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GW CANCRI: A W-TYPE W UMa SYSTEM WITH COMPLETE ECLIPSES

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The variability of GW Cancri was reported by Takamizawa (2000) and the system is listed in the GCVS with an L: variability type. Khruslov (2005), using ASAS3 and ROTSE data, showed that the correct variability type was EW and that the period was 0.281415 days. Intrigued by the possibility of complete eclipses as seen in the ROTSE data, we began observing GW Cnc with BVI_c filters at the Sonoita Research Observatory. We used the 14″telescope equipped with a Santa Barbara Instrument Group Research 1001XE CCD camera. Calibration (bias, dark, flat) and aperture photometry were done with IRAF.

Observations were made on twenty nights in the period November 2004 to April 2005 with a total of 302 observations with the B filter, 838 with V and 380 with I_c. GSC 1399-1976 was used as the comparison star and GSC 1399-0895 was the check star. The standard deviation for comparison minus check observations was 0.02 magnitudes in B and 0.01 magnitudes in V and I_c. On several photometric nights we measured standard colors for the stars. During the total primary eclipse, we find $B - V = 0.68 \pm 0.02$ for GW Cnc and we find the same result at phase 0.75. There are indications that the system may be very slightly bluer at phase 0.25 with $B - V = 0.66 \pm 0.02$ but further observations would be required to confirm that result. Tycho data for the comparison star give $B - V = 0.58 \pm 0.19$ and we measure it to be $B - V = 0.50 \pm 0.01$. Tycho data for the check star give $B - V = 0.52 \pm 0.17$ and we find $B - V = 0.48 \pm 0.01$. The instrumental differential magnitudes for GW Cnc are available from the IBVS web site as 5625-t2.txt (B), 5625-t3.txt (V) and 5625-t4.txt (I_c).

We analyzed our observations with the 2003 version of the Wilson-Devinney program (WD; Wilson & Devinney, 1971; Wilson, 1979). We used mode 3, appropriate for overcontact binaries of this type, and adjusted the parameters shown in Table 1. We set the mean effective temperature of star 1 (the star eclipsed at primary minimum) equal to 5620 K based on our $B - V$ value and the calibration of Flower (1996). Unadjusted parameters such as the gravity darkening exponents and bolometric albedos were set to their theoretically expected values for convective envelopes. Figure 1 shows the fits to the observations.

Table 1. Adjusted Parameters for the Light Curve Solution

Parameter	Value	Std. Error†
i	$83\overset{\circ}{.}4$	$0\overset{\circ}{.}4$
T_2	5350 K	28 K
q	4.15	0.01
Ω_1	7.98	0.02
HJD_0	2451554.030	0.004
P	$0\overset{d}{.}281413$	$0\overset{d}{.}000003$
$L_1/(L_1+L_2)_B$	0.280	0.001
$L_1/(L_1+L_2)_V$	0.274	0.001
$L_1/(L_1+L_2)_{I_c}$	0.263	0.001
x_{1B}	0.76	0.09
x_{1V}	0.51	0.07
x_{1I_c}	0.27	0.06

Initially, we used the logarithmic limb darkening law with coefficients interpolated from the Van Hamme (1993) tables but we found that we could not fit the depth of the primary minimum in the I_c light curve during the simultaneous solution with the B and V data. Since the current version of the WD program cannot adjust both parameters in the logarithmic limb darkening law, we adopted the linear cosine law and adjusted the limb darkening coefficient for star 1 (x_1). The limb darkening coefficient for the B light curve was essentially identical to its expected theoretical value and the value for the V light curve was slightly lower although by only about 1.6σ. The limb darkening coefficient for the I_c curve was 0.27 ± 0.06 as opposed to the theoretical value of 0.46. The fits to the secondary eclipses using the theoretical limb darkening coefficients did not show any major problems and test runs, where we adjusted the coefficient for star 2, did not result in values significantly different from the theoretical values. These results may indicate that the theoretical treatments of limb darkening may be inadequate for the low mass companions in W UMa systems with large mass ratios, especially at longer wavelengths.

Using the period-color-luminosity calibration of Rucinski and Duerbeck (RD; 1997), we can roughly estimate the absolute dimensions of the system. The RD calibration predicts $M_V \approx 4.62$ for a system with the color and period that we have measured for GW Cnc. By adjusting the semi-major axis of the system we can determine the value at which the absolute V magnitude matches that of the RD prediction and the result is $2.32R_\odot$. This value results in masses $M_1 = 0.4M_\odot$ and $M_2 = 1.7M_\odot$ as well as radii $R_1 = 0.6R_\odot$ and $R_1 = 1.2R_\odot$. Given the large intrinsic errors in this calculation, these absolute parameters should be considered only very rough estimates.

Because of its total/annular eclipses and overcontact configuration, the photometric mass ratio we have determined is well-determined (viz. Terrell & Wilson, 2005). Therefore, even if only one component's spectral lines could be reliably measured, a full solution for the absolute parameters of the system could be performed. If the system is double-lined, then the radial velocities could provide a check on the mass ratio. Further photometric observations could also prove useful since the system shows the night-to-night variability that is common for W UMa systems.

†Formal errors from the differential corrections solution.

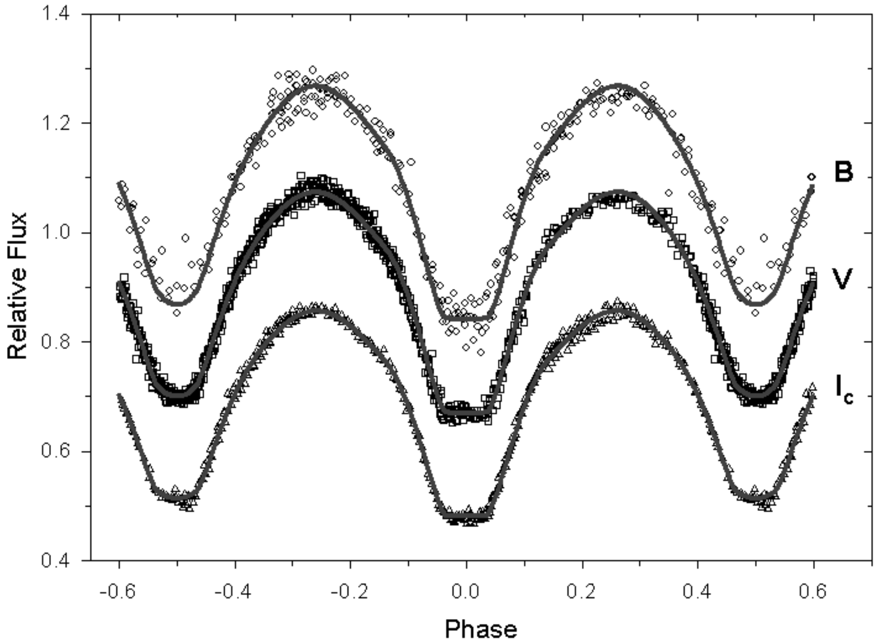

Figure 1. BVI_c light curves of GW Cnc and the fits from the Wilson-Devinney solution.

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