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# Investigation Light Curve Analysis for Short Period Eclipsing Binary CN Andromeda

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## ABSTRACT

In this article research, drawing and analyzing the light curve of short period binary (SPB) star CN Andromeda (CN And) with B, V, R, and I. Light curve fitting and results for the trajectory parameters of the CN And were obtained and compared with those obtained by previous works. The author will determine the size, luminosity and masse of the Individual star as well as the orbital size and orientation of the binary system. Also calculate the bolometric magnitude, reflection coefficient and absolute parameters for short period binary star. These coefficients are needed when analyzing light curves for eclipsing binary stars analyzed to facilitate getting numerical values for their relative and absolute characteristics. Some parameters are also fixed or calculated during light curve modeling. The graph of the dimmer binary luminosity in one complete orbital period is known as light curve. Furthermore, calculating the bolometric magnitude, reflection coefficients, armpit, and absolute parameters for CN, and these terms are very important for understanding the properties of CN And.

**Keywords:** Absolute parameter, bolometric magnitude, light curve, photometric analysis and binary star CN Andromeda

## INTRODUCTION

The majority of star systems are multi or binary star (BS) ones. Some portions of binary system has two stars that is enough apart to allow for the resolution of the individual stars. The eclipsing binary (EB) is made up of two stars whose orbits cause them to alternately obscure one another from Earth's perspective. Any periodic change over time relates to the redistribution for an object between the stars when the system loses or gains angular momentum. The period decreases, or if the vas versa appears, the period increases.[8,10,13] The evolution of eclipsing binaries light curves (LC), or magnitude versus time analysis, produces more accurate data thanks to ongoing improvements in observational techniques.[9,16] Since the early 20$^{th}$ century, significant efforts have been made to develop LC, to find and understand these systems. This has been inspired by the finding of transiting extrasolar planets. Evaluating for BS. Processing of transfer, mass lose, and angular momentum loss. They are sometimes called by W UMa type EB, because their LC is shaped and described. These systems' orbital durations typically range from 0.1 to 2 days, and the component mass ratios are typically between 0.1 and 0.5.[11,17,20] Form these points, the LC is very important for studying the CN And.

It is impressive how precisely the basic physical features can be identified. The masses and diameters of stars are frequently known with >1% accuracy. Although their masses may differ for various reasons, most contact binaries have eclipse depths in the LC that are typically equal because both components have almost the same surface temperature shows in Figure 1.[18,21]

Photometric plates were used as detectors in the initial surveys.[5,7] For several reasons, the study of close BS is interesting. For instance, one of the fundamental objectives of stellar astronomy is to comprehend the structure and evolution of stars. The BS is crucial to our galaxy's ongoing effort to comprehend the cosmos and its elements.[24,27] BS is particularly significant, since they are the major and most comprehensive source of information on the basic characteristics of stars: (Mass, size, radii, luminosities, velocities, separation distance, period,… etc.), and extra homes may be determined by understanding these homes supply information approximately stars whose proximity outcomes research them. A light curve is a graph of intensity through the years. One of these graphs is made using counting the number of photons coming from a supply over some time.[19,29] The importance of the LC, studying LC of EB

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to decide their houses, is a fundamental effect which ought to be allowed while reading the light curve of EB. The evolution of a star depends almost entirely on its mass and chemical composition.[3,31] The light and radial velocity curves were analyzed simultaneously using Wilson-Devinney 1971 (W-D) code to derive the optical and physical measurements of the BS components.[12,25] The discovery of transits of extra solar planets earlier this century has spurred considerable efforts to generate very high-quality LC that can be used to explore and study planets. This system instruments, observation methods, and analyzing data techniques were improved to now detect lunar eclipses to a depth of 600 ppm on individual goals.[14,35] In 1949 astronomer Hoffmeister discovered CN Andromeda (CN And), first reporting for exhibits β Lyr-like light variations. In 1956, Tsesevich found it's an Algol-like binary for periodic orbit 2,599 days. In 1976, Bozkurt reported asymmetric changes for light curve B and V. In 1996, Bozkurt found strongly emission X-ray of main system. Van Hamme proposed LC analyzing in 2001. In 2005, spectral types for components proposed by Zola are in the range F5-G5. In 2010, Rucinski announced recently radial velocities and LC analyzing for system, the variation of periodic orbit for CN And. Also, LC in the B, G, R, and I filters of CN And published. In 2015, Koju and Beaky illustrated system cycle variation and O'Connell effect. Maxted in 2016 describe flexible LC model. In 2017, Yilmaz studied LC and orbital period analysis of VX LAC. Menon in 2020 details evolutionary model for massive contact BSs. For extending these works, investigation LC analysis for CN And.

## THE IMPORTANT INFORMATION ABOUT CN AND BS

Third suspected component of the system is a red dwarf with a mass of about 0.1100 M⊙, at 38 ± 4 years' the orbit around the binary. The variability of the star CN And (BD = +39059, GSC = 2787 – 1815, PPM = 42831, TYC 2787 – 1815-1, RA = 00 h 20 m 30.60 s, Dec = +40 13 m 33.8 s spectral type F5V near contact was observed by Hoffmeister in 1949.[29] Based on the image data[15,32] classified the system as an Algol-like binary Skelton and Smits classified, it as a W UMa-like system.[23,32] The information about BS CN And for the first and second stars is very important, the period of CN Andromeda is 0.46279 days and contains in Table 1. Its eclipse depths differ by some 0.3000 mages in V. it is also an active solar-type binary with components of spectral type in the F5 to G5 range. For the first star, we have the following information $M_1$ = 1.4330, $R_1$=1.4800, $L_1$=3.400 and $T_1$=6450. Furthermore, for the second star, the following information exist $M_2$=0.5520, $R_2$=0.9500, $L_2$=0.4000, and $T_2$=4726.

The CN Andromeda has been observed by many authors and the V band light curve of CN Andromeda shows in Figure 2.[33,34] In this work, we study the phenomenon known as the dark coefficient and its relationship to the BS system shows in Figure 3, an approach that lies within atmospheric studies. In addition, we selected a CN And star using filters (B, G, R, and I), and for each star, a certain temperature was used, as indicated by the program Van Hamme, as well as the darkness of the limbs as well as the reflection effect.

## THE LIGHT CURVE MODEL

The profundities of the essential and auxiliary minimums within the orbital LC are distinctively demonstrating that the

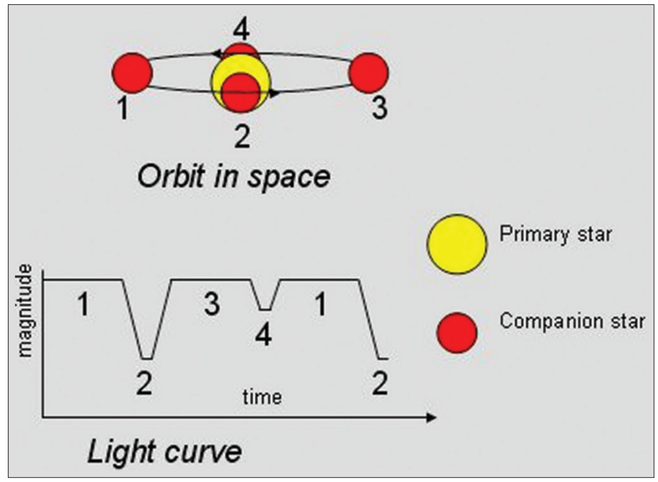


**Figure 1:** Shows LC for binary star system[8]

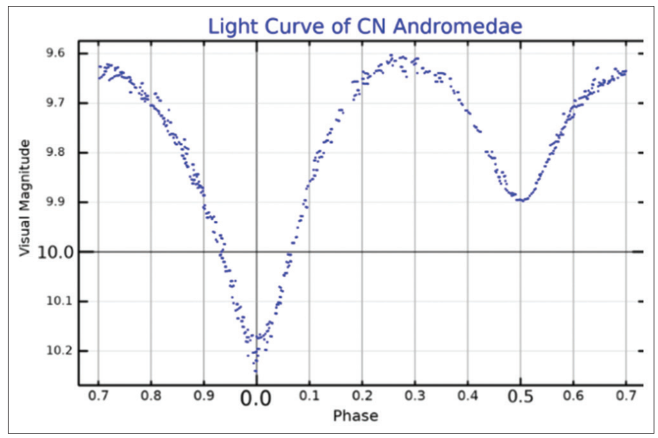


**Figure 2:** The V band light curve of CN And

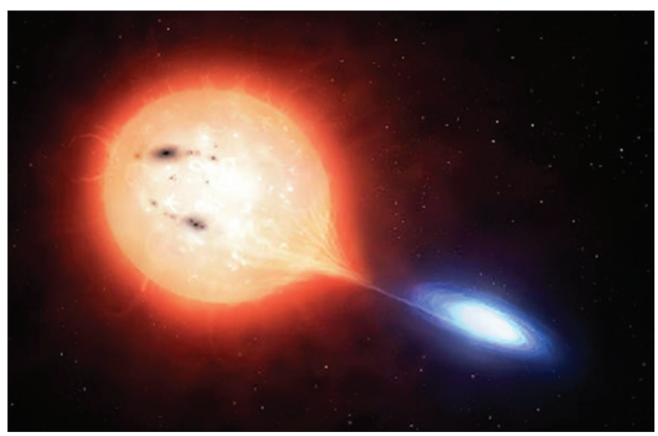

**Figure 3:** Cataclysmic BS photograph for CN And

temperatures of the two stars, although similar, they are the difference. For this reason, the attempt to model the system as W UMa with thermally exposed components failed. The foundation for the bright fringe analysis was created using W-D's composite light fringe and differential correction program in 1971 adjusted by Wilson (1979) to incorporate the spiral speed. The overhauled form of the program utilized (May 2003 form) incorporates the expansion of round pixels and Kurucz's demonstrate atmosphere, it adjusts the LC to bandwidth standard rather than the effective wavelength dimming. By studying this curve, a large number of fundamental astrophysical quantities can be determined in LC analysis. Illustrating the LC shown in Figure 5, the choice of LD rules is restricted to those implemented in the light curve codec we are using. It is important to generate results for several coefficients of difference to determine their effect on the solution.

## THE PHOTOMETRIC ANALYSIS OF CN AND

In arrange to decide, the photometric and geometric parameters to analysis, an overhauled adaptation of the W-D program was utilized, consolidating the expansion of photosphere focuses and altering the LC at diverse transfer speeds. Introductory values were gotten from distributed LC arrangements. After numerous tests, we have determined a set of parameters that are representative of the observed LC shows in Figure 6. The parameters adopted in the solution are as takes after: the temperature of first star is 6150K, the value of LD coefficients ($x_1$=$x_2$=0.4860) for V, 0.589 for B, 0.401 for R, and 0.475 for I bands), the value of the gravity-darkening coefficients ($g_1$=$g_2$=0.320), the esteem of the Albedo ($A_1$=$A_2$=0.50).[1,6,33] The tuning parameters utilized are orbital slant (i), normal temperature of the moment star ($T_1$) the possibilities of the components $\Omega_1$ and $\Omega_2$, as well as the monochromatic. The tuning parameters used are orbital inclination (i), mass ratio (q), average temperature of the second star ($T_2$) the potentials of the components ($\Omega_1$ and $\Omega_2$), as well as the monochromatic luminosity for first star ($L_1$). Fitting for calculating LC is stamped with strong lines in Figure 4 in V, B, R, and I bands. The photometric parameters are recorded in Tables 2 and 3. The LC within the show do not coordinate the watched information wells close the 0.2500 phase. For solving these, LC is as follows. Since there is asymmetry in the height of the CN And insulation curve and in each band as seen in Figure 5, the second maximum is the brightest point, for coming up with the aim that main half of the curve. Insulation is disturbed by a cool place. Let the 0.500–1.000 phase is unaffected by the point, at the same time, only 0.5 of the isolation curve is adjusted to produce binary parameters.

Where $\Omega_1$ and $\Omega_2$ are surfaces potential components, $C_1$ and $C_2$ are potential components, $f_1$ and $f_2$ are fill out of the major and minor stars components, and $L_1$ and $L_1$ are absolute parameters for component in the unit of solar Luminosity's.

## THE ABSOLUTE PARAMETERS OF CN AND

Flux for the star is the total amount of energy intercepted by the detector divided by the area of the detector, and the unit of flux is (Joule/meter$^2$). For determining the absolute parameters of CN And using equations (2) to (5), contains in references.[4,5] Utilizing Matlab program for calculating the parameters and recording in Table 4.

$$A^3 = 74.5p^2(m_1 + m_2). \quad (1)$$

$$R_1 = Ar_1\ ,\ R_2 = Ar_2 \quad (2)$$

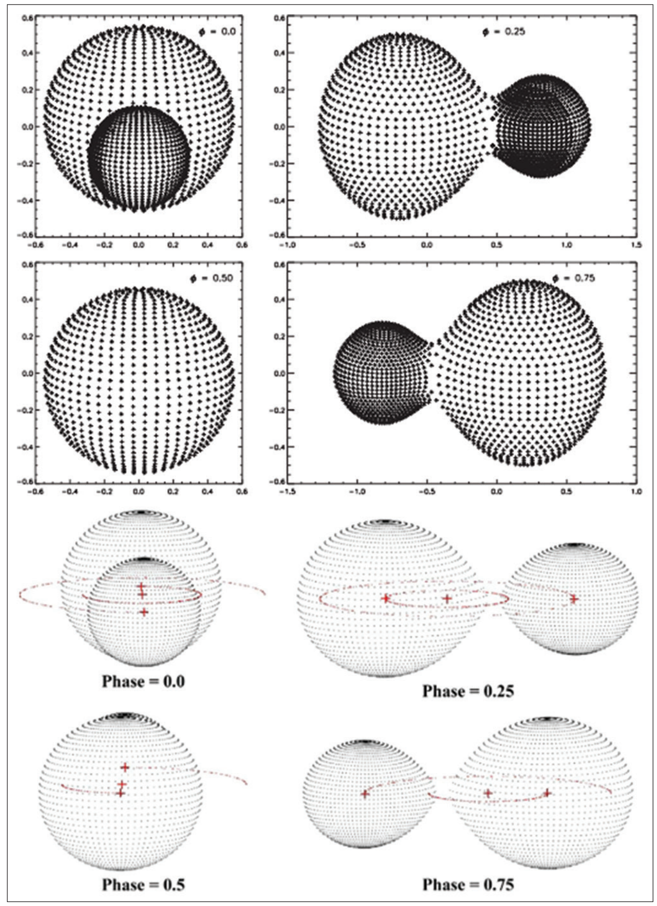


**Figure 4:** Gometrically of CN And created by PHOEBE at stages 0.00, 0.25, 0.50, and 0.75 individually

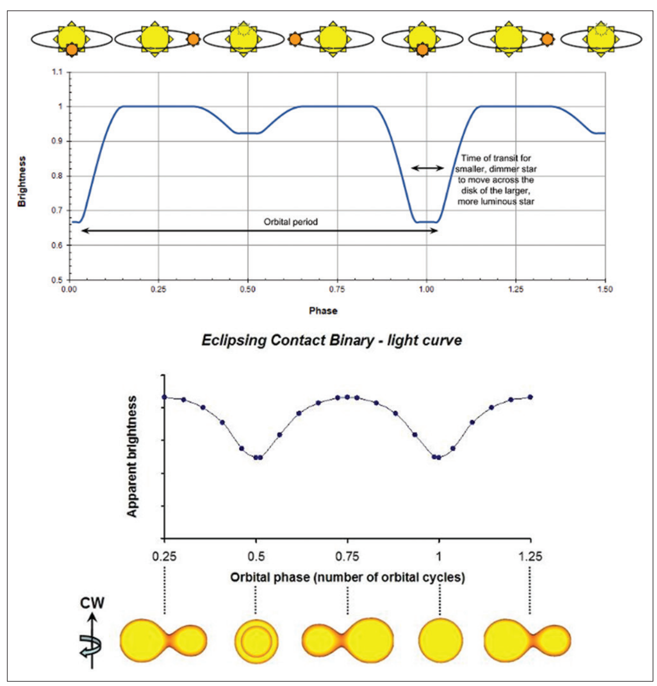


**Figure 5:** Descripts plot LC of eclipsing contact binary for CN And, one much brighter than the other

**Table 1:** The coordinates of the equator and the equinox 2000, HD, and BD NO. For the short-lived binary (SP) star of (SQR) as used in the present work

| BS | Period day | BH | Eclipse depth | Binary orbit | RM | | | Dec. | | | Spectral type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | H | M | S | Deg | M | S | |
| CN And | 0.462796 | +3959 | 0.3000 | $1.50\times10^{-7}$ | 00 | 20 | 30.55 | +40 | 13 | 33.8 | F |

**Table 2:** The output parameters for CN And

| Numbers | The output parameters | |
|---|---|---|
| 1 | Lagrangian $L_1$=3.3982 | Lagrangian $L_2$=0.3973 |
| 2 | C inner=3.901906 | C outer=3.559725 |
| 3 | $C_1$=3.901119 | $C_2$=3.901120 |
| 4 | surface area one=2.733721 | surface area two=1.145659 |
| 5 | $\Omega_1$=2.65400 | $\Omega_1$=2.65400 |
| 6 | $\Omega_{inner}$=2.654547 | $\Omega_{outer}$=2.416986 |
| 7 | $r_1$ (back)= 0.491417 | $r_2$ (back) = 0.325067 |
| 8 | $r_1$ (side) = 0.464739 | $r_2$ (side) = 0.292310 |
| 9 | $r_1$ (pole)= 0.435205 | $r_2$ (pole) = 0.280430 |
| 10 | mean radius one=0.463787 | mean radius two=0.299264 |
| 11 | $f_1$=0.002310 | $f_1$=0.002310 |

**Table 3:** LC fitting components of CN And

| Parameters | star one | star two |
|---|---|---|
| Surface Potential Ω | 2.654001 | 2.654001 |
| Limb Darkening | 0.8061 | 0.8329 |
| Reflection | 1.4328 | 0.9497 |
| Temperature | 6451.00 | 5376.00 |
| Gravity Darkening | 0.3210 | 0.3210 |
| Distance of Separation | 9.6201 | |
| Orbital Inclination | 68.5099 | |
| Mass Ratio $\left(\frac{M_2}{M_1}\right)$ | 0.38520 | |
| Period of orbit | 0.4627 | |

$$L_1 = R_1^2 T_1^4 \text{ , } L_2 = R_2^2 T_2^4 \tag{3}$$

$$M_1 = \frac{M}{1+q}, \tag{4}$$

$$M_2 = \frac{M_1}{1+q}, \tag{5}$$

$$F = \frac{(\Omega_{inner} - \Omega_{1,2})}{(\Omega_{inner} - \Omega_{outer})} \tag{6}$$

## THE BOLOMETRIC MAGNITUDES – $M_{BOL1}$ AND $M_{BOL2}$

The astronomer Allen in (1976) constructed this relationship for computing the parameters.[2]

$$M_{bol1} = 42.3600 - \log(T_1) - 5\log(\frac{R_1}{R_0}) \tag{7}$$

$$M_{bol2} = 42.3600 - \log(T_2) - 5\log(\frac{R_2}{R_0}) \tag{8}$$

The formulas of equations (7) and (8) used for compute the Bolometric Magnitudes (BM), Utilizing Matlab program for calculating the parameters and recorded in Table 5 the radius of the sun is $R_0 = 69570000m$. The present work shows the suitable armpit parameters for SP binary systems.

$$g_1 = \frac{c_2}{4\lambda T_1[1 - e^{(\frac{c_2}{\lambda T_1})}]} \tag{9}$$

$$g_2 = \frac{c_2}{4\lambda T_2[1 - e^{(\frac{c_2}{\lambda T_2})}]} \tag{10}$$

Computing the reflection coefficients using these equations.

$$E_{eff1} = t_1(T_2)^4 \frac{e^{(\frac{c_2}{\lambda T_2 - 1})}}{T_1(\frac{c_2}{\lambda T_1 - 1})} \tag{11}$$

$$E_{eff2} = t_2(T_1)^4 \frac{e^{(\frac{c_2}{\lambda T_1 - 1})}}{T_2(\frac{c_2}{\lambda T_2 - 1})} \tag{12}$$

## THE LC FROM PRESENT OBSERVATIONS

The LC of CN And in V, B, I, and R bands was showed in Figure 4. A round for phasing = 0.00 and nearly flat for phasing = 0.50 primary eclipse was observed, which is total eclipsing configuration for system. Primarily, eclipse is clearly deeper than for secondary eclipse. The contrast between essential and auxiliary minima ranges in greatness from 0.260 to 0.300 in groups V, B, I, and R. Then, the most least is more profound and happens when the hotter star passing behind cooler star. The shallower auxiliary least happens when the cooler star takes after the hotter star.

The distinction between the essential greatest stage = 0.250 and the essential greatest. The minimum magnitude is about 0.460, 0.480, 0.480, and 0.500, magnitudes in I, V, R, and B bands. The different between secondary maximum phase = 0.750 and secondary minimum ranges from 0.230 to 0.240 magnitude for I, V, R, and B bands. In the W UMa type system, because the two stars are so closer together, there

**Table 4:** Current work in relation to other research works

| The name of star | $M_{bol1}$ | $M_{bol1}$ | $M_{bol1}$ | $M_{bol1}$ | $M_{bol1}$ | $M_{bol1}$ | $M_{bol1}$ |
|---|---|---|---|---|---|---|---|
| CN And binary star | 1.4301 (2) | 0.9200 (1) | 1.3002 (5) | 0.5101 (2) | - | - | Van Hamme in 2001 |
| | 1.47998 (2) | 0.9402 (1) | 1.41989 (1) | 0.5602 (3) | 3.5199 (8) | 0.9980 (35) | Prˇsa, A. in 2005 |
| | 1.4801 (4) | 0.9499 | 1.43298 (31) | 0.5520 (2) | 3.4003 | 0.4003 | Siwak in 2010 |
| | 1.4774 (2) | 0.95003 | 1.4125 (2) | 0.54775 (3) | 3.5294 | 0.8753 | Awadalla in 2016. |
| | 1.4502 (2) | 0.9401 (1) | 1.4003 (3) | 0.54997 (2) | 3.4102 (8) | 0.9304 (5) | Muhammed In 2019 |
| | 1.3451 (2) | 0.8733 (4) | 1.2457 (3) | 0.4951 (2) | 3.1885 | 0.6441 (3) | Helen in 2020. |
| | 1.4782 (3) | 0.9456 | 1.4456 (2) | 0.5497 | 3.3982 (4) | 0.3973 | Present work (2022) |

**Table 5:** Subparameters adjusted for active short period of CN And

| CN And Pass bands | $M_{bol1}$ | $M_{bol1}$ | $g_1$ | $g_2$ | $E_{eff1}$ | $E_{eff2}$ |
|---|---|---|---|---|---|---|
| B | 0.58897 | 0.58897 | 0.87849 | 0.99329 | 6.32448 | 5.59357 |
| V | 0.48602 | 0.486011 | 0.81779 | 0.93449 | 6.79388 | 5.94547 |
| R | 0.40099 | 0.40099 | 0.76771 | 0.88572 | 7.23628 | 6.27219 |
| I | 0.47524 | 0.47524 | 0.78553 | 0.90321 | 7.12423 | 6.13827 |

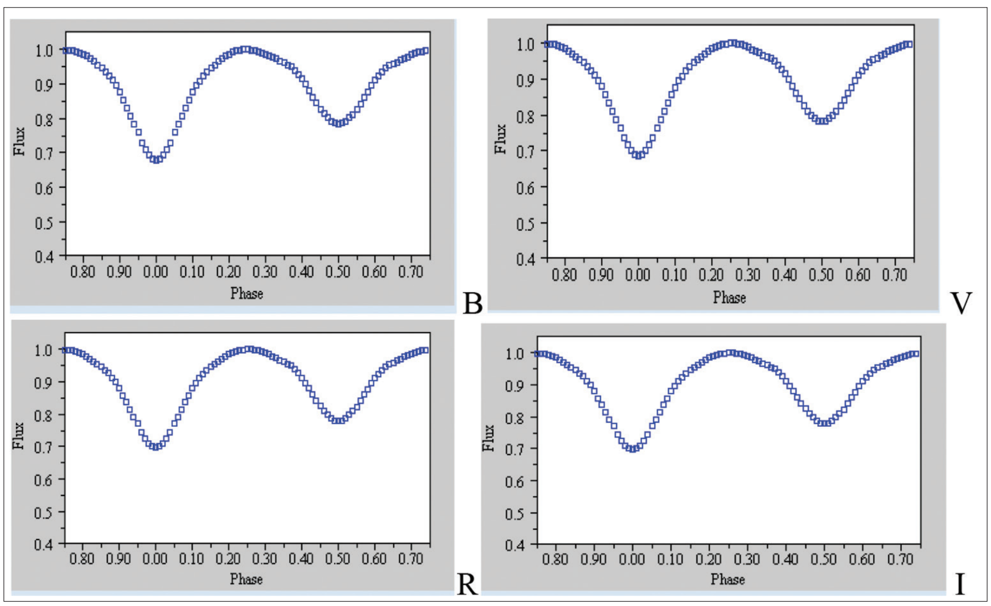


**Figure 6:** LC fitting for V, B, R, and I filter for CN And, respectively

exist constant light variation in addition to lunar eclipses. In addition, the stars will suffer from gravitational distortion and heating effects. These effects show the asymmetric LC of the W UMa type system. The watched LC of CN And were found to be deviated around the essential and auxiliary crests, with the auxiliary top being brighter than the essential. The distinction in adequacy between stage at 0.750, brighter, and stage at 0.250 shifts from 0.0390 to 0.04100 mag in groups V, B, I, and R. This can be more often than not clarified by the nearness of stains on binary system components. This indicates that the LC of CN And show the O'Connell effect.

## CONCLUSIONS

From this study, the evolution of LC photometric observations for binary CN And is discussed, photometric arrangements have been gotten by solving V, B, R, and I. The absolute parameters and BM coefficients are computed for it. When modeling BS LC, ATLAS stellar atmosphere models calculations should be used rather than Al-Naimiys calculations,[4,7] which were based on Carbon and Gingerich models in 1969,[4,7] concluding the following points:-

1. It is need to conduct additional observations of the system using 1000 m telescopes. With optimum mass ratio of q = 0.306000. Binary may well be an A-type over contact BS, agreeing to the current photometric arrangement in Tables 3 and 4. The mass ratio is relatively close to the indicator-derived spectroscopic is 0.325000.
2. There is small variation between parameters when comparing it with the others related published work in the same area. Mentioned in Tables 4 and 5.

3. That spin up at a rate around 100 times faster than the sun, indicating a significant level of magnetic activity. The current LC will be imply that the spots have vanished, symmetry, and volatility light curves are markers of spot activity.
4. Form the results appear that the primary star is the more enormous and hotter component, whereas the second star is the less enormous and cooler one.
5. The estimated orbital inclination of i = 82,000 suggesting that the CN And system is a general partial lunar eclipse. The higher mass component has a temperature $T_1$ up to T = 6231 k higher than to the smaller component. It brings in less light. Geometric exposure F defined in equation (8) is 1.010%, which means that CN And is an overexposed BS, according to symmetry of the LC.
6. The increasing stellar wind that has caused long-term drop for orbital period can be described for CN And is an over contact BS with a shared convective envelope between both components (f = 24.900%).
7. According to the results, indicated that the chosen system could conjointly be a contact system and also absolutely the parameters of the components are determined with acceptable accuracy that the physical parameters are obtained in associate in suitable manner extremely uniform technique.

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