An unusual eclipsing blue straggler
V8-NGC 6752

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ABSTRACT

We report the analysis of a binary blue straggler in NGC 6752 with a short orbital period of 0.315 d and a W UMA-type light curve. We use photometric data spanning 13 years to place limits on the mass ratio (0.15 ≲ q ≲ 0.35), luminosity ratio (L₁/L₂ ≈ 4), and the ratio of the radii of the components (r₁/r₂ ≈ 2). The effective temperatures of the components are nearly identical, and the system is detached or semi-detached (in the latter case the component filling its Roche lobe is the secondary). Such a configuration is unusual given the shortness of the orbital period, and it must have resulted from substantial mass exchange. We suggest that some secondaries of W UMa-type stars, normally regarded as main sequence objects which fill their Roche lobes to different degrees, in fact may be shell-burning cores of originally more massive components.

Key words: blue stragglers – binaries: eclipsing – globular clusters: individual (NGC 6752)

1 Introduction

Blue stragglers (BSs) occupy the extension of the main sequence above the turnoff point in color-magnitude diagrams of parent stellar populations. Since their detection in M3 (Sandage 1953) BSs have been identified in dozens of globular and open clusters. Two main mechanisms responsible for the formation of these objects have been advocated – mass transfer in close binaries (McCrea 1964), and mergers resulting from direct collisions between stars in dense environments (Benz & Hills 1987). Knigge et al. (2009) found that the number of BSs belonging to a given globular cluster (GC) scales nearly linearly with the core mass of that cluster but is nearly independent of the core radius. This implies that the main channel leading to the formation of BSs is binary. Moreover, Perets & Fabrycky (2009) argue that the progenitors of BSs form in primordial triple stars through the Kozai mechanism (Kozai 1962). This is in line with the observational evidence that most (possibly all) close binaries are formed in triple systems (Tokovinin et al. 2006).

The sample of candidate BSs in GCs includes several variables with light curves typical of contact binaries. The discovery of two W UMa type systems in NGC 5466 (Mateo et al. 1990) was followed by the detection of further such systems in other clusters, mostly by the OGLE and CASE groups (see Rucinski 2000). Surprisingly, until now not a single mass determination or even a reliable light curve solution has been obtained for a GC contact binary. In fact, masses resulting from the analysis of light and radial velocity curves have
been derived for just two binary BSs from GCs (Kaluzny et al. 2007a, 2007b). Some attempts have been made to estimate masses of apparently single BSs in GCs based on the modeling of spectra (e.g., De Marco et al. 2005) or pulsation periods of SX Phe variables (Gilliland 1998). However, the actual accuracy of these determinations is hard to estimate.

The eclipsing binary V8-NGC 6752 (hereafter V8) was discovered by Thompson et al. (1999) during a photometric survey of the cluster field. The system has a W UMa-type light curve, and an orbital period of 0.31 d. Our new photometry (Kaluzny & Thompson 2009) revealed that the secondary eclipse of V8 is total. As it was first discussed by Mochnacki & Doughty (1972), light curves of contact binaries showing total eclipses can be uniquely solved, yielding the mass ratio among other parameters. This is in contrast to contact systems with partial eclipses whose light curves usually cannot be reliably solved without spectroscopic information about the mass ratio. In short, the totality of the primary eclipse is sufficient to determine reliable apparent magnitudes of the individual components.

If V8 is indeed a contact binary belonging to the cluster then one can estimate its absolute parameters based solely on the photometric information, which together with the known distance to the cluster would yield the absolute magnitudes of its components. Then, based on effective temperatures estimated from colors, one can derive absolute radii of both stars. Knowing absolute radii and relative radii (the latter from the light curve solution) the absolute size of the orbit can then be derived, yielding the total mass of the system from Kepler’s law. Given the paucity of reliable determinations of masses for BSs in GCs we decided to analyze the light curves of V8 hoping to estimate its parameters. To our surprise it turned out that the binary is most likely a detached system with a mass ratio $q < 0.35$. This is an unexpected result given the short orbital period of the system and the similar effective temperatures of its components.

2 Observational properties of V8

2.1 The data

Photometric data used in this study are based on CCD images obtained at Las Campanas Observatory with the 2.5-m du Pont and the 1.0-m Swope telescopes. The du Pont data collected in 1998 season were described by Kaluzny & Thompson (2009). They have been supplemented with observations from 2007, 2008 and 2009 seasons. The Swope data collected in 1996 and 1997 seasons were described by Thompson et al. (1999). They have been supplemented with observations from the 2007 observing season.

Differential photometry was extracted using image subtraction techniques described by Kaluzny & Thompson (2009). We also re-reduced 1996 and 1997 Swope images analyzed earlier by Thompson et al. (1999). Differential light curves extracted with this method are free from systematic errors due to crowding. However, this holds only for light curves expressed in differential counts. Conversion of a given light curve from differential counts to stellar magnitudes requires determination of the pedestal flux for a target star on the reference image. At this stage a failure to correct for close visual companion(s) to the target leads to systematic errors in the light curve expressed in magnitudes. V8 is present on some HST-WFPC2 images available from the MAST archive.

*Except for relatively rare systems with mass ratios close to unity.
Table 1: Times of Minima and $O-C$ Values for V8

| Cycle  | $T_0$     | Error  | $O-C$  |
|--------|-----------|--------|--------|
| -2217.0| 263.59120 | 0.00060| 0.00004|
| -2216.5| 263.74830 | 0.00300| 0.00039|
| -1130.0| 605.90160 | 0.00090| 0.00077|
| -1127.5| 606.68900 | 0.00060| 0.00089|
| -1127.0| 606.84650 | 0.00090| 0.00093|
| -994.0 | 648.72850 | 0.00090| 0.00039|
| -810.5 | 706.51550 | 0.00120| 0.00021|
| 0.5    | 961.90910 | 0.00024| 0.00000|
| 3.5    | 962.85336 | 0.00018| 0.00048|
| 13.0   | 965.84528 | 0.00049| 0.00023|
| 19.5   | 967.89278 | 0.00019| 0.00034|
| 22.5   | 968.83727 | 0.00022| 0.00010|
| 10568.0| 4289.74410| 0.00270| 0.00001|
| 10568.5| 4289.90230| 0.00090| 0.00076|
| 12730.5| 4970.74223| 0.00033| 0.00045|
| 12839.0| 5004.90964| 0.00033| 0.00012|
| 12864.0| 5012.78232| 0.00027| 0.00025|

(Program 8256; PI W. Landsman). An examination of these images revealed two close visual companions to V8 at angular distances of about 1 arcsec but we found no evidence that the profile of V8 itself was affected by an unresolved blend. The two close companions posed no problem as they were resolved also in our ground based data.

2.2 Period Study

We measured 17 times of eclipses for V8 from the available data; their values, along with errors determined using the method of Kwee & Van Woerden (1956) are given in Table 1. The $O-C$ values listed in the table correspond to the linear ephemeris

$$\text{Min}(I) = \text{HJD 2 450 961.75164(9)} + 0.31491223(2)$$

which is determined from a least squares fit to the data. Formal errors of times of minima returned by Kwee & Van Woerden algorithm were increased by a factor of 3.0 to assure that the reduced $\chi^2$ of the fit is equal to unity. The linear ephemeris provides a good fit and there is no evidence for any detectable period change during the interval 1996–2009 covered by the observations. As there is a large gap in the observations between 1997 and 2007, this result should be viewed with some caution. However, observations analyzed separately for the 1996-1998 and 2007-2009 time intervals give the same orbital period. Most W UMa-type stars show noticeable changes of orbital period with $dP/dt \approx 10^{-5}$, resulting in $O-C$ deviations of the order of 0.01 d on a time base of a few years (Kreiner et al. 2000; Rucinski 1985). Also, noticeable changes of orbital periods are usually found in short-period algols. In this context the constancy of the orbital period of V8 is exceptional.
2.3 Light curves

In Fig. 1 we show $V$ and $B - V$ curves of the du Pont photometry of V8 phased according to the ephemeris given in equation (1). We note that these observations span 11 years, and yet they were obtained with the same instrumental setup with the only inhomogeneity due to changes in reflectivity of the telescope optics. The combined light curve is stable with little evidence for any seasonal changes of its shape. The depths of both minima as well as the level of maximum light were the same during all four observing seasons (1998, 2007, 2008 and 2009). Such stability of the light curve is very unusual for W UMa stars (Rucinski 1985). In fact, seasonal instability of light curves is common for all short period close binaries whose components have convective envelopes. It is believed that magnetic activity, and stellar spots in particular, are responsible for the observed changes. The data suggest that V8 shows little magnetic activity and that its components have radiative envelopes. This conclusion is further supported by the exceptional symmetry of the light curve. Apparently during periods covered by our observations no large spots were present on the photospheres of the V8 components.

The totality phase of the secondary eclipse of this system lasts for about 0.07 $P$. Figure 2 presents in detail three well sampled secondary eclipses from the 1998 season. The primary eclipse is only marginally deeper than the secondary one, and the color of V8 changes almost inappreciably with orbital phase. Apparently the effective temperatures of the components are very similar.

2.4 Membership Status

NGC 6752 is located at a relatively high galactic latitude of $b = -25.6^\circ$. Therefore the population of the central region of its field must be strongly dominated by member stars. V8 is seen at a projected distance $d = 2.0$ arcmin from the cluster center. For comparison, the half mass radius of NGC 6752 is $r_h = 2.34$ arcmin (Harris 1996). Thus there is a good chance that the system belongs to the cluster. However, a definitive assessment of the membership status has to wait until its proper motion or systemic radial velocity is determined.

We are planning to use our data to perform a detailed proper motion study of the cluster. For the moment we can only provide qualitative evidence in favor of the membership of V8. As discussed by Eyer & Woźniak (2001), the image subtraction technique can be used to detect high proper motion stars located in very dense stellar fields. Most stars at the center of the cluster field should show uniform displacements caused by the proper motion of NGC 6752 as a whole. In contrast, unrelated field objects (given the cluster’s location – mostly foreground stars) should exhibit noticeable displacements with respect to the background population. This is illustrated in Fig. 3 which shows the reference $V$ frame for the 1998 data together with a differential image obtained by subtracting the reference frame from an average of several individual exposures taken during the 2009 season. At the location of V8 only a symmetric residual is seen, resulting entirely from the variability of the star. Most stars leave no significant trace on the differential image. Characteristic bipolar residuals can be seen, however, for a few stars (likely field objects) displaced with respect to the cluster. We conclude that V8 is likely to share the proper motion of NGC 6752, which would mean that it belongs to the cluster.
3 Light curve solution

We analyzed the light curve of V8 using the Wilson-Devinney code (Wilson & Devinney 1971) as implemented in PHOEBE V29.d package (Prša & Zwitter 2005). The following parameters were adjusted: orbital inclination $i$, effective temperature of the secondary $T_2$, gravitational potentials $\Omega_1$ and $\Omega_2$, and the relative luminosity $L_1/L_2$. The mass ratio $q$ and the dimensionless potentials $\Omega_{1,2}$ translate into the relative radii of the components $r_{1,2}$. The temperature of the primary, $T_1$, was determined from the dereddened color index $(B-V)_1$ using the calibration of Worthey & Lee (2006). We adopted an interstellar reddening of $E(B-V) = 0.04$ and a cluster metallicity $[\text{Fe/H}] = -1.56$ (Harris 1996). During the totality phase of the secondary eclipse we measured $(B-V)_1 = 0.332$, leading to $T_1 = 6990$. This value places the primary between cool stars with convective envelopes and hotter stars with radiative envelopes. Since no photospheric activity is detected in our data, we assumed that the components of V8 have radiative envelopes (see Sec. 3.3). Accordingly, we adopted bolometric albedos $A_{1,2} = 1.0$ and gravity darkening coefficients $g_{1,2} = 1.0$.

For contact binaries with total eclipses the duration of totality together with the observed amplitude of light variation provides tight constraints on $q$ and $i$. Using Figure 3 from Mochnacki & Doughty (1972) we find that for a contact configuration the mass ratio of V8 cannot be larger than 0.30. In principle, for the allowed range of $q$, we only needed to find a unique pair $(i, q)$ which would reproduce both the length of totality and the amplitude of the light curve. However, it turned out that no such pair provides a satisfactory fit to the whole light curve as long as the contact configuration is enforced. All trial solutions with fixed $q$ evolved to a detached configuration. At this point we decided to obtain a grid of solutions for several values of $q$. Only the $V$ light curve was considered – it has a better quality and contains more points than the $B$ curve. Including the $B$ curve would have little impact on the results, as both components have a very similar surface brightness.

The grid of solutions is presented in Table 2 (the radii are geometrical averages of four values returned by the W-D code for the different axes of the components). Satisfactory fits to the light curve could be obtained for $0.15 \leq q \leq 0.30$. Fits for $q < 0.15$ and for $q > 0.30$ show systematic residuals for some sections of the light curve (in particular, for $q < 0.15$ the synthetic light curves have amplitudes that are too small). Solutions for $q > 0.16$ imply a detached configuration. With decreasing $q$ the secondary component fills larger and larger fraction of its Roche lobe, and finally at $q=0.15$ a semi-detached configuration is reached. The radius of the primary component is smaller than the radius of its Roche lobe by $11\%, 15\%$ and $19\%$ for $q = 0.30$, $q = 0.20$ and $q = 0.15$, respectively. The quality of the fit with $q = 0.20$ is illustrated in Fig. 4. For this value of $q$ a simultaneous solution for $BV$ curves was obtained in order to find the luminosity ratios in both filters.

One may wonder if a contact configuration could be fitted to the observations when convective envelopes are assumed for both components. Such envelopes imply bolometric albedos $A_{1,2} = 0.5$ and gravity darkening coefficients $g_{1,2} = 0.32$. A grid of solutions obtained for such a case is presented in Table 3. The results are very similar to those obtained earlier for the radiative case. The only difference is that satisfactory fits with a semi-detached configuration can now be obtained for a slightly wider range of $q$.

Finally we attempted to fit the light curve allowing for the presence of a third light ($l_3$). As mentioned above, the HST image does not indicate any blending,
Table 2: Light curve solutions for V8 for several values of the mass ratio $q$ (kept fixed during iterations). Radiative envelopes are assumed for both components.

| $q$  | $rms^a$ | $i$   | $T_2$ | $(L_1/L_2)_V$ | $<r_1>$ | $<r_2>$ | Conf$^b$ |
|------|---------|-------|-------|---------------|---------|---------|----------|
| 3.00 | 0.0353  | 90.00 | 7055  | 7.746         | 0.278   | 0.099   | D        |
| 2.00 | 0.0309  | 90.00 | 6961  | 6.900         | 0.313   | 0.119   | D        |
| 1.70 | 0.0289  | 90.00 | 6942  | 6.552         | 0.328   | 0.129   | D        |
| 1.45 | 0.0271  | 90.00 | 6936  | 6.111         | 0.343   | 0.139   | D        |
| 1.20 | 0.0234  | 90.00 | 6921  | 6.011         | 0.361   | 0.148   | D        |
| 1.05 | 0.0219  | 90.00 | 6891  | 5.884         | 0.373   | 0.155   | D        |
| 0.95 | 0.0205  | 90.00 | 6892  | 5.778         | 0.380   | 0.159   | D        |
| 0.85 | 0.0190  | 90.00 | 6883  | 5.640         | 0.390   | 0.166   | D        |
| 0.75 | 0.0171  | 90.00 | 6868  | 5.475         | 0.401   | 0.174   | D        |
| 0.65 | 0.0149  | 90.00 | 6848  | 5.373         | 0.413   | 0.182   | D        |
| 0.60 | 0.0138  | 90.00 | 6843  | 5.291         | 0.419   | 0.187   | D        |
| 0.55 | 0.0127  | 90.00 | 6836  | 5.190         | 0.425   | 0.192   | D        |
| 0.50 | 0.0116  | 90.00 | 6834  | 5.075         | 0.432   | 0.198   | D        |
| 0.45 | 0.0104  | 90.00 | 6835  | 4.969         | 0.439   | 0.203   | D        |
| 0.40 | 0.0094  | 90.00 | 6840  | 4.844         | 0.446   | 0.209   | D        |
| 0.35 | 0.0085  | 90.00 | 6849  | 4.672         | 0.453   | 0.216   | D        |
| 0.30 | 0.0080  | 89.93 | 6875  | 4.484         | 0.459   | 0.223   | D        |
| 0.275| 0.0076  | 89.86 | 6907  | 4.264         | 0.463   | 0.230   | D        |
| 0.25 | 0.0076  | 89.86 | 6907  | 4.264         | 0.463   | 0.230   | D        |
| 0.225| 0.0075  | 89.61 | 6948  | 4.146         | 0.464   | 0.232   | D        |
| 0.20 | 0.0075  | 89.27 | 6980  | 3.973         | 0.465   | 0.235   | D        |
| 0.185| 0.0075  | 90.00 | 7012  | 3.936         | 0.464   | 0.236   | D        |
| 0.175| 0.0076  | 90.00 | 7033  | 3.880         | 0.464   | 0.237   | D        |
| 0.17 | 0.0077  | 90.00 | 7046  | 3.853         | 0.464   | 0.237   | D        |
| 0.16 | 0.0077  | 90.00 | 7071  | 3.795         | 0.463   | 0.238   | D        |
| 0.15 | 0.0080  | 90.00 | 7045  | 3.735         | 0.464   | 0.247   | SD2      |
| 0.14 | 0.0081  | 90.00 | 7109  | 3.699         | 0.461   | 0.244   | SD2      |
| 0.13 | 0.0085  | 90.00 | 7177  | 3.633         | 0.457   | 0.238   | SD2      |
| 0.12 | 0.0100  | 90.00 | 7249  | 3.543         | 0.450   | 0.233   | SD2      |
| 0.11 | 0.0128  | 90.00 | 7333  | 3.505         | 0.449   | 0.227   | SD2      |

Note: $^a$ - $rms$ residual of the fit; $^b$ - D and SD2 indicate detached system and semi-detached system with the secondary component filling its Roche lobe.
Table 3: Same as in Table 2, but for components with convective envelopes.

| q   | rms$^a$ | i   | $T_2$ | $(L_1/L_2)_V$ | $<r_1>$ | $<r_2>$ | Conf$^b$ |
|-----|---------|-----|-------|---------------|---------|---------|---------|
| 0.60| 0.0121  | 90.00| 7184  | 4.388         | 0.4470  | 0.1943  | D       |
| 0.55| 0.0108  | 90.00| 7180  | 4.383         | 0.4563  | 0.1986  | D       |
| 0.50| 0.0097  | 90.00| 7155  | 4.292         | 0.4604  | 0.2050  | D       |
| 0.45| 0.0087  | 90.00| 7138  | 4.221         | 0.4653  | 0.2109  | D       |
| 0.40| 0.0080  | 90.00| 7126  | 4.133         | 0.4706  | 0.2174  | D       |
| 0.35| 0.0077  | 90.00| 7110  | 4.022         | 0.4751  | 0.2248  | D       |
| 0.35| 0.0077  | 86.74| 7108  | 4.011         | 0.4770  | 0.2259  | D       |
| 0.30| 0.0077  | 88.36| 7092  | 3.881         | 0.4779  | 0.2331  | D       |
| 0.30| 0.0076  | 85.63| 7096  | 3.876         | 0.4779  | 0.2331  | D       |
| 0.275| 0.0077 | 89.11| 7091  | 3.802         | 0.4810  | 0.2460  | D       |
| 0.275| 0.0076 | 85.29| 7090  | 3.794         | 0.4787  | 0.2370  | D       |
| 0.225| 0.0078 | 89.99| 7095  | 3.640         | 0.4760  | 0.2479  | D       |
| 0.225| 0.0077 | 85.84| 7098  | 3.638         | 0.4775  | 0.2442  | D       |
| 0.185| 0.0077 | 86.24| 7102  | 3.480         | 0.4798  | 0.2604  | D       |
| 0.17 | 0.0076 | 90.02| 7115  | 3.442         | 0.4700  | 0.2535  | SD2     |
| 0.17 | 0.0077 | 86.01| 7131  | 3.443         | 0.4728  | 0.2535  | SD2     |
| 0.17 | 0.0076 | 86.85| 7123  | 3.443         | 0.4715  | 0.2535  | SD2     |
| 0.16 | 0.0079 | 88.95| 7152  | 3.416         | 0.4669  | 0.2510  | SD2     |
| 0.15 | 0.0087 | 88.95| 7200  | 3.396         | 0.4641  | 0.2479  | SD2     |
| 0.14 | 0.0103 | 89.00| 7250  | 3.367         | 0.4593  | 0.2430  | SD2     |

Note: $^a$ - rms residual of the fit; $^b$ - D and SD2 indicate detached system and semi-detached system with the secondary component filling its Roche lobe.

nor there is any evidence for a light-time effect in the timing of the eclipses of V8. However, we cannot a priori exclude with certainty the possibility that the image of V8 is contaminated by an unresolved third star. After numerous trials we found that allowing for a third light in the system does not influence the results; independently of the assumed starting value of $q$ the solutions quickly evolved toward $l_3 = 0$. The same applies also to trial solutions with contact configurations.

We conclude that the V8 system is either detached or semi-detached (in the later case the component filling its Roche lobe is the secondary), and its mass ratio is low ($0.15 < q < 0.35$). Tables 2 & 3 indicate that the ratio of radii is $r_1/r_2 \approx 2$, and the ratio of $V$-band luminosities is $L_1/L_2 \approx 4$ (or 3.4 in the "convective" case).

### 4 Summary and Discussion

Our analysis indicates that, despite its short orbital period and W UMa-type light curve, the binary V8 is a detached or semidetached system. This is an unexpected finding, as non-contact systems are extremely rare among non-degenerate binaries with periods $P \leq 0.45$ d (Hilditch et al. 1988). To the best of our knowledge the only known systems of this kind are V361 Lyr (Hilditch et al. 1997; Kaluzny 1991; $P = 0.30$ d) and OGLE-BW3-V38 (Maceroni & Rucinski 1997; $P = 0.20$ d). The first of these is a semi-detached system with the more massive component filling its Roche lobe, while the latter is probably a detached system composed of two M dwarfs. Another possible non-contact binary of this kind is W Crv (Rucinski & Lu 2000), however its actual configuration is
poorly constrained. We note that V8 cannot be considered as an example of a system caught in the brief contact-break predicted by “the thermal relaxation oscillations theory” (Lucy & Wilson 1979). In such a system the primary of V8 would have to fill its Roche lobe, and the components should have very different effective temperatures (the secondary being cooler). This is certainly excluded.

The stability and symmetry of the light curve of V8 together with the apparent constancy of the orbital period favors a detached configuration. Despite the totality of one of the eclipses the photometric analysis does not allow an accurate determination of the mass ratio of the system. However, it strongly favors the range $0.15 \lesssim q \lesssim 0.35$. The components differ significantly in size ($r_1/r_2 \approx 2$), yet they have very similar effective temperatures. Figure 5 shows the location of the whole system and each of its components separately on the color-magnitude diagram of NGC 6752. When calculating the individual magnitudes of the components we adopted a luminosity ratio of 3.97, the value implied by the solution with $q = 0.20$ for radiative envelopes. Note, however, that the derived value of $L_1/L_2$ depends rather weakly on the assumed $q$ (see Tables 2 and 3).

It is worth noting that the primary of V8 is located right at the extension of the unevolved main sequence of the cluster. This gives one more argument for the cluster membership of the binary, and suggests that the primary has the properties of an undisturbed main-sequence star. In contrast, the secondary is located far to the blue of the cluster main-sequence for its luminosity. Also, the observed luminosity ratio $L_2/L_1 \approx 1/4$ is much too high compared to that expected for main-sequence stars with $m_2/m_1 < 0.35$. For stars with $0.43 < m < 2.0 \odot$ we have $L \sim m^4$ (Duric 2004). If the primary of V8 is indeed an ordinary main-sequence star then its mass can be estimated roughly at 0.8 $m_\odot$ given a cluster age of about 13 Gyr. In such a case one obtains $L_2/L_1 = 16$ for $q = 0.5$, a conservative lower limit for V8, as in fact $q < 0.35$. Clearly it is the the secondary which is the stranger component of the blue straggler V8.

Such an unusual system may throw some light on problems related to the evolution and observed status of W UMa-type binaries. The blind acceptance of the contact model (Lucy 1968a, 1968b) for very short period binaries with components of identical effective temperature, yet very different masses, has been recently strongly contested by the results for AW UMa (Pribulla & Rucinski 2008). This flagship case of the very low mass ratio binary ($q \lesssim 0.1$) whose light curve so well obeys the contact model turned out not to be in contact upon a more careful spectroscopic scrutiny; instead, it appears to be a detached or semi-detached system engulfed in an optically thick stream with temperature not different from that of the stellar photosphere. The picture is indeed confusing, as the control case of V566 Oph ($q = 0.26$) turned out to agree – both photometrically and spectrally – with the contact model. Apparently, a range in conformance to the contact model exists.

There is no doubt that the present configuration of V8 results from a substantial mass exchange between the components (it is obvious that the secondary component is overluminous given the constraints on the present mass ratio). Most likely the secondary lost nearly all matter from its original envelope, and is burning hydrogen in a shell. Such a situation occurs in some low mass algols (Paczynski 1971; Eggleton & Kisleva-Eggleton 2002). However, before considering any detailed evolutionary scenario one needs to determine absolute parameters of the system. This requires supplementing available photometric data with spectroscopic observations. Obtaining a radial velocity curve for V8 is a challenging task. The luminosity ratio of 1/4 is not a big obstacle, but the low apparent luminosity of the secondary ($V \approx 18.8$) makes the observations
difficult as the short orbital period of the system limits the exposure time to 15-20 minutes. Useful spectra can be obtained only on the largest available telescopes.

The spectroscopic masses are essential in relating our current results to the important finding of Gazeas & Niarchos (2006) that the masses of secondary components in W UMa-type binaries are amazingly similar, clustering around 0.45 $m_{\odot}$. It is possible that what we normally interpret as full-size secondaries (filling to different degrees their Roche lobes to different degrees) are in fact collapsed cores of originally more massive components, as envisaged by Stepien (2006, 2009).

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REFERENCES

Benz, W., & Hills, J. G. 1987, Astrophys. J., 323, 614.
De Marco, O., Shara, M. M., Zurek, D., Ouellette, J. A., Lanz, T., Saffer, R. A., & Sepinsky, J. F. 2005, Astrophys. J., 632, 894.
Duric, N. 2004, Advanced Astrophysics, Cambridge Univ. Press.

Eggleton, P. P., Kiseleva-Eggleton, L. 2002, Astrophys. J., 575, 461.
Eyer, L., & Woźniak, P. R 2001, MNRAS, 327, 601.

Gazeas, K. D., Niarchos, P. G. 2006, MNRAS, 370, L29.

Gilliland, R. L. et al. 1998, Astrophys. J., 507, 818.

Harris, W. E. 1996, Astron. J., 112, 1487.

Hilditch, R. W., King, D. J., & McFarlane, T. M. 1988, MNRAS, 231, 341.

Hilditch, R. W., Collier Cameron, A., Hill, G., Bell, S. A., & Harries, T. J. 1997, MNRAS, 291, 749.

Kaluzny, J. 1991, Acta Astron., 41, 17.

Kaluzny, J., Rucinski, S. M., Thompson, I. B., Pych, W., & Krzeminski, W. 2007a, Astron. J., 133, 2457.

Kaluzny, J., Thompson, I. B., Rucinski, S. M., Pych, W., Stachowski, G., Krzeminski, W., & Burley, G. S. 2007b, Astron. J., 134, 541.

Kaluzny, J., & Thompson, I. B. 2009, Acta Astron., in press.

Knigge, C., Leigh, N., Sills, A. 2009, Nature, 457, 288.

Kozai, Y. 1962, Astron. J., 67, 591.

Kreiner, J. M., Kim, C.-H., Nha, I.-S. 2001, An Atlas of O-C Diagrams of Eclipsing Binaries, Wydawnictwo Naukowe Akademii Pedagogicznej, Krakow, .

Kwee, K. K., & van Woerden, H. 1956, Bull. Astron. Inst. Netherlands, 12, 327.

Lucy, L. B. 1968a, Astrophys. J., 153, 877.

Lucy, L. B. 1968b, Astrophys. J., 151, 1121.

Lucy, L. B., & Wilson, R. E. 1979, Astrophys. J., 231, 502.

Macroni, C., Rucinski, S. M. 1997, P.A.S.P., 109, 782.

Mateo, M. M., Harris, H. C., Nemec, J., Olszewski, E. W. 1990, Astron. J., 100, 469.

McCrea, W. H. 1964, MNRAS, 128, 147.

Mochnacki, S. W., & Doughty, N. A. 1972, MNRAS, 156, 51.

Paczyński B. 1971, ARA&A, 9, 183.

Perets, H. B., Fabrycky, D. C. 2009, Astrophys. J., 697, 1048.

Prša, A., Zwitter, T. 2005, Astrophys. J., 628, 426.
Pribulla, T., Rucinski, S. M. 2008, *MNRAS*, **386**, 377.
Rucinski, S. M. 2000, *Astron. J.*, **120**, 319.
Rucinski, S. M. 1985, in *Interacting binary stars*, eds. J. E. Pringle & R. A. Wade, *Cambridge Univ. Press*, p. 85.
Rucinski, S. M., & Lu, W. 2000, *MNRAS*, **315**, 587.
Sandage, A. R. 1953, *Astron. J.*, **58**, 61.
Stepien, K. 2006, *Acta Astron.*, **56**, 199.
Stepien, K. 2009, *MNRAS*, **397**, 857.
Thompson, I. B. et al. 1999, *Astron. J.*, **118**, 462.
Tokovinin A., Thomas S., Sterzik M., Udry, S. 2006, *Astron. Astrophys.*, **450**, 681.
Wilson, R. E., & Devinney, E. J. 1971, *Astrophys. J.*, **166**, 605.
Worthey, G., & Lee, H.-c., 2005, *preprint*, astro-ph/0604590.
Figure 1: Phased light and color curves of V8.

Figure 2: Phased light curves of 3 secondary eclipses of V8 observed in 1998 season. The middle and top curves were shifted vertically by $-0.1$ and $-0.2$ mag, respectively.
Figure 3: Reference image for the neighbourhood of V8, obtained by averaging several images taken in 1998 (left) and a residual image obtained by subtracting the 1998 reference image from the reference image for 2009 data (right). Marked are two fast moving stars and V8 itself (at the right edge of the field).

Figure 4: Residuals from the light curve solution for \( q = 0.20 \).
Figure 5: A $V/(B-V)$ color-magnitude diagram of NGC 6752. The components of V8 are marked by squares, and the triangle shows the location of the composite image of the binary.