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

Number 5359

Konkoly Observatory
Budapest
30 December 2002

HU ISSN 0374 – 0676

SV Cam: LIGHT CURVE PARAMETERS AND SPOT ACTIVITY BETWEEN FEBRUARY 2000 AND APRIL 2001

FRIGO, A.[1]; PICCOLI, P.[1]; SETTI, A.[1]; TOMASONI, S.[1]; TOMOV, T.[2]; MUNARI, U.[3]; MARRESE, P. M.[3]; ZWITTER, T.[4]

[1] Museo Civico di Rovereto, Borgo S. Caterina, 38068 Rovereto (TN), Italy

[2] Centre for Astronomy, N. Copernicus University, ul. Gagarina 11, 87100 Torun, Poland

[3] Osservatorio Astronomico di Padova - INAF, Sede di Asiago, I-336032 Asiago (VI), Italy

[4] University of Ljubljana, Department of Physics, Jadranska 19, SI-1000 Ljubljana, Slovenia

SV Cam is a $P = 0.6$-day detached eclipsing RS CVn binary with a well pronounced surface activity. Recently Albayrak et al. (2001) presented results of 2 nights of photometric observations in 2000. A detailed light curve analysis pointed to a presence of two low temperature surface spots. The authors also derived parameters of a light curve fit. This year Lehmann, Hempelmann & Wolter (2002) published a detailed spectroscopic study that unambiguously determined absolute masses of both stars.

Here we present the results of a 2-year photometric monitoring of SV Cam and compare the results with the studies mentioned above. The observations were obtained on 21 nights between February 2000 and April 2001, altogether 504 points in V and 502 in B Johnson filters. The instrument was a 50-cm Ritchey-Chretien telescope located at Monte Zugna (altitude 1620 m) near Rovereto (Trento, Italy). It is equipped with a SSP5 photometer. The diaphragm had a size of 50 arcsec. Each point in the light curve was obtained as an average of 5 exposures of 5 seconds each. HD 45635 (K0) was chosen as a comparison star and TYC 4537 880 1 (F0) as a check star. Standard deviations of comparison star against the check star are 0.031 in V and 0.015 in B, the difference being due to the better B sensitivity of the SSP5 photometer. Table 1 reports the times of observed primary minima.

Table 1. Times of primary photometric minima with their standard deviations and type of filter used.

HJD −2451000.0	filter	HJD −2451000.0	filter	HJD −2451000.0	filter
587.3770 ± 0.0040	V	594.4937 ± 0.0005	B, V	597.4583 ± 0.0010	B, V
603.3892 ± 0.0003	B, V	718.4447 ± 0.0003	B, V	964.5718 ± 0.0004	B, V

The light curves are plotted in Figures 1a-d. Fig. 1e gives the value of the $B - V$ index obtained by linear interpolation of the bracketing V-band measurements to the epoch of the B-colour observation. Observations were always obtained by continuously switching between B and V filters. Orbital smearing of the $B - V$ index is negligible, as the time difference between consecutive B and V exposures was typically only 50 seconds.

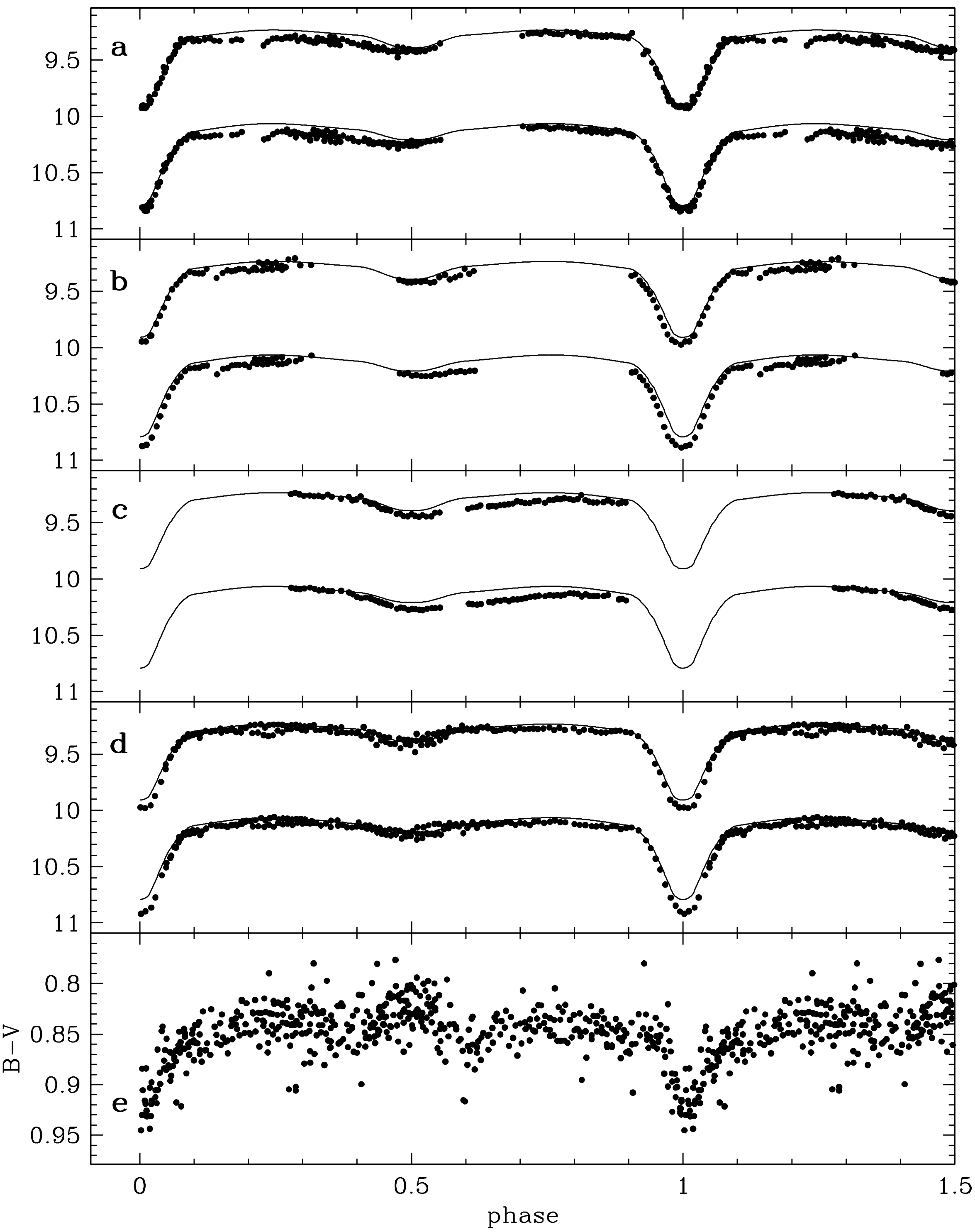

Figure 1. **(a-d):** V (upper) and B (lower) light curves of SV Cam for the observing intervals: $2451540 < HJD < 2451640$ (a), $2451640 < HJD < 2451800$ (b), $2451800 < HJD < 2451900$ (c), $2451900 < HJD < 2452000$ (d). Smooth curves are results of a theoretical model based on the literature that does not allow for the presence of dark surface spots. **(e):** $B - V$ light curve.

The whole set of photometric observations can be divided into four intervals of ~ 100 days. It is obvious that the light curves (Fig. 1a-d) do not repeat exactly in consecutive orbital cycles. Occasional fadings can be attributed to the presence of surface spots.

In order to assess the spot activity we used parameter values from the literature to construct a theoretical model that forms an upper envelope to all measurements in Fig. 1a-d. The results of the Wilson-Devinney code (WD98) computation using a fitting environment of Prša (2003) are plotted as smooth curves in Fig. 1. Parameters of the model are reported in Table 2. Note that we followed published models for values of most parameters, hence their errors are not quoted. In particular, relative dimensions of both components, their temperatures and gravity darkening coefficients were taken from Table 4 of Albayrak et al. (2001). On the other hand the values for masses of both components and absolute dimension of the orbit is derived much more accurately from spectroscopic observations, so we used the values reported in Lehmann et al. (2002). In addition we found that the value of inclination angle should be lowered from 89.6 deg (Albayrak et al. 2001) to 85 ± 1.5 ($2\,\sigma$) degrees; otherwise the eclipses would be deeper than observed. This is similar to the results of Kjurkchieva et al. (2000).

Table 2. Modeling parameters for a circular orbit without spots (smooth curves in Fig. 1).

parameter	value	ref.	parameter	value	ref.	parameter	value	ref.
Period (days)	0.5930718	L	T_1 (K)	6440	A	T_2 (K)	4480	A
Epoch (HJD)	2451465.7975	L	M_1 ($M_\odot$)	1.090	L	M_2 ($M_\odot$)	0.700	L
a ($R_\odot$)	3.60	L	V_γ (km s^{-1})	-14.0	L	e	0.0	L
R_2/R_1	0.63	A	R_1 ($R_\odot$)	1.29		R_2 ($R_\odot$)	0.81	
$q = \frac{M2}{M1}$	0.6422	L	$M_{bol,1}$	3.77		$M_{bol,2}$	6.34	
i (deg)	85.0		$\log g_1$	4.25		$\log g_2$	4.46	

Sources: L = Lehmann et al. 2002; A = Albayrak et al. 2001

Figure 2 plots the difference between the observed values and the theoretical spot-free model. Notable sinus-shaped fadings due to the presence of spots are present on at least three occasions, i.e. during time intervals *a*, *c* and *d*. Table 3 reports their phase ranges and V- and B-band depths. The situation changes from one time interval to another. This suggests that surface spots on the primary star of SV Cam last for ≈ 100 days and that they appear at different stellar longitudes.

Table 3. Presence of surface spots in different time intervals. Orbital phase of spot visibility and the fading of the binary system in the V and B bands at the moment of meridian passage are given. The errors are 0.03 in phases and 0.01 in magnitudes.

time interval	phase(start)	phase(end)	$\Delta\ V$	$\Delta\ B$
2451540 < HJD < 2451640 (a)	0.1	0.5	$0^{m}_{.}10$	$0^{m}_{.}10$
2451800 < HJD < 2451900 (c)	0.4	0.9	$0^{m}_{.}10$	$0^{m}_{.}12$
2451900 < HJD < 2452000 (d)	0.6	0.9	$0^{m}_{.}05$	$0^{m}_{.}05$

We performed a detailed modeling of the spot positions, sizes and temperatures. The results are somewhat ambiguous, but consistent with a large spot surface area and moderate temperature contrast. In particular, the spot observed during time interval c is most likely a large equatorial spot on the primary star with the temperature of 6000 ± 200 K.

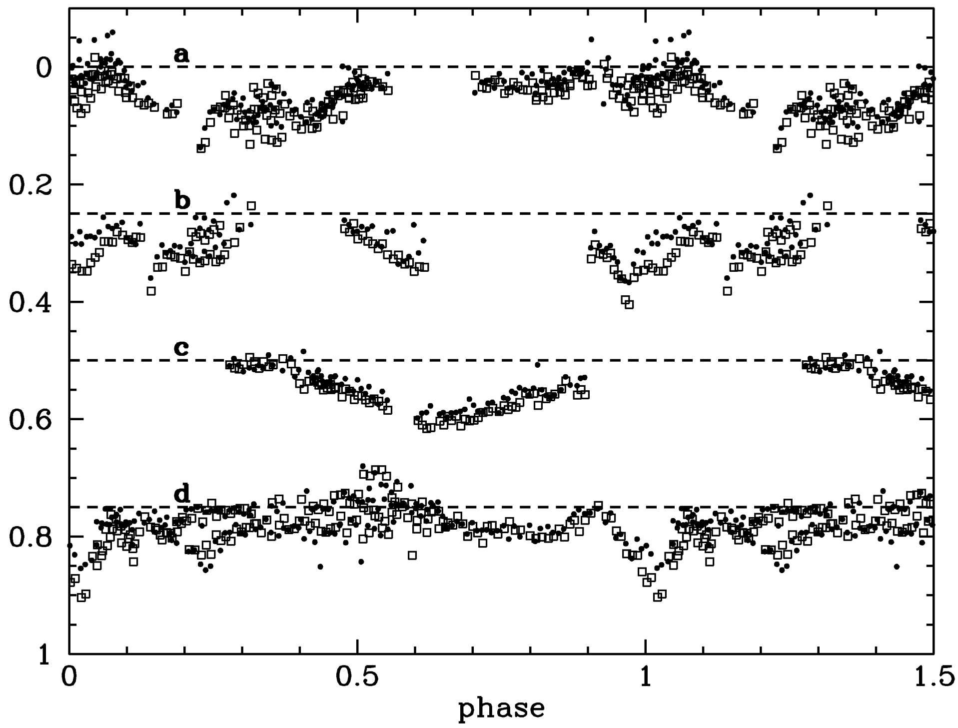

Figure 2. Difference between the observed V (dots) and B (open squares) magnitudes and the theoretical un-spotted curve reveals the presence of surface spots. Curves (a-d) correspond to the time intervals defined in Fig. 1. A vertical offset of 0.25 was applied to consecutive intervals.

When on meridian it covers 23 ± 7 % of the primary star's visible surface. The spot during interval d is smaller (covering 9 ± 3 % of the primary star's visible surface) but with a similar temperature.

These results are similar to the surface areas of spots found by Albayrak et al. (2001), but our temperature contrast is much smaller and possibly easier to justify with a physical model. A sharp dip near the primary minimum of interval d could be due to a spot activity which changed the shape of the eclipse of the brighter and spotty primary star.

This preliminary analysis of the light curve will be upgraded with results from 40 Echelle spectrograms with wide wavelength coverage that were obtained with the Asiago 1.8-m telescope atop Mt. Ekar. We expect to be able to directly address the spectral type and chemical composition of the primary, one of the primary sources of error in studies of SV Cam so far.

References:

Albayrak, B., Demircan, O., Djurašević, G., Erkapić, S., Ak H., 2001, *A&A*, **376**, 158
Kjurkchieva, D., Marchev, D., Ogloza, W., 2000, *Acta Astron.*, **50**, 517
Lehmann, H., Hempelmann, A., Wolter, U., 2002, *A&A*, **392**, 963
Prša, A., 2003, in GAIA Spectroscopy, Science and Technology, ed. U. Munari, *ASP Conf. Ser.*, in print