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PERIOD CHANGES OF THE ECLIPSING BINARY LP CEPHEI

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The semi-detached eclipsing binary LP Cephei (HBV 484 = SVS 681 = CSV 5400 = P 5577 = GSC 4248.1323; $\alpha_{2000} = 21^h19^m50\overset{s}{.}3$, $\delta_{2000} = +60°42'27''$, Sp. F2 + K1, $V_{\max} = 12.9$ mag) is a rarely investigated, rather faint binary with a short orbital period of about 0.693 days. This binary was selected as a possible system for the study of apsidal motion (Hegedüs 1988) and thus it was also added to our observational project of eclipsing binaries with eccentric orbit. LP Cep was discovered to be a variable star photographically by Wachmann (1972), who obtained also the first photographic light curve and determined the first light elements

$$\text{Pri. Min.} = \text{HJD } 2430517.4650 + 0.6930642 \times E.$$

Recently, the first multicolor $UBV(RI)_C$ photoelectric observations were carried out by Samec et al. (1995, 1997). They derived a photometric solution using the Wilson-Devinney code and concluded that LP Cep is in a near-contact semidetached configuration consisting of an F2 spectral-type primary and a K1 secondary filling its Roche lobe. They also calculated an improved linear ephemeris

$$\text{Pri. Min.} = \text{HJD } 2449621.7322 + 0.69306251 \times E.$$

Our new CCD photometry of LP Cep was carried out during the years 1995–1999 at the Ondřejov Observatory, Czech Republic. A 65-cm reflecting telescope with a CCD-camera SBIG ST-6 or ST-8 was used. The measurements were done using the standard R filter with typically 60 - 90 s exposure time. The nearby stars GSC 4248.00016 ($V = 13.4 mag$) and GSC 4248.01072 ($V = 12.9 mag$) on the same frame as LP Cep served as comparison and check stars, respectively. The standard error of measurements varies between 0.01 and 0.02 mag. The new moments of primary minimum and their errors were determined using the least squares fit to the data, by the bisecting cord method and the Kwee–van Woerden algorithm. Only the lower part of the eclipses was used. These 7 new times of primary minimum are presented in Table 1. In this table, N stands for the number of observations used in the calculation of the minimum time. The epochs were calculated using the linear light elements given by Wachmann (1972).

Table 1: New precise times of minimum of LP Cep.

JD Hel. – 2400000	Epoch	Error (days)	N
49999.45478	28110.0	0.00002	69
50261.4348	28488.0	0.0001	38
50261.4366*	28488.0	0.0019	13
50525.4934	28869.0	0.0002	29
50945.48889	29475.0	0.00005	38
51442.4113	30192.0	0.0002	34
51535.28135	30326.0	0.00002	67

* published also in Diethelm (1996)

The period change of LP Cep was studied by means of an $O-C$ diagram analysis. We took into consideration all photoelectric measurements of Samec at al. (1997) as well as the original photographic times of minimum obtained by Wachmann (1972). A total of 21 times of minimum light were used in our analysis, with only 2 secondary eclipses among them. The $O-C$ residuals for all times of minimum are shown in Figure 1. The mean seasonal photographic minima based on the plate archive study presented by Blättler (1996) are also plotted.

The variations of $O-C$ values are remarkable and could be caused by a light-time effect. A preliminary analysis of the third body orbit gives the following parameters:

$$P_3 \text{ (period)} = 6370 \pm 25 \text{ days, i.e. } 17.4 \text{ years}$$
$$T_0 \text{ (time of periastron)} = \text{J.D. } 2450490 \pm 30$$
$$A \text{ (semiamplitude)} = 0.0062 \pm 0.0002 \text{ day}$$
$$e = 0.42 \pm 0.12$$
$$\omega = 66^\circ \pm 2^\circ$$

These values were obtained together with the new linear ephemeris

$$\begin{array}{rl} \text{Pri. Min.} = \text{HJD } 2430517.4655 & + \; 0.69306252 \times E, \\ \pm 0.0003 & \pm 0.00000007 \end{array}$$

by the least squares method. Assuming a coplanar orbit ($i = 90^\circ$) and a total mass of the eclipsing pair with the F2 primary and K1 secondary, $M_1 + M_2 \simeq 2.2\ M_\odot$ (Harmanec 1988), we can obtain a lower limit for the mass of the third component $M_{3,\mathrm{min}}$. The value of the mass function $f(M) = 0.0051\ M_\odot$, from which the minimum mass of the third body follows as $0.35\ M_\odot$.

Only a small part of the third body period is well-covered by the precise CCD observations. Moreover, the current light-curve analysis of Samec et al. (1997) gives the third light $L_3 = 0$. Possible third component of spectral type M3-M4 with the bolometric magnitude about +9.2 mag could be practically invisible in the system with an F2 primary ($M_{\mathrm{bol}} = +3.2$ mag). Therefore, new high-accuracy timings of this eclipsing binary are necessary in order to confirm the light-time effect in this system.

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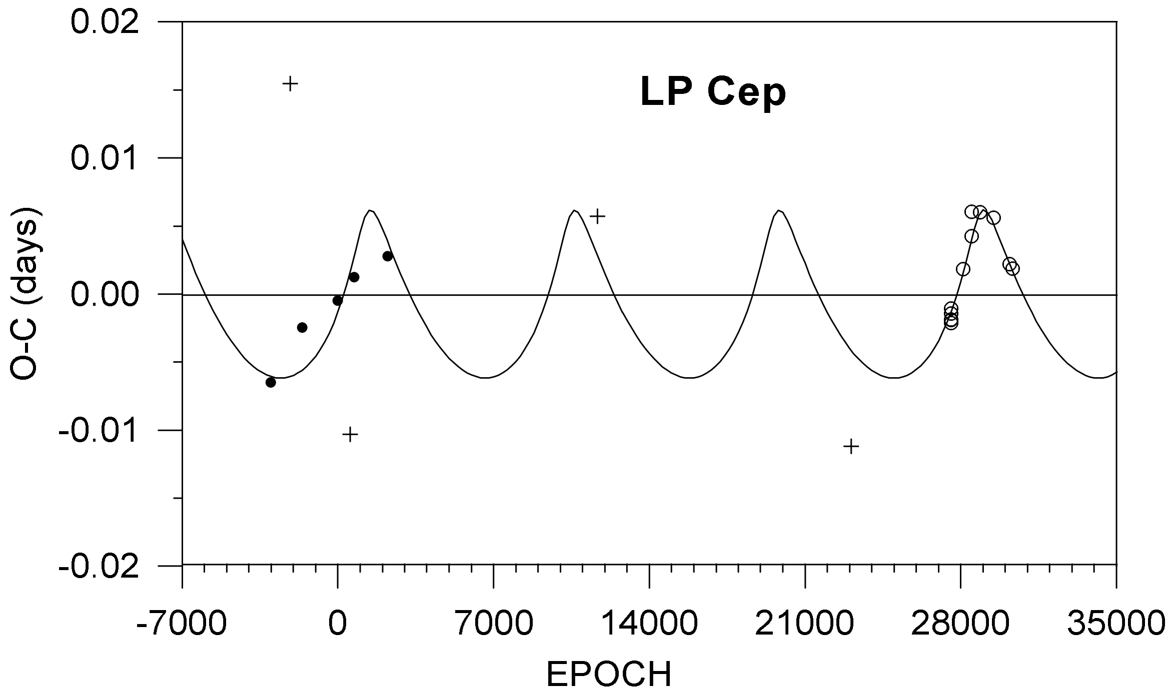

Figure 1. $O - C$ residuals for the times of minimum of LP Cep. The individual photoelectric or our CCD minima are denoted by circles, dots represents the original timings of Wachmann and crosses the mean seasonal minima of Blättler. The curve corresponds to a third body orbit.

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