Eclipses of OY Carinae in Outburst

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Abstract Observations of two eclipses of the dwarf nova OY Carinae are presented. The results obtained confirm that neither of the linear ephemerides presented in the astronomical literature appear to model accurately the observed results. Quadratic and sinusoidal alternatives are assessed and both appear to offer closer, but not perfect, predictive tools.

1. Introduction

OY Carinae is a dwarf nova of the SU Ursae Majoris subtype. This type of variable star consists of a close binary pair with a Roche lobe-filling secondary star transferring matter in a well-defined stream through the inner Lagrangian point of the secondary star to an accretion disk around a white dwarf primary star. The "hot spot" is where the material reaches this disk and it is the interactions within this disk that give rise to the observed outbursts. In the specific case of OY Car, the white dwarf and the hot spot are eclipsed by the secondary star every 91 minutes (Greenhill *et al.* 2006).

2. Observations

OY Car was observed with a 0.25-meter telescope and a SBIG ST-10XM CCD camera situated at the Riverland Dingo Observatory in Moorook, South Australia. The $f/6$ focal ratio gave a scale of 0.93 arc seconds per pixel and a field of view of 34×22.9 arc minutes. Multiple 30-second unfiltered exposures were made throughout both observing runs. Subsequent image processing was carried out using the software package MAXIM DL version 3.22 (Diffraction Limited 2004). Information about the comparison and check stars can be found in Table 1.

3. Light curves

Figure 1 shows the light curve for the first observing run on March 21, 2008. Figure 2 shows the light curve for the second run on March 27, 2008. In both cases the time of minimum light was calculated using the software package PERANSO (Vanmunster 2007) and the results are presented in Table 2.

As the bright spot rotates into view it results in a "hump" in the light curve prior to the onset of the eclipse. This can best be seen in the second light curve.

It should be noted that although the pre- and post-eclipse magnitudes differ by 0.1 on March 21 there is no such difference on March 28.

The rapid flickering, characteristic of dwarf novae, can best be seen in the second light curve after the end of the eclipse.

4. Results and analysis

At various times the ephemeris for OY Car has been represented by two different linear equations (Wood *et al.* 1989; and in the *Combined General Catalogue of Variable Stars (GCVS;* Samus *et al.* 2008), a quadratic equation (Greenhill *et al.* 2006), and a sinusoidal equation (Greenhill *et al.* 2006). Details of the four equations and the O–C results obtained using these four different equations from the three sources are presented in Table 3.

Greenhill *et al.* present strong evidence for rejecting a linear ephemeris and the results obtained in 2008 support this. The O–C value for both the linear equations, at between 2.9 and 3.5 minutes, is outside any possible error in the timings taken.

Both the quadratic (O–C between 20 and 60 seconds) and the sinusoidal ephemeris (O–C between 4 and 36 seconds) remain viable options although the analysis by Greenhill *et al.*(2006) contains the caveat that both alternative models still have, "highly significant systematic deviations with time-scales of years."

References

Diffraction Limited, 2004, MAXIM DL image processing software, http://www.cyanogen.com

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Wood, J. H., Horne, K., Berriman, G., and Wade, R. A. 1989, *Astrophys. J.*, **341**, 974.

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Table 1. Comparison and check stars.

Designation	*R.A. (2000)*	*Dec. (2000)*	*Assumed mag*
Comp GSC 9214-0727	$10^h\,05^m\,48.9^s$	–70° 17' 11.0"	12.50
Check GSC 9214-0973	$10^h\,05^m\,38.2^s$	–70° 16' 47.6"	n/a

The assumed magnitude used for the preparation of the light curve in PERANSO *(Vanmunster 2007) is not crucial for the estimation of the time of minimum light. However, it is important to note that although OY Carinae had faded significantly in the six days between the two observing runs, "changes in the eclipse light curve do not contribute to the observed changes in orbital period" (Greenhill et al. 2006).*

Table 2. Time of minimum light.

Run # Date	*Minimum Light (JD)*	*Error (JD) ±*	*Minimum Light (HJD)*	*Minimum Light (HJED)*
1) 03 21 2008	2454547.178290	0.000108	2454547.180031	2454547.180785
2) 03 27 2008	2454553.175111	0.000089	2454553.176977	2454553.177731

Table 3. O–C values for the two imaging runs.

Source	*Equation Type*	*O–C run #1 (days)*	*O–C run #2 (days)*	*Cycle number*
Wood	Linear Equation[1]	–0.002167	–0.001709	167197 and 167292
GCVS	Linear Equation[2]	–0.002457	–0.001999	167197 and 167292
Greenhill	Quadratic Equation[3]	+0.000229	+0.000691	167197 and 167292
Greenhill	Sinusoidal Equation[4]	–0.000044	+0.000414	167197 and 167292

For equations (1), (3), and (4) below, the O–C values were calculated using the time of minimum light expressed in HJED. For equation (2), the O–C value was calculated using the time of minimum light expressed in HJD.

[1] $HJED = (2{,}443{,}993.553839 \pm 9) + (0.0631209239 \pm 5)\ E$

[2] $HJD = 2{,}443{,}993.553241 + 0.0631209247\ E$

[3] $HJED = 2{,}443{,}993.553813 + 0.0631209343E - (1.47 \times 10^{-13})\ E^2$

[4] $HJED = 2{,}443{,}993.55406 + 0.0631209126E + (5.3 \times 10^{-4})$
$\sin(2\pi\ (E - 1.7 \times 10^{-4})/2 \times 10^5)$

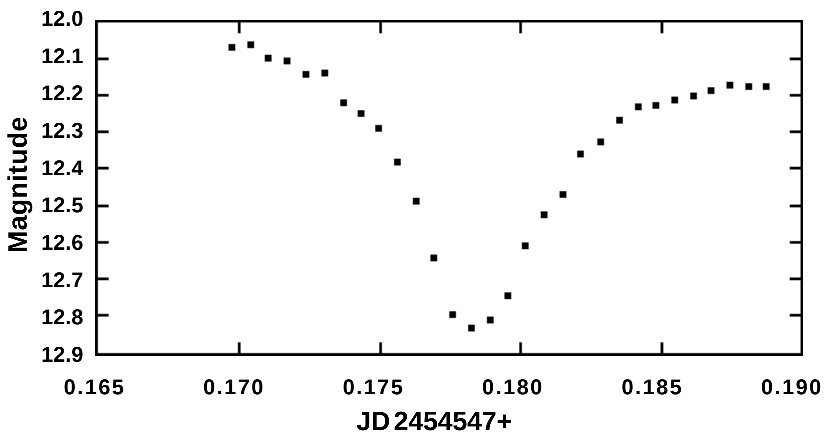

Figure 1. OY Car plot of magnitude versus time for the first observing run, March 21, 2008 (clear filter but using *V*-band comparison star magnitudes).

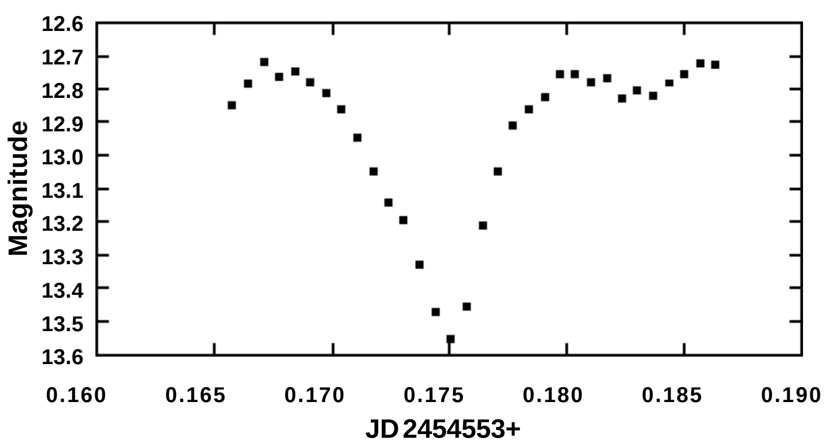

Figure 2. OY Car plot of magnitude versus time for the second observing run, March 27, 2008 (clear filter but using *V*-band comparison star magnitudes).