COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 3798

Konkoly Observatory
Budapest
29 October 1992

*HU ISSN 0324 - 0676*

## On the Variability of BD-3°5183

The star GSC 5198.00659 was reported to be variable by Hutton 1992. The star's position, brightness (V=9.8), color (B-V)=0.7, and finder chart are also given in Hutton 1992. This is a report of my observations of this star, also known as BD-3°5183.

BD-3°5183 was observed using the 0.5 meter reflector of the Climenhaga Observatory at the University of Victoria on ten nights between 31 July 1992 and 31 August 1992, using a photometer based on the Thomson 7882 CDA CCD chip. Computer control of the telescope allowed pointing it at the stars at the beginning of the night and then leaving it to follow the stars until either dawn, thick clouds or too large an airmass occured and observations were terminated. At the end of the night the computer closed the dome and stopped the telescope drive. Many of the nights were not of photometric quality, however the sky, variable, and comparison stars were observed on the same CCD frame, so thin clouds did not degrade the differential measurements. Due to the proximity of the variable and comparison stars in position, no extinction correction was neccessary and none has been made. The filters used with our CCD camera closely match the standard system (Robb et al 1992), so mean transformation coefficients have been used to transform the data to the standard system (Landolt 1983).

The small size of the CCD chip restricts our field of view to 8X5 arc minutes and so our choice of comparison and check stars was limited. For the comparison star we used SAO145329 at RA=$21^h21^m46^s$, Declination=$-3°11'57"$ and magnitude= 9.1 (Equinox 2000), where the position and magnitude are from the Hubble Space Telescope Guide Star Catalog (Jenker et al. 1990) and the spectral type is quoted as K0 in the SAO catalog. The exposure time was kept constant at 60 seconds for R band and 111 seconds for V band. Since there was no star in the field of view of the CCD bright enough to give an adequate signal, no check star was observed.

At the telescope the first frames showed the variable star's image to be elongated in the north-west direction, while the comparison star's image was round. To increase the resolution by decreasing the apparent seeing disc, (FWHM) a few one second exposures were made with no filter. These short exposures show a faint companion to the north-west. Using the ALLSTAR routines of DAOPHOT (Stetson 1987), simultaneous fits of the point spread function (FWHM=3") to the merged images of components A and B were made. Six frames were measured and the separation was found to be 5.2" $\pm$ 0.2" with a position angle of $321 \pm 2$ degrees east of north. The magnitude difference was $3.9 \pm 0.2$, but since no filter was used this magnitude can not be put on the standard system. Very roughly it corresponds to the red region of the spectrum. Many W UMa stars are part of multiple star systems, so the likelihood of this being a true multiple system is high, but the period of such a component would be so long that no change is likely to be measurable for a hundred years (Chambliss 1992).

Table 1

| |
|---|
| $2448835.7737 \pm .0012$ |
| $2448844.7616 \pm .0003$ |
| $2448844.9481 \pm .0003$ |
| $2448845.8848 \pm .0006$ |
| $2448852.8126 \pm .0004$ |
| $2448853.9351 \pm .0004$ |
| $2448858.8033 \pm .0003$ |
| $2448859.7404 \pm .0004$ |
| $2448859.9275 \pm .0005$ |
| $2448866.8560 \pm .0004$ |

Inspection of plots of the brightness of each of the stars for each night shows sinusoidal periodic variation of BD-3°5183. The longest nights show two minima and that the amplitude is about 0.3 magnitudes. Times of minimum were found for each well observed minimum and are given in Table 1. These times of minima are found from the method of Kwee and van Worden (1956) from all the data points within 0.03 days of each minimum. A least squares fit to these minima gives the ephemeris:

$$HJD\,Min\,I = 2448835.7736(3) + 0^{d}.374479(7)\,E.$$

Where the numbers in brackets are the errors in the last decimal place. The root mean square error of the times of minima from this ephemeris is 0.0005 days. This period is in good agreement with the period-color relation of Eggen (1967) for contact binaries. Inclusion of the eleven points from Hutton (1992), are almost consistent with this period and epoch, except for the the one at JD 2448507.6504, which falls below the curve by 0.2 magnitudes. These points have not been included in the determination of the period, since it is not known that the times of observations have been corrected to heliocentric time.

The V band light curve is plotted in Figure 1 according to the period discussed above and clearly shows the variation expected of a W UMa system. The flat minimum and small amplitude indicate an extreme mass ratio and large inclination of the orbital plane. The light curve modeling program LIGHT written by G. Hill and S. Rucinski (1992) was used to model the system. One hundred normal points were formed from the best nights for each of the R and V light curves. Figure 2 shows the R band normal points and the line is from the model; with inclination=78.3 degrees, mass ratio=0.146 and filled fraction=0.475. Where a filled fraction of 0.0 is the inner contact surface and 1.0 is the outer surface. Figure 3 shows the V band normal points and the line is from the model; with inclination=78.2 degrees, mass ratio=.164 and filled fraction=0.49. For these runs only the inclination, mass ratio, and filled fraction were allowed to vary. The temperature of both components was held constant at 6500 degrees, consistent with the average (B-V) reported by Hutton (1992). This temperature implies a convective envelope so the gravity darkening exponent $\beta$ was chosen to be 0.08 and the reflection efficiency was 0.5. For some runs of the model the temperature of the secondary was allowed to vary, but it changed by only about 10 degrees, so it was kept constant for the final runs. Simultaneous fits were also made to both colors, but no difference was seen. The light from the third component was not made a variable parameter, since it was measured to be so small, and would be a constant offset of the light curve. The asymmetry of the maxima preclude a good fit in that part of the curve and are probably due to star spots. The uncertainty of the fitted parameters are difficult to acertain, but from twenty runs of the model I estimate the uncertainty to be about 1.5 degrees in inclination, 0.1 in the filled fraction, and 0.02 in the mass ratio.

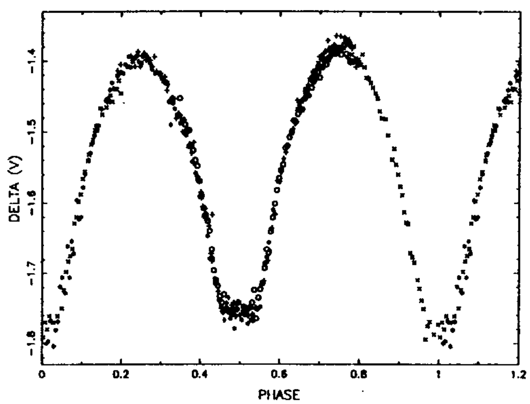


Figure 1. Light curve of BD-3°5183 in the V band plotted with the PHASE = ( HJD - 2448835.7736) / 0.374479

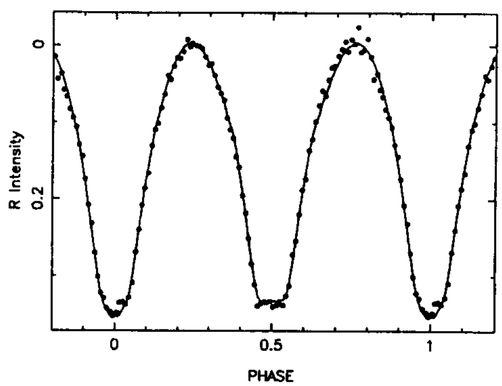


Figure 2. Normal points of BD-3°5183 in the R band plotted with the model light curve with inclination=78.3°, mass ratio=0.146, and filled fraction=0.475.

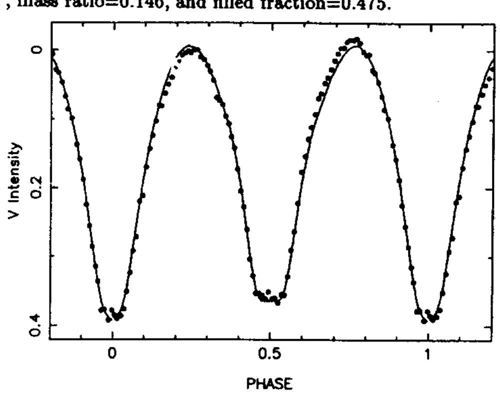


Figure 3. Normal points of BD-3°5183 in the V band plotted with the model light curve with inclination=78.2°, mass ratio=0.164, and filled fraction=0.49.

Contact systems are generally divided into A-type and W-type systems. The BD-3°5183 system has a light curve shape, small mass ratio and large filled fraction all consistent with it being an A-type system. The (B-V)'s reported by Hutton (1992), despite having an unusually large range of 0.63 to 0.78, after correcting for reddening, estimated from Burstein and Heiles (1982) to be approximately E(B-V)=0.08, indicate a spectral type later than G0. Since all A-type systems are hotter than G0 (Rucinski 1985) with the possible exception of FG Hya, the only other contact binary with an A-type light curve and a W-type color. The explanation for FG Hya's light curve is, that an unusual spot distribution is thought to distort the light curve and make it appear to be an A-type system.

Further observations of this very interesting system are urged. Spectroscopic observations are needed to allow spectral classification of the contact system and establish whether BD-3°5183 is an A-type or a W-type. High resolution spectra would allow spectroscopic determination of the mass ratio and hopefully support the rather small photometric mass-ratio. Further photometric observations will be of interest to refine the determination of the period and to check for period changes indicative of the system merging to become an FK Comae type system. Light curve changes are also expected, if the system is similar to FG Hya, and has many large and variable star spots.

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