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PHOTOMETRY OF THE ECLIPSING BINARY STAR GSC 0008_324 = 1RXS J001309+053550

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The star GSC 0008_324 (Jenkner et al., 1990) was found to have Ca H&K emission in a survey by Beers et al. (1994). Also called 1RXS J001309+053550, it was found to have significant X-Ray emission in a survey by the ROSAT satellite (Bade et al., 1998). In a survey of high proper motion stars it was classified as a K4-5 star by Stephenson (1986). Robertson and Hamilton (1987) measured $V = 10.59$, $B - V = 1.20$ and $V - I = 1.43$.

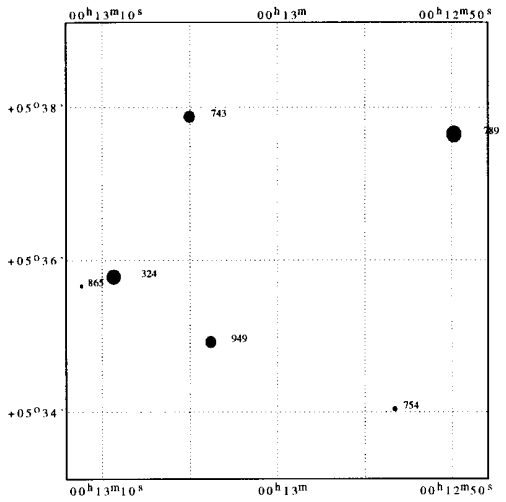

Figure 1. Finder chart labeled with the GSC numbers.

Plotted in Figure 1 is the field of stars observed with the automated 0.5-m telescope and reduced in a fashion identical to that described in Robb et al. (1997). Tabulated in Table 1 are the star's identification numbers, coordinates (J2000) and magnitudes from the Hubble Space Telescope Guide Star Catalog (GSC) (Jenkner et al., 1990). Our differential ΔR magnitudes are calculated in the sense of the star minus GSC 0008_789. 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

Table 1: Stars observed in the field of GSC 0008_324

GSC No.	R.A. J2000	Dec. J2000	GSC Mag.	ΔR Mag.	Std Dev Between	Std Dev Within
0008_324	$00^h13^m09^s$	$+05°35'47''$	10.3	0.913	0.019	0.067
0008_789	$00^h12^m50^s$	$+05°37'39''$	9.9	—	—	—
0008_743	$00^h13^m05^s$	$+05°37'53''$	11.4	1.872	0.007	0.005
0008_949	$00^h13^m04^s$	$+05°34'56''$	11.6	2.303	0.012	0.007
0008_754	$00^h12^m53^s$	$+05°34'02''$	13.8	4.789	0.005	0.024
0008_865	$00^h13^m11^s$	$+05°35'40''$	14.2	5.179	0.018	0.034

"Std Dev Between" in Table 1. Brightness variations during a night were measured by the standard deviation of the differential magnitudes during a night. The best night is tabulated in Table 1 as "Std Dev Within". The star GSC 0008_324 had obvious variations during a night and is thus a new eclipsing binary star.

There is no ambiguity in the determination of the orbital period of GSC 0008_324 since three of the nights included more than one cycle. Using data points within $0^d.02$ of the minimum, and the method of Kwee and van Woerden (1956), the heliocentric Julian Dates of minimum were found and are tabulated in Table 2. On some nights observations were made in more than one color and the separate times of minima are indicated.

Table 2: Times of Minimum (-2451400) of GSC 0008_324

JD	JD	JD	JD	JD
51.8770 R	54.9620 R	55.8858 I	60.9756 I	61.9009 R
53.8792 R	55.7301 I	55.8883 V	60.9758 B	74.7081 R
54.8043 R	55.7302 V	60.8232 I	61.7499 R	

A fit to these times gives the ephemeris:

$$\text{HJD of Minima} = 2451451^d.7204(7) + 0^d.30855(3) \times E.$$

where the uncertainties in the final digit are given in brackets and the mean square error of the fit is $0^d.0016$.

The differential (GSC 0008_324 $-$ GSC 0008_789) R magnitudes phased at this period are plotted in Figure 2 with different symbols for each of the nights. The asymmetry in the maxima is indicative of star spots, distributed asymmetrically over the surface of the star(s).

CCD frames of the field were obtained with B, V and I_C filters to ascertain the temperature and brightness of the variable star. The star GSC 0008_789 has B and V magnitudes measured by the Hipparcos satellite (ESA 1997) to be $V_T = 9.832 \pm .032$ and $(B-V)_T = 1.412 \pm .083$. Measurements of GSC 0008_324 relative to this star give $V = 10.64 \pm .05$ and $B - V = 1.07 \pm .20$ at maximum light. This $(B-V)$ is in agreement with the measurements of the Hipparcos satellite (ESA 1997) and also with Robertson and Hamilton (1987). From this color we estimate the spectral class of GSC 0008_324 to be approximately K4V (Cousins 1981) in agreement with Stephenson (1986).

The light curve leads us to expect this to be a near-contact system. Using Binmaker 2.0 (Bradstreet 1993), an example model light curve was made, assuming the temperature

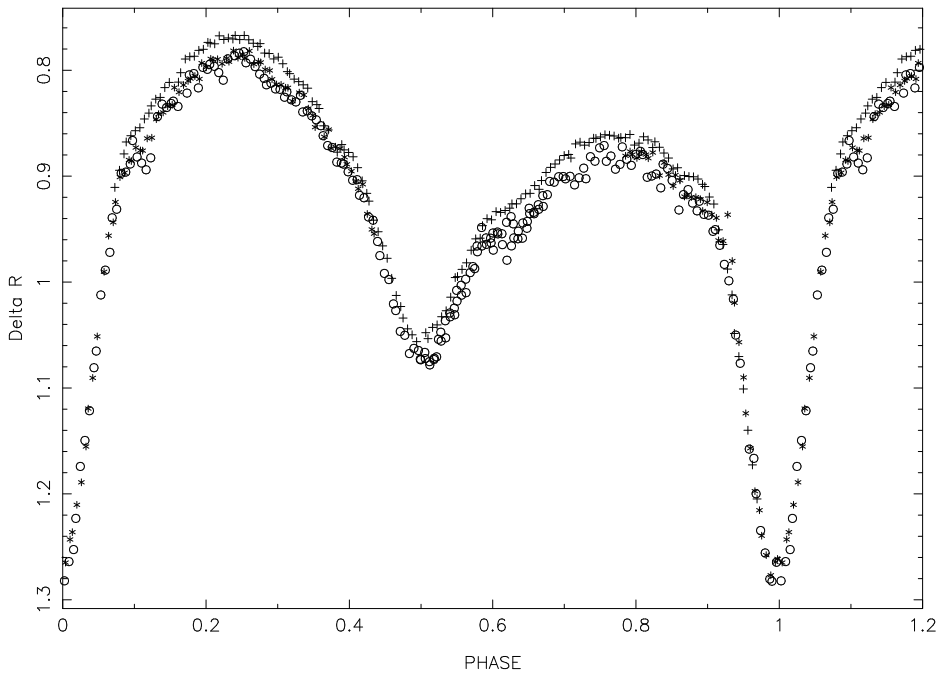

Figure 2. *R* band light curve of GSC 0008_324 for 1999

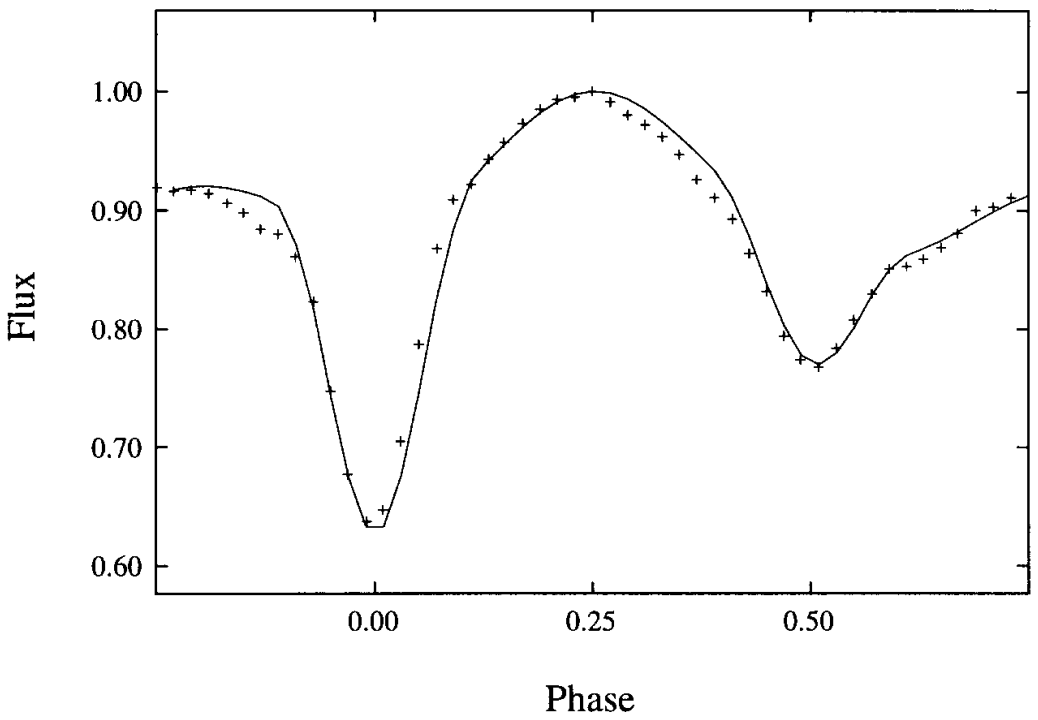

Figure 3. *R* band normal points with curve from an example model of the eclipsing system

of the hot star to be 4300 K the mass ratio of 0.83 and the latitude of the spot of 0°. The data are best fitted with an inclination of 71° and relative radii of 0.36 and 0.38. The temperature of the cool star was adjusted to 3650 K and a spot 20° in radius at a longitude of 270° was added to get the fit seen in Figure 3. Considering the cycle to cycle variations seen in the light curve, this is a satisfactory fit. The uncertainty in the inclination is about ±3° and the difference in temperature and spot diameter are known to about ±10%.

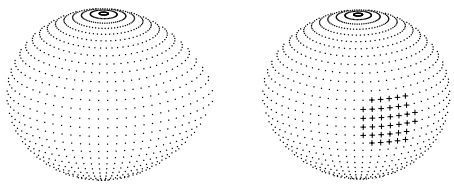

Figure 4. Three-dimensional model of the near-contact system at phase 0.75

The relative sizes and shapes of the components of the system and the spot are shown in Figure 4, again using Binmaker 2.0 (Bradstreet 1993).

The star GSC 0008_324 is therefore a near-contact eclipsing system with late-type components and at least one spot. Photometric observations should be continued to monitor light curve changes due to spot migration, flares, and period changes. Spectroscopic observations have been started to determine a precise spectral class for the system and to measure radial velocities to determine the masses and the scale of the system.

References:

Beers, T. C., Bestman, W. and Wilhelm, R., 1994, *AJ*, **108**, 268

Bade, N., Engels, D., Voges, W., Beckmann, V., Boller, Th., Cordis, L., Dahlem, M., Englhauser, J., Molthagen, K., Nass, P., Studt, J., Reimers, D., 1998, *A&A Sup.*, **127**, 145

Bradstreet, D.H., 1993, Binary Maker 2.0 User Manual, Contact Software, Norristown, PA 19401-5505, USA

Cousins, A.W., 1981, *SAAO Circ.*, **6**, 4

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

Jenkner, H., Lasker, B., Sturch, C., McLean, B., Shara, M., Russell, J., 1990, *AJ*, **99**, 2082

Kwee, K.K., van Woerden, H., 1956, *BAN*, **12**, 327

Robb, R.M., Greimel, R., Ouellette, J., 1997, *IBVS*, No. 4504

Robertson, T.H., and Hamilton, J.E., 1987, *AJ*, **93**, 959

Stephenson, C.B., 1986, *AJ*, **92**, 139