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The first photometric analyses and classification of the W-UMa eclipsing binary systems GSC 1283-53 and GSC 702-1892

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Abstract New CCD observations of the W UMa type binary systems GSC 1283-53 and GSC 702-1892 have been analyzed using the Wilson–Devinney Code to determine their photometric and geometric elements. The results show that the system GSC 1283-53 may be classified as A-subtype W UMa eclipsing binary with a photometric mass ratio $q = 0.277$, and the degree of over contact $f = 83.5\%$. While the system GSC 702-1892 is found to be a detached eclipsing binary with the photometric mass ratio $q = 0.49$.

1. Introduction

The eclipsing binary system GSC 1283-53 (ASAS J051305 + 155812 = NSVS 9553026 = 2MASS J05130606 + 1558122 = TYC 1283-53-1), with the coordinates $\alpha_{2000} = 05^h 13^m 06.069^s$, $\delta_{2000} = 15° 58' 12.22''$, was discovered to be a variable by Blattler and Diethelm (2007). They used a CCD camera attached to the Cassegrain 0.15-m Starfire refractor (Private observatory Schüsselacher) in Wald, Switzerland. They classified the system as W UMa eclipsing binary, with a period 0.383004^d.

The other eclipsing binary system GSC 702-1892 (ASAS J051245 + 101512 = NSVS 9512770 = 2MASS J05124486 + 1015104), which has the coordinates $\alpha_{2000} = 05^h 12^m 44.8^s$, $\delta_{2000} = 10° 15' 10''$, was discovered to be a variable by Blattler and Diethelm (2007). They classified the system as W UMa eclipsing binary with $V_{mag} = 11.9$ and $R_{mag} = 12.6$, and its period equals 0.276945^d.

2. Observations

Two sets of non-analyzed V and R band observational data for the eclipsing binary system GSC 1283-53 have been observed by Blattler and Diethelm, during the time interval between Dec. 13, 2006 and Jan. 14, 2007. They used a CCD camera (SBIG ST-7) attached to the Cassegrain 0.15-m Starfire refractor (Private observatory Schüsselacher) in Wald, Switzerland.

The phase curves based on 236 observations in both colors V and R were obtained, using SAO 94388 (9.19 V_{mag}) as comparison star and GSC 1283-239 (11.01 V_{mag}) as check star.

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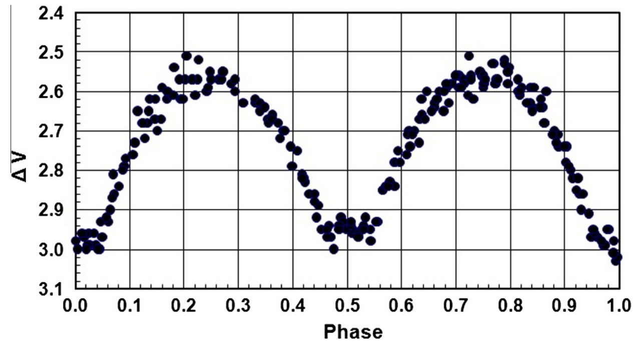

Fig. 1 Light curve for GSC 1283-53 in V-band.

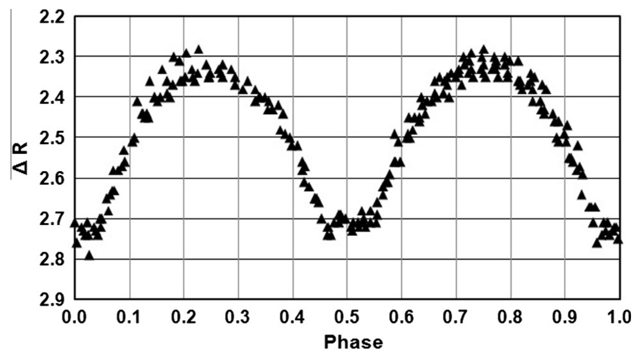

Fig. 2 Light curve for GSC 1283-53 in R-band.

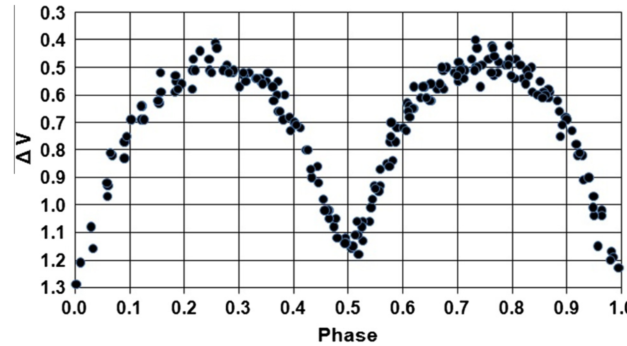

Fig. 3 Light curve for GSC 702-1892 in V-band.

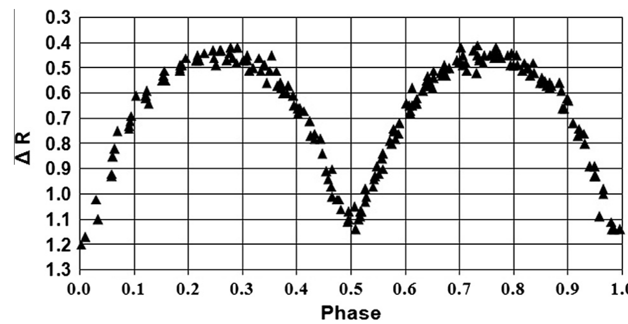

Fig. 4 Light curve for GSC 702-1892 in R-band.

Blattler and Diethelm (2007) determined the mean epoch of minimum light from the 12 times of minima. They determined the new ephemeris as follows:

$$\text{JD(Min. } I, \text{ Hel)} = 2454066.5778 + 0.383004 \times E$$

where E is the number of integer cycles. This ephemeris was used to calculate the phases and draw the light curves in both V and R bands as differential magnitude ΔV and ΔR (see Figs. 1 and 2).

The other sets of non-analyzed CCD observational data in V and R bands for the eclipsing binary system GSC 702-1892 have been obtained by Blattler and Diethelm (2007), using SBIG ST-7 camera attached to the Cassegrain, 0.15-m Starfire refractor (Private observatory Schüsselacher) in Wald, Switzerland. The observations were made during five nights between Dec. 13, 2006 and Jan. 14, 2007. A total of 221 measurements in both colors were obtained, using GSC 702-2174 (11.03 V_{mag}) as comparison and GSC 702-2730 (12.42 V_{mag}) as check star.

Nelson (2004) determined the light elements for the system as follows:

$$\text{JD(Min. } I, \text{ Hel)} = 2454083.5159 + 0.276945 \times E$$

where E is the number of integer cycles. This ephemeris was used to calculate the phases and draw the light curves in both V and R bands as differential magnitude ΔV and ΔR (see Figs. 3 and 4).

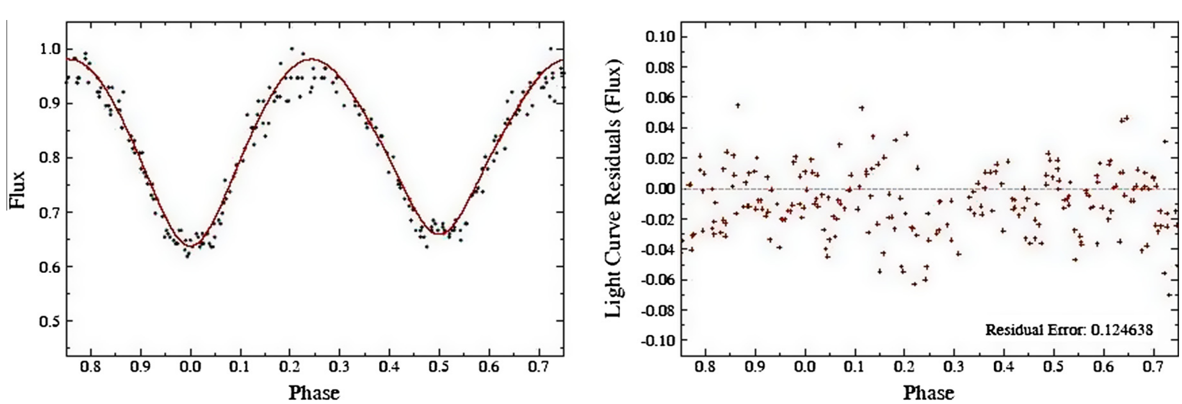

Fig. 5 V light curve of GSC 1283-53 (crosses) together with their Fitting (solid line) in Left Panel, while the Light Curve Residual shown in right panel.

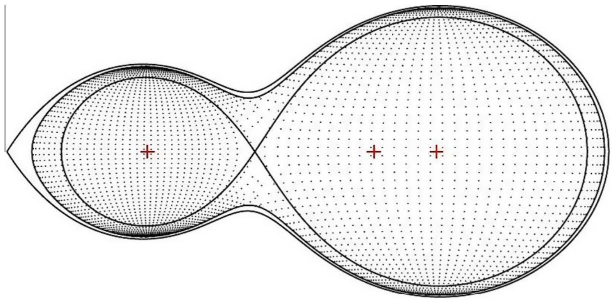

Fig. 6 Roche geometry of the system GSC 1283-53 in the *V*-band $\Omega_1 = \Omega_2 = 2.27$, overcontact = 83.4%.

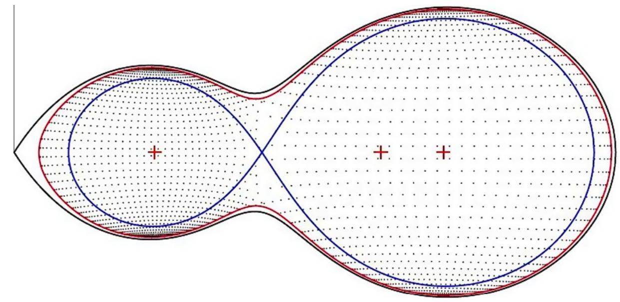

Fig. 9 Roche geometry of the system GSC 1283-53 in the *R*-band $\Omega_1 = \Omega_2 = 2.27$, Overcontact = 83.6%.

2.1. The photometric data analysis of GSC 1283-53

In order to determine the geometric and photometric parameters of the system GSC 1283-53 we used the Wilson and Devinney code (hereafter, WD), which consists of two programs: synthetic Light Curve program (hereafter, LC) and Differential Correction program (hereafter, DC).

The model has been described and quantified in papers by Wilson and Devinney (1971), Wilson (1979, 1990, 1993) and Wilson and van Hamme (2003).

The analyses were done for the available *V* and *R* light curves in Figs. 1 and 2 after transforming the magnitudes to normalized fluxes (hereafter, N. Flux). Different solutions, with and without spot/s on the components were tested.

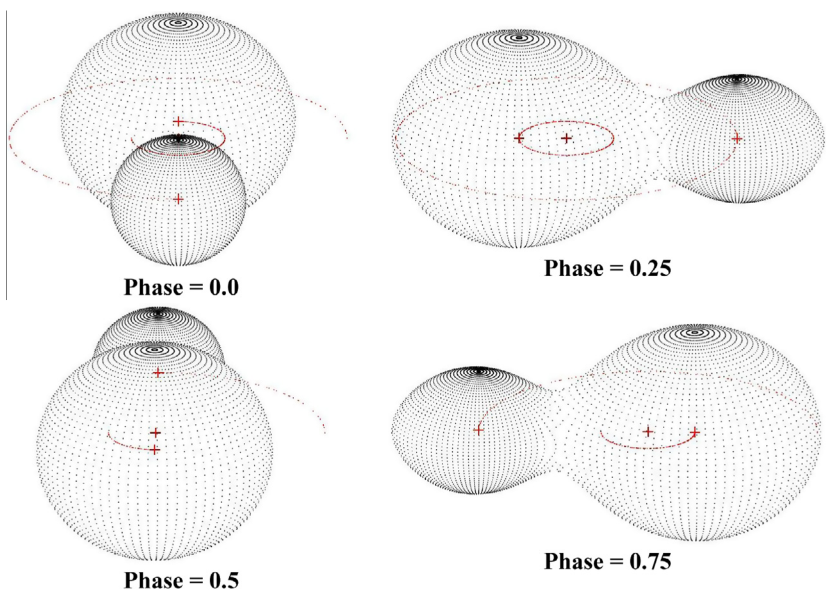

Fig. 7 The shape of the system GSC 1283-53 at phases 0.0, 0.25, 0.50, and 0.75 in *V*-band.

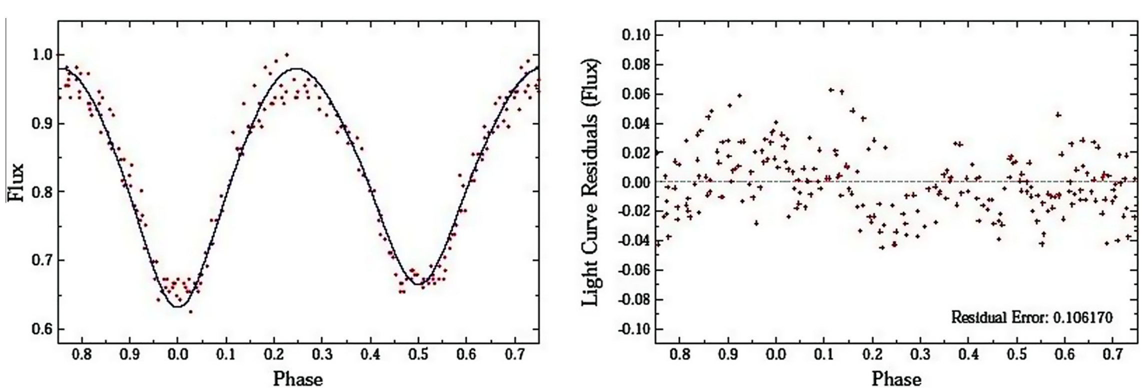

Fig. 8 *R* light curve of GSC 1283-53 (crosses) together with their fitting (solid line) in left panel, while the light curve residual shown in right panel.

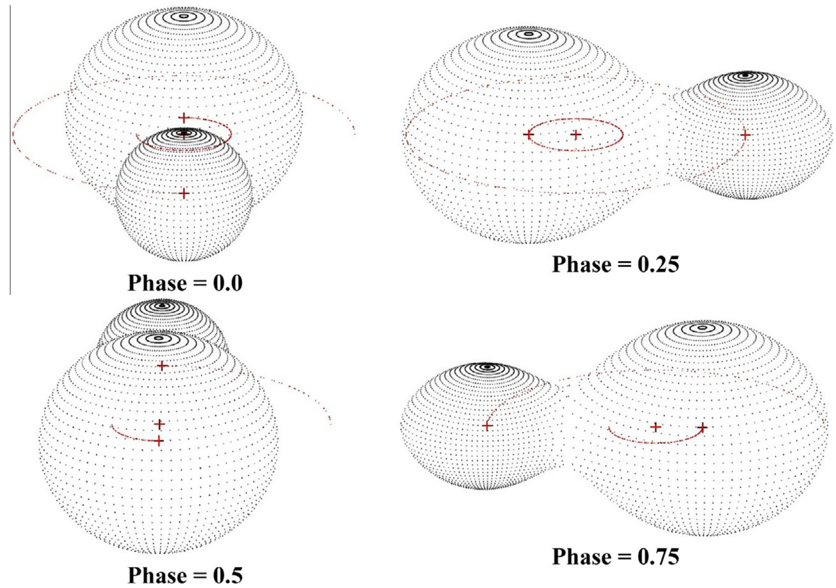

Fig. 10 The shape of the system GSC 1283-53 at phases 0.0, 0.25, 0.50, and 0.75 in *R*-band.

The preliminary solutions were determined by using the LC program. After many trials we derived a set of parameters which marginally represent the observed light curve.

The exponent of gravity darkening, $g_1 = g_2 = 0.32$ considered by Lucy (1967) and bolometric albedo, $A_1 = A_2 = 0.5$ considered by Rucinski (1969) for stars of convective envelop were assumed. The values of bolometric limb darkening, x_1 and x_2, were taken from van Hamme's Tables (1993). The overcontact mode 3 of WD code was adopted for LC solution.

Some parameters have to be assumed, e.g., orbital inclination i, surface potential of two components, $\Omega_1 = \Omega_2$. The other parameters, e.g., phase shift, surface temperature of the cold component star (T_2), and mass ratio (q) have to be adjusted and employed in the second part of WD code (DC program).

The relative brightness of the star 2 has been calculated by the stellar atmosphere model inside the DC program. The geometric and photometric parameters derived are listed in Table 1 with their standard deviations. The final fit of the observations has been plotted in Figs. 5 and 8 for *V* and *R* filters.

Results show that, star 1 is the more massive and hotter component, while star 2 is the less massive and cooler one.

Table 1 The geometric and photometric parameters of the system GSC 1283-53.

Parameters	*V* band	*R* band
Wavelength = λ	5500 Å	7000 Å
Phase shift	0.00352 ± 0.0025	0.0061 ± 0.0034
Inclination (i)	69° (assumed)	70° (assumed)
Surface temp. (T_1)	3870 K	3896 K
Surface temp. (T_2)	3811 K ± 24 K	3789 K ± 38 K
Surface potential ($\Omega_1 = \Omega_2$)	2.27 (fixed)	2.27 (fixed)
Mass ratio (q)	0.277 (assumed)	0.277 ± 0.0058
Fillout parameter (f_1 and f_2)	83.421%	83.674%
Bolometric albedo = ($A_1 = A_2$)	0.500 (fixed)	0.500 (fixed)
Gravity darkening ($g_1 = g_2$)	0.320 (fixed)	0.320 (fixed)
Angular rotation ($F_1 = F_2$)	1.000	1.000
Limb darkening (x_1)	0.571 (fixed)	0.506 (fixed)
Limb darkening (x_2)	0.556 (fixed)	0.499 (fixed)
$L_1/(L_1 + L_2)$	0.77534	0.81538
$L_2/(L_1 + L_2)$	0.22466	0.18462
r_1(back)	0.58239 ± 0.00	0.55259 ± 0.00316
r_2(back)	0.40061 ± 0.00	0.30028 ± 0.01611
r_1(side)	0.54419 ± 0.00	0.52692 ± 0.00195
r_2(side)	0.31057 ± 0.00	0.26069 ± 0.00775
r_1(pole)	0.49463 ± 0.00	0.48431 ± 0.00120
r_2(pole)	0.29201 ± 0.00	0.24952 ± 0.00632
Mean radius 1	0.54040	0.54050
Mean radius 2	0.33440	0.33479
LC residual	0.12645	0.10617

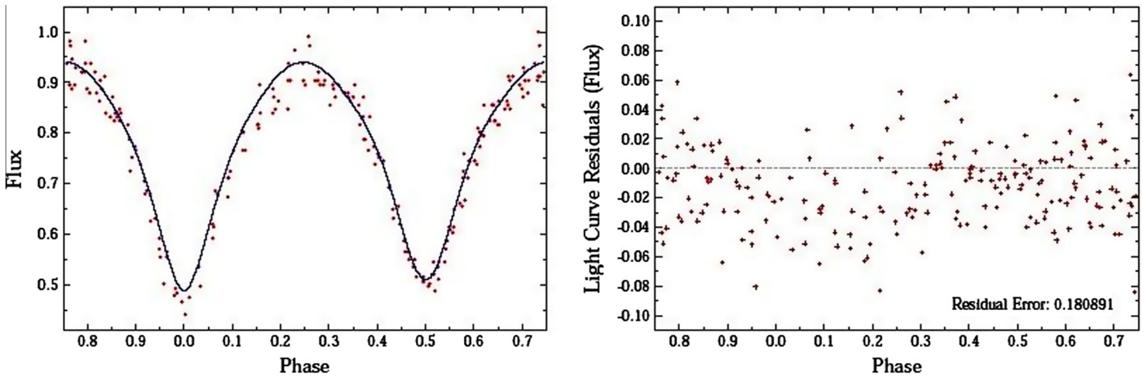

Fig. 11 *V* light curve of GSC 702-1892 (crosses) together with their fitting (solid line) in left panel, while the light curve residual shown in right panel.

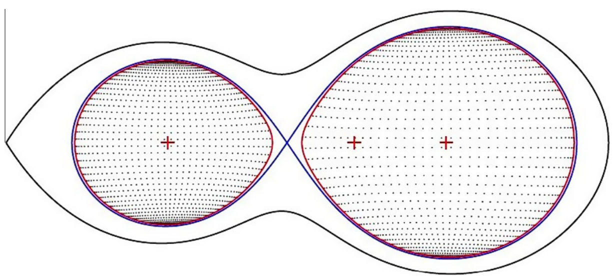

Fig. 12 Roche geometry of the system GSC 702-1892 in the *V*-band $\Omega_1 = \Omega_2 = 2.900$.

Geometric and photometric parameters listed in Table 1 were used with the Binary Maker 3 program (hereafter BM3), Bradstreet (2005), to present the Roche geometry of the system as shown in Figs. 6 and 9 for *V* and *R* filters, which show the degree of contact.

The same geometric and photometric parameters are employed with the same program (BM3) to display the system configuration at different phases (0.0, 0.25, 0.5, and 0.75) as shown in Figs. 7 and 10 for both *V* and *R* filters. The resultant fits in Figs. 5 and 8 seem to be quite satisfactory.

By comparing the properties of the system GSC 1283-53 in Table 1 with the properties of A and W subtypes of the W UMa binaries (see Rucinski, 1973) through its mass ratio, degree of contact, radii, temperature difference between both components, and the transit primary minimum (Binnedijk, 1970 and Al-Sadek, 2012) we found that the system is likely to be A-subtype of W UMa binary stars with fill out ratio ≈ 83.5.

2.2. The photometric data analysis of GSC 702-1892

To determine the geometric and photometric parameters of the system GSC 702-1892 we used the same code WD having two

Table 2 The geometric and photometric parameters of the system GSC 702-1892.

Parameters	*V* band	*R* band
Wavelength = λ	5500 Å	7000 Å
Phase shift	0.0024 ± 0.0007	0.0025 ± 0.0007
Inclination (i)	81.009 ± 0.530°	82.083 ± 0.470°
Surface temp. (T_1)	2977 K	2981 K
Surface temp. (T_2)	2862 K ± 6 K	2849 K ± 7 K
Surface potential ($\Omega_1 = \Omega_2$)	2.8995 ± 0.0144	2.8574 ± 0.0124
Mass ratio (q)	0.4944 ± 0.0058	0.4828 ± 0.0049
Fillout parameter (f_1 and f_2)	−1.1542%	−0.4990%
Bolometric albedo = ($A_1 = A_2$)	1.000 (fixed)	1.000 (fixed)
Gravity darkening ($g_1 = g_2$)	1.000 (fixed)	1.000 (fixed)
Angular rotation ($F_1 = F_2$)	1.000 (fixed)	1.000 (fixed)
Limb darkening (x_1)	0.561 (fixed)	0.561 (fixed)
Limb darkening (x_2)	0.561 (fixed)	0.561 (fixed)
$L_1/(L_1 + L_2)$	0.74556	0.72574
$L_2/(L_1 + L_2)$	0.25444	0.27426
r_1(back)	0.47021 ± 0.0023	0.47021 ± 0.00258
r_2(back)	0.33956 ± 0.0000	0.33956 ± 0.00259
r_1(side)	0.44287 ± 0.0017	0.44287 ± 0.00192
r_2(side)	0.30774 ± 0.0000	0.30774 ± 0.00149
r_1(pole)	0.41688 ± 0.0017	0.41688 ± 0.00148
r_2(pole)	0.29508 ± 0.0000	0.29508 ± 0.00121
Mean radius 1	0.43430	0.44065
Mean radius 2	0.31076	0.31314
LC residual	0.18089	0.10187

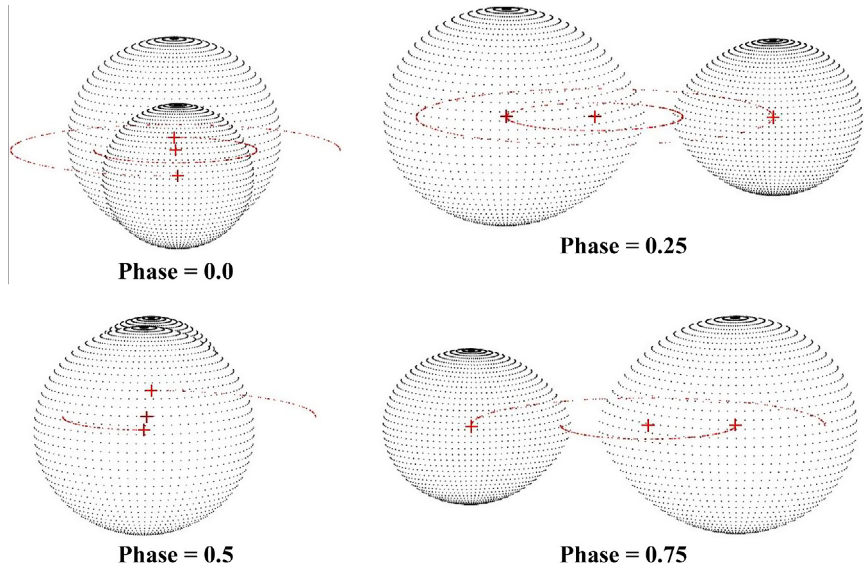

Fig. 13 The shape of the GSC 702-1892 at phases 0.0, 0.25, 0.50, and 0.75 in *V*-band.

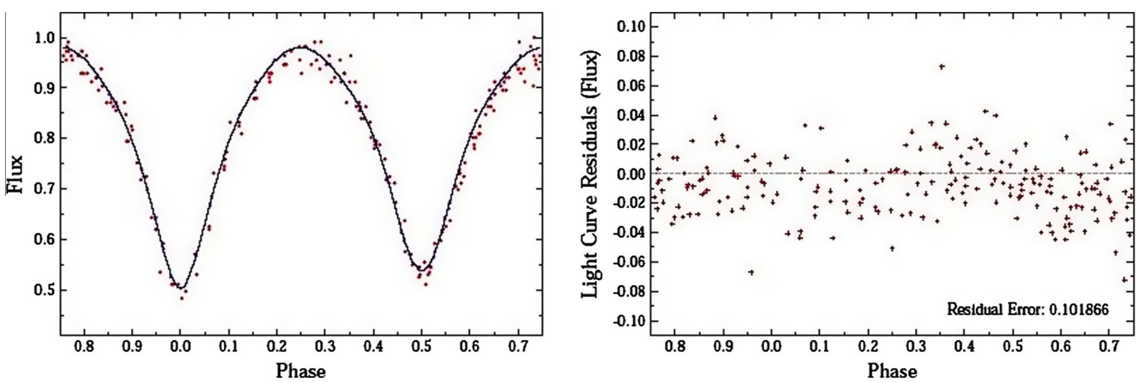

Fig. 14 *R* light curve of GSC 702-1892 (crosses) together with their fitting (solid line) in left panel, while the light curve residual shown in right panel.

parts LC and DC and also using the same program BM3 and the same procedure which have been used with the system GSC 1283-53.

After many trials we derived a set of parameters which marginally represent the observed light curve.

The exponent of gravity darkening, $g_1 = g_2 = 1$ considered by Lucy (1968) and bolometric albedo, $A_1 = A_2 = 1$ considered by Rucinski (1969) for stars of radiative envelop were assumed. The values of bolometric limb darkening, x_1 and x_2, were taken from van Hamme's Tables (1993). The detached mode 2 of WD code was adopted for LC solution.

Some other parameters have to be assumed, e.g., orbital inclination i, surface potential of two components, $\Omega_1 = \Omega_2$, and angular rotation ($F_1 = F_2 = 1$). The other parameters, e.g., phase shift, surface temperature of the cold component star (T_2), and mass ratio (q) have adjusted and employed in the second part of WD code (DC program).

The relative brightness of the star 2 was calculated by the stellar atmosphere model inside the DC program. The geometric and photometric parameters derived are listed in Table 2 with their standard deviations. The final fit of the observations has been plotted in Figs. 11 and 14 for V and R filters.

Results show that star 1 is the more massive and hotter component, while star 2 is the less massive and cooler one.

Geometric and photometric parameters listed in Table 2 were used with the BM3 program to present the Roche geometry of the system as shown in Figs. 12 and 15 for V and R filters respectively, which show that the configuration for the system is detached.

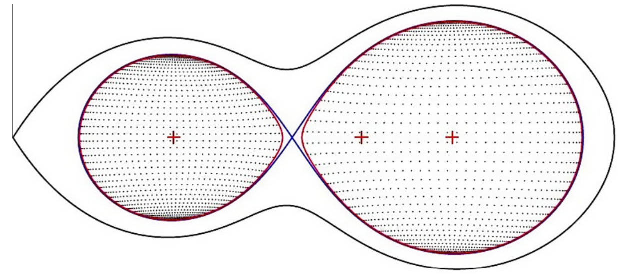

Fig. 15 Roche geometry of the system GSC 702-1892 in the *R*-band $\Omega_1 = \Omega_2 = 2.857$.

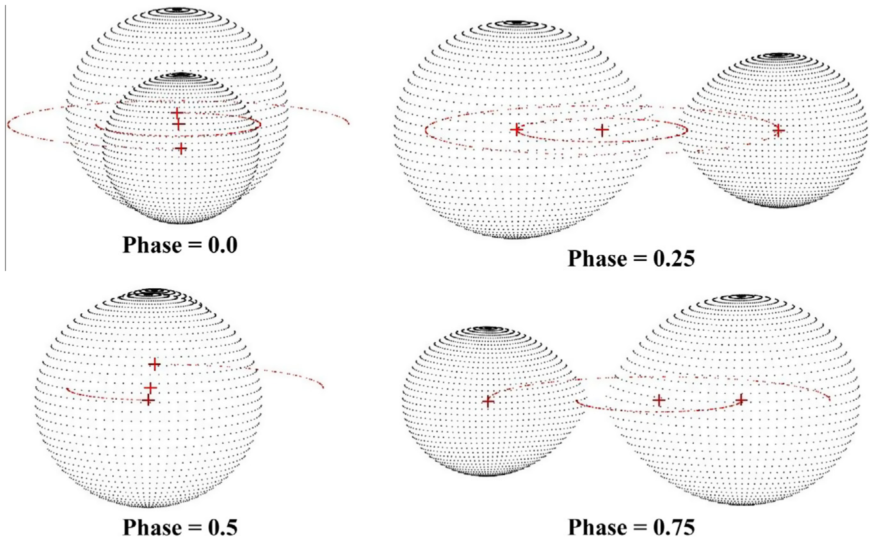

Fig. 16 The shape of the system GSC 702-1892 at phases 0.0, 0.25, 0.50, and 0.75 in *R*-band.

The same parameters are employed with the same program (BM3) to display the system configuration at different phases (0.0, 0.25, 0.5, and 0.75) as shown in Figs. 13 and 16 for both *V* and *R* filters. The resultant fits in Figs. 11 and 14 seem to be quite satisfactory.

From the properties of the system GSC 702-1892 tabulated in Table 2 and its Roche geometry in Fig. 12, we found that the system is likely to be in detached status of W UMa binary stars.

3. Conclusions and future remarks

The first photometric analyses have been presented out for the systems GSC 1283-53 and GSC 702-1892.

The solutions reveal that GSC 1283-53 is a over contact binary system by 83.5%, which leads to a deep convective common envelope that may be responsible for its high activity, while the system GSC 702-1892 is a detached binary system.

The contact binary system GSC 1283-53 may like to be an A-subtype of W UMa systems. While the system GSC 702-1892 is a detached eclipsing binary system.

More multi wavelength and radial velocity observations for both systems are needed to determine the absolute parameters, and provide the means to trace the evolutionary state of each system.

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