Preliminary Photometric Elements for the Algol-Type Binary Star GSC 3560_1804 = LD 355

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Abstract

From the CCD observations published in the IBVS 5018 the Algol-type binary star *LD 355* is here analysed with the purposed of the preliminary determination of its photometric orbital parameters. Using Binary Maker 2.0 we were able to determine the Mass Ratio (q), the Orbital Inclination (i), the Mean Fractional Ratios (r_1, r_2) and Luminosities (l_1 , l_2).

The temperatures (T_1, T_2) were adjusted in respect of the colour index suggested in the original paper.

1. Introduction

LD 355 (GSC 3560_1804, $V = 13^m.608$, $P = 1.105$ d) was recently discovered to be variable by Dahlmark L. (2000), during a photo-visual variable stars search in Lyra and Cygnus. The star was classified as an eclipsing binary (E) with an uncertain period of $25^d.81$ and amplitude of 0.8 magnitudes.
Subsequently new CCD V-filtered observations were obtained by a team of observers (Guilbault, et al, 2001). They collected a total of 647 frames in V light, from these observations the authors determined five times of primary minimum and three times of secondary minimum.
Using new and old minimums a new period and light elements were obtained:

$$\text{Min I} = \text{HJD } 2451874.6174 + 1^d.1051023 \times E.$$

The light curve shows that the star is an Algol-type eclipsing variable, that the primary eclipse is total and a shallow secondary eclipse occurs at phase 0.5.
Using the V-filtered CCD observations we have tried to solve the light curve of *LD 355* by means of the Binary Maker software (Bradstreet, 1983).

2. Lightcurve Fitting

The Binary Maker method compares favourably to the version of the Wilson-Devinney program, it uses the Planck body laws and the same schemes of Wilson-Devinney for determining eclipse and reflection effects.
The program was booted using the *menu brief* command and the software automatically assigned the values of some input parameters. Assuming a convective atmosphere for both the stars, Binary Maker have adopted the following usual values for the gravity exponents, the albedo coefficients and the limb-darkening coefficients.

	Primary	Secondary
Gravity exponent	$\alpha_1 = 0.32$	$\alpha_2 = 0.32$
Albedo coefficient	$A_1 = 0.5$	$A_2 = 0.5$
Limb-darkening coefficient	$u_1 = 0.6$	$u_2 = 0.6$

Initially the following parameters were treated as adjustable: (*q)* the mass ratio, *(i)* the orbital inclination, $(r_{1/2})$ and the mean fractional radii.
Considering the colour index $(B-V)_{max} = 0{,}310$ given in the original paper and using the tables of Popper (1980), Flower (1996) and those of Zombeck (1990) we found the temperature of the hotter star $T_1 = 7160$ K. The temperature of the cooler star was adjusted in respect of the temperature ratio, $T_2 = 4620$ K

The spectral class corresponding to the temperature of the primary component is the type F0, which is a generally accepted spectral type for the primary component of Algol stars. The determined temperature of the secondary component made us consider the spectral type between K2 – K5 for the star. The median spectral type F0 for the primary and the deduced spectral type between K2 - K5 of the secondary component make *LD 355* comparable to RW CrB (Binnendijk 1972) with spectral types F0 and K3 , AL Gem (Koch 1963) which spectral types are F5 and K7, and R CMa (Koch 1969) with primary star of spectral type A9 and the secondary K5. The evolution of these four systems may have been comparable.

The parameters of *LD 355* resulting from the light curve simulation are presented in Table 1. The theoretical light curve obtained from the elements given in Table 1 is shown in Figure 1 as solid lines. In this figure, the crosses represent the individual observations of Guilbault et al.

Table 1 Photometric elements of LD 355

Primary	Secondary
Mass Ratio = 0.919 ± 0.032	
Inclination = 87.300 ± 0.8	
Wavelength = 550 nm	
Fillout = -3.00	Fillout = -3.00
Lagrangian $L_1 = 0.508$	Lagrangian $L_2 = 1.684$
Mean radius = 0.239 ± 0.014	Mean radius = 0.226 ± 0.012
Temperature = 7160 K ± 50	Temperature = 4620 K ± 200
Luminosity = 0.893 ± 0.025	Luminosity = 0.107 ± 0.025

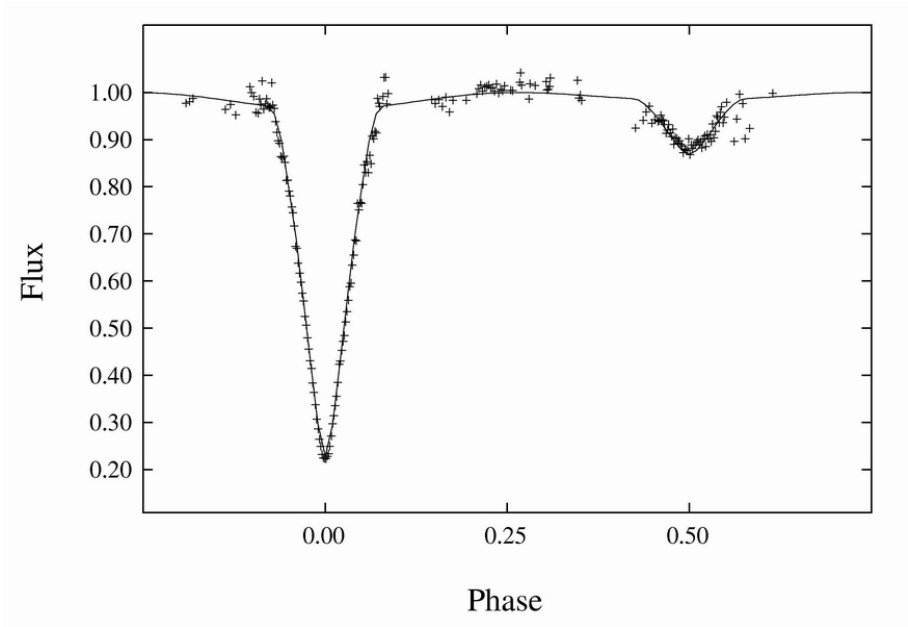

Figure 1. Theoretical light curve of LD 355 (line). The crosses are observed data of *Guilbault et al.* (2001).

Note the shallow secondary eclipse displaced exactly 0.5 *P* from primary eclipse, which implies a circular orbit.

3. Light curve analysis

From an analysis of the light curve of *LD 355* using the Binary Maker 2.0 light curve synthesis software is clear that it is a detached system, Figure 2 shows the configurations of the components of *LD 355* relative to their critical Roche lobes in the orbital plane and the configuration of the system seen at phase $0^p.0$ and at phase $0^p.25$.

As stated in the papers of Guilbault et al. (2001) *LD 355* shows at the primary minimum a flat bottom which resembles a total eclipse , though the primary minimum has just been proved to be partial occultation (transit, $r_h > r_c$) of the larger primary star by the smaller secondary component.

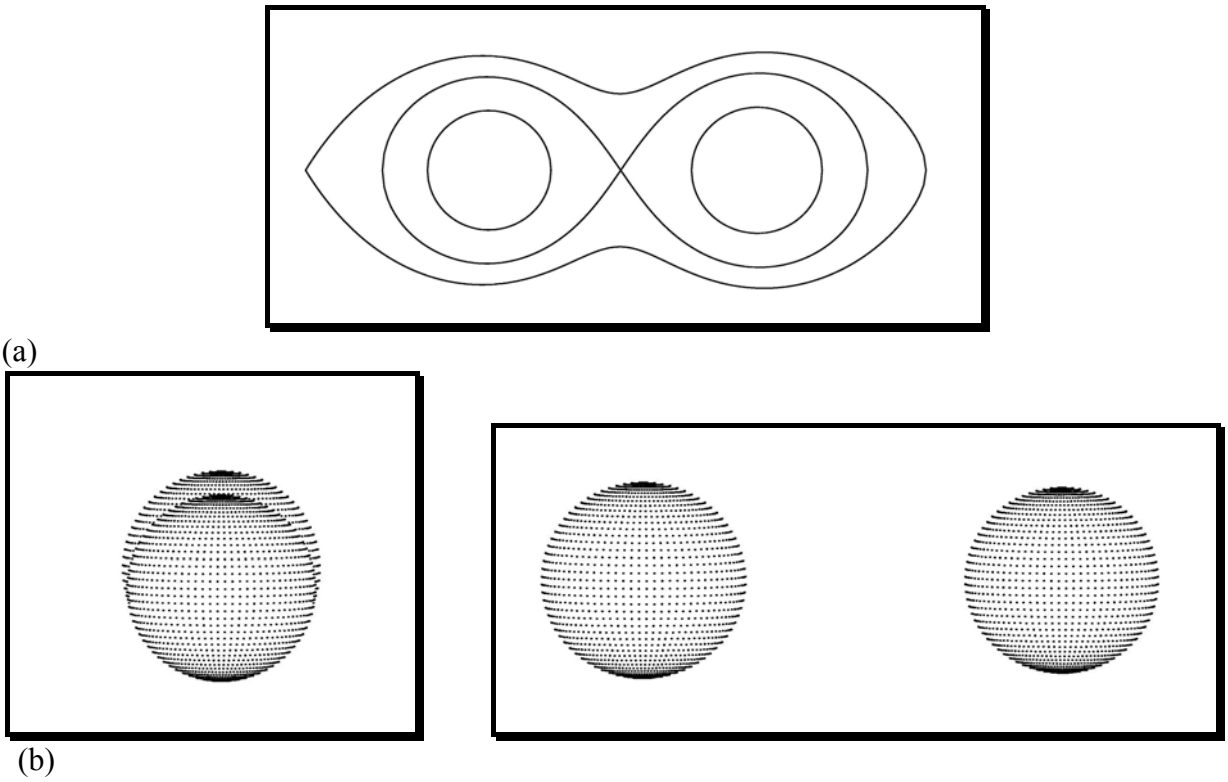

Figure 2 Derived configuration of LD 355. (a) Equatorial Configuration of the components and of the critical Roche lobes. (b) left. A view of LD 355 at orbital phase $0^p.0$ (the hot primary component is partially eclipsed by the cool secondary), and at orbital phase $0^p.25$, (b) right.

4. The eclipse of LD 355

Next we have investigate another possibility that the flat bottom observed in the primary minimum of the system should be caused by the total occultation of the primary component by the secondary. We have imposed restrictive conditions that the primary component should be totally eclipsed at the middle of the primary minimum and solved light curves for a series of totality solutions. It was found, however, that the best solution in the totality series gives the error bar values larger than that of adopted partial solution. Besides the theoretical light curve poorly fits the observation.

Moreover, from an analysis of the colour index, at the minima it was found that the colour of the system at the primary minima corresponds to spectral type F8, not to K, which implies that the primary star (F0) is visible at the middle of the primary minimum, or the eclipse is partial.

5. Conclusion

We have analysed the first data on *LD 355* with the purpose of the preliminary determination of its photometric elements. Our results show clearly that the star is a detached system. The primary eclipse appears to be due to a partial occultation of the primary, hotter, star by the secondary, cooler, star.
The colour index at the primary minimum support this supposition, so it is essentially difficult to explain the observed flat bottom.

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