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THE PERIOD OF LV HERCULIS REVISITED

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In a recent note (Torres 2000) the orbital period of LV Her (TYC 2076 − 1042 − 1; $17^{\rm h}35^{\rm m}32\overset{\rm s}{.}4$, $+23°10'31''$, J2000; SpT. F9, $V = 10.9$) was reported to be 18.13120 days based on radial velocity measurements made at the Harvard-Smithsonian Center for Astrophysics (CfA). This seemed to solve the long-standing mystery about the true period of this binary, claimed originally to be 2.634 days by Zessewitsch (1944) and later revised to 5.2674 days by Zessewitsch (1954). It also seemed to solve the problem posed by the preliminary spectroscopic orbit obtained by Popper (1996), with an even longer period of 9.218 days. That orbit implied a total mass for the system of only $\sim$1.0 $M_\odot$, which is too small for two very similar main-sequence stars of spectral type F9 or G0 in an eclipsing system.

Although the new 18.13120-day period gave a good fit to the CfA radial velocities, the report by Torres (2000) mentioned the lingering difficulty that the ephemeris did not agree with the few published times of minimum for LV Her. Continued spectroscopic observations at CfA eventually hinted at a problem with the orbit presented by Torres (2000), as additional velocity measurements began to show large residuals. In particular, new observations on the steeper portions of the velocity curves that were not well covered by the original data deviated considerably from the predictions.

Photometric (CCD) observations in the visual band by one of us (CHSL) with a robotic telescope at the Univ. of Arkansas also indicated discrepancies in the times of eclipse compared to the ephemeris by Torres (2000). It was soon found that a slight adjustment to the period of about +0.3 days gave an excellent fit to all the spectroscopic observations, as well as to the new and published eclipse timings.

Subsequently, numerous times of eclipse have been recovered from archival photographic plates going back nearly a century that are extremely valuable for confirming and improving the period of LV Her. Blue-sensitive patrol plates from the AC series at the Harvard College Observatory were measured by PRG using a sequence of steps to estimate changes in brightness. Similar material from the Sky Survey plates at the Sonneberg Observatory was measured by RD. In addition, a number of times of minimum have been derived from visual observations over the last decade by MEB. All of these observations are listed in Table 1, along with the CCD measurements mentioned above and also the historical times of minimum from the literature. A weighted least-squares adjustment to these data was performed by adopting typical uncertainties of 0.046 days and 0.012 days for the photographic and visual minima (determined by iterations), 0.004 days for the first two photoelectric minima, and 0.0008 days for the final more accurate timing. The ephemeris obtained for LV Her is:

$$\begin{aligned}\text{Min I} &= 2{,}452{,}066.66949(95) + 18.4359348(56) \cdot E\\ \text{Min II} &= 2{,}452{,}064.1673(29) + 18.4359348(56) \cdot E.\end{aligned}$$

where the figures in parenthesis represent the uncertainty in the last digits. Separate solutions for a period from the primary and secondary minima show no evidence for apsidal motion.

Table 1. Times of minimum for LV Her (HJD−2,400,000).

HJD	Type[1]	Obs[2]	Cycle	O−C	Ref[3]	HJD	Type	Obs	Cycle	O−C	Ref
15929.712	2	pg	−1960	−0.0231	1	37906.406	?	pg	−768	(−1.4956)	4
16224.798	2	pg	−1944	+0.0879	1	38147.573	1	pg	−755	+0.0043	2
16669.658	1	pg	−1920	−0.0467	1	38587.449	2	pg	−731	−0.0500	2
17351.799	1	pg	−1883	−0.0353	1	40744.498	2	pg	−614	−0.0053	2
18605.473	1	pg	−1815	−0.0049	1	41060.502	1	pg	−597	+0.0556	2
23601.681	1	pg	−1544	+0.0648	1	41982.251	1	pg	−547	+0.0078	2
24062.505	1	pg	−1519	−0.0096	1	42664.347	1	pg	−510	−0.0258	2
26032.643	2	pg	−1412	+0.0156	2	46001.268	1	pg	−329	−0.0090	2
26032.644	2	pg	−1412	+0.0166	1	46941.483	1	pg	−278	−0.0266	2
26090.482	1	pg	−1409	+0.0146	2	47381.384	2	pg	−254	−0.0559	2
26219.577	1	pg	−1402	+0.0581	1	48100.425	2	pg	−215	−0.0163	2
26901.699	1	pg	−1365	+0.0505	1	48487.60	2	v	−194	+0.0041	5
27212.514	2	pg	−1348	−0.0132	2	48508.60	1	v	−193	+0.0359	5
27636.462	2	pg	−1325	−0.0917	2	48545.52	1	v	−191	+0.0840	5
27657.429	1	pg	−1324	−0.0928	2	48745.70	2	v	−180	+0.0010	5
28281.830	2	pg	−1290	+0.0186	1	48948.50	2	v	−169	+0.0057	5
30254.522	2	pg	−1183	+0.0655	1	49098.540	1	pg	−161	+0.0260	2
31268.42	2	v	−1128	−0.0129	3	49206.61	2	v	−155	+0.0126	5
31289.35	1	v	−1127	−0.0510	3	49667.49	2	v	−130	−0.0058	5
31326.29	1	v	−1125	+0.0171	3	49688.48	1	v	−129	+0.0161	5
31342.16	2	v	−1124	−0.0166	3	49925.65	2	v	−116	+0.0511	5
34626.332	1	pg	−946	+0.0268	2	52008.85	2	pe	−3	−0.0095	6
37444.539	2	pg	−793	+0.0680	2	52045.74	2	pe	−1	+0.0086	6
37869.519	?	pg	−770	(−1.5107)	4	52066.6993	1	pe	0	−0.0002	6

[1]Type: 1 = primary eclipse, 2 = secondary eclipse.
[2]Obs: pg = photographic, v = visual, pe = photoelectric.
[3]Ref: 1 = Guilbault (Harvard plates), 2 = Diethelm (Sonneberg plates), 3 = Zessewitsch (1954), 4 = Huth (1964), 5 = Baldwin (visual), 6 = Lacy (CCD)

Only the two photographic timings by Huth (1964) give large residuals of ∼1.5 days (indicated in parentheses in the table), and were not included in the fit. Inspection of the original plates from the Sonneberg Observatory by one of us (RD) revealed an anomalously bright comparison star on both dates (which is possibly variable) as well as a plate defect on the second date, which make these measurements highly suspect.

The large eccentricity ($e = 0.61$) and peculiar orientation of the orbit of LV Her result in a secondary minimum that does not occur midway in phase between two primary minima, but instead at phase 0.8626 ± 0.0032. The separation of only 0.137 from the primary eclipse has no doubt contributed to the confusion of the early observers and to the difficulty in establishing the period. The new value, which is essentially double the period proposed by Popper (1996), along with the spectroscopic observations from CfA implies minimum masses of 1.20 $M_\odot$ and 1.17 $M_\odot$ for the components, in good agreement with the spectral type. The apparently synchronous rotation of the stars (see Torres 2000) and the eccentric orbit make this system potentially very interesting for a comparison with current theories of tidal evolution. Spectroscopic observations at CfA as well as photometric (CCD) observations are being continued, and a detailed investigation of the binary will be the subject of future paper.

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References:

Huth, H. 1964, *Mitt. Veränd. Sterne, Sonneberg*, Band 2, Heft 5, 112
Popper, D. M. 1996, *ApJS*, **106**, 133
Torres, G. 2000, *IBVS* 4971
Zessewitsch, V. P. 1944, *Astron. Circ.*, **36**, 5
Zessewitsch, V. P. 1954, *Odessa Report*, **4**, 113