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Photometric study of contact binary star MW And

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ABSTRACT

The Tarleton Observatory's 0.8m telescope and CCD photometer were used to obtain 1298 observations of the short period eclipsing binary star MW And. The observations were obtained in Johnson's BVR filters. The light curves show that MW And is an eclipsing binary star with a period of 0.26376886 days. Further analysis showed that the period of MW And is changing at the rate of $0.17\,\mathrm{sec}/year$. The photometric solutions were obtained using the 2015 version of the Wilson-Devinney model. The solutions show that MW And is an eclipsing binary star of W UMa type. Our analysis suggests that the system has a light curve of W-subtype contact system. Its spectral type of K0/K1, as estimated from its color, places it in the Zero-Age contact zone of the period-spectral type diagram. Luminosity from the solutions indicates that it is a double-line spectroscopic system and therefore, spectroscopic observations are recommended for further detail study.

1. Introduction

W Ursae Majoris (W UMa) stars are short period eclipsing binary stars (EB) in which there is a common envelope around both stars due to overflowing Roche lobes of the stars. Inspection of All-Sky Survey data indicates that W UMa systems are very common (Malkov et al., 2006). Our understanding of their origin, structure, and evolution is vastly incomplete and as such, it has been difficult to develop a satisfactory theory for their occurrence. It is not known for sure whether the systems are born as Siamese twins or are formed from detached binaries through Angular Momentum Loss (AML) (Vilhu, 1981), or through Kozai Cycle because of a third component (Kozai, 1962). More work needs to be done in this respect (Paczyński et al., 2006). Their lifetimes are also not very well known and various numbers from 1.0 Gyr to >5.68 Gyr are quoted in literature by different authors (de Loore and Doom, 1992; Kraft, 1967). Observational data shows that the light curve of the W UMa can be classified either as an A-type system (primary minimum due to eclipse of the larger more massive component) or a W-type system (primary minimum due to eclipse of the smaller less massive component). It has been suggested that in W-type systems, the primary component is an un-evolved main-sequence star, with later spectral type, smaller mass, lower luminosity, larger mass ratio, and a thick common envelope, while in A-type systems the primary component is approaching terminal age of the main-sequence state with earlier spectral type, larger mass, higher luminosity, smaller mass ratio, and a shallow convective envelope. Further detailed discussion on A-type and W-type can be found in various literature (see for example Van Hamme, 1982; Hilditch et al., 1988; Rucinski, 1985), but in short, whether they originate from the same base system, or they form from one type to the other and what will be their final fate remain unanswered questions.

Data on well-determined parameters of W UMa systems are few and limited while there is no shortage of known W UMa systems from All-Sky Surveys. The problem is that for many of these systems, there is no detailed and comprehensive spectroscopic and photometric data available for the determination of absolute parameters. In addition, spectroscopic observations of faint systems, magnitude >14 require 1.5 m or larger telescopes, and considering that large telescope time is hard to secure for binary star work, it becomes much more important to first obtain photometry data to analyze the light curve and to obtain preliminary parameters of the binary system. For this reason, we have embarked on a project to obtain UBVRI photometry data on 14 and fainter magnitude W UMa systems.

In this paper, we present the photometric data analysis and modeling of MW And. The General Catalog of Variable Stars (GCVS) (Samus' et al., 2017) lists MW And as a possible W UMa contact system. SIMBAD (Wenger et al., 2000) search show that there are only eight references as of this writing. The available references (Drake et al., 2014; Paschke, 2012; Otero et al., 2006) discusses the light elements of MW And only and none contain detailed photometric and modeling analysis. The references contained therein also do not provide any further information about photometric parameters. No other literature review resulted in

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Table 1
Identification data for MW And.

Star	Identifier	B	V	R	α(2000)	δ(2000)
MW And	*GSC* 2836 − 1495	15.00	14.00	13.30	02 31 28.95	39 41 19.3
C1	*TYC* 2836 − 1736	12.98	12.49	–	02 31 38.95	39 38 51.09
C2	*TYC* 2836 − 1381	12.44	12.22	–	02 31 15.29	39 39 02.89

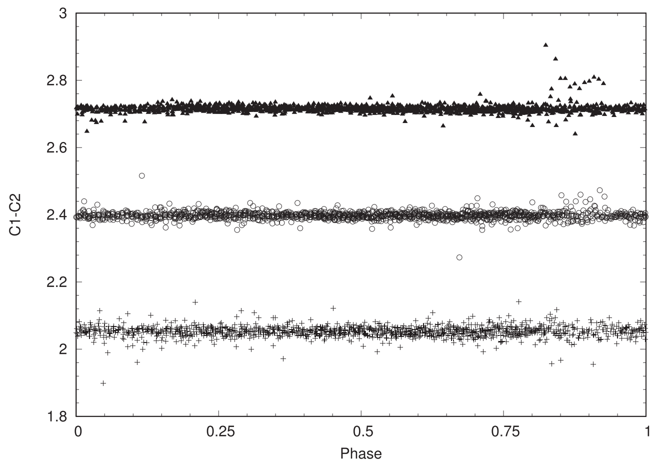

Fig. 1. The difference in constant stars magnitudes is plotted with phase. The triangle is B-filter whereas the hollow circle and + represents the V and R filters, respectively.

any additional information. Therefore, we selected this system in our list of targets to observe.

2. CCD photometry

The finder chart of the system can easily be obtained from SIMBAD. However, we present the GSC and Tycho catalog numbers, magnitudes, and coordinates of the target and constant stars respectively in Table 1. The constant stars are plotted with phase to check their variability in Fig. 1. The Tarleton Observatory's 0.8 m Ritchey–Chretien telescope was used to obtain 1298 observations in 15 nights, spanning four months from November, 2012 to February, 2013. Photometry data was obtained in B, V, and R band pass filters with the help of FLI CCD camera PL4240 that has a field of view of 0.282 degrees in 1 × 1 binning. The exposure time of 90 s, 30 s, and 10 s in B, V, and R band pass filter, respectively, provided best fits images. Heliocentric Julian Date (HJD) and magnitude data in B, V, and R band pass was derived from the observation nights using GCX photometric reduction software (Corlan, 2004) and Python scripts provided by Goderya at Tarleton Observatory. A sample set of the observed data is shown in Table 2.

3. Period analysis

Several previously published epoch of minima can be found, these are all listed in Table 3 with dates and references. The first light element was reported by Otero et al. (2006) and is shown in Eq. (1). A more precises value of the period is reported by Paschke (2012) and is shown in Eq. (2). The period in Eq. (2) is also published in the Catalina Sky Survey (Drake et al., 2014). One more light element can be found from the work of Bob Nelson (Nelson, 2011) and this is shown in Eq. (3). If we compare the period in Eqs. (1) and (2), we find the difference to be + 2×10^{-5} *days* (approximately 1.73 s), while the difference between the period in Eqs. (3) and (2) is − 6×10^{-7} *days* (or approximately − 0.052 s).

$$Min.\,(I) = H.\,J.\,D.\;\; 2451523.637 \; + \; 0^{d}.\,26375\,E \tag{1}$$

Table 2
Sample of observed data for MW And.

MJD[a]	B	*MJD*[a]	V	*MJD*[a]	R
6239.7765	1.9525	6239.7794	1.6520	6239.7799	1.4005
6239.7807	1.9880	6239.7816	1.6640	6239.7821	1.4235
....	......	....	......	....	......
6248.7053	2.0155	6248.7062	1.7045	6248.7067	1.4475
6248.7076	2.0050	6248.7085	1.6835	6248.7090	1.4465
....	......	....	......	....	......
6252.6667	1.9760	6252.6676	1.6755	6252.6681	1.4070
6252.6740	1.9415	6252.6749	1.6110	6252.6753	1.3805
....	......	....	......	....	......
6264.6583	2.0795	6264.6567	1.7845	6264.6572	1.5220
6264.6605	2.0430	6264.6592	1.7450	6264.6597	1.4680
....	......	....	......	....	......
6265.6446	2.0070	6265.6455	1.7195	6265.6460	1.4765
6265.6478	2.0605	6265.6487	1.7625	6265.6492	1.5150
....	......	....	......	....	......
6266.6392	1.9980	6266.6472	1.6755	6266.6477	1.4220
6266.6436	1.9870	6266.6494	1.6680	6266.6499	1.4030
....	......	....	......	....	......
6268.5569	2.1825	6268.5602	1.9330	6268.5628	1.7185
6268.5593	2.2140	6268.5624	1.9880	6268.5650	1.7810
....	......	....	......	....	......
6272.5612	2.5650	6272.6182	1.5780	6272.6209	1.3625
6272.6151	1.8925	6272.6204	1.6605	6272.6231	1.3675
....	......	....	......	....	......
6273.5486	1.9600	6273.5473	1.6420	6273.5499	1.4010
6273.5508	1.9865	6273.5495	1.6570	6273.5521	1.4270
....	......	....	......	....	......
6274.5428	2.1100	6274.5437	1.7975	6274.5465	1.5125
6274.5451	2.0895	6274.5461	1.7950	6274.5487	1.4845
....	......	....	......	....	......
6279.5646	2.0100	6279.5632	1.7075	6279.5659	1.4485
6279.5668	2.0180	6279.5655	1.7055	6279.5681	1.4085
....	......	....	......	....	......
6310.5617	1.9950	6310.5550	1.6770	6310.5630	1.4360
6310.5638	1.9585	6310.5567	1.6420	6310.5652	1.4370
....	......	....	......	....	......
6311.5375	2.0290	6311.5384	1.7120	6311.5496	1.5740
6311.5439	2.0985	6311.5448	1.8025	6311.5518	1.6125
....	......	....	......	....	......
6328.5997	2.4080	6328.5979	2.1115	6328.6060	1.7115
6328.6024	2.3720	6328.6006	2.0680	6328.6082	1.6695
....	......	....	......	....	......
6330.5907	2.2125	6330.5892	1.9245	6330.5965	1.5405
6330.5929	2.1745	6330.5916	1.8815	6330.5987	1.5160

[a] H.J.D = MJD + 2450000.0000

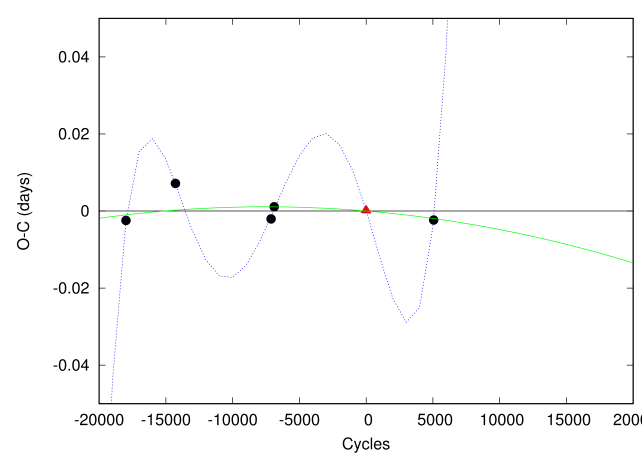

Fig. 2. O-C plot in Kwee and van Woerden algorithm. The red triangle represents the observed values in V-filter. The filled circles represents the literature values and the green curve is quadratic fit for which the values are listed in Table 3. The blue dotted curve represents fifth order correction. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)