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OBSERVATIONS OF THE GSC 3505_677 FIELD

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We observed the field containing one of the objects, (16548-39) = GSC 3505_497, found in a survey by Beers et al. (1994I, who concluded from objective prism spectral observations that it was "a medium faint star displaying moderate to strong CaII H&K and Balmer emission".

The automated 0.5-m telescope, Cousins V, R and I filters and CCD camera of the Climenhaga Observatory of the University of Victoria (Robb and Honkanen, 1992) were used to make photometric observations of the stars. Using IRAF[1] routines, the frames were de-biased and flat-fielded, and the magnitudes were found from 6 arc second aperture photometry using the Gaussian centering option of the PHOT package.

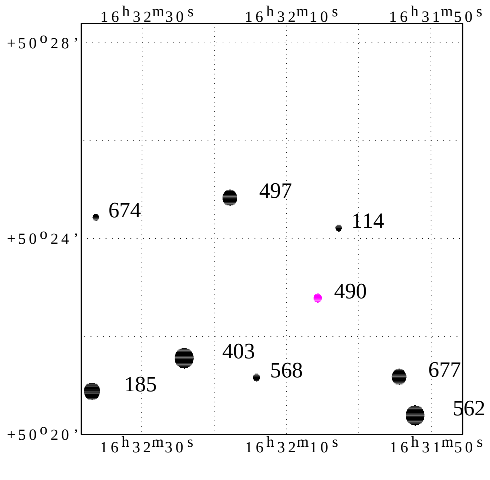

Figure 1. Finder chart of the field labeled with the GSC numbers (Jenkner et al., 1990)

The field of stars is shown in Figure 1 and their designations, coordinates (J2000) and magnitudes from the Hubble Space Telescope Guide Star Catalog (GSC) (Jenkner et al., 1990) and the measured ΔR magnitudes are tabulated in Table 1. The ΔR differences in magnitude are found from our data in the sense of the star minus GSC 3505_403. To look for brightness variations during a night the standard deviation of the differential

[1]IRAF is distributed by National Optical Astronomy Observatories, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract to the National Science Foundation

Table 1: Stars observed in the field of GSC 3505_677

GSC No.	RA J2000.	Dec. J2000.	GSC Mag.	ΔR Mag.	V	V−R_C	R−I_C
3505_497	$16^h32^m18^s$	$+50°24'50''$	13.3	$+1.080 \pm .006$	13.24	0.36	0.38
3505_403	$16^h32^m24^s$	$+50°21'33''$	12.2	–	12.10	0.30	0.29
3505_185	$16^h32^m37^s$	$+50°20'53''$	12.9	$+0.825 \pm .006$	12.95	0.31	0.35
3505_677	$16^h31^m54^s$	$+50°21'10''$	13.3	$+1.368 \pm .083$	13.52	0.59	0.37
3505_562	$16^h31^m52^s$	$+50°20'23''$	12.2	$+0.097 \pm .007$	12.44	0.55	0.33

Table 2: Heliocentric Julian Dates of minimum light 2450000+

R Filter		R filter		I Filter	
HJD	O−C	HJD	O−C	HJD	O−C
624.7432	.0001	634.7865	.0005	649.8529	.0024
627.8118	.0001	634.9254	−.0001	650.8259	−.0010
632.8325	−.0007	648.7342	−.0005		
633.8095	−.0001	648.8733	−.0008		
633.9494	.0003				

magnitudes for each star during a night was calculated and ranged from $0^m_.005$ for bright stars on a good night to $0^m_.030$ for the faint stars on poor nights. To measure night to night variations a run mean of the eight nightly averages was calculated and is shown as ΔR in Table 1. While the object of our initial interest, GSC 3505_497, proved constant, GSC 3505_677 is a significantly variable star. Due to the small field of view extinction effects were negligible and no corrections have been made for them. No corrections have been made to transform the ΔR magnitude to a standard system. Brightness variations in GSC 3505_677 were evident during each night. A least squares fit of a single sine wave to all the the data shows a deep minimum in χ^2 at an inverse period of $7.17d^{-1}$, but a plot of the light curve shows unequal minima which led us to double the period. By the method of Kwee and van Woerden (1956) eleven heliocentric Julian times of minima were found and are tabulated in Table 2. A fit to these times gives the ephemeris:

$$\text{HJD of Minima} = 2450624^d_.7430(5) + 0^d_.27897(2) \times \text{E}.$$

where the uncertainties in the final digit are given in brackets. The differences of the times of minima and the ephemeris are the O−C values given in Table 2.

A plot of the differential (GSC 3505_677−GSC 3505_403) R magnitudes phased at this period is shown in Figure 2 with different symbols for each of the nights. I band data, observed on three nights, shows the same light curve shape. Forty normal points were formed from the R and the I light curve and then the color R−I was found from the normals. The maxima were approximately 0.01 redder than the minima, indicating very little temperature difference across the star and between stars.

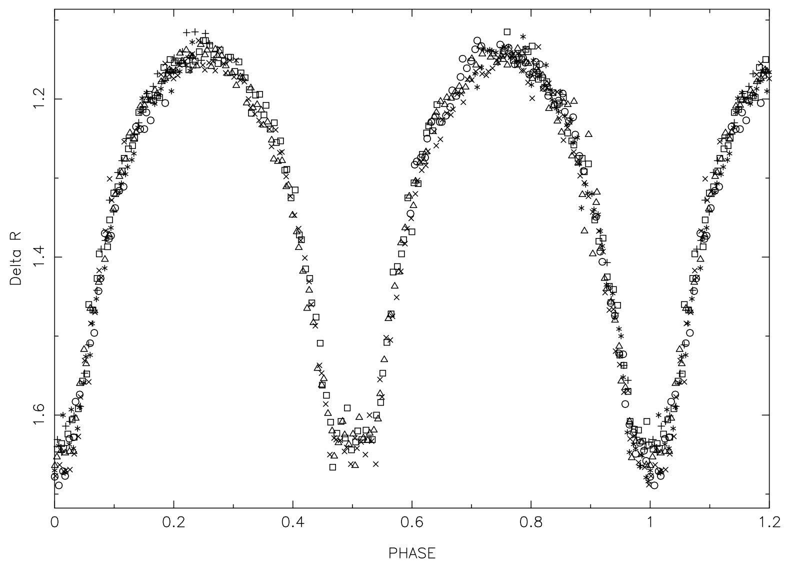

Figure 2. R band light curve of GSC 3505_677 for 1997

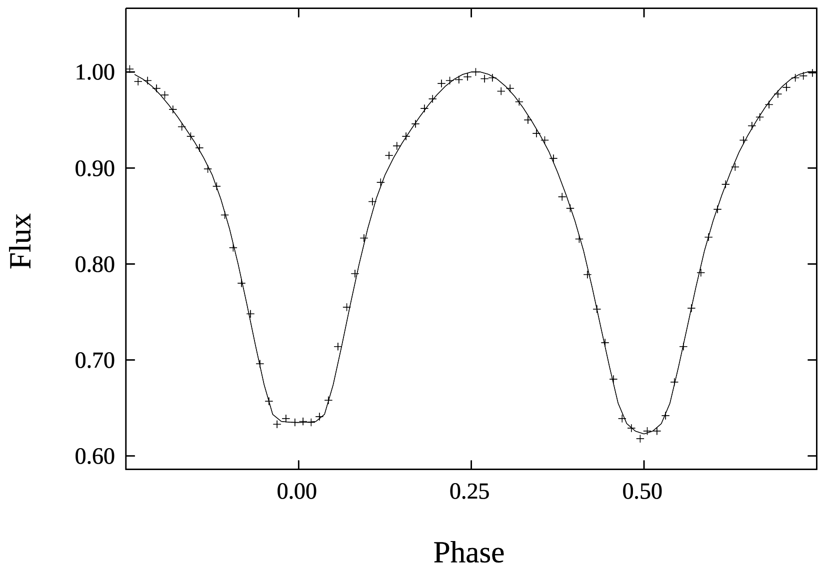

Figure 3. R band light curve (points) with example model (line) of the contact system

To help classify the variable star V, R and I frames were obtained under photometric conditions along with observations of four nearby bright standard stars (Moffett and Barnes, 1979). The V band brightness, $(V-R)_C$, and $(R-I)_C$ colors are listed in Table 1 for the brightest stars in our field. However 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). This period and $(V-I)_C$ agree very well with the short-period/blue envelope relation given by Rucinski (1997) for W UMa systems.

While certainly not definitive these colors confirm that GSC 3505_677 is a late type (approximately K1V) star (Cousins 1981). A dwarf star of this color would be expected to have an absolute magnitude of approximately V=6.2 (Allen 1976), so from our apparent magnitude of 13.52±.08 at maximum brightness, we find the distance to be about 300±100 parsecs. Using the period, $(V-I)$, relation for absolute I magnitude for contact systems (Rucinski 1997), the distance can be found to be 400 ± 60 parsecs.

From the color information and the shape of the light curve we can surmise that the primary star and the secondary star is a contact system. To make an example model light curve using Binmaker 2.0 (Bradstreet 1993), the phases of the points have been increased half a cycle and the temperature of the large star was assumed from the $(R-I)C$ to be 4750K. The data are best fitted with an inclination of 85°, a mass ratio of 3.45 and a fill out factor of 0.1. The temperature of the small star was adjusted to 4820 K to get the excellent fit seen in Figure 3. The mass ratio and fill-out factor are correlated such that an increase in the mass ratio of about 0.2 can be compensated by an increase in the

fill out factor by 0.1 to get nearly as good a fit. The relative sizes and shapes of the components of the system are shown in Figure 4, again using Binmaker 2.0.

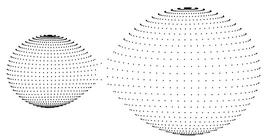

Figure 4. Three-dimensional model of the contact system at phase 0.25

The star GSC 3505 677 is therefore a W UMa system with late type components. Further photometric observations will be valuable to look for period changes due to mass transfer and to observe precise colors and thus determine the temperature of the stars. Spectroscopic observations will be important to get a good spectral class for the system and radial velocities will measure the scale of the system and the masses. RG would like to thank the Austrian Ministry of Science for financial support.

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