Period Change and Third Body Analysis of a Binary Star V523 Cassiopeiae

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Period Change and Third Body Analysis of a Binary Star V523 Cassiopeiae

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Abstract. V523 Cassiopeiae (V523 Cas) is a W UMa type of the eclipsing binary system which its orbital period is 0.23369 days. This study using a 0.5-meter telescope with CCD photometric system in V and R filters was conducted at the Regional Observatory for the Public, Chachoengsao, Thailand during 20 – 21 December 2018, UT. The obtained data were calculated using photometry method to construct the light curve of each wavelength bands and to determine the time of minimum. Consequently this study obtained the time of minimum of V523 Cas that HJD2458472.996 and HJD2458473.111, respectively. These values were used to compute the O-C curve and period change. The results show that the period of the V523 Cas is increasing which the rate of 5.59×10^{-3} second/year. Furthermore, the V523 Cas might be the third body in its system which far from the center of mass about 6.04 AU the orbital period is 91.3 years.

1. Introduction

The short-period binary V523 Cas is a W UMa type of the eclipsing binary system which R.A. 00h 40m 06.27s and Dec. $+50^0$ 14' 15.52" [9]. The orbital period is around 0.2336933 day and the visual magnitude is 10.91 [2]. This system was classified in K5 spectral type [1]. The period changes of V 523 Cas is increasing [5] which a rate of $dP/dt = 8.84\times10^{-8}$ day/year [6]. In 2004, Samec et.al, suggested that V523 Cas is a three-star system and forecasted the mass of a third star is about 0.41 Solar mass [4]. In this research, the period change (O-C) in this study were analyzed and explained their evolution.

2. Experimental

V523 Cas was observed 20 – 21 December 2018, UT at the Regional Observatory for the Public, Chachoengsao, Thailand. The 0.7 - meter reflecting telescope and CCD with the standard visual (V) and red (R) filters of the UBV system were used. The photometry was analyzed that the observational light curve of V523 Cas in V and R wavelength bandwidth are showed in Figure 1 and Figure2, respectively. The times of minimum light were calculated and used in the O-C diagram to compute their period change and forecast the third body in this system.

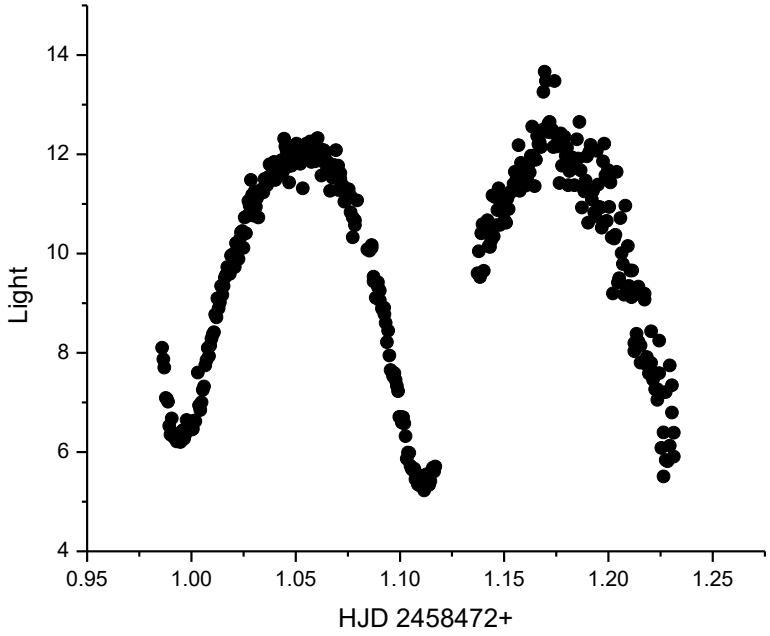

Figure 1. The light curve of V523 Cas in V filter.

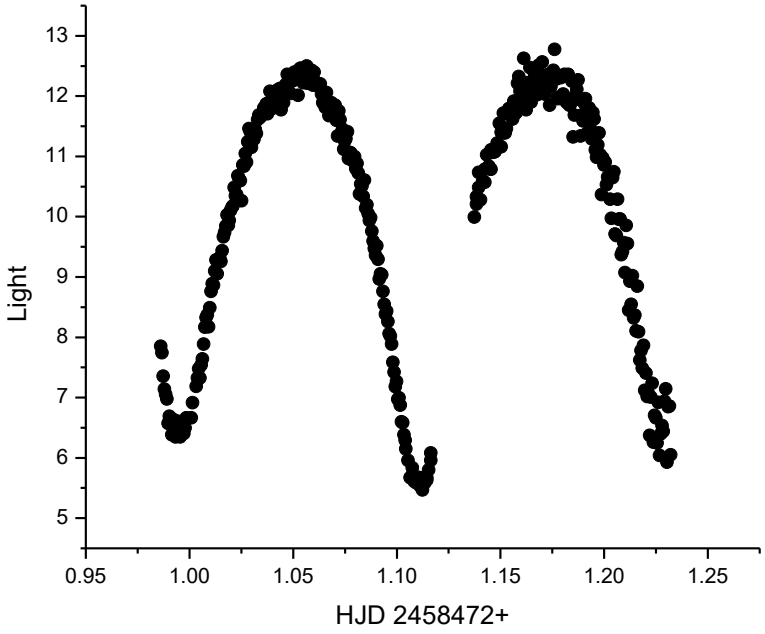

Figure 2. The light curve of V523 Cas in R filter.

3. Results and Discussion

The time of minimum light from the V523 Cas light curve was determined and constructed the O-C diagram. It derived from the linear ephemeris equation obtained from the Database of Eclipsing Binary O-C Files by Bob Nelson, AAVSO [7] as follows:

$$\text{HJD Min} = 2452500.109 + 0.23369471E \quad (1)$$

When HJD Min is the photoelectric times of the minimum light,
and E is the epochs of the minimum light.

In this observation, the light curves were calculated the times of minimum light that are the secondary and primary eclipses as shown Table 1.

Table 1. The O-C values of the V523 Cas from this observation.

HJD Min	Type of Minimum	Epoch	O-C
2458472.996	secondary	73826.5	0.127554
2458473.111	primary	73827	0.125696

The O-C values in this research from table 1 combined with the values from another astronomers in the past were fitted by Quadratic Polynomial Fitting Method as shown in Figure 3 [7,8].

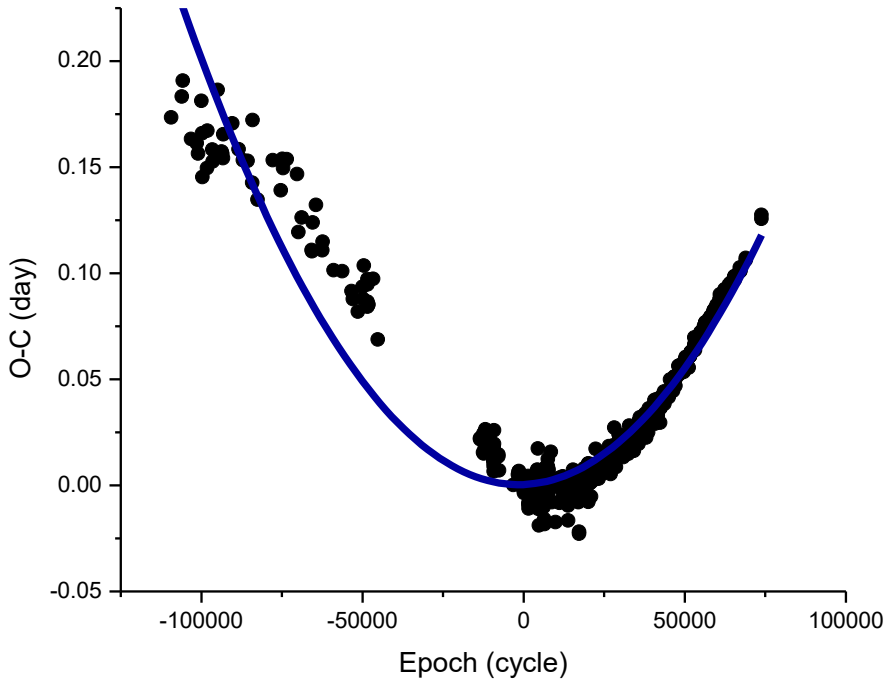

Figure 3. O-C Diagram of the V523 Cas.

The O-C diagram in Figure 3 shows that the increasing period change of the binary system V523 Cas. The best solution to the quadratic ephemeris is shown as follows:

$$\text{O-C} = 2.07\times10^{-11}\text{E}^2 + 6.24\times10^{-8}\text{E} + 0.000393 \quad (2)$$

The quadratic ephemeris equation shows that the value of the period change (dP/dE) in this binary system V523 Cas is $2 \times (2.07 \times 10^{-11})$ day/cycle. That means the period is increased changing

continuously by approximately 5.59 × 10^{-3} second/year. Beside of this relation, there are the periodic oscillation in the diagram as shown in Fig 4.

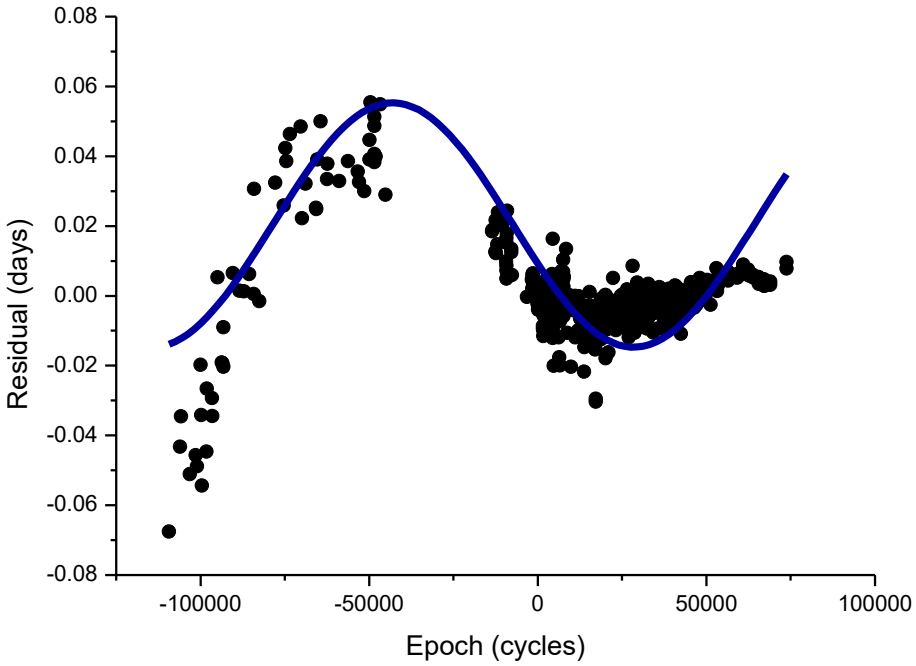

Figure 4. Residual of the V523 Cas.

Figure 4 shows the sinusoidal changing of the residual. The best solution to the periodic oscillation is shown as follows:

$$\text{Residual} = 0.02028 + 0.035 \sin\left(\pi \frac{\text{E - 64095.28113}}{71385.63049}\right) \quad (3)$$

From the relation, we found that the V523 Cas has a third body in the system. The computation shoes that distance of the third body is 3.63 AU far from the center of mass and the orbital period is 90.3 years. The mass can be calculated by the relation as follows:

$$f(m) = \frac{m_3^3}{(m_1 + m_2 + m_3)^2} \sin^3 i' = \frac{1}{P'^2} (a' \sin i')^3 \quad (4)$$

When m_1, m_2 and m_3 are the mass of the first, the second and the third star, respectively,

i' is the inclination,

a' is the distance of the third body from the binary system

and P' is the orbital period of the third body.

In 2009, O. Latkovic, M. Zboril and G. Djurasevic computed the masses of the 2 stars in the V523 Cas are 0.78 and 0.4 Solar mass [3]. If the orbital of the third body is circle, the mass of the third body is 0.4 Solar mass.

4. Conclusion

The eclipsing binary system V523 Cas was observed on 20 – 21 December 2018 at the Regional Observatory for the Public, Chachoengsao, Thailand and was analyzed at Faculty of Science and Technology, Chiang Mai Rajabhat University, Chiang Mai, Thailand. In this research, the O-C diagram and the solution of the period change as shown in Figure 5. The solution shows that

$$\text{O-C} = 2.07\times10^{-11}\text{E}^2 + 6.24\times10^{-8}\text{E} + 0.000393$$

$$+ 0.02028 + 0.035 \sin\left(\pi\frac{\text{E - 64095.28113}}{71385.63049}\right) \quad (5)$$

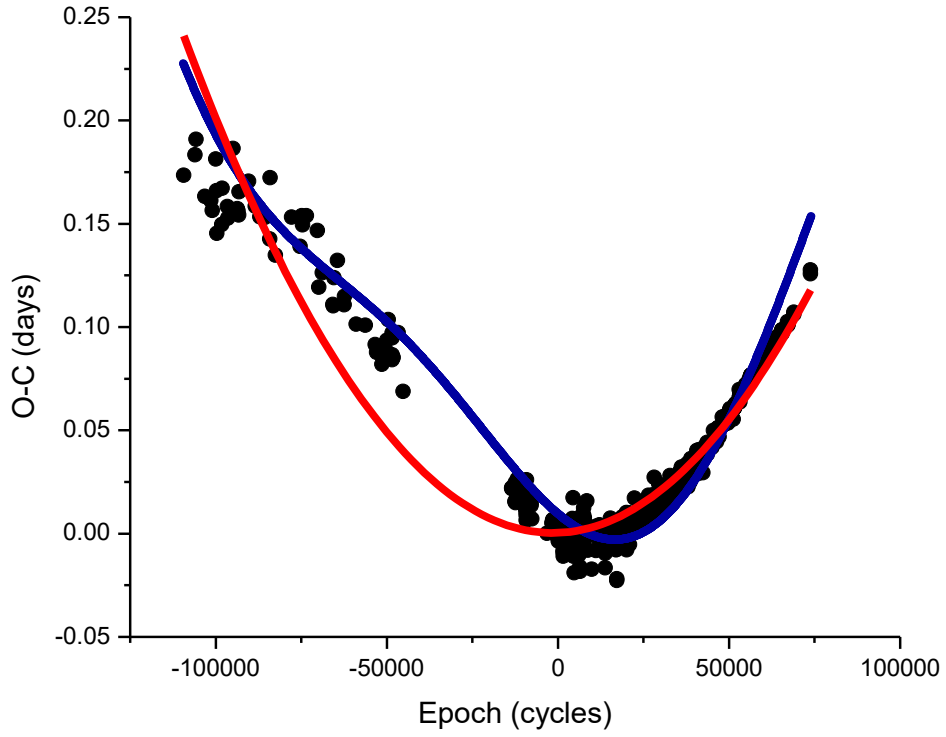

Figure 5. The O-C diagram and the solution for a binary system V523 Cas.

The O-C diagram and the solution show that the period of V523 Cas is increasing which the rate about 5.59×10^{-3} second/year. In addition, the values in this diagram is variance between near-contact binary system and contact binary system that corresponding to the Thermal Relaxation Oscillation (TRO) theory. It explains about the binary system evolution when the orbital period is increasing. Furthermore, the calculation found that their orbital periods has a sinusoidal oscillation that means a third body in this binary system witch an orbital period is about 91.3 years, and the distance from the center of mass of the binary system is about 6.04 AU. Finally, if we assume the third body is a circular orbit that we can calculate its mass is 0.4 Solar mass.

5. Acknowledgment
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6. References
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