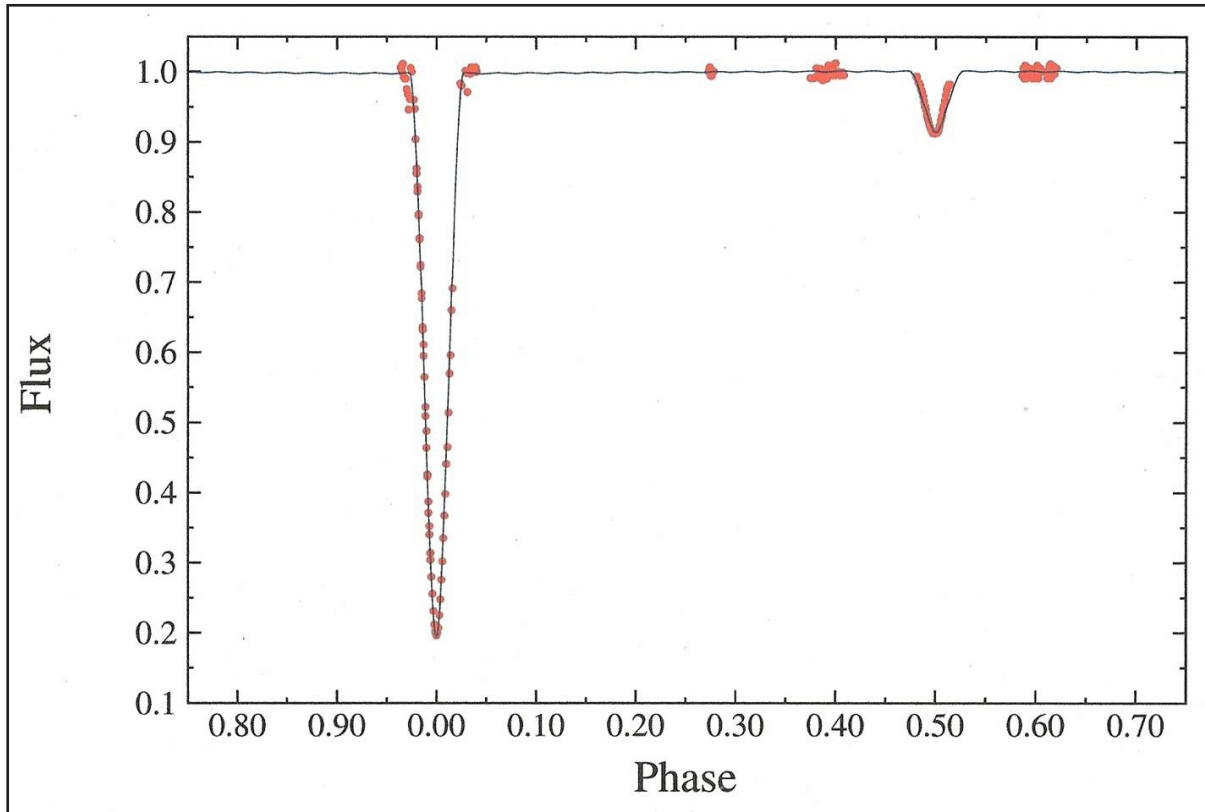




Observations and model light curve of the eclipsing binary V871 Ara. Col Bembrick, Tony Ainsworth and Jeff Byron collaborated on this project in 2001 and have now updated it with a model light curve and new stellar parameters. See their article on page 17 for details.

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* *deceased*

From the director – *Mark Blackford*

Happy New Year to you all, welcome to 2018. I hope you managed to squeeze in some observing between Christmas celebrations at the end of last year.

At Congarinni Observatory the weather has been poor since November, most nights that started clear either clouded out early in the evening or fogged over after midnight. A couple of nasty storms certainly tested the observatory's new, enhanced, weather proofing (a tube of silicon sealant applied along the roof tracks) but I'm happy to report no water made it into the interior. I've enjoyed only a few clear nights but have managed to observe a number of eclipsing binaries. Hopefully 2018 will bring a higher percentage of clear night skies than 2017 did for many of us.

The 28th NACAA will be hosted by the Ballarat Astronomical Society in collaboration with the Ballarat Municipal Observatory and Museum over the Easter weekend, 30th March to 2nd April. Whilst VSS is not formally involved there will be a strong contingent of our members attending and presenting their work. I look forward to an article or two in following VSS Newsletters.

As I mentioned in the previous VSS Newsletter, the 5th Variable Stars South Symposium will be held immediately after the May 4th – 6th RASNZ Conference in Christchurch. It promises to be an exciting symposium and a great opportunity to meet fellow VSS members and other people interested in variable stars. Christchurch is easily accessible so we hope to attract a large contingent of our New Zealand and Australian members, as well as from further afield. See below for further details.

I had intended to participate in the joint BAA-AAVSO meeting in Warwick, UK in July (<https://www.britastro.org/node/10727>), unfortunately we've had to bring forward our travel plans due to family commitments. So I will not be able to represent VSS in Warwick.

In the meantime, clear skies and good observing.



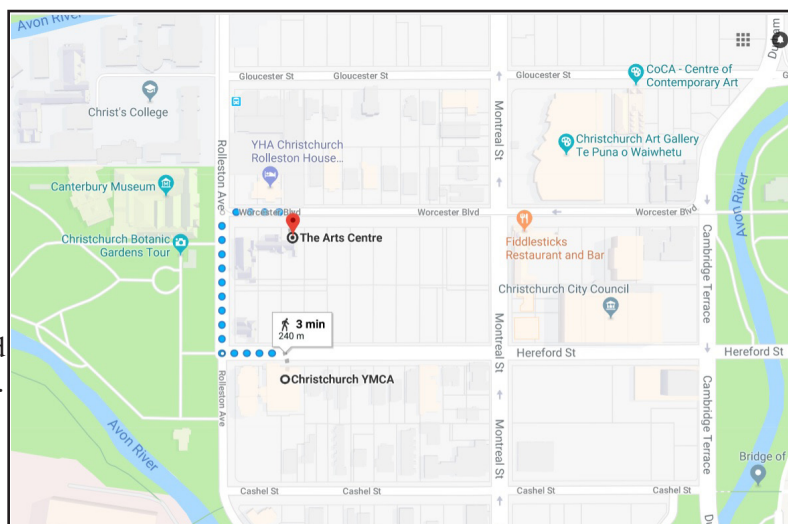
2018 RASNZ conference and 5th VSS symposium

The 2018 RASNZ Conference will be held in Christchurch from Friday May 4th to Sunday May 6th and promises to be an exciting meeting. VSS will hold the 5th Variable Stars South Symposium immediately following the conference on the Sunday evening and Monday May 7th. Please mark those dates in your calendar and seriously consider presenting your work in a talk or poster.

For the symposium any presentations related to variable stars would be welcome. These include, but are not limited to, visual/DSLR/CCD/PEP observing programmes, datamining of professional survey databases, analysis of pulsating and eclipsing binary light curves, exoplanet transit timings, cataclysmic variables, equipment reviews, etc. In particular we encourage talks on how astrophotographers can change their image acquisition and processing routines to allow them to make variable star observations with their existing equipment.

Registration for both the conference and symposium will be via the RASNZ Conference website which, at the time of writing, has not yet been launched. A notice will be posted to the VSS Google Discussion Group when registrations are open.

The conference venue is The Arts Centre and the symposium will be held nearby in the YMCA conference room. Both venues are centrally located and within easy reach of accommodation, pubs and restaurants. I look forward to catching up with everyone there.



Abstract

The results of a programme to compile precise positions for 2398 SMC variables are reported. The stars are those designated SMC V0001 to V2398 in GCVS Vol. 5 (1995, 2002) for variables in the SMC region. I give a short list of stars with suggested corrections to published positions and other remarks.

GCVS Vol 5 extragalactic variables.

This volume first appeared in 1995, in book form. A revised version appeared several years later, as a downloadable plain text file (2002). I have employed both versions. 2398 SMC variables are listed for equinox 1950; positional precision is limited with RA to nearest 0.1s, and Dec rounded to whole arcsec. In the most crowded SMC regions this precision may be ambiguous for the purpose of correct identification. Fortunately extensive references are provided to published finder charts, in particular the atlas of the SMC by Hodge and Wright (1977). The GCVS volume covers the whole historical period of SMC studies, from early 1900s to the late decades of the 20th century. The post-2000 deep surveys, such as *OGLE* (*Optical Gravitational Lensing Experiment*) are not covered, but some mention shall be made of this work, below.

Method

I worked through the entire list of 2398 stars, precessing the positions forward to J2000 using my own in-house programs, ensuring that any inherent offsets or random errors were not amplified, and the original accuracy ($\pm 0.1s$, $\pm 1''$) was preserved. Each star's position was then entered into *GUIDE9* planetarium software and matched with the following astrometric catalogues, as appropriate. Most of them were downloaded, as required, from Vizier.

A2	USNO-A2.0	CDS I/252
B1	USNO-B1.0	CDS I/284
G2	GSC2.3	CDS I/305
g	Gaia DR1	CDS I/337
M	2MASS	CDS II/246
S	SPM4.0	CDS I/320
T	Tycho-2	CDS I/259
U	UCAC 4	CDS I/322A
V	VSX	http://www.aavso.org/vsx
*	Not verified - GCVS position copied.	

In practice I found that GCVS position could be consistently matched with astrometric stars with offsets of, usually, no greater than $\sim 0.5s$ RA, and $2''$ Dec. Any star exceeding these rough limits was flagged, and investigated further, often using the best resolution images from the SuperCosmos server. These go deeper than the Hodge & Wright atlas, while offering a choice of filters - B, V, R and IR especially. Note that a certain fraction of variables in the SMC region are in fact foreground galactic stars and are flagged as such by the authors of the GCVS. A few other variables are embedded in the globular clusters 47 Tuc (NGC 104) and NGC 362, both foreground objects. I have been able to isolate these variables using Gaia and direct images.

Cordoba variables (CV)

Dartayet and Landi Dessy (1959) published 333 new SMC variables on special charts. Unfortunately the said charts are not readily accessible and therefore I have had to rely entirely on the coordinates provided in the GCVS. The vast majority of the CV stars could be matched with astrometric stars by position alone, in the absence of charts. I have done some statistics on CV stars, which appear in the GCVS, as follows.

Statistics on Cordoba Variables.

Sample Size : 288 stars

Sense	$RA_{\text{GCVS}} - RA_{\text{astrom}}$	$DEC_{\text{GCVS}} - DEC_{\text{astrom}}$
Diff (mean)	+0.29s	+0.4"
Std. Dev	± 0.22	± 1.2
Variance	0.05	1.4

Conclusions

1. GCVS RA is, on average, too large by 0.29s, compared to astrometry. Variance is low, 0.05, indicating strong clustering around mean difference.
2. GCVS Dec. shows mean offset of +0.4" (northwards), a relatively small value. Variance is 1.1, a somewhat greater amount of scatter around the mean.

OGLE-III catalogue (2013)

This recent catalogue is a result of the *Optical Gravitational Lens Experiment*, which intensively monitored several selected fields, the SMC, the LMC and the Galactic Bulge especially. Thousands of new variables have been discovered and published online. The SMC field spans RA $0^{\text{h}}53^{\text{m}}.8$ to $1^{\text{h}}24^{\text{m}}.7$ (J2000), and 5109 variables are listed. It can be perused online at <http://ogle.astrouw.edu.pl/> The cutoff is $V \sim 20$; stars are sorted into these classes:

- Classical Cepheids
- Anomalous Cepheids
- Type II Cepheids
- RR Lyrae stars
- Long period variables
- Double period variables
- R CrB stars
- Delta Scuti stars

Astrometrically precise positions are provided for all entries, as well as finder charts and lightcurves. I have compared OGLE-III carefully with my own work. While the former contains 5109 stars I find that many Cordoba (CV) objects are missing. Perhaps they don't fit neatly into any of the above classes, or may not be variable at all. Nevertheless, as OGLE-III provides the facility of cross-matching many entries with previously known variables, it is very useful in verifying the accuracy of my own work. GCVS and HV names are included in OGLE-III.

Updated file

The result of my efforts is a text file, called **SMCVARS_1.TXT**, which merges astrometric positions for equinox J2000 with original data from the GCVS file. The important fields are enumerated thus:

- | | |
|--|---------------------------------------|
| 1. No. according to GCVS naming system.
"90" = SMC. | 9. Minimum magnitude |
| 2. SMC variable number | 10. Passband - B; V; p = photographic |
| 4,5. J2000 position | 11. Epoch, JD 24... |
| 6. Source of position - see list above, in Method. | 12. Period, in days |
| 7. Type of variable | 13. M-m or D |
| 8. Maximum magnitude | 14. Spectral type |
| | 15. Identity #1 |
| | 16. Identity #2 |

Note that historical identifications have not been copied over completely. Generally only HV and CV numbers have been copied, as well as constellation-based GCVS names (eg SS Tuc, VY Hyi). Most cryptic or unfamiliar identities have been omitted. The coded GCVS references to published studies and finder

charts have also been omitted. If a star has a HV number (as most do) then it can be found in the SMC atlas by Hodge and Wright (1977). Accurate though the positions are, it is wise for the user to consult a finder chart as an additional check. See Figure 1, for a fragment of the table.

It is interesting to compare the photographic light curves for Cepheid variables in the study by Payne-Gaposchkin & Gaposchkin (1966) with the recent and more comprehensive data in the OGLE-III catalogue (2013).

Table 1. Remarks/corrections for selected SMC variables

V0373 = CV1	Position ambiguous. Nothing on SuperCosmos R or IR images.
V0434 = CV34	Red. J-Ks = 1.409 2MASS
V0447 = CV45	Gaia position. Close double; southern comp. is redder. No IR excess.
V0507 = CV66	Red. J-Ks = 1.201 2MASS Revised position.
V0514 = CV72	Red. J-Ks = 1.00 2MASS Revised position.
V0541 = CV81	Corrected position from GSC2.3; m=18.0
V0544 = CV85	Red. J-Ks = 1.026 2MASS Id confirmed.
V0598 = CV114	No astrometric match found. Not verified.
V0628 = CV129	Gaia position used. G=19.449. Relatively bright in B; faint in R, and IR.
V0754 = CV177	New posn. 00 51 16.57 -72 42 23.0 G2 Central star of 5, in 8"x 8" cross. Super-Cosmos B.
V0773 = CV187	Gaia position used. G=18.297. Relatively bright in B; trace in R and IR.
V0787 = CV190	Not found on SuperCosmos B,R,IR. Not in Gaia DR1.
V0878 = CV218	Close pair in Gaia. 00 52 11.846 -72 53 36.74 G=19.046 / 00 52 11.799 -72 53 36.66 G=19.212
V0916 = CV237	NE comp. of 2" pair. Fainter by 0.55mag. Not red.
V1007 = CV265	00 53 29.71 -73 03 32.3 Gaia DR1. Crowded. Close companions.
V1033 = CV272	Crowded. Blend of 2 or 3 stars. Not red.
V1039 = CV277	New position 00 53 48.11 -72 38 38.8 G2. Nothing seen at GCVS position. I suspect the variable is 10" N of GCVS position. This star is 17.80p. Apparently identified in SCA9, but P not confirmed.
V1087 = CV295	J-Ks = 0.566. Blend of 4 stars; only 2 strong in IR.
V1088 = CV295	Red. J-Ks = 1.78. Faint on B plate; brighter in R and IR.
V1109 = CV305	Revised position 00 54 31.35 -72 30 42.9 G2.
V1253	GCVS RA-s error. 6.2 not 7.1. OGLE-III confirms
V1418 = HV12146	GCVS Dec-m typo? Too far south by 10'
V1478 = HV11187	Should be 00 59 13.36 -71 34 46.0 G2. P=1.2984982. OGLE-III verifies prov. P=1.30:d.
V1543	Magnitude unknown. No finder chart. Verification not possible.
V1589 = HV1849	Blend. 01 00 46.39 -72 03 36.9 OGLE-III I=15.470 V=16.073 P=3.49219d
V164	Corrected posn. 01 01 03.33 --72 04 39.5 Bad error in source paper. Chart posn. used.
V1733	Error in GCVS; has printed position for 1975, NOT 1950. Error noted and fixed.
O G L E - S M C - CEP-3323	01 01 56.36 -71 19 05.6 OGLE-III I=16.632 V=17.274. This position seems to refer to a different star than SMC V1699 = HV11443 (checked against H&W chart 35B). OGLE-III and GCVS periods match closely: 1.7229063d and 1.722887d respectively.
V2117 = HV2114	01 09 17.23 -71 26 11.7 OGLE-III. GCVS incorrect.
V2181 = HV2151	01 10 41.81 -71 28 59.6 OGLE-III. This differs from the GCVS position, which is ~41"N. The periods (OGLE vs GCVS) are nearly identical. Not resolved as to which is the true HV2151.

SMC V1806 = HV1604.

I have noted this anomaly, which perhaps reflects some of the vagaries of early work on SMC variables. The OGLE-III catalogue records *two* Cepheid variables in this region but carrying the same GCVS / HV number. The basic data from OGLE-III is as follows:

Name	(J2000)	I	V	Period (d)
OGLE-SMC-CEP-2198	00 54 15.49 -71 56 14.4	16.387	17.045	2.0720995
OGLE-SMC-CEP-2200	00 54 16.02 -71 56 04.8	16.124	16.755	2.1435736

The Gaposchkin study (SCA9, 1966) reported a period (2.072058) which matches OGLE 2198, but his own finder chart points to OGLE 2200. [In fairness, he recognized *both* stars as variable back then, but he considered the southern star (2198) as “semi-regular”, with only one Cepheid here.]

OGLE-III finds that *both* stars are Cepheids, with fairly similar periods. Gaposchkin obviously studied 2198, the *southern* star, contradicting his own identification chart, which was soon copied in the SMC atlas by Hodge and Wright (1977). In a case like this it is probably best to use the OGLE-III names for the respective variables. This removes all ambiguity.

Concluding remarks

The Cepheid population in the SMC has been of great astronomical importance in establishing a yardstick for the distance scale of the universe. The pioneering work of Henrietta Leavitt (1868-1921) established the *period-luminosity relationship* between 1908 and 1912, all without the help of computers, precision photometry and CCDs.

My updated file of SMC variables is designed to be readable by GUIDE 9.0, and to make it accessible the file *SMCVARS_1.TXT* is accompanied by a Text Definition File (TDF). Both files will be found on the VSS website. <https://www.variablestarssouth.org/member-contributed-catalogues/> Otherwise, these files can be obtained directly from the author. The files can be read with any commonly available text editor or word processor. Numerous positional errors have been detected and amended, to make the final product as error-free as humanly possible..

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- Soszynski et al 2010b *Acta Astron.*, 60,91 (Type II Cepheids in SMC)
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- Udalski, Szymanski, Soszynski & Poleski 2008 *Acta Astron.*, 58,69 (OGLE-III photometry)
- VSS : Variable Star Index. www.aavso.org/vsx
- OGLE-III URLs. <http://ogle.astrouw.edu.pl/> or <ftp://ftp.astrouw.edu.pl/ogle/ogle3/OIII-CVS/SMC/lpv/>

ASTROMETRIC J2000 POSITIONS FOR SMC VARIABLES															
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
900001	V0001	14.9	0	5	58.57	-74	6	48.6	V	RR	14.9	15.8	P	UW Tuc	HV6318
900002	V0002	14.1	0	6	33.51	-69	0	33.7	V	UG	14.1	16.5	V	NSV00035	HV8001
900003	V0003	16.1	0	7	18.56	-74	28	33.5	V	CMA	16.1	16.9	P	XV Hy1	
900004	V0004	14.43	0	10	24.08	-75	10	37.0	V	DCEP	14.43	15.31	V	R Hy1	HV6320
900005	V0005	11.2	0	12	30.05	-74	5	3.0	V	LB:	11.2	12.2	P	XZ Tuc	HV6321
900006	V0006	13.5	0	14	9.53	-72	36	35.3	V	RRAB/BL	13.5	14.7	P	UX Tuc	HV6323
900007	V0007	15.5	0	17	11.46	-74	6	0.6	V	RRAB	15.5	16.5	P	AP Tuc	
900008	V0008	9.91	0	17	21.51	-71	54	56.9	V	EW	9.91	10.48	V	AQ Tuc	HD 1372
900009	V0009	16.9	0	18	4.77	-73	44	31.0	S	DCEP	16.9	17.8	P		HV12899
900010	V0010	15.8	0	18	23.66	-74	16	55.8	V	EA	15.8	16.3	P	CH Tuc	
900011	V0011	13.1	0	18	53.72	-74	1	56.6	V	I	13.1	14.3	P	VV Tuc	HV6325
900012	V0012	15.4	0	20	19.09	-73	52	7.9	V	UG:	15.4	<16.5	P	VW Tuc	HV6327
900013	V0013	15.7	0	20	55.32	-73	33	13.7	S	VAR:	15.7	16.7	P		HV1213
900014	V0014	13.0	0	21	0.97	-75	47	30.7	V	E	13.0	14.0	P	NSV00140	HV6328
900015	V0015	11.72	0	21	35.06	-71	59	58.9	S	SRB:	11.72	11.85	V		
900016	V0016	15.3	0	21	54.64	-73	35	16.8	V	RRC	15.3	15.7	P	AR Tuc	HV11214
900017	V0017	19.6	0	22	19.20	-71	23	4.3	B1	RRAB	19.6	20.4	B		
900018	V0018	14.9	0	22	25.26	-71	19	50.6	V	RRAB	14.9	15.8	B	AD Tuc	HV11212
900019	V0019	11.8	0	22	35.78	-72	11	11.2	S	SRB	11.8	12.22	V		
900020	V0020	19.2	0	22	38.55	-71	25	8.0	B1	RRAB	19.2	20.3	B	V28/NGC 104	
900021	V0021	16.2	0	22	40.48	-73	31	1.0	V	DCEP	16.2	16.9	P	AS Tuc	
900022	V0022	19.5	0	22	44.12	-71	51	42.1	B1	RRAB	19.5	20.3	B		
900023	V0023	15.6	0	22	52.25	-73	24	13.4	S	VAR:	15.6	16.3	P		
900025	V0025	15.6	0	22	58.02	-73	37	46.5	V	RRAB	15.6	16.5	P		
900024	V0024	11.96	0	22	58.40	-72	6	55.8	S	SRB	11.96	12.69	V	CI Tuc	
900026	V0026	15.7	0	23	10.07	-73	31	26.4	V	DCEP	15.7	16.73	V	V13/NGC 104	
900027	V0027	19.5	0	23	17.25	-71	21	3.3	B1	RRAB	19.5	20.3	B	AT Tuc	HV11216
900028	V0028	18.9	0	23	21.23	-71	20	15.8	B1	RRAB	18.9	20.2	B		
900029	V0029	11.61	0	23	29.24	-72	6	20.8	S	VAR:	11.61	11.83	V		
900030	V0030	11.86	0	23	30.02	-72	22	36.3	S	LB:	11.86	12.27	V		
900031	V0031	11.74	0	23	34.85	-72	7	39.4	S	VAR:	11.74	11.84	V		
900032	V0032	19.0	0	23	38.04	-71	35	52.2	B1	RRAB	19.0	20.0	B		
900033	V0033	19.5	0	23	38.83	-71	31	37.8	B1	RRAB	19.5	20.4	B		
900034	V0034	19.5	0	23	39.55	-71	38	14.8	S		19.5	20.5	B		
900035	V0035	13.6	0	23	40.67	-72	5	59.9	S	RRAB	13.6	14.7	B		
900036	V0036	19.6	0	23	46.64	-71	8	13.9	B1	RRC:	19.6	20.2	B		
900037	V0037	11.6	0	23	47.60	-72	2	49.6	B1	LB:	11.6	11.9	V		
900038	V0038	12.0	0	23	50.37	-72	5	50.5	S	LB:	12.0	13.0	V		
900039	V0039	11.83	0	23	55.61	-71	57	28.6	S	SRB	11.83	12.07	V		
900040	V0040	11.52	0	23	58.94	-72	2	34.4	S	SRB	11.52	12.48	V		
900041	V0041	10.9	0	24	0.75	-72	7	25.2	S	SRB	10.9	12.7	V		
900042	V0042	17	0	24	6.68	-72	3	40.1	B		17				
900046	V0046	15.28	0	24	7.21	-73	56	26.2	S	DCEP	15.28	16	V		
900043	V0043	11.8	0	24	7.75	-72	4	31.6	B	LB:	11.8	12.1	V		

Figure 1. An extract from SMCVARS_1.txt, first 44 lines of data only.

Introduction

As we are trying to understand the changes which occur in Mira stars which have been a traditional mainstay of amateur variable star observing for more than a century perhaps we should take a look at the most famous of these objects. The time is appropriate as it should reach maximum in late January/early February and indications are that the present maximum might be quite bright, perhaps reaching about 2.0 visually.

This prediction is based upon recent measures of Figure 1 as shown on the International Database.

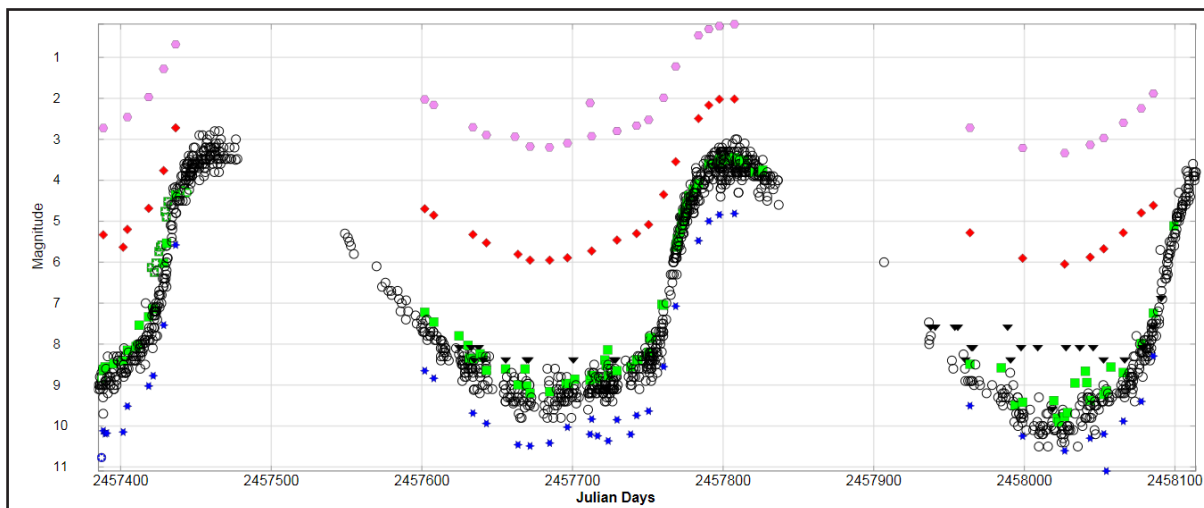


Figure 1. BVRI and visual measures of Mira over the last two years from the International Database maintained by the AAVSO.

The historical picture

The first clear records begin in 1596 but it was obviously known in non-European areas as an unusual object for millenia before that. Beginning with Fabricius in 1596 epochs of maximum are available at intervals although some are quite crude by today's standards. These are shown in Figure 2.

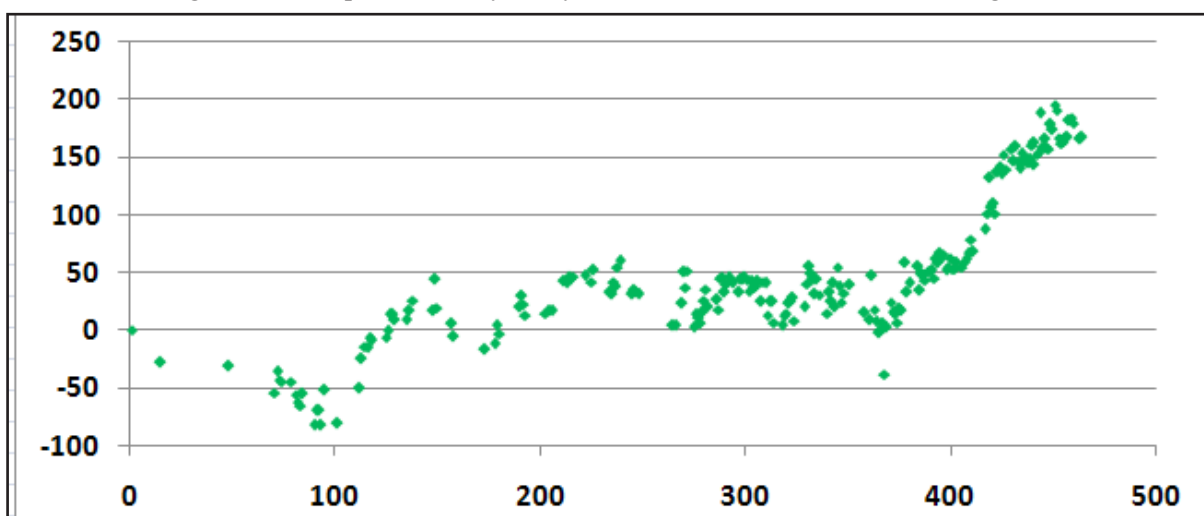


Figure 2. Epochs of maxima of Mira since 1596, which is epoch 0. The ephemeris is JD 2304169 + 331.45E. Note the abrupt period change with cycle 365 in 1927 - coincidentally the year in which the RASNZ Variable Star Section was founded. The vertical scale is days before or after the ephemeris prediction, the horizontal scale cycles since AD 1596.

The present period is ~ 333 days, perhaps as much as 333.25 days. An O-C diagram since epoch 365 appears in Figure 3. A strange feature of this O-C diagram is that the increased scatter is associated with a 20 day shift toward later maxima. Was this a real event or did a revision of sequence values lead to a change in shape of the brighter parts of the light curve and hence a change in the determinations of maximum?

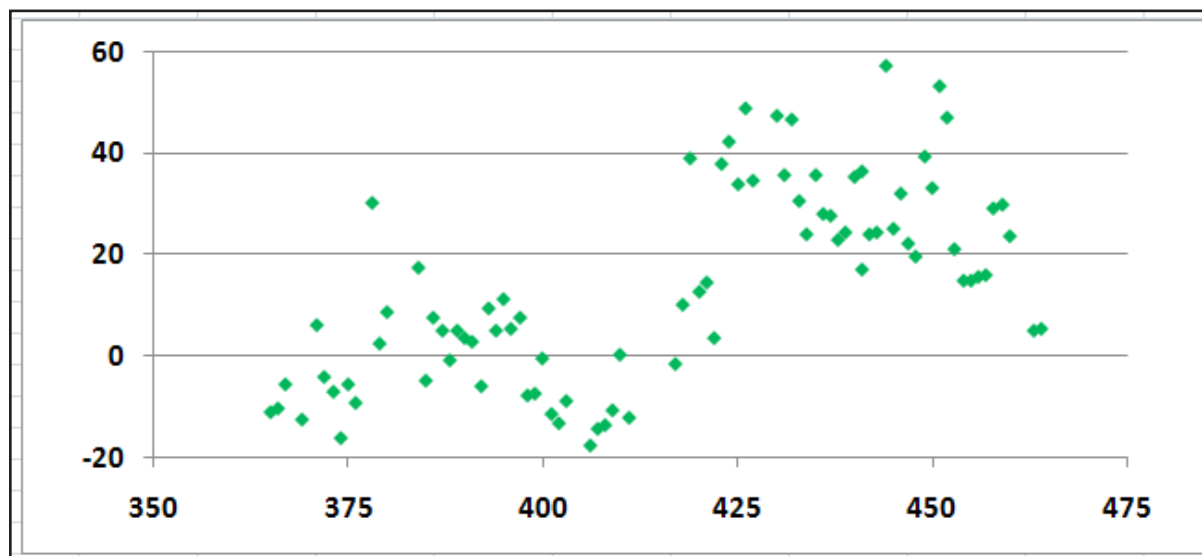


Figure 3. Epochs of maximum since 1927 fitted to the ephemeris $JD\ 2424492.3 + 333*(E-364)$. There is a marked increase in scatter from epoch 423 in 1979 caused, it appears, by this becoming a popular target for inexperienced observers. Apart from this it shows the alternations of period common to many Mira stars. Note the comments in the text about the abrupt jump near cycle 423.

Physical information

The GCVS is rather sparing of information. It quotes in 1985 a 1981 epoch and a period of 331.96 days which, by that date, was 135 days out at maximum, based on that period. Also a spectral class of M5IIIe to M9IIIe and a range in V of 2.0 to 10.1. More attention is given to its companion, the white dwarf star VZ Ceti with a V range from 9.5 to 12.0. The galactic latitude is -57.98 , well away from the galactic plane, but not unusual due to its proximity to us and age.

The abrupt period change at cycle 365 is unusual. The few real observed changes in period of these stars fall into two categories - a slow reduction of $\sim 30\%$ in period over several hundred years thought to be associated with a helium flash, or a more abrupt $\sim 25\%$ increase of period over several decades which is less well understood. The semi-regular star L² Puppis also showed an abrupt period change in 1967 of ~ 1.5 days but a reduction, not an increase. Other types of variables also show these abrupt changes.

The binary system appears to show a separation of 0.6" or 70 AU, a period of between 300 and 500 years depending on the source, which leads to a rather low combined mass of a little over two solar masses. Direct measures of Mira show a radius of 300 solar units, a slightly non-spherical star with a small tail extended toward its companion. Ultra-violet measures also show a trail extending for 13 light years associated with the Mira's stellar wind interacting with the interstellar medium as it moves through it. All these measures are difficult to make and of doubtful accuracy so perhaps Gaia will come up with better results.

There is little colour photometry available. A few UB_V measures show B-V of 1.50 and U-B of 0.08 at about mid-brightness but these include both stars. The white dwarf presence is more noticeable at minimum. In this context it is interesting in that UB_V measures of quite a number of Mira stars also show the effects of a companion, although not necessarily an evolved white dwarf. Any main sequence companion would normally be too faint to affect the colours much as stars on the AGB should be quite old. But how well is the evolution of such a system understood?

CCD Measures

The database contains 174 measures over the last 500 days of which 104 were by SAH. Of the remaining 70 many were V alone with a scatter up to 0.4 magnitudes at times. Those by SAH are shown in Figure 4, phased with a 333 day period and offset by 160 days to show maximum more clearly. Unfortunately there are large unobserved intervals in the dataset which covers 498 days only. Perhaps these could be filled in by someone? Now is an ideal time to extend measures of the decline before it gets too close to the Sun in the sky.

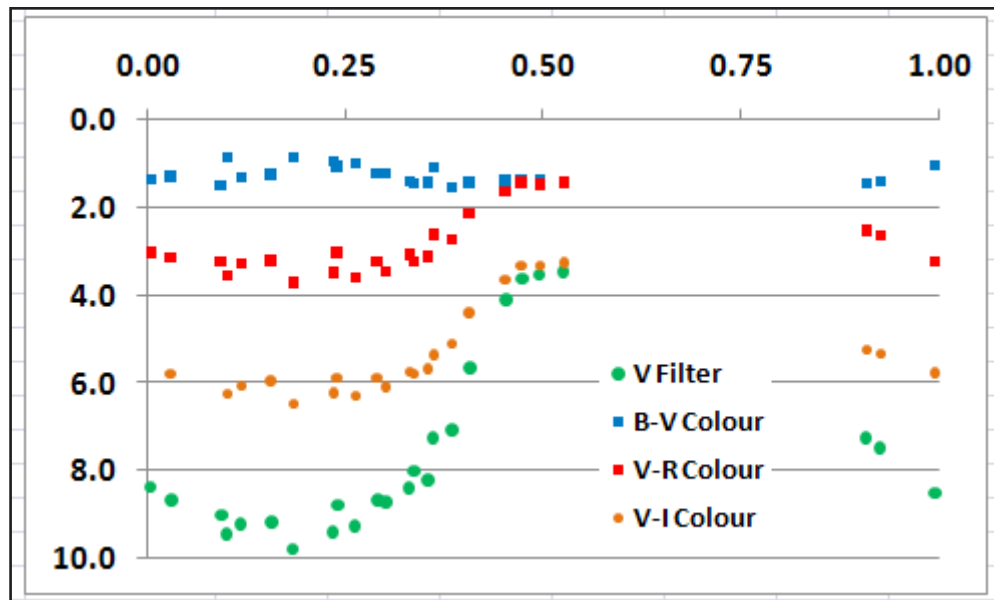


Figure 4. *V, B-V, V-R, V-I, measures of Mira by observer SAH from JD 2457601 to JD 2458099, plotted to JD 2457300 + 333 days.*

As expected with the presence of a white dwarf in this system and too close to be omitted from the measurement aperture the B-V colour is largely in antiphase to the V measures. The V-R and V-I colours are fairly normal except near minimum where the effects of the companion's colour flattens out the colour curves and the overall amplitude.

Mira B, VZ Ceti, is immersed in Mira's stellar wind and the interaction has been observed to create brightness variations, to some extent in antiphase. This is a reminder of a project of the 1960s when the nature of X-ray sources was not clear and visual observers were requested to look at other Miras suspected of having compact companions. Variations might be expected to show some evidence of interaction with the material ejected at minimum of these Mira stars when opacity was highest and surface gravity lowest. But a more plausible explanation for the X-ray objects was found quite quickly.

The omicron/VZ Ceti system is rather too difficult for the average CCD observer to make useful contributions other than provide a picture at this epoch for future observers to match measures in the hope of detecting change.

Observing methods and to summarise

The presentation of data in the International Database does not lend itself well to this type of analysis being expressed in filter values. These are difficult to disentangle, particularly if they do not follow a systematic order. One southern observer always measures in the sequence B, I, R, V which makes it simple to change to V plus colours. But other observers change from night to night or observe through four filters some nights, but two or three on others - and in any order which strikes them on the night. This type of data is the first to be discarded and never used in analyses. So if you are using standard filters be consistent in your methods.

The Mira project operated by Variable Stars South has been revised to study long term changes. Some comments about the problems associated with this appear in the article on page 23.

In summary Mira is an interesting object but is unlike most other Mira stars in some ways due to its companion. It also illustrates that contrary to the theoretical concept of long term evolutionary changes taking the form of a slow increase or decrease of period they can be abrupt. What type of event causes this - is it similar to earthquake faults where tension build-up in a long period of stability is suddenly released. In this context there is also the case of the period alternations where in an O-C diagram they diverge from the average period to a certain limit for any one star and then reverse. This limit is usually 20% to 40% of the fundamental period.

Interesting questions, but these stars evolve so slowly that we must resort to endeavouring to place them in order on a timescale of billions of years. Maybe an unresolvable question? So let's keep looking and measuring.

The DY Per star V487 Vel – *Andrew Pearce*

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V487 Vel is a relatively under-observed DY Per type star with a very short observational history. DY Per stars are thought to be a subclass of the RCB variables and only a handful are known. They are carbon-rich asymptotic giant branch (AGB) stars that exhibit pulsational variability of AGB stars and irregular fades similar to R CrB stars.

As noted by Miller et al (2011), DY Per stars and RCB stars both show an overabundance of carbon in their atmospheres and unpredictable, large amplitude declines in their light curves. Several properties differ between the two. DY Per stars apparently have symmetric declines in their light curves, clearly show ^{13}C in their spectra, are on average approximately 10 times fainter than RCB stars, and may have significant hydrogen in their atmospheres.

A detailed examination of the differences in the mid-infrared excesses of RCB stars and DY Per stars in the Magellanic Clouds led to the conclusion in Tisserand et al (2009) that DY Per stars are most likely normal carbon stars that experience ejection events rather than an extension of the RCB phenomenon to lower temperature stars. It is therefore believed that DY Per stars are heavily enshrouded carbon-rich AGB stars that are an extension of typical variables rather than a separate class of variable stars.

There is some limited near-infrared and JHK photometry and millimetre observations reported in the literature but very little UVBRI photometry.

The AAVSO VSX notes that the star exhibits cycles with a period around 280 days and an amplitude of up to 1 magnitude. It has limited observations within the AAVSO AID dating back only to 2012. The longest and most detailed data set is the visual observations currently in the AAVSO AID since early 2012 which are shown in figure 1 below.

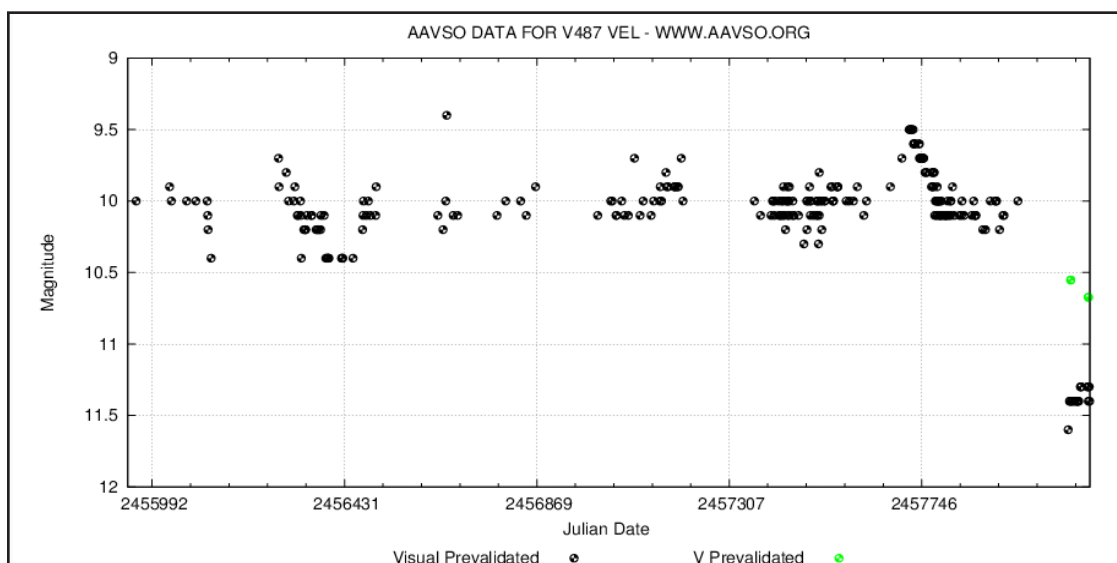


Figure 1. Visual observations of V487 Vel from the AAVSO International Database

This data has been obtained predominantly by Stephen Hovell and myself with smaller data sets obtained by a few others. The visual observations have shown several instances where the star brightened quite rapidly to around magnitude 9.5 from its normal state at around magnitude 10.0.

A preliminary DC DFT analysis using VStar on all the visual observations in the AID produced a signal with a lot of noise with no clear periodicity evident that matched the data. The strongest signal is at 367 days with possible harmonic or annual alias periods at 183 and 121 days, however I always treat periods close to one calendar year with suspicion! It has a visual maximum in the range of 9.5 to 10.

I was quite late to pick up V487 Vel after solar conjunction in November 2017 but immediately noticed that it had undergone a fading event since last observed in July 2017. Visually it had faded to around mag 11.5 which can be seen in figure 2 below.

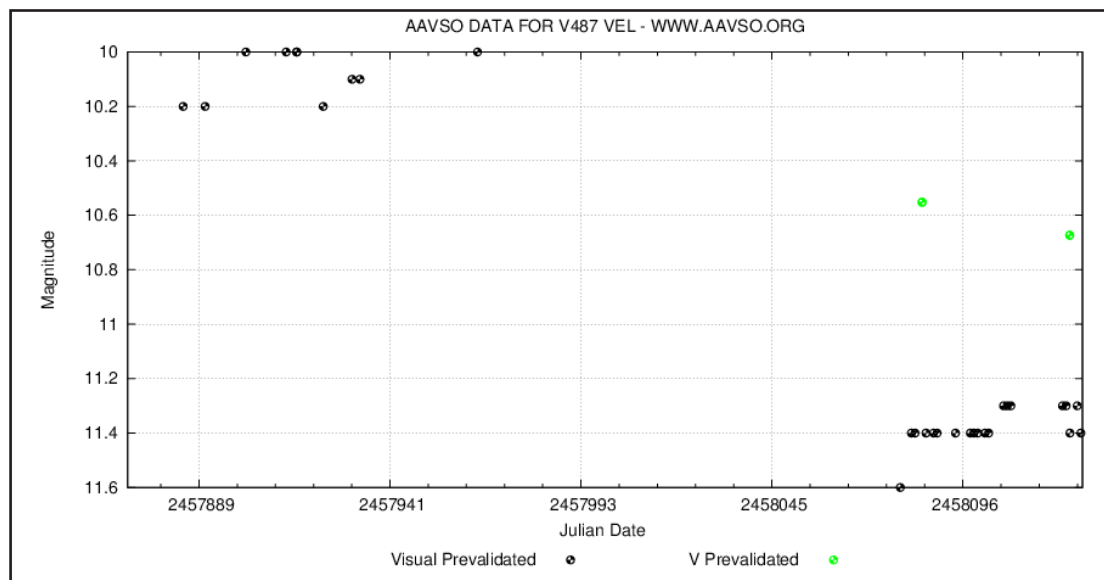


Figure 2. Visual measures of V487 Vel from May to December 2017.

I was also able to perform some BVR photometry using one of the iTelescopes on selected dates in December 2017 and January 2018. This data showed colour indices of $B-V=3.5$ and $V-R=1.6$. The redness of the star, which is quite apparent visually, would account to some extent for the difference between visual and V magnitude estimates.

The ASASSN system has been keeping a close watch on V487 Vel and I downloaded the data that it has acquired and is presented in figure 3 below. ASASSN picked up V487 Vel in late September 2017 when it is apparent that the fade was already well underway. As can be seen from the data, it has undergone a gradual and slow fade until it bottomed out around late November 2017.

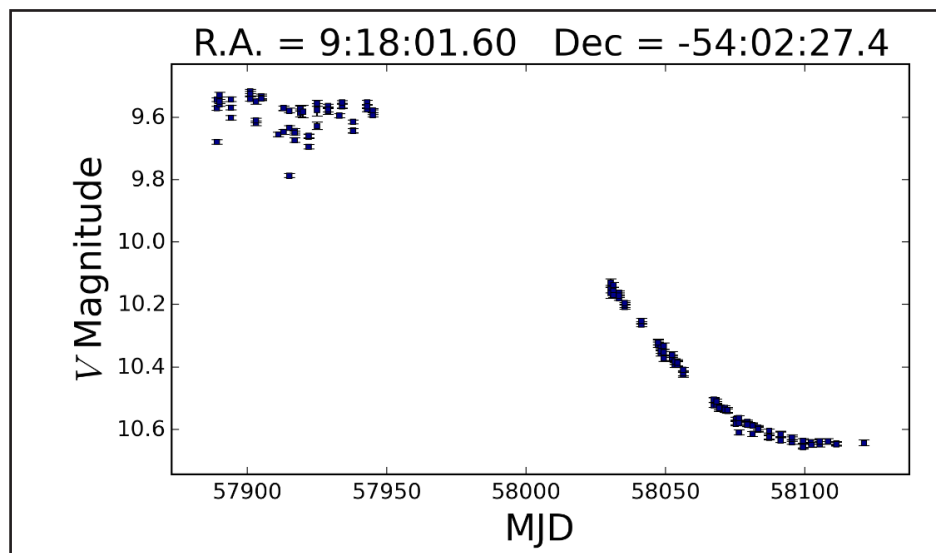


Figure 3. V487 Vel has undergone a gradual and slow fade until it bottomed out around late November 2017.

I have just had an AAVSONet proposal approved to conduct BRVI photometry on V487 Vel from now until the star recovers to its steady state maximum.

I would encourage other observers, particularly with I and R filters to follow this interesting star.

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V382 Carinae – a yellow hypergiant star – *Stan Walker*

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Abstract

V382 Carinae was once catalogued in the GCVS as a Cepheid which led to some observers taking an interest in its behaviour, given an apparent magnitude of $V=4.0$. Its variability has been both confirmed and denied but it appears that it does have outbursts, rather small in amplitude and infrequently. This article reviews the various datasets and suggests a more practical method of monitoring the light variations.

V382 Carinae, HD 96918, was added to the GCVS in 1985 as a possible Cepheid, based largely upon its colour and apparent variability. The range was given as 3.84 to 4.02 with a spectral class of F8-G2Ia. Its galactic latitude is 1.29 degrees which suggests a considerable degree of reddening.

This star was added to the Auckland group's Cepheid programme in 1992 as it was thought then that it was a previously unknown naked eye Cepheid. But it didn't behave like one, taking 47 days to rise 0.146 magnitudes. An email from a colleague in Hungary suggested it was a yellow hypergiant, much more luminous than any Cepheid, and since by late May Carina was getting low it was dropped until the following year when 19 measures were made. After two measures in 1994 I shifted to Kaitia and no further measures were made in Auckland. The 25 UBV measures are shown in Figure 1, also Hipparcos measures from JD 2448550.

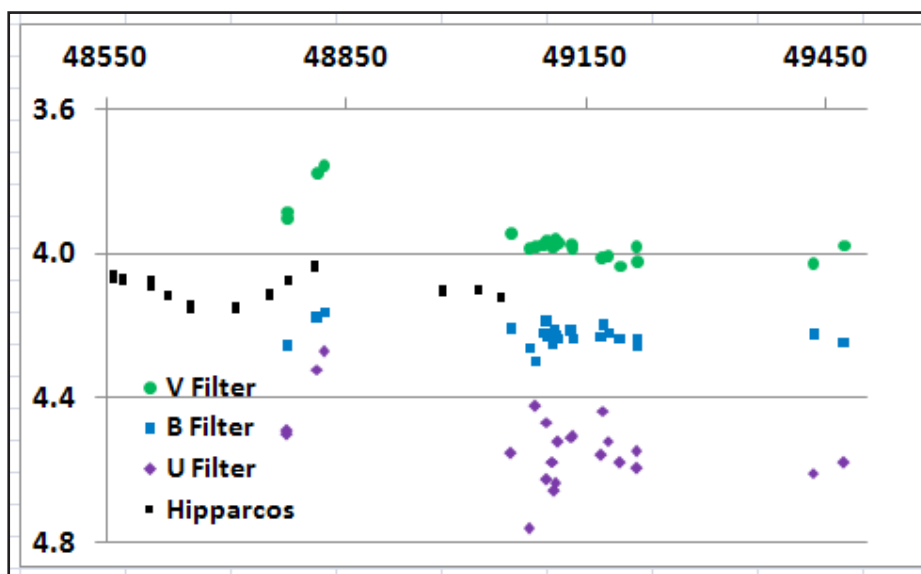


Figure 1. UBV measures made with the 53cm Milton Road telescope using an EMI 9924 11 stage photomultiplier and a current to frequency converter. Measures made from the Hipparcos satellite before and during this interval are shown.

Quite clearly this star is not a Cepheid but was observed during some type of event. Since the UBV measures are sparse, Hipparcos measures are shown to provide veracity of this probable outburst. All measures from Hipparcos are shown in Figure 2.

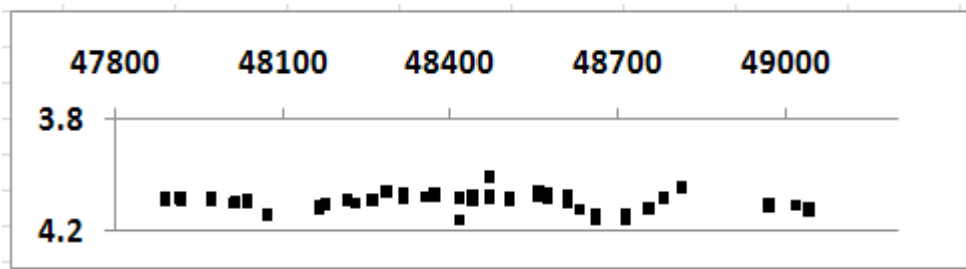


Figure 2. This clearly shows the consistency of almost all the Hipparcos measures. There is one measure near JD 2448100 which is probably not real but the remainder show little variation except for the interval shown in Figure 1. The apparent zero point offset is discussed in the following section.

Other measures

Berdnikov and Turner, 1995, made 29 BV measures over an interval of 25 days in 1995. Their derived values were $V = 3.934$ and $B-V = 1.248$. In both cases the standard deviations were 0.008 magnitudes. From this limited sample they concluded it was not variable. Stift, 1979, made UBV measures on 14 nights. These show amplitudes of 0.05 in U, 0.04 in B and 0.03 in V over 30 nights during January and February, 1977. These were all published as differential values from HD 96566 but based on Simbad V, B-V, values of 4.606, 1.016. The values at the start of this rise were $V = 3.926$, $B-V = 1.208$. Fernie, 1976, made 6 UBVRi measures from which he derived, $V = 3.84$, $B-V = 1.26$, $U-B = 0.98$, $V-R = 0.95$ and $V-I = 1.51$. The latter two values are not in the current UBVRcIc system. These compare with the mean of the 19 Auckland values, at or approaching minimum 1993, of $V = 3.987$ (0.024), $B-V = 1.231$ (0.023), $U-B = 1.064$ (0.078).

Observers	Interval	V	V Err	B-V	B-V Err	U-B	U-B Err	No Obs
Stift	43148-43155	3.912		1.203				7
Hipparcos	47884.48467	4.082	0.021					70
Walker	49054-49212	3.987	0.024	1.231	0.023	1.064	0.078	19
Berdnikov & Turner	49803-49827	3.934	0.008	1.248	0.008			29

Table 1. Observations at minimum - not including outbursts

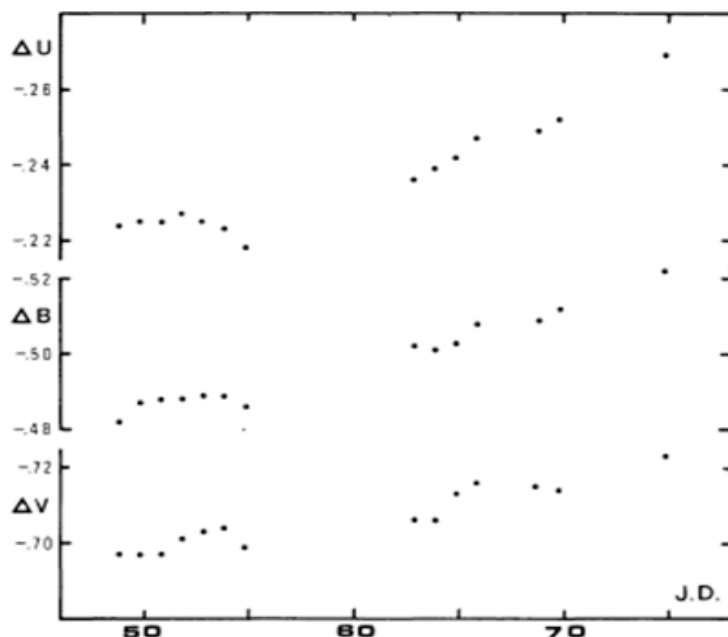


Figure 3. A reproduction of Stift's Figure 1 showing UB measures during a rise, presumably associated with a low amplitude outburst. The magnitudes are differential UB in the sense HD 96918 - HD 96566. The bottom scale is JD - 2443100. The U-B value at minimum is not included in Table 1 as a U-B for the comparison star is not available.

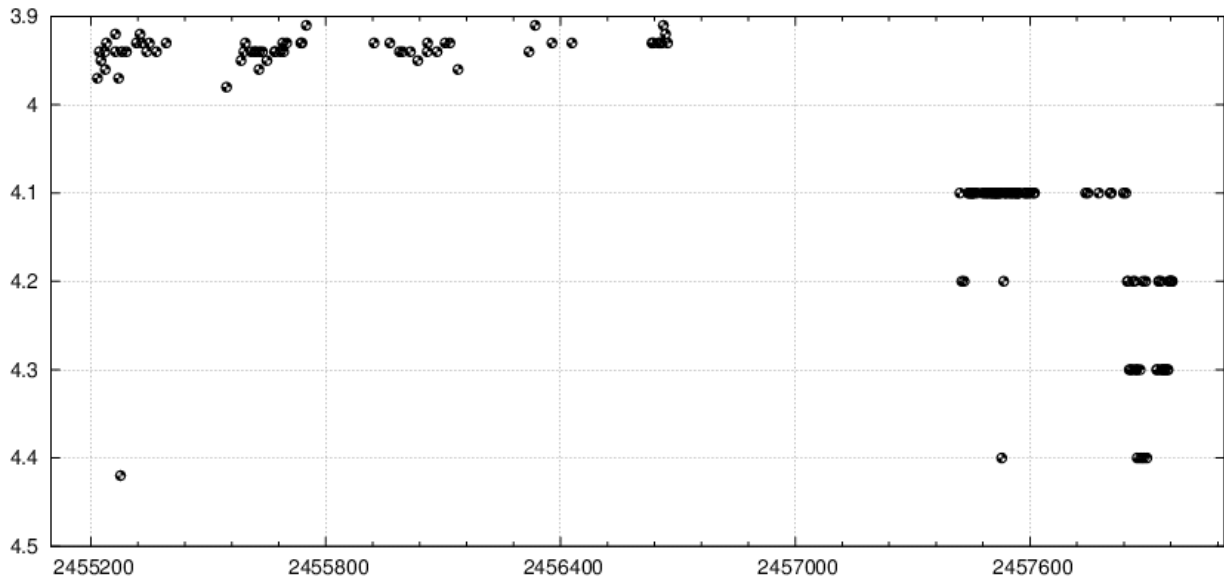


Figure 4. Visual measures from the International Database. The brighter and earlier ones are by Sebastian Otero who uses special techniques to obtain quite high accuracy, most of the remainder are by Peter Williams using standard visual methods.

What is the nature of variability?

HD 96918 appears in Cape Annals, 1928, as a possible spectroscopic binary but this is unlikely given the high mass and luminosity of the yellow hypergiant main component. Humphreys et al, 1971, using infrared, detected silicate re-radiation from a possible hot dust shell. Nicolet, 1978, lists it as variable but his conclusion was based on a compilation of measures from many different sources, some of which, in the early days of PEP, were of doubtful accuracy.

The rising colours in the UBV filters and B-V, U-B are similar to that on the rising branch of a pulsating star but such erratic events are unlikely to be pulsations. The dip in brightness as measured by Hipparcos which precedes the rising event observed in Auckland seems suggestive of an ejection event with an initial obscuration followed by a brightening as a small shell expands with some increased radiation due to a small amount of emission. Unfortunately, the only prolonged monitoring was visually by Sebastian Otero when the star seems to have been inactive. Due to its brightness it's a difficult target for CCD cameras.

The position of yellow hypergiants in the HR diagram is suggestive of a stage between the luminous blue variables and the red supergiants, but they have not been observed to show the large stellar winds and massive ejection events of these other two groups of stars. A more plausible explanation is that with a much lower mass loss rate the hotter regions of the envelope are being exposed without too much obscuration - almost like a return to a younger star phase. The Auckland observations were fortunate to record one of the few 'outbursts'.

A detailed analysis appears in Achmad et al, 1992. This uses the techniques available at that time to make estimates of the physical aspects of V382 Carinae. This paper is well worth reading for an insight to the methods of using these techniques to determine various values of the star under scrutiny. They derived the following:

Distance	2700 pc $\pm$ 1000
Radius	700 $\pm$ 250 sun
Luminosity	L/L sun 5.5 $\pm$ 0.4
Magnitude absolute	-9.0
Mass	20 $\pm$ 10 sun.

Guide 9 uses the Hipparcos parallax of 0.52 ± 0.17 mas to place it closer at 1920 ± 630 pc with a rather smaller luminosity. This calculation does not appear to make a correction for interstellar absorption.

Observing suggestions

V382 Carinae is not a useful visual target. It is, however, well suited to DSLR photometry but not on a continuous basis. One quality measure each month will probably provide adequate warning of any brightenings and enable more specialised instruments to be brought into action in the event of a rare outburst being detected.

Comparison stars are not plentiful. Most are K or early B spectral classes. HD 96566 is about 3.5 degrees south and the K0 spectral class is not ideal, although it was used by Stift. Various values, similar but not identical, are given for this star. Whichever comparison and check are adopted they should be rematched to the E Region standards. Any member beginning to observe this star should indicate values determined for the comparison and check stars.

Another point of interest is that it is close to other variables of VSS members observe - AG Carinae, an S Doradus or LBV star, U Carinae, an interesting Cepheid and several others.

There are not many of these stars in the Milky Way galaxy apart from in clusters. Achmad et al list the following field objects. No doubt a few more have been located since then.

rho Cassiopeia	4.1-6.2	320 days	V382 Carinae	3.84-4.02
V509 Cassiopeia	4.75-5.5		Variable A in M33	
V1302 Aquilae	13.7-15.0		IRAS 18357-0604	
V706 Centaur	14.1-15.0		IRAS 17163-3907	
V1427 Aquilae?				

The ones in clusters are difficult to observe, due to either the faintness and proximity of other stars or the obscuration by gas and dust in the cluster. A typical example is Westmorlund W1 in Ara. An ESO image of this appears below.



Figure 5. An ESO image of W1, 16 47 04 (2000) -45 51 05, the brightest stars in which are about $V = 15$ apparent. They are luminous blue objects but appear yellow or orange in this image due partly to interstellar material but mainly to the obscuring material in the cluster itself. The blue and white stars are all foreground objects.

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Photometry and initial modelling of the eclipsing binary V871 Ara

– Col Bembrick, Tony Ainsworth* & Jeff Byron

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Abstract

Further unfiltered CCD photometry of the eclipsing binary V871 Ara has yielded an accurate epoch of primary minimum (HJD 2452101.1205 $\pm$ 0.0009) and a refined period of 9.41667 $\pm$ 0.00003 days. The primary (total) eclipse exhibits a flux drop of 80% (1.80 magnitudes) while the secondary eclipse (now observed in more detail) has a drop of only 8% (0.08 magnitudes). Modelling of the light curve using Binary Maker 3 suggests the system contains an F0 type primary ($T_1 = 7434\text{K}$) while the secondary is a late K type ($T_2 = 4200\text{K}$).

Introduction

The star is designated as HDE 331015 or GSC 8329 3364. Other designations include CPD -48 8614, AAVSO 1629-48, TYC 8329-3364-1, CD -48 10986, ASAS J163723-4842.2, 2MASS J16372332-4842104. The SIMBAD database gives V magnitude of 10.97 and B magnitude of 11.4, while an overall spectral type of A is quoted. (There is clearly a mismatch here between the B-V and spectral type - see later discussion).

The variability of V871 Ara (Kazarovets et al 2000) was discovered by Camillari in 1991 (see Williams, 1998). It has been observed visually (Williams, 1998, Williamson & Williams, 1998, Williams, 2003) and has previously been the subject of unfiltered CCD photometry by two of the authors (Bembrick and Ainsworth, 2001). The latter paper presented an ephemeris for this interesting system, based on visual and photometric data, with a period of 9.4165 $\pm$ 0.0006 days. This paper is by way of a progress report and update following additional observations.

Observations

Previous CCD observations of this star were undertaken by two of the authors between May and Sept 2000. The paper by Bembrick and Ainsworth (2001) details the equipment and methodology used at that time. The observing programme documented here ran from June to Sept 2001, with the same observers and equipment. In addition, a small number of observations of a secondary eclipse were contributed by Jeff Byron (see Table 1). The precision of the photometry was again of the order of 1% and the same comparison and check stars were used. The comparison star was GSC 8329 3176 (approx B-V of 0.35) and the check star was GSC 8329 3458 (approx B-V of 0.24).

Date	Eclipse	Observer
June 21	Primary	CB & AA
25	Out of eclipse	CB
26	Secondary	CB, AA & JB
27	Out of eclipse	CB
July 10	Primary	CB
29	Primary	CB
Aug 10	Out of eclipse	CB
12	Secondary	CB
31	Secondary	CB
Sept 05	Out of eclipse	AA

Table 1. Summary of observations, 2001

In 2001 the details of the primary eclipse minima were observed on two occasions. This more detailed photometry shows that the system exhibits a total eclipse at primary minimum. The light curve is flat-bot-

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tomed (Figure 1), with total phase lasting 47 minutes (0.0035Φ). The (instrumental) magnitude drop at primary eclipse was 1.8 (cf 1.75 in 2000).

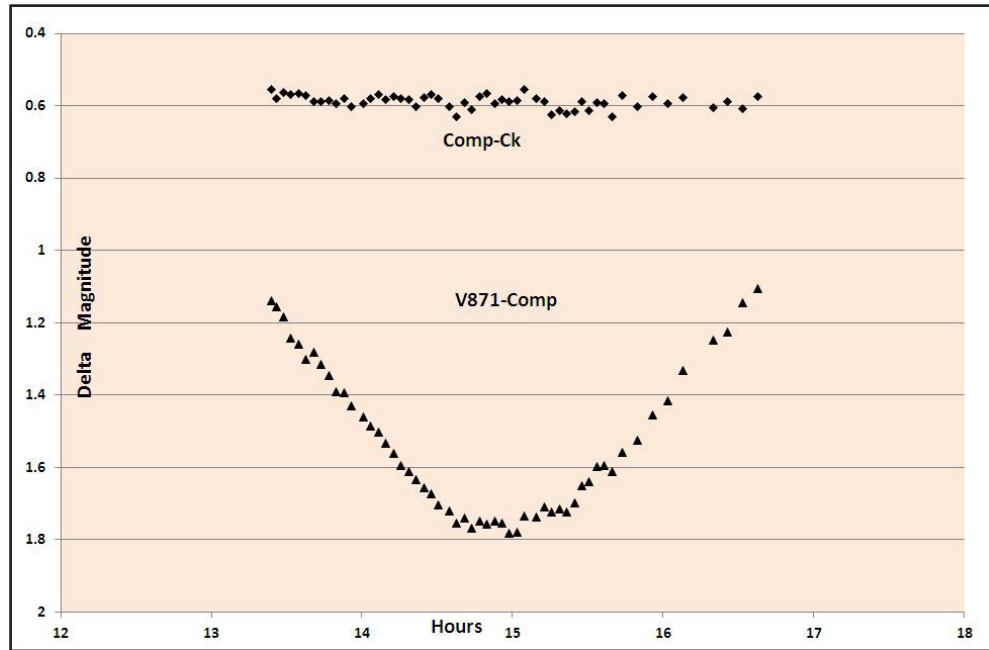


Figure 1. Primary eclipse of V871 Ara

The secondary eclipse was also observed in considerably more detail (Figure 2) on three occasions. The drop in magnitude was found to be 0.08 (cf estimate 0.15 in 2000). The small amplitude and noise of this part of the light curve means that the shape of the curve here cannot be accurately defined, but this has been modelled with a 5th order polynomial (Figure 2). Both primary and secondary eclipses appear to have an overall duration of close to 11 hours ($0.05 \pm 0.002\Phi$).

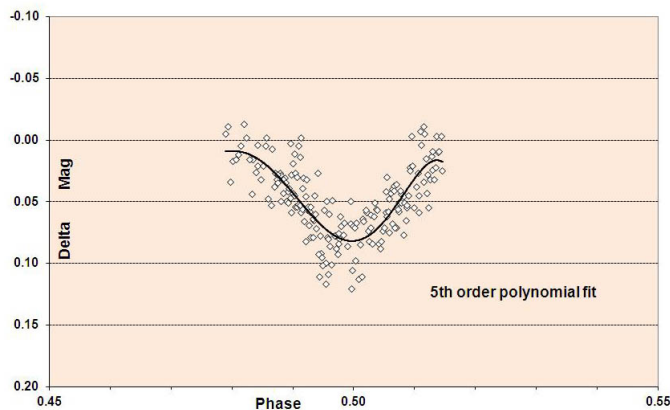


Figure 2. The secondary eclipse - composite observations, with fitted curve.

The out-of-eclipse light curve is essentially flat, with a variation of less than ± 0.02 magnitudes where we have sampled it on four separate dates over a period of 73 days (see Table 1), totalling about 14 hours.

Period determination

Observations of V871 Ara have been both visual and photoelectric. All available epochs of minimum light at primary eclipse are summarised in Table 2. The period has previously been quoted as 9.4165 ± 0.0006 days (Bembrick & Ainsworth, 2001). This period was refined by fitting a weighted linear regression to all the known minima (Table 2). In applying this weighted regression we have estimated the uncertainty of the visual data as 0.03 days and the CCD data as 0.001 days. This gave a value for P of 9.41667 ± 0.00003 days. Using this period, the O-C plot may be fitted with a horizontal straight line as shown in Figure 3, indicating a constant period.

Obs. Min. HJD 245...	Calc. Min. HJD 245...	O-C (days)	Cycle No	Method	Source
0198.9614	0198.9533	0.008	-202	visual	Williams,2003
0246.0310	0246.0367	-0.006	-197	"	"
0311.9786	0311.9534	0.025	-190	"	"
0603.9121	0603.8701	0.042	-159	"	"
0613.3294	0613.2868	0.043	-158	"	LW&PW,1998
0632.1074	0632.1201	-0.013	-156	"	Williams,2003
0650.9869	0650.9534	0.034	-154	"	"
0716.8907	0716.8701	0.021	-147	"	"
1733.8695	1733.8704	-0.001	-39	CCD	Bemb&A,2001.
2101.1211	2101.1205	0.001	0 (Epoch)	CCD	Bemb&A,2001.

Table 2 Data of observed primary minima

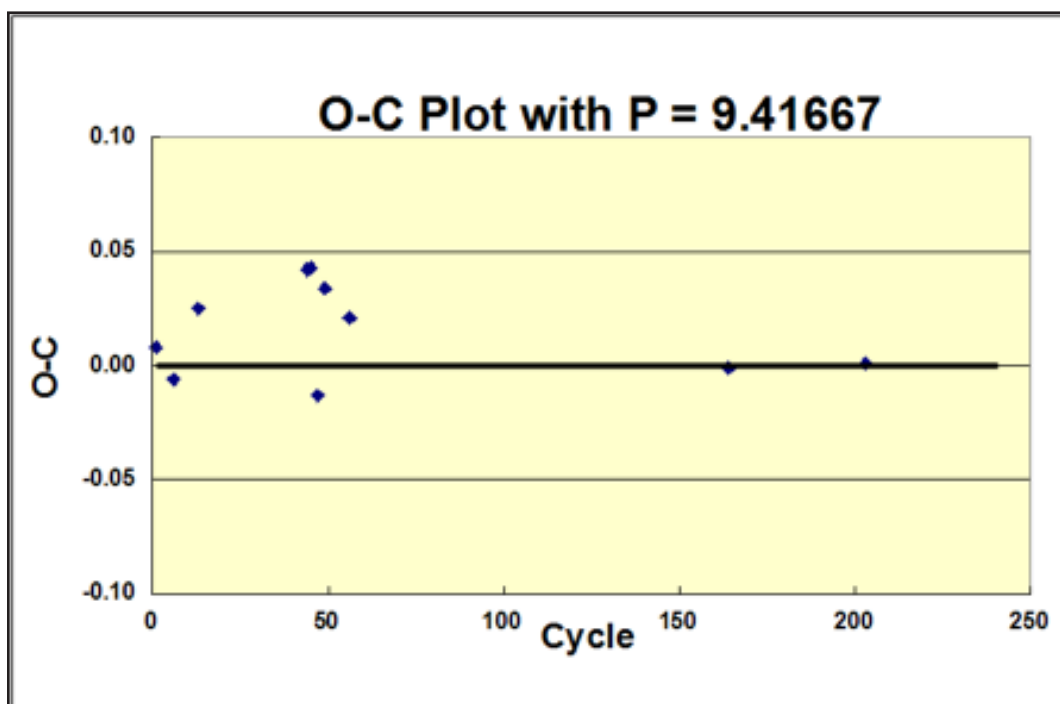


Figure 3. Plot of O-C (vertical axis) against Cycle number using the data of Table 2.

To confirm that our interpretation fits the ASAS data, raw data was downloaded and phased with our epoch and refined period. The primary minima are well defined, but the very small secondary minimum is lost in the scatter of the ASAS data. This is consistent with our photometric results of a secondary eclipse of only 0.08 mag.

Modelling

Using the refined period and the latest epoch from Table 2, the composite, phase-folded light curve is presented in Figure 4, where the magnitudes have been normalised with respect to the out-of-eclipse value. In this composite light curve, the fitted curve (see Figure 2) from the secondary eclipse has been used to ensure clarity of the figure.

These data, with the magnitudes transposed to a flux scale, were then used as input to the Binary Maker 3 (BM3) modelling software (Bradstreet, 2004).

In the modelling process, we start with an initial examination of the (normalised) light curve (Figure 4), which reveals that the secondary eclipse occurs at 0.5 phase, implying circular orbits for this binary system. The primary eclipses are total (Figure 1), as indicate by the flat-bottomed light curve. The out-of-

eclipse light curve is essentially flat, implying that the stars are spherical and relatively detached. Thus an Algol system (Sterken and Jaschek, 1996) has been previously suggested (Bembrick & Ainsworth, 2001). The considerable difference in eclipse depths (over 1.7 magnitudes) implies a marked difference in luminosities between the primary and secondary stars. Thus the V871 Ara system is likely to be a single-lined spectroscopic binary (SB), where only the primary component is detectable in the spectra.

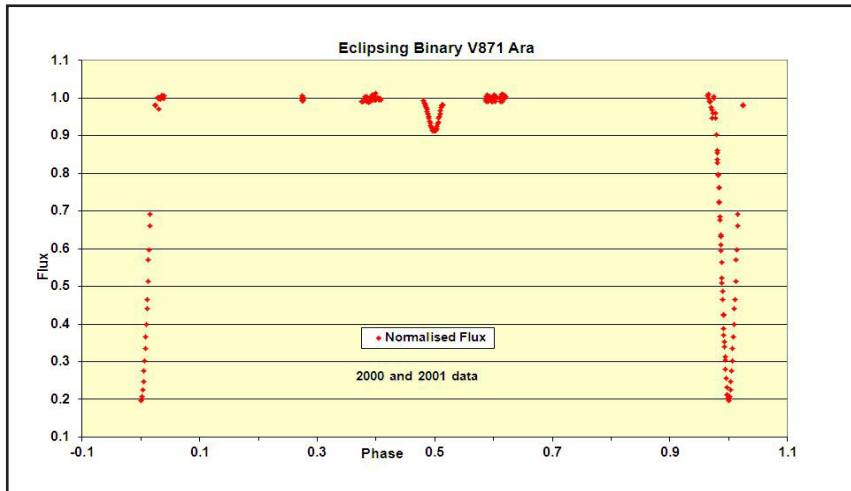


Figure 4. Composite phase-folded light curve.

We next need to make an estimate of the temperature of star one (the primary star), preferably by utilising the spectral type or a colour index - if available. Here we have some difficulty with V871. In various catalogues (eg Nesterov, 1995) the spectral class is invariably given as A, while the B-V has been variously quoted as 0.501, 0.47, 0.379. More recent determinations (eg APASS, 2015), quote the B-V as 0.279 or 0.31. There is clearly some mismatch here and we have proceeded on the basis that the spectral type of A is not reliable. The more recent B-V indices imply an F0 star and the catalogue of Ammons et al 2006 derives $T_{\text{eff}} = 7434\text{K}$, which seems plausible, so this has been used as the initial input temp of star one. The relative depths of the primary and secondary eclipses then give an estimate of the temperature difference between the stars. The absolute depth of the eclipses can be adjusted by varying the inclination, i .

Finally we need to make an estimate of the mass ratio (q) between the two stars. One way to approach this problem is to do a 'q-search' (for quick-n-nifty q -search see Bembrick, 2016). From an initial guess-estimated value of q , the model is rendered and the goodness-of-fit parameter noted. Then the value of q is varied in discrete steps either side of the initial value while noting the fit parameter. A plot of q versus the fit parameter should hopefully show a minimum for q (see Figure 5). This is then adopted as the best fit q to input in the modelling process.

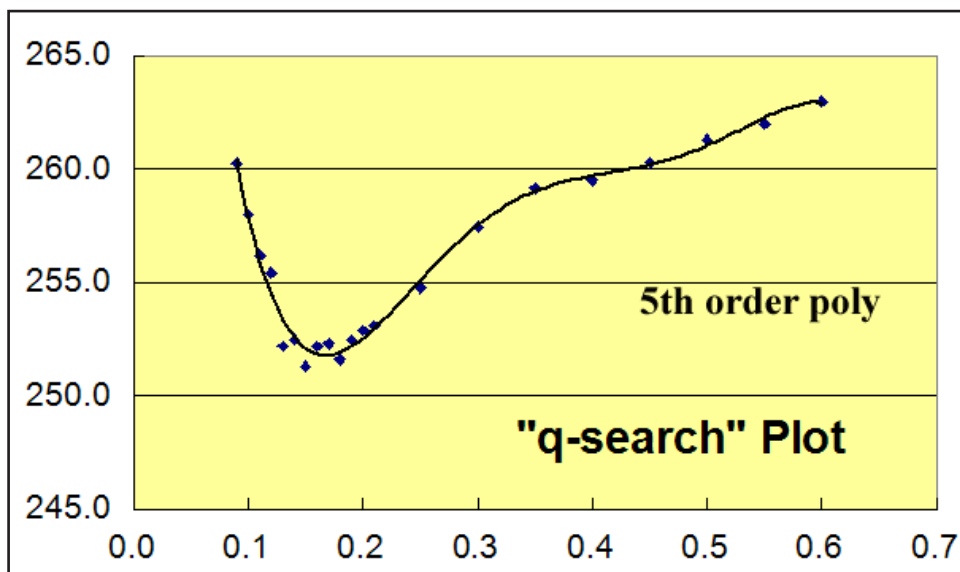


Figure 5. Plot of the "q-search", with min $q = 0.172$

As there are no radial velocity or reliable spectral data available, the model is necessarily preliminary only. However, as this relatively new system has been poorly studied to date we advance our preliminary model here to encourage others to obtain further observations, especially spectral data and radial velocities. The interpreted model parameters are summarised below in Table 3, while the model fit to the observed light curve is shown in Figure 6.

Observing wavelength = 650nm	mass ratio, $q = 0.172$
Mean Radius, $R_1 = 0.074$	Mean Radius, $R_2 = 0.099$
$T_1 = 7434$ K	$T_2 = 4200$ K
Luminosity ₁ = 0.865	Luminosity ₂ = 0.144
Gravity coeff ₁ = 1.00	Gravity coeff ₂ = 0.32
Limb darkening ₁ = 0.53	Limb darkening ₂ = 0.75
Reflection ₁ = 1.0	Reflection ₂ = 0.5
Third light = zero	Inclination, $i = 87.7^\circ$

Table 3. Final model parameters

In developing this model we have taken the limb darkening parameters from the tables of Van Hamme (1993). For gravity brightening exponents we have followed the scheme of Lucy (1967), while for the reflection coefficients values we adopt the values of Rucinski (1969).

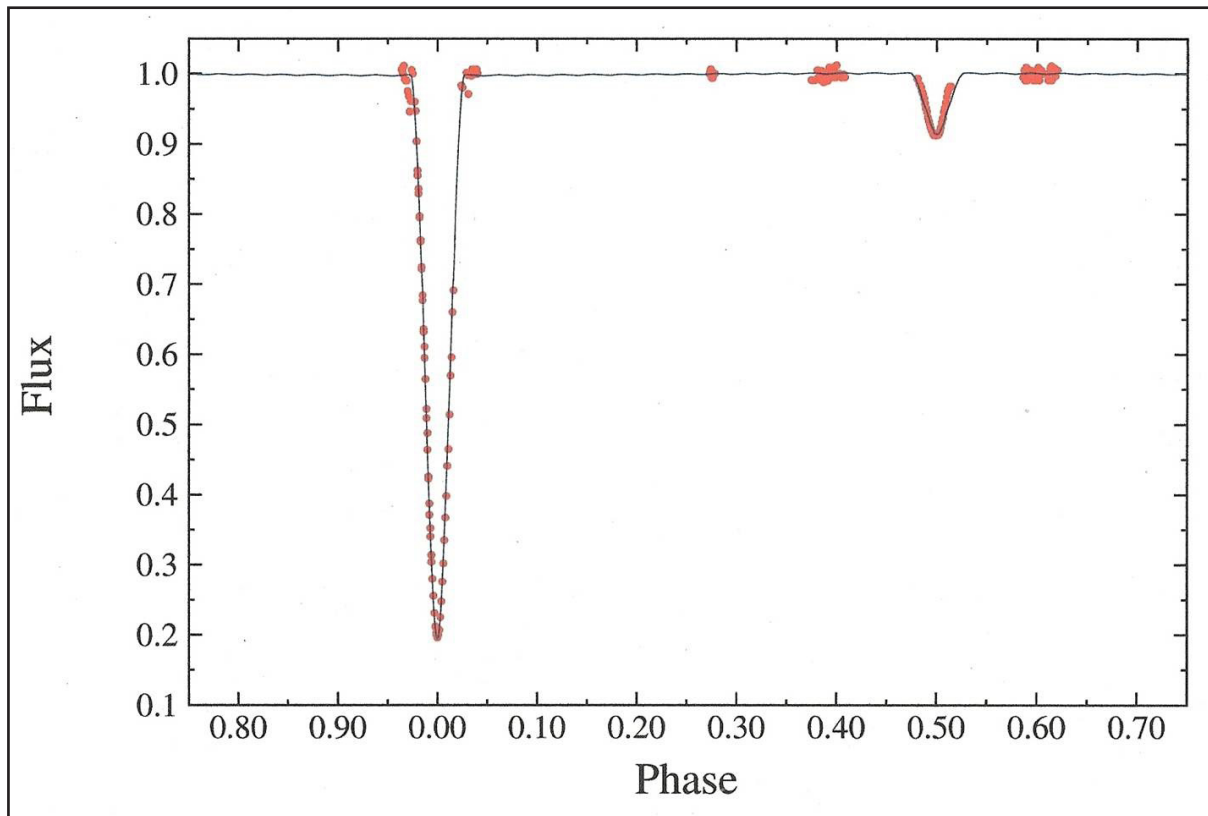


Figure 6. Model fit to observed flux

Conclusion

Recent observations of the interesting eclipsing binary system V871 Ara have led to a refined period and more accurate epoch of minimum light. The improved (linear) ephemeris is:

$$\text{Primary Min (HJD)} \ 2452101.1205 \pm 0.0009 + 9.41667 \pm 0.00003 \times E$$

A preliminary model of this system is now proposed, but as high quality spectral and radial velocity data are lacking, this cannot be definitive at this stage. This model suggests a detached Algol-like system, with an early F type primary ($T_1 = 7434$ K) and a late K type secondary ($T_2 = 4200$ K). This model shows

that the primary eclipse is briefly total, while the secondary eclipse is partial as the hotter star transits the cooler star.

The uneclipsed V magnitude of this system is 10.97 (Simbad), and our model shows that the primary star contributes almost 86% of the luminosity, so its V magnitude should be 9.43. The absolute magnitude of a main sequence star of spectral class F0 is +2.7 (Cox, 1999), so the distance modulus is 6.73, giving a distance of some 222 pc – neglecting interstellar extinction.

The mass of a main sequence F0 star is typically $1.6M_{\odot}$ (Cox, 1999), so with our model mass ratio star two should be $0.27M_{\odot}$. Then from Newton's modification of Kepler's Third Law, we have the orbital radius, $a = 10.8 \times 10^{-2}$ AU.

Additional photometry is obviously highly desirable, particularly to obtain a more complete light curve and accurate delineation of the secondary eclipse.

Acknowledgements

CB acknowledges the valuable assistance and initial instruction given by Hans D Kennedy in using Binary Maker. Also, Dr Bradley Carter is warmly thanked for his valuable discussion. This research made use of SIMBAD database, maintained by the CDS at Strasborg, France.

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Changes in the pulsating variables projects - Mira stars with long periods – *Stan Walker*

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Historical development

The article on Mira elsewhere in this newsletter summarises the way in which this field has developed over the past several centuries. Emphasis has been placed upon a study of the periods of these stars in the belief that this will allow us to understand them better. To a large extent this is correct. Should this provide all the answers then the goal should be to seek more accurate measures of the periods of an increasing number of these objects which is becoming more simple with greater accuracy of brightness and timing measures. All of this is what is called time series photometry, TSP, where only time and brightness are taken into account.

The increasing popularity of CCD measures amongst amateurs has resulted in a change in amateur observing. Visual measures are declining in number and there is an increasing number of measures at other than visual wavelengths using filters to isolate these wavelengths. With care these measures can be transformed to an accurate standard system. Measures at these different wavelengths cannot be used effectively in TSP. The reason is that all pulsating variable stars reach maximum brightness at different times, dependent upon wavelength - the shorter the wavelength, the earlier the maximum.

Evolution of pulsating variable stars

In general, as a star converts lighter elements into heavier elements to provide energy it will slowly expand and its surface will cool. This is clearly shown in Sandage diagrams in the Hertzsprung-Russell diagram. The main interruptions to this picture occur when the nuclear processes in the core shift to heavier elements and there is an associated contraction and heating of the envelope. These evolutionary changes are normally extremely slow.

All of this was deduced a century or more ago using spectroscopy and brightness measures of stellar clusters. But it is simpler and quicker to use colour photometry now that it has become quite accurate. The main colours used are B and V, where the effective wavelengths have been agreed upon and effectively defined. B is blue, V is visual in the spectrum. From these measures B-V 'colours' have been determined and tables of B-V/temperature relationships established for the various luminosity classes determined by Morgan and Keenan.

Evolution of Mira variable stars

Miras are old population I stars located in the asymptotic giant branch (AGB). They have lost much of their mass and are now only several times more massive than the Sun. They are believed to be evolving up the AGB, becoming brighter and cooler, thus their radii are expanding and their periods are lengthening. Models of pulsating variables show a strong relationship between radius and period. A question arises - can we use a mix of TSP and colour photometry to examine this evolution?

Periodicities in Mira stars are not simple. The well known pulsation periods range from about 100 days to 600 or so days. Superimposed on this is a 2-5% alternating decrease/increase of period with a timescale of a few decades. There are also period changes - a decrease in period of ~30% in several centuries usually attributed to a '*helium flash event*', an increase of period of ~25% over about two decades, and perhaps random changes as shown by Mira itself and the semi-regular variable L² Puppis. In this context there is an arbitrary division of these cool red variables based on amplitude - below 2.5 magnitudes amplitude a Mira becomes an SR star so that many low amplitude Miras with strongly carbon envelopes are described as SR stars.

Another feature of Mira stars is that a small number of these show dual maxima. Also, many Miras show humps or standstills on the rising light curve. These two phenomena may be related as BH Crucis changed from a 421 day dual maxima Mira to a single maximum Mira of 510 days with a pronounced hump on the rise where the first maximum was previously, as well as brightening by a substantial percentage.

Colour photometry of Mira stars - general and those with humps

Both BH Crucis and L² Puppis showed substantial colour changes with the change in period, although the latter has also undergone some other type of event causing a substantial fading. Colour photometry of R Centauri during its changing period is also being carried out although there are problems which are discussed below.

The project is discussed in depth on the upgraded website and more details of the targets and comparisons should be complete within the next month. Miras with periods in excess of 400 days should be nearing the end of their ascent of the AGB and evolving into something else. It also appears that almost all of the true period changes occur in these 400+ day stars. Humps may also be more prevalent in that period range as well.

Colour photometry and accuracy

To do effective colour photometry over decades high accuracy is needed. A level of 10 millimagnitudes or better is needed. This requires:

- Very accurate transformation to the standard UBVRcIc system
- Comparison and check stars which do not vary in magnitude
- All observers using the same comparison and check stars
- Accurate values for these stars

The most important are B and V with B-V which allows use of the various empirical relationships already developed and published. U and I are also useful to provide U-B and V-I. The importance of everyone using the same stars and values is seen in the article on V382 Carinae elsewhere in this issue.

Where are these available? In the southern hemisphere the E and F regions can be used to determine substandards in each Mira star's field. Within a decade values to 3 millimag accuracy should be available from Gaia. We are aware of APASS and other sets of measures but these are not sufficiently accurate for this project. The desired accuracy of <10 mmags is achievable with care. At Auckland Observatory we used sequential PEP to derive accuracies of this order in V, B and B-V. With CCDs, where all the required data is on one simultaneous image this accuracy should not be difficult to match or better.

We have adopted an interim approach. Sets of comparison and check stars based on spectral types A, F and G have been selected. Published V and B-V values, usually from Guide 9, have been adopted. V-R and V-I values have then been calculated from the average relationships determined from E Region values. U-B is then calculated using values from Allen's Astrophysical Quantities. These spectral types are the most stable - almost all M stars are variable at some level, many K stars show long term variations possibly associated with star spots rather more extensive than our Sun's. Blue stars are hard to measure accurately with common detectors.

An analysis of BVRI measures in the International Database, both through those filters and after changing to the conventional V, B-V, V-R and V-I, shows large scatter in many cases. This needs to be eliminated if the measures are to be useful in astrophysical analyses.

S Orionis as an example

Figure 1 shows all observers' measures of S Orionis, a Mira star located just a little south of the celestial equator. Thus both northern and southern observers are involved. Figure 2 shows Giorgio di Scala's measures from ~33S alone. In each figure blue is B-V, red is V-R, light brown is V-I and green is the V magnitude. The epoch is near minimum to present maximum more clearly.

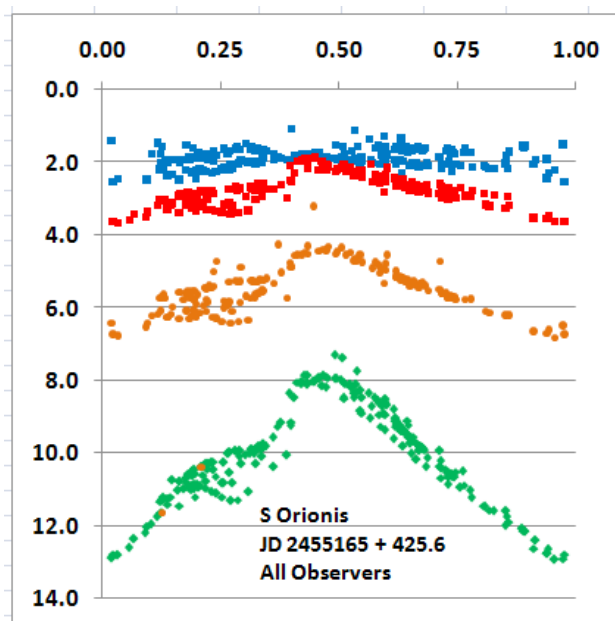


Figure 1. All observers measures of S Orionis

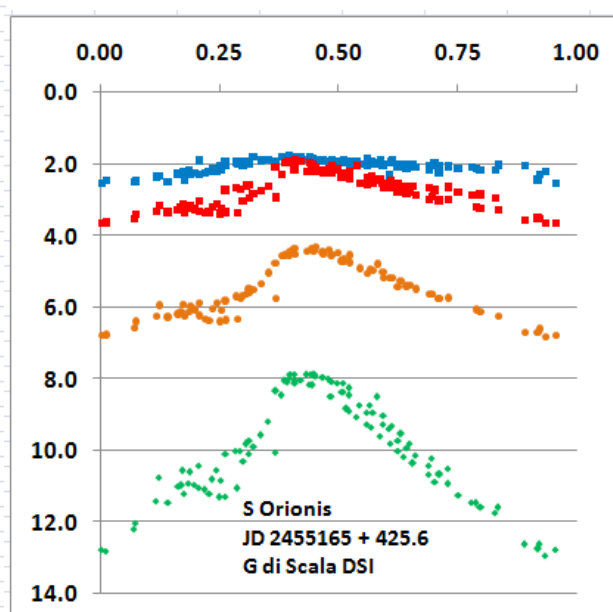


Figure 2. measures of S Orionis by Giorgio di Scala

In each figure blue is B-V, red is V-R, light brown is V-I and green is the V magnitude

There is a clearly defined hump on the rise and the interval covers approximately 10 cycles although quite obviously no one cycle is covered in full. The B-V colour changes only a small amount with temperature and colour as is shown in Figure 2.

The scatter in the B-V of Figure 1 is up to about 0.5 magnitudes. Some may be observer error but most result from incorrect values of comparison stars. The AAVSO photometry table for this star lists 24 different comparison stars from 6 different sources with errors in B-V ranging from 0.027 to 0.173. This makes most of the observations quite valueless. Six to eight highly accurate comparisons would be much more useful. The problem appears to arise in large part in that the chart producers do not include any people with experience in UBVR photometry. Also, many of the observers are inexperienced and do not realise the need for accuracy at the levels discussed here.

Conclusion and summary

Variable Stars South is designed to make observations in specifically targeted projects. This is a step forward from merely making measures in the hope that they will be useful. So to make colour measures of Mira stars (and other pulsating variables) useful in extending our understanding of them we need this additional accuracy. The TSP aspects of Mira stars are adequately covered by the visual observers. Given the rather erratic amplitudes and variations in the times of maxima, filtered photometry can add nothing of value to this aspect of the study.

Colour photometry can, however, provide direct information about temperature changes by changes in the B-V index. Combined with the V measures this provides information on brightness changes. These can then be used to study changes in radius both during a pulsation cycle and on a long term basis using the relationship $L = T^4 \cdot R^2$ although it must be remembered that luminosity in this relationship is bolometric, not merely V magnitude.

Once a complete cycle has been measured in colours there is little need to repeat this for a decade or so unless there are ongoing period changes. Studies of the colours during the 20 to 50 year period alternations may be better at 5 year intervals. So, apart from the accuracy requirements, the project is not particularly demanding.

The website discusses the determination of more accurate V and colour measures of the comparisons by use of the E and F regions of Cape standards. In due course Gaia should provide excellent outside-atmosphere values for these but some observers might find the time to upgrade our assumed values by measuring against the Cape standards. This would be welcome as would colour measures of the target stars.

V0454 Car spectroscopic and photometric campaign – *Mark Blackford*

Campaign Coordinator: Mark Blackford

Professional Advisor: Ed Budding

Ed Budding and Roger Butland are currently investigating this relatively bright but neglected eclipsing binary (range ~ 6.96 to ~ 7.16 V Mag, period 0.980417d). They've measured radial velocities from high resolution spectra recorded with the HERCULES spectrometer on the 1m McLellan telescope on Mt John and proposed that V0454 Car is probably another quaternary system – not unlike QZ Car, but a bit less massive.

The RV curve of the close binary system (eclipsing pair) is well covered, and they can get a reasonably good picture of it from both its sets of spectral lines. However, the third component shows unexpected short term variations superposed on a much longer term trend. They think that it is in a binary arrangement with a lower mass companion having a period of order a week or two. However they don't have enough information to form a very clear picture at the moment.

Spectroscopy

Ed and Roger are requesting assistance from spectroscopists in Variable Stars South to help determine the details of this system. Ideally they are looking for one spectrum per night for about a fortnight. This is because the short term variations of the non-close-binary lines suggest a period on that order. The requested data may then point up details on the second binary referred to above.

The exposures might have to be a bit long – but they do not need to use these spectrograms to study the close binary (that has already been done) so a long exposure (say an hour or two) is not a problem.

The expected shifts of the (fairly sharp) lines of the third component have amplitude of about 1 Angstrom at ~ 6000 Å (roughly). So, allowing for some possibilities of averaging different results from different lines and different exposures, a resolution of ~ 3000 or greater should be ok.

With the HERCULES spectrometer the best line is generally the HeI 6678 feature. But 4471 or 5876 could be also good, or indeed the lower Balmer lines, although the H lines tend to have inherent complications and are not generally favoured so much for reliable RV determinations.

Photometry

Multi-filter photometric observations of the entire eclipsing binary light curve are also requested for modelling purposes. A partial V filter light curve by Mark Blackford is shown in Figure 1. As a minimum we require full BVRc light curves; however U and Ic would also be useful. A finder chart is shown in Figure 2. Check star and comparison star data are given in Table 1.

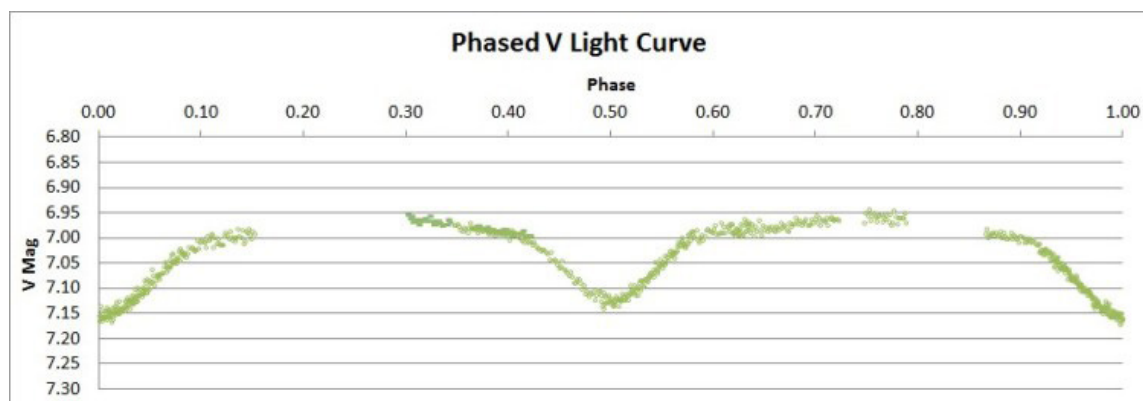


Figure 1. Partial V light curve of V0454 Carinae by Mark Blackford from DSLR images.

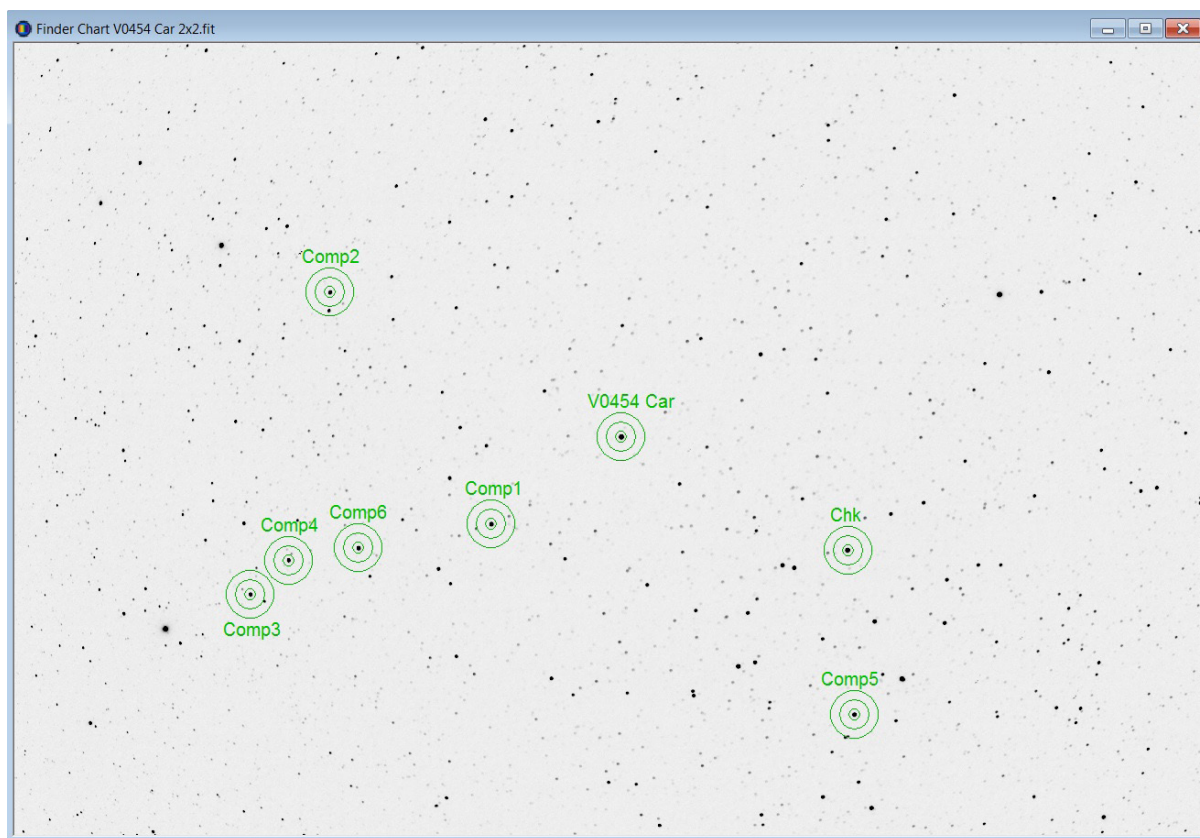


Figure 2. Finder chart for V0454 Carinae, image is 2.66 degrees x 1.78 degrees.

Star	ID	RA (deg)	DEC (deg)	V	B – V	V – R
Var	V0454 Car	113.1923	-53.5553	6.997	-0.099	-0.039
CHK	HD 61056	113.6170	-54.0653	7.268	0.591	0.332
C1	HD 60930	113.5248	-53.2649	8.045	-0.046	-0.007
C2	HD 60227	112.6660	-52.8971	8.190	0.465	0.273
C3	HD 61140	113.7898	-52.7247	8.074	1.081	0.553
C4	HD 61055	113.6626	-52.8100	7.985	1.555	0.856
C5	HD 61560	114.2459	-54.0804	8.063	0.552	0.314
C6	HD 61033	113.6168	-52.9682	7.566	0.743	0.409

Table 1. Check and Comparison star list.

Photometrists are asked to use these comparison stars so our measurements can be directly compared. Star C1 should be used when calculating variable and check star standardised magnitudes with only one comparison star.

V0454 Car will culminate at about 23:30hrs East Australian Summer Time on February 1st so will be well positioned for spectroscopy and time series photometry for several months.

If you can help with spectroscopy or photometry of this interesting target please contact Ed Budding (ed.budding@gmail.com) or Mark Blackford (markblackford@outlook.com).

Request for cooperation

David Moriarty has been working with Pierre Maxted of Keele University who has asked if he could help with obtaining light curves during transits of low mass stars across sun-like stars, their project linked to the Kepler 2 mission.

David suggests that other VSS members may like to participate in this project details of which follow.

EPIC 205148699

This is a binary system in which a low-mass star (M-dwarf, $\sim 0.25 M_{\text{sun}}$) transits a Sun-like star. The star was observed by the Kepler K2 mission as part of campaign field 2. The identifier is EPIC 205148699. Various versions of the K2 data can be seen here ...

https://archive.stsci.edu/hlsp/hlspmap/search.php?hdm_dataset_name=205148699 &action=Search

The J2000.0 coordinates of the stars are 16:52:38.52 -19:09:41.7

The B and V magnitudes from APASS DR9 are ..

$$B = 13.344 \pm 0.026$$

$$V = 12.614 \pm 0.043$$

The observations we need are a light curves in I-band and (if possible) V-band covering the eclipse. The eclipse duration is 5 hours.

The ephemeris for the times of mid-transit is $\text{HJD}(\text{mid-transit}) = 2456896.513 + 4.377347 E$

The following times of **mid-transit** are visible from Australia ...

Cycle	Geocentric JD	UT date and time (including accumulated error in minutes)	HA	sec(z)	Night
296	2458192.2068	2018 Mar 14, 16 57 46.0 (± 14.23 m) UT	-2 31	1.24	ngt
301	2458214.0915	2018 Apr 5, 14 11 43.8 (± 14.44 m) UT	-3 50	1.66	ngt
304	2458227.2225	2018 Apr 18, 17 20 22.6 (± 14.57 m) UT	0 10	1.02	ngt
309	2458249.1080	2018 May 10, 14 35 27.9 (± 14.79 m) UT	-1 09	1.06	ngt
312	2458262.2396	2018 May 23, 17 45 00.4 (± 14.92 m) UT	2 53	1.32	ngt
314	2458270.9942	2018 Jun 1, 11 51 35.5 (± 15.00 m) UT	-2 26	1.22	ngt
317	2458284.1263	2018 Jun 14, 15 01 48.6 (± 15.13 m) UT	1 36	1.10	ngt
319	2458292.8811	2018 Jun 23, 9 08 50.9 (± 15.22 m) UT	-3 43	1.60	ngt
322	2458306.0137	2018 Jul 6, 12 19 43.6 (± 15.35 m) UT	0 20	1.03	ngt
327	2458327.9018	2018 Jul 28, 9 38 37.2 (± 15.57 m) UT	-0 55	1.05	ngt
330	2458341.0349	2018 Aug 10, 12 50 19.1 (± 15.70 m) UT	3 09	1.39	ngt
335	2458362.9237	2018 Sep 1, 10 10 10.8 (± 15.91 m) UT	1 55	1.14	ngt

The following stars should be useful comparison/check stars ...

2MASS 16524626-1908072, $V=12.54$, 16:52:46.26 -19:08:07.5

TYC 6226-666-1 $V=12.07$, 16:52:45.74 -19:12:11.2

Publication watch

The Southern Eclipsing Binaries group has been busy and productive in the last quarter with a paper in the Open European Journal of Variable Stars.

Richards, T; Butterworth, N; Blackford, M G, 2017. *Note on the Period of V883 Sco*. 2017. OEJV 186 1R

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.

And your editor is one of 53 co-authors on the discovery paper for the exoplanet KELT-19Ab

Sivervd, Robert J; Collins, Karen A; et al 2017. *KELT-19Ab: A P~4.6-day Hot Jupiter Transiting a Likely Am Star with a Distant Stellar Companion*. AJ, 186, 35S

Abstract: We present the discovery of the giant planet KELT-19Ab, which transits the moderately bright ($V \sim 9.9$) A8V star TYC 764-1494-1 with an orbital period of 4.61 d. We confirm the planetary nature of the companion via a combination of radial velocities, which limit the mass to $\leq 4.1 M_J$ (3σ), and a clear Doppler tomography signal, which indicates a retrograde projected spin-orbit misalignment of $\lambda = -179.7^{+3.7}_{-3.8}$ degrees. Global modeling indicates that the $T_{\text{eff}} = 7500 \pm 110\text{K}$ host star has $M_* = 1.62^{+0.25}_{-0.20} M_{\odot}$ and $R_* = 1.83 \pm 0.10 R_{\odot}$. The planet has a radius of $R_p = 1.91 \pm 0.11 R_J$ and receives a stellar insolation flux of $\sim 3.2 \times 10^9 \text{ erg s}^{-1} \text{ cm}^{-2}$, leading to an inferred equilibrium temperature of $T_{\text{eq}} \sim 1935\text{K}$ assuming zero albedo and complete heat redistribution. With a $v \sin i_* = 84.8 \pm 2.0 \text{ km s}^{-1}$, the host is relatively slowly rotating compared to other stars with similar effective temperatures, and it appears to be enhanced in metallic elements but deficient in calcium, suggesting that it is likely an Am star. KELT-19A would be the first detection of an Am host of a transiting planet of which we are aware. Adaptive optics observations of the system reveal the existence of a companion with late G9V/early K1V spectral type at a projected separation of $\sim 160\text{AU}$. Radial velocity measurements indicate that this companion is bound. Most Am stars are known to have stellar companions, which are often invoked to explain the relatively slow rotation of the primary. In this case, the stellar companion is unlikely to have caused the tidal braking of the primary. However, it may have emplaced the transiting planetary companion via the Kozai-Lidov mechanism.

Former BAA President (now Vice-President) Jeremy Shears has published dozens of papers on cataclysmic variables over the last decade and more. His new contribution is an excellent summary of what CVs are, why they're important and how amateur observations have been crucial to our understanding of observed phenomena of the various types. Shears presents an optimistic view of amateur involvement in future CV research in the era of large scale ground and satellite sky surveys. Continued visual monitoring of known CVs will be crucial in alerting professional astronomers to outbursts, and amateurs equipped for CCD photometry and spectroscopic studies will be vital in the verification and follow-up studies of newly discovered CVs.

Jeremy Shears. 2017 *Amateur astronomers and the new golden age of cataclysmic variable star astronomy*. <https://arxiv.org/abs/1712.05393>

Abstract. The study of cataclysmic variable stars has long been a fruitful area of co-operation between amateur and professional astronomers. In this Presidential Address, I shall take stock of our current understanding of these fascinating binary systems, highlighting where amateurs can still contribute to pushing back the frontiers of knowledge. I shall also consider the sky surveys that are already coming on stream, which will provide near continuous and exquisitely precise photometry of these systems. I show that whilst these surveys might be perceived as a threat to amateur observations, they will actually provide new opportunities, although the amateur community shall need to adapt and focus its efforts. I will identify areas where amateurs equipped for either visual observing or CCD photometry can make scientifically useful observations.

About

Variable Stars South is an international association of astronomers, mainly amateur, interested in researching the rich and under-explored myriad of southern variable stars.

Renamed from the Variable Star Section of the Royal Astronomical Society of New Zealand, it was founded in 1927 by the late Dr Frank Bateson, OBE, and became the recognised centre for Southern Hemisphere variable star research.

VSS covers many areas and techniques of variable star research, organised into projects such as Beginners' Visual Observations and Dual-Maxima Miras. The goal of each project is to obtain scientifically useful data and results. These may be published in recognised journals, or supplied to international specialist data collection organisations.

VSS is entirely an internet based organisation, working through our website <http://www.VariableStars-South.org> and its e-group <http://groups.google.com/group/vss-members>. It also encourages members to work in with major international organisations such as the British Astronomical Association, the Center for Backyard Astrophysics and the American Association for Variable Star Observers.

To find out more, please visit our website, where, incidentally, you will find PDF copies of all our newsletters. Our website has a great deal of information for VSS members, and for anyone interested in southern hemisphere variable star research. All VSS project information and data is kept here too.

Who's who

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Treasurer/Membership Bob Evans

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After you've joined and received your membership certificate, you will be signed up to the VSS-members egroup (see above), and you will also receive a password to access the members' areas of our website.

Newsletter items

These are welcomed and should be sent to the Editor (phil@astrofizz.com) who prefers Microsoft Word (or compatible) files with graphics sent separately. Don't use elaborate formatting or fancy fonts and please do not send your contribution as a fully formatted PDF file.

Publication dates are January, April, July and October, nominally on the twentieth day of these months and the copy deadline is the thirteenth of the month though earlier would always be appreciated.

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