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Basic physical properties of the low-temperature contact binary system V781 Tau and the near-contact binary system V836 Cyg

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ABSTRACT

We present a detailed photometric study of the low-temperature contact binary V781 Tau, and the near-contact binary V836 Cyg. We have combined the parameters obtained from the light-curve analysis with those found by the spectral studies and we have determined the orbital and physical parameters of the stars. We have collected the times of the mid-eclipses obtained so far and combined with the times obtained in this study. By analysing all these data we determined the mass transfer rate from the massive star to the less massive one for V781 Tau, and from the less massive component to the massive one in the case of V836 Cyg. Finally, we have compared the results obtained for V781 Tau and for V836 Cyg with similar systems.

Key words: techniques: photometric – binaries: eclipsing – stars: fundamental parameters – stars: individual: V781 Tau – stars: individual: V836 Cyg.

1 INTRODUCTION

V781 Tau ($P = 0.34$ d, G0V) is a W-type low-temperature contact binary (LTCB) system. The variability of V781 Tau was discovered by Harris (1979) and has since been observed a few times. The first photometric light curves were obtained by Cereda et al. (1988). Spectroscopic observations were made by Lu (1993) and Zwitter et al. (2003). The radial-velocity (RV) solution of Zwitter et al. was combined by them with the *Hipparcos* light curve and they gave the basic parameters as $M_{\mathrm{c}} = 1.150(27)\ \mathrm{M}_{\odot}$, $M_{\mathrm{h}} = 0.510(6)\ \mathrm{M}_{\odot}$, $R_{\mathrm{c}} = 1.111(7)\ \mathrm{R}_{\odot}$, $R_{\mathrm{h}} = 0.759(7)\ \mathrm{R}_{\odot}$. The rate of period change of V781 Tau was studied by Liu & Yang (2000) and Donato et al. (2003).

The eclipsing binary system V836 Cygni ($P = 0.65$ d, A0V) was first observed by Strohmeier, Kippenhahn & Geyer (1956). In the same year Schmidt (1956) obtained the photographic light curve of the system and classified it as an Algol-type binary. The first photoelectric observations of the system were made by Deinzer & Geyer (1959). Wester (1977) obtained B and V light curves of the system. Later, Breinhorst & Duerbeck (1982) made a comparison between the light curves which were obtained during 1971, 1976 and 1980 at Kitt Peak and Hoher List observations, and showed a brightness deficiency on the ascending branch of the secondary minimum. Breinhorst, Kallrath & Kämper (1989) found that the system is detached and they concluded that V836 Cygni has lost a significant fraction of its orbital angular momentum during its evolution. They also suggested that the star falls in a group of short-period non-contact close binary systems showing EB-type light curves. Duerbeck & Schumann (1982) obtained the first spectroscopic orbit of the system. They derived $K = 90.3$ km s^{-1}, $V_{\mathrm{o}} = -43.3$ km s^{-1} and $f(m) = 0.050$ from the RV solution.

2 OBSERVATIONS

2.1 V781 Tauri

The observations in the Johnson B, V and R bands of V781 Tau were carried out on 2001 November 26, December 14, and 2002 January 28, October 28, with the 30-cm Schmidt–Cassegrain telescope of Ege University Observatory (EUO). On 2002 October 28, the system was observed only for times of minimum light. We collected *BVR* photometry using the SSP-5 type photometer including a Hamamatsu R4457 detector. An integration time of 10 s was used for each measurement in each filter. The comparison star also used by Cereda et al. (1988) was HD 38980; the constancy of the brightness for this star was already assured by Cereda et al. (1988) and they obtained the brightness and B–V colour of HD 38980 as 7.14 and 0.44 mag, respectively. Using the given B–V magnitudes for the comparison star, our observations give the system's B–V values at maximum as 0.58 mag. The differential observations, in the sense variable minus comparison, were corrected for atmospheric extinction using the extinction coefficients obtained for each night from the brightness variation of the comparison star by using the ATMEX code package (Keskin, private communication). The standard deviations for each differential observation are estimated to be 0.03, 0.02

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Table 1. *BVR* measurements of V781 Tau (Fig. 1a). The phases were calculated using the following ephemeris HJD = 245 2303.4833 + 0.34490799 d × *E*. 1, 2 and 3 denote *B*, *V*, and *R* filters (F), respectively. The full version of this table is available in Synergy, the on-line version of Monthly Notices.

F	Phase	Δm	F	Phase	Δm	F	Phase	Δm	F	Phase	Δm
1	0.004	1.961	1	1.458	1.848	2	0.992	1.802	3	0.472	1.669
1	0.011	1.916	1	1.459	1.857	2	0.992	1.810	3	0.488	1.682
1	0.015	1.899	1	1.467	1.884	2	0.999	1.794	3	0.493	1.745
1	0.015	1.937	1	1.467	1.852	2	1.005	1.802	3	0.497	1.738
1	0.023	1.919	1	1.471	1.890	2	1.012	1.788	3	0.498	1.670
1	0.028	1.882	1	1.487	1.884	2	1.015	1.765	3	0.504	1.662
1	0.038	1.863	1	1.496	1.867	2	1.016	1.827	3	0.507	1.731

and 0.03 mag for the *B*, *V* and *R* bands, respectively. A total of 326 observations in *B*, 342 in *V* and 336 in *R* were obtained. For convenience of future investigators, we publish all these observations in Table 1.

The differential *B*, *V* and *R* magnitudes were plotted against the orbital phase and are shown in Fig. 1(a). Five times of light minima were obtained using the method of Kwee & van Woerden (1956). The times of minima are averages of the *BVR* passbands. These times of minima are listed in Table 2 together with the previously obtained timings.

2.2 V836 Cygni

We used the same set-up as for V781 Tau, besides TÜBİTAK National Observatory's (TUG) 40-cm Cassegrain telescope. The system was observed on 10 nights during 2001 July, August and September and on two nights in 2002 August. The comparison and check stars were HD 202768 and BD + 35° 4460, respectively. The extinction coefficients were obtained for each night using the brightness variation of the comparison star, and the differential magnitudes were corrected for differential atmospheric extinction by using the computer program ATMEX. We initially assumed the ephemeris given by Yakut et al. (2003). The standard deviations for each differential observation are estimated to be 0.03, 0.02 and 0.02 mag for the *U*, *B* and *V* bands, respectively. A total of 579 observations in *U*, 520 in *B* and 572 in *V* were obtained. For convenience of future investigators, we publish all these observations in Table 3.

The differential magnitudes plotted versus the orbital phase for each band are shown in Fig. 1(b).

3 ANALYSIS OF THE O–C CURVE

3.1 V781 Tau

Times of light minimum of V781 Tau were collected from several publications up to date and are listed in Table 2. The first quadratic ephemeris was derived by Liu & Yang (2000), and superseded by Donato et al. (2003):

$$\text{Pri.Min.} = \text{HJD } 244\,3853.9110 + 0.344909292(3) \times E - 2.5 \times 10^{-11} \times E^2. \quad (1)$$

The $(\text{O–C})_\text{I}$ residuals indicate the differences between the observed times of eclipses and those calculated. Assuming that the photoelectric (pe) observations are much more accurate than those of photographic (pg) observations we assign weight 1 to the pg and 10 to the pe times of minimum. A weighted least-squares solution

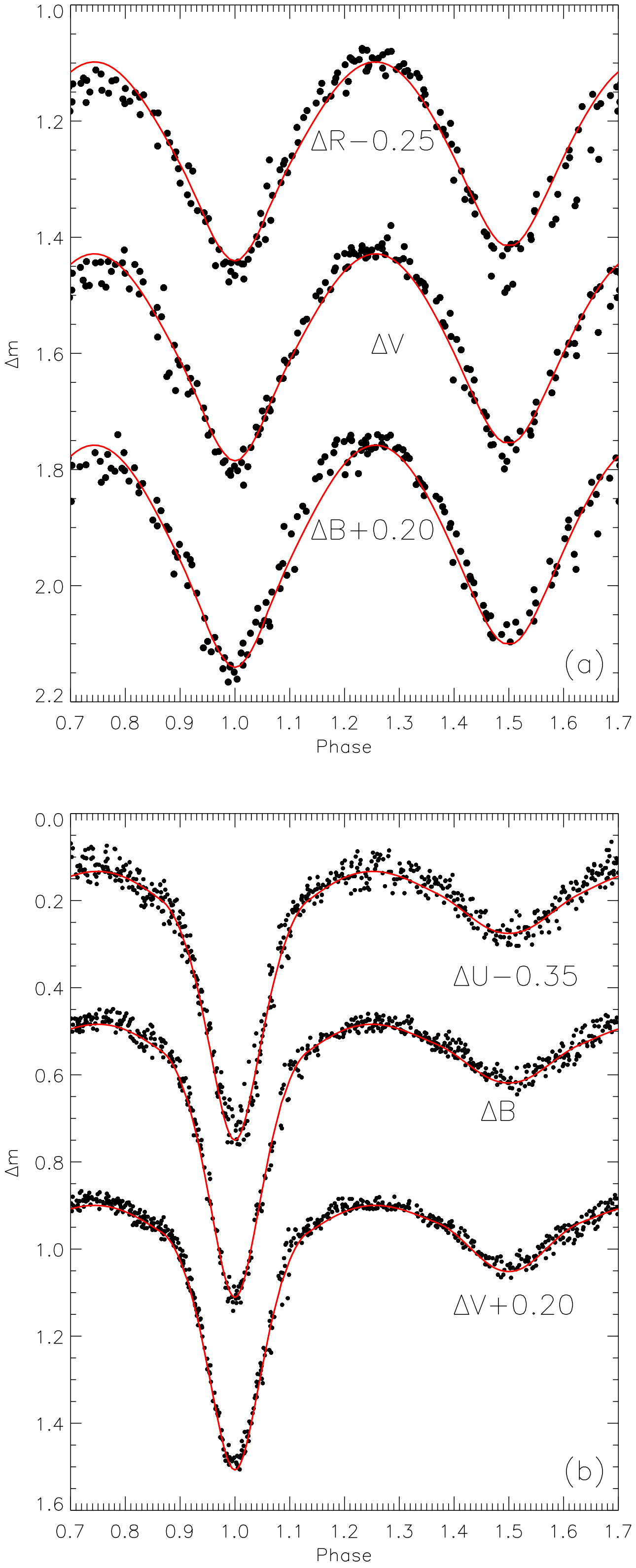

Figure 1. (a) A comparison of the observed (dots) and computed (solid line) *B*, *V* and *R* light curves of V781 Tau. The curves in *B* and *R* bands are moved by +0.2 and −0.2 in intensity for good visibility. (b) A comparison of the observed (dots) and computed (solid line) *U*, *B* and *V* curves of V836 Cyg. The *U* and *V* values are moved −0.35 and +0.2 for good visibility.

Table 2. Times of the primary (I) and secondary (II) minima in $\mathrm{JD}_{\mathrm{h}}^{*}$ (JD_{h} 240 0000) for V781 Tau. pe and pg denote photographic and photometric, respectively. References are as follows: 1, Berthold (1983); 2, Cereda et al. (1988); 3, Pohl et al. (1987); 4, Wunder et al. (1992); 5, Liu & Yang (2000); 6, this paper; 7, Nelson (2003); 8, Donato et al. (2003); 9, Tanrıverdi et al. (2003); 10, Selam et al. (2003).

$\mathrm{JD}_{\mathrm{h}}^{*}$	t	Min.	Ref	$\mathrm{JD}_{\mathrm{h}}^{*}$	t	Min.	Ref	$\mathrm{JD}_{\mathrm{h}}^{*}$	t	Min.	Ref
32881.460	pg	I	1	46113.4117	pe	II	3	50818.1359	pe	I	5
33950.515	pg	II	1	46115.3090	pe	I	3	52240.3647	pe	II	6
34775.368	pg	I	1	46775.4650	pe	I	2	52258.4735	pe	I	6
35540.371	pg	I	1	46775.4652	pe	I	2	52303.3121	pe	I	6
36610.285	pg	I	1	46788.3980	pe	II	2	52303.4815	pe	II	6
36957.442	pg	II	1	46788.3982	pe	II	2	52554.9210	pe	II	7
38088.397	pg	II	1	46798.4001	pe	II	2	52229.5042	pe	I	8
38440.378	pg	I	1	46798.4008	pe	II	2	52230.5361	pe	I	8
39536.327	pg	II	1	46802.3682	pe	I	2	52231.3946	pe	II	8
40981.332	pg	I	1	46802.3682	pe	I	2	52231.5723	pe	I	8
41329.345	pg	I	1	46802.5394	pe	II	2	52252.4369	pe	II	8
41330.381	pg	I	1	46802.5398	pe	II	2	52252.6076	pe	I	8
41337.279	pg	I	1	48268.2285	pe	I	4	52260.3694	pe	II	8
42839.363	pg	I	1	48268.3996	pe	II	4	52576.4788	pe	I	6
43853.9088	pe	II	2	48268.4024	pe	II	4	52658.3967	pe	II	8
43853.911	pe	II	1	48607.2723	pe	I	4	52659.4252	pe	II	8
43874.9482	pe	II	2	48607.2734	pe	I	4	52666.3276	pe	II	8
43874.954	pe	II	1	48607.4447	pe	II	4	52594.5853	pe	II	9
44636.3390	pe	I	2	48607.4460	pe	II	4	52924.4952	pe	I	10
44637.3710	pe	I	2	50814.1688	pe	II	5				

Table 3. *UBV* measurements of V836 Cyg (Fig. 1b). The phases were calculated using the ephemeris given by Yakut et al. (2003). 1, 2 and 3 denote U, B and V filters (F), respectively. The full version of this table is available in Synergy, the on-line version of Monthly Notices.

F	Phase	Δm	F	Phase	Δm	F	Phase	Δm	F	Phase	Δm
1	0.700	0.419	1	1.384	0.505	2	1.221	0.469	3	0.916	0.888
1	0.702	0.450	1	1.384	0.504	2	1.221	0.486	3	0.916	0.868
1	0.704	0.430	1	1.387	0.539	2	1.222	0.488	3	0.917	0.847
1	0.710	0.490	1	1.388	0.520	2	1.224	0.501	3	0.919	0.866
1	0.712	0.471	1	1.392	0.516	2	1.224	0.480	3	0.919	0.896
1	0.713	0.497	1	1.392	0.503	2	1.226	0.485	3	0.920	0.895
1	0.716	0.481	1	1.394	0.541	2	1.226	0.504	3	0.921	0.869

leads to the following light elements with a quadratic term:

$$\text{Pri.Min.} = \text{HJD } 244\,3853.91116(5) + 0.344909289(3) \times E - 2.51(2) \times 10^{-11} \times E^{2}. \quad (2)$$

Equation (2), which is obtained with additional data (pe+pg) and different weighting schemes, is consistent with equation (1). In Figs 2(a) and (b) the quadratic fits are compared with the O–C residuals. The period decrease resulting from equation (2) is $\mathrm{d}P/\mathrm{d}t = -5.32 \times 10^{-8}$ d yr^{-1}, or $P/\dot{P} = -6.5 \times 10^{6}$ yr. Such a period change is usually attributed to mass transfer. If the period decrease is indeed caused by mass transfer, we can use the following equation in order to estimate mass transfer between the components:

$$\dot{M} = \frac{1}{3}\frac{\dot{P}}{P}\left(\frac{M_{\mathrm{c}}M_{\mathrm{h}}}{M_{\mathrm{c}} - M_{\mathrm{h}}}\right). \quad (3)$$

From equation (3) the mass transfer rate of $\mathrm{d}M/\mathrm{d}t = -5.3 \times 10^{-8}$ $\mathrm{M}_{\odot}$ yr is found. Because the mass transfer occurs from the secondary (i.e. cooler, more massive) component to the primary, the secondary component should shrink with time. Besides, any mass loss from L_2 will affect the orbital period change of the system (see Zwitter et al. 2003).

3.2 V836 Cyg

The O–C analysis of the system was made by Breinhorst & Duerbeck (1982). They concluded that the O–C curve can be represented by two terms: first, a sinusoidal variation, which is the result of a third component, and secondly, a parabolic variation due to mass transfer between the components. In their study, they found a period increase with the approximation of a parabolic shape of variation. Furthermore, the times of minimum light obtained up to 1981 were given by the same authors. Published times of minima up to now were collected from the literature and are given in Table 4. Only photoelectric times were used and these residuals for all the times of minimum light of V836 Cyg are plotted versus epoch numbers in Fig. 2(c).

The O–C values show a parabolic-shaped curve. Such a change of the O–C deviations may indicate the occurrence of mass transfer in the system. The upward parabola demonstrates that the mass transfer occurs from the less massive component (the secondary, for V836 Cyg) to the more massive. In order to obtain the parameters ΔT_0, ΔP and Q, we used a weighted least-squares solution. The iterations were continued until the best fit was reached. In Fig. 2(c), we plot O–C residuals obtained only from the photoelectric times of minimum light versus epoch, i.e. cycle number. The analysis yielded quadratic ephemeris:

$$\text{HJD (Min I)} = 244\,1239.4680(3) + 0.65341173(5)\text{ d} \times E + 7.1(4)10^{-11} \times E^{2}. \quad (4)$$

According to the values obtained, we found the period increase $\mathrm{d}P/\mathrm{d}t = 7.9 \times 10^{-8}$ d yr^{-1}, and $P/\dot{P} = 8.2 \times 10^{6}$ yr. Because this analysis is based on much more data, the results obtained in this study are much more accurate than the results obtained previously by Breinhorst & Duerbeck (1982). The mass transfer rate, if we

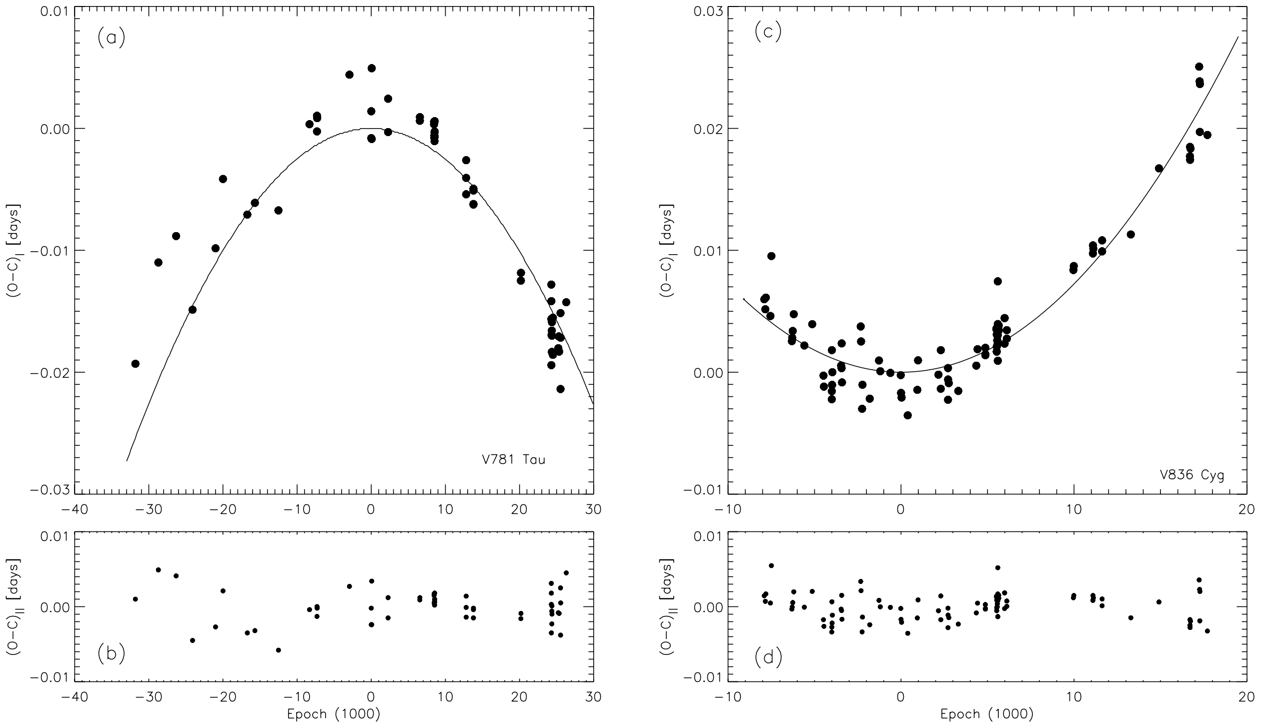

Figure 2. (a) Residuals for the times of minimum light of V781 Tau. The solid line is obtained with the quadratic terms in ephemeris (2). (b) The difference between the observations and the quadratic ephemeris (2). (c) The O–C diagram of the times of mid-eclipses for V836 Cygni, from the linear ephemeris (Yakut et al. 2003). (d) The difference between the observations and the quadratic ephemeris (4).

assume that the system does not lose matter during the evolution, is $dM/dt = 4.9 \times 10^{-8}$ $M_{\odot}$ yr^{-1}. The (O–C)$_{II}$ residuals indicate a sine-like change (Fig. 2d) with a period of nearly 29 yr and with an amplitude of 7 min. However, this small amplitude change will have to be confirmed with future observations.

4 LIGHT-CURVE ANALYSIS

4.1 V781 Tau

The *BVR*-band light curves of the system obtained in the years 2001 and 2002 (over 63 d) were analysed for the orbital parameters. The 2004 version of the Wilson–Devinney (WD) code (Wilson & Devinney 1971; Wilson 1994; Wilson & Van Hamme 2004) was employed for our light-curve analysis. Mode 3, which assumes both of the components filled their Roche lobes, was used. The following values were adopted for the light-curve analysis: the temperature of the primary component was set at $T_1 = 6150$ K according to the system's colour we obtained from our observations and equation (3) of Zwitter et al. (2003), and the mass ratio according to the spectroscopic study of Zwitter et al. The albedos were taken from Rucinski (1969), the limb darkening coefficients from Claret (2000) and the values of the gravity darkening coefficients from Lucy (1967). The adjustable parameters are the inclination i, the temperature of the secondary component T_2, the luminosity L_1 (L_{1B}, L_{1V}, L_{1R}), the surface potential Ω, and the phase shift ϕ_0.

The light curve was solved in B, V and R bandpasses simultaneously. The differential correction (DC) code was run until the corrections to the input parameters were lower than their errors. The results and the adopted values are given in Table 5. The light curves computed using the parameters given in Table 5 are shown by the solid lines in Fig. 1(a) and compared with all the observations. The LC program was used to create the synthetic light curves. The filling factor, $f = 0.29$, is the expression $(\Omega_{in} - \Omega)/(\Omega_{in} - \Omega_{out})$ and varies from zero to unity from the inner to the outer critical surface.

4.2 V836 Cyg

Cester (1963) and Harris (1968) used the Russell–Merrill method and Wester (1977) solved the light curve with the Wood and Hutchings–Hill method. Breinhorst et al. (1989) used the WD code to solve the data taken from Duerbeck & Breinhorst (1984). They also analysed *uvby* light curves of the system. Zhukov & Markova (1993) analysed their light curve and found that the system is almost semidetached.

Mode 5 in the DC code was used for the light-curve analysis. This mode solves the light curves of semidetached eclipsing binaries such as V836 Cyg, where the secondary (cooler) component fills its corresponding Roche lobe while the primary (hotter) is well detached. Because of the non-existence of a spectroscopic mass ratio for the system in the literature, we tried to find the photometric mass ratio by using the light curve obtained with the V filter. The minimum Σ(O–C)^2 of the analysis was obtained at the mass ratio value of 0.3.

After yielding the approximate value of the mass ratio, observed light curves in U, B and V filters were analysed in mode 5 optimization of the DC code for obtaining the final parameters. The following values were adopted for light-curve analysis: $T_1 = 9790$ K, the mean temperature of the primary component, taken from Drilling & Landolt (2000), the values of the gravity darkening coefficients g_1 (von Zeipel 1924) and g_2 (Lucy 1967), the values of the albedos A_1 and A_2 (Rucinski 1969), and the limb darkening coefficients x_1 and x_2 (Claret 2000). Values of these parameters are given in Table 5.

Table 4. Times of the primary (I) and secondary (II) minima in JD_h^* (JD_h 240 0000) for V836 Cyg. References are as follows: 1, Deinzer & Geyer (1959); 2, Cester (1963); 3, Fürtig (1963); 4, Harris (1968); 5, Kızılırmak & Pohl (1969); 6, Popovici (1968); 7, Pohl & Kızılırmak (1970); 8, Popovici (1970); 9, Breinhorst & Duerbeck (1982); 10, Kızılırmak & Pohl (1974); 11, Brancewicz & Kreiner (1976); 12, Wester (1977); 13, Diethelm (1979); 14, Patkos (1980); 15, Derman et al. (1982); 16, Bozkurt (1982); 17, Bozkurt (1991); 18, Zhukov & Markova (1993); 19, Wolf & Diethelm (1992); 20, Hegedüs et al. (1996); 21, Bíró et al. (1998); 22, Yakut et al. (2003); 23, Dvorak (2003); 24, Demircan et al. (2003); 25, Bakış et al. (2003); 26, Zejda (2004).

JD_h^*	Min.	Ref.	JD_h^*	Min.	Ref.	JD_h^*	Min.	Ref.
36073.6008	I	1	40455.3740	I	8	44894.3305	II	16
36113.4581	I	1[a]	40836.3129	I	8	44894.3340	II	16
36132.4080	I	1[a]	41230.3200	I	9	44895.3076	I	16
36305.5606	I	1[a]	41239.4663	I	9	44895.3097	I	16
36343.4634	I	1[a]	41260.3751	I	9	44929.2875	I	16
37116.4425	I	2	41492.3348	I	10	44929.2879	I	16
37129.5110	I	2	41854.3270	I	10	45151.4464	I	17
37148.4605	I	2	41881.4460	II	10	45151.4485	I	17
37188.3200	I	2	42653.4508	I	11	45234.4301	I	17
37587.5520	I	3	42740.3534	I	12	45234.4308	I	17
37885.5095	I	2	42742.3168	I	12	47749.4175	I	18
38309.5695	I	4	43013.4786	I	12	47764.4463	I	18
38326.5573	I	4	43013.4812	I	9	48486.4673	I	19
38623.8586	I	4	43015.4405	I	12	48488.4282	I	19
38625.8195	I	4	43043.5369	I	12	48503.4564	I	19
38627.7831	I	4	43401.6059	I	12	48833.4291	I	20
38635.6212	I	4	44082.4630	I	13	48833.4300	I	20
38644.7700	I	4	44129.5100	I	14	49919.4008	I	21
38976.7037	I	4	44423.8721	II	9	52151.4617	I	22
38993.6922	I	4	44424.8516	I	9	52153.4227	I	22
38997.6147	I	4	44425.8318	II	9	52156.362	I	22
39008.7195	I	4	44840.4236	I	15	52172.3715	I	22
39716.3690	I	5	44842.3839	I	15	52499.4108	II	22
39729.4360	I	5	44853.4900	I	16	52516.3983	II	22
39769.2886	I	6	44853.4904	I	16	52524.5618	I	23
39782.3588	I	6	44874.3997	I	16	52528.4862	I	24
40057.444	I	7	44874.4001	I	16	52811.4093	I	25
40406.3690	I	7	44879.3013	II	16	52854.5337	I	26

[a] Recalculated by Breinhorst & Duerbeck (1982).

The adjustable parameters are the inclination i, the temperature of the secondary component T_2, the surface potential of the components Ω_1, Ω_2, the luminosity L_1 (L_{1U}, L_{1B}, L_{1V}), the mass ratio of the components q and the phase shift (ϕ). The results are given in Table 5. The light curves computed using the parameters given in Table 5 are shown by the solid lines in Fig. 1(b) and compared with all the observations.

5 BASIC PHYSICAL PROPERTIES OF THE SYSTEMS

5.1 V781 Tau

The new B and V light curves of the system analysed by the latest version of WD code, along with the radial-velocity study made recently by Zwitter et al. (2003), give the orbital parameters as $i = 66\overset{\circ}{.}80$, $a = 2.4478\ \mathrm{R}_\odot$, $q = 2.278$. Because in their study they do not give K_h, K_c, $a\sin i$ and $M_\mathrm{h,c}\sin^3 i$, we use their orbital parameters and the Kepler equation to derive $K_\mathrm{h} = 229.4$ and $K_\mathrm{c} = 100.7\ \mathrm{km\ s^{-1}}$. Combining these values with the orbital period of the system and the inclination of the orbit with respect to the plane of the sky, which we derived by the light-curve analysis, we can derive the absolute parameters of the system listed in Table 6. For solar values, we have taken $T_\mathrm{eff} = 5780$ K and $M_\mathrm{bol} = 4.75$ mag.

5.2 V836 Cyg

By using the parameters derived from the present photometric study and the spectroscopic elements given by Duerbeck & Schumann (1982), we computed the absolute parameters of the system and these are presented in Table 6. The mass of the primary is taken from Popper (1980). The light-curve analysis indicates that the system is semidetached. The less massive secondary component fills its Roche lobe and transfers mass on to the primary from its inner Lagrangian point. In addition, the O–C curve of the system shows an upward parabolic shape, which agrees with the result obtained from the light-curve analysis, meaning that the less massive component is indeed transferring mass to the other component.

6 SUMMARY AND CONCLUSIONS

In this study, we have redone the O–C and light-curve analyses of the W-type LTCB system V781 Tau and the NCB system V836 Cyg, and we have derived their orbital and physical parameters. It seems that there is good agreement with the derived physical parameters of V781 Tau and V836 Cyg and other LTCBs and NCBs.

The spectroscopic study of V781 Tau comes from Zwitter et al. (2003), who combined their spectral data with the *Hipparcos* light curve and derived the parameters. We have determined the physical parameters of the system with the simultaneous solution of our

Table 5. Photometric elements of V781 Tau, V836 Cyg and their standard deviations in parentheses. Star 2 is the cooler star in both systems. Ω_i, x_i, g_i and A_i are the potential, the limb darkening, the gravity darkening and albedos of the components, respectively.

Parameter	V781 Tau *BVR*	V836 Cyg *UBV*
i (°)	62.3(6)	77.1(2)
T_2 (K)	5885(50)	5462(43)
Ω_1	5.466(26)	2.793(14)
Ω_2	5.466(26)	2.589
L_1 U	–	12.319(27)
B	4.414(138)	12.162(23)
V	4.234(098)	11.845(25)
R	4.147(081)	–
$[L_1/(L_1+L_2)]_U$	–	0.982
$[L_1/(L_1+L_2)]_B$	0.390	0.976
$[L_1/(L_1+L_2)]_V$	0.372	0.952
$[L_1/(L_1+L_2)]_R$	0.365	–
q	2.278^a	0.357(6)
x_{1_U}	–	0.520^a
x_{1_B}	0.718^a	0.603^a
x_{1_V}	0.672^a	0.520^a
x_{1_R}	0.597^a	–
x_{2_U}	–	0.890^a
x_{2_B}	0.777^a	0.834^a
x_{2_V}	0.672^a	0.736^a
x_{2_R}	0.597^a	–
g_1	0.32^a	1.0^a
g_2	0.32^a	0.32^a
A_1	0.5^a	1.0^a
A_2	0.5^a	0.5^a
$\bar{r}_1$	0.3352(10)	0.4255(7)
$\bar{r}_2$	0.4768(9)	0.2920(7)

[a] Fixed value.

ground-based three colour light curves (*BVR*) with the spectroscopic study of Zwitter et al. (2003). Although the radial velocities we use in the present investigation and those of Zwitter et al. are the same, because of the differences between the light curves, small differences between the physical parameters occurred. Calculated physical parameters of V781 Tau have been presented with their errors in Table 6. We have collected and analysed all the times of minima for V781 Tau. The plot of (O–C) versus epoch gives a downward parabola. This property can be explained as mass transfer from the massive component of V781 Tau to the less massive component. As a result we have found the quadratic term of equation (5). From equation (5) we can say that the period of the system decreases by about 5.3×10^{-8} d y^{-1}, which may be produced by a mass transfer rate of about 3×10^{18} gr per second.

The remaining residuals after the parabolic fit to the $(\mathrm{O–C})_{\mathrm{II}}$ curve of V836 Cyg seem cyclic-shaped and this may be taken as a signature either of magnetic activity on the surface of one of the components (the secondary component probably) or of the third-light effect. We also tried to approximate the $(\mathrm{O–C})_{\mathrm{II}}$ variation with a periodic curve; however, it does not give good agreement with the observational points. Future observations, especially those which we will carry out in the next five years, may bring to light the real behaviour of the curve. The primary is an A0V star which is well detached from its corresponding Roche lobe. We assumed that the G-type secondary is a main-sequence star at the beginning of our analysis, but the values we obtained gave the fact that the secondary component is overluminous for its temperature according to its MK classification (see Fig. 3). Some distortions at about the 0.1 phase in the light curve, especially in the *B* and *V* filters, can be seen. Such distortion may be the result of looking at the hot region which is produced by the matter flowing from the secondary component to the primary at this phase. V836 Cyg is an extreme system within the group of 'short-period non-contact close binary systems showing EB-type light curves', as Breinhorst et al. (1989) suggested. This group contains secondaries which have the same character as the secondary (i.e. less massive) components of A-type W UMa systems. We can consider the possibility that the system is very near to contact and might reasonably be called 'pre-contact'.

In the study of Yakut & Eggleton (2005, hereafter YE05) on close binary systems, the stars whose physical parameters are well known are collected. They plotted *M–R*, *M–T*, *R–T* and *M–L* relations and the Hertzsprung–Russell (HR) diagram of these related objects. The physical parameters given in this study (Table 6) are in good agreement with the systems given in YE05 (and also with the diagrams given by Hilditch, King & McFarlane 1988). Fig. 3 shows the HR diagram of W-subtype LTCBs and NCBs in which the components of V781 Tau and V836 Cyg are shown. The location of V781 Tau is consistent with other W-type LTCBs. The location of the less massive component of V781 Tau seems to be overluminous and oversized like other secondary stars. The companion seems to be below the zero-age main sequence (ZAMS) and the massive component relays at about the terminal-age main sequence (TAMS). The primary component of V836 Cyg is just above the ZAMS and the secondary is above the TAMS. In the evolution of the close binaries, there exist strong evolution connections between the detached closed binaries (DCBs), NCBs and LTCBs (see YE05 for details). In order to study the evolution of the close binaries, the parameters of V781 Tau and V836 Cyg will be a good example of well-defined parameters.

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Table 6. Absolute parameters for V781 Tau and V836 Cyg. The standard errors σ in the last digit are given in parentheses. HC denotes hot component, and CC cool component.

Parameter	Unit	V781 Tau HC	CC	V836 Cyg HC	CC
Mass	$\mathrm{M}_\odot$	0.57 (3)	1.29 (7)	2.2 (2)	0.78 (2)
Radius	$\mathrm{R}_\odot$	0.852 (4)	1.212 (3)	1.94 (3)	1.34 (2)
Effective temperature	K	6150	5885 (50)	9790	5462 (43)
Luminosity	$\mathrm{L}_\odot$	0.93 (4)	1.58 (4)	31.0 (1.9)	1.4 (1)
Surface gravity (log g)	$\mathrm{cm\,s^{-2}}$	4.33	4.38	4.21	4.08
M_{bol}	mag	4.83 (5)	4.25 (2)	1.02^{+6}_{-7}	4.37 (5)

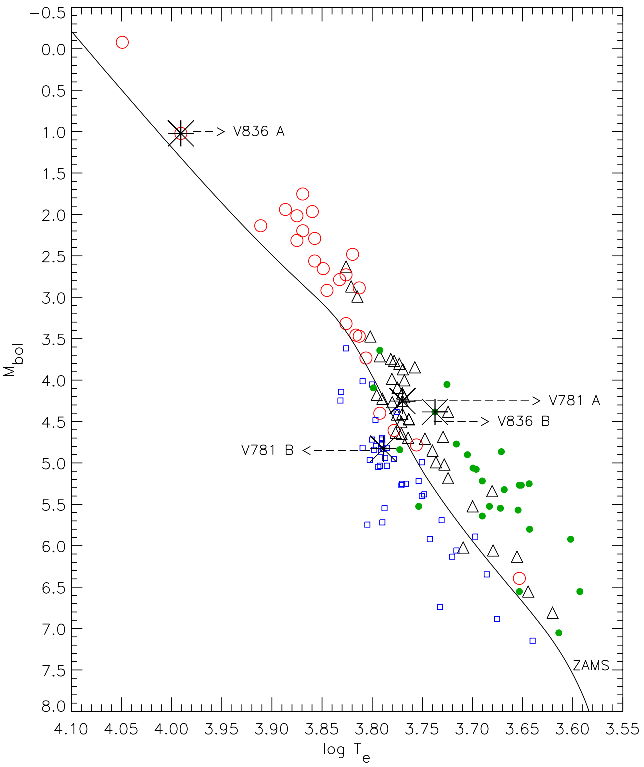

Figure 3. The HR diagram for primary and secondary components of W-type LTCBs and NCBs (Yakut & Eggleton 2005). Open circles and triangles denote primary components of NCBs and LTCBs, respectively, and filled circles and squares denote secondary components of NCBs and W-type LTCBs, respectively. 'Primary' means the more massive component, in all cases. The ZAMS lines are taken from Pols et al. (1995).

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SUPPLEMENTARY MATERIAL

The following supplementary material is available online as part of the full-text version of this article from http://www.blackwell-synergy.com.

Table 1. *BVR* measurements of V781 Tau.
Table 3. *UBV* measurements of V836 Cyg.

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