COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 5563

Konkoly Observatory
Budapest
21 September 2004

HU ISSN 0374 – 0676

VARIABLE DEPTHS OF MINIMA OF THE ECLIPSING BINARY V685 Cen

MAYER, PAVEL[1]; PRIBULLA, THEODOR[2]; CHOCHOL, DRAHOMÍR[2]

[1] Astronomical Institute, Charles University, V Holešovičkách 2, 180 00 Praha 8, The Czech Republic

[2] Astronomical Institute of the Slovak Academy of Sciences, 059 60 Tatranská Lomnica, The Slovak Republic

Among eclipsing binaries, there are several cases where the depths of minima change (IU Aur, SS Lac, RW Per, V907 Sco), or which are not "eclipsing" binaries at present (SV Cen, AY Mus); see e.g., Mayer (2004). The reason of these changes is most probably precession of the orbital plane due to a third body in the system, i.e., a change of orbital inclination. Knowledge of these cases is important for studies of multiple systems, and any addition of a further case to the existing sample is of great interest. New cases may be found when light curves obtained terrestrially decades ago are compared with more recent light curves – usually produced by satellites or by large-size surveys.

We found a change of amplitude for the eclipsing binary V685 Cen (HD 99218, HIP 55675) when comparing photometry done 27 years ago, with data obtained by ASAS 3 (Pojmański 2002). The original Walraven $VBLU$ photometry was obtained by van Houten using the 90 cm telescope of the Leiden Southern Station in South Africa. The photometry was published recently by van Houten et al. (2003). New ephemeris and light-curve solution was published by Chochol et al. (2003).

The V magnitude of this star is 8.83 in maximum, the period is $1\overset{d}{.}191$ and spectral type is A0. The star was measured also by HIPPARCOS (ESA 1997). In Fig. 1, the V light curves of V685 Cen from available sources are displayed; the ephemeris according to Chochol et al. (2003) is used:

$$\mathrm{Prim.\,Min.} = \mathrm{HJD}\ 2443586.3313 + 1\overset{d}{.}19096085 \times E.$$

The HIPPARCOS magnitudes were transformed to the V values using a formula by Harmanec (1998). Since $B-V = 0.00$ – this value corresponds to $(V-B)_{\rm Walraven} = 0.006$ (found by Chochol et al. 2003) according to Brand & Wouterloot (1988) – and $U-B$ has also be close to zero due to the A 0 spectral type (the exact value being unimportant since the coefficient in the transformation equation is small), the correction is only $+0.007$.

From the values offered by ASAS the $mag2$ were used, since their scatter is the smallest and also $mag2$ magnitude of the comparison star HD 99415 (8.99) equals to its V magnitude according to Deutschman et al. (1976). Therefore, the differential data of van Houten et al. were shifted adding 8.99 mag. Note that ASAS 3 data are given as magnitudes determined in diaphragms of four various sizes, from diameter 28 to 112 arcsec. ASAS 3 data with errors larger than 0.030 mag were discarded; 237 measurements have been left.

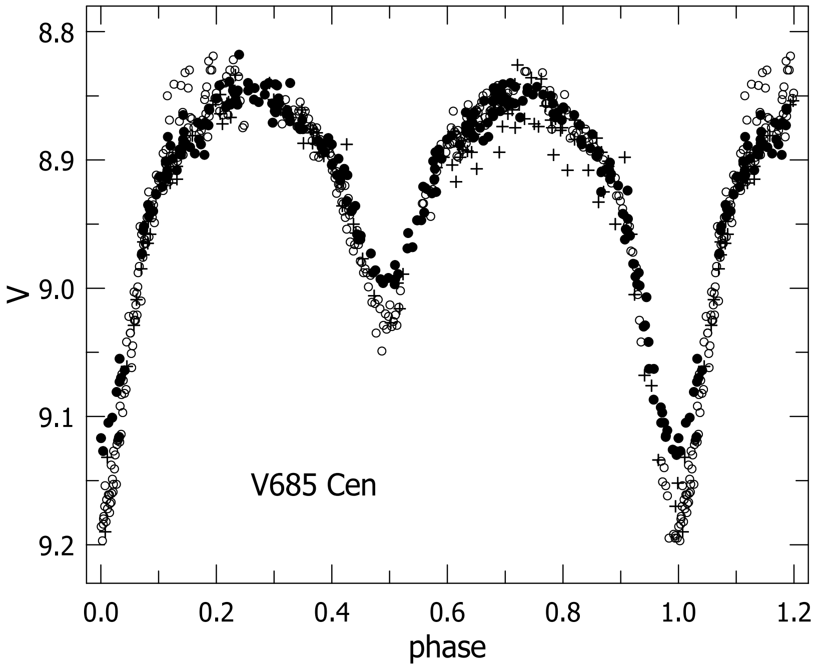

Figure 1. *V* light curves of V685 Cen. Dots – ASAS 3, crosses – HIPPARCOS, circles – van Houten.

The time intervals covered by these sources, and the respective depths of primary and secondary minima are:

- van Houten: from JD 2443249 to 2443599 (centre JD 2443450); depths 0.35 and 0.25 mag
- HIPPARCOS: from JD 2447884 to 2448969 (centre JD 2448500); depths 0.32 and 0.23 mag
- ASAS: from JD 2451807 to 2453223 (centre JD 2452500); depths 0.28 and 0.21 mag

The time of the minimum according to HIPPARCOS is 2448500.2358 and fits exactly the ephemeris ($O-C=0$ for $E=4126$). The ASAS data give $O-C=-0\overset{d}{.}0023\pm10$ for $E=7484$, therefore their phases are shifted by $+0.0019$ in Fig. 1.

The variability of the star was discovered by Uitterdijk; Uitterdijk & van Houten (1960) gave depths (photographic) of minima as 0.4 and 0.1 mag. The star was observed also as BV 724 (Strohmeier et al. 1965); only the depth of one minimum (0.2 mag) was given there. These photographic depths of minima are probably too uncertain and cannot be used for a discussion of the long time scale behaviour of the V685 Cen light curve.

The smaller amplitude in the ASAS database might be a result of including into this photometry also a visual component (which would be out of the diaphragm when the star was measured by a photomultiplier). To explain the observed depth change that companion should be 1.6 mag fainter than V685 Cen. According to GSC, there is a companion, magnitude 10.9, 75 arcsec apart. This companion should however not be included in the ASAS photometry, since the diameter of the aperture called "2" is 56 arcsec. There is also no dependence of the depth of the minima on the diameter of the aperture.

The change of the minimum depths is probably real, and its reason is most likely the change of the orbital inclination, as noted above. If this explanation is correct, a third light might be present in V685 Cen. A solution of the photometric elements was attempted by Chochol et al. (2003). In this solution, the authors tried to remove discrepancies in the light curve fitting by an increase of temperature of the primary component. The presence of a third light might however be a more natural reason of the discrepancies.

Therefore, we repeated the light-curve solution, using this time the code ROCHE (written by TP; Pribulla 2004). As soon as non-zero third light was allowed, better fit of light curves was obtained, and also the resulting parameters were more acceptable than in the original solution without the third light. As it is common in similar cases, the correlation between the amount of the third light and inclination was strong, the matter being worse in this case due to unknown mass ratio $q = m_2/m_1$. We assumed the primary component temperature $T_1 = 11900$ K found by Chochol et al. (2003) and model atmospheres with $g = 3.5 - 4.0$.

Trying solutions with q in a wide interval (from 0.2 to 2.2) we observe, that:

1. in V, l_3 rises from 0.25 to 0.58 ($l_1 + l_2 + l_3 = 1$), but not monotonically; always l_3 is lower in other bandpasses, i.e., the third light is redder than the light of the binary;
2. sum of squares of residuals reaches its minimum for $q = 1.25$; however, it changes in a small interval only (between 0.0265 and 0.0231) and cannot discriminate among solutions;
3. for approximately $0.40 < q < 1.10$, the configuration is semidetached, with the secondary component filling its Roche lobe;
4. as it could be expected, for larger l_3 also inclination is larger, increasing approximately from 79° to 84°; inclination for ASAS data is always about 5° smaller;
5. temperature of the secondary component is always close to $T_2 = 8200$ K, the corresponding spectral type being A5 .

In case the system is detached, one could assume that all three components are normal stars, then the mass-luminosity relation could be applied. However, e.g. for $q = 0.38$ the solution gives bolometric luminosity of the secondary component as $L_{2,\mathrm{bol}} = 0.148\,L_{1,\mathrm{bol}}$, but according to the L/M relation, $L_{2,\mathrm{bol}}$ should be only 0.03. By other words, the secondary component radius is too large for a main sequence star. Therefore, the semidetached configuration, with the secondary component filling its Roche lobe, seems to be more probable since in such a case the secondary components are commonly overluminous by about a magnitude (bolometric); for V685 Cen, such an overluminosity appears for $q = 0.50$. Also the sum of squares of residuals is smaller for these configurations in our solutions. The system was classified as SD also by Svechnikov & Kuznetsova (see Budding et al. 2004, Table 6d).

As already noted, the third component spectral type appears to be somewhat later than the primary component one. If both are to be main-sequence stars, then $L_3 < L_1$, which in our solutions happens for $q < 0.38$.

With the inclination changing by 5° in a quarter of a century, the period of the orbital precession might be of the order of several centuries, which means, that the orbital period of the third body would be under one year. Then the eclipsing binary should display light-time effect with this period, and with the semiamplitude of several minutes; the semiamplitude of course depends on the long-orbit inclination (this inclination being close to zero, amplitude would be also close to zero). The presently available photometry does not allow to find the effect.

It seems to be of great interest to confirm that the depths of minima change by a more precise photometry than can be offered by ASAS; and to confirm the expected third light spectroscopically, finding the lines of a tertiary component in the spectra. The high dispersion spectroscopy and the method of spectra disentangling will allow to determine the spectral type of each component and its contribution to the total light of the system as well as to find the mass ratio of the binary. Then it will be easy to find the appropriate solution of the multicolour light curve analysis.

Acknowledgements: The work of TP and DC was supported by VEGA grant 4014, the work of PM by the research plan J13/98:113200004 Ministry of Education, Youth and Sport.

References:

Brand, J., & Wouterloot, J.G.A., 1988, *A&AS*, **75**, 117

Budding, E., Erdem, A., Çiçek, C., Bulut, I., Soydugan, F., Soydugan, E., Bakis, V., & Demircan, O., 2004, *A&A*, **417**, 263

Chochol, D., van Houten, C.J., Kwee, K.K., Pribulla, T., & Grygar, J., 2003, *Contr. Astr. Obs. Skalnaté Pleso*, **33**, 107

Deutschman, W.A., Davis, R.J., & Schild, R.E., 1976, *ApJS*, **30**, 97

ESA, 1997, The Hipparcos and Tycho Catalogues, ESA SP-1200, Noordwijk, ESA

Harmanec, P., 1998, *A&A*, **335**, 173

Mayer, P., 2004, ASP Series (Dubrovnik Conference 2003), in print

Pojmański, G., 2002, *Acta Astron.*, **52**, 397

Pribulla, T., 2004, ASP Series (Dubrovnik Conference 2003), in print

Strohmeier, W., Knigge, R., & Ott, H., 1965, *IBVS*, 155

Uitterdijk, J., & van Houten, C.J., 1960, *Leiden Ann.*, **21**, 355

van Houten, C.J., Kwee, K.K., Chochol, D., Pribulla, T., & Grygar, J., 2003, *Contr. Astr. Obs. Skalnaté Pleso*, **33**, 135

ERRATUM FOR IBVS 5503

HV 11094 is specified by Mayall to lie 'south preceding CoD −36 1043'; in addition there is a finder chart that matches this description. This makes the identification with the red star there certain, despite its evident faintness in DSS images. Thus

```
IRAS 02443-3626 = NSV 917 at: 2 46 21.09  -36 13 35.6 (J2000, 2MASS).
```

In the same field, the star given by Kamath as CD−36 1043 is actually CD −36 1041 = CPD −36 282, which is correctly catalogued in SIMBAD. The true

```
CD-36 1043 = TYC 7017-880-1 = NSV 919,
```

about 20″ northeast of IRAS 02443-3626, also correct in SIMBAD. The faint red star to the southwest ($2^h45^m00\overset{s}{.}6$; $-36°16'11''$) seems to be unrelated to any of these; it is probably a distant M dwarf.

Kamath has also misidentified HV 11102, which is the relatively bright star and IRAS source IRAS 14265-6254. Again, Mayall provides a chart which makes the ID unambiguous:

```
SV* HV 11102 = IRAS 14265-6254 = GSC 9010-4846 = NSV 6681:
          at: 14 30 28.06  -63 07 45.5 (J2000, 2MASS)
```

Finally, there appears to be a −20″ Dec typo for the coordinates of HV 11105. This should be given as: $18^h03^m28\overset{s}{.}86$; $-41°54'03\overset{''}{.}2$ (J2000, UCAC2). There is no star at Kamath's position.

Brian Skiff