COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 5772

BAV MITTEILUNGEN NO. 185

Konkoly Observatory
Budapest
17 May 2007
HU ISSN 0374 – 0676

GSC 3377-0296 IS A NEW SHORT-PERIOD ECLIPSING RS CVn VARIABLE

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During a programme of optical identification of X-ray sources the uncatalogued variable, NSVS 4620766 in the ROTSE1 database (Wozniak et al., 2004), has been found to be coincident the variable X-ray source 1RXS J064117.0+464904 from the ROSAT all-sky survey bright source catalogue (Voges et al., 1999, Fuhrmeister & Schmitt 2003). The variable lies within the 10″ uncertainty in the position of the X-ray source. The star is also identified as GSC 3377-0296 and is catalogued by 2MASS at $06^{h}41^{m}16\overset{s}{.}76$ $+46°49'09\overset{''}{.}0$ (2000). Further details of the programme are presented in Bernhard et al. (2005) and Bernhard & Frank (2006). GSC 3377-0296 has $V = 12.32$ and $B - V = 0.83$ transformed from the Tycho-2 catalogue (Høg et al., 2000), the Tycho Input Catalogue, revised version gives $V = 11.80$ (Egret et al., 1992), the 2MASS catalogue gives $J - K = 0.676$ (Cutri et al., 2003). The star is a high proper-motion object (Kislyuk et al., 1999; Zacharias et al., 2004).

Further observations were made using both a 20-cm Schmidt–Cassegrain telescope and a Starlight XPress SX CCD camera with BVR filters in Linz, Austria and a 34-cm Cassegrain telescope with a CCD camera SBIG ST-6 and a V filter in Gemmingen, Germany. The comparison star used was GSC 3377-0179. No reliable magnitude estimates exist for this star. The Tycho-2 magnitudes are most probably wrong, as these contradict other available photometric information. The check stars were GSC 3377-0285 and GSC 3377-0811, which were found to be constant within < 0.02 mag.

The following primary minima were observed in 2006 and 2007:

Table 1: Times of primary minima of GSC 3377-0296 (HJD 245...)

minimum time	filter	observer	$O - C$ (d)
4085.5907 (2)	V	Monninger	−0.0003
4092.3513 (2)	V	Monninger	+0.0008
4096.5776 (2)	V	Monninger	+0.0024
4171.3497 (3)	V	Bernhard	−0.0021

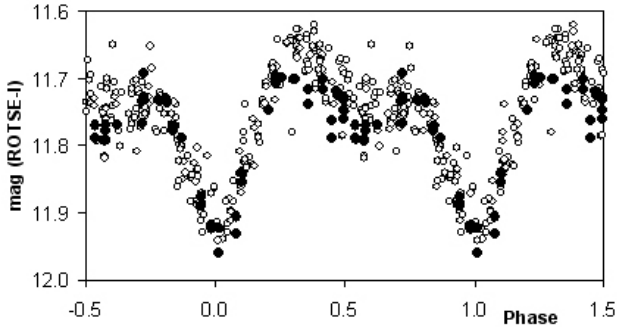

Figure 1. ROTSE1 light curve of GSC 3377-0296 folded with a period 0.4224672 days

Figures in brackets denote rms errors in units of the last decimal, $O-C$ values were calculated with the ephemeris given below.

A Fourier analysis of all the available data including TASS (http://www.tass-survey.org/) and ROTSE1 was performed to search for periodicity of the light variations. The following ephemeris can be derived from the analysis with the algorithm Period04 (Lenz & Breger, 2005):

$$\begin{array}{cc} \mathrm{HJD}_{\mathrm{MinI}} = 2454085.591 & + 0\overset{\mathrm{d}}{.}422467 \times E. \\ \pm 3 & \pm 1 \end{array}$$

The folded ROTSE1 light curve is shown in Figure 1, which identifies GSC 3377-0296 with a very short period and heavily spotted RS CVn type star. The ROTSE1 dataset (April 1999–March 2000) was divided into two parts of equal length to search for secondary variations (April 1999–October 1999: filled circles; November 1999–March 2000: open circles). It can be seen, that the shape of the light curve varies between phase 0.2 and 0.5 due to the changing activity of star spots.

The folded light curve of our observations with V filters (G. Monninger: 15–27 December 2006, filled circles; K. Bernhard: 4–15 March 2007) is given in Figure 2. Small offsets have been applied to G. Monningers data set as part of the fitting process.

It shows distinct variations within the time span of four months from phase 0.4 to 0.8. Changes of the light curve were noticed even within a week near phase 0.7 (see filled circles). Considering the ROTSE1 data, large parts of the light curve (phase 0.2 to 0.8) are affected by stellar activity, which suggests, that there could be two active longitudes similar to other RS CVn variables (e.g. Berdyugina and Tuominen, 1998).

The folded $\Delta V, \Delta(B-V), \Delta(V-R_C)$ light curves, relative to GSC 3377-0179, of the filtered observations in March 2007 are shown in Fig 3. The $B-V$ and $V-R_C$ colour differences between the variable and the comparison are relatively small, and indicate a slight reddening of the star, when it enters the minimum of the spotted light curve at phase 0.63.

The magnitude difference between the maximum and this minimum, determined by low order polynomial fitting, is for the B band about 0.14 mag, for the V and R_C band

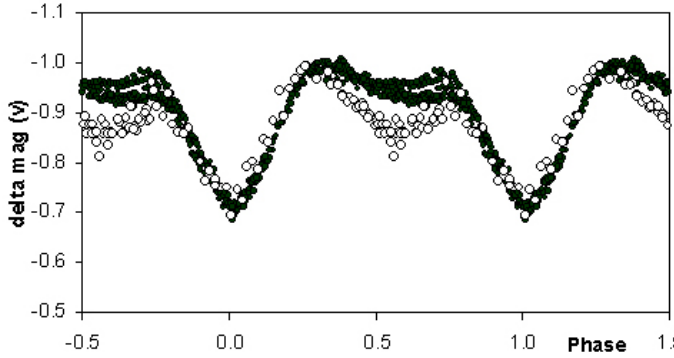

Figure 2. Our V-band observations from 15 December 2006–15 March 2007 relative to GSC 3377-0179

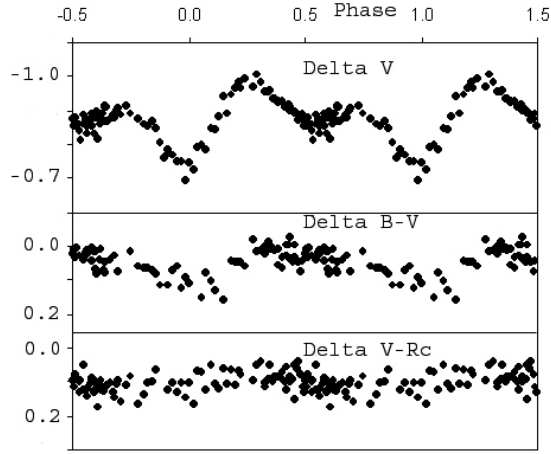

Figure 3. Folded ΔV, $\Delta(B-V)$ and $\Delta(V-R_C)$ light curves of GSC 3377-0296, March 2007

only 0.12 and 0.10 mag. This is in good agreement with data from literature, where a $\Delta R/\Delta V$ value of 0.90 for active stars has been determined (Drake, 2006).

The median magnitude of the NSVS data of the variable is 0.87 mag brighter than of the comparison star GSC 3377-0179, which is similar to the respective value of our observations in R_C band (0.96 mag) and V band (0.89 mag).

The variability type RS CVn is also supported by the X-ray identification and the 2MASS colours $J - H = 0.54$ and $H - K = 0.14$, which suggest a spectral type of K3.

The period of 0.4224672 days is very short for an RS CVn star. It is shorter than the periods of all 206 binary systems listed in the second edition of the catalogue of chromospherically active binary stars (shortest period: XY UMa, 0.4789944 days; Strassmeier et al., 1993).

Although the period is similar to that of XY UMa the light curve is rather different (Collier Cameron & Hilditch 1997), and suggests a smaller, near-contact system. The light curve is similar to the near-contact binary GR Tau (P=0.42985 days Zhang et al., 2002), although this class of star is limited to spectral types A–F and does not show RS CVn-like chromospheric activity. GSC 3377-0296 clearly shows evidence of cool spots, probably at two opposite longitudes, but is also probably a near-contact system.

Acknowledgements: This research has made use of the SIMBAD and VizieR databases operated at the Centre de Données Astronomiques (Strasbourg) in France.

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