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PHOTOMETRY OF THE ECLIPSING BINARY 1RXSJ010124.9+411503

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In a continuing effort to identify X-ray sources discovered by the ROSAT satellite (Voges et al., 1996), optical photometric measurements of 1RXSJ010124.9+411503 = GSC 2807_1423 (Jenkner et al., 1990) were made. The data were observed with the automated 0.5m telescope and reduced in a fashion identical to that described in Robb et al. (1997).

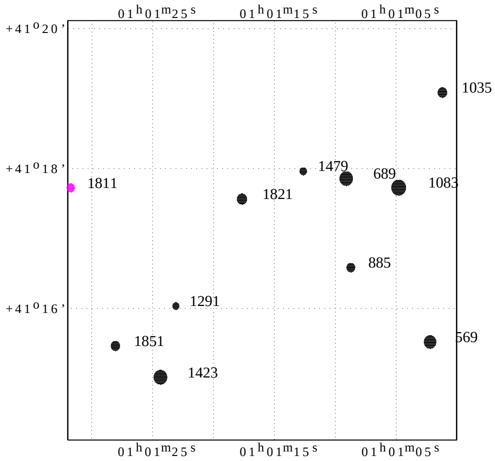

Figure 1. Finder chart of the field labeled with the GSC numbers (Jenkner et al., 1990)

In Figure 1 the field of stars is shown. Their designations, coordinates (J2000) and magnitudes from the Hubble Space Telescope Guide Star Catalog (GSC) (Jenkner et al., 1990) are tabulated in Table 1. Brightness variations during a night were measured by the standard deviation of the differential magnitudes, which ranged from $0\overset{m}{.}004$ for bright stars on a good night to $0\overset{m}{.}030$ for the faint stars on poor nights. Night to night variations were measured by a run mean of the five nightly averages, calculated and shown as ΔR in Table 1. The errors shown are the standard deviations, not the errors in the mean, and emphasize the high precision of this data. The ΔR differences in magnitude are calculated in the sense of the star minus GSC 2807_1083. Extinction effects were negligible due to the small field of view and no corrections have been made for them.

There is no ambiguity in the determination of the orbital period since three of the nights included more than half the light curve. Using the method of Kwee and van Woerden (1956), using data within $0\overset{d}{.}05$ of the minimum, three heliocentric Julian Times of primary

Table 1: Stars observed in the field of GSC 2807_1423

GSC No.	RA J2000.	Dec. J2000.	GSC Mag.	ΔR Mag.
2807_1851	$01^h01^m28^s$	$+41°15'28''$	13.0	$3.267 \pm .002$
2807_1423	$01^h01^m24^s$	$+41°15'01''$	10.8	$0.840 \pm .029$
2807_1083	$01^h01^m05^s$	$+41°17'44''$	10.2	-
2807_0689	$01^h01^m09^s$	$+41°17'51''$	10.9	$1.157 \pm .001$
2807_1821	$01^h01^m18^s$	$+41°17'34''$	12.6	$2.755 \pm .002$
2807_0885	$01^h01^m09^s$	$+41°16'35''$	13.3	$3.184 \pm .004$
2807_0569	$01^h01^m02^s$	$+41°15'31''$	11.4	$1.260 \pm .001$
2807_1035	$01^h01^m01^s$	$+41°19'05''$	12.8	$2.848 \pm .003$
2807_1811	$01^h01^m32^s$	$+41°17'43''$	13.6	$3.787 \pm .004$

minimum were found to be 2450785.8949(2), 2450787.9224(4), and 2450821.7243(3). A secondary minimum occurred at 2450784.8830(2). A fit to these times gives the ephemeris:

$$\text{HJD of Minima} = 2450784\overset{\text{d}}{.}5434(10) + 0\overset{\text{d}}{.}67601(8) \times \text{E}.$$

where the uncertainties in the final digit are given in brackets.

The differential (GSC 2807_1423−GSC 2807_1083) R magnitudes phased at this period are plotted in Figure 2 with different symbols for each of the four December nights. The obvious asymmetry in the maxima, is indicative of starspots distributed asymmetrically over the surface of the star(s).

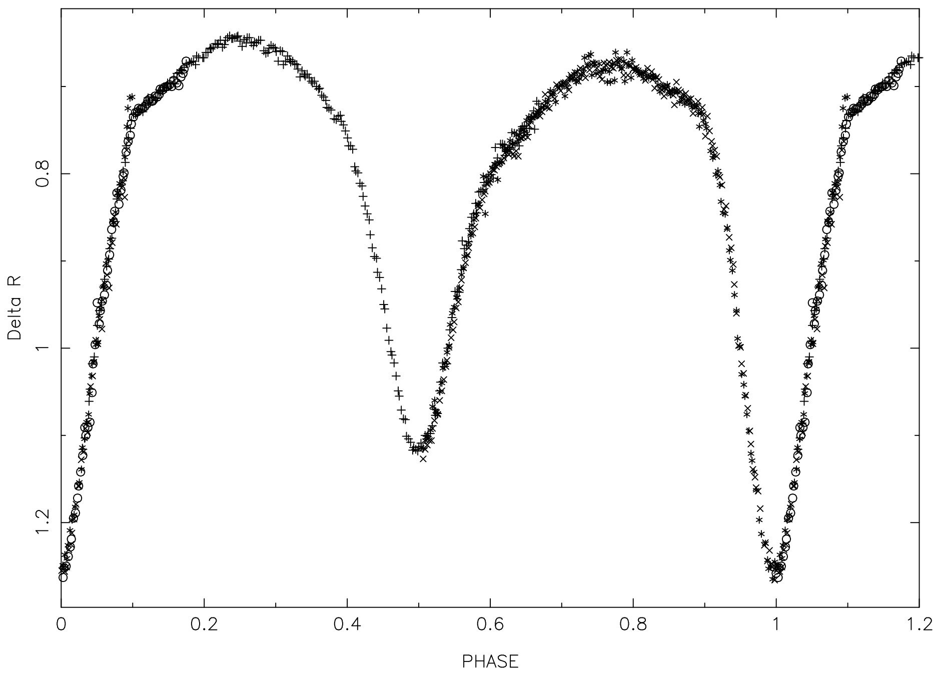

Figure 2. R band light curve of GSC 2807_1423 for 1997

To ascertain the temperature and brightness of the variable star, B and V frames of the field were obtained. Stars GSC 2807_1083 and GSC 2807_689 have B and V magnitudes (Urban 1998) measured by the Hipparcos satellite (ESA 1997). Relative to these stars,

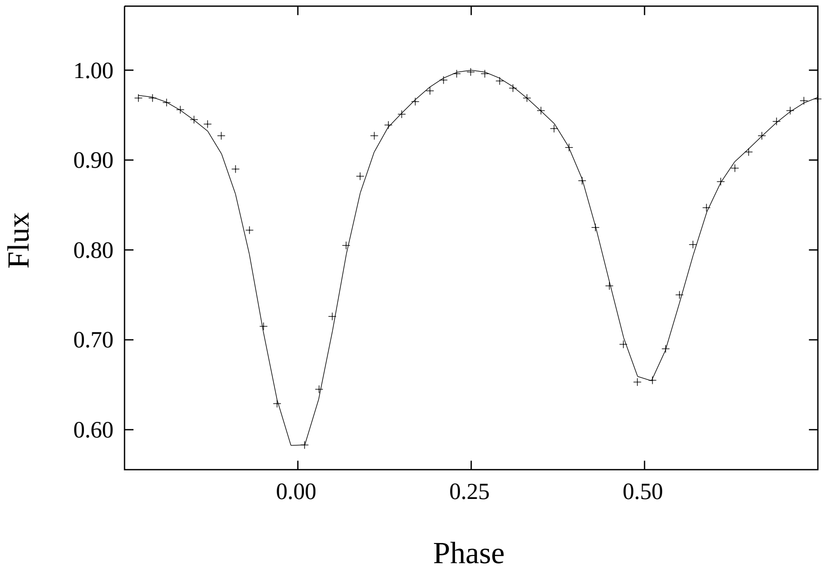

Figure 3. R band light curve (points) with example model (line) of the eclipsing system

measurements of GSC 2807_1423 give V=10.85 ± .03 and (B−V)=0.98 ± .02 at maximum light. Under rather poor photometric conditions with observations of only four nearby bright standard stars (Johnson et al., 1966), the colors of the variable star at maximum light were approximately $(V-R)_C = 0.5$, and $(R-I)_C = 0.4$. Great caution should be exercised in using these data since they are derived from only a few standard stars and the colors were transformed from the Johnson system to the Cousins system using the equations of Taylor (1986). These colors indicate that GSC 2807_1423 is a K1 spectral class star (Cousins 1981) and probably not a heavily reddened early type star.

From the shape of the light curve we can surmise that this is a detached system, which is nearly in contact. Using Binmaker 2.0 (Bradstreet 1993), an example model light curve was made, assuming the temperature of the large star to be 4750K. The data are best fitted with an inclination of 76.5°, a mass ratio of 0.84 and relative radii of 0.39 and 0.37. The temperature of the small star was adjusted to 4400K and a spot 14° in radius at a longitude of 230° was added to get the excellent fit seen in Figure 3. The mass ratio is not well determined but the uncertainty in the inclination is about ±2°. The relative radii, difference in temperature, and spot diameter are known to about ±5%.

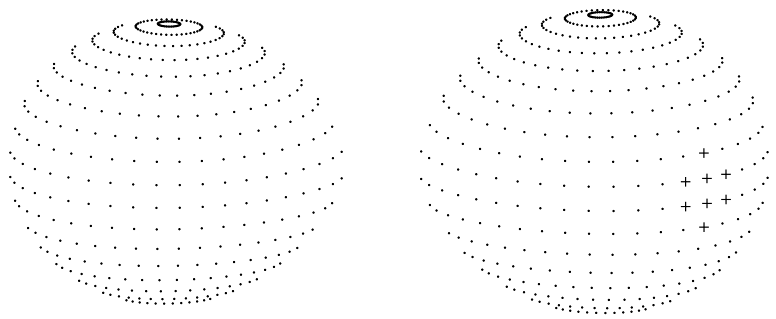

Figure 4. Three-dimensional model of the detached system at phase 0.75

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 main-sequence system CG Cyg has a nearly identical period and spectral class yet it has much smaller relative radii of 0.24 and 0.22 (Popper 1994). To have such large relative radii GSC 2807_1423 must have either a smaller semi-major axis and therefore a smaller total mass or the stars are larger or some combination of these two parameters. Four scenarios which may explain the large size/small mass are: that the stars could be the end product of mass exchange; that they are two sub-giants approaching contact; that they are two stars contracting toward the main-sequence or that they have an unlikely distribution of spots mimicking distorted stars.

The star 1RXSJ010124.9+411503=GSC 2807_1423 is therefore a detached eclipsing system with late type components, at least one spot and an active corona or flares producing X-ray emission. Photometric observations are continuing to monitor light curve changes due to spot migration and period changes. Spectroscopic observations have been started to determine a spectral class for the system and to measure radial velocities to determine the masses and the scale of the system.

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