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New Light Curves and Ephemeris of W UMa-type binary star BX Pegasi

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Abstract

In this article, the new light curve of W UMa type eclipsing binary star BX Peg is presented. The observations were made at the University of Kashan Observatory by DSLR camera method in Clear filter. The new light curve, times of minima and period were calculated, and finally, the O-C diagram was drawn by previous information and the new calculation in this project.

Keywords: Variable star, DSLR photometry, Period, W UMa

Introduction

W Ursae Majoris eclipsing variables type have a short period. These stars are close binaries of spectral types F, G, or K that share a common envelope of material and are thus in contact with one another. They are termed contact binaries because the two stars' touch and transfer mass through the connecting neck, although astronomer R.E. Wilson argues that the term "overcontact" is more appropriate (Wilson, 2001). In this type of v=eclipsing variable stars, the depths of the primary and secondary minima are almost equal or differ insignificantly. Light amplitudes are usually <0.8 mag in V. The components generally belong to spectral types F-G and later (F. Hosseini, 2015).

BX Peg (GSC 02197-01458) is an eclipsing binary of W UMa type with a short period 0.28 day. It is located in Pegasus constellation and its Spectral category is G4.5 D, and with magnitude range in V filter between 10.89 to 11.53.

The variable behavior of BX Peg was first discovered by Shapley and Hughes (1934) and thereafter studied by numerous investigators. In 1979 photoelectric light curves were presented by Zhai and Zhang (1979). In 1982, Hoffman published observations in V-B filters, and Kaluzny (1984) analyzed these observations with Rucinski's computing code. Then, Samec and Bookmyer (1987) observed this binary system with a photoelectric method in V and B filters. Later, some other observations were reported by Samec (1990), Samec and Hube (1991), Lee JW, et al. (2004 and 2009) presented CCD photometric observations and determined the period of this system. Alton (B. Alton, 2013) and Sakhaei (B. Sakhaei, 2016) are the present result of new CCD photometric observation and determined the ephemeris of this system.

In this article, the DSLR camera method was used for the observation part. In order to find the exact time of the light curve's minimums, we have imported the data range of the minimums into the software Table

Curve, and the exact times of them were determined. We were calculated a new ephemeris and a O-C diagram.

Observation

The photometry of the BX Peg binary system was carried out at the university of Kashan observatory located at Niasar, Kashan, Iran with geographical coordinates E 51° 8′ 26.9”, N 33° 58′ 19.3” and 1774 meters above the sea level. The applied equipment comprised of a Canon 6D DSLR camera and a 16" (406mm) f/10 Meade LX200-GPS telescope with an alt-azimuth mount. The observations were acquired over one night on third September 2019. Photography was started at 16:55′ to 23:59′(UTC). We took 269 photos in Clear filter during the observation time. Exposure time was 30 seconds and the ISO speed was 6400. The example photo and positions of variable star, comparison and reference are shown in figure 1. Specifications of variable, comparison and reference stars are shown in table 1. For data reduction was used with Maxim DL v.5. Finally, the light curve was obtained is shown in figure 2.

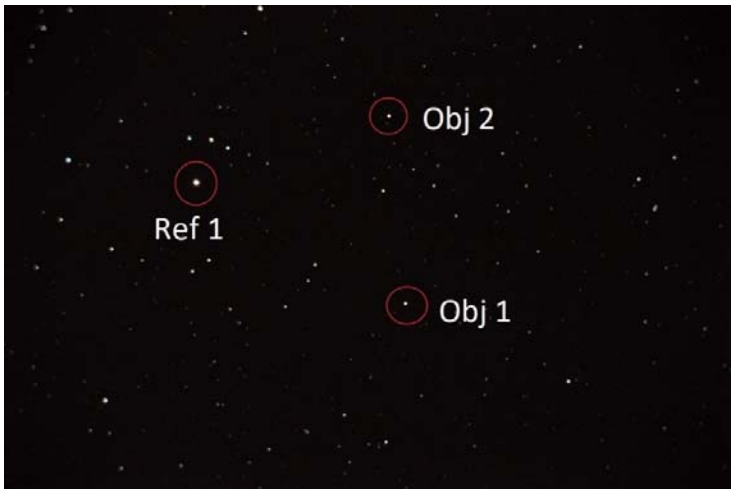

Figure 1. Sample photo and positions of the variable star (Obj 1), comparison (Obj 2) and reference (Ref 1)

Table 1. General specifications of variable, comparison and reference stars[1]

Specifications		Variable	Comparison	Reference
Star name		V* BX Peg	TYC 2197-1871-1	HD 206124
Star No. (GSC catalogue)		02197-01458	02197-01871	02197-01887
Mag (V)		10.890	11.70	8.37
ICRS Coord. (ep=J2000)	**RA**	21 38′ 49.3905754055′′	21 39′ 23.1833383332′′	21 39′ 25.9038784662′′
	DEC	+26° 41′ 34.205957391′′	+26° 44′ 02.795237038′′	+26° 35′ 29.022953125′′
Spectral type		G4.5 D	-	K0 D

[1] http://simbad.u-strasbg.fr/simbad/

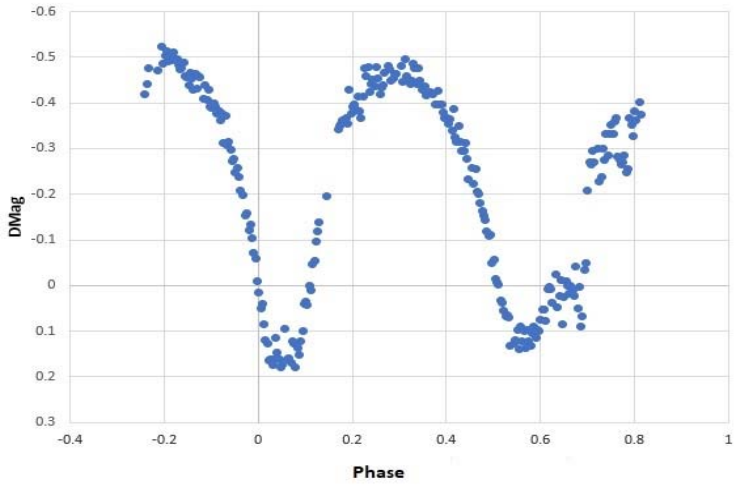

Figure 2. Light curve for BX Peg obtained with DSLR camera observations in Clear filter

The Times of Minima Computation

In order to plot the light curve, we converted time from Julian Date (JD) to Barycentric Julian Dates (BJD) by Time Utilities web site[2].

Finding the exact times of two minimums, done by fitting a Gaussian curve with using Table Curve software that shown in figure 3. Then we calculated the epochs of two minimums in order to find new ephemeris, based on the minimum I of B. Alton (2013) that shown in Equation 1.

$$\text{Min I (Hel.)} = 2455873.3958\ (8) + 0.2804\ (8)\ E \qquad (1)$$

We computed the new ephemeris, which is shown in Equation 2.

$$\text{Min I (BJD)} = 2458730.2931\ (\pm\ 0.000198) + 0.2804 \times E \qquad (2)$$

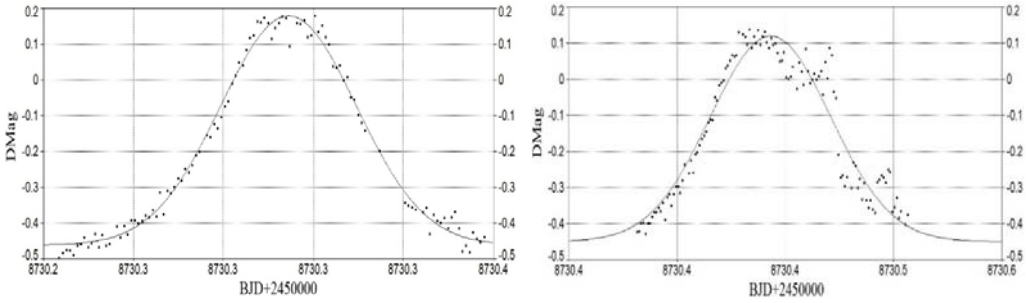

Figure 3. Calculating minimums and their errors by curve fitting

The O-C diagram was used to determine the variation of the system's period. We can also predict the next approximate period. This process is very important to comprehend the evolution of contact binary systems. The evolution of contact binary stars is very faster than other binary systems because they are contacted.

[2] http://astroutils.astronomy.ohio-state.edu/time/

We calculated the new epochs for first and second minimums and added them to the list of the previous observations obtained from the website of the American Association of Variable Star Observers (AAVSO)[3]; they are shown in table 2. Finally, a new calculated epoch and O-C with all other extracted from articles and reports were added to the O-C diagram that are shown in Figures 4 and 5.

Table 2. Parameters to plot O-C diagram

Epoch	O-C	Min type	Reference	Epoch	O-C	Min type	Reference
-83403.4208	-0.3984	II	HA 90.4	12780.4982	-0.0004	I	OEJV 0074
-60093.0492	-0.1540	II	IODE 4.2.288	12780.5154	0.0043	I	OEJV 0074
-60092.5428	-0.1522	I	IODE 4.2.288	12780.5278	0.0078	I	OEJV 0074
-47054.8345	-0.0938	II	AA 9.52	13282.9444	-0.0155	II	OEJV 0074
-47054.8309	-0.0928	II	AA 8.48	14074.9680	-0.0089	I	IBVS 5220
-47054.3638	-0.1020	I	AA 9.52	14132.4366	-0.0177	II	IBVS 5296
-47054.3352	-0.0940	I	AA 8.48	14160.9382	-0.0173	II	IBVS 5583
-47015.8250	-0.0911	II	AA 8.48	15301.8871	-0.0316	II	OEJV 0074
-47015.3472	-0.0973	I	AA 8.48	15301.8921	-0.0302	I	OEJV 0074
-45749.8030	-0.0849	II	AC 174.17	15440.9724	-0.0077	II	OEJV 0074
-45749.3145	-0.0882	I	AC 174.18	15444.4319	-0.0190	II	IBVS 5484
-24696.0628	-0.0176	II	BBSAG Bull...33	15462.4299	-0.0196	II	IBVS 5484
-15439.5144	-0.0040	II	AJ 100,808	15487.4783	-0.0060	I	OEJV 0074
-14190.5044	-0.0012	II	IBVS 2999	15501.4305	-0.0194	I	IBVS 5583
-11953.9761	0.0066	II	BRNO 26	15501.9329	-0.0188	II	IBVS 5583
-11879.0169	-0.0047	II	BAAVSS 59,16	16549.9249	-0.0210	I	IBVS 5443
-10694.9436	0.0158	II	BAAVSS 60,15	16549.9359	-0.0179	I	IBVS 5443
-10637.9932	0.0019	II	BAAVSS 60,15	16774.4277	-0.0202	II	IBVS 5657
-9275.9471	0.0148	II	BAAVSS 60,15	16802.9268	-0.0205	I	IBVS 5592
-9264.9742	0.0072	II	BAAVSS 60,15	16806.4291	-0.0198	II	IBVS 5643
-9161.9714	0.0080	II	BAV-M 38	16881.414	-0.0241	I	OEJV 0074
-9104.9781	0.0061	II	BAV-M 38	16903.9238	-0.0213	I	IBVS 5494
-8997.9780	0.0061	II	BAV-M 38	16904.4281	-0.0201	II	IBVS 5494
-7991.9627	0.0104	II	BAAVSS 61,14	16956.4227	-0.0216	II	IBVS 5643
-7959.9428	0.0160	II	BAAVSS 61,14	16963.4006	-0.0278	I	OEJV 0074
-5570.3747	0.0351	II	BRNO 28	16998.9206	-0.0222	II	OEJV 0074
-5570.3676	0.0371	II	BRNO 28	17052.4306	-0.0194	I	OEJV 0074
-5545.4442	0.0156	II	BRNO 28	17951.4195	-0.0225	I	IBVS 5668
-5545.4371	0.0176	II	BRNO 28	17954.9160	-0.0235	II	IBVS 5668
-5335.4301	0.0195	II	BRNO 28	17955.4182	-0.0229	II	Pribulla et al. (2005)
-5335.4087	0.0255	II	BRNO 28	17965.9156	-0.0236	I	Pribulla et al. (2005)
-5335.3873	0.0315	II	BRNO 28	17993.9169	-0.0232	II	IBVS 5668
-5244.4638	0.0101	II	IBVS 2999	17994.4155	-0.0236	II	Pribulla et al. (2005)
-5241.4576	0.0118	II	IBVS 2999	18008.4156	-0.0236	II	Pribulla et al. (2005)
-5157.4359	0.0179	II	BRNO 28	18022.4138	-0.0241	I	OEJV 0074
-5103.9482	0.0145	II	BBSAG Bull.79	18050.9162	-0.0234	I	Pribulla et al. (2005)
-4047.4410	0.0165	II	BAV-M 50	18051.4130	-0.0243	II	Pribulla et al. (2005)
-3987.4879	0.0033	II	BBSAG Bull.86	18065.4095	-0.0253	II	Pribulla et al. (2005)
-2853.4718	0.0078	II	BBSAG Bull.89	18065.9148	-0.0238	I	Pribulla et al. (2005)
-2828.3844	0.0324	II	BBSAG Bull.89	18101.3929	-0.0300	II	IBVS 5684
-2806.4672	0.0091	II	BRNO 30	18126.4060	-0.0263	II	IBVS 5657
60.5175	0.0049	II	IBVS 3582	18424.9087	-0.0256	I	IBVS 5653
182.0114	0.0032	I	IBVS 3581	18492.9101	-0.0252	I	Zejda et al. (2006)
12780.4833	-0.0046	I	OEJV 0074	19352.9061	-0.0263	II	IBVS 5731
12780.4858	-0.0039	I	OEJV 0074	19352.9061	-0.0263	II	IBVS 5731
19395.9096	-0.0253	II	IBVS 5731	20600.3955	-0.0292	II	Nagai (2007)

[3] https://www.aavso.org/bob-nelsons-o-c-files

19398.9077	-0.0258	II	OEJV 0074	20654.3979	-0.0286	I	IBVS 5761
19406.3990	-0.0283	I	OEJV 0074	20654.8950	-0.0294	II	IBVS 5761
19409.9056	-0.0264	II	OEJV 0074	20722.3986	-0.0284	II	IBVS 5746
19461.9026	-0.0273	I	Nagai (2006)	20746.9111	-0.0249	II	OEJV 0074
19462.4043	-0.0268	II	Nagai (2006)	20737.4011	-0.0277	I	IBVS 5843
19530.9045	-0.0267	II	OEJV 0074	20746.8919	-0.0303	II	IBVS 5761
19530.9057	-0.0264	II	IBVS 5731	20775.3895	-0.0309	I	OEJV 0074
19559.9047	-0.0267	II	IBVS 5731	20782.8916	-0.0304	II	IBVS 5761
19575.9015	-0.0276	I	Nagai (2006)	21771.3920	-0.0302	I	OEJV 0073
20518.893	-0.03	I	IBVS 5898	21834.8923	-0.0302	I	IBVS 5898
20599.8927	-0.0300	I	Nagai (2007)	21941.8906	-0.0306	II	OEJV 0074
21952.8921	-0.0302	II	OEJV 0074	21945.3873	-0.0316	I	OEJV 0074
22057.8930	-0.03	I	Nagai (2008)	21945.3896	-0.0309	I	OEJV 0074
22152.8961	-0.0291	I	JAVSO..36..171	21952.8910	-0.0305	II	OEJV 0074
27315.8407	-0.0446	II	OEJV 0160	27315.8410	-0.0445	II	OEJV 0160
27330.8393	-0.0450	I	JAVSO..40..975	25708.8650	-0.0378	I	IBVS 5960
27330.8393	-0.0450	I	JAVSO..40....1	27315.8385	-0.0452	II	OEJV 0160
27355.8408	-0.0446	I	JAVSO..40..975	22273.8884	-0.0312	I	JAVSO..36..171
27355.8408	-0.0446	I	JAVSO..40....1	23094.8847	-0.0323	I	JAVSO..36..186
27370.3473	-0.0428	II	IBVS 6011	23193.3833	-0.0327	II	IBVS 5898
27373.8378	-0.0454	I	IBVS 6011	23236.3889	-0.0311	II	IBVS 5898
28410.8381	-0.0453	I	IBVS 6084	23279.8863	-0.0318	I	JAVSO..36..186
28542.3383	-0.0453	I	IBVS 6084	23347.8852	-0.0321	I	JAVSO..37...44
28552.8369	-0.0457	II	IBVS 6044	23401.3839	-0.0325	II	Lee, 2009PASP..121.1366
28574.3390	-0.0451	I	IBVS 6084	23401.8827	-0.0328	I	Lee, 2009PASP..121.1366
28607.8406	-0.0446	I	JAVSO..41..122	23404.8823	-0.0329	I	Lee, 2009PASP..121.1366
28671.8330	-0.0468	I	IBVS 6042	23405.3843	-0.0324	II	Lee, 2009PASP..121.1366
28689.8339	-0.0465	I	IBVS 6042	23408.3841	-0.0324	II	Lee, 2009PASP..121.1366
29645.8398	-0.0449	I	JAVSO..41..328	23483.3838	-0.0325	II	Lee, 2009PASP..121.1366
29836.8304	-0.0475	II	OEJV 0160	23486.8811	-0.0333	I	Lee, 2009PASP..121.1366
29836.8423	-0.0442	II	OEJV 0160	23490.3841	-0.0324	II	Lee, 2009PASP..121.1366
29836.8428	-0.0440	II	OEJV 0160	23575.8821	-0.0330	I	Lee, 2009PASP..121.1366
29837.3463	-0.0430	I	OEJV 0160	23579.3830	-0.0328	II	Lee, 2009PASP..121.1366
29837.3465	-0.0430	I	OEJV 0160	24341.8702	-0.0363	II	OEJV 0137
29837.3470	-0.0428	I	OEJV 0160	24341.8702	-0.0363	II	OEJV 0137
29883.8437	-0.0438	I	JAVSO..41..328	24341.8713	-0.0360	II	OEJV 0137
30115.8481	-0.0425	I	JAVSO..42..426	24652.8677	-0.0370	I	JAVSO..38..183
31074.3540	-0.0409	I	OEJV 0168	24722.8611	-0.0389	I	JAVSO..38..183
31270.3378	-0.0454	I	IBVS 6167	24773.8797	-0.0337	I	IBVS 5920
32237.3312	-0.0473	I	IBVS 6167	24774.3665	-0.0374	II	IBVS 5920
24862.8704	-0.0363	I	JAVSO..38..183	**10188.0551**	**-0.0154**	**I**	**This paper**
				10188.5905	**0.0026**	**II**	**This paper**

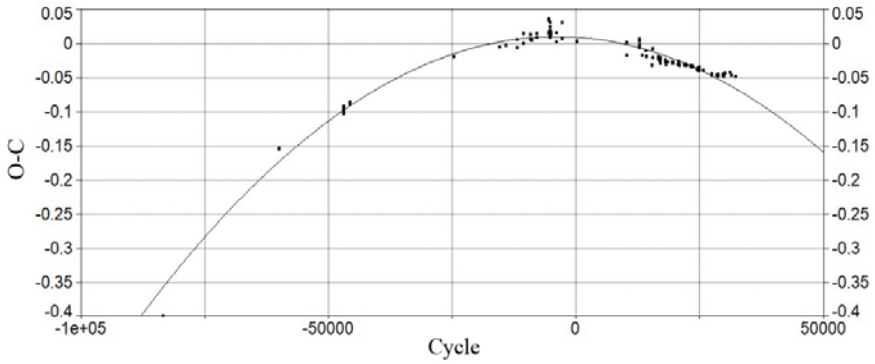

Figure 4. The O-C diagram of BX Peg binary system with a fitted

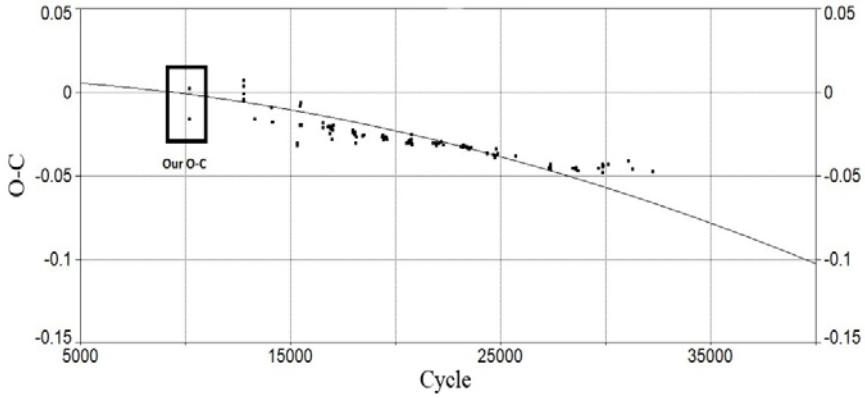

Figure 5. Showing new O-C calculated in this paper on the diagram

Conclusion

In this article, we studied the BX Peg W UMa type eclipsing binary star and its photometry by DSLR method that the new ephemeris was calculated and given in equation 2.

Therefore, we calculated the epochs for new minimums and added them to the list of the previous observations obtained from the website of the AAVSO. The corresponding O-C values and results were calculated and plotted in figures 4 and 5. It can be used to predict the minimum times for this binary system.

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