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2001 AND 2003 PHOTOMETRY OF WY CANCRI

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As part of an ongoing study of WY Cancri, (#82 in the catalog of Strassmeier et al. 1993) a short period eclipsing RS CVn system, I collected new optical photometry in 2001 and 2003. Heckert (2001) and Heckert et al. (1998) have collected annual light curves of WY Cnc since 1988. These works note secular luminosity increases of nearly 0.1 magnitudes in both 1988 and 1997, which may signal the onset of a new cycle in spot activity with a change in the direction of longitudinal spot migration. Kjurkchieva et al. (2003) report photometry and spectroscopy during 2001. They note a secular luminosity increase in February 2001, after my 2001 data were taken. Their spectroscopy also confirms recent detections (Pojmanski, 1998; Arévalo and Lázaro, 1999) of spectral lines from the secondary in this system, which has previously been classified as a single lined system.

I observed WY Cnc with the San Diego State University 61-cm telescope on Mt. Laguna. The 2001 light curves were obtained on the nights of December 30, 2000 and January 2, 3, & 6, 2001. The 2003 light curves were obtained on January 9, 10, 11, 13, 18, 21,& 24, 2003. I used SAO 80583 as the comparison star. The light curves, with 135 data points per filter in 2001 and 132 in 2003, are plotted in Figures 1 and 2. The data are differential magnitudes (var-comp) in the standard Johnson-Cousins system. I used the ephemeris of Hall and Kreiner (1980):

ϕ_0=2426352.3895+0.82937122 E.

I modelled the data using Budding and Zeilik's (1987) Information Limit Optimization Technique (ILOT). Initial values for stellar parameters were the same as those of Heckert et al. (1998) and Heckert (2001). I adopted temperatures of 5520K and 3500K for the primary and secondary stars. After the initial fit, the ILOT extracts a distortion wave which I then fit for two circular 0K spots. The fits for each color are performed independently. The reported longitude, latitude and radius of each spot are in degrees, and are given in Table 1.

Being more difficult to fit, the latitudes are less reliable than the other parameters. However the two spots during both years include both high and low latitudes. Heckert et al. (1998) note a tendency for spots in the 270° ALB to be at higher latitudes than those in the 90° ALB. This tendency appears to hold in the 2001 data. The 2003 data however show the reverse tendency. The 90° ALB spot is at higher latitude. By comparing the R or I data to the 0K spot solutions at B or V, the ILOT can estimate spot temperatures. Doing so I find an average value of the spot temperature of T_s=3993K±321K for 2001 and T_s=3930K±100K for 2003.

Kjurkchieva et al. (2003) modelled the spots in their light curves from November and December 2000. With spots at 220° and 345° longitude, their models differ from this

Table 1. Spot Fits

2001	B band	V band	R band	I band
$Longitude_1$	287.5±1.7	286.6±2.5	286.4±2.8	284.8±4.0
$Latitude_1$	59.8±3.8	57.8±8.0	60.0±9.5	60.3±17.5
$Radius_1$	26.1±2.4	22.3±3.8	21.5±4.5	19.7±7.3
$Longitude_2$	146.0±4.6	148.3±6.3	149.5±9.3	149.4±12.0
$Latitude_2$	0.0±14.5	0.0±23.8	0.0±19.7	0.0±20.1
$Radius_2$	9.3±0.5	8.7±0.6	8.3±0.7	8.1±0.8
χ^2	68.4	52.6	44.9	44.0
2003				
$Longitude_1$	93.2±4.1	87.5±4.7	90.2±6.6	91.3±7.9
$Latitude_1$	74.4±4.4	73.5±5.8	76.0±6.6	78.0±6.7
$Radius_1$	25.5±4.7	22.6±5.4	21.5±6.6	21.2±7.4
$Longitude_2$	299.7±4.6	302.0±6.8	303.7±9.1	305.4±10.5
$Latitude_2$	0.0±19.6	0.0±20.8	0.0±27.0	0.0±29.4
$Radius_2$	9.1±0.7	8.5±0.8	7.8±0.9	7.0±1.0
χ^2	161.4	110.5	91.4	70.3

work. To check my models for nonunique solutions, I tried using their spot solution as an initial guess for modeling my data. The solution converged to that reported here. Hence the spots changed rapidly. Noting that Kjurkchieva et al. (2003) observed a secular luminosity increase in February 2001, suggests that rapid changes in the spot structure occur just before the secular luminosity increases. If these luminosity increases result in some way from increased magnetic activity, such rapid changes would be expected. This magnetic activity could be either spot activity that disappears or a bright magnetic network similar to, but much more extensive than, that on the Sun. Figure 3 plots the estimated unspotted light level following Heckert (2001). The data from this work and Kjurkchieva et al. (2003) are added to Heckert's (2001) original figure. In addition to the original caveats, note that the Kjurkchieva et al. (2003) data are in the instrumental system. Hence the apparent brightness decrease from December 2000 to January 2001 is likely a calibration artifact. If so, the February 2001 secular luminosity increase is closer in brightness to those of 1997 and 1988 than it appears in the figure. Also note that the February 2001 data are very limited phase coverage. The secular luminosity increase seems to rise on a time scale of a few months.

After the spot fits, I performed clean fits to the light curves removing the effects of the distortion wave from the spot as modelled in that filter. The fits at each wavelength were done independently. The color independent parameters generally agree to within the quoted errors. Table 2 shows values for each filter and the mean for the wavelength independent parameters. Figure 4 shows the V band clean fits.

The quantities in Table 2 are as defined by Budding and Zeilik (1987). The fractional luminosities of the primary and secondary components, L_1 and L_2, are normalized to sum to approximately but not exactly 1. The sum can deviate from unity because the normalization is performed before the light curve is corrected for the spot effects, and subtracting the spot causes the out of eclipse intensity to be slightly more or less than 1. These results agree to within the errors with previous work. The mass ratio, q, has been a particular problem for WY Cnc. The results above compare with previous photometric values of q=0.31±0.23 and q=0.384±0.099 (Heckert, 2001 and Heckert et al., 1998). More recently it has been possible to determine this value from spectroscopy. The photometric mass ratios and inclinations for 2003 are very close to the spectroscopic values of q=0.59±0.07, i=87° and q=0.55±0.06, i=88° (Arévalo and Lázaro, 1999 and Kjurkchieva et al., 2003). The 2001 values however are closer to the previous lower photometric determinations of q and the corresponding inclinations of 90° for most of the data sets.

Table 2. Clean Fits

2001	B band	V band	R band	I band	Mean
L_1	0.961±0.004	0.956±0.005	0.940±0.005	0.912±0.005	
$k(=r_2/r_1)$	0.612±0.003	0.611±0.004	0.612±0.004	0.607±0.005	0.611
$\Delta\theta_0$	10.597±0.115	10.589±0.122	10.542±0.127	10.485±0.133	10.553
r_1	0.241±0.003	0.240±0.003	0.236±0.003	0.237±0.003	0.239
i(deg)	90.0±1.3	90.0±1.2	90.0±1.4	90.0±1.4	90.0
L_2	0.028±0.005	0.034±0.005	0.050±0.006	0.075±0.006	
$q(=m_2/m_1)$	0.326±0.054	0.326±0.070	0.335±0.094	0.313±0.124	0.325
χ^2	41.9	32.0	30.2	32.6	
2003					
L_1	0.995±0.004	0.972±0.004	0.951±0.004	0.924±0.004	
$k(=r_2/r_1)$	0.638±0.012	0.626±0.007	0.627±0.006	0.617±0.006	0.627
$\Delta\theta_0$	11.916±0.105	11.953±0.109	11.910±0.113	11.871±0.117	11.913
r_1	0.240±0.003	0.239±0.003	0.238±0.003	0.239±0.003	0.239
i(deg)	86.8±1.0	88.2±1.5	88.1±1.3	88.2±1.4	87.8
L_2	0.009±0.005	0.025±0.005	0.042±0.006	0.070±0.006	
$q(=m_2/m_1)$	0.534±0.052	0.550±0.067	0.594±0.084	0.593±0.100	0.568
χ^2	140.4	95.7	83.6	66.2	

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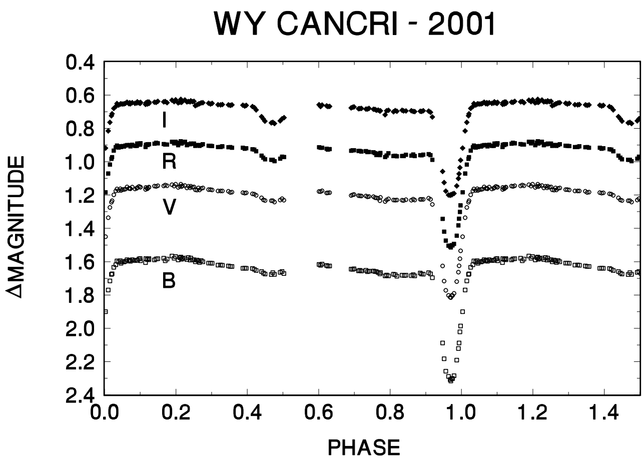

Figure 1. The light curve of WY Cnc in 2001, with 135 data points per filter.

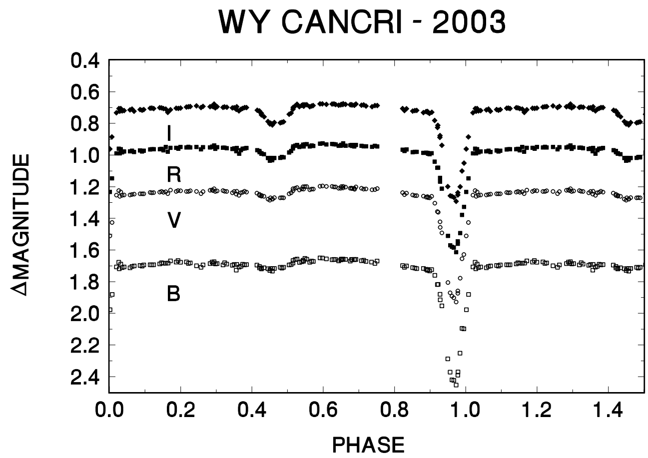

Figure 2. The light curve of WY Cnc in 2003, with 132 data points per filter.

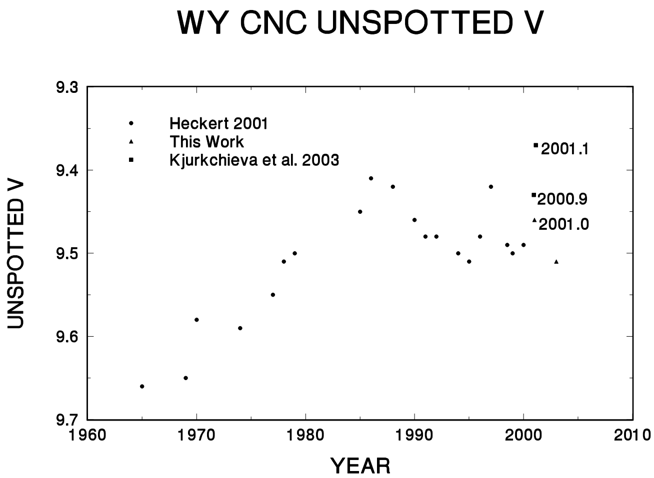

Figure 3.

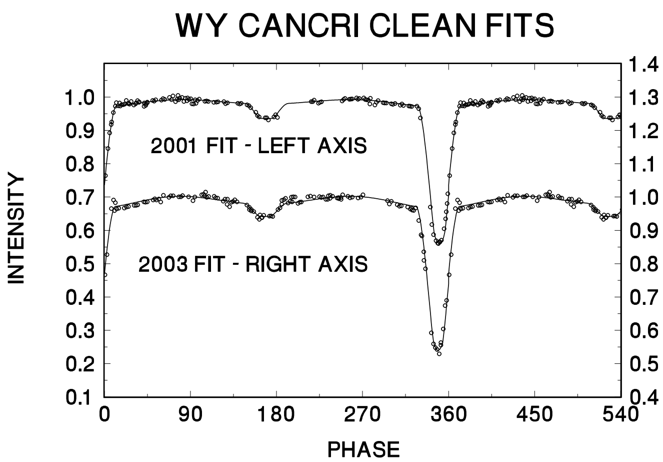

Figure 4.