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The New Ephemeris of BZ Leo, V2545 Cyg, and V0402 Gem

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Abstract

The new ephemeris of three eclipsing binary systems BZ Leo, V2545 Cyg, and V0402 Gem are presented. The observation was made with CCD through the C filter. These three W UMa systems studied for the first time so we used the Czech astronomical society's database to extract raw data from the complete light curves, to obtain the time of minimums to calculate O-Cs with the new ephemeris.

Keywords: Star, Contact, Binary, W UMa

Introduction

W UMa systems are eclipsing binaries with a short period of about 0.25 to 1.0 day (Acerbi, 2011). Each of the components in the binary is of nearly the same spectral type, from around middle A to early K, with the bulk concentrated in middle F through early G. They can be easily recognized by their light curve shape. The depth of primary and secondary minima in these systems is approximately equal or equal, and the magnitude variability range is about 0.1 to 1 (Rucinski, 2000).

we studied three UMa-type systems that they haven't studied of period changes in any article. The first one is BZ Leo as an eclipsing binary star system which is located in the Leo constellation. The period is approximate to 0.269722 (Hořková K, 2013). The first observation and calculating time of minimum was in the year 2010 (Trnka J, 2010).

The second star is V2545 Cyg, located in the Cygnus constellation. Also known as GSC 02685-01453, with the period 0.369190 d (Hubscher Joachim, 2016). This binary system first observed in the year 2005 (Peicha Ondreg, 2005).

The third star is V0402 Gem, located in the Gemini constellation. Also known as GSC 01338-01984, with the period 0.399253. This binary system first observed in the year 2000 d (Sebastian A. Otero, 2008).

In this paper, the new light curve and ephemeris are presented. The data which used had inserted into the variable star section of Czech astronomical society's database¹. We used these data to obtain the time of minimums, then calculate O-C with the new ephemeris for each star.

Observation

The observations for the star BZ Leo were made on 31 March 2017 at Sedlčany station; for the star V2545 Cyg observed on 27 August 2016 at Private observatory Motešice, and for the star V0402 Gem observed on 30 January 2018 at Víglaf station. These observations were done by CCD photometry through the filter

¹ <http://var2.astro.cz>

clear. The information on the observations is given in Table 1, and the general characteristics of the stars are listed in Table 2.

Table 1. Information of observers and instruments

Star name	Observer	Location	Tools	Filter
BZ Leo	Lomoz F	Sedlčany	STN 254/1016+G2-8300	Clear
V2545 Cyg	Smolka M.	Private observatory Motešice, SK	REF 127/1200 + Canon 450D + reducer 0.8x	Clear
V0402 Gem	Nosál P.	Víglaš	NWT 150/600 + Canon 20D + MPCC mk.III	Clear

Table 2. Characteristics of the variable stars (from: SIMBAD² query result)

Star name	GSC	Magnitude (V.)	RA.	Dec.
BZ Leo	-	15.34	11 42 00.2871059246	+22 52 08.457191184
V2545 Cyg	02685-01453	11.57	20 27 26.5396956384	+31 05 38.401333791
V0402 Gem	01338-01984	11.68	06 42 17.3723291145	+20 16 48.365462819

These data transforming from JD to BJD_TDB by the code of Jason Eastmano that published on an open webpage³. Then we changed to phase, based on the selective ephemeris shown in Table 3. The light curves of observations are presented in Figures 1, 2 and 3.

Table 3. Reference ephemeris of stars

Star Name	ToM (BJD_TDB)	Period	Reference
BZ Leo	2456052.378298	0.269725	OEJV 0160
V2545 Cyg	2453258.399458	0.369182	IBVS 6157
V0402 Gem	2451612.703731	0.399248	IBVS 5964

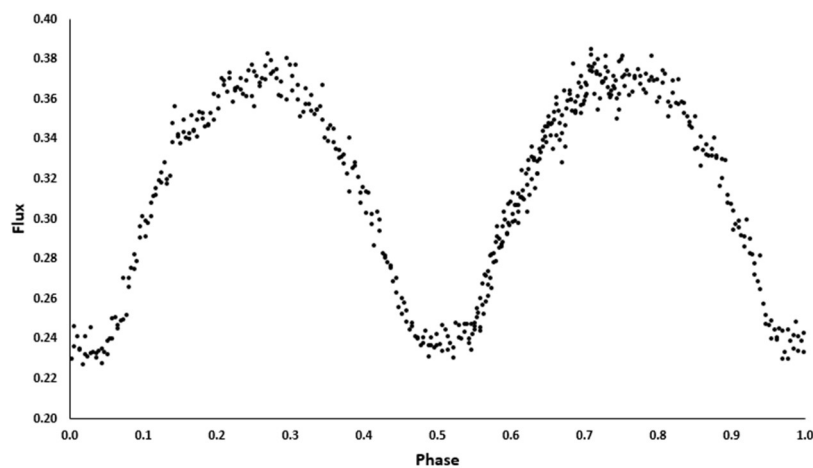


Figure 1. The light curve of BZ Leo

² <http://simbad.u-strasbg.fr/simbad/>

³ <http://astrutils.astronomy.ohio-state.edu/time/>

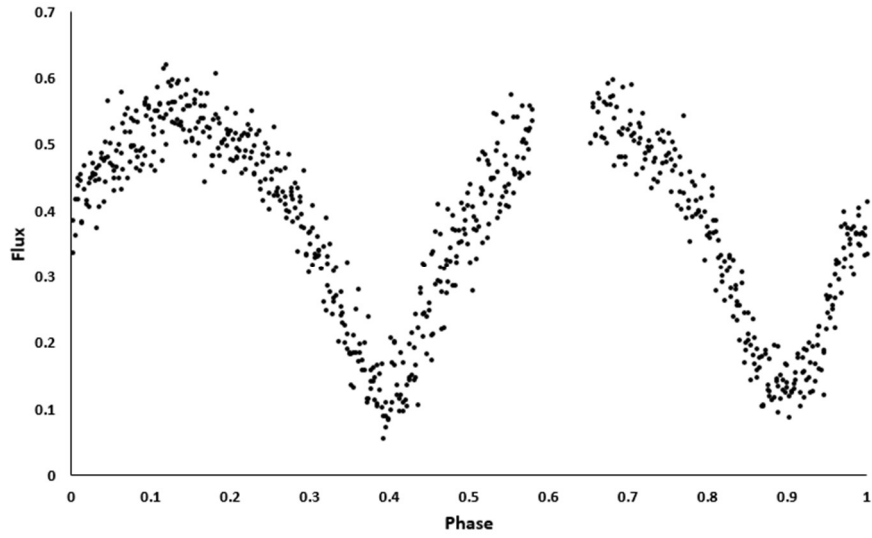


Figure 2. The light curve of V2545 Cyg

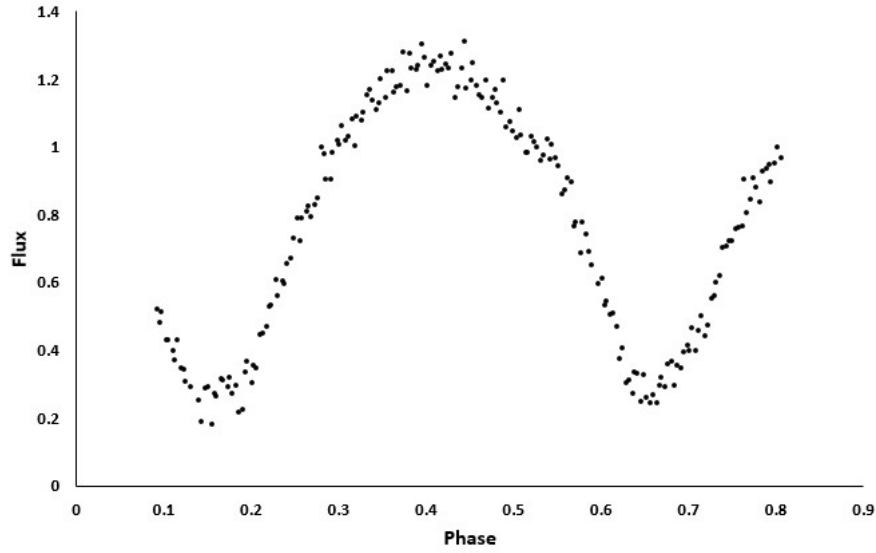


Figure 3. The light curve of V0402 Gem

Times of minimum

To determine the exact time of minimums through filter clear, the data were imported into the Table Curve software. Then by fitting a Gaussian curve, we get the minimum times. The results are given in Table 4.

Table 4. The new Times of minimum in the Clear filter

Star name	Min I (BJD_TDB)	Error Min I	Min II (BJD_TDB)	Error Min II
BZ Leo	2457844.433700	0.000297	2457844.567408	0.000277
V2545 Cyg	2457628.368276	0.000327	2457628.552307	0.000538
V0402 Gem	2458149.255420	0.000542	2458149.456591	0.000483

To calculation the new period, at first we should calculate epochs for each new minimum, so we have used Equation 1. In this equation, P (Period) and T_0 (ToM) is related to reference ephemeris (Table 3) and T is the new Time of Minimum. The results of this equation present in Table 5.

$$T = P \times E + T_0 \quad (1)$$

Table 5. The new epehmries of the stars

Star name	Min I (BJD_TDB)
BZ Leo	$2456052.381171 (\pm 0.000901) + 0.269725202 (\pm 0.000000198) \times E$
V2545 Cyg	$2453258.389491 (\pm 0.009495) + 0.369179725 (\pm 0.000000962) \times E$
V0402 Gem	$2451612.700600 (\pm 0.002596) + 0.399252387 (\pm 0.000000184) \times E$

To obtain a new period, we use the gradient of the diagram. The diagram contains previous ephemeris and calculations. They are given in Tables 6, 7 and 8.

Table 6. Other Observation's Information for BZ Leo

Min (BJD_TDB)	Min Type	Epoch	O-C	Observer / Reference
2455223.515190	I	-3073	-0.001817	Trnka J / OEJV 0137
2455223.652390	II	-3072.5	-0.004154	Trnka J / OEJV 0137
2456002.350379	II	-185.5	-0.006068	Lomoz F / OEJV 0160
2456002.479079	I	-185	0.000094	Lomoz F / OEJV 0160
2456052.378298	I	0	0.0	Trnka J / OEJV 0160
2457101.342160	I	3889	-0.003337	Lomoz F / OEJV 0179
2457101.478660	II	3889.5	-0.004974	Lomoz F / OEJV 0179
2457844.433700	I	6644	-0.002502	Lomoz F / This study
2457844.567408	II	6644.5	-0.001347	Lomoz F / This study

Table 7. Other Observation's Information for V2545 Cyg

Min (BJD_TDB)	Min Type	Epoch	O-C	Observer / Reference
2453226.467358	II	-86.5	0.011913	Zejda Miloslav / IBVS 5741
2453227.389758	I	-84	0.011363	Zejda Miloslav / IBVS 5741
2453228.498458	I	-81	0.012524	Zejda Miloslav / IBVS 5741
2453233.479958	II	-67.5	0.010098	Zejda Miloslav / IBVS 5741
2453257.480258	II	-2.5	0.013716	Pejcha O / IBVS 5645
2453258.399458	I	0	0.0	Pejcha O / IBVS 5645
2454646.461539	I	3760	-0.043718	Ehrenberger Roma / BRNO 035
2456535.356784	II	8876.5	-0.056535	Agerer Franz / BAV 0234
2456801.914487	II	9598.5	-0.046594	Nelson Robert / IBVS 6131
2456954.393788	II	10011.5	-0.038519	Raetz M / BAV 0241
2457332.456597	II	11035.5	-0.015749	Agerer Franz / BAV 0244
2457605.480292	I	11775	-0.000460	Smolka M. / BRNO 040
2457607.512292	II	11780.5	0.001050	Smolka M. / BRNO 040
2457608.435392	I	11783	0.001201	Smolka M. / BRNO 040
2457612.495692	I	11794	0.000524	Smolka M. / BRNO 040
2457627.448992	II	11834.5	0.002045	Smolka M. / BRNO 040
2457628.368276	I	11837	-0.001619	Smolka M. / This study
2457628.552307	II	11837.5	-0.002178	Smolka M. / This study

2457641.477992	II	11872.5	0.002296	Smolka M. / BRNO 040
2457905.460497	II	12587.5	0.001706	Agerer Franz / BAV 0247
2457966.561195	I	12753	0.002215	Agerer Franz / BAV 0247
2457988.348494	I	12812	0.021217	Agerer Franz / BAV 0247
2457988.529894	II	12812.5	0.022671	Agerer Franz / BAV 0247
2457991.489494	II	12820.5	0.028366	Walter F. / BRNO 041

Table 8. Other Observation's Information for V0402 Gem

Min (BJD_TDB)	Min Type	Epoch	O-C	Observer / Reference
2451612.703731	I	0	0.0	Otero Sebastian / OEJV 0091
2455533.954175	II	9821.5	0.036212	Diethelm Roger / IBVS 5960
2455538.943975	I	9834	0.035412	Diethelm Roger / IBVS 5960
2455842.976664	II	10595.5	0.040749	Nelson Robert / IBVS 6018
2457365.728693	II	14409.5	0.060906	Nelson Robert / IBVS 6164
2457385.292294	II	14458.5	0.061355	Agerer Franz / IBVS 6196
2457385.492394	I	14459	0.061831	Agerer Franz / IBVS 6196
2457780.353322	I	15448	0.066487	Urbanik M / OEJV 0194
2457800.315622	I	15498	0.066387	Mazanec J. / OEJV 0194
2457800.316422	I	15498	0.067187	Mazanec J. / OEJV 0194
2457800.316522	I	15498	0.067287	Mazanec J. / OEJV 0194
2457800.316622	I	15498	0.067387	Urbanik M / OEJV 0194
2457800.316722	I	15498	0.067487	Mazanec J. / OEJV 0194
2458095.561333	II	16237.5	0.068202	Urbanik M / OEJV 0194
2458149.255420	I	16372	0.063433	Nosal P / This study
2458149.456591	II	16372.5	0.064980	Nosal P / This study

To calculating O-C we used Equation 2, and the diagrams of the stars shown in Tables 5, 6 and 7.

$$O - C = (E - E') \times P_0 \quad (2)$$

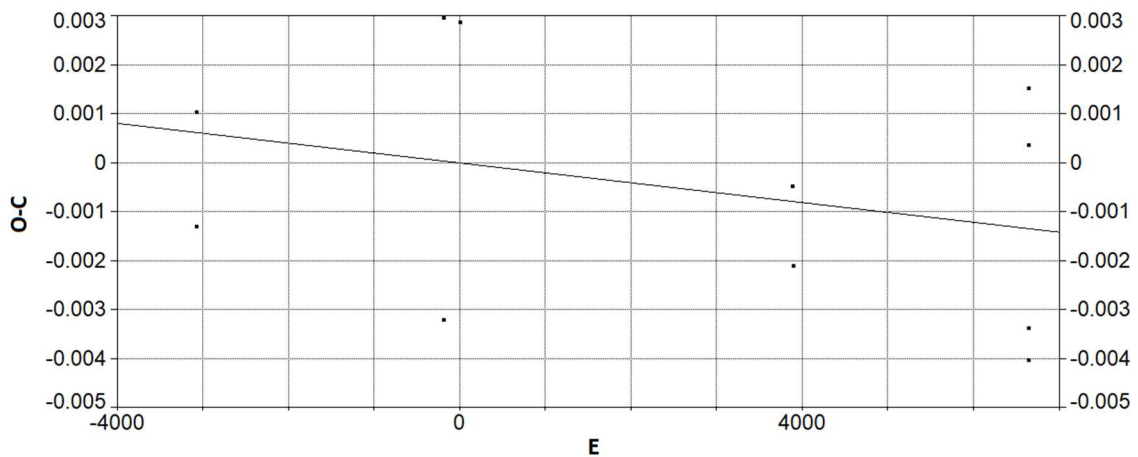


Figure 5. O-C Diagram of BZ Leo

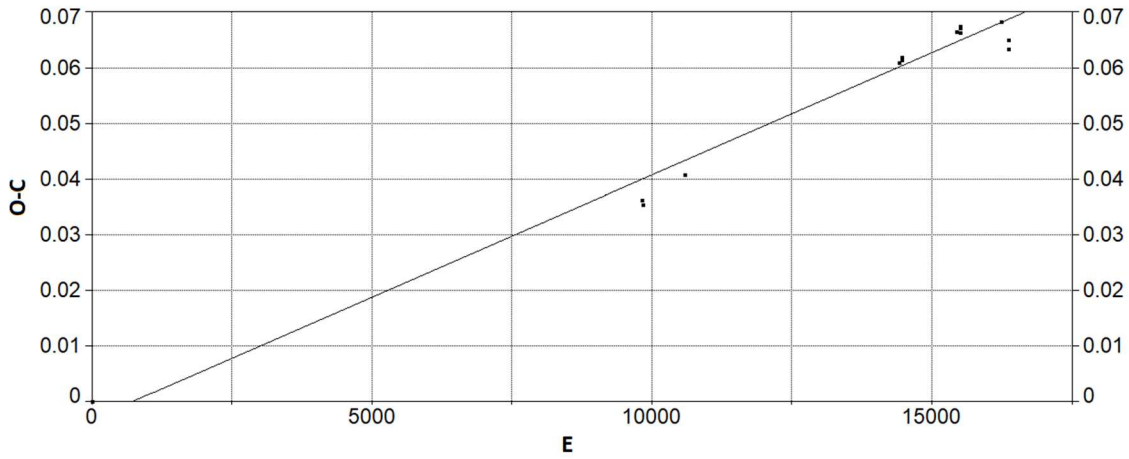


Figure 6. O-C Diagram of V0402 Gem

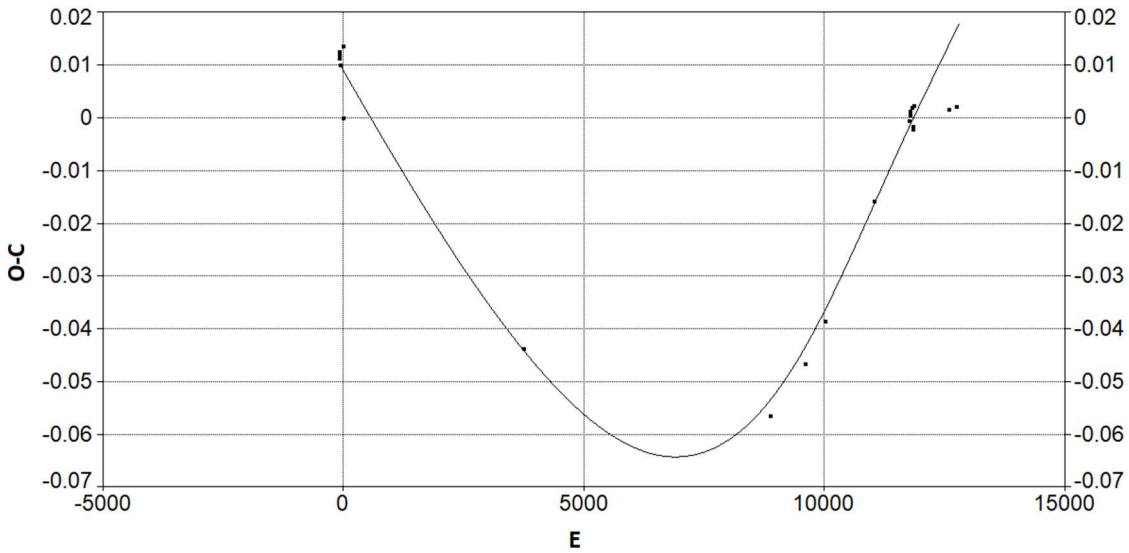


Figure 7. O-C Diagram of V2545 Cyg

According to the O-C diagram, the star V0402 Gem shows the positive slope of the fitted line indicates a smooth increase in the period, indicating that the period of the system is slightly longer than given by reference ephemeris. And for the star BZ Leo, the O-C diagram shows the negative slope of the fitted line indicates a smooth decrease in the period, indicating that the period of the system is slightly shorter than given by reference ephemeris. However, is hard to interpret this as an indication of a transit time variation. Many more Eclipse observations are needed to get the clear diagrams for these stars. According to the O-C diagram of V2545 Cyg, we see a parabolic chart that shows mass transferring between companions.

Conclusion

This paper's goal is to present the new ephemeris of three W Uma-type eclipsing binaries BZ Leo, V0402 Gem, and V2545 Cyg. All of these stars are overcontact binary because of deeps of light curves primary and secondary minimums. With this assumption, we can conclude that not seeing a parabola diagram may be due to the low number of observations for the BZ Leo and V0402 Gem stars. As can be seen, for the V2545 Cyg system the duration and number of observations, represent the parabolic graph and thus the mass transfer between companions.

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