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Research article

W UMa-type Light-Curve Analysis V700 Cyg Binary Star

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Abstract: V700 Cyg is a W Ursae Majoris (W UMa)-type contact binary star located in the constellation Cygnus. Photometric observations were conducted using a 0.7-meter reflecting telescope equipped with a CCD photometric system and *B* and *V* filters at the Regional Observatory for the Public, Songkhla, operated by the National Astronomical Research Institute of Thailand (Public Organization), during the night of August 6–7, 2021. The observational data were analyzed using the Wilson-Devinney method to generate a synthetic light curve that best represents the physical properties of the system. The results indicate that the effective temperatures of the primary and secondary components are 7692 K and 6078 K, respectively, with a mass ratio (q) of 2.98 and a degree of contact of 3.48%.

Keywords: V700 Cyg; W UMa-type star; Wilson-Devinney technique

1. Introduction

W Ursae Majoris-type (W UMa-type) contact binaries are close binary systems in which both stars share a common envelope, allowing continuous mass and energy exchange. These systems exhibit smooth, characteristic light curves, making them excellent subjects for studying stellar evolution and interactions in tight orbits [1-3]. We can learn about the physical characteristics of distant stars that are impossible to study directly by employing physically motivated light-curve modeling, such as the Wilson–Devinney models, that can infer otherwise inaccessible stellar parameters [4-6]. The V700 Cyg is a W-subtype contact binary star system. It was analyzed by using CCD imaging and the Wilson–Devinney model, and concluded that the system might be a triple system [7]. The Spot-induced asymmetry, similar to that seen in V700 Cyg [8], has been modeled in other W UMa systems, such as V523 Cas [9], which motivates our adoption of a spot hypothesis in the present analysis.

We selected V700 Cyg because existing solutions were obtained at earlier epochs, which leaves open the question of whether its spot configuration and contact degree persist. Additionally, its relatively large mass ratio and shallow contact make it a valuable test-bed for energy transfer in W-subtype systems. The target is also accessible from our site, enabling a dense phase coverage for an independent BV solution. According to the SIMBAD Astronomical Database [10], V700 Cyg, located in the constellation Cygnus, is a W-subtype W UMa contact binary. Its equatorial coordinates are Right Ascension (R.A.) = 20h 31m 05.247 s and Declination (Dec.) = +38° 47′ 00.461 ″ (J2000). In such systems, the less massive star is paradoxically hotter than its more massive companion. Studying these binaries provides key insights into mass transfer mechanisms and the internal dynamics of short-period binary stars.

To analyze the observed light curves of contact binaries, we employed the Wilson–Devinney (WD) model, which remains the standard tool for light-curve synthesis. The WD code numerically solves the geometry of close binary systems under a Roche potential, allowing for the simultaneous adjustment of orbital inclination, temperature ratio, mass ratio, surface potentials, and luminosities of the components, as well as spot parameters if required. It incorporates physical effects such as limb darkening, gravity darkening, and reflection, thereby enabling realistic modeling of distorted stellar shapes and mutual irradiation. Since its original formulation [4], the WD code has undergone significant updates and refinements [5, 11-14], making it widely applicable to detached, semi-detached, and contact binaries. By citing and utilizing this framework, our analysis of V700 Cyg builds upon a robust and well-established foundation.

In this study, photometric data of V700 Cyg aims to determine the physical parameters using the Wilson-Devinney (WD) code, a widely used tool for modeling eclipsing binary systems.

2. Materials and Methods

Photometric observations of V700 Cyg were conducted on the night of August 6–7, 2021, using a 0.7-meter reflecting telescope equipped with an Apogee Altra U42 CCD camera and *B* and *V* filters of the standard *UBV* Johnson system. The observations were carried out at the Regional Observatory for the Public, Songkhla, operated by the National Astronomical Research Institute of Thailand (Public Organization). The V700 Cyg photograph and its information [10], as shown in Figure 1 and Table 1, respectively.

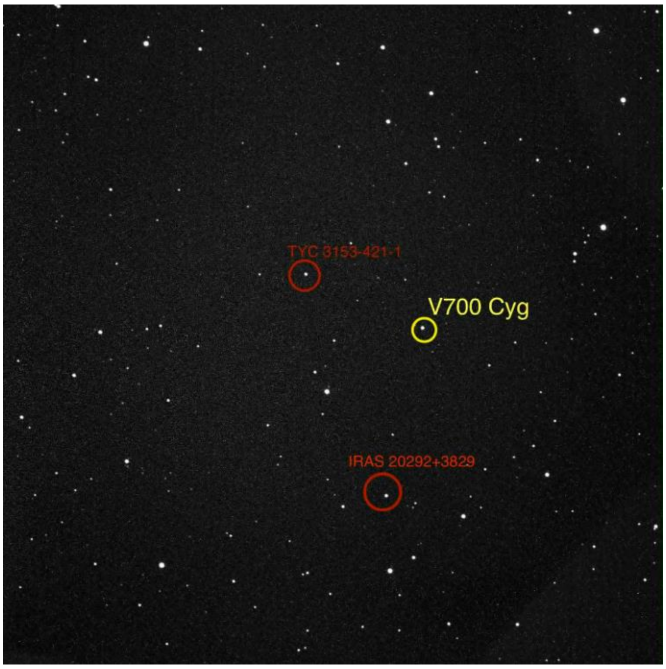

Figure 1. Photograph of the V700 Cyg

Table 1. Information of the V700 Cyg

Star	R.A. (h m s)	Dec (° ′ ″)	Magnitude *V*
V700 Cyg	20 31 05.247	+38 47 00.461	11.14
IRAS 20292+3829 (comparison)	20 31 10.959	+38 40 12.966	10.54
TYC 3153-421-1 (check)	20 31 29.629	+38 48 52.992	12.17

The image processing and photometric analysis were performed using MaxIm DL software. This observation was made in a partly cloudy and nearly clear sky. However, the V700 Cyg was observed in *the B* *filter with an exposure time of 60 seconds and the V filter with an exposure time of* 50 seconds each. The data were collected, consisting of 176 pictures in the B filter and 181 pictures in the *V* filter. Furthermore, the noise reduction must use the dark, bias, and flat at the same time of observation too. The analysis began with the determination of the mass ratio ($q = m_2/m_1$) between the secondary and primary components. A range of trial mass ratios from 0.1 to 3.0 was systematically tested to identify the value that minimized the residuals between the observed and synthetic light curves.

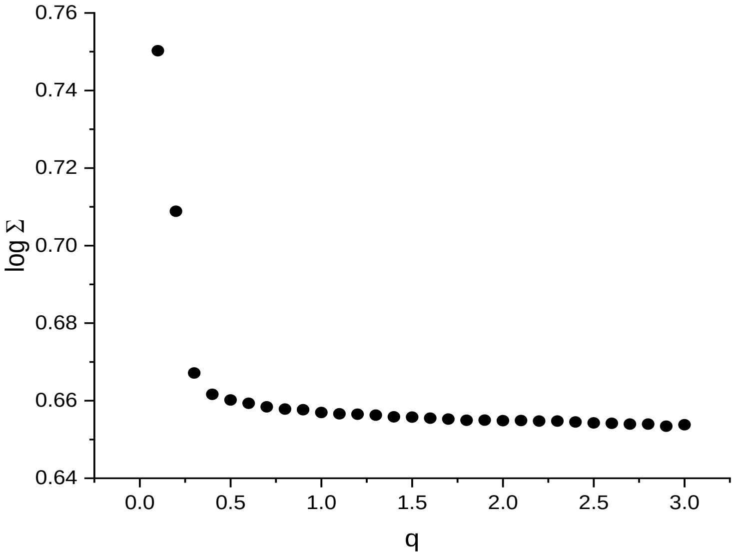

Figure 2. Variance of the mass ratio q of the V700 Cyg

Figure 2 illustrates that the optimal solution was obtained at q = 2.9, as shown in Figure 1, which presents the relationship between the mass ratio and the corresponding sum of squared residuals (Σ). This value served as a reference point for further modeling of the system's physical parameters.

3. Results and Discussion

The photometric data of V700 Cyg were analyzed using the Wilson-Devinney (WD) code to generate synthetic light curves, which were compared with observational data. The resulting light curve is presented in Figure 2, where the red line represents the theoretical model and the black dots denote observed data points. The overall shape and depth of the eclipses confirm that V700 Cyg is an eclipsing binary system of the W UMa type. According to Kim & Jeong (2012) [15], the optimal solution obtained from the light curve modeling is summarized; the orbital inclination of the system is approximately 79.9°. In the present study, the effective temperature of the primary component (T_1) was found to be 7692 K, and that of the secondary component (T_2) was 6078 K. The system's mass ratio was determined to be q = 2.984. These results are similar to the q 2.54028 from Liao, Qian, and Liu (2012) [8], but differ from those of Ostadnezhad, Forozani, and Ghanaatian (2019) [16], who reported a mass ratio of 0.544, indicating potential evolutionary processes such as mass transfer. The gravity darkening coefficients for both the primary and secondary components ($g_1 = g_2 = 0.32$) and the bolometric albedos ($A_1 = A_2 = 0.5$) suggest that both stars possess convective envelopes. The degree of contact was found to be 3.48%, indicating a shallow contact configuration. The best solution and the synthetic light curve of V700 Cyg are shown in Table 2 and Figure 3, respectively.

Table 2. Parameter for simulate the V700 Cyg

Parameter	The Best Solution
i	74.30 ± 1.79
g_1	0.32
g_2	0.32
$\Omega_1 = \Omega_2$	6.446986 ± 0.073870
Ωin	6.595188
Ωout	2.334606
T_1 (K)	7692 ± 239
T_2 (K)	6078
A_1	0.50
A_2	0.50
q	2.984122 ± 0.064080
$L_1/(L_1+L_2)_B$	0.54235 ± 0.02918
$L_1/(L_1+L_2)_V$	0.48928 ± 0.02026
Degree of Contact (%)	3.48
Lat $(spot)_2$ (degree)	62
Long $(spot)_2$ (degree)	90
R $(spot)_2$ (degree)	18
T.E. $(spot)_2$ (percent)	0.75

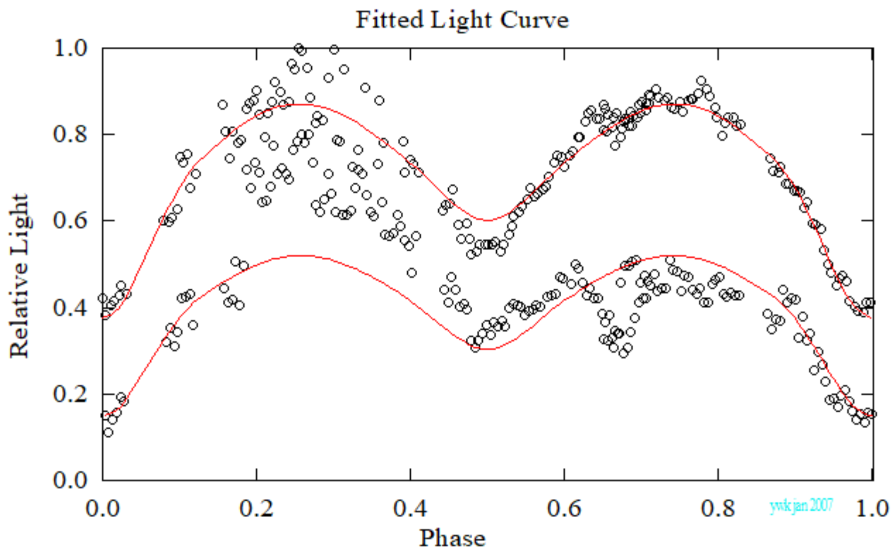

Figure 3. Synthetic light curve of the V700 Cyg.

Figure 3 shows an asymmetry between the two maxima of the light curve; maximum I (at phase ~0.25) is brighter than maximum II (at phase ~0.75). This phenomenon is known as the O'Connell effect. The phenomenon occurs exclusively in interacting close binary star systems, which may result from starspots on one or both components, hotspots caused by mass transfer, or the collision of circumstellar material with the stars during orbit [17]. Alternatively, the O'Connell effect is not a result of a static structure but rather a transient thermal variation on the stellar surface. This variation is correlated with the binary's orbit, causing an asymmetry in the system's brightness [18]. This interpretation is consistent with the findings of Ostadnezhad, Forozani, and Ghanaatian [16], who modeled a similar asymmetry in the *BVR* light curves of V700 Cyg by introducing a cold spot on the secondary component. The best parameters from Table 2 present the derived physical parameters used for simulation, such as the orbital inclination, effective temperature, mass ratio, and spot characteristics. These parameters were utilized to construct the three-dimensional configuration of the binary system, as depicted in Figure 4.

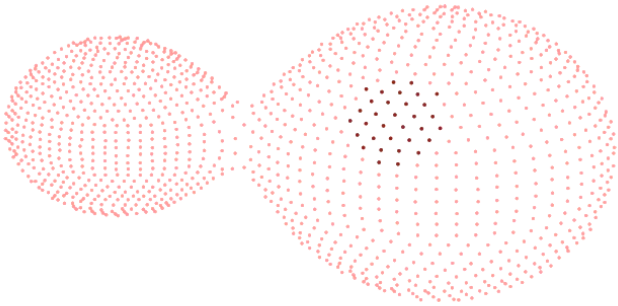

Figure 4. The V700 Cyg model at the orbital phase 0.2.

4. Conclusions

The physical and orbital parameters of the W UMa-type contact binary system V700 Cyg were determined using photometric data obtained on August 6–7, 2021, from the Regional Observatory for the Public in Songkhla, operated by the National Astronomical Research Institute of Thailand (Public Organization). The analysis, carried out using the Wilson-Devinney method, revealed that the system has a mass ratio of 2.984 and a contact degree of 3.48%, indicating a shallow-contact configuration. The primary and secondary components exhibit effective temperatures of 7692 K and 6078 K, respectively. Additionally, the presence of a cool spot with a radius of approximately 18 degrees on the surface of the secondary star was inferred to account for the observed O'Connell effect.

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