New Astronomy 65 (2018) 52–58

Contents lists available at ScienceDirect

New Astronomy

journal homepage: www.elsevier.com/locate/newast

First CCD photometric investigation of the eclipsing binary V737 Per

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ARTICLE INFO

Keywords:
Binaries: close
Binaries: eclipsing
Stars: evolution
Stars: individual (V737 Per)

ABSTRACT

New CCD photometric observations of the eclipsing binary V737 Per have been performed in 2015 and complete BV bands light curves are obtained. From the observations, four times of light minimum are determined. By combining these times of light minimum with those collected from literature, we derive a new linear ephemeris and investigate the orbital period variation. The result shows that no significant period variation can be found during the past twelve years. The present light curves are analyzed by using the Wilson–Devinney code. The photometric solutions indicate that the system is an A-type, shallow-contact binary with a mass ratio of 0.41 and a degree of contact of 8.73%. Also, the asymmetry of the light curves is observed. It can be explained by a cool spot on the secondary component. Finally, we estimate the absolute parameters of V737 Per and discuss its evolutionary status. The results suggest that the primary of V737 Per has evolved away from the zero age main sequence.

1. Introduction

The eclipsing binary V737 Per (GSC 02359–00782, NSV 1217, GR 110) was discovered by Romano (1965). According to GCVS, V737 Per is a W UMa-type contact binary with the magnitude range from $12^{m}.65$ to $13^{m}.22$ in V band and a short period of 0.366556 days. Since its discovery, this system has been paid very less attention and its photometric data is quite scarce. Until 2005, Otero and Wils (2005) reported some new elements and improved the period determination. Recently, several authors (Diethelm, 2009; 2010; 2011; 2012; 2013; Brát et al., 2011; Hoňková et al., 2013; 2015; Samolyk, 2016; Juryšek et al., 2017) published some charge-coupled device (CCD) times of light minima. However, its complete light curves are still missing. To our knowledge, neither photoelectric or CCD light curves nor photometric analysis have been published so far. In view of its short orbital period and the lack of light curves and photometric solutions, V737 Per was included in our observational program.

2. New CCD photometric observations

Photometric observations of the eclipsing binary V737 Per have been performed on three nights in 2015 with the 85-cm reflecting telescope at the Xinglong Station of the National Astronomical Observatories of China. A total of 712 frame images in B and V bands were obtained on these three nights. In the field of view, two stars were selected as the comparison star(2MASS J03405752 + 3303443) and the check star(TYC 2359–719–1). Their coordinates are listed in Table 1. By means of the aperture photometry package of IRAF,[1] the images have been properly reduced to photometric data. The photometric data are listed in Tables 2 and 3 in the form of delta magnitudes (i.e., the variable minus the comparison star).

3. Period determination

From our observations, four times of light minimum, including two primary eclipses and two secondary eclipses, were calculated from a parabolic fit. These times were averages of BV-band determinations. The new minima times and other times collected from literature are summarized in Table 4. Based on these CCD times of light minimum, a new linear ephemeris is derived as follows

$$\mathrm{Min.I} = \mathrm{HJD}2456233.9554(2) + 0.366599(1)E. \qquad (1)$$

With this ephemeris, the $O-C$ values of minimum light times are calculated and listed in the sixth collum of Table 4. The corresponding $O-C$ diagram is depicted in Fig. 1. Since the $O-C$ curve show no significant trend, its orbital period seems to be stable at recent decade. In order to detect its orbital period changes, long-term observations are required in the future.

4. Light curves characteristics and photometric solution

The light curves in B and V bands are shown in Fig. 2. The phases of

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[1] IRAF is distributed by the NOAO, which are operated by the Association of the Universities for Research in Astronomy, Inc., under cooperative agreement with the NSF.

https://doi.org/10.1016/j.newast.2018.06.007
Received 16 April 2018; Received in revised form 30 May 2018; Accepted 13 June 2018
Available online 15 June 2018
1384-1076/

Table 1
Coordinates of V737 Per, the comparison and the check stars.

Stars	α_{2000}	δ_{2000}
V737 Per	$03^h40^m20.18^s$	33°04′07.12″
The comparison	$03^h40^m57.52^s$	33°03′45.75″
The check	$03^h40^m46.01^s$	33°04′53.71″

Table 2
The CCD Photometric data of V737 Per in the B band.

JD (Hel.)	Phase	Δm	JD (Hel.)	Phase	Δm	JD (Hel.)	Phase	Δm
7056.9624	0.4058	0.143	7057.9434	0.5468	−0.360	7058.1595	0.7981	−0.427
7056.9645	0.4036	0.183	7057.9456	0.5438	−0.354	7058.1615	0.7940	−0.398
7056.9667	0.4014	0.204	7057.9484	0.5399	−0.353	7058.1635	0.7901	−0.433
...	...	...	...	...	...	...	...	...
7057.9369	0.5559	−0.305	7058.1515	0.8143	−0.407	7059.1631	0.4044	0.155
7057.9390	0.5528	−0.330	7058.1535	0.8102	−0.373	7059.1653	0.4022	0.130
7057.9412	0.5498	−0.323	7058.1555	0.8061	−0.440	7059.1675	0.4000	0.189

Note: Complete data set is presented as the supplementary material which can be found in the online version.

normalization, listed in the second column of Tables 2 and 3, were calculated by Eq. (1). The basic characteristics of the light curves are summarized in Table 5. They are typical EW-type light curve. The magnitude at primary eclipse is somewhat larger than that at secondary eclipse, which indicates two components have nearly the same temperature. In addition, an unequal altitude can be found in the observed light curves, namely, the light curves exhibit the well-known O'Connell (1951) effect, which indicates that active spots may exist on this system.

Although V737 Per is not a newly discovered W UMa-type binary, its photometric study is still missing. In order to understand its geometrical structure and evolutionary status, the light curves are analyzed by using the 2003 version of the Wilson–Devinney code (Wilson and Devinney, 1971; Wilson, 1990; 1994; Wilson and Van Hamme, 2003). According to the color index B − V = 0.69 mag given in the VizieR database,[2] we fixed the temperature of star 1 (i.e., star eclipsed at primary minimum of light) as $T_1 = 5660$ K (Drilling and Landolt, 2000) corresponding to a spectral type of about G5. The gravity-darkening coefficients $g_1 = g_2 = 0.32$ (Lucy, 1967) and the bolometric albedo $A_1 = A_2 = 0.50$ (Rucinski, 1969) were adopted in view of the convective envelopes for its two components. We adopted a square-root limb darkening law with coefficients $x_{1B} = x_{2B} = 0.684$, $x_{1V} = x_{2V} = 0.397$ taken from van Hamme (1993). Due to the contact configuration of V737 Per, we adopted model 3 which is appropriate for contact binaries that are not in thermal contact. The remaining parameters, such as the orbital inclination (i), the mean temperature of star 2 (T_2), the dimensionless potentials of stars ($\Omega_1 = \Omega_2$), the mass ratio $q = m_2/m_1$, and the monochromatic luminosity of star 1 (L_1), were adjustable. The relative brightness of the secondary star was calculated by the black body radiation model.

So far, no mass ratio of V737 Per is reported. Here, we employ the q-search method to obtain a preliminary mass ratio. The search range of mass ratio is from 0.36 to 2.00. The corresponding relation between the sum of squared residuals $\sum(O-C)^2$ and mass ratio q is depicted in Fig. 3. According to the values of Σ, we estimate that a possible mass ratio should be between 0.39 and 0.43. After we relaxed q as a free parameter, the solution is finally converged on a mass ratio $q = 0.41$. According to the definition of the filling factor, $f = (\Omega_{in} - \Omega)/(\Omega_{in} - \Omega_{out})$, the degree of contact of V737 Per is estimated to be $f = 8.05\%$, which suggests V737 Per is a shallow-contact W UMa binary. The photometric parameters of the converged solution (i.e., the model without spot) are listed in the second column of Table 6. The corresponding theoretical light curves are plotted as solid lines of Fig. 2.

Due to the O'Connell (1951) effect, the theoretical light curves displayed in Fig. 2 can not fit the observed data satisfactorily. Usually, the O'Connell effect can be interpreted as active spot on the star surface. In our light curves, the Max.II is significantly higher than Max.I, which is referred to the negative O'Connell effect. It can be attributed to the following four spot models: (1) a cool spot on the primary star around phase 0.25; (2) a cool spot on the secondary star around phase 0.25; (3) a hot spot on the primary star around phase 0.75; (4) a hot spot on the secondary star around phase 0.75. With the Wilson-Devinney program, we obtain four converged solutions which are summarized in Table 6. The label "Cool spot1" and "Cool spot2" denote that a cool spot is on the primary and secondary star, respectively. While the label "Hot spot1" and "Hot spot2" denote that a hot spot is on the primary and secondary star, respectively. All computed light curves are depicted by solid curves in Fig. 4. As can be seen from Fig. 4, all four spot models can fit the asymmetric light curves well. The solution labeled "Cool spot2", i.e. the one with a cool spot on the secondary star, turns out to be of slightly better quality than the others. The geometrical structure with a cool spot on the secondary star at phases 0.25 is displayed in Fig. 5. Because of the small difference among the sums of squared residuals for these four solutions, it is uncomfortable to conclude that the O'Connell effect for V737 Per is caused by a cool area appearing on the surface of the secondary component.

5. Estimation of absolute parameters and analysis of evolutionary status

In order to investigate the possible evolutionary status of V737 Per, we need to know the absolute elements of its components. Unfortunately, no spectroscopic studies have been reported for this system so far. Therefore, we estimate its absolute parameters by using the statistical relations between absolute parameters and known properties. As shown in the study of Gazeas (2009), the absolute parameters of contact binaries are closely correlated with their fundamental observational characteristics, such as the orbital period and the mass ratio. Also, they extracted the empirical relations from the statistical results. Here, we first made an estimation of the mass of the primary component of V737 Per according to the empirical relation of Gazeas (2009)

$$\log M_1 = 0.725\log P - 0.076\log q + 0.365. \tag{2}$$

Since the mass ratios obtained from the four solutions with different spot models are close to each other, an average mass ratio $q = 0.405$ is adopted due to the very small difference of their photometric qualities. The remaining physical parameters are then calculated by means of the following relations

[2] http://vizier.u-strasbg.fr/, operated as CDS, Strasbourg, France.

Table 3
The CCD Photometric data of V737 Per in the V band.

JD (Hel.)	Phase	Δm	JD (Hel.)	Phase	Δm	JD (Hel.)	Phase	Δm
7056.9631	0.4051	0.909	7057.9420	0.5488	0.431	7058.1603	0.7964	0.332
7056.9653	0.4029	0.927	7057.9441	0.5458	0.429	7058.1623	0.7924	0.358
7056.9675	0.4007	0.931	7057.9463	0.5428	0.410	7058.1643	0.7884	0.367
…	…	…	…	…	…	…	…	…
7057.9354	0.5579	0.458	7058.1523	0.8126	0.344	7059.1640	0.4035	0.901
7057.9376	0.5548	0.459	7058.1543	0.8086	0.384	7059.1662	0.4013	0.921
7057.9398	0.5518	0.472	7058.1583	0.8004	0.343	7059.1683	0.3991	0.921

Note: Complete data set is presented as the supplementary material which can be found in the online version.

Table 4
The times of light minimum of V737 Per.

JD (Hel.)	Method	Type	Error	Epoch	$O-C$	Reference
2451536.7240	C	I	–	−12813.0	0.00024	Otero and Wils (2005)
2454833.7329	C	II	± 0.0007	−3819.5	0.00201	Diethelm (2009)
2455127.9249	C	I	± 0.0002	−3017.0	−0.00160	Diethelm (2010)
2455421.5720	C	I	± 0.0003	−2216.0	−0.00025	Brát et al. (2011)
2455483.5274	C	I	± 0.0002	−2047.0	−0.00006	Brát et al. (2011)
2455497.4584	C	I	± 0.0001	−2009.0	0.00024	Brát et al. (2011)
2455499.4739	C	II	± 0.0002	−2003.5	−0.00057	Brát et al. (2011)
2455500.9403	C	II	± 0.0004	−1999.5	−0.00057	Diethelm (2011)
2455849.9422	C	II	± 0.0004	−1047.5	−0.00082	Diethelm (2012)
2455873.4049	C	II	± 0.0002	−983.5	−0.00043	Hoňková et al. (2013)
2455882.3884	C	I	± 0.0005	−959.0	0.00133	Hoňková et al. (2013)
2456233.9545	C	I	± 0.0004	0.0	−0.00086	Diethelm (2013)
2456630.4317	C	II	± 0.0002	1081.5	−0.00035	Hoňková et al. (2015)
2457029.2914	C	II	± 0.0006	2169.5	−0.00025	Juryšek et al. (2017)
2457056.9716	C	I	± 0.0005	2245.0	0.00173	This paper
2457057.1528	C	II	± 0.0007	2245.5	−0.00037	This paper
2457058.0707	C	I	± 0.0004	2248.0	0.00104	This paper
2457058.9858	C	II	± 0.0006	2250.5	−0.00036	This paper
2457393.5073	C	I	± 0.0001	3163.0	−0.00035	Samolyk (2016)
2457393.6912	C	II	± 0.0001	3163.5	−0.00025	Samolyk (2016)

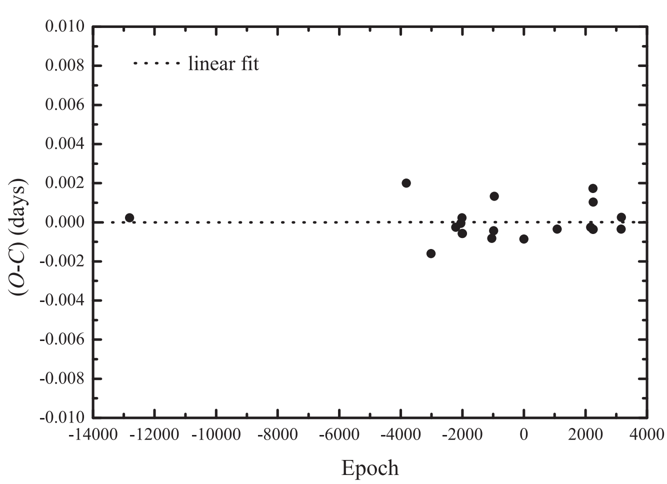

Fig. 1. $O-C$ diagram for V737 Per from Eq. (1).

$$
\begin{aligned}
M_2 &= qM_1, \\
R_1 &= (74.55M_1(1+q)P^2)^{1/3}r_1, \\
R_2 &= (r_2/r_1)R_1, \\
L_{1,2} &= R_{1,2}^2(T_{1,2}/T_{\odot})^4, \\
A &= R_1/r_1,
\end{aligned}
$$

where r_1 and r_2 are the “equal-volume” mean radii of two components by using the separation of the binary as the unit of length, the quantities $M_{1,\,2}$, $R_{1,\,2}$, $L_{1,\,2}$ and A are the masses, radii, luminosities, and the separation in solar units, P denotes the orbital period in day and $T_{1,\,2}$ are the surface temperatures of two components in unit of Kelvin. The estimated physical parameters are listed in Table 7. From the estimated

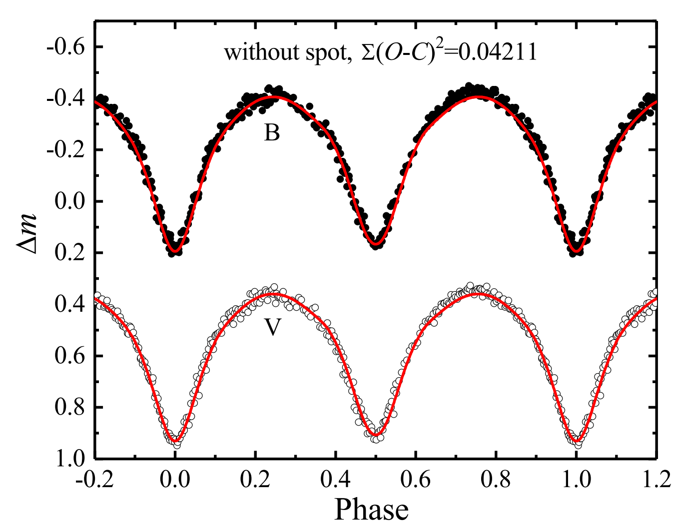

Fig. 2. New CCD photometric light curves in B and V bands of V737 Per. Filled and empty circles represent the observations in B and V bands, respectively. Solid lines are the theoretical light curves without spot which are computed by the parameters in the secondary column of Table 6.

Table 5
Light curve characteristics of V737 Per.

Phase	0.00	0.25	0.50	0.75
Δm(B)	+0.194	-0.405	+0.166	−0.422
Δm(V)	+0.930	+0.360	+0.907	+0.345
	Max.I-Max.II	Min.I-Min.II	Min.I-Max.I	Min.II-Max.II
Δm(B)	+0.017	+0.028	+0.599	+0.588
Δm(V)	+0.015	+0.023	+0.570	+0.562

Table 6
Photometric solutions with and without spot.

Parameter	Without spot	Cool spot 1	Cool spot 2	Hot spot 1	Hot spot 2
i(degree)	78.48 ± 0.19	79.15 ± 0.22	78.60 ± 0.19	77.78 ± 0.17	78.26 ± 0.18
$g_1 = g_2$	0.32	0.32	0.32	0.32	0.32
$A_1 = A_2$	0.50	0.50	0.50	0.50	0.50
$\Omega_1 = \Omega_2$	2.6686 ± 0.0011	2.6218 ± 0.0087	2.6790 ± 0.0096	2.7133 ± 0.0074	2.6602 ± 0.0072
T_1(K)	5660	5660	5660	5660	5660
T_2(K)	5653 ± 11	5634 ± 10	5624 ± 10	5653 ± 10	5669 ± 11
$q = m_2/m_1$	0.41 ± 0.01	0.38 ± 0.01	0.41 ± 0.01	0.43 ± 0.01	0.40 ± 0.01
$x_{1B} = x_{2B}$	0.684	0.684	0.684	0.684	0.684
$x_{1V} = x_{2V}$	0.397	0.397	0.397	0.397	0.397
$\frac{L_{1B}}{L_{1B}+L_{2B}}$	0.6963 ± 0.0037	0.7102 ± 0.0038	0.6999 ± 0.0036	0.6872 ± 0.0035	0.6962 ± 0.0033
$\frac{L_{1V}}{L_{1V}+L_{2V}}$	0.6960 ± 0.0029	0.7088 ± 0.0030	0.6979 ± 0.0029	0.6870 ± 0.0026	0.6969 ± 0.0023
r_1(pole)	0.4353 ± 0.0018	0.4404 ± 0.0019	0.4344 ± 0.0020	0.4305 ± 0.0015	0.4357 ± 0.0014
r_1(side)	0.4653 ± 0.0024	0.4715 ± 0.0025	0.4643 ± 0.0027	0.4595 ± 0.0020	0.4657 ± 0.0019
r_1(back)	0.4935 ± 0.0033	0.4997 ± 0.0035	0.4927 ± 0.0037	0.4877 ± 0.0027	0.4934 ± 0.0025
r_2(pole)	0.2873 ± 0.0027	0.2840 ± 0.0031	0.2888 ± 0.0031	0.2902 ± 0.0021	0.2850 ± 0.0019
r_2(side)	0.3001 ± 0.0034	0.2966 ± 0.0038	0.3017 ± 0.0038	0.3030 ± 0.0026	0.2975 ± 0.0023
r_2(back)	0.3354 ± 0.0059	0.3326 ± 0.0067	0.3372 ± 0.0067	0.3377 ± 0.0044	0.3321 ± 0.0040
$f = \frac{\Omega_{in}-\Omega}{\Omega_{in}-\Omega_{out}}$	8.05%	9.90%	8.73%	6.18%	5.93%
ϕ(degree)	–	129.04 ± 1.50	63.21 ± 1.35	55.59 ± 1.37	59.18 ± 1.59
θ(degree)	–	241.84 ± 1.86	49.69 ± 2.14	100.75 ± 0.71	304.53 ± 2.49
γ(degree)	–	15.16 ± 0.79	15.61 ± 0.59	8.07 ± 0.31	11.57 ± 0.32
T_s/T_{ph}	–	0.798 ± 0.024	0.807 ± 0.021	1.177 ± 0.017	1.214 ± 0.010
$\Sigma(O-C)^2$	0.04207	0.03682	0.03625	0.03823	0.03723

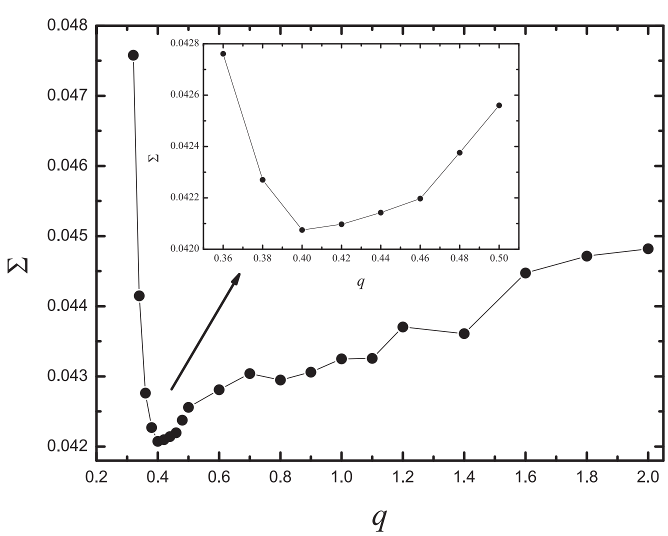

Fig. 3. Relation between the sum of squared residuals Σ and the mass ratio q.

physical parameters, we depict the locations of two components of V737 Per in the Hertzsprung–Russell (H-R) diagram (i.e., Fig. 6). For comparison, some other A- and W-type W UMa binaries compiled by Yakut and Eggleton (2005), are also included in this H-R diagram. As can be seen in Fig. 6, the primary component (i.e., the more massive one) is located above terminal age main sequence (TAMS) line, while the secondary component (the less massive one) is just on the zero age main sequence (ZAMS) line. From this perspective, the primary component of V737 Per is evolved and the secondary one is not yet evolved.

A more direct implication of the evolutionary status of a binary may be deduced from the mean densities of its components (Mochnacki, 1981; 1984; 1985). With the orbital period, relative radii, and mass ratio, the mean densities ($\bar{\rho}_1$, $\bar{\rho}_2$) of two components of a binary system can be determined according to the following equations (Roberts, 1899; Kopal, 1959; Mochnacki, 1981)

$$\bar{\rho}_1 = \frac{0.079}{V_1(1+q)P^2}\mathrm{g\cdot cm^{-3}}, \tag{3}$$

$$\bar{\rho}_2 = \frac{0.079q}{V_2(1+q)P^2}\mathrm{g\cdot cm^{-3}}, \tag{4}$$

where $V_1 = \frac{4}{3}\pi r_1^3$ and $V_2 = \frac{4}{3}\pi r_2^3$ represent the relative volumes of the primary and secondary components, q is the mass ratio m_2/m_1, and P is the orbital period in day. For V737 Per, the mean densities of its primary component and secondary one are calculated to be 0.99 $\mathrm{g\cdot cm^{-3}}$ and 1.39 $\mathrm{g\cdot cm^{-3}}$, respectively. According to the study of Mochnacki (1981), the density-color diagram of the primary can provide a comparison with the main-sequence and evolutionary models for single stars. In view of the energy transfer from the primary to the secondary, the color index needs to be corrected (Mochnacki, 1981). Following the studies of Mochnacki (1981), the temperature and the corresponding color index for the primary of V737 Per are corrected as $T_1 = 6165$ K and $(B-V)_1 = 0.55$ mag, respectively. The mean density $\bar{\rho}_1$ of the primary against the corrected color index $(B-V)_1$ is shown in Fig. 7. In Fig. 7, ZAMS and TAMS lines are taken from Fig. 3 of Mochnacki (1981). As a reference, the primaries of some other contact binaries are also added in Fig. 7. They are selected from the catalogue compiled by Pribulla et al. (2003) where the contact binaries with poor thermal contact and high temperature are excluded. Similar to the majority of A-type contact binaries, the primary of V737 Per is less

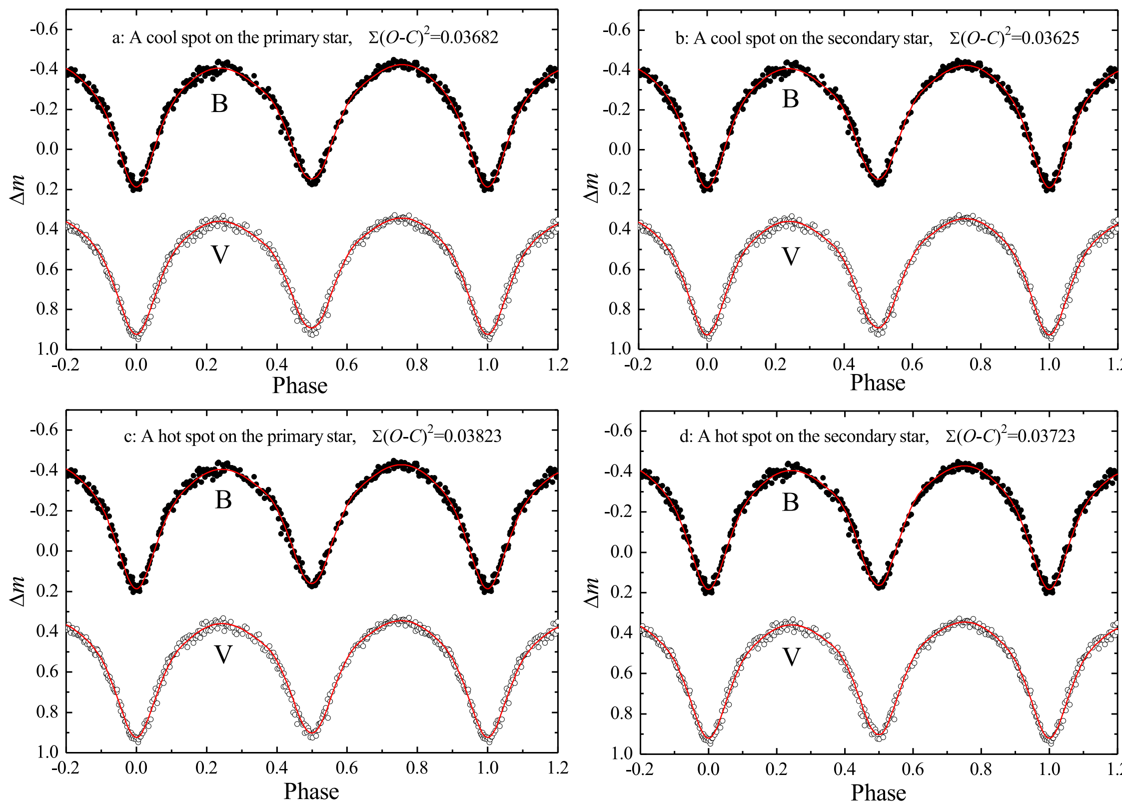

Fig. 4. CCD photometric and theoretical light curves in B and V bands of V737 Per. Filled and empty circles represent the observations in B and V bands, respectively. The theoretical light curves (Solid lines) are computed based on four different spot models with the parameters in Table 6.

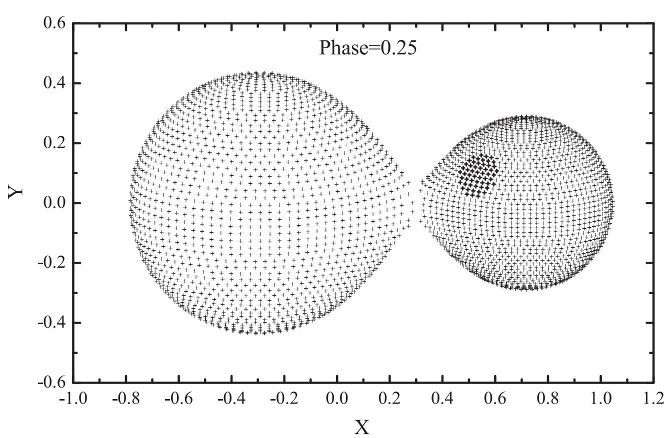

Fig. 5. Geometrical configuration with a cool spot on the secondary star at phase 0.25.

Table 7
Absolute parameters of V737 Per.

Parameter	Primary	Secondary	Unit
M	1.20(4)	0.49(6)	$M_\odot$
R	1.19(8)	0.79(5)	$R_\odot$
L	1.32(5)	0.57(7)	$L_\odot$
$\bar{\rho}$	0.99(2)	1.39(4)	g·cm^{-3}
A	2.57(6)		$R_\odot$

dense than ZAMS stars. This is in agreement with the inferred result of Wilson (1978) where the A-type binaries are moved away from ZAMS line, while the W-type systems are usually close to the ZAMS line. The location of V737 Per in the density-color diagram indicates again that its primary seems to be evolved and close to TAMS. The density of its secondary $\bar{\rho}_2 = 1.39$ g·cm^{-3} is nearly equal to the density of a ZAMS star with the same spectral type, which is well agreement with its location in Fig. 6. This means that the secondary component of V737 Per seems to be not yet evolved. However, it is difficult to infer its evolutionary status because the properties of the secondary are possibly influenced by its contact with the primary (Yang and Liu, 2001; Yang et al., 2001).

Finally, in the study of Eker et al. (2006), a critical orbital angular momentum was empirically determined from a statistical analysis of the orbital angular momentum and systemic mass of 119 chromospherically active binaries(CAB) and 102 W UMa-type binaries, i.e.,

$$\log J_{\rm cr} = 0.522(\log M)^2 + 1.664(\log M) + 51.315. \quad (5)$$

As has been pointed out in their study, if the orbital angular momentum of a binary system is less than the critical orbital angular momentum, this binary should be in a contact status. Otherwise, it would be a detached system. In other words, Eq. (5) defines a empirically boundary to separate the contact and detached binaries. With the absolute physical parameters, we calculated the orbital angular momentum of V737 Per by using the following definition

$$J_{\rm O} = \frac{q}{(1+q)^2}\sqrt[3]{\frac{G^2(M_1+M_2)^5P}{2\pi}}. \quad (6)$$

and obtained the logarithm of its orbital angular momentum, $\log J_{\rm O} = 51.2349$. As displayed in Fig. 8, V737 Per is located at a dense region of contact binary under the borderline, which indicates V737 Per should be a typical contact binary.

6. Discussion and conclusions

In this paper, we have performed the first CCD photometric study for V737 Per and revised its orbital period by combining the new minima times with previous ones. The photometric solution suggests

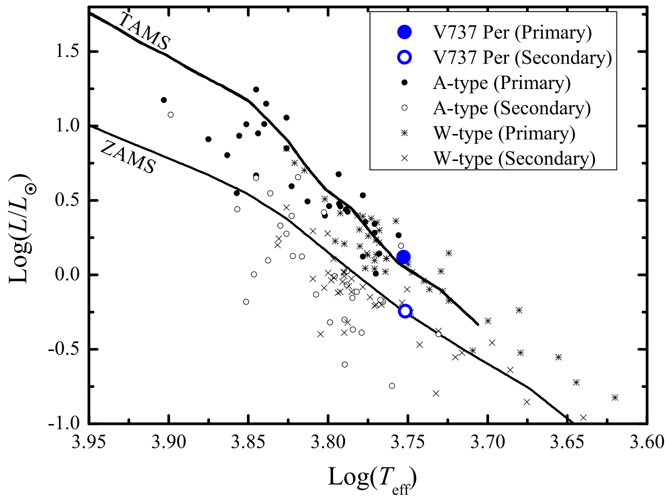

Fig. 6. Locations of the components of V737 Per in H-R diagram. The sample of W- and A-type systems was obtained from Yakut and Eggleton (2005). ZAMS (lower) and TAMS (upper) lines for solar-metallicity are obtained from Girardi et al. (2000).

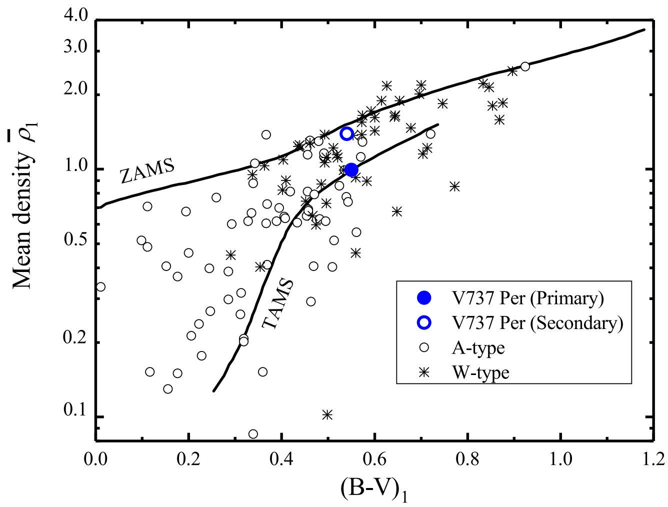

Fig. 7. Corrected color-density diagram for the primaries of both A-type (open circles) and W-type (crosses) contact binaries. V737 Per is represented with a filled circle. The ZAMS and TAMS lines (solid and dotted lines) are taken from Fig. 3 of Mochnacki (1981).

that V737 Per is a shallow contact binary with a degree of contact of $f = 8.73\%$. According to the classifications of Binnendijk (1970), it is an A-type binary system with a textbfmass ratio $q = 0.41$. However, the temperature of the secondary component is almost equal to that of the primary component. The significant O'Connell effect with Max.I fainter than Max.II has been detected and may be explained by one of four spot models. The best fit is the model with a cool spot on the secondary star.

In view of the absence of the spectroscopic elements of V737 Per, both estimated physical parameters and mean densities of its two components are obtained to uncover its evolutionary status. Twofold indicators suggest that the primary component of V737 Per has evolved into TAMS star. However, our analysis is highly speculative due to the uncertainties of the photometric solutions and estimated physical parameters. Since the period variation can provide a very important clue to understand its evolutionary status, further long-term

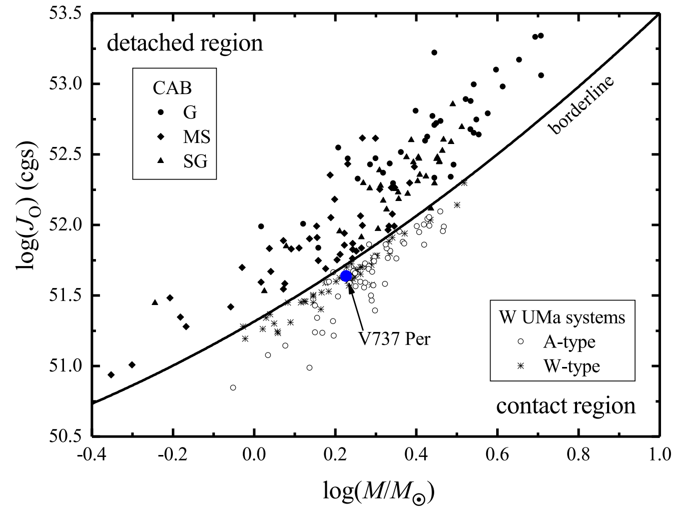

Fig. 8. Location of V737 Per in the $\log T - \log M$ diagram is under the J_{cr} borderline, which confirms its geometrical contact configuration. Among the CAB, G group denotes systems contain at least one component being a giant, while SG group denotes systems contain at least one subgiant but no giant. MS group means the components of the systems are on the main sequence.

photometric observations are required for uncovering its possible period changes. Also, the spectroscopic observations should be needed to derive its absolute physical parameters and resolve its evolutionary status more firmly.

Appendix A. Supplementary data

The complete data for Tables 2 and 3 are presented as the Supplementary data associated with this article and can be found in the online version.

Acknowledgments

This work was supported by the Joint Research Funds in Astronomy (U1531108, U1731106 and U1731110) under cooperative agreement between the National Natural Science Foundation of China and Chinese Academy of Sciences, and the National Natural Science Foundation of China (11703020). Also, we acknowledge the support of the staff of the Xinglong 85cm telescope. This work was partially supported by the Open Project Program of the Key Laboratory of Optical Astronomy, National Astronomical Observatories, Chinese Academy of Sciences. Finally, we thank the anonymous reviewer for his/her careful work and thoughtful suggestions that have helped improve this paper.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.newast.2018.06.007.

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