COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 4624

Konkoly Observatory
Budapest
28 August 1998

HU ISSN 0374 – 0676

PERIOD CHANGE IN UV LEONIS

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UV Leo is a detached binary with two main sequence, G2 and G0, components, (Popper 1993, 1995). Period variations have been suspected by Herczeg (1962), Mallama (1980), and Rafert (1982). This prompted a study of all available earlier times of minimum by Snyder & Mattingly (1995). This study included times going back to October 1926 but because of the scatter associated with visual data only photographic and photoelectric times of minimum were used with equal weigh. The times from Oburka (1964) and Soliman, et al. (1985) were plotted but because they were misplaced from the least-squares parabolic fit a comparison was made of the sum-squares with the data deleted and the RMS residuals were improved by 15%, therefore both data were considered to be discordant and were not used in this paper. Wunder (1995) acquired two times of minimum indicating a period change and published data back to February 1949 using photoelectric data only.

Since the Snyder and Wunder papers nineteen new times of minimum have been published (Table 1). Added to this is the most recent unpublished time of 50544.7507 acquired at the MacLean Observatory. These new data have been archived with I.A.U. Comm. 27 Archive for Unpublished Observations of Variable Stars (Schmidt, 1992) and are available as file no. 299E and 338E. The data from the two papers were added to the most recent times and the linear light elements of equation (1) of Rafert (1982) were used to compute the $O-C_1$ residuals:

$$\mathrm{Hel.Min.JD} = 2438440.72525 + 0.600085011 \times \mathrm{E} \qquad (1)$$

Figure 1 shows the residual $O-C_1$ plot with a polynomial fit which displays an abrupt increase in the orbital period around 9,000 cycles, JD 2444000. A quadratic fit over the range $-15166 < E < +\,9000$ compared to the range $+\,9000 < E < +18352$ gives the magnitude of the period increase of $\Delta P/P = +6.5 \times 10^{-7}$.

The equation for the least-squares fitting in Figure 1 was added to equation (1) to obtain the quadratic ephemeris

$$\begin{array}{llll} \mathrm{Hel.Min.JD} = 2438440.72525 & + 0.600085011 \times \mathrm{E} & + 3.02147 \times 10^{-11}\mathrm{E}^2 & (2) \\ \qquad\qquad \pm 0.00026 & \pm 0.000000026 & \pm 0.200 & \end{array}$$

which was used to compute $O-C$ residuals, which when plotted showed a sine curve. A sinusoidal correction

$$\begin{array}{llll} f(e) = (1.855 \times 10^{-3}) & \sin (2.577 \times 10^{-4}\ \mathrm{E} & + 1.959) & (3) \\ \qquad \pm 0.241 & \qquad \pm 0.117 & \pm 0.091 & \end{array}$$

was added to equation (2) and resulted in decreasing the sum of the squares of the residuals by 31%, These O−C values are shown in Table 1 as O$-$C$_2$ and plotted in Figure 2 with a line representing a fitting of the sine function to the O−C values by least-squares.

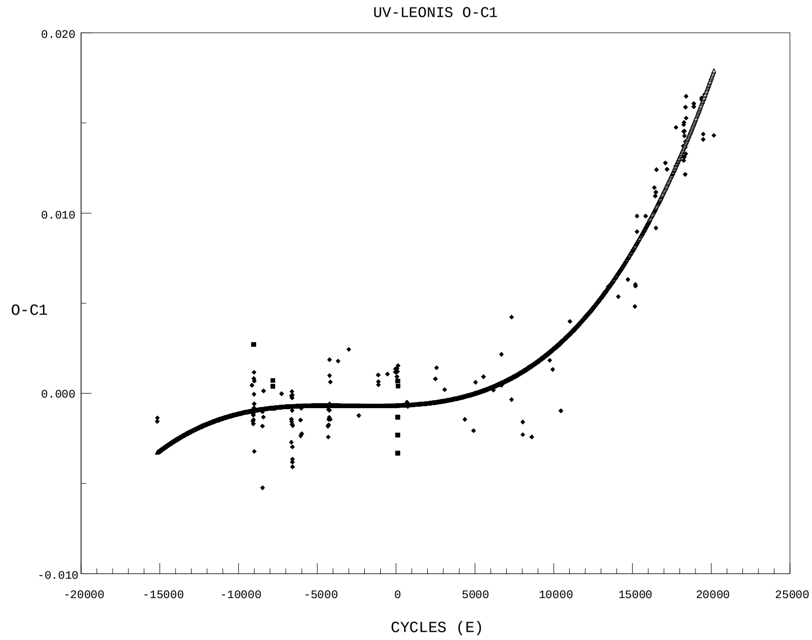

Figure 1. O−C diagram from the linear ephemeris using Equation (1). Solid line is least−squares fit. Diamond symbols = Photoelectric data; Squares = Photographic data

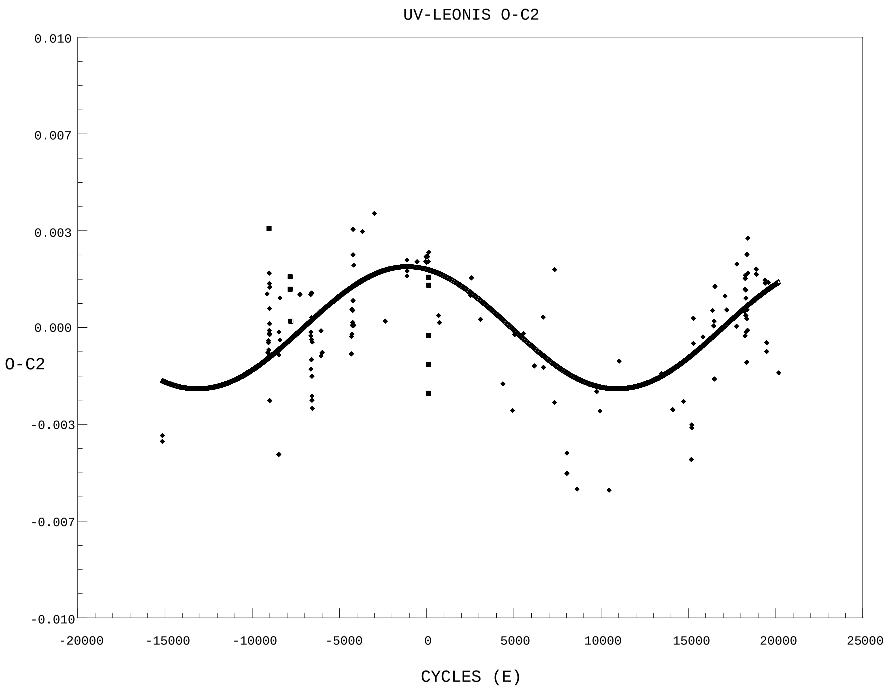

Figure 2. O−C diagram from the quadratic ephemeris with sinusoidal correction, Equation (2). Solid line representing a sine function fitting. Diamond symbols = Photoelectric data; Squares = Photographic data

Table 1

HJD	Ref	E	(O−C)$_1$	(O−C)$_2$	HJD	Ref	E	(O−C)$_1$	(O−C)$_2$
29339.8390	1	−15166.0	−0.0016	−0.0039	38495.6353	2	91.5	0.0012	0.0023
29345.5400	1	−15156.5	−0.0014	−0.0037	38504.3320	:4	106.0	−0.0033	−0.0023
32951.4513	2	−9147.5	0.0005	0.0012	38504.3330	:4	106.0	−0.0023	−0.0013
32981.4535	2	−9097.5	−0.0015	−0.0009	38504.3340	:4	106.0	−0.0013	−0.0003
32995.5559	2	−9074.0	−0.0011	−0.0004	38504.3360	:4	106.0	0.0007	0.0017
32997.3561	2	−9071.0	−0.0012	−0.0005	38512.4380	2	119.5	0.0015	0.0026
32999.4559	2	−9067.5	−0.0017	−0.0010	38513.3370	:4	121.0	0.0004	0.0015
33000.3565	2	−9066.0	−0.0012	−0.0005	38852.3840	2	686.0	−0.0005	0.0004
33006.3571	2	−9056.0	−0.0015	−0.0008	38882.3880	2	736.0	−0.0007	0.0002
33011.4620	:3	−9047.5	0.0027	0.0034	39940.3390	2	2499.0	0.0008	0.0011
33021.3615	2	−9031.0	0.0008	0.0015	39978.4450	2	2562.5	0.0014	0.0017
33024.3602	2	−9026.0	−0.0009	−0.0002	40291.3880	2	3084.0	0.0002	0.0003
33024.3603	1	−9026.0	−0.0008	−0.0001	41060.3950	2	4365.5	−0.0014	−0.0019
33027.3627	2	−9021.0	0.0012	0.0019	41390.4410	2	4915.5	−0.0021	−0.0029
33030.3610	2	−9016.0	−0.0010	−0.0002	41466.3544	2	5042.0	0.0006	−0.0002
33030.3619	2	−9016.0	−0.0001	0.0007	41766.3971	2	5542.0	0.0009	−0.0002
33033.3618	2	−9011.0	−0.0006	0.0001	42147.4502	2	6177.0	0.0002	−0.0013
33039.3600	2	−9001.0	−0.0032	−0.0025	42450.4950	5	6682.0	0.0022	0.0004
33039.3639	2	−9001.0	0.0007	0.0014	42453.4937	2	6687.0	0.0004	−0.0014
33349.3052	2	−8484.5	−0.0018	−0.0009	42838.4473	2	7328.5	−0.0003	−0.0026
33349.3060	1	−8484.5	−0.0010	−0.0001	42839.3520	5	7330.0	0.0042	0.0020
33354.4025	2	−8476.0	−0.0052	−0.0044	43266.3058	6	8041.5	−0.0023	−0.0050
33386.8110	2	−8422.0	−0.0013	−0.0004	43266.3065	2	8041.5	−0.0016	−0.0043
33390.7130	2	−8415.5	0.0001	0.0010	43608.3540	2	8611.5	−0.0024	−0.0056
33740.5630	:3	−7832.5	0.0007	0.0017	44292.4549	2	9751.5	0.0018	−0.0022
33743.5630	:3	−7827.5	0.0004	0.0013	44404.3702	2	9938.0	0.0013	−0.0029
33772.6660	:3	−7779.0	−0.0008	0.0002	44716.4120	2	10458.0	−0.0010	−0.0056
34078.4100	1	−7269.5	0.0000	0.0011	45061.4657	2	11033.0	0.0040	−0.0012
34451.3600	1	−6648.0	−0.0027	−0.0014	46521.4739	2	13466.0	0.0059	−0.0016
34454.3630	2	−6643.0	−0.0001	0.0011	46903.4273	2	14102.5	0.0054	−0.0028
34456.4620	2	−6639.5	−0.0014	−0.0002	47270.3801	2	14714.0	0.0063	−0.0025
34457.3620	2	−6638.0	−0.0016	−0.0003	47538.6165	7	15161.0	0.0048	−0.0045
34475.3660	2	−6608.0	0.0001	0.0012	47557.5204	7	15192.5	0.0060	−0.0034
34477.4640	2	−6604.5	−0.0002	−0.0011	47559.6206	7	15196.0	0.0060	−0.0035
34479.5650	2	−6601.0	−0.0017	−0.0004	47615.4315	2	15289.0	0.0090	−0.0005
34481.3660	2	−6598.0	−0.0010	0.0003	47616.3325	2	15290.5	0.0098	0.0003
34487.3640	2	−6588.0	−0.0038	−0.0025	47945.4790	2	15839.0	0.0098	−0.0003
34488.5650	2	−6586.0	−0.0030	−0.0017	48277.6275	7	16392.5	0.0114	0.0006
34489.4680	2	−6584.5	−0.0001	0.0012	48308.5314	7	16444.0	0.0109	0.0001
34493.3650	2	−6578.0	−0.0036	−0.0024	48332.5350	2	16484.0	0.0112	0.0002
34496.3650	2	−6573.0	−0.0041	−0.0028	48339.4340	7	16495.5	0.0092	−0.0018
34501.4680	2	−6564.5	−0.0018	−0.0005	48358.3399	2	16527.0	0.0124	0.0014
34803.6110	2	−6061.0	−0.0015	−0.0001	48700.3886	2	17097.0	0.0128	0.0011
34808.4108	2	−6053.0	−0.0024	−0.0010	48757.3963	2	17192.0	0.0124	0.0006
34827.3150	2	−6021.5	−0.0008	0.0005	49099.4448	7	17762.0	0.0126	0.0001
34844.4160	2	−5993.0	−0.0022	−0.0009	49103.3475	7	17768.5	0.0148	0.0022
35846.5580	2	−4323.0	−0.0018	−0.0003	49373.9847	8	18219.5	0.0137	0.0006
35850.7580	2	−4316.0	−0.0024	−0.0009	49393.7867	8	18252.5	0.0129	−0.0003
35867.5619	2	−4288.0	−0.0009	0.0006	49395.8886	8	18256.0	0.0145	0.0013
35871.4616	2	−4281.5	−0.0017	−0.0002	49398.8894	8	18261.0	0.0149	0.0017
35873.5622	2	−4278.0	−0.0014	0.0001	49407.8908	8	18276.0	0.0150	0.0018
35895.4654	2	−4241.5	−0.0013	0.0002	49420.7907	8	18297.5	0.0131	−0.0002
35897.5661	2	−4238.0	−0.0009	0.0006	49423.7917	8	18302.5	0.0137	0.0004
35901.4670	2	−4231.5	−0.0006	0.0009	49424.6927	8	18304.0	0.0146	0.0013
35904.4690	2	−4226.5	0.0010	0.0025	49425.8926	8	18306.0	0.0143	0.0010
35905.3700	2	−4225.0	0.0019	0.0034	49453.7944	9	18352.5	0.0121	−0.0012
35934.4708	2	−4176.5	−0.0014	0.0001	49453.7959	9	18352.5	0.0136	0.0003
35935.3730	2	−4175.0	0.0006	0.0021	49462.7975	9	18367.5	0.0140	0.0006
36231.5160	1	−3681.5	0.0018	0.0033	49462.7994	9	18367.5	0.0159	0.0025
36637.4740	1	−3005.0	0.0024	0.0039	49475.3986	2	18388.5	0.0133	−0.0001
37017.3240	2	−2372.0	−0.0012	0.0002	49484.7019	9	18404.0	0.0153	0.0019

Table 1 (cont.)

HJD	Ref	E	(O−C)$_1$	(O−C)$_2$	HJD	Ref	E	(O−C)$_1$	(O−C)$_2$
37758.7310	2	−1136.5	0.0010	0.0023	49484.7031	9	18404.0	0.0165	0.0031
37764.7313	2	−1126.5	0.0005	0.0018	49775.4436	2	18888.5	0.0159	0.0018
37765.6316	2	−1125.0	0.0006	0.0019	49776.3439	2	18890.0	0.0161	0.0020
38111.5809	2	−548.5	0.0011	0.0023	50080.5871	10	19397.0	0.0163	0.0015
38413.7237	1	−45.0	0.0012	0.0023	50080.5872	10	19397.0	0.0164	0.0016
38416.7243	2	−40.0	0.0014	0.0025	50139.3932	10	19495.0	0.0141	−0.0008
38440.7275	2	0.0	0.0012	0.0023	50139.3935	10	19495.0	0.0144	−0.0005
38470.7315	2	50.0	0.0009	0.0020	50190.4029	11	19580.0	0.0166	0.0016
38474.6325	2	56.5	0.0014	0.0024	50544.7507	12	20170.5	0.0143	−0.0016

:Denotes photographic observations. All others photoelectric. Both used with equal weight.

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The sinusoid would suggest a triple system interpreted that the timing residuals are caused by the light-travel time differences as the eclipsing system moves about the barycentre of the triple. The size of the triple system inferred by the light-travel time is a third body orbital period of 40.1 years and the magnitude of the binary's motion about the barycentre of the triple of 0.32 AU. There is no evidence as yet of a third body.

Rotation of the line of apsides is not plausible as a plot of the secondary minima does not show a sinusoidal variation 180 degrees out of phase with the primary and binaries of this short period have circular orbits. A mass transfer mechanism would produce a period change in one direction, increase or decrease, not both. Two other alternative explanations, a magnetic cycle and a starspot wave as explained for such binaries by Hall and Louth (1990) are possible.

Acknowledgments: I am grateful to the MacLean family for the use of the MacLean Observatory. This research has made use of the SIMBAD database, operated at CDS, France.

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