VISUAL PHOTOMETRIC STUDY OF W CRUCIS

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Abstract

The period of the eclipsing binary W Crucis was studied in order to refine the known elements for this star. The new elements are:

$$JD_{Max} = 2447283.924 + 198.537\ E.$$
$$\pm 0.527 \quad \pm 0.003$$

1. Introduction

W Crucis (R.A. = $12^h06.9^m$, Dec. = -58° 30' (1950)) is a southern eclipsing variable star. The shape of the light curve, analyzed in a previous work (Dominguez 1992), and afterwards confirmed photoelectrically by Pazzi (1993), demonstrates that W Cru is a beta Lyrae-type eclipsing variable. The elements (GCVS, Kukarkin *et al.* 1969) for this star are:

$$JD_{Max} = 2440731.6 + 198.53\ E. \qquad (1)$$

The range of variation is 0.8 magnitude in B light, and the duration of the eclipse is 60 days (O'Connell 1936).

2. Observations

The present study is based on 416 visual brightness measurements made by the author, covering the interval JD 2447424–2449224 (1800 days) and nine cycles of the star. The measurements were made by Pogson's method, using as a comparison sequence the stars listed in Table 1, taken from Jaschek *et al.* (1972). The instrument used was a 104-mm (4"), f/8.9, Newtonian focus reflecting telescope, with a 23-mm Kellner eyepiece. It has an apparent field of 1 degree, 40x magnification power, and a limiting magnitude of about 11. Figure 1 shows the light curve based on these measurements.

Table 1. Stars used as a comparison sequence for W Cru.

Star		*RA (1950)* *h*	*m*	*Dec* *deg*	*'*	*V*	*B-V*	*U-B*	*Spectral Type*
HD	107509	12	16.3	-60	59	7.92	+0.56		G 5
HD	105353	12	02.7	-58	44	8.02	- 0.05	- 0.39	B 7 V
HD	107944	12	19.1	-61	21	8.34	+0.74		F 5
HD	105233	12	01.8	-59	08	8.55	+0.23	+0.04	A 9.5
CPD	-58°4067	12	00.1	-58	55	8.86	+1.83	+1.79	K 0-2
HD	105054	12	00.6	-58	34	8.93	+0.05	- 0.05	B 8-9
HD	106871	12	12.3	-57	36	9.00			B 0 IV
CóD	-60°4153	12	19.3	-61	08	9.18	+0.03	- 0.39	

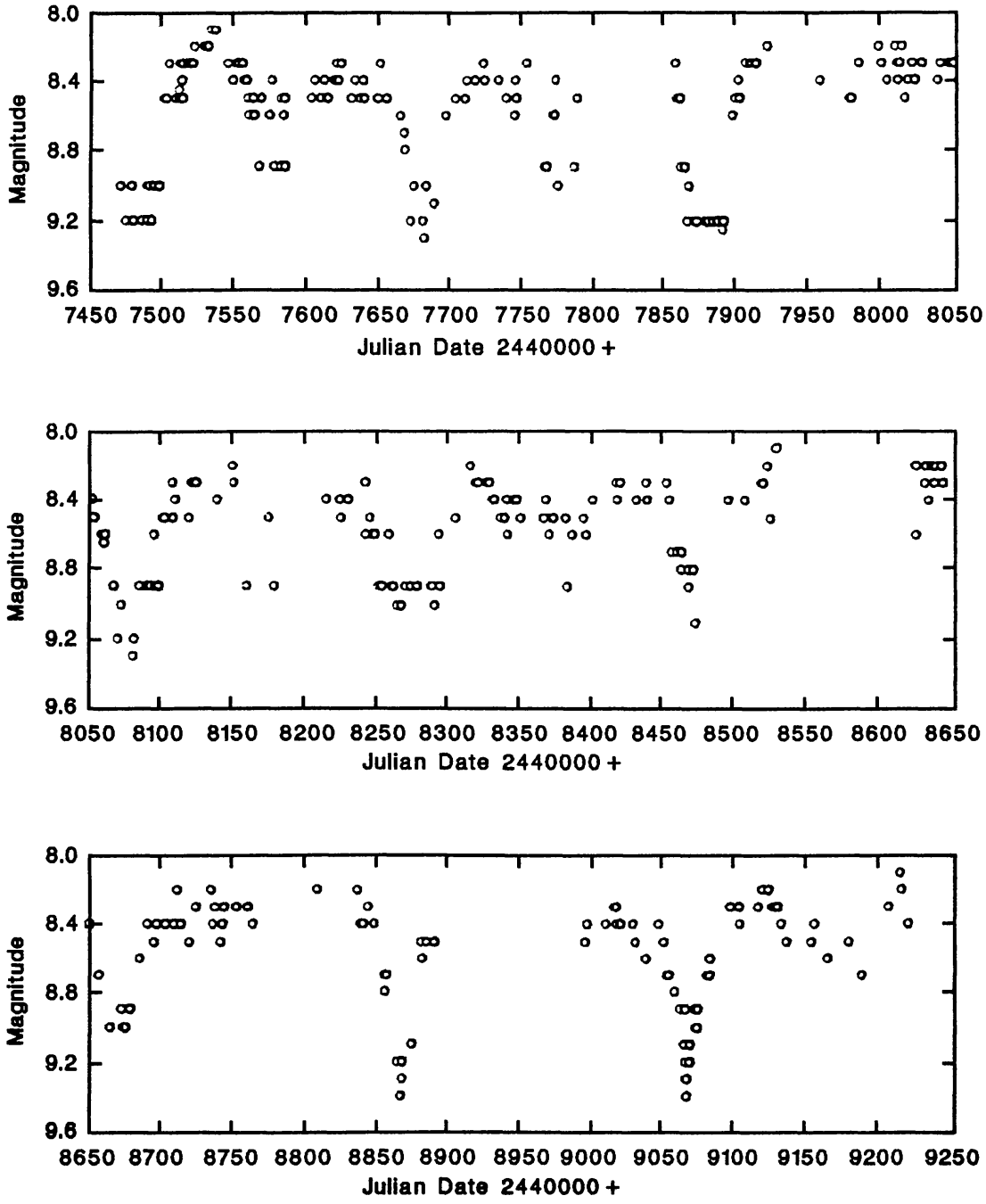

Figure 1. Light curve for W Cru, JD 2447450–2449250.

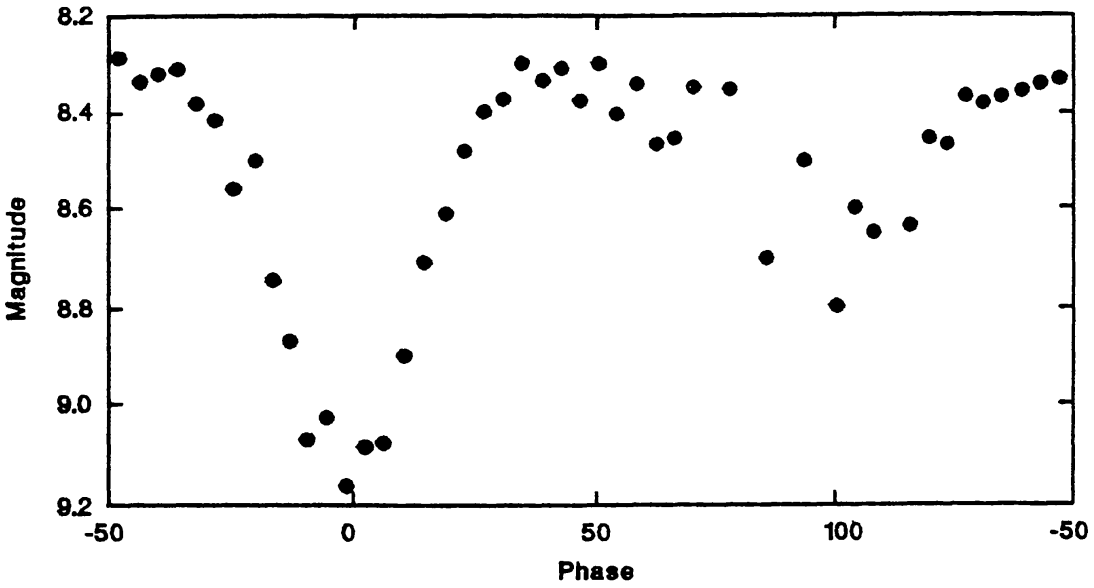

Figure 2. Mean light curve for W Cru, centered on primary minimum.

3. Reduction and analysis

Using the data of Figure 1, we determined the mean light curve using JD 2447581.718 as an initial epoch of primary minimum and a period of 198 days.

The observations were subjected to discrete Fourier analysis, using the software written by Bazterra and García (1992). Two periods were determined: the primary of 201.547 days and the secondary of 99.885 days. The corresponding periodgram is given in Figure 3.

We then determined the times of primary minima, shown in Table 2, using a least-squares fitting to the light curve at minimum. We note that the uncertainties of the times of minima are on the order of 1 day.

In addition, we used the values in Table 2 to calculate the O-C (observed minus computed) residuals using equation (1); the results are shown in Table 3 and Figure 4.

Once we obtained the observed times of minima, we proceeded to calculate the new elements for this star in order to compare them with those of O'Connell (1936). We

Table 2. Times of primary minimum for W Cru (least-squares method).

Epoch	*JD Minimum*
34	2447483.25 ± 1.14
35	2447680.00 ± 0.87
36	2447879.50 ± 1.35
37	2448079.25 ± 0.77
38	2448276.25 ± 1.01
39	2448474.75 ± 1.00
40	2448673.00 ± 0.86
41	2448871.25 ± 0.35
42	2449072.25 ± 0.53

Table 3. O-C residuals derived from equation (1) for values shown in Table 2.

Epoch	*JD Minimum*	*O-C*
34	2447481.62	1.63
35	2447680.15	-0.15
36	2447878.68	0.82
37	2448077.21	2.04
38	2448275.74	0.51
39	2448474.27	0.48
40	2448672.80	0.20
41	2448871.33	-0.08
42	2449069.86	2.39

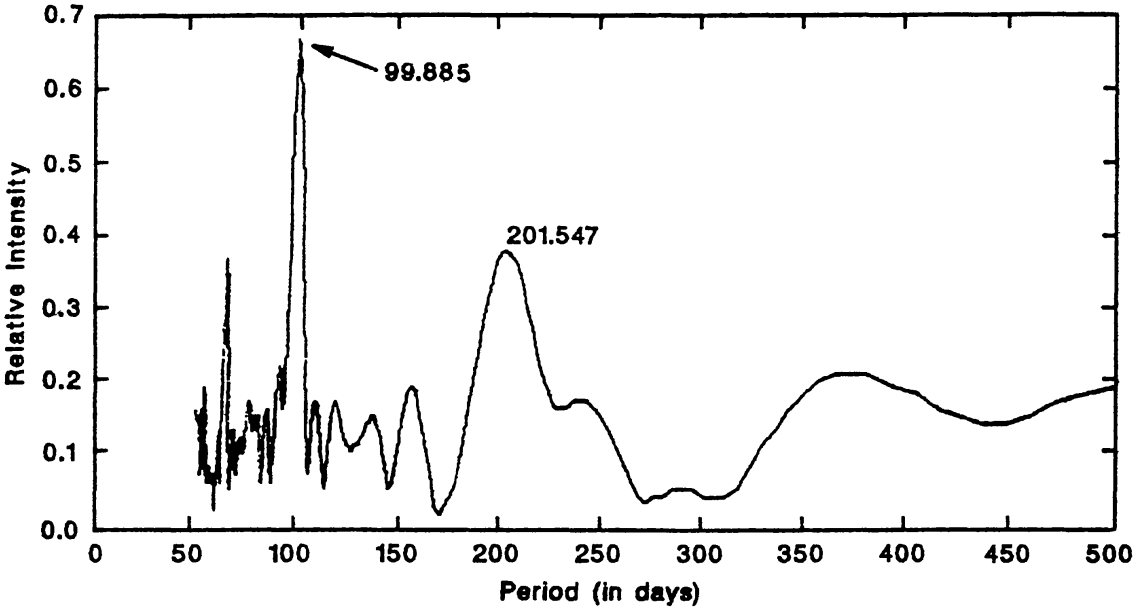

Figure 3. Periodogram for W Cru.

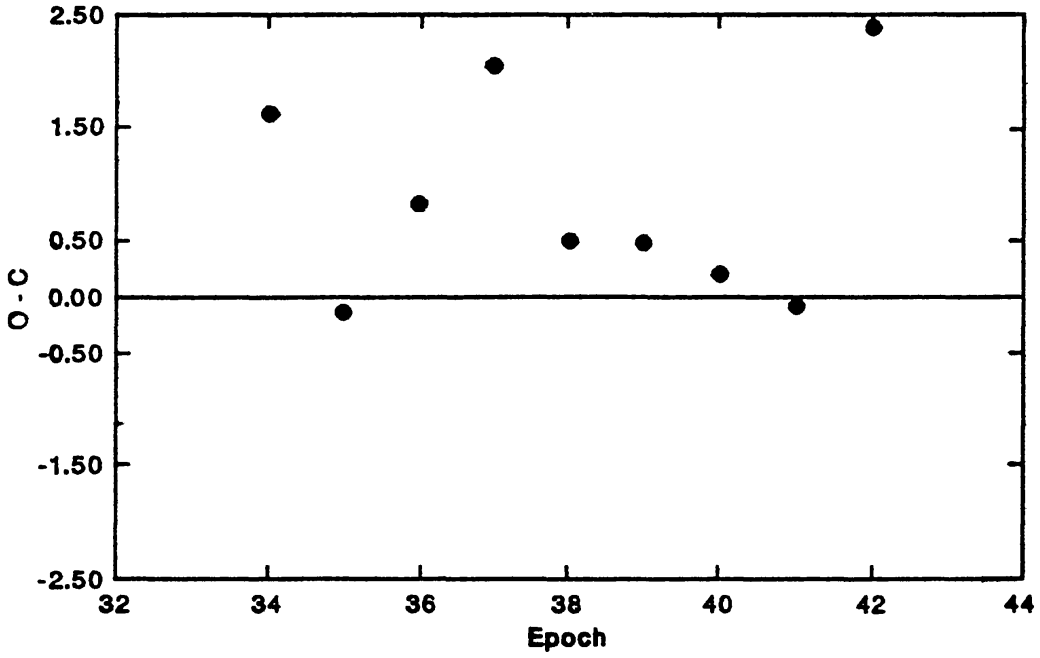

Figure 4. Results of using equation (1) to calculate O-C residuals for W Cru.

utilized the method used by Muzzio and Marraco (1966) to obtain the following new elements:

$$JD_{Max} = 2447283.924 + 198.537\,E. \qquad (2)$$
$$\pm 0.527 \quad \pm 0.003$$

We then calculated an ephemeris using equation (2) and O-C and relative (O-C)/P residuals. The latter value gives a precise idea of the O-C deviations in terms of period. The values for O-C and (O-C)/P are shown in Table 4; O-C residuals are shown in Figure 5.

Table 4. Ephemeris for W Cru using equation (2) and O-C and (O-C)/P residuals.

Epoch	*JD Minimum*	*O-C*	*(O-C)/P*
1	2447482.461	0.789	0.003974
2	2447680.998	0.998	0.005026
3	2447879.586	0.086	0.000181
4	2448078.078	1.177	0.005928
5	2448276.611	-0.361	-0.001818
6	2448475.148	-0.398	-0.002004
7	2448673.686	0.686	0.003455
8	2448872.223	-0.973	-0.004900
9	2449070.761	1.489	0.007499

The fundamental astrophysical parameters for W Cru (range, type of variability, maximum magnitude, minimum magnitude), have been recalculated following the procedure given in Dominguez (1992), and are shown in Table 5. The period was obtained by applying the least-squares method to the observed times of minima.

Table 5. Fundamental astrophysical parameters for W Cru.

Parameter	*Value*
Type of variability	beta Lyrae
Period	198.537 ± 0.003 d
Magnitude at maximum light	8.25 ± 0.1
Magnitude at minimum light	9.13 ± 0.14
A (M - m)	0.88 ± 0.07

4. Conclusions

As we can see, the newly-obtained elements derived from equation (2) represent the star's behavior to within the uncertainties of the data. Even though these elements have been calculated for the interval 1988–1993 (covering the interval of our observations), it is interesting to compare them with a photoelectrically-determined time of minimum of JD 2445894.08 ± 0.13 day (Marino *et al.* 1984). The residual obtained from equation (1) is (O-C) = +0.70 day, while the residual obtained from equation (2) is (O-C) = -0.080*d*.

It is very important to continue monitoring this star because, as Figure 5 shows, it seems to have period changes.

Finally, we note that the figures in Pazzi (1993), which show W Cru's phase curve based on photoelectric observations taken during the interval JD 2446168.3081–JD 2448466.2246 (overlapping the interval in this study), show exactly the same behavior as our light curve in Figure 2.

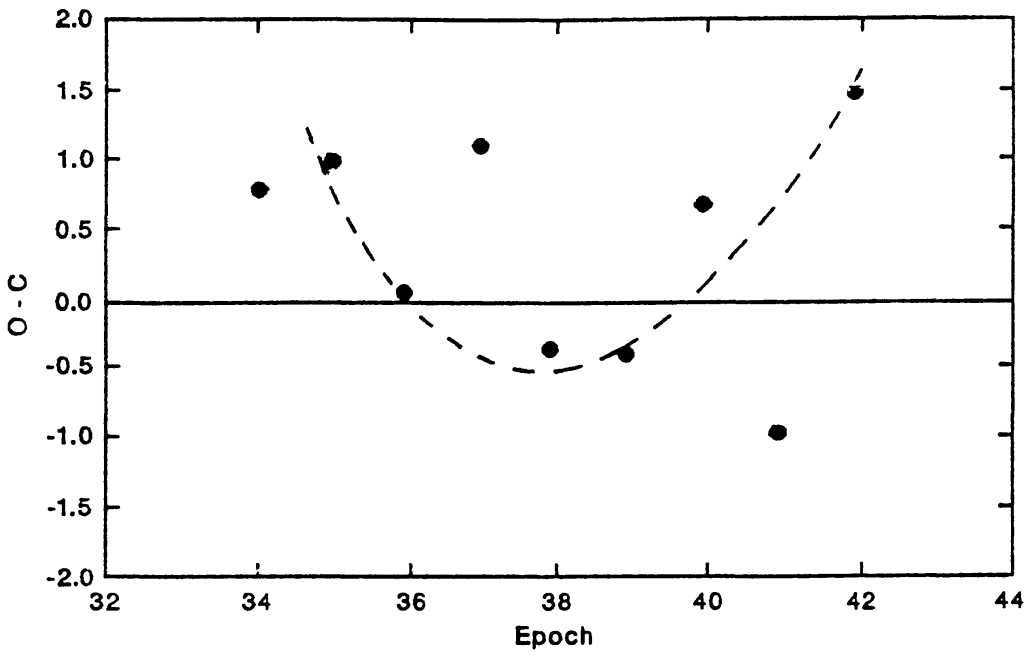

Figure 5. Results of applying equation (2) to the O-C residuals.

5. Acknowledgements

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