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PHOTOMETRY OF THE W UMa SYSTEM GSC 3869_484

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The star GSC 3869_496 (Jenkner et al. 1990) was found to have Ca H&K emission in a survey by Beers et al. (1996). It was also studied by Stephenson (1986) as part of a search for nearby K and M dwarfs. He classified it as a K5 star with V=11.4. The field of that star was observed with the automated 0.5m telescope and reduced in a fashion identical to that described in Robb et al. (1997).

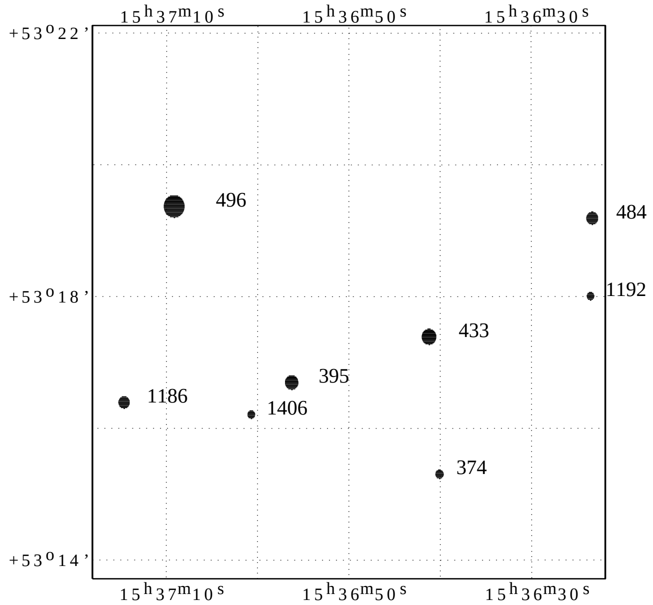

Figure 1. Finder chart labeled with the GSC numbers.

Plotted in Figure 1 is the field of stars and 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). Differential ΔR magnitudes are calculated in the sense of the star minus GSC 3869_433. Brightness variations during a night were measured by the standard deviation of the differential magnitudes, which ranged from $0\overset{m}{.}008$ for bright stars on a good night to $0\overset{m}{.}030$ for the faint stars on poor nights. The standard deviation of the nine nightly means is a measure of the night to night variations. The run means and standard deviations were calculated and are shown as ΔR in Table 1. The high precision of these data can be seen from the standard deviation of the ΔR of GSC 3869_395 minus GSC 3869_433. The fainter stars have the expected larger standard deviation. The standard deviation of $0\overset{m}{.}013$ for GSC 3869_496 is larger than we expected but not large enough for us to be certain there are photometric variations. However the star GSC 3869_484 had obvious variations during a night and is thus a new variable star and we devote the rest of this paper to it.

Table 1: Stars observed in the field of GSC 3869_496

GSC No.	R.A. J2000	Dec. J2000	GSC Mag.	ΔR Mag.
3869_496	$15^h37^m09^s$	$+53°19'22''$	11.1	$-2.272 \pm .013$
3869_484	$15^h36^m23^s$	$+53°19'11''$	13.7	$0.133 \pm .040$
3869_1192	$15^h36^m24^s$	$+53°18'00''$	15.	$1.930 \pm .017$
3869_433	$15^h36^m41^s$	$+53°17'23''$	12.9	—
3869_395	$15^h36^m56^s$	$+53°16'42''$	13.3	$-0.001 \pm .002$
3869_1406	$15^h37^m01^s$	$+53°16'13''$	15.0	$1.876 \pm .020$
3869_1186	$15^h37^m15^s$	$+53°16'24''$	13.9	$0.664 \pm .006$

There is no ambiguity in the determination of the orbital period of GSC 3869_484 since five of the nights included more than half the light curve. Using data points within $0\overset{d}{.}04$ 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.

Table 2: Times of Minimum of GSC 3869_484

Minimum	Minimum	Minimum
2450977.7701	2450977.9033	2450981.7882
2450984.8705	2450985.9425	2450986.8826
2450992.7796	2450992.9134	2450993.8528

A fit to these times gives the ephemeris:

$$\text{HJD of Minima} = 2450977\overset{d}{.}5005(7) + 0\overset{d}{.}26805(4) \times \text{E}.$$

where the uncertainties in the final digit are given in brackets and the mean square error of the fit is $0\overset{d}{.}0012$.

The differential (GSC 3869_484−GSC 3869_395) 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 and V filters to ascertain the temperature and brightness of the variable star. The star GSC 3869_237, 10' south of GSC 3869_484, has B and V magnitudes (Urban et al. 1998) measured by the Hipparcos satellite (ESA 1997). Relative to this star, measurements of GSC 3869_484 give V=13.54 ± .05 and (B−V)=0.73 ± .12 at maximum light. From this color we estimate the spectral class of GSC 3869_484 to be approximately G6 (Cousins 1981). Its period and color are consistent with the "period-color" diagram of Rucinski (1997).

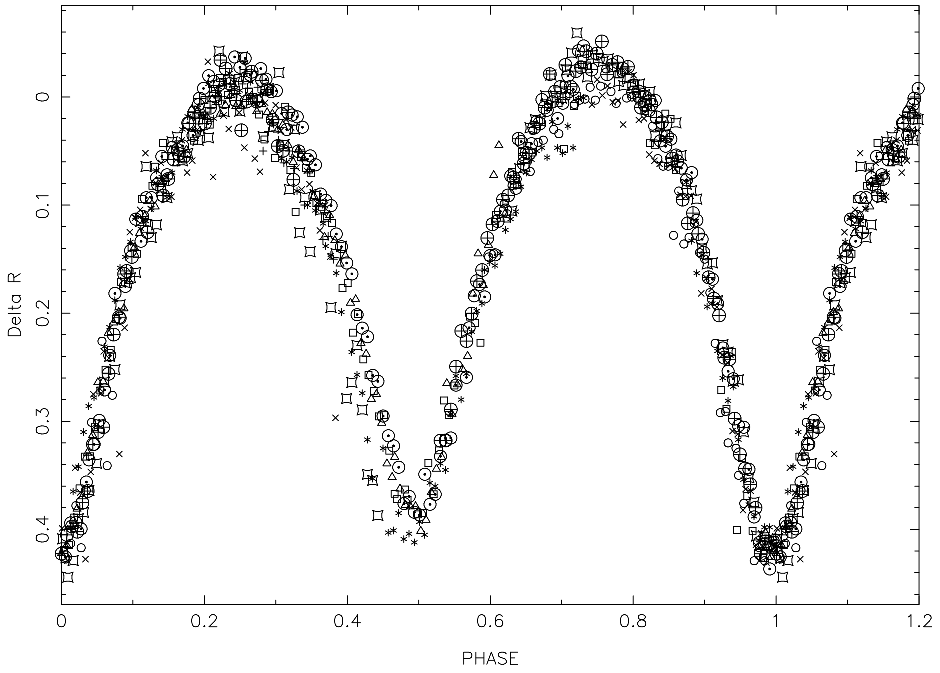

Figure 2. R band light curve of GSC 3869_484 for 1998

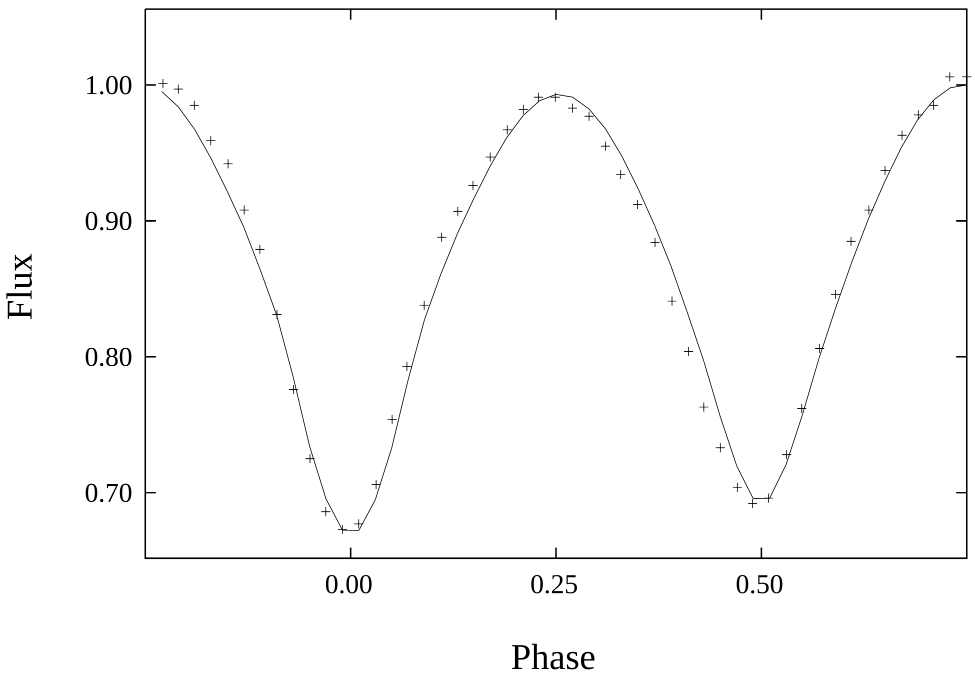

Figure 3. R band light curve (points) with example model (line) of the eclipsing system

The light curve leads us to expect this to be a contact system. Using Binmaker 2.0 (Bradstreet 1993), an example model light curve was made, assuming the temperature of the large star to be 5400K. The data are best fitted with an inclination of 69°, a mass ratio of 2, and fillout factor of 0.2. The temperature of the small star was adjusted to 5600K and a spot 12° 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 mass ratio and fillout factor are poorly determined but the uncertainty in the inclination is about $\pm 2°$. The difference in temperature and spot diameter are known to about $\pm 10\%$.

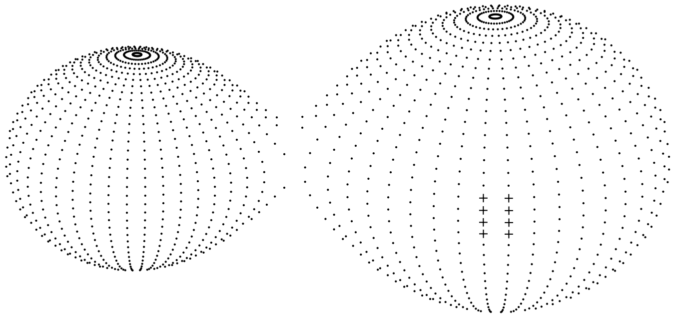

Figure 4. Three-dimensional model of the contact system at phase 0.25

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 3869_484 is therefore a 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 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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