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

Number 5231

Konkoly Observatory
Budapest
31 January 2002

HU ISSN 0374 – 0676

GSC 0983.1044: A SHORT-PERIOD RS CVn BINARY

KAISER, D.H.[1]; PULLEN, A.C.[2]; HENDEN, A.A.[3]; BALDWIN, M.E.[4]; GUILBAULT, P. R.[5]; HAGER, T.[6]; TERRELL, D.[7]

[1] 2631 Washington Street, Columbus, Indiana 47201, USA, e-mail: dhkaiser@sprynet.com

[2] 10215 Davis Road, P.O. Box 930, Wilton, California 95693, USA, e-mail: cpullen@pacsafe.com

[3] Universities Space Research Association/U.S. Naval Observatory, P.O.Box 1149, Flagstaff, Arizona 86002-1149, USA, e-mail: aah@nofs.navy.mil

[4] 8655 N. Co. Road. 775E, Butlerville, Indiana 47223, USA, e-mail: mbald00@hsonline.net

[5] P.O. Box 287, Chepachet, Rhode Island 02814, USA, e-mail: pete1199@aol.com

[6] 34 Mount Tom Road, New Milford, Connecticut 06776, USA, e-mail: thager@pcnet.com

[7] Department of Space Studies, Southwest Research Institute, 1050 Walnut Street, Suite 426, Boulder, Colorado 80302, USA, e-mail: terrell@boulder.swri.edu

M. Baldwin, chairman of the AAVSO eclipsing binary committee, initiated an observing program to study stars from the ROTSE 1 sky survey (Akerlof et al., 2000). Baldwin chose those stars that were likely eclipsing binaries and did not appear elsewhere in the literature. Once eclipses were confirmed visually, he asked AAVSO CCD observers to time eclipses and to construct accurate light curves so that periods, types and amplitudes could be defined.

One such star, GSC 0983.1044 = ROTSE 1 J165241.80 +124905.2, was listed in the ROTSE catalogue as a 13th magnitude eclipsing star with a period of $0\overset{d}{.}40763$ and an amplitude of 1.022 magnitudes. After eclipses were confirmed visually by Baldwin, Henden used the USNO1.0-m telescope with a SITe 1024 × 1024 thinned, backside illuminated CCD and Johnson-Cousins BVR_cI_c filters along with Landoldt standards to determine standard magnitudes for the variable at maximum and comparison stars. These data are gathered in Table 1 and the errors in the last decimal place are given in parenthesis. GSC 0983.1313 was chosen as the comparison and GSC 0983.0566 as the check star. Astrometry is based on USNO-A 2.0 and has less than 100mas internal errors.

Table 1. Standard magnitudes and color indices,Henden

Star	GSC	RA	DEC	V	$B-V$	$V-R_c$	R_c-I_c
Variable[1]	0983.1044	16:52:41.80	+12:49:05.3	12.901(1)	0.775(3)	0.460(2)	0.438(3)
Comparison	0983.1313	16:52:33.70	+12:47:37.9	13.015(1)	0.627(2)	0.380(2)	0.366(4)
Check	0983.0556	16:52:19.09	+12:50:44.2	12.218(1)	0.943(3)	0.534(2)	0.431(3)

1 = at phase 0.11

More complete photometric information about all stars within 5 arcmin of the variable can be found in 5231-t4.txt at the *IBVS* website.

Pullen observed GSC 0983.1044 with his 0.28-m SCT + ST-6 CCD + V filter. Kaiser used his 0.35-m SCT + ST-9E CCD + V filter. A total of 6 times of minimum were obtained.

Guilbault and Hager visited the Harvard College Observatory and examined 58 blue-sensitive plates. Observations were made by eye, using a sequence of steps to estimate the changes in brightness. Two instances of faint light were found.

Table 2. Times of minimum, GSC 0983.1044

HJD 2400000+		Error +/−	Cycle	$O-C$	Observer	Type
45901.652			−7195	−0.002	PG/TH	pg
46116.891			−6931	+0.001	PG/TH	pg
51738.7197	†	(4)	−35.5	−0.001	ACP	CCD
51740.7594		(4)	−33.0	0.000	ACP	CCD
51747.6883	†	(2)	−24.5	−0.001	DHK	CCD
51753.8028		(2)	−17	−0.001	ACP	CCD
51767.6641		(1)	0	0.000	DHK	CCD
52084.8118		(1)	+389	0.000	DHK	CCD

† Secondary minimum

The CCD times of minimum were determined with the software AVE (Barbera 2000) based on the Kwee and Van Woerden method (Kwee - Van Woerden 1956). The time of minimum from the Harvard data is the mid-point of the exposure. A least squares solution with the CCD minima weighted as 10 and the photographic data as 1 results in the new elements:

$$\text{Min. I} = \text{HJD } 2451767.6637 + 0\overset{\text{d}}{.}81528987 \times E.$$
$$\pm 0.0001 \pm 0.00000006$$

This period is very close to twice the ROTSE 1 period. All data are phased to these elements and are shown in Figure 1. The maximum magnitudes at phases 0.25 and 0.75 differ by $0\overset{\text{m}}{.}07$ V suggesting the possibility of spots. Indeed when Kaiser's year 2000 observations are compared to his 2001 data at phase 0.9, they differ on the order of 0.04 magnitudes in V. Such seasonal variations are typical of RS CVn binaries.

Solutions to the 2000 light curve using equatorial spots were done with the Wilson-Devinney light curve program (Wilson and Devinney, 1971; Wilson, 1979; Wilson, 1990). The effective temperature of the primary (5300 K) was chosen to be consistent with our rough spectral type estimate based on the outside-eclipse $B-V$ value. The composite $B-V$ of the system at maximum light is about $0\overset{\text{m}}{.}8$ and the monochromatic luminosity ratio in V from our light curve solution is about $0\overset{\text{m}}{.}6$. Although we do not have full light curves in B to compute the color of the individual components precisely, it is clear that the $B-V$ of the primary should be a bit less than $0\overset{\text{m}}{.}8$ and the $B-V$ of the secondary should be a bit more than $0\overset{\text{m}}{.}8$. *Astrophysical Quantities* (2000) gives a $B-V$ of $0\overset{\text{m}}{.}74$ for a G8 V star and a $B-V$ of $0\overset{\text{m}}{.}81$ for a K0 star. Therefore we estimate that the primary is mid-to-late G-type and the secondary is an early K-type, making the system an RS CVn binary (Morgan and Eggleton, 1979). A single-spot solution could not achieve a fit to the light curve, but a two-spot model does fit reasonably well as seen in Figure 2. The solution indicates that the system is detached and has large spots on the secondary component, again indicative of an RS CVn system.

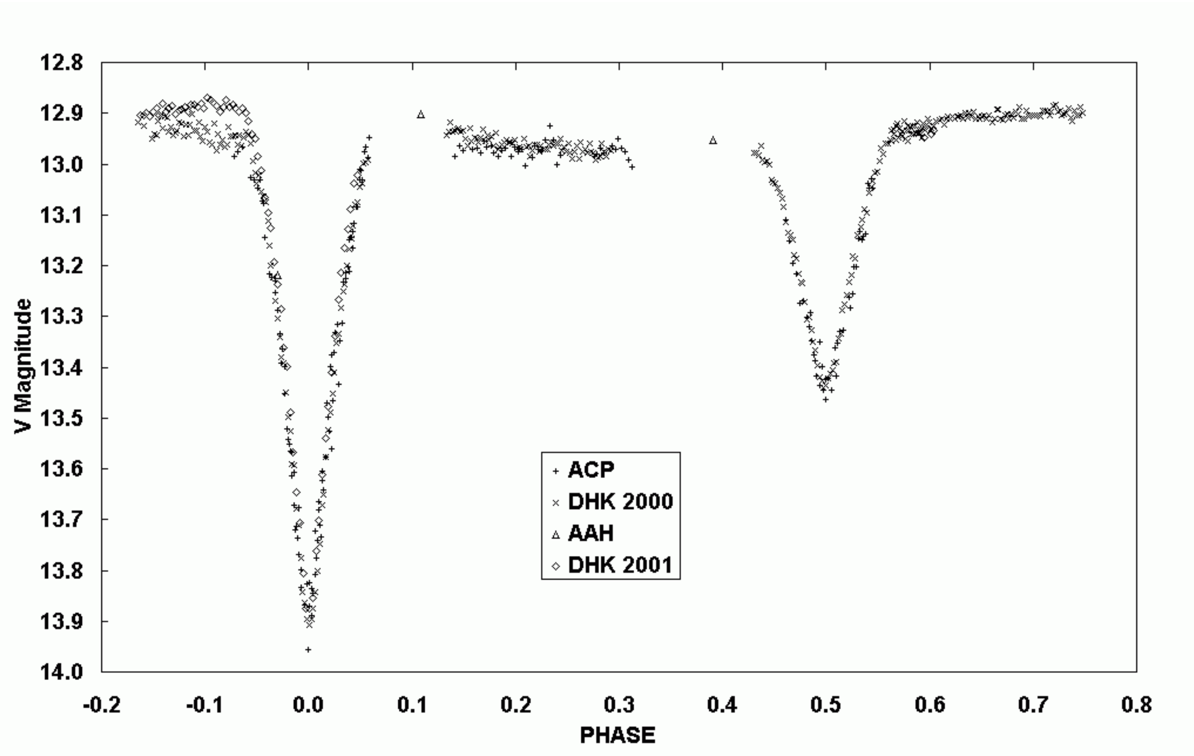

Figure 1. Phased light curve, GSC 0983.1044.

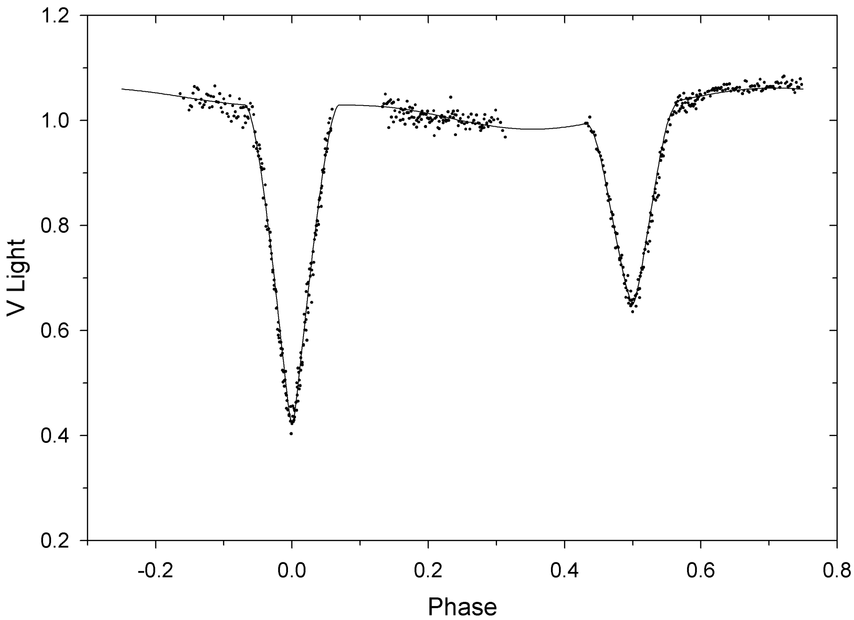

Figure 2. The two-spot light curve solution, GSC 0983.1044.

Table 3 shows the various parameters from the best-fit solution but with data in only one filter, the parameters should be considered preliminary, especially the spot parameters as attested by their large errors. High-precision $UBVRI$ photometry should enable us to reliably determine the spot parameters (e.g., Samec and Terrell, 1995) and a radial velocity study would be needed to confirm that the mass ratio is near unity.

Table 3. Parameter values and errors for the best-fit solution

Parameter	Value
i	89.°2 +/−0.°5
ΔT	417 K +/−88K
q	1.0 (assumed)
Ω_1	5.71 +/− 0.08
Ω_2	5.94 +/− 0.05
$L_1/(L_1+L_2)$	0.628 +/− 0.13
$g_1 = g_2$	0.32 (assumed)
$A_1 = A_2$	0.5 (assumed)
Spot 1 longitude	1.09 rad +/− 0.86
Spot 1 radius	0.85 rad +/− 0.52
Spot 1 temperature factor	0.94 +/− 0.02
Spot 2 longitude	3.58 rad +/− 2.89
Spot 2 radius	0.26 rad +/− 0.31
Spot 2 temperature factor	0.87 +/− 0.19

We wish to thank Alison Doane, acting Curator of the Astronomical Photograph Collection at the Harvard College Observatory, for use of the Harvard Patrol Plates.

References:

Akerlof, C., et al., 2000, *AJ*, **119**, 1901
Allen's Astrophysical Quantities, 4th edition, A. N. Cox ed., Springer-Verlag, New York, 2000
Barbera, R., `http://www.gea.cesca.es`
Kwee, K. K., and Van Woerden, H., 1956, *BAN*, **12**, No. 464, 327
Morgan, J.G., and, Eggleton, P.P, 1979, *MNRAS*, **187**, 661
Samec, R.G., and Terrell, D., 1995, *PASP*, **107**, 427
Wilson, R.E., and Devinney, E.J., 1971, *ApJ*, **166**, 605
Wilson, R.E., 1979, *ApJ*, **234**, 1054
Wilson, R.E., 1990, *ApJ*, **356**, 613