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THE ORBITAL PERIOD OF LV HERCULIS

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The variability of this star (TYC 2076-1042-1; $17^{\rm h}35^{\rm m}32\overset{\rm s}{.}4$, $+23°10'31''$, J2000; Sp F9, $V = 10.9$) was announced by Hoffmeister (1935), but has received little attention since then. Zessewitsch (1944) reported a period of 2.634 days and classified it as an Algol type system, but in a later study presenting times of minimum (Zessewitsch 1954) the period is listed as being 5.2674 days, or twice as long. Further times of minimum for LV Her were given by Huth (1964), but they do not seem to fit either ephemeris.

Spectroscopic observations were reported by Popper (1996), who determined the spectral type of the nearly equal components to be G0, in good agreement with the F9 type implied by the Strömgren photometry by Hilditch & Hill (1975). Popper expressed difficulty in finding an orbital period fitting his observations, and ruled out the value of 5.2674 days. Less than half of his 29 spectra showed double lines, indicating substantial orbital eccentricity. The mass ratio was estimated to be close to unity. He concluded that an orbital period of 9.218 days fits 11 of his 13 double-lined spectra, with an eccentricity of 0.45, and also seems to agree with the times of minimum reported by Zessewitsch (1954). However, he pointed out that this period is inconsistent with two of his observations, and that a further more serious inconsistency is given by the fact that the total mass for the system implied by the 9.218-day period orbit is only about 1.0 $M_{\odot}$, much too small for two main-sequence stars of spectral type F9 or G0 in an eclipsing system.

LV Her was observed spectroscopically at the Harvard-Smithsonian Center for Astrophysics (CfA) in order to clarify the issue. A total of 18 observations have been obtained to date with an echelle spectrograph on the 1.5-m Tillinghast reflector at the F. L. Whipple Observatory (Mt. Hopkins, Arizona, USA). A single echelle order spanning 45 Å was recorded at a resolving power of $\lambda/\Delta\lambda = 35{,}000$, centered at a wavelength of 5187 Å. Radial velocities for both components were derived with the two-dimensional cross-correlation technique TODCOR (Zucker & Mazeh 1994), which uses two templates, one for each component. The templates for this star were selected from an extensive library of synthetic spectra based on model atmospheres by R. L. Kurucz (available at `http://cfaku5.harvard.edu`), computed by Jon Morse (Morse & Kurucz, in preparation).

An excellent fit to the velocities was found for a period of 18.13120 days, which is nearly twice the tentative period given by Popper. The observations and the double-lined orbital solution are shown graphically in Fig. 1, and the preliminary elements are given in Table 1. The orbit is indeed quite eccentric, and the mass ratio close to unity, as reported by

Popper. More importantly, the minimum masses of the components, while still relatively poorly determined because of the lack of observations near maximum velocity separation, are close to 1 $M_{\odot}$ for each star, in excellent agreement with the spectral type. Grids of cross-correlations against templates over a range of effective temperatures indicate that both stars are best fit with spectra having a temperature of 6000 K, corresponding to spectral type F9. This confirms Popper's classification, and leaves little doubt that the period in this well-detached system now is well established. From the measured projected rotational velocities ($v \sin i$ = 12 km s^{-1} for both stars), the components appear to be synchronized with the orbital motion at periastron (pseudo-synchronized).

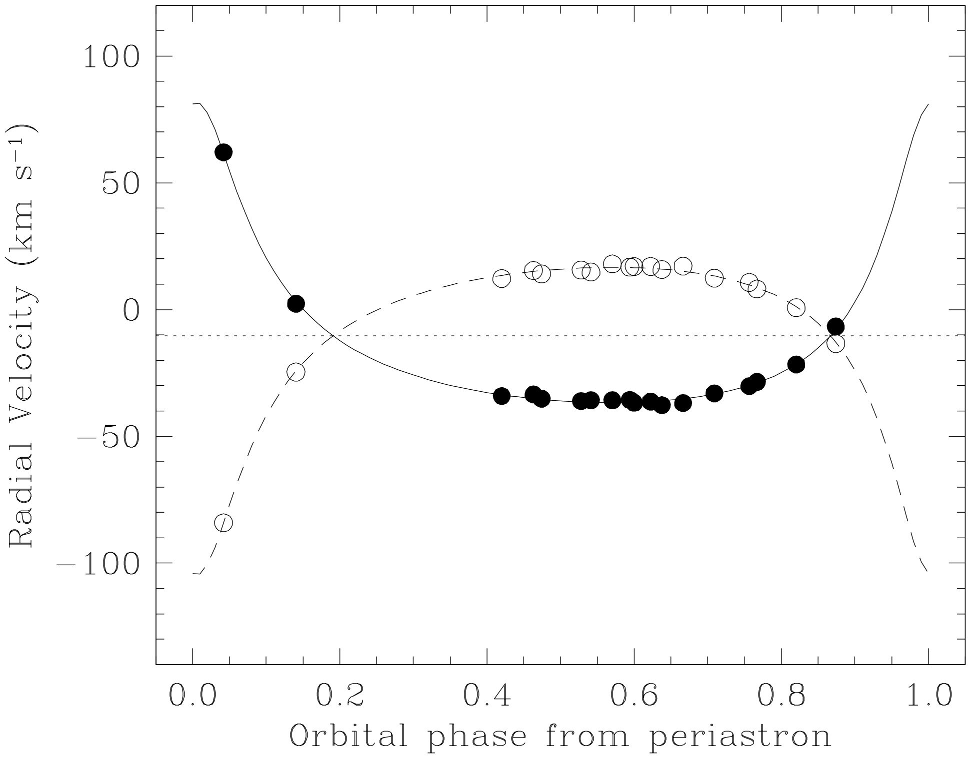

Figure 1. Spectroscopic orbital solution for LV Her

The ephemeris for eclipses that we derive for LV Her from these data is:

$$\text{Min I} = 2,450,538.23\,(\pm\,0.20) + 18.13120\,(\pm\,0.00074) \times E,$$
$$\text{Min II} = 2,450,535.24\,(\pm\,0.12) + 18.13120\,(\pm\,0.00074) \times E.$$

A difficulty remains, however, in that the published times of minimum do not fit this ephemeris. Apsidal motion, though certainly possible in this eccentric system, is expected to be very small due to the wide separation of the stars, and thus cannot explain the discrepancy.

Further times of minimum would be very helpful to improve our knowledge of the system, and the ephemeris presented above is intended to facilitate the observation. Complete photoelectric light curves on a standard system are also needed in order to establish the absolute dimensions of the components accurately. To this end, spectroscopic observations of LV Her will continue at the CfA until a definitive orbit is obtained.

Table 1: Preliminary spectroscopic elements for LV Her

Parameter	Value
P (days)	18.13120 ± 0.00074
γ ($\mathrm{km\,s^{-1}}$)	-10.34 ± 0.20
K_A ($\mathrm{km\,s^{-1}}$)	59.2 ± 3.6
K_B ($\mathrm{km\,s^{-1}}$)	60.7 ± 3.7
e	0.562 ± 0.027
ω (deg)	351.4 ± 1.0
$T_{\rm peri}$ (HJD)	$2{,}450{,}536.485 \pm 0.028$
$a_A \sin i$ (10^6 km)	12.22 ± 0.54
$a_B \sin i$ (10^6 km)	12.52 ± 0.55
$M_A \sin^3 i$ ($\mathrm{M_\odot}$)	0.93 ± 0.12
$M_B \sin^3 i$ ($\mathrm{M_\odot}$)	0.91 ± 0.12
$q \equiv M_B/M_A$	0.976 ± 0.016
N	18
σ_A ($\mathrm{km\,s^{-1}}$)	1.00
σ_B ($\mathrm{km\,s^{-1}}$)	1.08

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