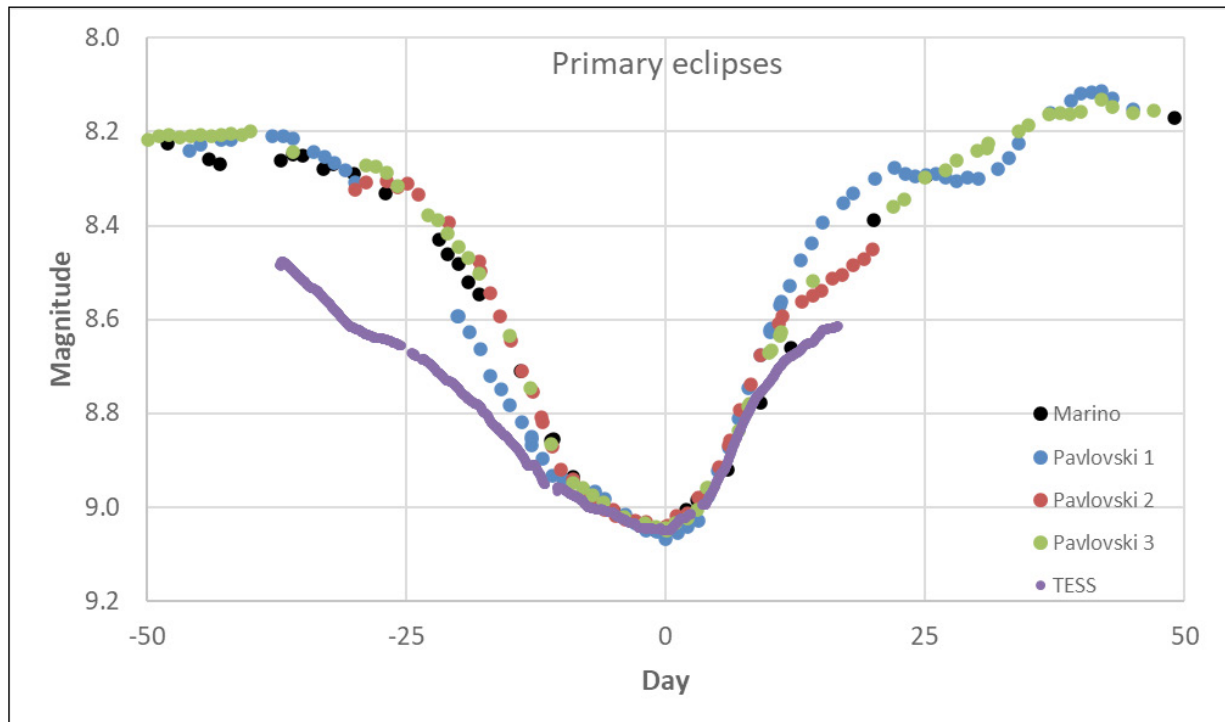




W Crucis (HD 105998) is an unusual beast. It is classified as a W Serpentis type binary, a rare class of Algol-like eclipsing binaries with high mass transfer rates, and prominent accretion discs surrounding and, in some cases, completely obscuring the mass-gaining component. The W Serpentis stars provide important clues to accretion processes and evolutionary history of Algol binaries. Combining light curve data from several observers with new data from TESS has enabled Mark Blackford to revise the O - C diagram for W Crucis. See Mark's article on page 6.

Contents

From the director — Mark Blackford	2
Active research in astronomy – Stan Walker	3
Resolving LMC V2536 and PSR B0525-66 – Mati Morel	4
Revised O-C diagram of W Crucis – Mark Blackford	6
Adding TESS data to the VSS EB database: a collaboration with the AAQ – Roy Axelsen	12
The VSS bright Cepheid project – an update –Stan Walker	16
Publication watch	24
About	26

From the Director – *Mark Blackford*

Welcome to the second edition of the Newsletter for 2023, in it you'll find articles by some of our regular contributors. Mati Morel's detective work clears up an historical confusion, Roy Axelsen describes a collaboration between VSS and the Astronomical Association of Queensland and Stan Walker has two items, a discussion about amateur research and an update of the VSS bright Cepheid project. The long period eclipsing binary W Crucis is the subject of my article in which observations from various photometric surveys are used to extend the O-C diagram to look for evidence of period change.

Congratulations to Andrew Pearce for his discovery of a bright transient in Scorpius on 2023 Apr. 20.6780 UT. Initially designated PNV J17224490-4137160 it was captured at 8th magnitude on images from a Canon 800D DSLR + 85mm lens. Spectroscopy has since confirmed it to be a nova and the permanent GCVS designation V1716 Sco has now been assigned.

In February/March this year my wife and I visited Antarctica. Apart from spectacular scenery and incredible wildlife encounters we were fortunate to experience a couple of reasonably clear, if rather chilly, nights. From Congarinni Observatory the large Magellanic Cloud never gets higher than about 50 degrees altitude, from the Antarctic peninsula it was at the zenith and very bright. Many knots of nebulosity were visible through 8x40 binoculars, but neck strain and imminent frost bight curtailed my observing session after just 15 minutes. At the end of our cruise, we experienced the surreal sight of the near-full moon scraping along the tops of impressive mountains surrounding Ushuaia, never more than a degree or two above the peaks.

Meanwhile, back in the normal world, the 2023 RASNZ Conference will be held over the Queen's Birthday Weekend from June 2nd to the 4th, hosted by the Auckland Astronomical Society (AAS). Variable Stars South members are encouraged to present their research via oral or poster presentations. I plan to be there and would love to catch up with other variable star observers.

If travelling to Auckland isn't an option, you might be interested in a workshop recently announced by AAVSO Director, Brian Kloppenborg, which will be held on the same weekend. The two day "Small Ground and Space Telescopes in the New Era of Big Telescope Surveys" workshop at the American Astronomical Society 242 meeting in Albuquerque NM will be a hybrid in-person/Zoom event.

Autumn has seen slightly improved observing conditions at Congarinni Observatory, although I haven't always been able to take advantage of them. The CCD camera on my 80mm refractor had to be returned for repairs due to a communication problem, I suspect it will be months before it is back in operation. In the meantime, I still have my larger photometry rig so observations will continue when conditions allow.

Wishing you all clear skies and good health,

Mark Blackford



Introduction

Our parent body, The Royal Astronomical Society of New Zealand, has recently conducted a survey of members' interest in the active observing field. There were 94 replies to a series of questions designed to find what telescopes and equipment were available, whether members were interested in serious observing with a purpose, who was doing this already, and a variety of other aspects relating to participation in observing within the scope of amateur abilities. There were some professional replies as well.

Some of our members are already active in various areas apart from variable stars: exoplanets, asteroid and minor planets, SETI, and others but these areas are not ideal as there is not general involvement. When was the last time that we saw an article in our newsletter describing such activities or what they are seeing? Amateur involvement is a convenient source of good measures at little cost to the professional project organiser.

An additional aspect of the survey was a trio of Zoom meetings in early April in which groups of eight or nine members discussed any aspects related to active observing, or "Observe with Intent" as the RASNZ president, Nalayini Davies has called the initiative. Most of those involved in such meetings were enthusiastic. It was clear, however, that what to observe was the important question. Zooniverse was mentioned as was SETI but neither of these provide a satisfying sense of involvement or, once again, items in our newsletter.

Selection of research projects

What appears to be lacking are projects of the type that Variable Stars South is based on - observations which are scientifically valuable and which provide satisfying and publishable results within an acceptable time span. There is no shortage of these in the eclipsing binary field but outside this it's not so easy to find useful targets. Over the past two years the massive multiple system of QZ Carinae has been the subject of several more papers as mentioned in the section's annual report to the RASNZ and it now appears that the light time effects defining the orbit of the two major pairs in this system are now being repeated, defining the "long period" of 42.045 years. A good result.

Projects in the traditional amateur field of Miras and other pulsating variable stars are not as easy to find. About a thousand of these stars have been observed for ~150 years, some much longer, and evolutionary period changes found in less than a dozen. Not a satisfying result. But the research is now shifting to unusual behaviour – I've been interested in several of these for more than 50 years – and can see possible useful projects in two or three areas. One of these, the measures of long period Cepheids, is outlined elsewhere in this newsletter. This and another on Miras with dual maxima – which may represent a short-lived evolutionary phase - will be presented as poster papers at this year's RASNZ conference in Auckland.

But there must be opportunities elsewhere. We had a very interesting review of B emission stars last year – can something be set up in this area? And others, not necessarily in the VS area? Has anyone ideas – either of new projects, or of providing help to make existing projects more attractive?

ProAm cooperation

A little over two years ago the International Astronomical Union set up a working group to promote this type of activity. A survey was carried out – many of our members answered this – but what is happening? Apparently, nothing.

We have been fortunate in the past in that we have received help and ideas from professional astronomers both in New Zealand and overseas – Bruce Slee, Brian Warner, Michael Bessell, Joseph Patterson and in NZ, Karen Pollard and Peter Cottrell from Canterbury, Robert White and Alec Chisholm from Auckland and a variety of graduate students who worked with us on various projects. Most effective, however, has been Edwin Budding who, since the early 1980s, has collaborated with amateurs, mainly on a variety of observing projects on binary stars, his specialty. I have recently worked with him on two

major reviews, one of which about QZ Carinae has just appeared in the May newsletter of the RASNZ. Seems May is a little early this year!

Amateurs need this collaboration. Firstly in selecting a suitable project, then discussing its ongoing results, finally in working up a paper or presentation and selecting the conference or publication for its presentation. But those who wish to enjoy such a collaboration need to be aware of what is happening in the amateur areas. I have been working in another area with Ed Budding and this involved a study of the Auckland observers' work in the decade or two after the Observatory was opened in 1967. What was impressive was not the level of research but how well this was communicated to those involved in New Zealand and elsewhere on the amateur scene.

Now it seems that I must read Mark Blackford's section report to the RASNZ to find out what many of our members are doing. I didn't feature in this because at my age I no longer observe.

So in order to set up our end of a ProAm collaboration we need to be more aware of what is being done by members of VSS on an ongoing manner. Phil Evans produces a good quarterly newsletter but he needs more frequent information to publish. We must all help and by so doing help the respondents in the RASNZ survey to make Nalayini's vision of "Observing with Intent" a reality.

Resolving LMC V2536 and PSR B0525-66 – *Mati Morel*

mmorel7@bigpond.com

Abstract

Using images from HST and Chandra X-Ray Observatory I have studied the question of whether LMC V2536 and PSR B0525-66 are related, or identical as implied by older references. The extraction of more precise positions shows conclusively they are separate and not related.

Introduction

Brief bursts of X-rays and gamma rays from deep space have been known since the 1960s. However the ability to obtain useful images was limited as the bursts were not accompanied by a definite optical signal, and the source was almost impossible to identify. On 1979 March 5 the most intense gamma ray burst ever recorded was detected by multiple satellites, and was found to be located in the LMC Supernova remnant, commonly known as N49. For a non-technical report on the burst, known as GRB 790305 see *Sky & Tel April 1980 p294*. It was eventually found that the gamma ray burst was coincident with an X-ray pulsar and Soft Gamma Ray Repeater (SGR). As sky positions could not be specified with high precision one would tend to point to their location as an "error box". In the early 1980s an understanding of the mechanism behind these bursts began to develop (See *Sky & Tel June 1982 p562*). The source was unknown, and no useful wide-field images could be obtained and sky coordinates were only approximate. The only approach was to examine all stars within the error box for anything spectroscopically unusual, or showing optical activity.

PSR B0525-66 = GRB 790305

A search of SIMBAD turns up a long list of references (and aliases). The given coordinates are apparently only approximate as: (J2000) 05:26:00.7 -66:04:35. We now know that this object is an X-ray pulsar (XPSR), a rapidly spinning, strongly magnetized neutron star with a stream of gas being drawn towards the poles. The neutron star has no thermonuclear processes of its own, to speak of, and cannot be observed in optical wavelengths at considerable distance, such as the LMC. There are many subtypes of XPSRs.

LMC V2536

GCVS Vol V data: (J2000) 05:26:00.07 -66:04:37.5 Range 7.2 -15:V The data results from a search for GRB 790305, or optical counterpart, in the early 1980s. The Remarks section in GCVS Vol. V gives a concise summary of reported V and B magnitudes. But, as we now know the XPSR cannot be seen in

the optical. The GCVS states that LMC V2536 is the same as GRB 790305, but this is incorrect. They do provide useful clues to the star's location, to quote: "*The star 3, with multicomponent structure, in the error box may be variable in the range 14.8 - 16:B Optical flares up to 8.^m.7 were reported.*" An examination in detail of a HST image (optical), shows that the GCVS description and coordinates match a compact group of 6 or 7 faint (19mag?) stars, superimposed on a bright filamentary "structure". One of them, "3" is said to be the variable. Only on the images can the stars be resolved. Otherwise the group will appear as a fuzzy blur of magnitude 15-16. The precise location of star 3 in the group is unclear at this stage.

Chandra X-ray image

The Chandra X-ray Observatory was launched in June 1999, with an expected life of 5 years. In 2022 it was still operational. With its advanced systems it is capable of producing direct images of X-ray bursts. One of the images of N49 is in the public domain and shows the XPSR in outburst, labelled "point source". See Figure 1. This downloaded image has been cropped to show the relevant region, the northern half of N49. Chandra and HST images have been used to extract more precise positions for the objects of interest, relative to Gaia DR3 stars.

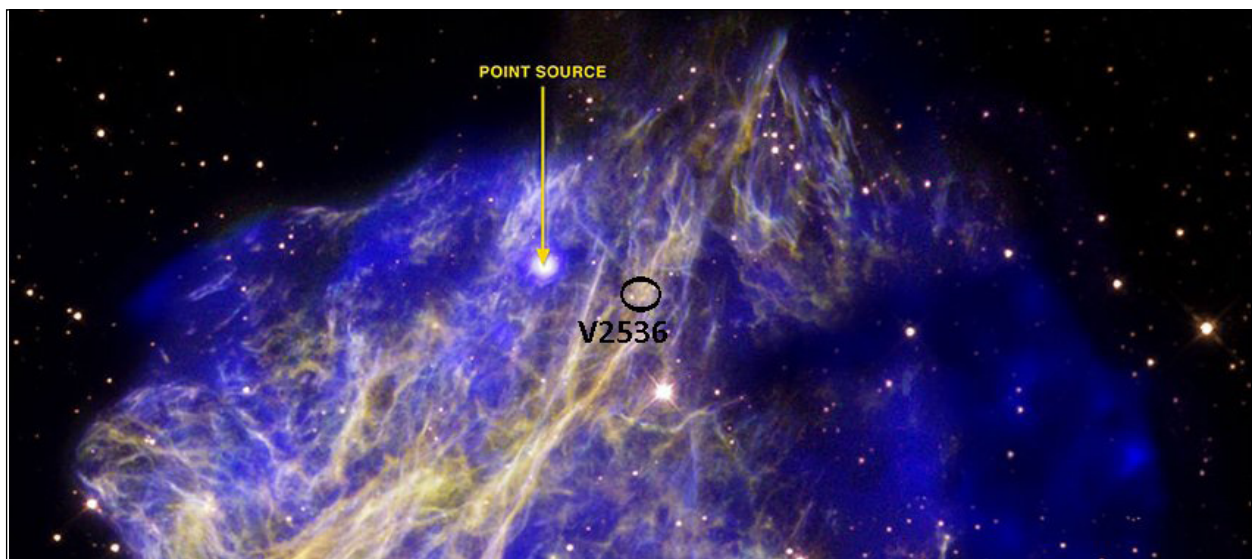


Figure 1. Chart for the SNR N49 (northern half), indicating LMC V2536 (circled) and the pulsar PSR B0525-66 "point source". North is at top. Adapted from Chandra X-ray Obs. image.

Improved positions

LMC V2536 (group centre) (J2000) **05^h25^m59.65^s -66°04'38.7"**

PSR B0525-66 = SGR0525-66 " **05 26 00.96 -66 04 36.3**

Conclusion

The two objects studied are quite separate. It is possible that the group of stars circled in Figure 1 belong to a star cluster *behind* the SNR, but this is beyond the scope of this study.

Introduction

W Crucis (HD 105998) is an unusual beast. It is classified as a W Serpentis type binary, a rare class of Algol-like eclipsing binaries with high mass transfer rates, and prominent accretion discs surrounding and, in some cases, completely obscuring the mass-gaining component. The W Serpentis stars provide important clues to accretion processes and evolutionary history of Algol binaries.

The high mass-transfer rate of W Serpentis stars should lead to high rates of period change as mass and angular momentum are transferred from the mass-losing to the mass-gaining component. To determine the rate of period change we need to measure times of eclipse minima over many years and construct an Observed minus Calculated diagram, as I've explained in several articles in previous editions of this newsletter. Figure 1 shows the O-C diagram of W Crucis from the O-C Gateway website with all available times of minimum, the earliest being 1886 from photographic plates and the most recent being 2001 from All Sky Automated Survey (ASAS) CCD images. I set out to update the O-C diagram using archival survey data.

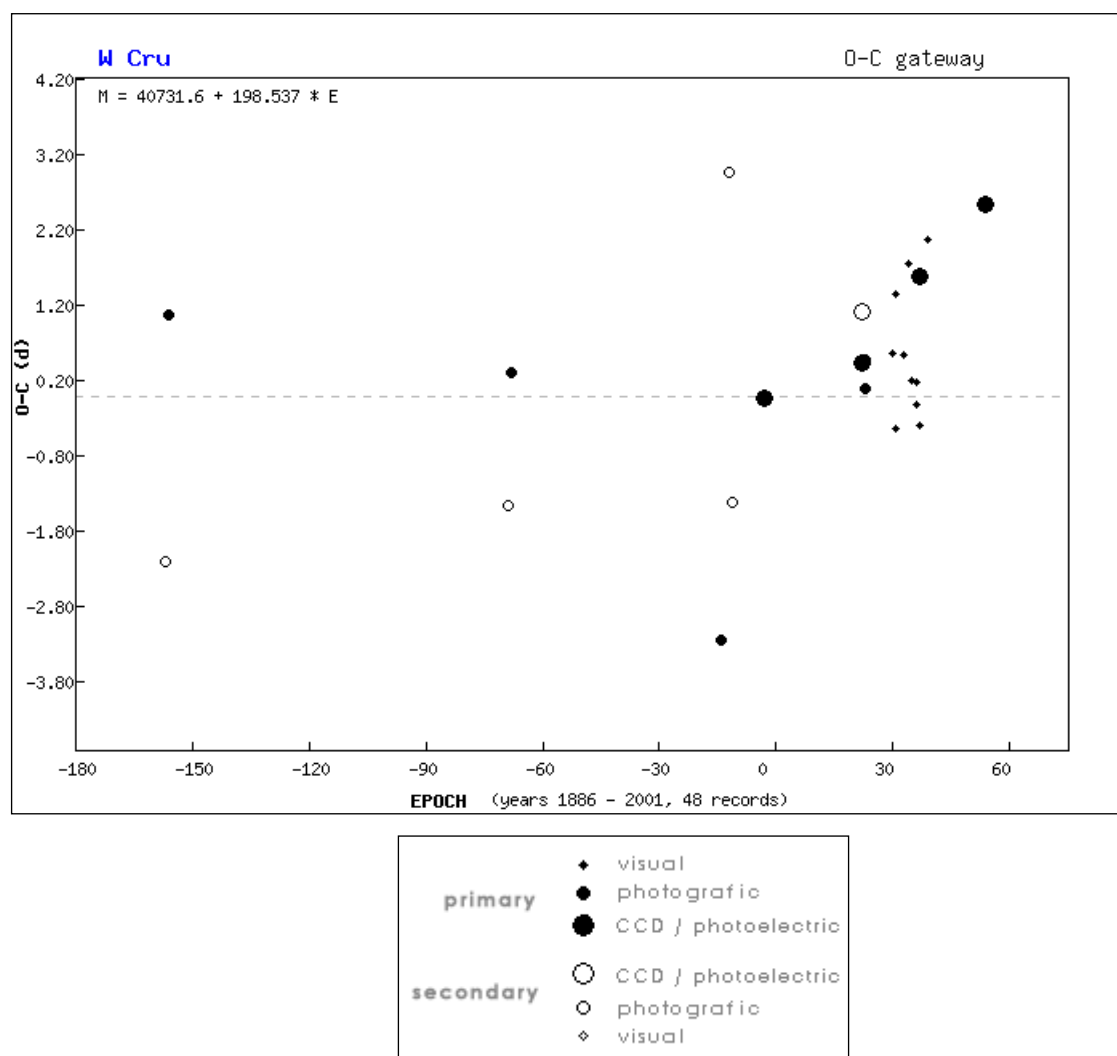


Figure 1. Observed minus Calculated diagram of W Crucis from the O-C Gateway website (<http://var2.astro.cz/ocgate/>)

Historical photographic observations

The nearly 200-day period of W Crucis, the longest of all the W Serpentis stars, makes it a difficult target for photometric study. The earliest light curve (Figure 2) was determined by Henry Norris Russell

measured from photographic plates recorded in the 1880s (Russell, 1912). A photographic light curve by Father O’Connell was reported in Kopal (1940), showing a similar coarse sampling.

Better coverage of a primary eclipse was reported by Menzies & Jones (1984), and Kohoutek (1988) reported one primary and two secondary times of minimum measured from archival plates but did not publish a light curve.

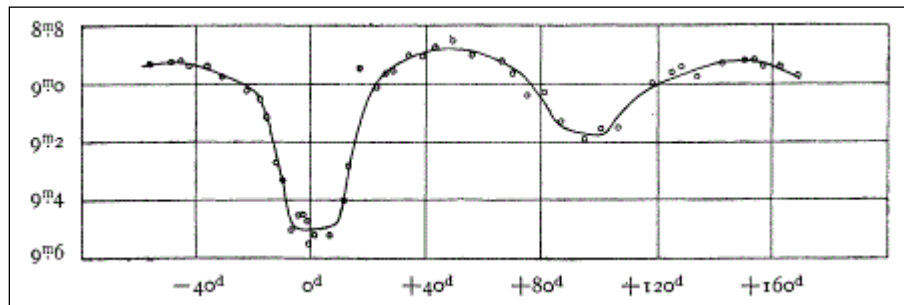


Figure 2. *Photographic light curve of W Crucis from Russell (1912).*

Historical photometric observations

Brian Marino and former VSS director Stan Walker were the first to record relatively complete light curves. Their UBV observations were made between 1984 and 1985 (Marino, Walker and Budding, 1988), one primary and one secondary eclipse time of minimum were determined from these. The phased V light curve is shown in the upper left panel of Figure 3.

Pavlovski et al. (2006) published light curves in 7 pass bands from observations recorded between 1984 and 1989, however they did not report any times of minimum. The observations are available online at the Strasbourg astronomical Data Center (CDS) website. A total of 386 V band observations were recorded, including good coverage of 3 primary and one secondary eclipse. The phased light curve is shown in the top right panel of Figure 3.

The Hipparcos satellite recorded 149 observations between 7/12/1989 and 23/2/1993, however, there were few data points during primary eclipses, middle left panel of Figure 3.

Between 30/11/2000 and 13/8/2009 the All-Sky Automated Survey (ASAS-3) recorded 702 observations, middle right panel of Figure 3. Unfortunately, W Crucis is too bright for the All-Sky Automated Survey for Super Novae (ASAS-SN).

A total of 3398 observations were made by the Optical Monitoring Camera (OMC) on the INTEGRAL satellite between 2/3/2003 and 5/8/2022, bottom panel of Figure 3.

Secondary eclipses are relatively shallow and broad, therefore I decided to only use primary eclipses from photographic, photoelectric photometer (PE) and CCD studies. I do not have access to original observations prior to the 1984 Marino et al. data so I used the OC Gateway epochs for these. I would appreciate hearing from anyone with knowledge of other photometry surveys with suitable quality and quantity of observations of W Crucis.

TESS observations

TESS observed W Crucis in 2019 (sectors 10 and 11) at 30-minute cadence, and again in 2021 (sectors 37 and 38) at 10-minute cadence. The data were processed by the Quick-Look Pipeline (QLP) which produces two light curves. The first uses Simple Aperture Photometry (SAP) and involves minimal processing. The second, called Pre-search Data Conditioning SAP (PDCSAP), removes long term trends in the data, rendering the PDCSAP data useless for long period variables. Therefore, I used the SAP data for this study.

Processing of TESS data is optimised for detection of exoplanet transits, not for light curves of long period variables. Each sector is divided into two halves and each half is processed separately which results in magnitude offsets in Simple Aperture Photometry (SAP) light curves of long period variables such as W Crucis. Blue data points in Figure 4 are raw SAP light curves showing these offsets. Red data points show the light curves after correcting offsets.

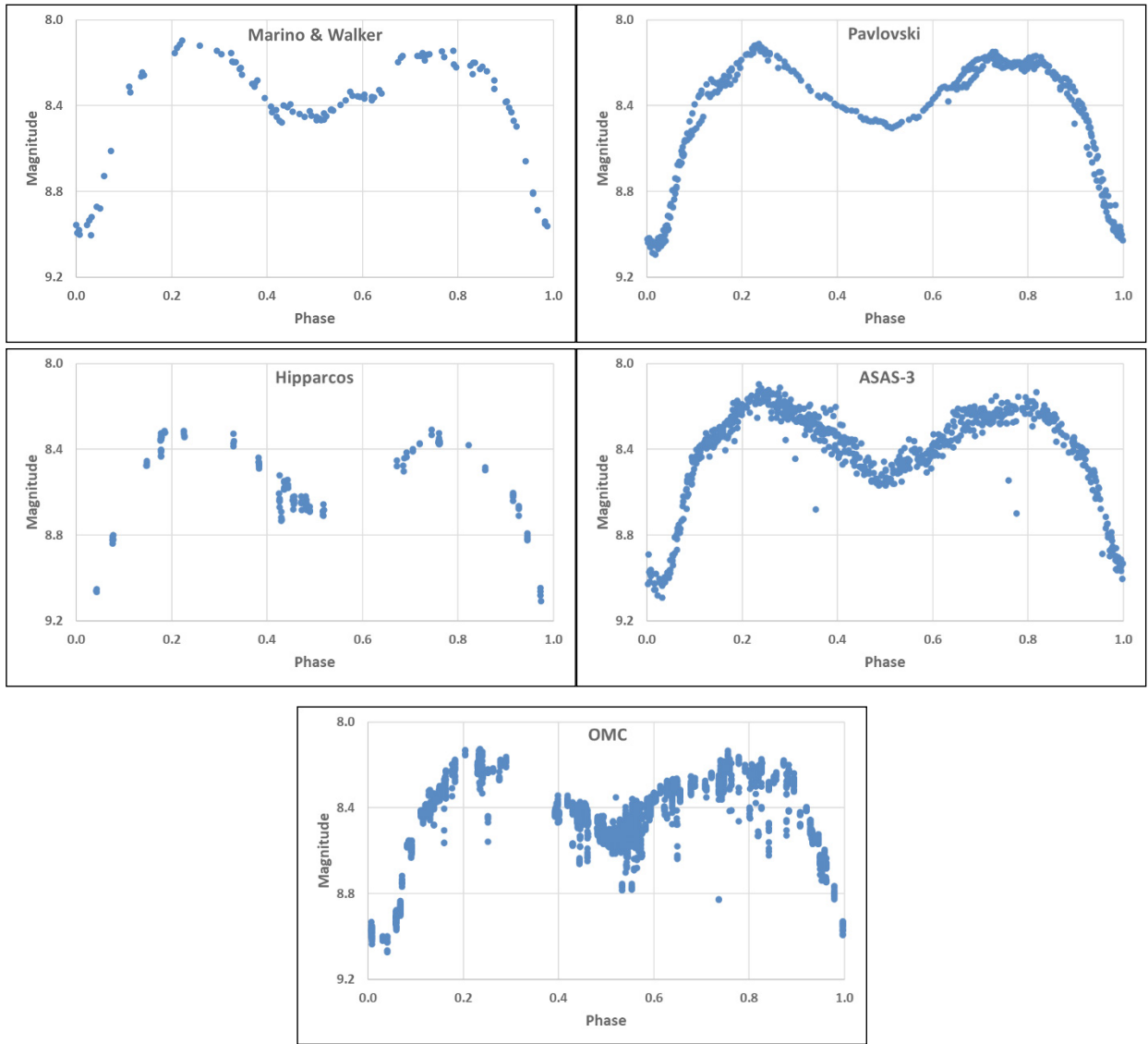


Figure 3. Light curves from various photometric survey archives, phased using period 198.53 d and epoch 2440731.6 HJD listed in the AAVSO's Variable Star Index (VSX).

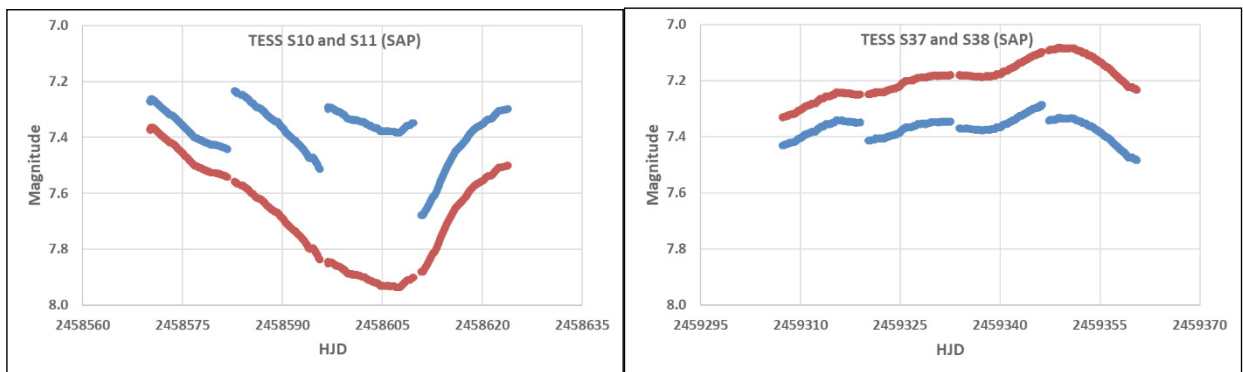


Figure 4. TESS light curves recorded in 2019 (left) and 2021(right). Raw observations are shown in blue and corrected observation in red.

Sectors 10 and 11 coincided with a primary minimum, sectors 37 and 38 cover the maximum preceding a primary eclipse. There is a low frequency variation superimposed on the eclipsing binary light curve. Figure 5 shows the phased SAP light curve for all four sectors.

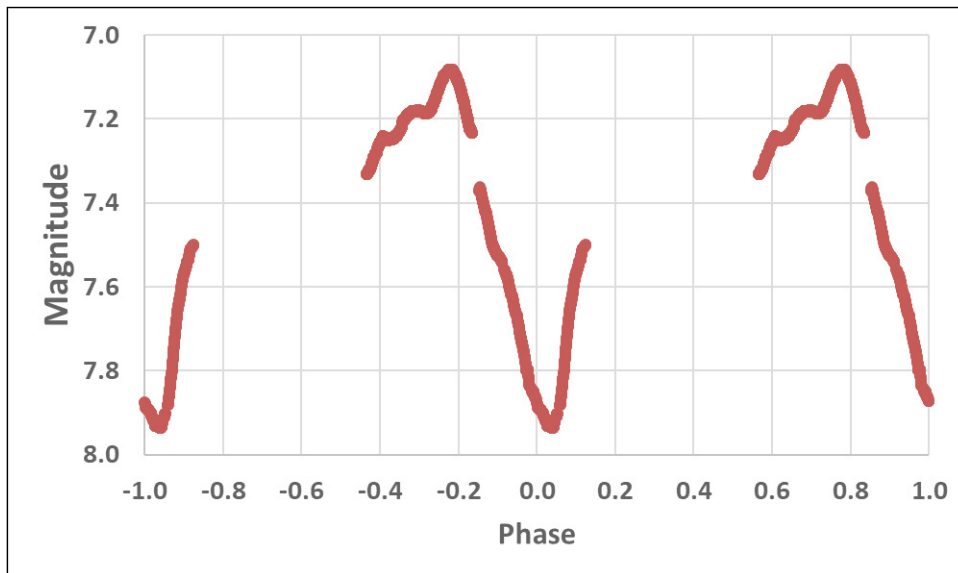


Figure 5. *TESS light curve phased using the VSX period and epoch.*

W Cruxis is scheduled to be observed again in Sector 64 between 2023-Apr-06 and 2023-May-04, covering phases 0.25 to 0.4, approximately.

New Times of Minimum

Measuring times of primary eclipse minima is complicated by the asymmetric shape of the light curves as seen in Figure 6 which plots the Marino & Walker, Pavlovski and TESS observations superimposed. The Marino & Walker and TESS light curves are vertically shifted to align with the minimum magnitude of the Pavlovski light curves.

In the interval -9 to +9 days either side of primary minimum, all 5 light curve shapes are quite similar, despite the TESS observations being more than 30 years after the Marino & Walker and Pavlovski observations. I therefore used just that range to determine the time of minimum for each primary eclipse (Table 1). No attempt was made to measure secondary eclipse times of minima.

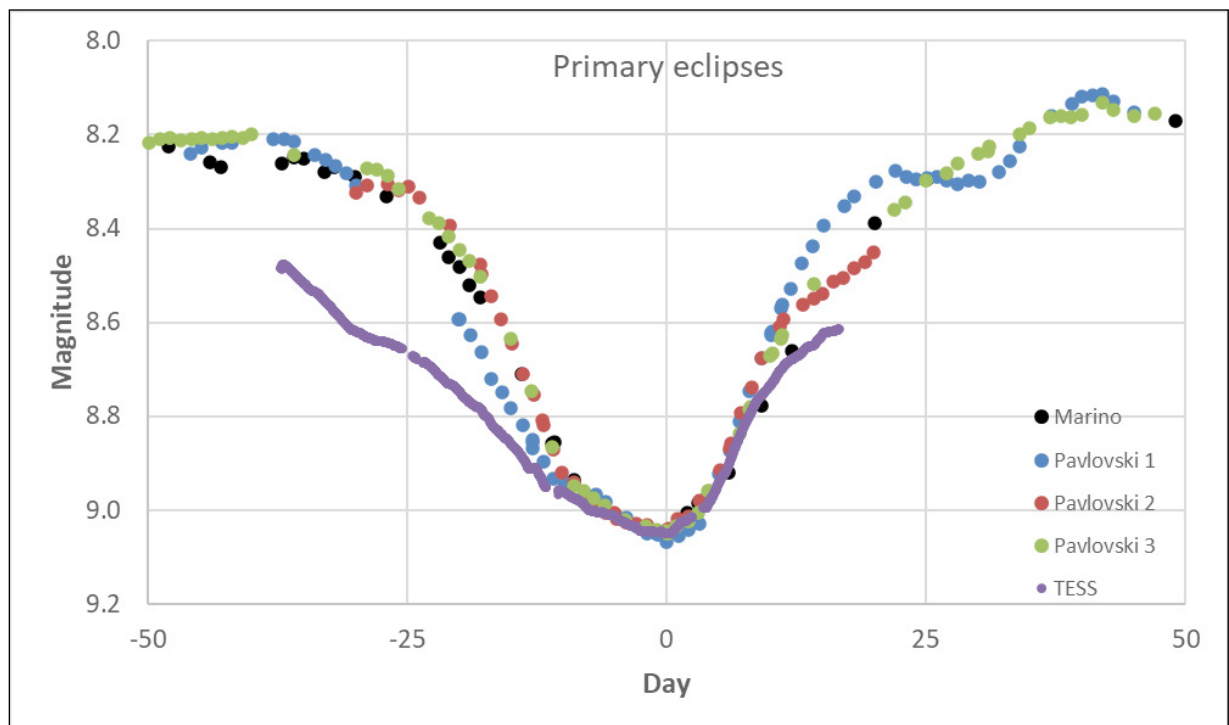


Figure 6. *Marino et al. (1988), Pavlovski et al. (2006) and TESS primary eclipses superimposed to show cycle to cycle variations.*

Minima of individual primary eclipses observed by Marino & Walker, Pavlovski and TESS were measured by polynomial fitting in Peranso.

Epochs of primary minima of the Hipparcos and ASAS-3 observations were measured using the sparse photometry technique I described in the January 2022 VSS Newsletter. ASAS-3 observations were split into 3 roughly equal time periods. One epoch was determined from OMC observations between 2016 and 2022. Data listed in Table 1 were used to construct the O-C diagram in Figure 7.

Table 1. Epochs of primary minima used for the O-C diagram in Figure 6. Epochs remeasured for this study from historical observations and survey archives are in the lower part of the table. The O-C values were calculated using $E0 = 2440731.6\text{HJD}$ and period 198.537d .

HJD	Error (d)	O-C	Cycle	Technique	Observer/Source
2410158.00		1.10	-154	pg	Russell/OC Gateway
2427628.50		0.34	-66	pg	OConnell/OC Gateway
2438544.50		-3.19	-11	pg	Kohoutek/OC Gateway
2445893.70		0.14	26	pg	Menzies/OC Gateway
2440731.60		0.00	0	pe	Knipe/OC Gateway
2445695.50		0.48	25	pe	Kviz/OC Gateway
2445894.55	1.16	0.99	26	pe	Marino/MGB
2446096.79	0.40	4.69	27	ccd	Pavlovski 1/MGB
2446491.74	0.65	2.57	29	ccd	Pavlovski 2/MGB
2447683.81	0.50	3.41	35	ccd	Pavlovski 3/MGB
2448277.96	1.03	1.95	38	ccd	Hipparcos/MGB
2452449.96	1.34	4.68	59	ccd	ASAS3 part 1/MGB
2453442.83	1.15	4.86	64	ccd	ASAS3 part 2/MGB
2454634.49	0.95	5.30	70	ccd	ASAS3 part 3/MGB
2458407.78	0.60	6.39	89	ccd	OMC/MGB
2458606.80	0.20	6.87	90	ccd	TESS/MGB

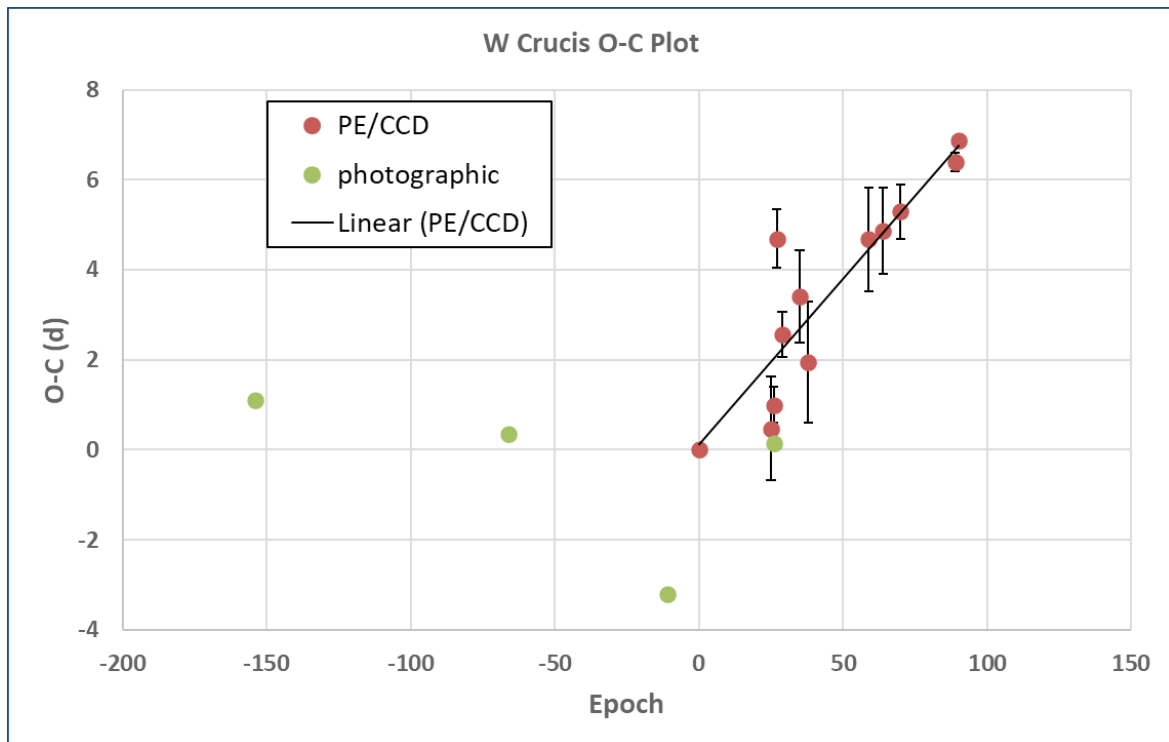


Figure 7. Updated O-C diagram for *W Crucis* using primary eclipse epochs listed in Table 1.

The PE/CCD datapoints in Figure 7, although showing significant scatter between epochs 25

and 38, lie on an upward sloping line. This suggests the true period of the eclipsing binary was slightly longer than the 198.537d period used to calculate O-C values.

The most precise epoch is that derived from TESS data, 2458606.80(0.20) HJD, and linear regression of the PE/CCD data in Table 1 yields a period of 198.610(0.014)d. Therefore, I propose the following revised light elements for predicting future primary minima times:

$$\text{Primary} = 2458606.80(0.20) \text{ HJD} + 198.610(0.014)\text{d} \times E$$

The latter two photographic datapoints are reasonably consistent with the PE/CCD trend, however, the two early photographic datapoints are not.

Conclusions

If the photographic epochs are reliable the O-C diagram could be explained by a change in the orbital period. However, the Russell and O'Connell light curves were only coarsely sampled which would lead to relatively large uncertainties in the reported times of minimum. Therefore, it is probably best to treat the early photographic data as suspect.

Clearly more data is required to determine if period change is occurring due to mass exchange between the component stars. The next primary eclipse is predicted to occur on August 31st, 2023, followed by March 17th and October 1st, 2024.

Ideally, observations should be made once or twice per night for at least 3 weeks either side of minimum.

Acknowledgements

This research made use of the AAVSO VSX database and the SIMBAD and VIZIER databases, operated at CDS, Strasbourg, France and of NASA Astrophysics Data System Bibliographic Services. This paper includes data collected by the TESS mission, which are publicly available from the Mikulski Archive for Space Telescopes (MAST), as well as Hipparcos, OMC, ASAS-3 and ASAS-SN data.

References

- Kohoutek, L., 1988, Information Bulletin on Variable Stars, No.3272
- Kopal, Z., 1940, Harvard College Observatory Circular, vol. 441, pp.1-11
- Marino, B. F., Walker, S. G., & Budding, E. 1988, Ap&SS, 150, 103
- Menzies, J. W. & Jones, J. S., 1984, Information Bulletin on Variable Stars, No. 2623
- Pavlovski, K., Burki, G., & Mimica, P. 2006, A&A, 454, 855
- Russell, N. H., 1912, Astrophysical Journal, 36, 133-155

Adding TESS data to the VSS EB database: a collaboration with the Astronomical Association of Queensland – *Roy Axelsen*

royaxelsen7@gmail.com

Variable Stars South (VSS) has a database of nearly 200 eclipsing binary (EB) stars, many of which have been the subjects of publications. The majority of the observations comprise light curve data and times of mid eclipse for both primary and secondary eclipses, and have been contributed by VSS members. There are also data from TESS, but at the time this project was commenced in early 2023, TESS observations had been uploaded for only a minority of stars. The addition of further TESS data would be valuable, but with so many binaries in the database assistance in finding and adding the data would be an advantage. An invitation was therefore extended to members of the Astronomical Association of Queensland (AAQ) to participate in such a project. It was considered that a further benefit of the invitation was that amateur astronomers could have an involvement in variable star research without having to navigate the learning curve involved in undertaking photometry. This paper describes the collaboration, and an unexpected early benefit.

At the time of writing AAQ members Peter Culshaw and Brent Joyce have been participating actively in the project for several weeks.

Methods

The author maintains a database of VSS eclipsing binaries, which for this project are sorted alphabetically first by constellation then by variable star name. Working alphabetically through the database, the author allocates eclipsing binaries in groups of ten to each of the volunteers, who then query the light curve and period analysis software Peranso (Paunzen and Vanmunster, 2016) for TESS data on these stars. Each set of data from TESS covers approximately one month of observations, mostly with a cadence of 2 minutes, comprising approximately 16,500 to 18,500 observations. From each such set, mid eclipse times of primary and secondary minima from near the start, middle and end of the data are determined, resulting in 6 minima timings for each set.

Figures 1 to 6 demonstrate the steps in Peranso taken to display and measure TESS light curves. Figure 1 is the display after File > New is selected, in which any one of more than a dozen public access databases can be chosen after clicking the icon at the top marked with a red circle. The TESS option is near the bottom of the list, also marked in red.

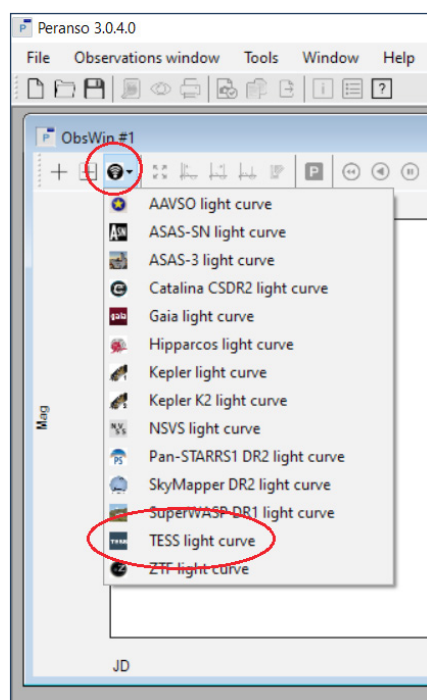


Figure 1. Selection of TESS light curve in Peranso.

After a TESS light curve is selected from the list on the left of the window shown in Figure 1, the window shown in Figure 2 is displayed. The Star name is entered, or, if previously found, selected from the pick list above the Star name box. It is important that the Search radius is kept small, and 3 arcsec is the size routinely chosen. Among Additional fields, the buttons for Raw (SAP) and Brightness as Magnitude are checked. After the Plot command is clicked, and if TESS data is available for the star, the window shown in Figure 3 is displayed. If no TESS data can be found, a pop up text box to that effect appears.

Figure 2. The star name is entered, and the Plot command clicked.

Figure 3 shows the window listing the datasets available for the star. For some stars, only one set may exist. Importantly, note the first column, TIC (TESS Input Catalogue) id, which should be checked in SIMBAD (<https://simbad.u-strasbg.fr/simbad/sim-fid>) to be sure that it corresponds (in this case) to CY Hyi. If the Search radius (box shown in Figure 2) displays a value which is too large, such as 15 arcsec, a star other than the desired target may be displayed. Click the check box in the Import column on the right against the set of data you wish to display, then click the Apply button at the bottom left. The light curve for the chosen data set will be displayed (Figure 4).

TIC id	Median mag	Median mag err	Sector #	Type - #Obs	Start & End date	Import
31655792	8.966	0.0126	27	(2 min): 16560	2020-07-04 .. 2020-07-30 (26d)	☒
31655792	8.966	0.0126	2	(2 min): 18720	2018-08-22 .. 2018-09-20 (29d)	☐
31655792	8.966	0.0126	1	(2 min): 18000	2018-07-25 .. 2018-08-22 (28d)	☐
31655792	8.966	0.0126	3	(2 min): 18000	2018-09-20 .. 2018-10-18 (28d)	☐

Figure 3. After the action taken in Figure 2, if TESS data on the chosen star exists, a table of results is displayed. To display a light curve of one of the listed datasets, check the corresponding box in the Import column, the last on the right.

The light curve window shown in Figure 4 is displayed at a small size for this article, and the portion of the light curve shown is a very small part of the entire curve. In practice, the window would be maximised.

The left and right panels of Figure 5 and the legend for this figure illustrate and describe the steps taken to select a segment of the light curve for the fitting of a polynomial function to determine the time of mid eclipse, taken as the time corresponding to the minimum value of the function (i.e., the magnitude at minimum brightness). The portion of the light curve to be measured is delimited by left and right margin cursors, the positions of which are set by the user with mouse clicks. The left mouse cursor icon is selected first, then a mouse click positions the cursor on the light curve. This is repeated for the right margin cursor. For precise light curves from TESS such as that shown here, only a small portion of the curve need be measured, and a low order polynomial function (typically 4th degree) can be selected.

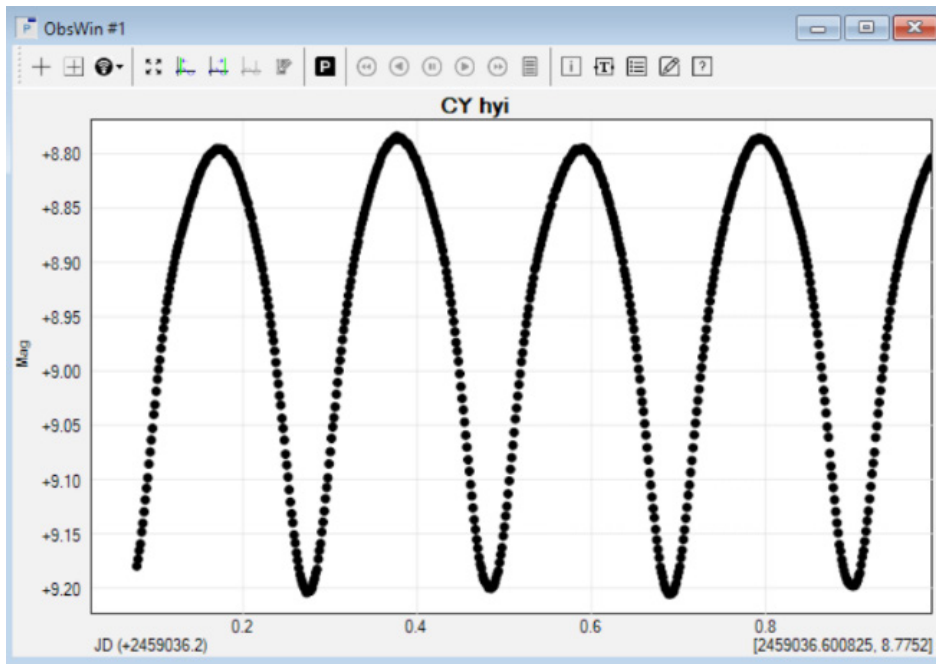


Figure 4. After the action taken in Figure 3 is completed, a light curve is displayed. This figure is zoomed in to show only the first two cycles.

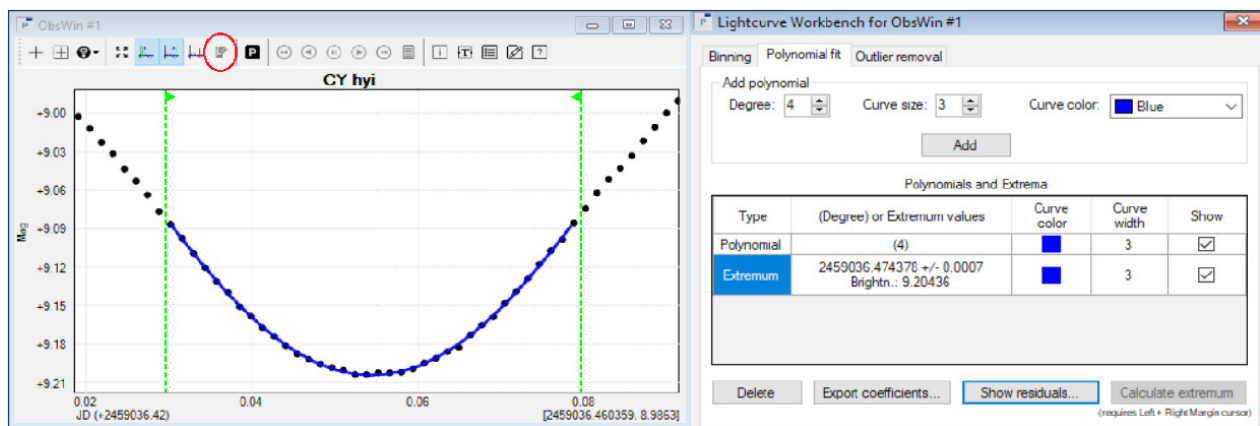


Figure 5. After zooming in further on the light curve as shown in the left panel, the left and right margin cursors are set by clicking the two icons (highlighted in light blue near the top of the window). The display on the right appears after clicking the Lightcurve Workbench icon (circled in red, left panel). Here, a 4th degree polynomial fit has been selected, and the Add button (shown just below the centre top of the right panel) clicked. The blue fitted polynomial function is overlayed on the light curve. The next step is to click the Calculate extremum button at the bottom right of the right panel, which then displays the time of mid eclipse in JD and the error of the estimate.

At the time of writing this paper 67 eclipsing binaries from the VSS database have been allocated to the volunteers for study. Peranso found no TESS data for 35 stars. Data for 22 stars has been uploaded to the VSS database, and data for several further stars have been found and recorded but not yet uploaded.

An unexpected result was found by Brent Joyce when he recognized that the TESS light curve for X Cae was not that of an eclipsing binary star (Figure 6). This is the pattern of a delta Scuti star with multiple pulsational frequencies. The nature of this star has been known for some time (Mantigazza et al, 2000), but the Variable Star Index (VSX) of the American Association of Variable Star Observers (AAVSO) listed it as an eclipsing binary. The AAVSO was notified of the error, and the VSX now correctly lists it as a delta Scuti variable.

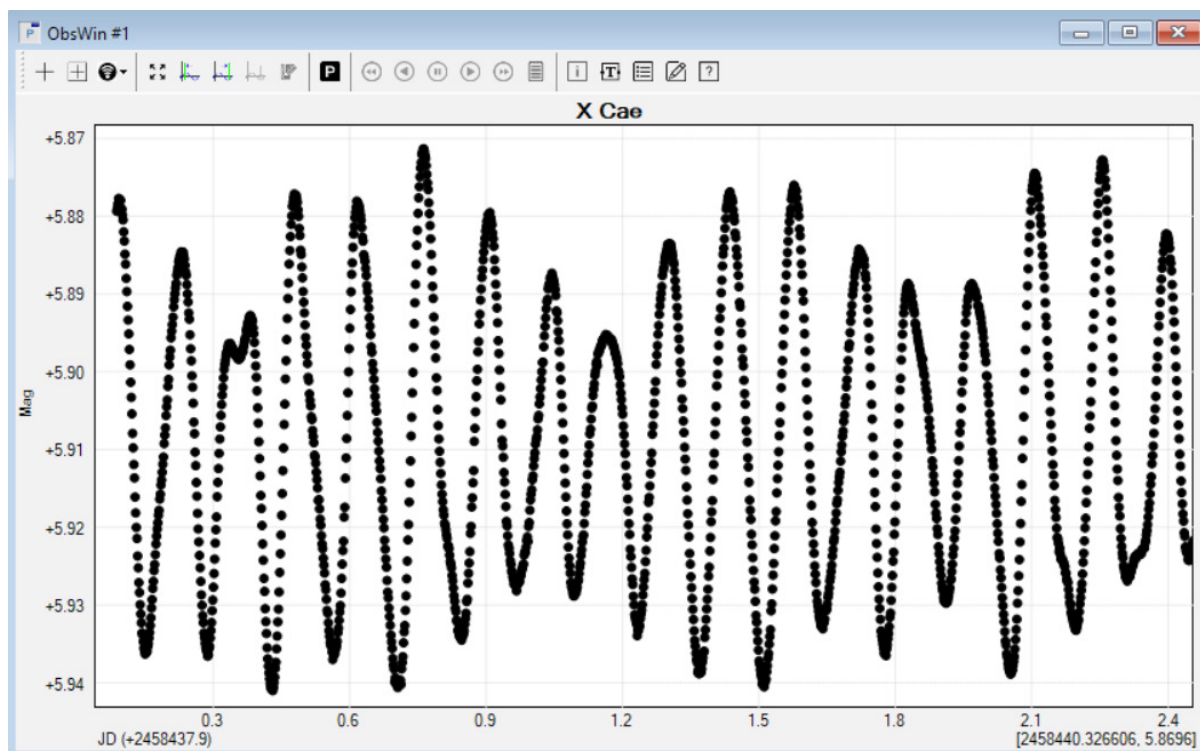


Figure 6. Part of the TESS light curve of *X Cae*. Results

Discussion

A procedure for accessing TESS light curves was described in a previous edition of this newsletter (Blackford, 2021). It involved downloading TESS data folders from the MAST Portal (<https://mast.stsci.edu/portal/Mashup/Clients/Mast/Portal.html>), unzipping the folders, saving the files to disc, and accessing those files using the Kepler/TESS plugin for VStar, the light curve analysis software of the American Association of Variable Star Observers. The procedure in Peranso is simpler, requiring a one-click operation to download the list of available files once the star name is entered in a search box. A further two clicks display the light curve. There are other differences between the VStar and Peranso approaches. Peranso provides an estimate of the error of the calculated time of mid eclipse, whereas VStar provides the root mean square of the residuals from the polynomial fit. Peranso converts the TESS BJD_TDB (barycentric Julian date, barycentric dynamical time) into JD_UTC. VStar downloads the TESS BJD_TDB times unchanged. In both cases, the times must be converted to HJD_UTC prior to uploading into the VSS database. VStar is freely available to anyone, whereas Peranso requires the purchase of a licence for €26.

It is unfortunate that a substantial fraction (more than half, at the time of writing) of the eclipsing binaries in the VSS database cannot be found in TESS by Peranso. These stars can be surveyed via the MAST portal which allows the TESS database can be queried directly, but a systematic search using this strategy has not yet been carried out. In the process of solving a problem which occurred when the search radius was inadvertently set too large in Peranso, data for one star not identified in Peranso was in fact found by implementing a search in the MAST portal.

Conclusion

A project to increase the number of eclipsing binaries with TESS data in the VSS database has so far proven successful. Motivated volunteers provide the resources necessary to find and download the data, which is subsequently uploaded by a VSS member familiar the structure of the eclipsing binary database. Just under one third of the eclipsing binaries in the database have been allocated and surveyed, even though the project only commenced early this year (2023). Unfortunately, more than one half of the VSS stars surveyed proved to have no TESS data identifiable by the software Peranso. An early unexpected bonus of the project was the finding that *X Cae*, a star identified for some years in the AAVSO's Variable Star Index as an eclipsing binary, is in fact a delta Scuti star.

Acknowledgments

The valuable assistance of Peter Culshaw and Brent Joyce, members of the Astronomical Association of Queensland, is gratefully acknowledged.

This research made use of Peranso (www.peranso.com), a light curve and period analysis software.

References

Blackford, M., 2021. Variable Stars South Newsletter, October 2021, page 12.

Mantegazza, L., Zerbi, F.M., and Sacchi, A. 2000. A&A, 354, 112-124.

Paunzen, E., Vanmunster, T., 2016. Astronomische Nachrichten 337, 239-246

The VSS bright Cepheid project – an update –*Stan Walker*

astroman@xtra.co.nz

Introduction - the purpose and value

This project for visual observers combines simplicity with genuine astronomical research and will provide valuable information about the period variations of these massive pulsating stars. The observations can be made with binoculars in many cases although a small telescope may provide a steadier mount. The project is ideal for the observer who likes to see the sky whilst he observes – alternatively for beginners in the field of serious observing.

We are studying the period changes in these stars caused by evolution. Whilst this is on astronomical time scales of millennia or more these changes can be arranged in patterns (the Hertzsprung-Russell diagram is a good example) which show us at what stage a particular star's evolution has reached. Comparison of events on a number of stars will then map out a pattern of evolution for stars of a particular type, in this case massive Cepheids.

U Carinae, the fourth discovered variable star in Carina, is a good example. A seasonal light curve is our first illustration. This comprises 96 measures made during a season. What we are seeing here is a change in the brightness of the star caused by shock waves generated by the ionisation and recombination of helium deep in the stellar interior.

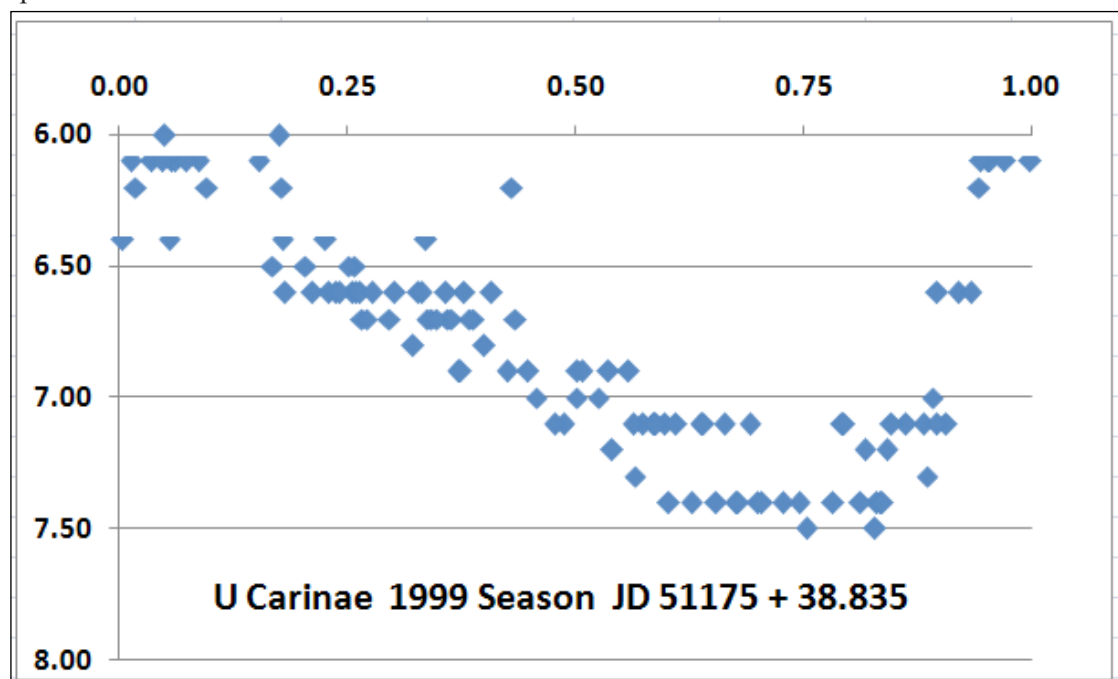


Figure 1. *U Carinae* reaches maximum brightness every 38.835 days and we follow this by plotting a season's nightly measures, phased to the ephemeris shown in the graph. How this is compiled and used is discussed below. This plot shows the 1999 season's visual measures. From these we can derive a seasonal epoch accurate to 3 hours or better.

Making the measures

Variable Stars South has prepared special visual charts for use in measuring these stars, Figure 2 (over-leaf). They are meant to be used with a telescope in a more comfortable position - as compared to binoculars - providing better accuracy. Since most telescopes use a diagonal the charts are reversed E/W but direct view charts for binoculars are available. Comparison values are expressed to 0.1 magnitudes. As with any new skill it takes a little time to learn the techniques.

Only one measure a night is needed. Maximum cannot be determined with any one night's measures so don't try. A 3 to 7 day interval is probably best and the weather may well determine this. All times should be expressed in UT, not local or daylight saving time, to the nearest minute and then corrected to Julian Dates. For our purposes we use the conventional 5 integer 4 decimal notation, 12345.6789, but if you submit your measures to the International Database they use the full seven integer version.

There are usually 5 - 10 comparison stars on each chart with steps of about 0.2 to 0.4 magnitudes. Pick the two between which the brightness of the target appears to lie and then estimate where the target lies in this interval - half, quarter or third up or down. Add or subtract appropriately from the comparisons for your observed value. Record the time and value. These should be submitted to the Cepheid group in the form Julian Date (JD), magnitude, quality (EX, VG, G, F, P) after each month has ended.

Comparison star sequence

Such a sequence should comprise stars of a similar B-V colour to the target star. The range of most of the medium to long period Cepheids (20 to 45 days) varies between 1.0 and 1.5 magnitudes so that a spacing of 0.2 magnitudes with a 0.1 overlap at the bright and faint ends of variation is ideal. This is not always possible.

We use 6 to 10 comparison stars with no magnitude duplicates. Our target stars change colour - as shown by spectra or B-V colours - mid-A to late G spectra or B-V 0.3 to 1.0 so this affects our selection. Fortunately the unaided eye has a response near the centre of this colour range so if care is taken quite accurate results can be obtained.

An aspect of the colour changes in the target star itself is that maximum brightness is affected by the wavelength - *thus it will occur first at shorter wavelengths. Blue is shorter than red*. If measures are made in the UBVRI system maximum brightness differs by ~2.0 days between the B and I filters for these longer period Cepheids. This is avoided with the unfiltered eye estimates.

Errors

The most common error and simplest to correct occurs when different observers are using comparison sources published by different groups. So always use the VSS charts for this project. Figure 3a and 3b show two light curves - the one on the left is comprised of three different observers using three different comparison star sequences, the one on the right a partial correction using VSS software - discussed below.

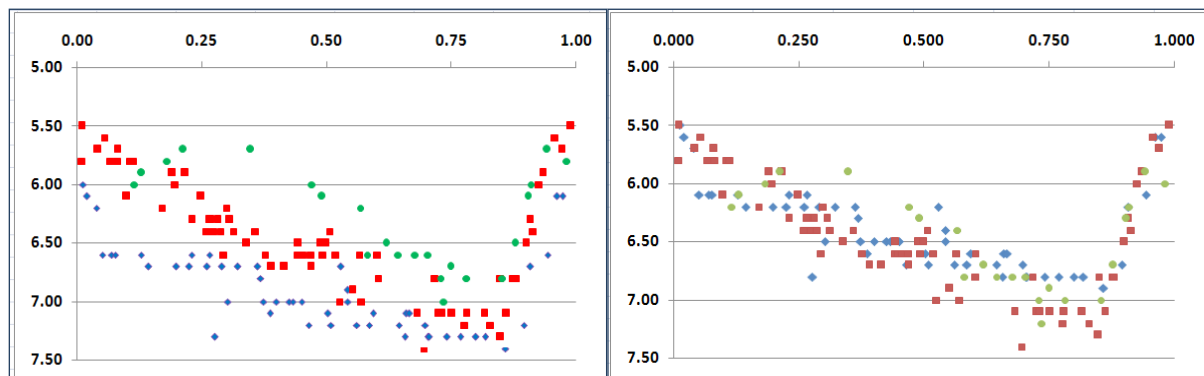


Figure 3a and 3b. Measures by three experienced observers using RASNZ, AAVSO and a South American sequence. Before correction is shown in 3a, after correction in 3b. The latter provides an accuracy of ~3 hours or 0.125 days, adequate for the goals of this project.

RS Puppis

RA 8 13 04 2000 Dec -34 34 43
 Epoch 35734.426 Period 41.3876 days Range in V 6.52 - 7.67
 Direct view chart Vertical scale ~5.0 degrees

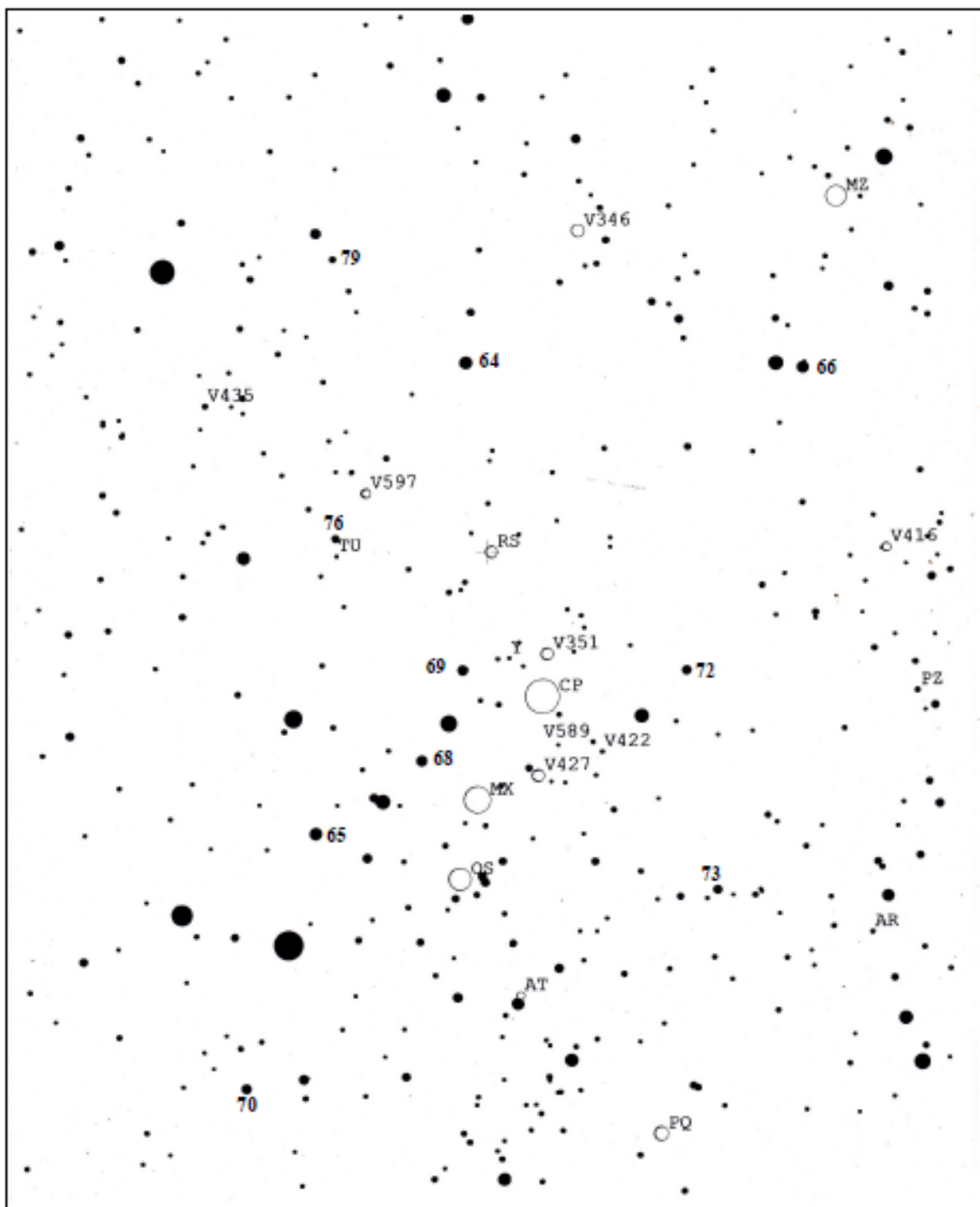


Figure 2. This is typical of the charts that have been prepared. The scale is the field dimension vertically, other information is in the heading. The brightness of the selected comparison stars is in magnitudes, for example 6.5, but with the decimal point omitted by convention. The larger the star image the brighter. Unfilled circles are known variable stars. Since their magnitudes vary they may not always be visible, or may look fainter than their image dimension. The epoch is the zero date of a historical maximum expressed in JD -2400000.

The message here is use only VSS charts. There are other types of errors but we avoid most of these by careful selection of comparisons.

Every eye is slightly different and the response is affected by dark adaption. These errors, however, are less than 0.1 magnitudes normally. Use of a red torch minimises the time for dark adaption. Using an iPhone or similar is definitely not recommended so you must use the old red torch, pencil and paper method. But measures to the nearest minute - or even 5 to 10 minutes - are adequate.

There are also observer errors. Often these arise because of the emphasis upon the number of measures made monthly or yearly - an unfortunate feature with some observing groups. Quality is always better than quantity! The most common of these errors is to assign the observed magnitude as the same as the nearest comparison star. This can be seen in Figure 4 where there are two rows containing a disproportionate number of estimates. Figure 1 also shows this.

Derivation of Epochs of Maximum

These epochs are derived by using an Excel routine devised by Mark Blackford. It fits a season's observations, either by one or a few observers, or all observations in a season, to a mean light curve and provides an epoch of maximum.

It shows the beginning and end of the season, the number of the epoch from a selected starting epoch (which may be before or after the epoch of the data being analysed - we can end up with negative cycle numbers) and the epoch of maximum determined from the measures. Some measures at maximum and minimum are omitted as these are of low weight with the star's brightness change slow at these two points. Other information is presented and highlighted in orange. This cannot be changed.

There are three manual corrections which can be made. These are highlighted in green. The first is a magnitude offset which comes into play when the actual measures are systematically higher or lower than the mean light curve. This would only be needed when analysing measures made using other sequences. The third is an amplitude factor which allows compression or expansion of the range in variation. Once again, this comes in useful when analysing data using other sequences.

The second is most important. It shows how much the epoch differs from that using the known basic epoch and period. This takes into account all measures but notice the asymmetric shape of the light curve. There is a very sharp rise beginning at phase ~0.80. If the fit of the other data is not good a better epoch may be determined by manually correcting this figure and redoing the operation.

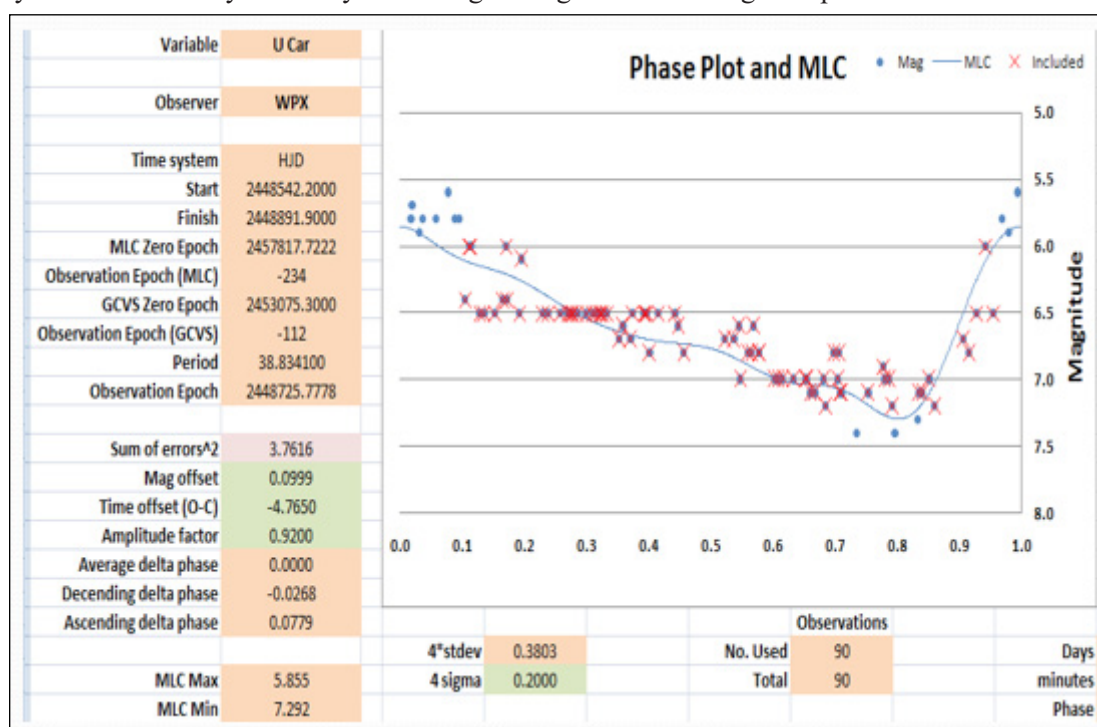


Figure 4. Analysis of a season's measures by one observer. Note the measures at 6.5 and 7.0, an error explained in the text.

What should be recorded from this graph is the year, number of measures, cycle number and the JD of the observation epoch. Add also your idea of the quality of the data fit and any other comments.

Analysis

To use the measures effectively they must be treated in a certain manner. It is not possible to follow a star like U Carinae and build up a light curve from one cycle. In practice we try to make 30 to 50 good quality measures over one season which usually comprises the six to eight months the Milky Way is visible from any one observatory. The JDs (time and date) are then converted to phases to create a graph.

Building the light curve

We recommend that you use Excel to build up a light curve for each star each season

From this an epoch of maximum is derived. These epochs provide a marker which we then use to see if the period is constant or is varying in some manner.

An historical picture - the O-C diagram

The behaviour of a star over the interval since discovery is very important. An instant picture of any changes in period is provided by comparing the observed epochs with the predicted or calculated JD epochs (O-C) using the light elements which comprise the original epoch and the mean period. This is shown in Figure 5.

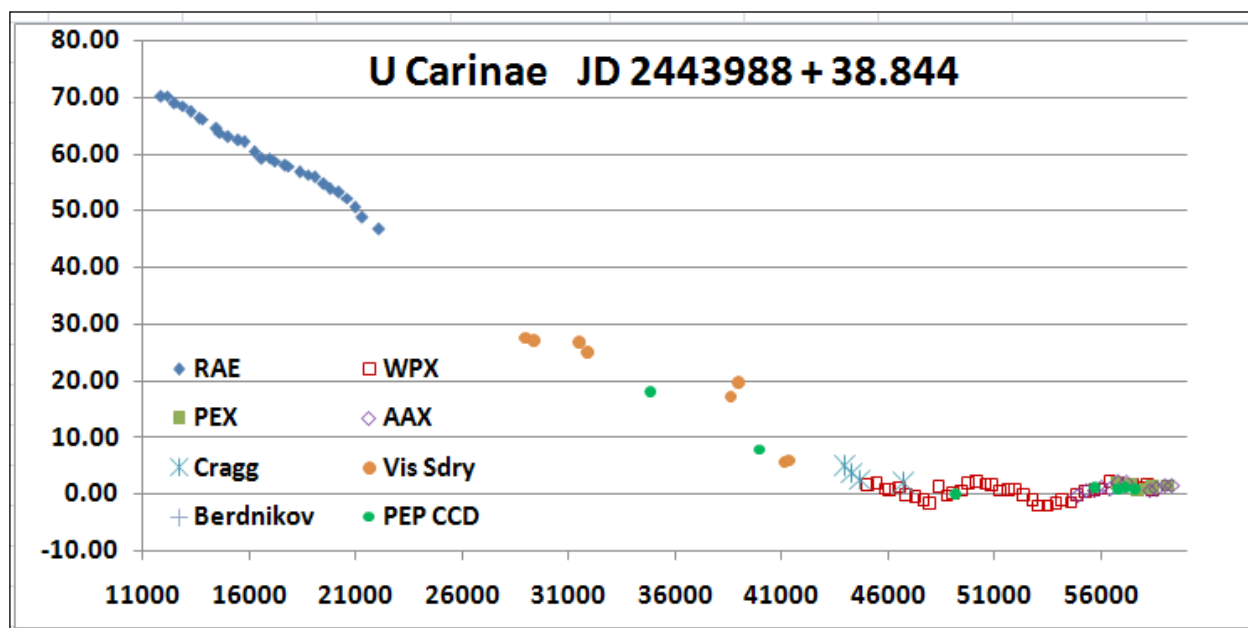


Figure 5. This shows U Carinae's observed epochs of maximum over the period 1889 to 2021. The period used is that observed at present, lightly longer than the period at discovery. A major change occurred about 1982. There are also slight indications of waviness in the early measures by Alex Roberts.

To understand this we now move into the realm of astrophysics in an attempt to determine what the observations are telling us about the structure and behaviour of the target star.

Low mass stars follow a different evolutionary path than massive Cepheids but there are many similarities. In both types of variable star the fundamental period is caused by the ionisation and recombination of helium in one case, hydrogen the other. The low mass stars, mainly comprising those known as Miras after the prototype object, pulsate with much longer periods 90-600 days, and larger amplitudes 2.5 to 10 magnitudes. Figure 6 is an O-C diagram from Walker, et al, 1997, in which the behaviour of 88 southern Mira stars was shown to alternate between two periods separated by 3% to 5% of the mean period. Later, Karlsson has extended this earlier analysis to northern hemisphere stars as well.

An earlier discussion with Brian Warner of SAAO, 1986, regarding BH Crucis suggested that the period irregularities might result from some type of event in the extensive Mira outer convective regions. This

appears to be the case, although what and why is not clear. This project will help find an answer.

The fundamental periods of both types of stars are closely related to the diameter of the region in which ionisation occurs and it is difficult to propose a method which creates the period variations in this region on anything other than an evolutionary time scale. So the measures and analysis of these is aimed at exploring the alternative idea that the short term Cepheid secondary period variations arise in a convective envelope in the coolest and most massive stars of this type.

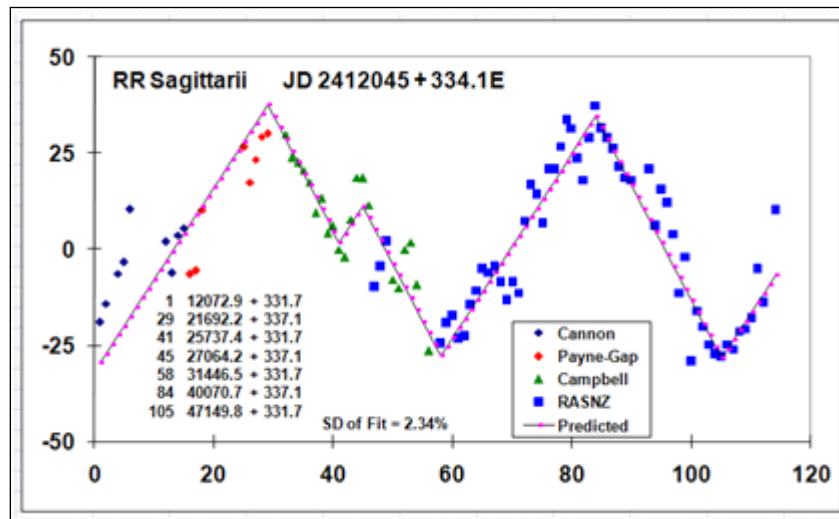


Figure 6. This graph seems to indicate two main slopes each separated from the mean period of 334.1 days by ~ 2.7 days. They change at irregular intervals. There are also brief reversals and often an apparent reversion to the mean period. We believe that the longer period Cepheids, those with periods of over 20 days and convective envelopes during all or part of the pulsation cycle, show similar behaviour. Testing this premise is a main goal of this project - another is to gather better data on Cepheid periods and changes therein.

This has led to the present extension of the original VSS Bright Cepheid Project. The brightest and most massive Cepheids lie in the upper right of the Hertzsprung-Russell diagram. A check of the spectral classes show that many of these have classifications extending into late G and a few to early K. Main sequence stars begin to develop convective outer layers at about F5, or 6700K. So it may be that some Cepheids, and we suspect those with periods from 10 to 20 days and longer, may also be subject to events in a convective envelope which distort the fundamental period.

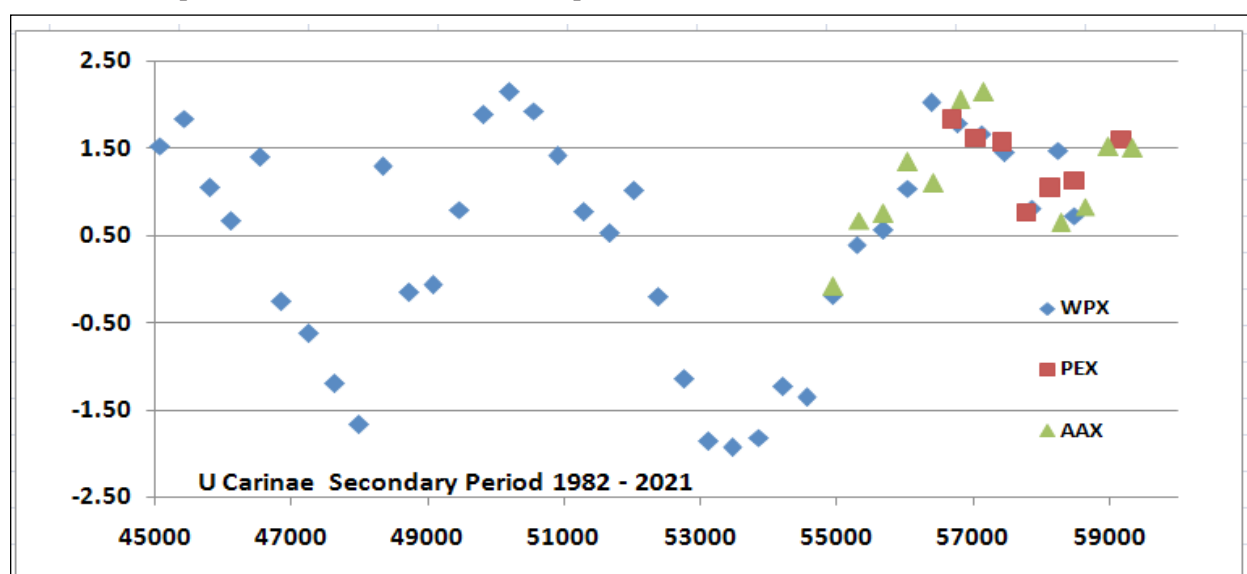


Figure 7: U Carinae was little observed from 1918 to 1982. This figure shows deviations from the main period of 38.844 over the last 40 years. As with the Mira stars this shows two reasonably consistent slopes but there are erratic changes to the alternate secondary period.

For this analysis we need well observed stars. Table 1 contains a list of longer period Cepheids together with the numbers of measures in the international Database (IDB) maintained by the AAVSO but containing measures from observers, world-wide. These have been used to produce Figure 7 and Figure 8.

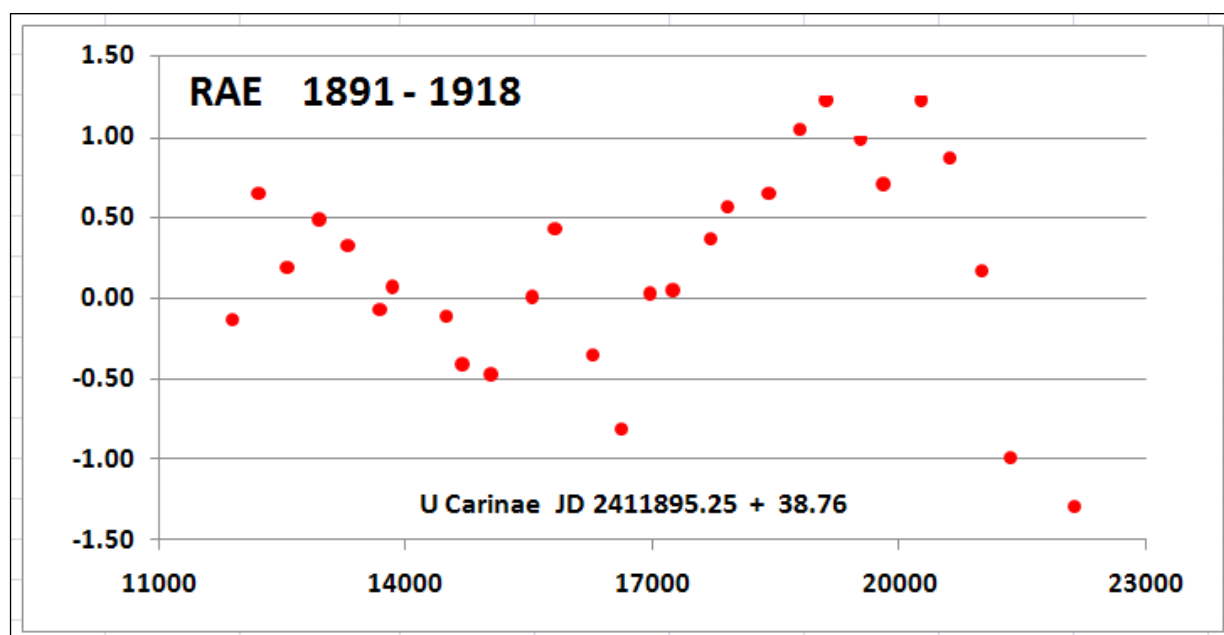


Figure 8. This graph is based on the measures by Roberts who was probably using stars from the Cape Photographic Durchmusterung. These have been corrected and analysed using fits to the mean light curve. The pattern is similar to the measures made around a century later.

Help & mentoring

The present project convenor is Stan Walker - astroman@xtra.co.nz or phone 64 9 406 8863 - who has wide experience in visual and various aspects of electronic photometry.

Target stars

A summary of the target stars is shown in Table 1. The top section contains those stars expected to show the low amplitude secondary period. There are direct and reversed charts for these.

The second section lists bright stars largely with periods below 20 days where a secondary period may not exist. Comparison sequences are available but no charts exist. One of these stars, AQ Puppis is unusual in that it shows a continuous, slow period change.

Data mining

Measures of all these stars are listed in the International Database. Some stars have more than 10,000 visual measures, I Carinae and T Monocerotis being two such. There are few measures during the interval 1922 to 1960. This was an era of photographic patrol observations but the density and accuracy of measures is not good. The visual measures, if the different comparison values can be resolved, is another area needing investigation.

There are also assorted UBVRI measures since the 1960s and Leonid Berdnikov has catalogued those available. I have been trying to obtain an updated copy of the last decade or so but due to the problems in that part of the world haven't yet succeeded

There are many interesting Cepheids out there and this project is, so far, limited to the brighter ones. Many CCD observers are making BVRI measures of Mira stars – perhaps it might be more rewarding to make some V, B-V measures of Cepheids which because of their greater mass are evolving thousands of times faster!

Name	RA	Dec	Max	Min	Ampl	Epoch	Period	Rise	Spectrum
X Pup	73247.0	-205435	7.82	9.24	1.42	41108.8	25.961	15	F6-G2
VZ Pup	73835.2	-282959	8.92	10.35	1.43	41121.19	23.171	17	F5-G2
RS Pup	81304.2	-343443	6.52	7.67	1.15	35734.43	41.3876	24	F9-G7
RZ Vel	83701.3	-440653	6.42	7.64	1.22	34845.57	20.39824	30	G1Ib-G8
SW Vel	84338.7	-472411	7.44	8.96	1.52	40738.24	23.441	15	F8/G0Ib
I Car	94514.8	-623228	3.28	4.18	0.90	37320.06	38.7681	21	F6Ib-K0Ib
RY Vel	102041.0	-551917	7.86	8.89	1.03	44017.94	28.1357	22	F5-G3Ib/II
SV Vel	104456.3	-561722	7.91	9.12	1.21	36195.125	14.09707	34	F6-G5II
WZ Car	105518.7	-605624	8.65	10.01	1.36	44143.17	23.0132	17	F8
U Car	105748.2	-594356	5.72	7.02	1.30	37320.06	38.7681	21	F6-G7Iab
RY Sco	175052.3	-334220	7.51	8.44	0.93	28265.45	20.31322	37	F6-G2
WZ Sgr	181659.7	-190433	7.45	8.63	1.18	35506.63	21.84971	31	F8-K1
RU Sct	184156.4	-40638	8.82	10.02	1.20	31171.67	19.70062	36	F4-G5

SS CMa	72607.2	-251526	9.26	10.36	1.10	41109.19	12.361	45	F6-G2
AD Pup	74803.9	-253440	9.27	10.36	1.09	41126.18	13.594	25	F5-G2
AQ Pup	75822.1	-290748	8.08	9.39	1.31	44676.57	30.104	17	F5Ib-G2Ib
LS Pup	75859.2	-291828	9.8	10.80	1.00	38376.500	14.1464	35	
BN Pup	80621.5	-300549	9.2	10.40	1.20	28078.04	13.6731	29	G4
VY Car	104432.7	-573355	6.87	8.05	1.18	10009.58	18.99	36	F6-G4Iab-Ib
XZ Car	110413.5	-605848	8.05	9.13	1.08	36205.754	16.6499	37	K5
UU Mus	115217.7	-652415	9.13	10.28	1.15	36208.270	11.63641	37	F7/G0p
VW Cen	133359.0	-640320	9.67	10.72	1.05	44023.17	15.03618	38	
XX Cen	134018.6	-573647	7.3	8.31	1.01	40366.24	10.95435	49	F6-G4(F7/8II)
TX Cen	143512.0	-605952	9.85	11.14	1.29	34964.000	17.0936	38	
U Nor	154220.9	-551843	8.63	9.83	1.20	44788.5	12.64371	46	F6-F8Ib/II-G5
Z Sct	184257.3	-54915	9.05	10.16	1.11	36247.160	12.90133	40	F8-G4
KN Cen	133636.9	-643330	9.28	10.36	1.08	36238.172	34.0457	21	??
V0340 Ara	164519.1	-512033	9.63	10.76	1.13	52351.75	20.8111	24	

Table 1. Target stars for the Cepheid project. The upper half shows those stars expected to show the low amplitude secondary period while the lower half lists bright stars largely with periods below 20 days where a secondary period may not exist.

Publication watch

Mark Blackford has one publication and **Phil Evans** has had four papers published as a co-author since January.

Tanriver, Mehmet; Poro, Atila; Bulut, Ahmet; Keskin, Ahmet; Blackford, Mark G., *The First Multiband Photometric Light Curve Solutions of the V Gru Binary System from the Southern Hemisphere*, Research in Astronomy and Astrophysics, Volume 23, Issue 5, id.055005, 8 pp.

Abstract

The first multiband photometric solutions of the short-period V Gru eclipsing binary from the southern hemisphere are presented in this study. Light curves of the system were observed through BVI filters at the Congarinni Observatory in Australia for 15 nights. In addition to the new ground-based data, we also used the TESS observations in two sectors. We analyzed the light curves of the system using the PHysics Of Eclipsing BinariEs (PHOEBE) 2.4.7 version code to achieve the best accordance with the photometric observations. The solutions suggest that V Gru is a near-contact binary system with $q = 1.302(81)$ mass ratio, $f_1 = 0.010(23)$, $f_2 = -0.009(21)$, and $i = 73.45(38)$. We considered the two hot spots on the hotter and cooler components for the light curve analysis. We extracted the minima times from the light curves based on the Markov Chain Monte Carlo (MCMC) approach. Using our new light curves, TESS, and additional literature minima, we computed the ephemeris of V Gru. The system's eclipse timing variation trend was determined using the MCMC method. This system is a good and challenging case for future studies.

Mistry, Priyashkumar; et al. *VaTEST I: validation of sub-Saturn exoplanet TOI-181b in narrow orbit from its host star*. 2023MNRAS.521.1066M

Abstract

We present here a validation of sub-Saturn exoplanet TOI-181b orbiting a K spectral type star TOI-181 (mass: $0.822 \pm 0.04 M_{\odot}$, radius: $0.745 \pm 0.02 R_{\odot}$, temperature: 4994 ± 50 K) as a part of Validation of Transiting Exoplanets using Statistical Tools (VaTEST) project. TOI-181b is a planet with radius $6.95 \pm 0.08 R_{\oplus}$, mass $46.16 \pm 2.71 M_{\oplus}$, orbiting in a slightly eccentric orbit with eccentricity 0.15 ± 0.06 and semimajor axis of 0.054 ± 0.004 au, with an orbital period of 4.5320 ± 0.000002 d. The transit photometry data were collected using Transiting Exoplanet Survey Satellite (TESS) and spectroscopic data for radial velocity analysis were collected using The European Southern Observatory's (ESO) High Accuracy Radial Velocity Planet Searcher (HARPS) telescope. Based on the radial velocity best-fit model we measured RV semi-amplitude to be $20.56 \pm 2.37 \text{ m s}^{-1}$. Additionally, we used VESPA and TRICERATOPS to compute the False Positive Probability (FPP), and the findings were FPP values of 1.68×10^{-14} and 3.81×10^{-04} , respectively, which are significantly lower than the 1 percent threshold. The finding of TOI-181b is significant in the perspective of future work on the formation and migration history of analogous planetary systems since warm sub-Saturns are uncommon in the known sample of exoplanets.

Brahm, Rafael; et al. *Three long period transiting giant planets from TESS*. arXiv:2304.02139

Abstract

We report the discovery and orbital characterization of three new transiting warm giant planets. These systems were initially identified as presenting single transit events in the light curves generated from the full frame images of the Transiting Exoplanet Survey Satellite (TESS). Follow-up radial velocity measurements and additional light curves were used to determine the orbital periods and confirm the planetary nature of the candidates. The planets orbit slightly metal-rich late F- and early G-type stars. We find that TOI 4406b has a mass of $M_p = 0.30 \pm 0.04 M_J$, a radius of $R_p = 1.00 \pm 0.02 R_J$, and a low eccentricity orbit ($e=0.15 \pm 0.05$) with a period of $P= 30.08364 \pm 0.00005$ d. TOI 2338b has a mass of $M_p = 5.98 \pm 0.20 M_J$, a radius of $R_p = 1.00 \pm 0.01 R_J$, and a highly eccentric orbit ($e=0.676 \pm 0.002$) with a period of P

= 22.65398 ± 0.00002 d . Finally, TOI 2589b has a mass of $M_p = 3.50 \pm 0.10 M_J$, a radius of $R_p = 1.08 \pm 0.03 R_J$, and an eccentric orbit ($e = 0.522 \pm 0.006$) with a period of $P = 61.6277 \pm 0.0002$ d . TOI 4406b and TOI 2338b are enriched in metals compared to their host stars, while the structure of TOI 2589b is consistent with having similar metal enrichment to its host star.

Psaridi, Angelica; et al. *Three Saturn-mass planets transiting F-type stars revealed with TESS and HARPS.* arXiv:2303.15080

Abstract

While the sample of confirmed exoplanets continues to increase, the population of transiting exoplanets around early-type stars is still limited. These planets allow us to investigate the planet properties and formation pathways over a wide range of stellar masses and study the impact of high irradiation on hot Jupiters orbiting such stars. We report the discovery of TOI-615b, TOI-622b, and TOI-2641b, three Saturn-mass planets transiting main sequence, F-type stars. The planets were identified by the Transiting Exoplanet Survey Satellite (TESS) and confirmed with complementary ground-based and radial velocity observations. TOI-615b is a highly irradiated ($\sim 1277 F_{\oplus}$) and bloated Saturn-mass planet ($1.69^{+0.05}_{-0.06} R_{Jup}$ and $0.43^{+0.09}_{-0.08} M_{Jup}$) in a 4.66 day orbit transiting a 6850 K star. TOI-622b has a radius of $0.82^{+0.03}_{-0.03} R_{Jup}$ and a mass of $0.30^{+0.07}_{-0.08} M_{Jup}$ in a 6.40 day orbit. Despite its high insolation flux ($\sim 600 F_{\oplus}$), TOI-622b does not show any evidence of radius inflation. TOI-2641b is a $0.37^{+0.05}_{-0.04} M_{Jup}$ planet in a 4.88 day orbit with a grazing transit ($b = 1.04^{+0.05}_{-0.06}$) that results in a poorly constrained radius of $1.61^{+0.46}_{-0.64} R_{Jup}$. Additionally, TOI-615b is considered attractive for atmospheric studies via transmission spectroscopy with ground-based spectrographs and JWST. Future atmospheric and spin-orbit alignment observations are essential since they can provide information on the atmospheric composition, formation and migration of exoplanets across various stellar types.

Rodriguez, Joseph E. et al. *Another Shipment of Six Short-Period Giant Planets from TESS.* 2023MNRAS.tmp..609R.

Abstract

We present the discovery and characterization of six short-period, transiting giant planets from NASA's Transiting Exoplanet Survey Satellite (TESS) - TOI-1811 (TIC 376524552), TOI-2025 (TIC 394050135), TOI-2145 (TIC 88992642), TOI-2152 (TIC 395393265), TOI-2154 (TIC 428787891), & TOI-2497 (TIC 97568467). All six planets orbit bright host stars ($8.9 < G < 11.8$, $7.7 < K < 10.1$). Using a combination of time-series photometric and spectroscopic follow-up observations from the TESS Follow-up Observing Program (TFOP) Working Group, we have determined that the planets are Jovian-sized ($R_p = 0.99$ - $1.45 R_J$), have masses ranging from 0.92 to $5.26 M_J$, and orbit F, G, and K stars ($4766 \leq T_{eff} \leq 7360$ K). We detect a significant orbital eccentricity for the three longest-period systems in our sample: TOI-2025 b ($P = 8.872$ days, $0.394^{+0.035}_{-0.038}$), TOI-2145 b ($P = 10.261$ days, $e = 0.208^{+0.034}_{-0.047}$), and TOI-2497 b ($P = 10.656$ days, $e = 0.195^{+0.043}_{-0.040}$). TOI-2145 b and TOI-2497 b both orbit subgiant host stars ($3.8 < \log g < 4.0$), but these planets show no sign of inflation despite very high levels of irradiation. The lack of inflation may be explained by the high mass of the planets; $5.26^{+0.38}_{-0.37} M_J$ (TOI-2145 b) and $4.82 \pm 0.41 M_J$ (TOI-2497 b). These six new discoveries contribute to the larger community effort to use TESS to create a magnitude-complete, self-consistent sample of giant planets with well-determined parameters for future detailed studies.

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

Director Mark Blackford

Treasurer/Membership Bob Evans

Newsletter Editor Phil Evans

Webmaster David O'Driscoll

Visit our website to see a list of our area advisers, and to find out about our projects and how to contact their leaders

Membership

New members are welcome. There is no annual subscription but donations would be gratefully received. Find out how to join by visiting the VSS website. There you will find out how to join by post, email, or directly online. If you join by email or online and wish to make a donation you will get a link to pay by PayPal's secure online payment system, from your credit card or bank account.

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). I'd prefer 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.

Reproduction rights

To obtain permission to reproduce any content for legitimate scientific or educational purposes please contact the director, Mark Blackford, at director@variablestarssouth.org.

Citations of material in this newsletter should refer to "Newsletter of Variable Stars South, RASNZ" with year and number, and include the download URL.