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

Number 5449

Konkoly Observatory
Budapest
18 September 2003

HU ISSN 0374 – 0676

BRIGHTNESS VARIATIONS OF SAO 84309

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The study of stars with active regions may further our understanding of the solar dynamo. These stars can be discovered by searching for X-ray sources with periodic photometric variations. The star SAO 84309 is catalogued as the X-ray source 1RXSJ162013.2+243606 by the ROSAT satellite (Voges et al., 1999). It is listed in the TYCHO Catalogue (ESA, 1997) as TYC 2047-320-1, which gives its parallax as 7 ± 14 mas, its V as $9.60 \pm .02$, its B as $10.91 \pm .04$ and its $(B-V)$ as $1.11 \pm .04$. 2MASS measurements of SAO 84309 reveal that J=7.55, H=6.99 and K=6.83 all with an uncertainty of ± 0.02. All these colour measurements are consistent with a spectral class of K5V$\pm$1 or K2III$\pm$2. A K5V star would have a parallax of about 36 mas so the giant classification is much more likely.

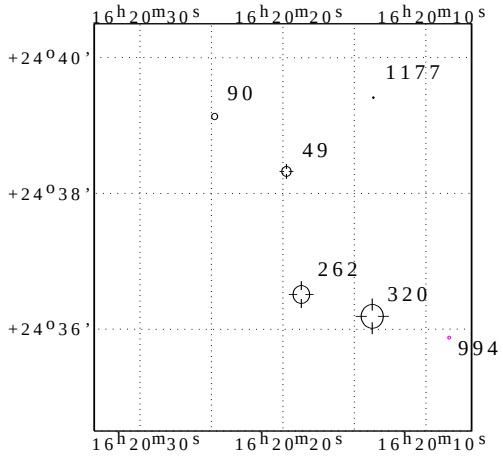

Figure 1. Finder chart labelled with the GSC identification numbers from region 2047. 320 is SAO 84309.

The observations were made with the University of Victoria automated 0.5m telescope, VRI filters and Star I CCD, and reduced in a fashion similar to that described in Robb and Greimel (1999). The field of stars observed is shown in Figure 1.

Table 1: Stars observed in the field of SAO 84309=GSC 2047-320

Star GSC Id	R.A. J2000	Dec. J2000	GSC Mag.	ΔR Mag.	Std Dev Between	Std Dev Within	Δ (V-I)	Std Dev Between
0320	$16^h20^m14^s$	$24°36'11''$	9.3	-1.536	0.045	0.004	0.513	0.063
0262	$16^h20^m19^s$	$24°36'31''$	10.8	–	–	–	–	–
0994	$16^h20^m08^s$	$24°35'53''$	14.3	3.891	0.012	0.046	1.462	0.043
1177	$16^h20^m14^s$	$24°39'25''$	14.7	4.285	0.022	0.078	1.121	0.082
0049	$16^h20^m20^s$	$24°38'19''$	12.7	2.376	0.005	0.013	0.341	0.007
0090	$16^h20^m25^s$	$24°39'08''$	13.5	2.648	0.009	0.013	0.433	0.010

The Julian Dates of observation (–2452800) are 16-19R, 23R, 24R, 26R, 27R, 32R, 37-39VRI, 41-45VRI, 47VRI, 48VRI, and 50-56VRI. Table 1 lists the stars' identification numbers, positions and magnitudes from the Hubble Space Telescope Guide Star Catalogue (GSC) (Jenkner et al., 1990) All observations were made using a filters identical to the Johnson V and the Cousins RI, but were not transformed to the standard system.

Our differential ΔR and $\Delta(V-I)$ magnitudes are calculated in the sense of the star minus GSC 2047-262. Brightness variations during a night were measured by the standard deviation of the differential magnitudes and are listed for the most photometric night in the last column as "Std Dev Within". A"Std Dev Within" one night of 0.004 sets an upper limit on variations of an hourly timescale. For each star the mean of the nightly means is shown as ΔR in Table 1. The standard deviation of the nightly means is a measure of the night to night variations and is called "Std Dev Between" in Table 1. The smallest "Std Dev Between" is 0.005 magnitudes. This excellent photometry shows that night to night variations in GSC 2047-262 must be less than a few millimagnitudes.

The star SAO 84309 did not vary significantly in brightness during any night but had obvious variations from night to night. The data were fit with sine curves using Period98 (Sperl, 1998), and two periods were found to be significant; 19.07 days and the first overtone (9.54 days) with amplitudes of 0.0588 and 0.0175 magnitudes respectively. Our best estimate of the ephemeris is:

$$\text{HJD of Maximum Brightness} = 2452819\overset{d}{.}8(9)+19\overset{d}{.}1(2)\times E.$$

where the uncertainty in each final digit is given in brackets. In Figure 2 the differential ΔR_C magnitudes are plotted as filled circles with the Period98 fit plotted as a dark line. The differential V and I light curves are also plotted in Figure 2; shifted by an arbitrary amount and with line segments connecting the observations. Also in Figure 2 we plot the Δ(V-I) showing a small but significant variation, which is indicative of an effective temperature change during the last cycle.

SAO 84309 has a light curve which brightens more rapidly than it fades, so a possibility is that the star is a pulsating star similar to the small amplitude cepheid variables. The light curve is almost identical in period, shape and amplitude to V1658 Aql = HD191616 (Robb et al., 2001). However both stars also have a K spectral type and are X-ray sources, which is not consistent with Cepheid variability.

Stars with active regions and/or spots such as BY Dra or FK Comae stars can have light curves of almost any shape. Light curve differences between the two rotations are probably due to the active regions' area and/or position changes.

SAO 84309 seems to be a rotating, late type giant star with active regions covering

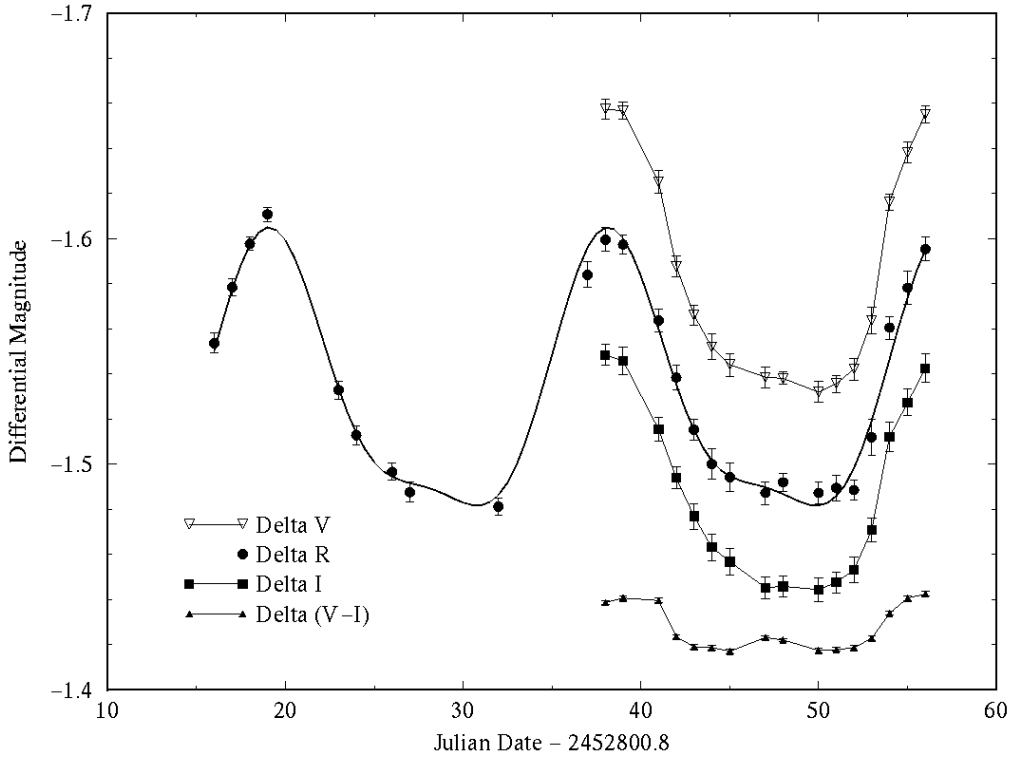

Figure 2. Differential VRI and $(V - I)$ filtered light curves of SAO 84309.

a significant part of its surface and energizing a hot corona producing X-rays. Further spectral observations will be of interest to see if there is Hα emission as found in V1658 Aql. Photometric observations will be important to tell if differential rotation will modify the period and/or shape of the light curve.

Acknowledgements

This research has made use of the NASA/ IPAC Infrared Science Archive, which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

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