Analysis of Structure and Evolution of Binary System GV Leo

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Abstract. GV Leo is a W Ursa eclipsing binary with an orbital period of 0.266727 day. From the previous investigation of its light curve, it was found that this binary system has a continuous orbital period change. A light curve of GV Leo was analyzed using program MaxIm DL3 and its period change was also calculated. The results revealed that the orbital period of GV Leo was continuously decreased at rate of 0.004524349151 seconds per year to 0.005440856529 seconds per year and using PHOEBE software was used to compute the best system is parameters. The over contact binary system with g = 0.829, i = 69.86 degree. The temperature of primary star and secondary star were 5,020 K and 5,650 K respectively. From the analysis of physical parameters and model, it was found that GV Leo had a contact characteristic with high mass ratio. It is possible that the evolution of GV Leo would be a single star due to mass transfer of the system.

1. Introduction

The study of binary star systems is one of the primary means of measuring stellar properties. The target of this research was the eclipsing binary star GV Leo (RA 10h 11m 59.2s and DEC +16° 52' 30") with an orbital period of 0.266727 day. There are many W Ursa that have a shorter period than this [1]. These stars are in physically contact and share a common atmosphere. A photometric study was undertaken to obtain high quality light curves which could then be analyzed with a light curve synthesis program [2]. Spectroscopic measurement was used to determine the physical properties of the individual stars including masses, luminosities and temperatures. In addition, a period study was investigated to look for evidence of mass streaming between the stars.

2. Observations

Observation of GV Leo were carried out at Thai National Observatory on January 28, 2014 by using a 0.5 meter reflecting telescope with CCD photometric system in B, V and R wavelength bands and exposure time of 20 second. The Sky6 program [3] was used to identify the stars and its finding chart is shown in Figure 1. The coordinates of the GV Leo were check and comparison stars. One of the CCD image is shown in Figure 1, where “Obj1” refers to the object in this study GV Leo, “Ref1” refers to the reference star GSC 01419-00805, and “Chk1” refers to the check star TYC 1419-1147-1 [4, 5].

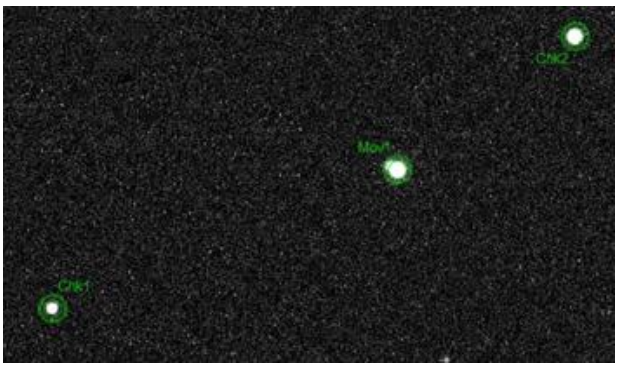

Figure 1. Finding chart, showing GV Leo (Obj1), the comparison star (Ref1), and check star (Chk1).

Figure 2 shows B, V and R light curves of GV Leo where differential magnitude are plotted with phase. The light curves show a contact binary system.

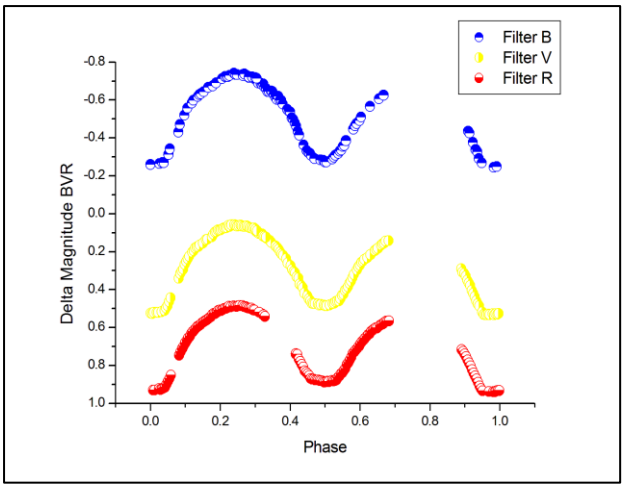

Figure 2. Observed and theoretical light curves determined by analyzing the three colour light curves individually. The theoretical light curves in the B, V and R bands are very well fit at the primary minimum**.**

3. Period analysis

The minimum time and epoch of GV Leo obtained from observations are shown in Table 1. The linear ephemeris of minimum time from previous authors and this study are calculated by equation (1) as follows:

$$\text{MinI} = 2452754.46152 + 0.266731563E \quad (1)$$

Table 1. The example data minimum time for primary (I) and secondary (II) eclipse and epoch of GV Leo from previous authors [6,7] and this study.

HJD	Minimum	Epoch	O-C (days)
52754.45980	I	0	-0.0004000
53437.69730	II	2561.5	0.0158895
53437.82930	I	2562.0	0.0145260
53441.82910	I	2577.0	0.0134210
56246.64035	II	13092.5	0.0569025
56246.64068	II	13092.5	0.0572325
56246.64112	II	13092.5	0.0576725
56246.64132	II	13092.5	0.0578725
56686.33605	I	14741.0	0.0531474

[a] HJD calculated from this study

The first light element is the time of primary eclipse, the second light element is the orbital period in day and E is the cycle count. Using this ephemeris, a predicted time of minima was computed and compared to observed minima by calculating the residuals (O-C). The results of a linear and quadratic regression analysis to these data were user to calculate new ephemerides shown in Figure 3. The changes in the orbital period were analyzed by using our eclipse times together with those collected from literature. By using a second-order polynomial fitting on the O-C curve, the relationship between the O-C and epoch shown as equation (2) is as follow:

$$O\text{-}C = [(-2.105665050 \pm 0.193659581) \times 10^{-10} E^2 + (7.281366330 \pm 0.289258381) \times 10^{-6} E - (-1.6142511 \pm 1.0054829) \times 10^{3}] \text{ days} \quad (2)$$

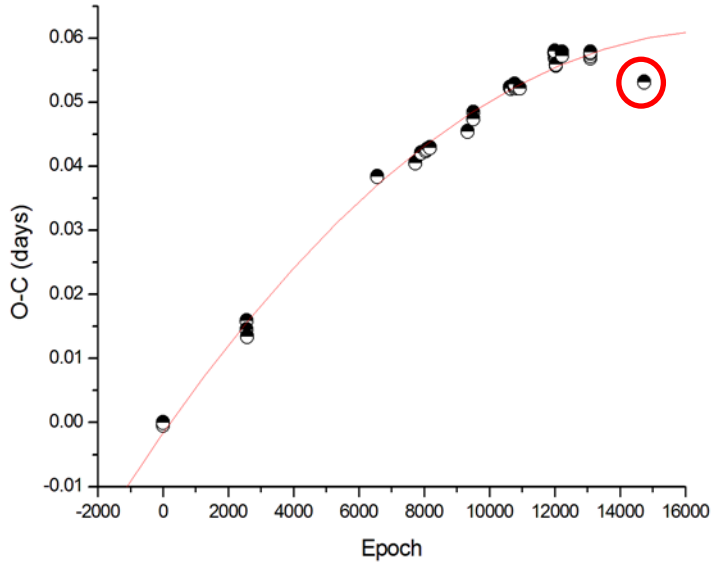

Figure 3. The O-C curve of GV Leo data from this study is in the square.

4. Photometric solution

From the light curve in Figure 2, it is classified as a type of contact binary system. Physics of eclipsing binaries program PHOEBE was used to calculate the physical parameters of GV Leo. The best solution of GV Leo is shown in Table 2 and its surface potential and configuration are constructed using PHOEBE program and are shown in Figure 4.

Table 2. The best solution of GV Leo.

Parameters	Best solution	
	primary star	secondary star
mass ratio (secondary over primary)	0.829±0.059069	
mass	3.209852	2.648128
inclination in degree	69.860±0.079908	
temperature (K)	5020±191.625424	5650±213.5099205
star surface potential, (Ω)	3.421352	2.997222
star surface albedo, ALB1=ALB2	0.2	
star gravity brightening, GR1=GR2	0.95	
radius	1.345820	1.247273
Mbol	5.066408	4.752307
Log(g)	4.698881	4.669847
stars surface brightness	2.812468	3.846785

5. Discussion

The light curve synthesis solution confirms that GV Leo as member of the W Ursa class of interacting eclipsing binary stars. From the calculation, it can be concluded that GV Leo is a contact binary system. The O-C curve of GV Leo indicates that orbital period is decreasing due to the high mass ratio or angular momentum loss (AML) via magnetic stellar wind. If orbital period change is continuously decreased, this binary star system may finally evolve into the contact stage within the better understanding on the physical properties and evolution of this binary system.

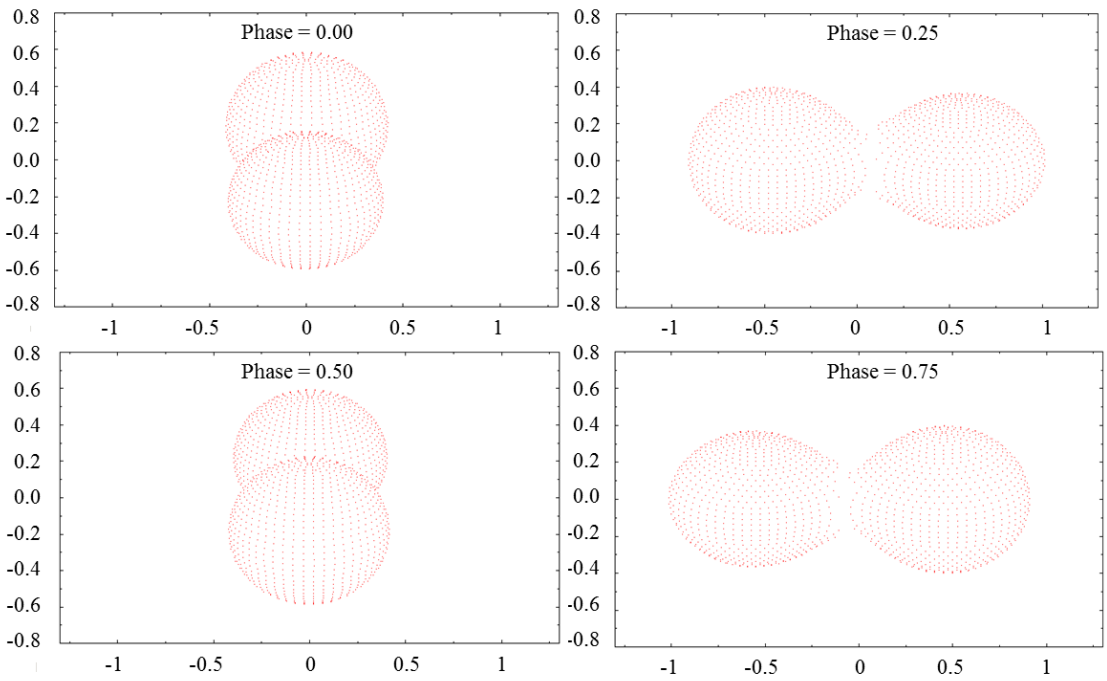

Figure 4. Geometrical structure at phases of 0.0, 0.25, 0.5 and 0.75.

6. Acknowledgement

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7. References

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