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THE POLAR CSS 081231:071126+440405 AT A LOW ACCRETION RATE

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CSS 081231:071126+440405 (AAVSO Alert Notice #142) is a suspected polar that went into bright outburst in early 2009. A polar is an accreting white dwarf with a strong magnetic field that disrupts the accretion disk, funneling material directly on to the magnetic poles. CSS 081231:071126+440405 shows deep eclipses with a period of about 1.94 hours and reached a peak brightness of $V \sim 14^{\rm m}\!\!.8$ in March, 2009 (AAVSO Special Notice #149).

We imaged CSS 081231:071126+440405 with the Vatican Advanced Technology Telescope (VATT) over four consecutive nights 2009 October 22-25 (UT) using the VATT4K CCD. The CCD was binned by two pixels and only the first 512 pixels were read out, reducing the overhead to 10 sec. We continuously took 30 sec exposures in the V band spanning 3.5 hours on the first two nights, then switched to 20 sec exposures in the B-band for the final two nights. Using images of the Landolt (1992) standard region SA113, we estimated a zeropoint for the VATT photometry. For the star at the USNO-B.1 coordinates $\alpha = 7^{\rm h}11^{\rm m}22^{\rm s}\!\!.839$, $\delta = +44^\circ04'12''\!\!.45$ (30 arcsec west of the variable) we find $V = 16.57 \pm 0.05$ mag and $B - V$=0.36 mag.

The V-band light curve is shown Figure 1. Two short, deep eclipses are clearly seen each night and the heliocentric corrected times of mid-eclipse are given in Table 1. We derived a period of 117.181±0.004 minutes and used it to phase the photometric data. The eclipse times in Table 1 provide an ephemeris in heliocentric Julian days of

$$\mathrm{HJD} = 2455126.8960(1) + \mathrm{E} \times 0.081376(3)$$

where the numbers in parentheses are the uncertainties on the final decimal place. We find the full eclipse length is 0.058±0.001 in phase or 6.80±0.12 minutes.

The light curve from Oct. 22-23 shows a bright plateau between phases -0.25 and $+0.25$ surrounding the eclipse. During the plateau, the star is strongly variable but shows a dip in brightness near phase $+0.1$ which is likely to be self-absorption by the accretion column. Between phases $+0.25$ and $+0.75$ the star displays a slow, steady rise of 0.1 mag and a brightness that is extremely consistent from orbit to orbit.

The light curve is similar to the eclipsing polar HU Aqr in its low accretion state (Schwope et al., 2001). We expect CSS 081231:071126+440405 has a single hotspot on the accreting white dwarf which is in synchronous rotation with the secondary star. The hotspot is occulted by the white dwarf for half the spin period, opposite the phase of the eclipse, suggesting that the accreting magnetic pole is nearly facing the secondary star.

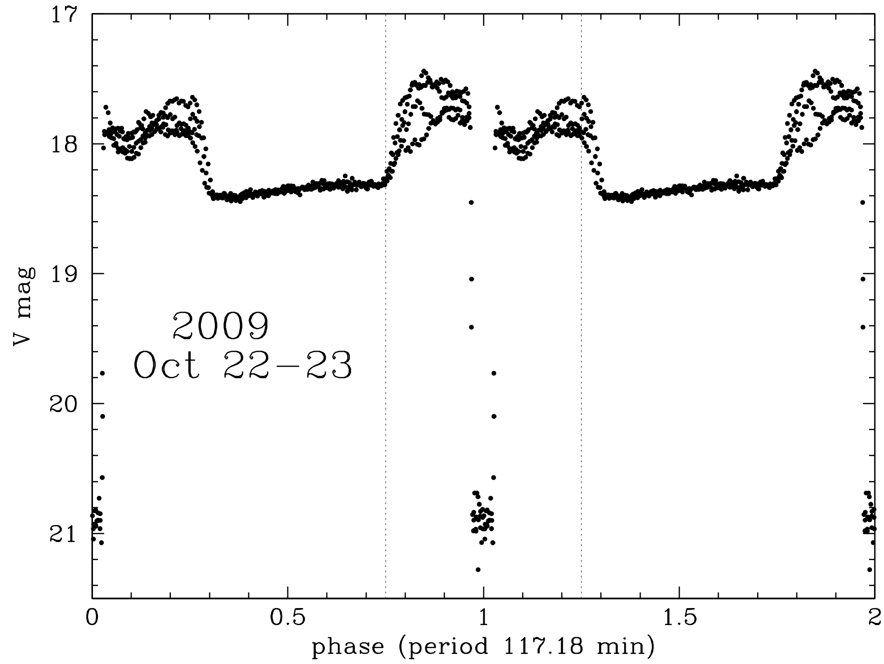

Figure 1. The phased V-band light curve from the first two nights of VATT observations. The accreting hotspot is visible on each side of the eclipse but is occulted by the white dwarf for half the orbit. The dotted lines marks phases $\pm 90^\circ$ to show that the hotspot lags the companion by 10°.

A careful look at the light curve shows that the occultation of the hotspot is shifted by 10.5 degrees (0.03 in phase) relative to the eclipse. This implies that the hotspot trails the line between the primary and secondary stars by about 10°. In HU Aqr, the accretion spot leads the secondary by 30° to 50°.

The time it takes for the plateau phase to rise to full brightness or disappear depends on the size of the hotspot as it is revealed or blocked by the white dwarf limb. The hotspot latitude and vertical displacement also affect the timing of the hotspot occultation (Schwope et al., 2003). We estimate the ingress/egress of the hotspot takes about 0.05 ± 0.01 in phase. While the hotspot is occulted there is a 10% rise in brightness suggesting that temperature varies with longitude on the white dwarf. The color of the system while the hotspot is occulted is $B - V = 0.17 \pm 0.02$ mag.

Figure 2 shows that the B-band phased light curve from Oct. 24-25 differs significantly from the previous two nights. While the plateau from the hotspot is present during the first orbit each night, it is essentially gone on the second cycle. This suggests the mass transfer is "sputtering" as it ends an active accretion phase. The star is three magnitudes fainter than its peak in 2009 March, and the accretion may be becoming sporadic at this low rate.

Assuming the eclipse is total, we estimated the brightness and color of the secondary star. At minimum the star is very faint, so the eight to ten individual short exposures during each eclipse were added together to improve the signal-to-noise ratio. The secondary star's brightness is $V = 20^{\rm m}_{.}86 \pm 0^{\rm m}_{.}05$ and $B = 22^{\rm m}_{.}6 \pm 0^{\rm m}_{.}2$, consistent with a late M-type dwarf star (note that reddening in this direction is as much as E$(B - V)$=0.075 mag (Schlegel et al., 1998)). Correcting for the contribution of the secondary star, the color of the white dwarf plus accretion stream is $B - V$=0.09 mag, but at this low accretion rate the light is likely dominated by the white dwarf.

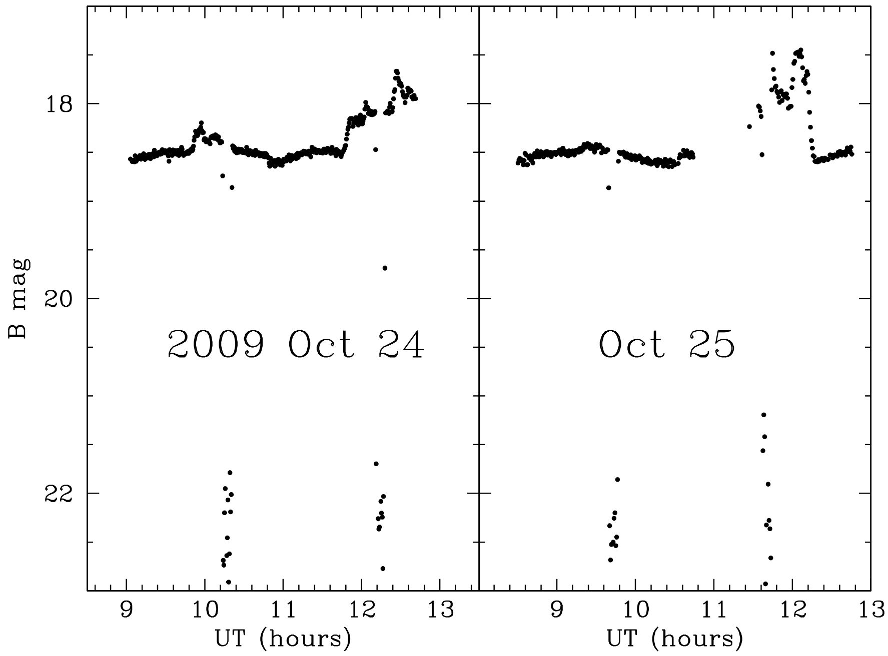

Figure 2. The *B*-band light curves from the last two nights of VATT observations. A gap in the Oct. 25 light curve around 11 UT was caused by clouds. On both nights the hotspot is very weak during the first orbit but has recovered on the second orbit suggesting the mass transfer is becoming sporadic.

Table 1. Observed Times of Mid-Eclipse

Date (UT)	Bandpass	Epoch	HJD	error (days)
2009 Oct. 22	*V*	0	2455126.8960	0.0001
2009 Oct. 22	*V*	1	2455126.9773	0.0001
2009 Oct. 23	*V*	12	2455127.8724	0.0001
2009 Oct. 23	*V*	13	2455127.9539	0.0001
2009 Oct. 24	*B*	25	2455128.9303	0.0001
2009 Oct. 24	*B*	26	2455129.0117	0.0001
2009 Oct. 25	*B*	37	2455129.9069	0.0001
2009 Oct. 25	*B*	38	2455129.9883	0.0002

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