 1974; (10) Faulkner 1986; (11) Niarchos 1987; (12) Muthsam 1972; (13) Pohl 1967; (14) Soliman, Hamdy, & Mahdy 1986; (15) Evren, Akan, & Ibanoglu 1985; (16) Niarchos 1985; (17) Faulkner, Basilico, & Bookmyer 1979; (18) Faulkner, & Bookmyer 1978; (19) Chou 1963; (20) Brownlee 1957; (21) Hinderer 1960; (22) Broglia 1962; (23) Widorn 1962; (24) Bookmyer 1965; (25) Lang, & Vetešnik 1966; (26) Rucinski 1968; (27) Semeniuk 1971; (28) Baldinelli 1973; (29) Skillman 1977; (30) Baldinelli, & Ghedini 1976; (31) Pohl, & Gülmer 1981; (32) Aslam et al. 1981; (33) Hopp et al. 1982; (34) Faulkner, & Kaitchuk 1983; (35) Margrave 1982; (36) Pohl et al. 1982; (37) Pohl et al. 1983; (38) Margrave 1983; (39) Leung et al. 1984; (40) Faulkner, & Bookmyer 1980; (41) Present paper.

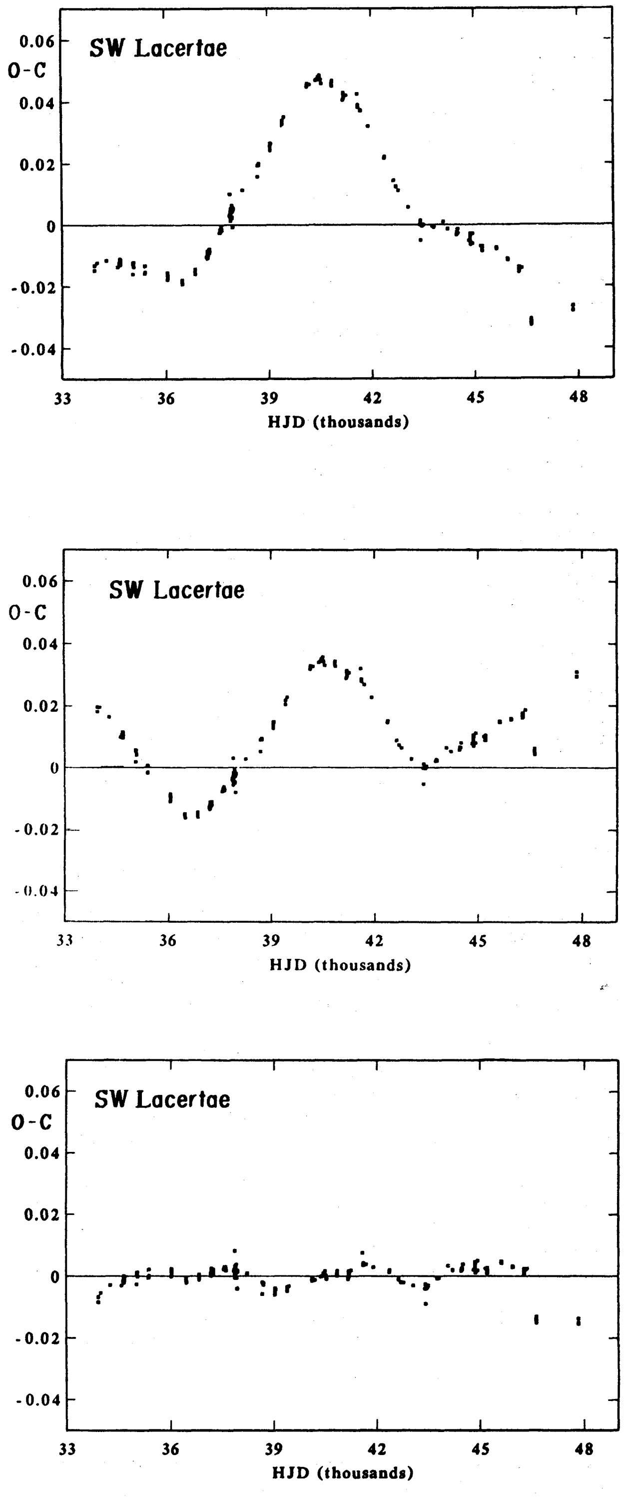

Fig. 4*a*. O-C versus HJD, using the linear ephemeris HJD_{min} = 2443459.7476 + 0.3207220 E. *b*. O-C versus HJD, using the ephemeris HJD_{min} = 2443459.7476 + 0.3207195×E − 2.45 × 10^{-10} $E^2/2$. *c*. O-C versus HJD, using the harmonic ephemeris found in the present paper.

rate of 4.82 s/century, a result consistent with what has been known for a long time.

The residuals, after subtracting the effect of this period variation, can be and have been interpreted in several ways: The existence of a third body being one of the most plausible solutions (Schilt 1923), but the anharmonic residuals left cannot be explained by the existence of a fourth body (Panchatsaram & Abhyankar 1981) and even without this last restriction, the frequency found would imply, as a lower limit, a third star of mass 1.35 $M_\odot$ located at 5.43 AU from the system. The observational data do not show evidence of a third component, although the possibility that it might be a white dwarf has been raised (Panchatsaram & Abhyankar 1981). However, since the residuals of the harmonic behaviour, a sinusoidal curve with a period of about 10^4 days or 29 years give a much smaller value, this effect has to be taken into account. For example, a recently developed theory proposed by Applegate (1992) explains these orbital period modulations as a consequence of magnetic activity in one of the stars in the binary by distribution of angular momentum as an effect of the changes in the active star as it goes though its activity cycle (consistent with the 29 yr found). In this theory Applegate (1992) supposes that the variations in the distribution of angular momentum produce variations in the oblateness of the star which are communicated to the orbit by gravity, changing the orbital period.

If this model is to be tested, as was done with the somewhat similar eclipsing binary CG Cygni (Hall 1991), we will have to follow Applegate's (1992) own testable predictions: "The luminosity variation is required to have the same period as the orbital period modulation. In addition, any other indicator of magnetic activity (starspots amplitude, coronal X ray luminosity, emission cores in CaII or Mg II lines etc.) should also show this period. The luminosity variation should be entirely due to a temperature variation since large changes in the radius of the star are ruled out by energetics. The star should be hottest, and thus bluest, when it is most luminous".

Unfortunately, no recent spectroscopic observations of this interesting system exist and hence, no observational evidence of a magnetic star in the system is available. Therefore, future spectroscopic, polarimetric and photometric observations of SW Lac are strongly encouraged.

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Marco A. Hobart: Facultad de Física, Universidad Veracruzana, Apartado Postal 270, 91000 Xalapa, Ver., México.

José H. Peña: Instituto de Astronomía, UNAM, Apartado Postal 70-264, 04510 México, D.F., México.

Eloy Rodríguez: Instituto de Astrofísica de Andalucía, Apdo. Correos 2144, E-18080 Granada, Spain.