OPEN EUROPEAN JOURNAL ON VARIABLE STARS
December 2017 http://var.astro.cz/oejv ISSN 1801-5964

NOTE ON THE PERIOD OF V883 SCO

RICHARDS, THOMAS J [1]; BUTTERWORTH, NEIL D [2]; AND BLACKFORD, MARK G [3]

1) Pretty Hill Observatory, Kangaroo Ground, Vic., Australia, tomprettyhill@gmail.com
2) Townsville Observatory, Mount Louisa, Qld., Australia.
3) Congarinni Observatory, Congarinni, NSW, Australia.

Abstract: Photometric data of the eclipsing binary V883 Sco obtained at Townsville Observatory since 2015 shows it is an eccentric system of type EA and has a period of 4.34119(4) d; not an EB/KE with period 1.29484 d as stated in the *General Catalogue of Variable Stars* and other sources. We also derive a new zero epoch from our primary minimum times of HJD 2457579.114(3). Our period is confirmed and rendered more precise by an analysis of INTEGRAL-OMC and ASAS3 data. An O-C analysis of earlier non-CCD minimum times (which led to the incorrect GCVS light elements) shows that our light elements can be applied with very good precision to them.

1. Introduction

V883 Sco (ASAS3 165752-3759.8, CD-37 11118, CPD-37 6811, HD 152901, IOMC 7868000033, SAO 208238) is recorded in the GCVS as eclipsing binary of variability type EB/KE, located at J2000 coordinates 16 57 52.45 -37 59 47.5 and of V magnitude 7.34-7.66 (Samus et al 2017).

Its variability was originally reported by Friedrich & Schoffel (1971) without any variability data. Its widely quoted period of 1.29484 d and zero epoch may be found in the GCVS, VSX (Watson, Henden & Price 2006), and any other catalogue that records eclipsing binary periods. The source of this period estimate is Strohmeier & Knigge (1973, hereafter S&K) which lists 26 minimum times made from Sonneberg and Mount John plates. Otherwise a single visual minimum estimate – claimed to be primary – is available in the literature (Diethelm et al 1976).

Until our work reported here, there do not appear to be any other recorded minima or period estimates. However both INTEGRAL-OMC (Alfonso-Garzon, J. et al. 2012) and ASAS3 (Pojmanski 2002) provide V-band photometric data. Retrieval of online INTEGRAL-OMC data shows a light curve folded on the S&K period (Figure 1). It appears to show three minima (the third at phase 0.8), indicating the chosen period does not sit well with the photometric data.

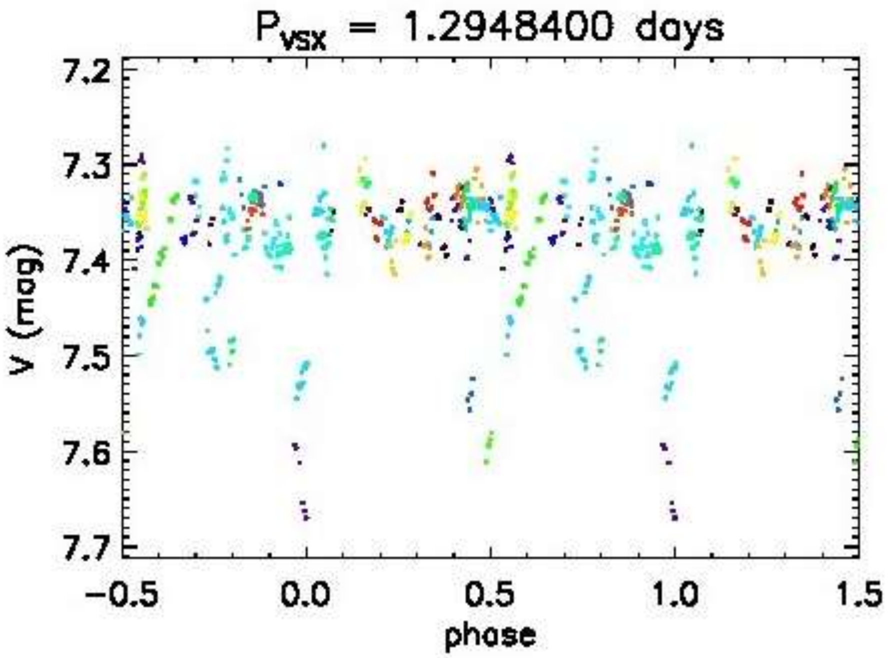

Figure 1. INTEGRAL-OMC data folded on the discovery period of 1.29484 d.

The ASAS3 light curve folded on the same period is even less convincing (Figure 2).

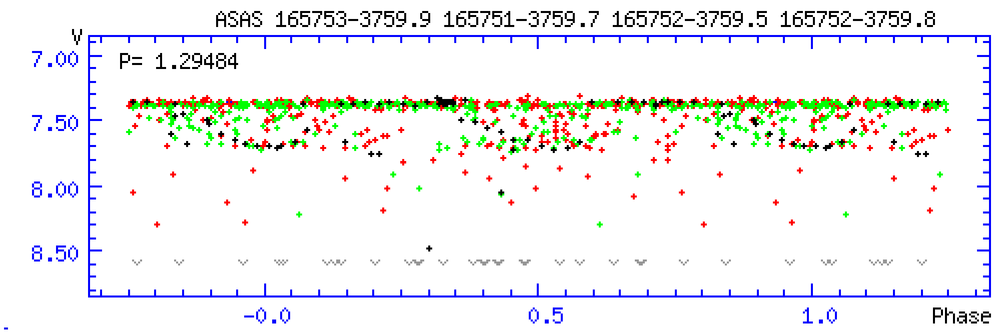

Figure 2. ASAS3 data folded on the discovery period of 1.29484 d.

2. Observations

One of us (NDB) conducted 19 nights of time series observations at his private observatory in Townsville, Qld., Australia, latitude -19° 16' 21", longitude 146° 44' 40" E, height 30 m AMSL. Equipment used was a Canon 550D camera with 135 mm f/2.0 lens on a tracking mount. Table 1 records the observations. The data are available online as a supporting material to this paper.

Table 1. Observations

Date UT (y-m-d)	N obs	Duration (h:m)
20150715	70	5:54
20150718	89	7:26
20150730	80	6:22
20150807	66	5:07
20150808	71	5:54
20150811	72	5:49
20150812	60	5:33
20150813	56	4:19
20150903	61	4:22
20150905	31	2:13
20150918	42	3:27
20160515	99	7:58
20160525	67	6:26
20160624	105	8:51
20160709	84	1:58
20160724	71	4:59
20170604	168	8:22
20170617	122	7:11
20170905	60	2:54

The comparison stars used were HD 152754, 1525621, 151681 and 152041. This paper reports data from the native G filter of the DSLR. Hereafter we refer to this as the NDB data.

3. Analysis and Results

Our data

Six minimum times were derived from the NDB observations in Table 1 using PERANSO (Vanmunster 2015). These are recorded in Table 2. The method used was polynomial fitting, usually of order 5. Columns 1 and 2 record these minimum times and their error, and column 3 the eclipse type (P)rimary or (S)econdary, based on eclipse depth. Column 4 records the cycle count of each minimum as derived from our light elements in Equation (1) below, and column 5 the resulting (O-C) values with their errors in the last column.

Table 2. Primary and secondary minimum times (NDB data).

HJD of min	error	Eclipse	Cycle	O-C (d)	error
2457268.933	0.007	S	-71.5	0.214	0.008
2457283.916	0.007	P	-68	0.003	0.009
2457564.133	0.006	S	-3.5	0.213	0.008
2457579.108	0.006	P	0	0.000	0.006
2457909.047	0.006	P	76	0.004	0.007
2457922.068	0.007	P	79	0.001	0.008

Since it was clear that the primary minima data in Table 2 column 1 were completely incommensurate with the S&K light elements, a search of the A and B grade ASAS3 data to find a plausible period was executed in VStar using its Discrete Fourier Transform algorithm (Benn, 2017). A period of 2.1706 d was found initially, which produced a folded light curve with two displaced eclipses. Replotting with period twice that (4.3412 d) worked very well. Data from ASAS3 folded on that period is shown in Figure 3.

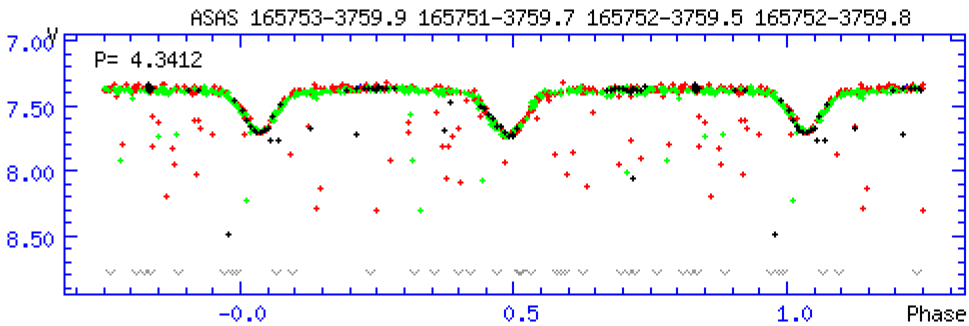

Figure 3. ASAS3 A and B data folded on 4.3412 d.

This period was used to provide a cycle count of the four primary NDB minima (see Table 2 column 4), using the second primary minimum (2457579.112) as cycle 0. A linear regression on the primary minima times against that cycle count provided the following light elements:

$$\text{MinI} = \text{HJD } 2457579.114(3) + 4.34119(4)E \qquad (1)$$

Our data was then folded on those light elements, yielding the light curve displayed in Figure 4. The mean G-band primary minimum magnitude (from PERANSO) is 7.682(7); both secondary minima were 7.635, 0.047 mag. shallower. In Table 2 secondary minima have a nominal 0.5-period cycle count. This plainly differs considerably from their actual phase of ~0.549, as Figure 4 shows.

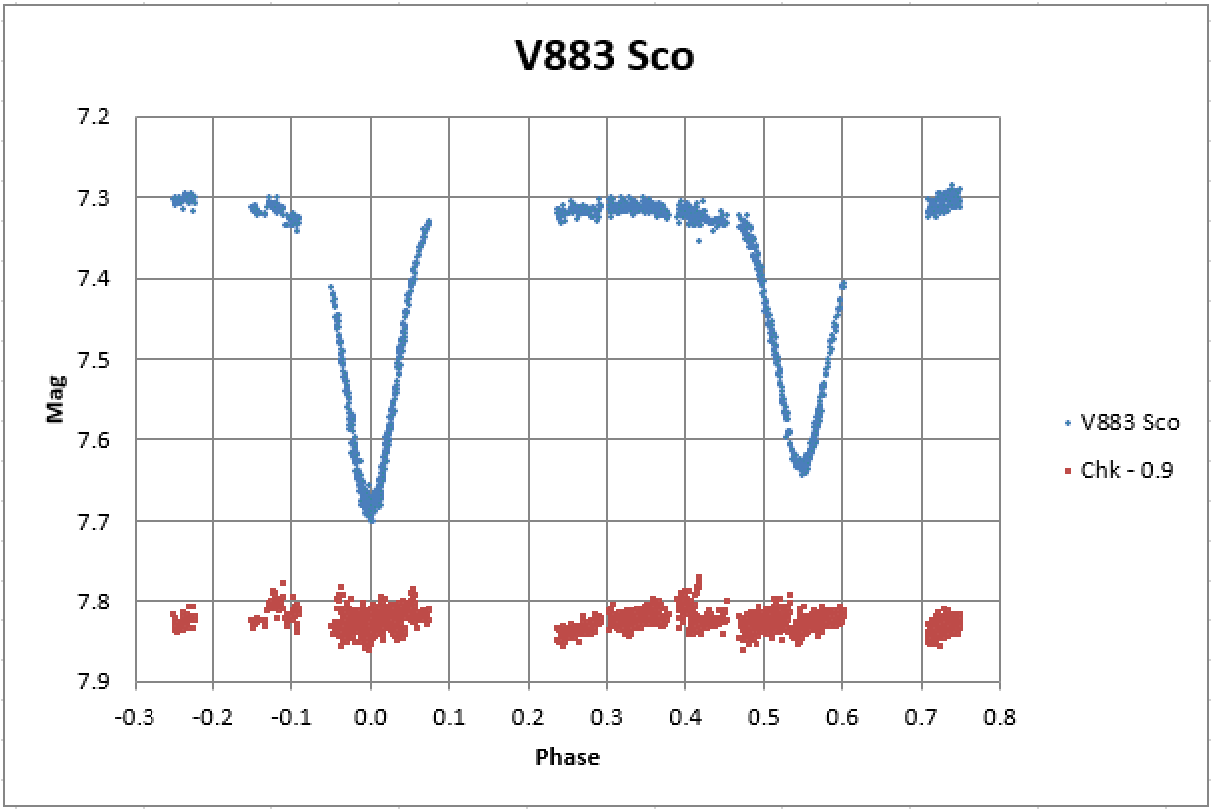

Figure 4. Light curve of Table 1 observations folded on our Equation (1) light elements. The data for the check star are shifted by -0.9 mag.

ASAS3 and INTEGRAL-OMC data

To confirm our light elements, we investigated further to obtain minima, periods and O-C values from the ASAS3 and OMC data for V883 Sco.

We divided the 650 A and B grade ASAS3 data points into two halves at the median HJD date of the data points. The earlier dataset covered 324 data points from HJD 2451931.857 to 2453564.729; the second 326 from HJD 2453571.569 to 2455092.548. For each dataset a period P was derived in PERANSO using the method of Lafler and Kinman (1965). A light curve folded on P was generated, and its epoch E_t set (as a trial) to the HJD of the median data item in the set. The resulting phase offset O of the primary minimum in the folded light curve was then estimated using the method of Kwee and Van Woerden (1956). Then the derived epoch is given by $E = E_t + P \times O$.

We applied the same method to the 1884 data points in the OMC data, which covered from HJD 2452713.779 to 2457607.688. The results for all four datasets are in Table 3

Table 3. Minima and periods derived from ASAS3 and OMC data as described in the text; together with O-C values calculated from the light elements in Equation (1). Upper table gives primary minima, lower secondary with O-C calculated from the half-cycle. Periods were calculated using only the primary minima. Parenthesised numbers in the sources refer to the chronologically first and second half of the datasets.

Source	MinI	error	Period	error	Cycle	O-C	error
ASAS3 (1)	2452925.3884	0.0002	4.341	0.002	-1072	0.03074	0.0447
ASAS3 (2)	2454344.9487	0.0004	4.341	0.001	-745	0.02169	0.0311
OMC (1)	2455247.8954	0.0002	4.341	0.001	-1072	0.03074	0.0447
OMC (2)	2455972.90984	0.00012	4.341	0.003	-745	0.02169	0.0311

Source	MinII	error	Cycle	O-C	error
ASAS3 (1)	2452927.7501	0.0010	-1071.5	0.22177	0.0446
ASAS3 (2)	2454347.3233	0.0010	-744.5	0.22571	0.0311
OMC (1)	2455250.2880	0.0002	-536.5	0.22287	0.0225
OMC (2)	2455975.2731	0.0005	-369.5	0.22915	0.0156

The light curves for the four datasets, folded on P = 4.341 d, are shown in Figure 5.

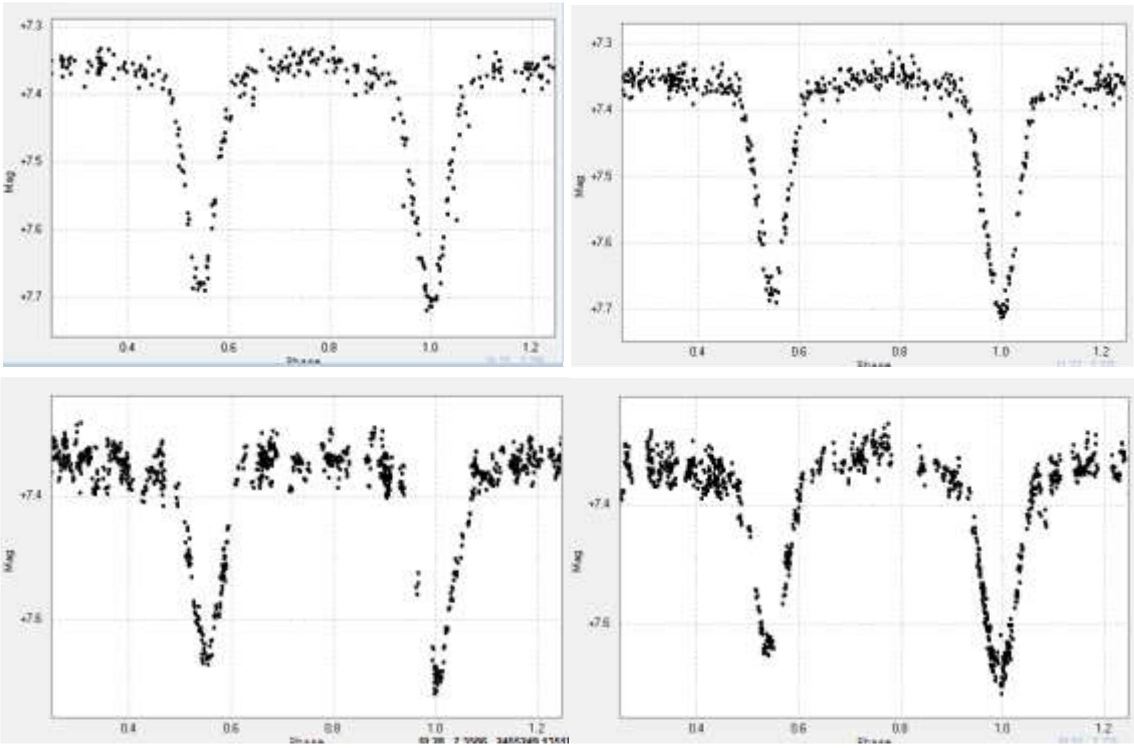

Figure 5. Light curves folded on P=4.341 d, with phase of primary minimum set to 0.0 (=1.0) as described in the text. Top row from left: ASAS3(1) and (2), bottom row OMC(1) and (2). Abscissa is orbital phase, ordinate is V magnitude.

The minima data from all the CCD observations – ASAS3, OMC and NDB – yield the following light elements:

$$\text{MinI} = \text{HJD } 2457283.917(5) + 4.341164(11)E \qquad (2)$$

$$\text{MinII} = \text{HJD } 2457268.936(3) + 4.341182(6)E \qquad (3)$$

The orbital phase of the epoch of the secondary minimum is 0.549, identical to that of the NDB data.

The Strohmeier-Knigge data

The S&K data, with its period of ~1/3 of that in Equation (2), cannot be reconciled with it by postulating a period increase of such magnitude in so short a time. So the S&K analysis of their minimum times must be wrong. This could be due to incorrect assignments of primary and secondary status to their minima – especially since primary and secondary depths are close. We tested this hypothesis by using an O-C diagram.

Figure 6 is an O-C diagram of all recorded minima, based on Equation (2). In its legend, M1 refers to primary minima (filled shapes) and M2 to secondary (hollow shapes). For the CCD data, the primary and secondary minima are determined by their depths in the light curves; for S&K by the cycle number (integral or half-integral) in that paper's data table; and Diethelm (1976) asserts his minimum is primary.

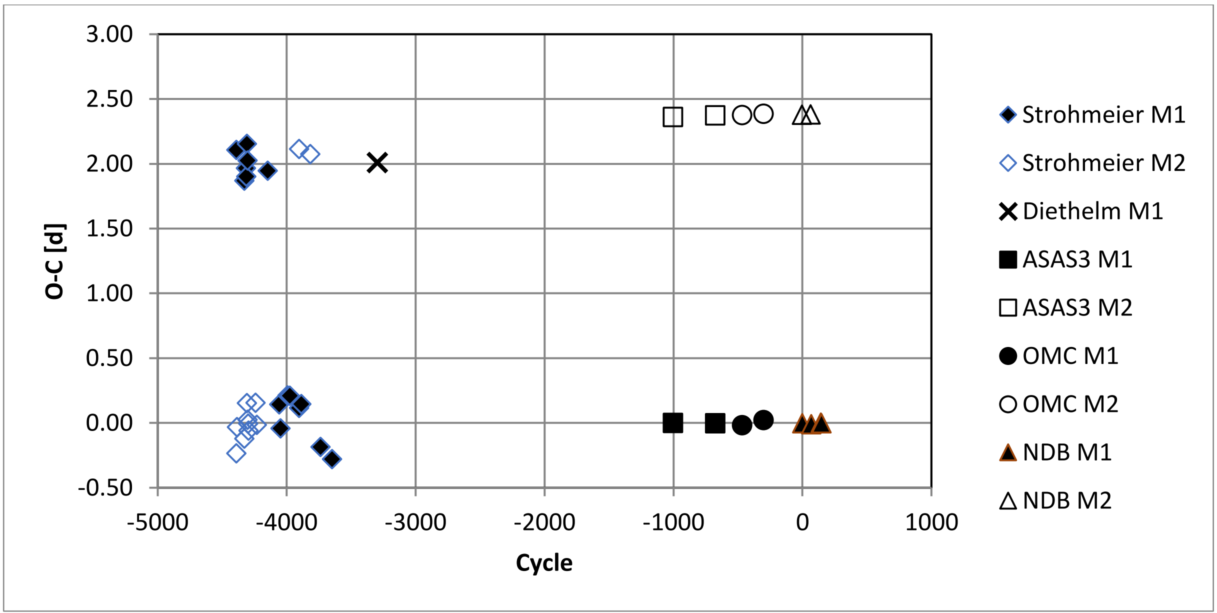

Figure 6. O-C diagram of all minima based on Equation (2). Details of the legend are in the text.

Figure 6 establishes that the non-CCD minima data divide well into two clusters around O-C = 0.0 and 2.0 d, as of course do the CCD minima. The upper cluster contains some minima listed in S&K as primary and some as secondary; and the same for the lower cluster.

Together the Figure 6 primary minima data (i.e. clustering around O-C = 0.0) yield the following ephemeris:

$$\text{MinI} = \text{HJD } 2457283.92(5) + 4.341161(14)E \qquad (4)$$

And for the secondary minima:

$$\text{MinII} = \text{HJD } 2457268.96(4) + 4.341259(11)E \qquad (5)$$

We consider that the precision of these equations, being very similar to Equations (2) and (3) especially for period, together with the obvious clustering in Figure 6, adequately confirms the above hypothesis.

The period derived from secondary minima – Equation (5) – is significantly longer than for the primary minima in Equation (4). It is also significantly longer than for the CCD secondaries in Equation 3, as the slope of points around O-C = 2.0 in Figure 6 shows.This may indicate some apsidal motion, which we are not in a position to quantify.

4. Conclusion

V883 Sco is an EA binary in an eccentric orbit, not EB/KE as reported in the GCVS (Samus et al 2017). Our period estimate based on available CCD minima data (ASAS3, INTEGRAL-OMC and ours) is 4.341164(11) d, at variance with the period of 1.29484 d originally announced in S&K, which we also reject. The phase of the secondary minimum is 0.549.

An analysis of the available non-CCD minima data in S&K and one minimum in (Diethelm 1976) shows those minimum times can be divided into two groups, one containing estimates of primary minima (on the CCD ephemerides) and the other secondary minima. Diethelm's minimum is shown to be a secondary, not primary as claimed in that paper. Several of the minima S&K claim to be primary are in fact (i.e. based on our CCD ephemerides) secondary, and vice versa. There is some indication of apsidal motion.

A remaining question is what led to the incorrect period and minima-type assignments in S&K. We speculate that three issues were involved: (a) aliasing effects of the observing times; (b) inabiliy to distinguish from photographic plates (or visually with Diethelm 1976) a clear difference between the two close minima depths; and (c) the absence of sufficient magnitude estimates during the eclipses to establish with any precision minima based on curve profiles.

Acknowledgements

INTEGRAL-OMC data from the OMC Archive at CAB (INTA-CSIC), pre-processed by ISDC. International Variable Star Index (VSX) database, operated by AAVSO, Cambridge, Massachusetts, USA. The authors are grateful to the editor of the OEJV for helpful advice on an earlier draft.

References

Alfonso-Garzon, J. et al, 2012. A&A 548, A79. 2012A&A...548A..79A

Benn, D., 2017. *VStar 2.19.0 User Manual*. https://www.aavso.org/vstar

Diethelm, R. 1976. *BBSAG* 29, 1. 1976BBSAG..29....1B

Friedrich, D. & Schoffel, E., 1971. *IBVS*, 558, 1. 1971IBVS..558....1F

Kwee, K.K., van Woerden, H. 1956, *Bull. Astron. Inst. Neth.*, 9, 252. 1956BAN....12..327K

Lafler, J., Kinman, T.D. 1965. *ApJS* 11, 216. 1965ApJS...11..216L

Pojmanski, G., 2002. AcA 52, 397. 2002AcA....52..397P

Samus N., et al 2017. *General Catalogue of Variable Stars*: new version. GCVS 5.1, *ARep*, 2017, 60, 1. 2017ARep...61...80S http://www.sai.msu.su/gcvs/gcvs/gcvs5/htm/

Strohmeier, W. & Knigge, R. 1973. *Bamberg Veroeffentlichungen der Remeis-Sternwarte*, 10, 106. 1973BamVe..10..106S.

Vanmunster, T. 2015. *PERANSO Light Curve and Period Analysis Software*. http://www.peranso.com.

Watson, C.L., Henden, A. A., & Price, C. A. 2006, The International Variable Star Index (VSX). 25th Annual Symp., The Society for Astronomical Sciences, 47. 2006SASS...25...47W http://www.aavso.org/vsx (accessed 2017 June).