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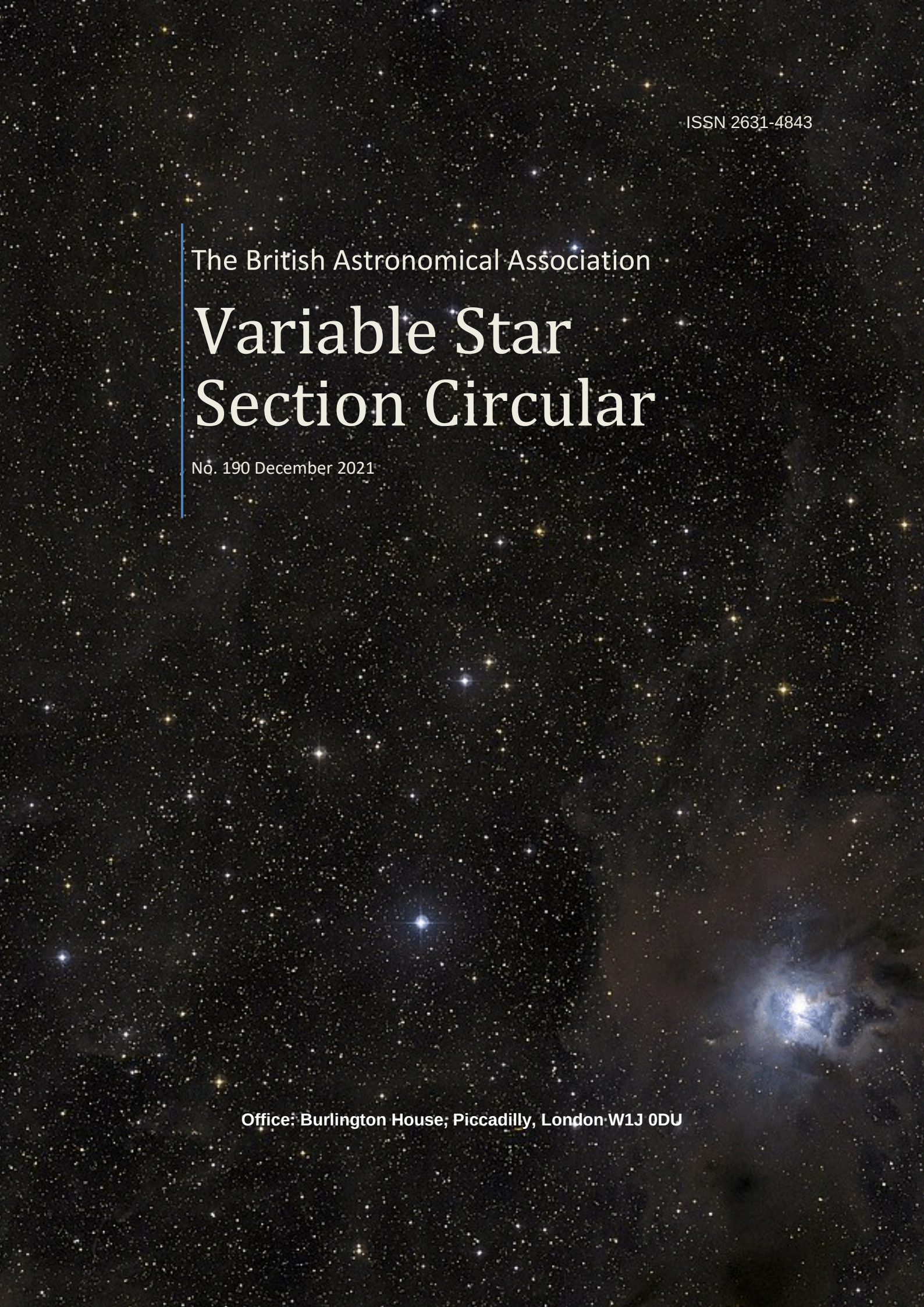
Variable Star Section Circular

No. 190 December 2021



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Cover Picture

The field of the Mira star T Cephei and its environs (ESA/Hubble)

From the Director *Jeremy Shears*

Welcome to the December 2021 Variable Star Section Circular. Whilst we are certainly not out of the woods yet, the Covid situation in the UK is much better than when I wrote this column during the pre-Christmas lockdown this time last year. Fingers crossed for a better 2022. I would certainly like to take this opportunity to wish all observers and supporters of the VSS a Merry Christmas and a Healthy & Prosperous New Year filled with clear skies!

During 2021, we've been treated to a number of interesting VS events including an eruption of the recurrent nova **RS Oph** and a rare outburst of the dwarf nova **LL And**. We also enjoyed several bright classical novae, including **V606 Vul** and **V1405 Cas**, both dusty objects. The latter was discovered back on March 18 and is still bright at 9th mag – have a look at the stunning image below by Mazin Younis taken some 7 months after the nova erupted. This nova is still keeping everyone on their toes with its various re-brightening episodes. And in mid-November, another recurrent nova briefly appeared on stage for its annual performance: **M31N 2008-12a**. What exciting events will the long winter nights bring us?

V1405 Cas and the Bubble Nebula (NGC7635) on 2021 Oct 24. The nova was mag ~7.5
(Mazin Younis, Hale Barnes, Manchester)

VSS Circular articles available via NASA ADS

Chris Lloyd has been working on a project to make articles from VSSCs available and searchable via the NASA Astrophysics Data System (ADS). Many of these articles contain important information about variable star astronomy that has not been published elsewhere. This will be a tremendous boon to the research community.

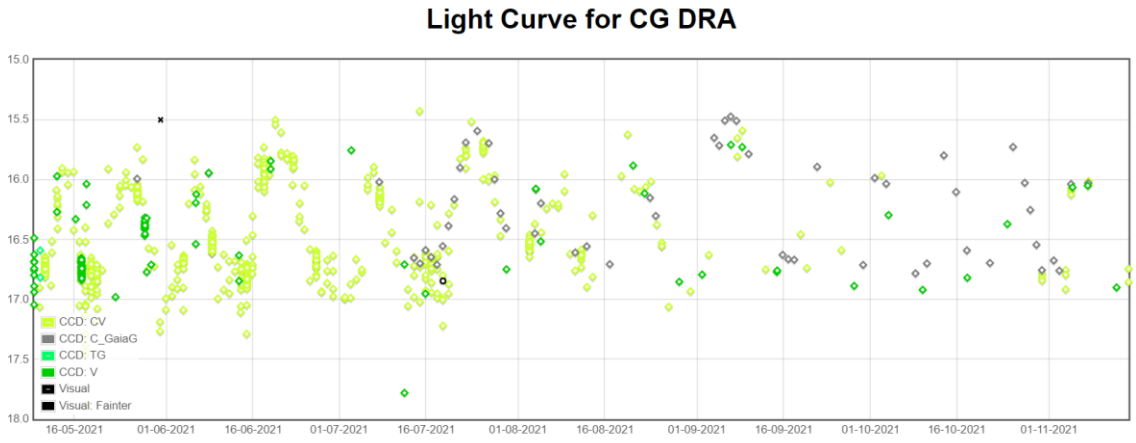
VSSCs after 2009, and some from earlier years, are now available and searchable. I would like to thank Chris for his hard work and diligence in bringing this project to fruition. Do have a look at Chris's article in this current Circular about using ADS and how to access Circulars.

There is further work to do to make some of the earlier Circulars available on ADS, especially the preparation of indexes. If you think you can help with this, please contact me. In the meantime, Chris will prepare some instructions to guide the volunteers in this task.

VSS observing campaigns on CG Dra and ER UMa systems

A reminder that these campaigns are still ongoing (see VSSC 188).

CG Dra remains accessible into the new year, so nightly measurements or time series photometric runs are welcomed. Many thanks to everyone that has submitted data to the VSS database so far: G D Coates, N D James, P C Leyland, R Pearce, R D Pickard, G Poyner, R Sargent, J Shears, F Tabacco, M Usatov, I L Walton.



Contributors: G D Coates, N D James, P C Leyland, R Pearce, R D Pickard, G Poyner, R Sargent, J Shears, F Tabacco, M Usatov, I L Walton

Keep an eye on the BAA Forum for regular updates on the ER UMa campaign, which involves determining the supercycle length of some of these short supercycle dwarf novae. Stewart Bean has an article on **RZ LMi** later in the Circular. The most recent superoutburst of **IX Dra** was detected by Nick James on the evening of Oct 31 (14.8 CV), some 56 days after the previous one according to Stewart Bean's running tally. Will we see another before Christmas? There are other UGER systems available during the winter/spring including **ER UMa** itself, **V1159 Ori**, **YZ Cnc** and **DI UMa**.

***Eclipsing Binary Observing Guide* now available in print**

Hard copies of the revised VSS *Eclipsing Binary Observing Guide* by Des Loughney can now be purchased from the BAA online shop: https://britastro.org/node/26286. The standard price is £7.50 or £6.00 for BAA Members. Many thanks to Ann Davies for arranging the printing of this valuable book.

The *Guide* can also be downloaded in PDF format free of charge from the VSS website.

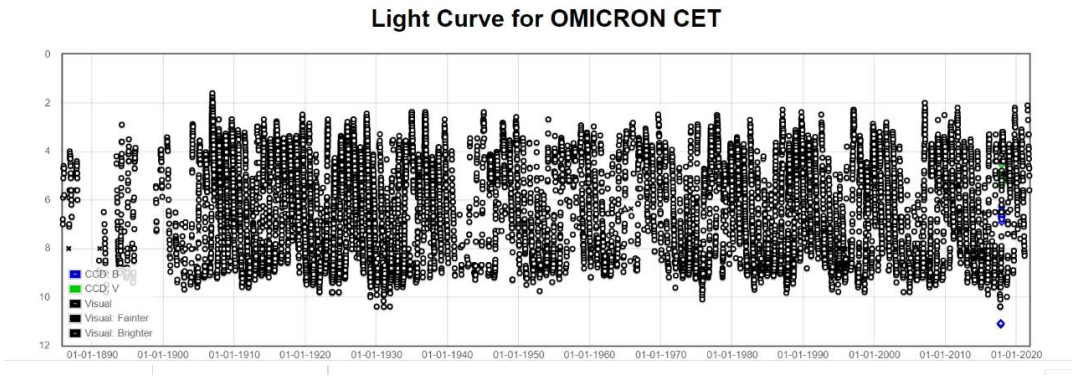
Report of the Pulsating Star Programme

Shaun Albrighton

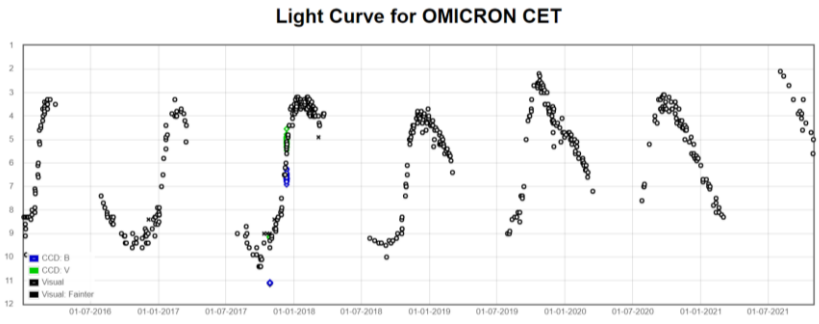
This report covers the August 2001 maximum of Mira (omicron Ceti), and 50 years of BAAVSS observations of the SR star V UMi.

Mira (omicron Cet)

Discovered in 1596 by David Fabricus, Mira (omicron Ceti) has been observed by members of the BAAVSS since 1885. The VSX lists the star as having a range of 2-10.1 with a period of 331.96 days. The rise from minimum to maximum is 38% or 126d. As will be seen from the lightcurve of all observations, the star displays considerable variation in the brightness of maximum. It should be noted however that the star lies south of the ecliptic, means that from British latitudes Mira is lost in the Sun's glare during the period from mid-March till August. This means that maxima that occur during this period are missed. For observers in the southern hemisphere this period is reduced considerably.



For this cycle, Mira was first picked up by John Toone on 3rd August 2021 at mag 2.1. This appears to have been at or very near to maximum, and is verified by observations submitted to the AAVSO, which show a peak of 2.2/2.3 during early August. Comparing this maximum to previous, it would appear to be the third brightest ever recorded. The brightest max was recorded in December 1906, in the range of 1.6-1.8 by several observers. The next brightest appears, at first glance to be that of 2007, with two recorded estimates of 2.0. However other observers recorded a fainter maximum, in the range of 2.3-2.7. It is therefore highly probable that this cycle has seen the second brightest recorded maximum. Below is a plot of results showing the lightcurve for Mira, during the period 2016 – Nov 2021. It will be seen that not only is there variation in the maximum brightness of the star, but in the shape of the overall curve, with some cycles displaying broader maxima.



V UMi

Lying at a declination of +74 deg. this star is circumpolar from mid to higher northerly latitudes, and as a result can be followed throughout the year. VSX records this red variable of type SRb, spectral type M4 – M7IIIab, mag range 7.06-8.7V, Period 73d, with the rise taking 45% (33d). The GCVS Team lists a mean brightness variation with P2=760d.

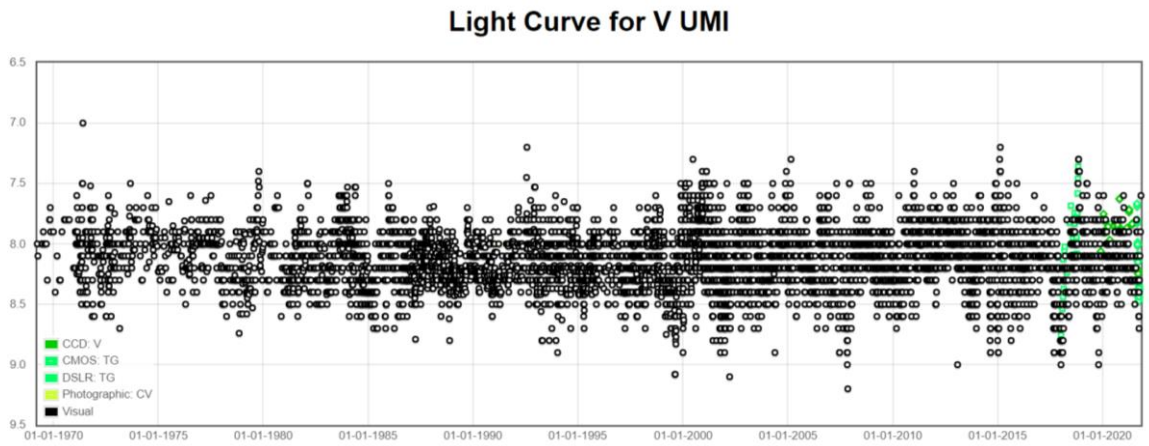
In a 1999 study by Kiss [1], V UMi is listed along with several other SRb programme stars, including, U Cam, ST Cam, X Cnc, AF Cyg and TX Dra as being triply periodic. V UMi and TX Dra are identified as having the most defined triple periods. Their study yields a dominant period of 73d, with two further periods of 737d and 126d. The study adds that the pulsations are not smooth and repetitive, mild chaos being present. The cause is due to the extended atmosphere and strong inner convection within the star. This creates a very complex environment where slight changes result in large effects in the pulsations.

A second study by Lebzelter [2], utilising results from the Twin Automatic Photoelectric Telescopes (APT). It compares the results of the APT (74 points over 511 days), together with over 6,000 visual estimates over a much longer time frame.

APT Data		Visual Data	
Period (days)	Amplitude (mag)	Period (days)	Amplitude (mag)
72.5	0.40	71.9	0.28
794	0.27	670	0.22
65.9	0.11	64	0.11
124	0.06	132	0.09

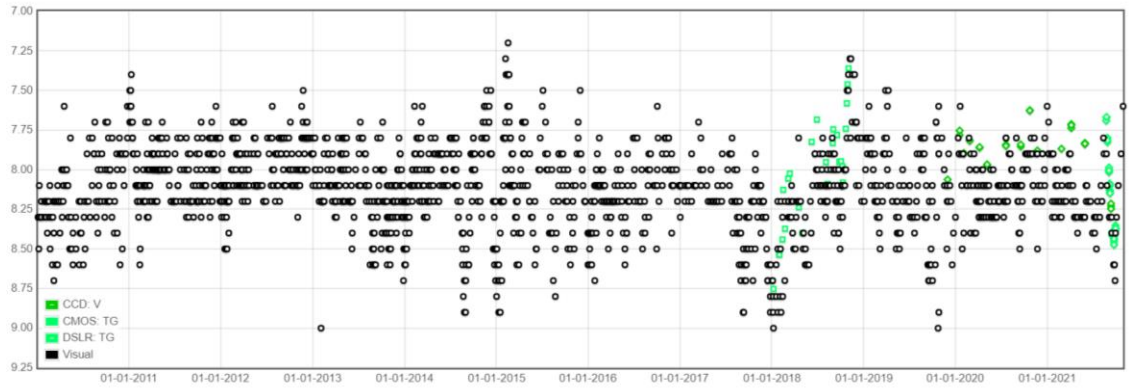
Turning to BAAVSS results, a total of 7,008 observations have been logged to date. A plot of these observations (see below) reveals a magnitude range slightly fainter than that listed in the VSX of, 7.3-9.0. It will be noted that there appears to be an increase in range when comparing results since 1999 to those for the period of the 1970s, in particular. It should also be noted that there was poor/scattered coverage during this earlier period

Analysis of results using the AAVSOs VStar program [3] gives a dominant period of 72.9 days (VSX 73d), together with a longer period of 756 days, which is close to the GCVS Team result of 760d. There are additional periods in the range 71-75d, which may be due to slight fluctuations in the dominant period. There is no conclusive evidence for any additional periods.



The second plot below covers the period 2010-Nov 2021, during which time there was both better and more consistent results. Examining results purely from this period gives the following results.

Period (days)	Amplitude (mag)
71.9	0.26
719	0.20
120.6	0.15
124.1	0.14



To sum up, BAAVSS observations of V UMi confirm both the dominant shorter period in the range of 71.9 - 72.9d, and the longer period in the region of 719 - 756d. The results hint that there is some fluctuation in these two periods. In addition, a third period of 124.1 days is detected in more recent results which confirms previous findings, however the 2001 result using APT of 65.9d is not confirmed.

Finally, it remains for me to ask for observers continue to conduct regular and careful observations of this easy to find and interesting binocular variable, to enable further analysis at a future date. Observers using suitable CCD and DSLR cameras are also encouraged to add this star to their program.

References

1: Multiperiodicity in semiregular variables. General properties by Kiss, Szatmáry, Cadmus and Mattei. Published Astronomy and Astrophysics, v346, p.542-555 (1999).

2: Monitoring of LPVs with an automatic telescope. A comparison of APT data and visual observations by Lebzelter, T.; Kiss,L. L. Astronomy and Astrophysics v.380,p.388-396 (2001).

3: AAVSO VStar program.

T Cephei: An interesting target for spectroscopy?

Tracie Louise Heywood

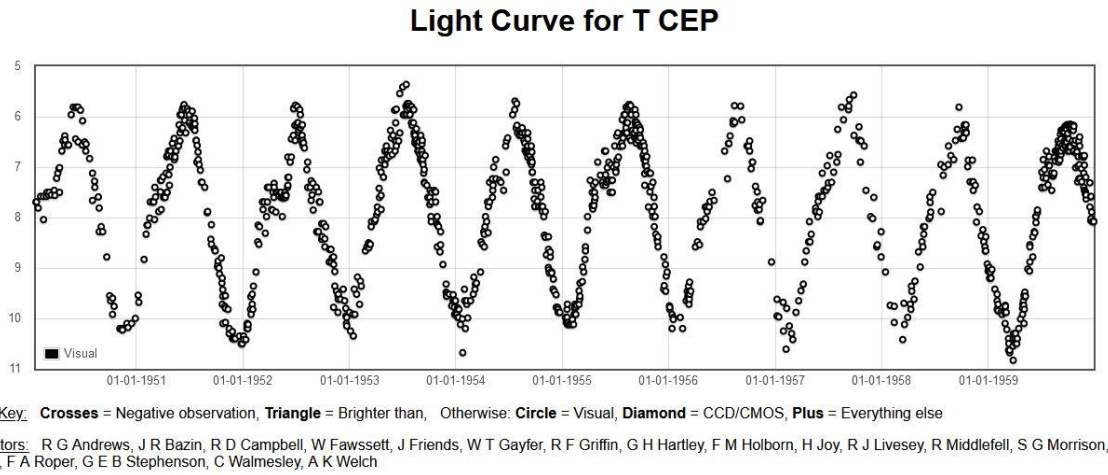
The Mira type variable T Cephei is circumpolar from the UK and can be followed through most of its brightness range using binoculars.

T Cephei's catalogued magnitude range is 5.4 to 11.0, with the average range usually being quoted as 6.0 to 10.3. The average period is 389 days, which means that maxima will typically occur nearly a month later in successive years.

Mira type variables may have catalogued periods and magnitude ranges, but no two cycles of variation are the same. The peak magnitude varies from cycle to cycle, and the date of maximum can only be predicted to within a week or two.

I find T Cephei particularly interesting due to the "pause" near magnitude 8.0 that it often shows during the rise to maximum. In earlier decades this "pause" seems to have only occurred intermittently, but it has become more common and more prolonged in recent decades.

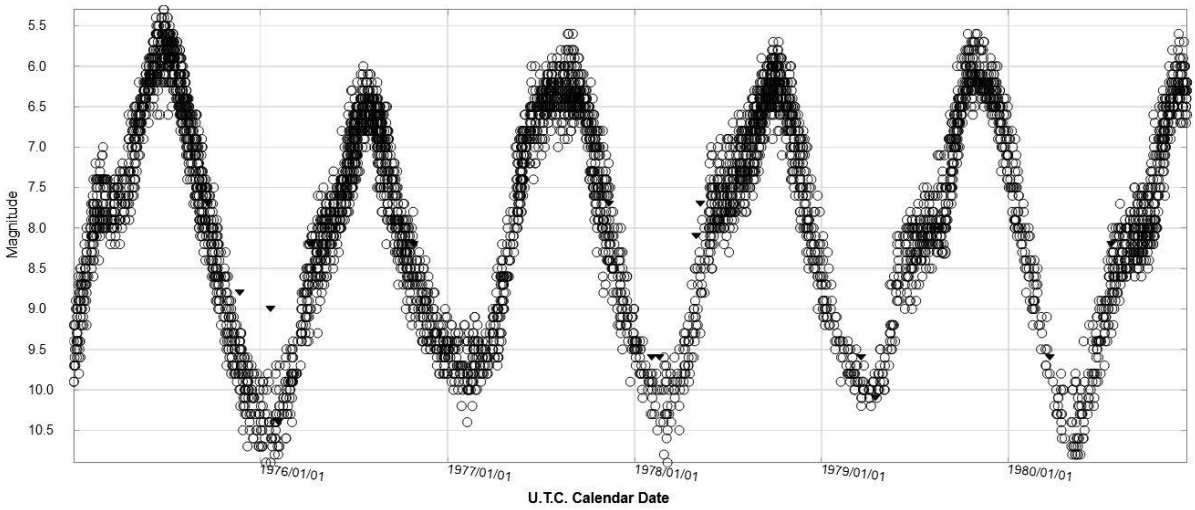
Looking at the BAA VSS light curve from the 1950s, there is clearly a pause during the rise to maximum in 1950, 1952 and 1955, but it seems to be largely absent in most other years.



BAAVSS light curve for T Cephei: 1950-1959

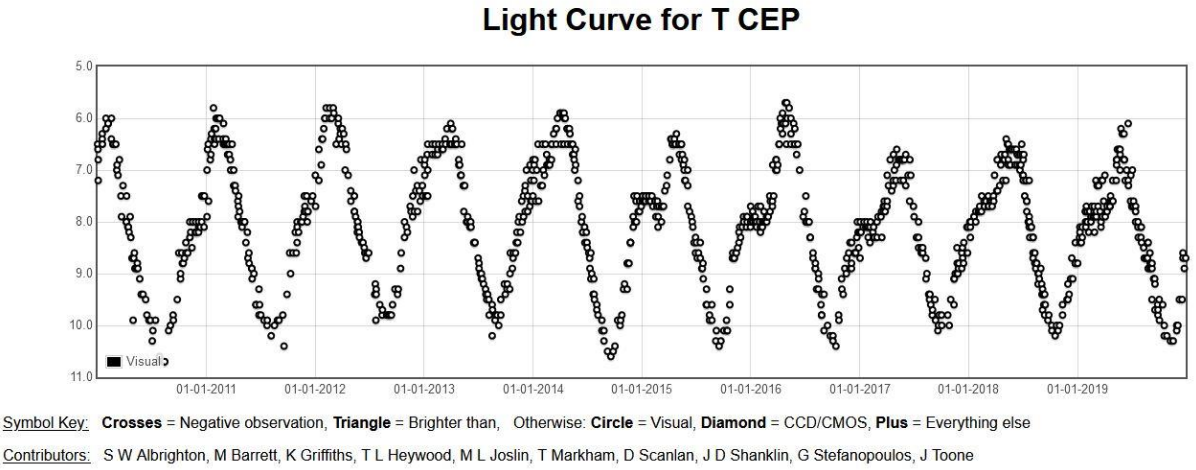
The BAA VSS light curve from the early 1970s shows pauses in 1973 and 1974 … and then T Cephei was dropped from the BAA programme for four decades!

The AAVSO light curve shows pauses also occurred in 1975, 1978 and 1979 and on several occasions during the 1980s.



The AAVSO light curve for T Cephei: 1975-1980

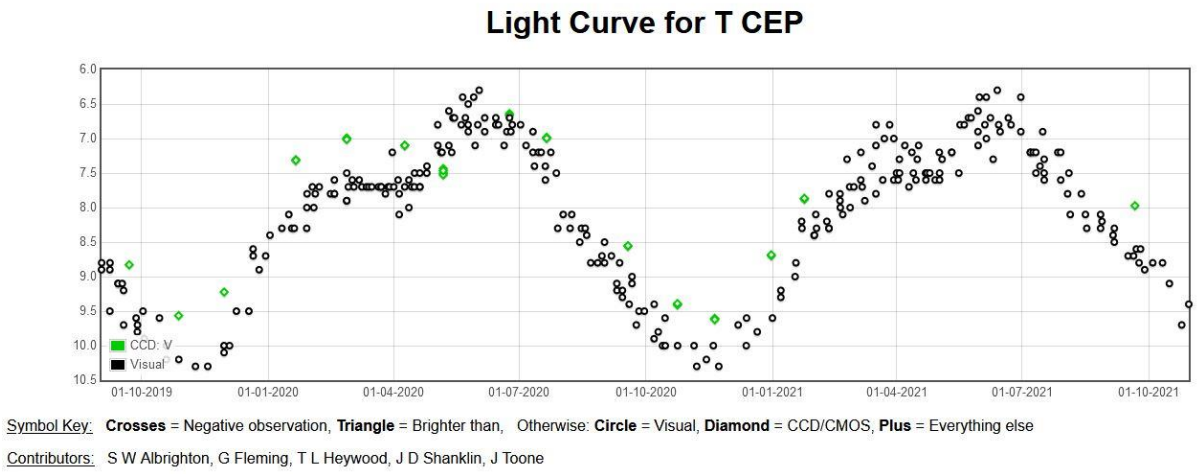
I observed “pauses” during the rise to maximum in most years during the 1990s and early 2000s. Since 2015, the “pause” has been becoming increasingly prolonged.



BAAVSS visual light curve for T Cephei: 2010-2019

It is also interesting to note that the annual date of maximum of T Cephei seems to have shown only small changes in recent years, indicating that the current “average” period is in the region of 370 days rather than 389 days.

In the 2020 and 2021 visual light curves there are signs of it becoming a ‘hump’ rather than a pause - this is also suggested by the smallish number of CCD observations uploaded. Might T Cephei be on its way to becoming a Mira variable with a double maximum?



BAAVSS light curve for T Cephei: 2020-2021

What is physically happening in T Cephei to cause these changes? I have over the years made several attempts to have T Cephei made the BAA VSS Variable Star of the Year, but without success.

Monitoring the changes in the spectrum of T Cephei as it rises to and fades from maximum could be an interesting project. T Cephei will most likely have passed through minimum during November 2021 and will then be rising towards an early summer 2022 maximum.

Any takers?

The only spectroscopic study I know of that might give a clue was by Maurice Gavin in 1999, when he captured spectra on three nights during T Cephei's rise to maximum and noted that during the 'pause', T Cephei remained constant in the 400-450 nm range while continuing to brighten in neighbouring parts of the spectrum. His report can be found at https://britastro.org/vss/00091a.html

WINTER MIRAS

M = Max, m = min.

W And	m=Jan/Feb
R Aql	m=Jan/Feb
UV Aur	M=Jan
V Cam	M=Nov/Dec
X Cam	M=Jan/Feb
SU Cnc	m=Jan
U CVn	m=Dec
RT CVn	M=Dec
T Cas	M=Dec/Jan
W CrB	m=Feb
R Cyg	M=Dec
T Dra	M=Jan/Feb
SS Her	m=Jan
W Lyn	m=Jan
X Lyn	M=Jan
U Ori	m=Dec
R Ser	m=Nov/Dec
T UMa	m=Feb

Source BAA Handbook

CV&E News

Gary Poyner

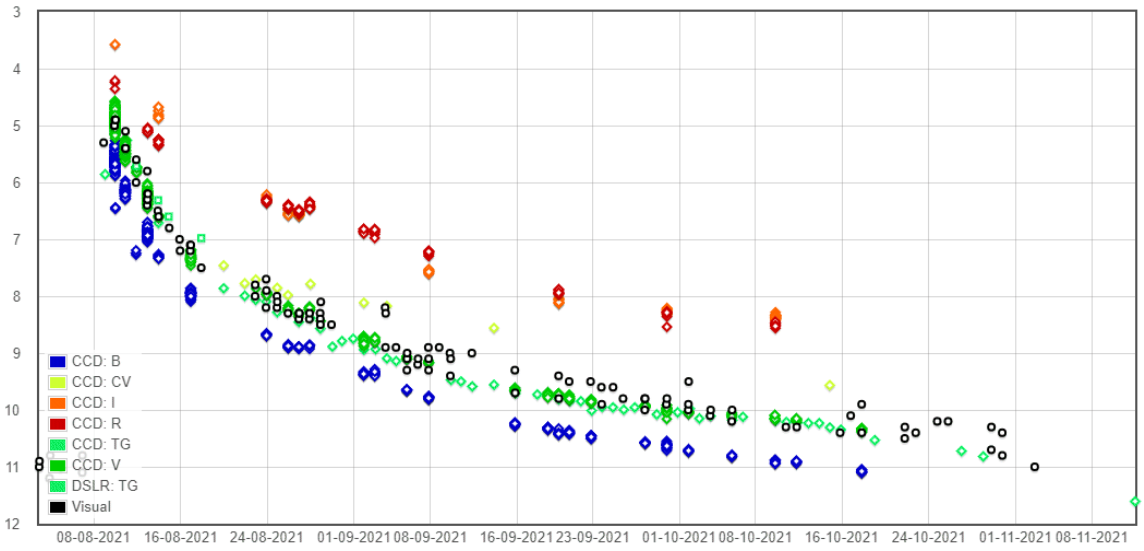
Details are given of BAAVSS coverage of the 2021 outburst of the recurrent nova RS Ophiuchi, the new UGWZ star in Andromeda XM78HT, the UGSU star SW UMa and the 2021 superoutburst of the UGWZ star LL And.

RS Oph

Details of the August 2021 outburst of the recurrent nova RS Oph were given in VSSC 189 whilst the outburst was still ongoing. Now in mid-November it's possible to make comparisons with the previous 2006 outburst using data reported to the BAAVSS DB.

The problem with comparing outburst lengths is to decide at what stage the outburst is over. In this case the 2006 outburst data is fragmentary towards the end, however a reasonable value to give would be mv=10.0. Using this we can say that the recent 2021 outburst has been considerably shorter than the 2006 event – 58 days compared to 85 days, with the peak magnitude similar at 5.3-5.4 mv The most recent outburst has been well covered – some 5,897 observations of various wavelengths have been submitted to the DB, which includes 100 visual estimates. Compare this to the 2006 event, where just 50 observations were reported, all visual! Undoubtably a part reason for this is that the 2006 outburst began in February and ended in May, whereas the most recent outburst started in balmy August and ended in October.

As I write these words in mid-November, the last datapoint in the BAAVSS database has RS Oph at magnitude 11.6TG on Nov 12.02UT.



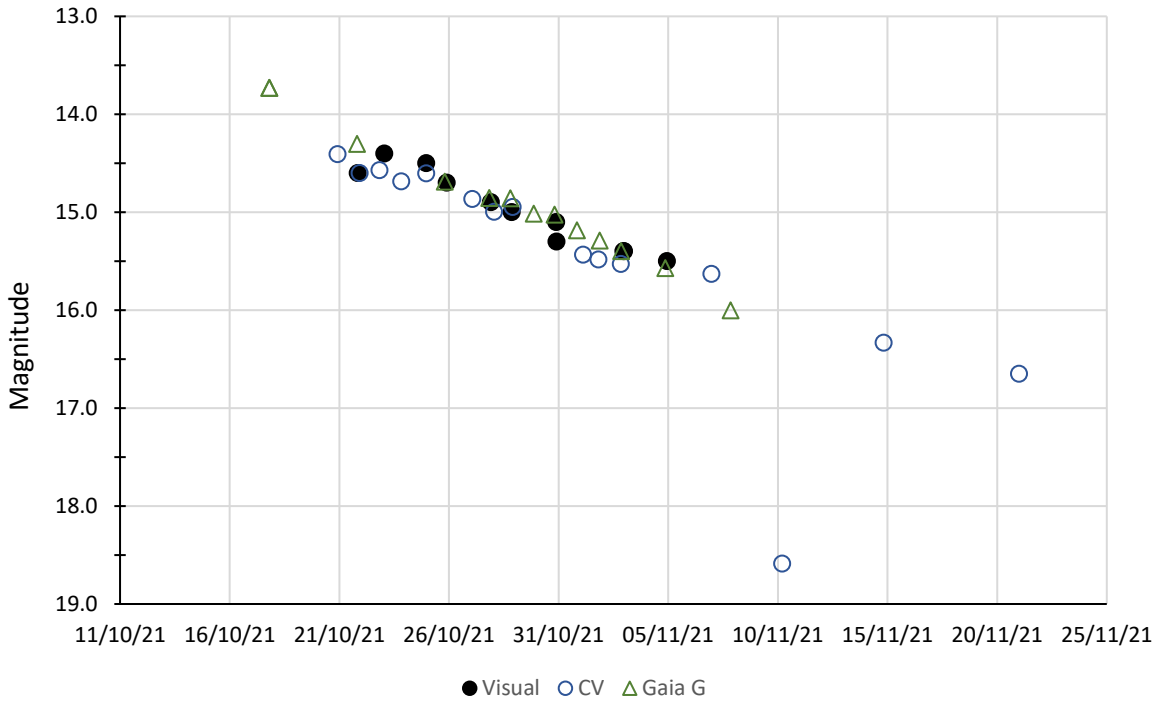
BAAVSS data for RS Oph during the 2021 outburst. Observers: P G Abel, S W Albrighton, D Boyd, L K Brundle, D Dobbs, R B I Fraser, M L Joslin, P C Leyland, W Parkes, R Pearce, R D Pickard, G Poyner, J D Shanklin, J Shears, J Simpson, J Toone, T Vale

SW UMa

A superoutburst of this UGSU star was first reported by Hiroyuki Maehara on vsnet-outburst 27790 as being at magnitude 10.88cg on October 05.799 UT and observed by Kenji Hirosawa. The outburst was also picked up by ASAS-SN sky patrol data on Oct 05.558 UT at magnitude 12.255g. According to the BAAVSS DB SW UMa was fainter than <14.6 visual on Oct 5.14UT – giving a rise of over two magnitudes in just over 9 hours. SW UMa then faded to magnitude 11.8TG by Oct 16 and 15.4C by Oct 23. AAVSO data for October 7 show superhumps of an amplitude of ~0.4V, consistent with previous superoutbursts. The previous (normal) outburst occurred in June 2020, and a superoutburst in December 2018.

XM78HT (AT 2021abog)

A new large amplitude dwarf nova was discovered to be in outburst in the constellation Andromeda on October 15 by the ASAS-SN sky patrol at 14.82g, and announced on vsnet-alert 26332. The object has been catalogued as a new UGWZ type star in VSX.



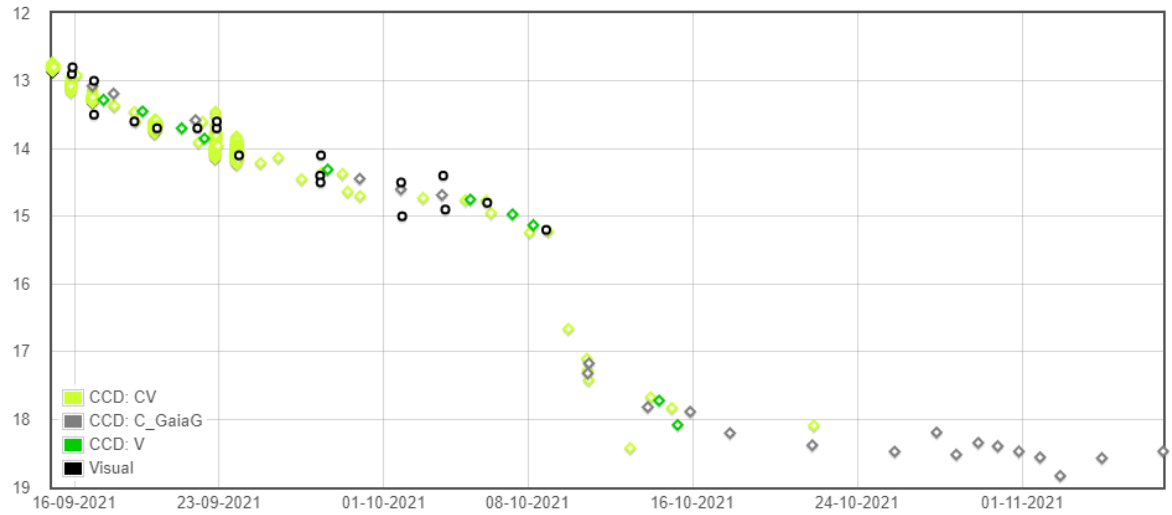
BAAVSS data for XM78HT. Observers N D James, M L Joslin, G. Privett & G. Poyner

Only 40 observations from four observers have been reported to the database (see light curve above), but the outburst has been fairly well covered. From detection the object faded steadily to magnitude 16.0G in just 21 days by Nov 7, before dropping to magnitude 18.59CV three days later on Nov 10. A rebrightening to magnitude 16.0CV occurred on Nov 14 and at the time of writing (Nov 21) XM78HT has faded slightly to magnitude 16.65C.

LL And

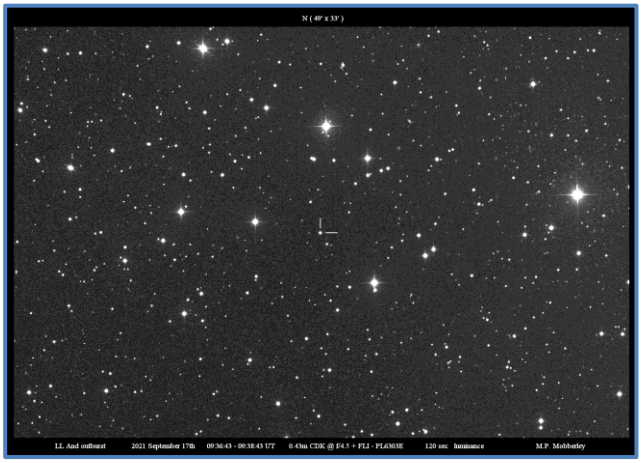
A rare outburst of this UGWZ star was detected by Jeremy Shears on September 14.902 UT at magnitude 12.8C. The object was later determined to be in outburst two days earlier on Sep 12.43 UT at magnitude 12.3g from ATLAS forced photometry data, and reported as such by Patrick Schmeer to various variable star groups in October.

The previous outburst occurred in late May 2004 and peaked at magnitude 12.7 visual. Coverage was fairly sparse with the outburst occurring in the Summer months, but the AAVSO light curve shows that LL And faded to magnitude 16.6V 18 days later by June 15, and 17.1V by July 18. Two rebrightenings appear to have occurred to mag 15.3V on Aug 28 and 16.1V on Sep 29. LL And was first seen in outburst in December 1993 where all the observations made were visual. There appear to have been two rebrightenings on this occasion too, both brighter than 2004 (mag 14.0).



BAAVSS data for the 2021 outburst of LL And. Observers N D James, M Joslin, M Mobberley, G Poyner, G J Privett, J Shears, I L Walton & P. B Withers

The 2021 outburst has been well covered by BAAVSS observers (see light curve above). Following detection, LL And faded gradually for 26d to magnitude 15.2 by October 8 before rapidly declining to 18.4C in just four days on the 12th, making a slight recovery to 17.8 the following night before fading to the mid 18's by the end of October. The last positive observation in the database is 18.985G from Nick James on Nov 21st. Despite the good coverage no brightenings have been seen, unless the aforementioned 0.6 mag rise on Oct 13 can be counted as such.



LL And in outburst. September 17.401 UT iTel New Mexico. M. Mobberley

(*Click on image for larger view*)

Observations of RZ LMi

Stewart Bean

This UGSU dwarf novae has been monitored to investigate if the super-cycle period is increasing and whether it is evolving into a state of permanent superoutburst. The first topic offers an update on a 2013 paper indicating that the super-cycle period of most, but not all, UGSU stars are increasing. The second topic arose in a Vsnet-alert in 2020 following a superoutburst of forty days duration.

Introduction

Dwarf novae (DNe) are binary systems comprising a white dwarf with an accretion disc that is drawing matter from the second star. This flow of matter leads to temperature oscillations in the accretion disc which in turn produce a series of brightenings known as normal outbursts. When the disc radius grows to a particular size, the disc becomes unstable and a long duration superoutburst, one magnitude brighter than normal outbursts, returns the disc to its initial state. The sequence of normal outbursts followed by a superoutburst then repeats. The time between superoutbursts is known as the super-cycle period P(sc). The Variable Star Index (VSX) [1] gives the following definition for the UGER stars:

ER Ursae Majoris-type subclass of UGSU dwarf novae. These stars typically spend a third of their time in super-outburst with a super-cycle of 20-90 days. Outside of super-outburst they typically pack in a rapid succession of normal outbursts.

UGER stars therefore offer the opportunity to observe several superoutbursts per year and measure the average P(sc) value for an observing season. RZ LMi is a UGER star with a super-cycle period of less than 25 days. This may be the shortest such period known which in turn leads to some observing challenges as it is difficult to make sufficient observations per cycle.

The super-cycle period, and its evolution, is considered one parameter that models of DNe should describe. M. Otulakowska-Hypka and A. Olech [2] presented a collection of P(sc) results for some UGER stars and suggested that the super-cycle period may be increasing for many of them including RZ LMi. In this note recent results for RZ LMi obtained during the last observing season using AAVSOnet telescopes under AAVSO program number 163 are reported. These results complement the existing observations of the BAA and AAVSO dating from 1995. The observing season for RZ LMi runs from October to June.

RZ LMi

Kato et al [3] reported and analysed the observations made between 2013 and 2016 by many amateur observers and gave a detailed history of the star. They noted:

In 2016, the supercycles of this object substantially lengthened in comparison to the previous measurements to 35, 32, 60 d for three consecutive superoutbursts. We consider that the object virtually experienced a transition to the novalike state (permanent superhumper).

Subsequently in November 2020 Kato, T. issued Vsnet-alert 25015 requesting observations of RZ LMi in order to check if the star was still demonstrating long superoutbursts. This note briefly reviews the

literature on RZ LMi and its super-cycle period and summarises the results to date.

The historical record.

The earliest observation in the BAA and AAVSO records was on March 18 1995 by visual observer PYG. However, it was not until September 2006 that the frequency of observations allowed identification of the start of most superoutbursts with only a few days uncertainty. This process is not easy with the sparse early data and another author would have a slightly different interpretation. Hopefully the overall picture would be similar.

From 1996/97 to the conclusion of the last observing season, this author has estimated the start of each well recorded superoutburst using BAA, AAVSO, Lasair, and ASAS-SN records. Figure 1 plots the interval between individual superoutbursts in the period from JD 2450000.

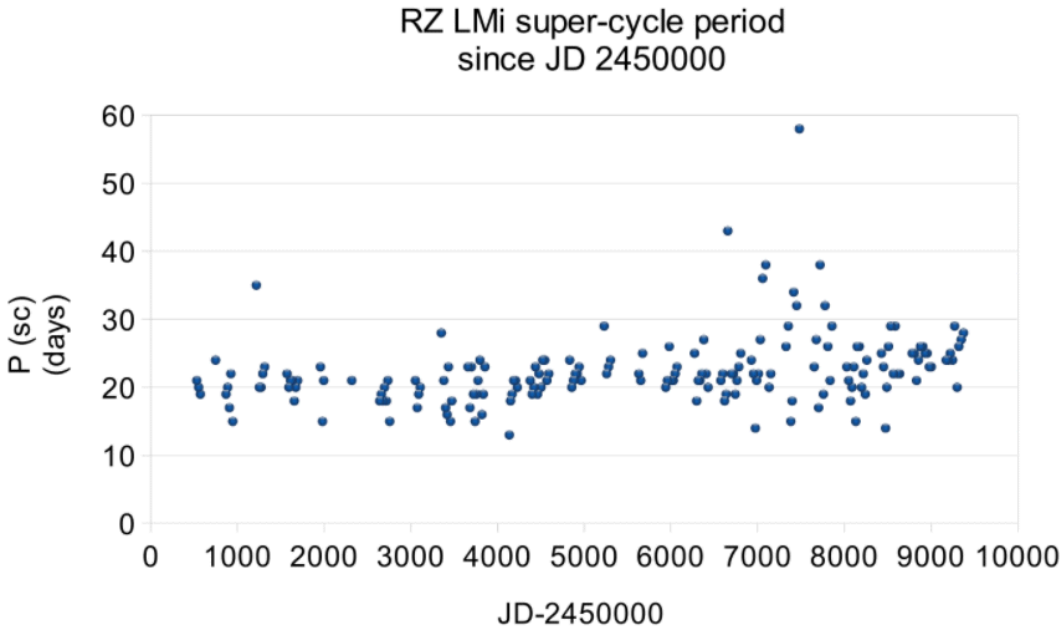


Figure 1. Individual super-cycle periods for RZ LMi since JD 2450532

The supercycle period for RZ LMi usually lies between 20 and 30 days over the last 9000 days (or nearly 25 years). A possible lengthening of the supercycle is suggested in Figure 1. In addition, the period between JD 2456500 and JD 2458000 does show some scatter both to higher and lower values. It includes the 58 day cycle that attracted the attention of Kato, T.

There are two questions that may be posed:

Is the supercycle period increasing?

Is RZ LMi evolving into a permanent state of outburst?

Is the supercycle period increasing?

From the individual measurements in Figure 1, the average supercycle period for each observing season is plotted in Figure 2. This approach is one way in which to reduce the data further. The linear

fit to this data has a gradient of 5.5 x 10^{-4} which is in agreement with the 5.0+/-1.9 x 10^{-4} estimated by M. Otulakowska-Hypka and A. Olech [2] . So, for RZ LMi it does appear that the supercycle period is increasing.

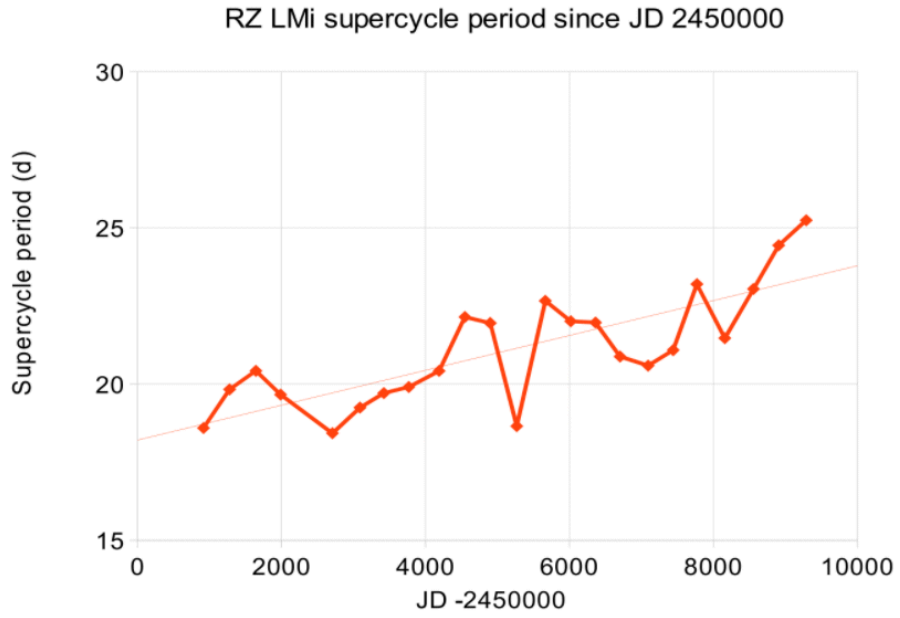


Figure 2. The average super-cycle period for each observing season with a linear fit.

Evolution into a permanent superhumper?

Figure 3 shows the light curve for the period around JD 2457500 taken from Figure 1 of Kato et al. The superoutburst that started at JD 2457484 continued for more than 40 days. This corresponds to the 58 day data point in Figure 1. This behaviour prompted Kato to issue Vsnet-alert 25015 asking for more measurements to establish whether RZ LMi was evolving into a novalike state (permanent superhumper).

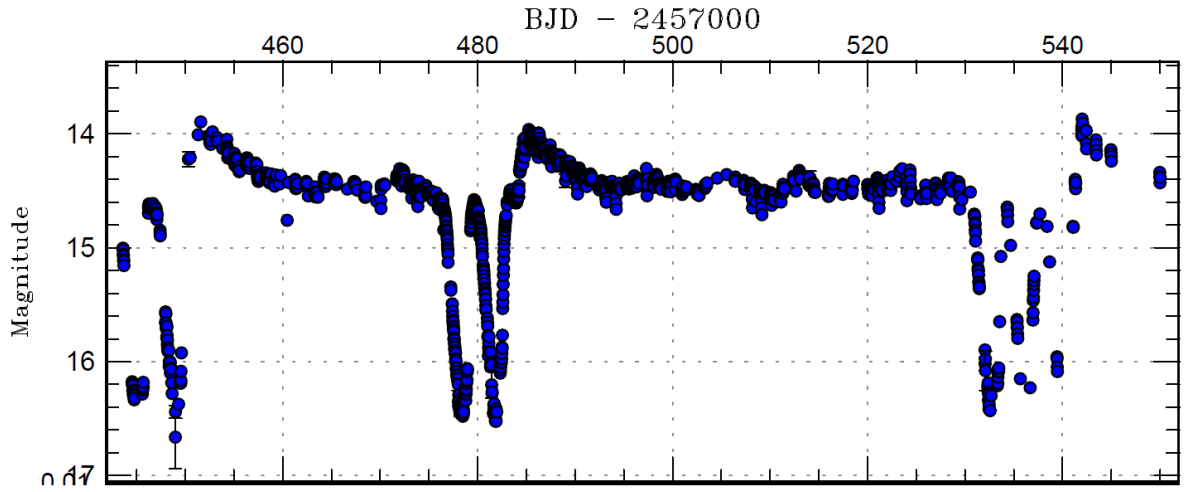


Figure 3. The light curve of RZ LMi around JD 2457500 from Figure 1 of Kato et al (3)

The AAVSO light curve for recent observing seasons is more sparse than Figure 3 but does not show superoutbursts of long duration. The present observing season also does not show a long duration superoutburst. It appears that there is no recent evidence for a rapid evolution into a permanent superoutburst state.

Conclusions and future work

It appears that the supercycle period for RZ LMi is increasing at a rate of 5x10-4 or 0.2 days per year. RZ LMi has not yet transformed into a permanent superhumper – but is capable of showing interesting behaviour and is worth following.

Further observations by BAA-VSS, AAVSO and other observers, complemented by AAVSO program #163, will track the evolution of RZ LMi.

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A first look at the galactic microlensing event Gaia21efs

Christopher Lloyd, Tonny Vanmunster and Sjoerd Dufoer

A preliminary fit to the still continuing galactic microlensing event Gaia21efs using survey and time-series photometry finds that the maximum occurred at 2021 November 2.0 and the amplification of the event was 3.5 magnitudes. The ASAS-SN g-band data fully covered the event but are blended with nearby stars and cannot be directly compared with other data. The event so far appears to be a simple single source.

On 2021 September 24 the Gaia alert system announced the discovery of a new transient, Gaia21efs, that was identified as a possible galactic microlensing event or Be-type outburst. The star had historically been constant at *G* =15.76 and had brightened by ~$0^m.4$ over the course of some 50 days. Gaia21efs (= UCAC4 607-106941) lies at 20 29 41.896 +31 17 42.99 and was also reported as AT 2021ziw. It lies close to the galactic plane at *l*=71.7, *b*=−4.5. Spectra taken near maximum by Leadbeater, and Tagchi et al. (see AT 2021ziw) suggest that the star is a reddened K-type giant and that would be consistent with the Gaia derived distance of 6.0±0.9 kpc [1].

The event has been observed by the ASAS-SN project [2&3], and also by the Zwicky Transient Facility (ZTF) [4], although this only covers the early rise. The ASAS-SN g-band data cover the whole event to date but unfortunately there are four stars within 20 arcsec and two magnitudes of Gaia21efs, so given the 15 arcsec PSF of the ASAS-SN images there will be some blending. The historical magnitude is *g* =16.51 but the ZTF, using the admittedly slightly different *zg* band, gives *zg* =17.27, suggesting $0^m.8$ of blending.

Recently time-series data have been taken in different wavebands, but most consistently in *V*, and partly due to technical issues, *CV* as well. The profile of the microlensing event should be independent of wavelength, so it is simply an issue of aligning the different data sets to a common, unlensed, level. While this is possible for the survey data it is currently not possible for the time-series data as they

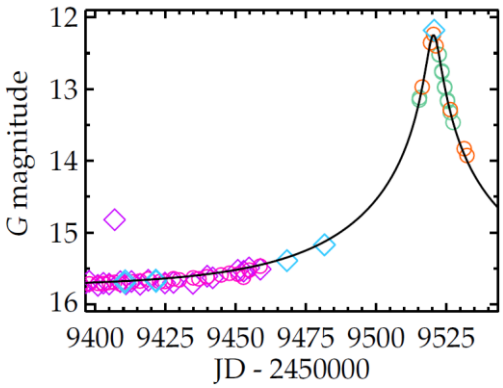

Figure 1: The microlensing event from 2021 July to mid-November showing the Gaia G-band data (blue diamonds), the ZTF g (purple diamonds) and r-band data (red circles), and the recent V (green circles) and CV (orange circles) time-series data. These data have been aligned with the Gaia data for a simultaneous fit.

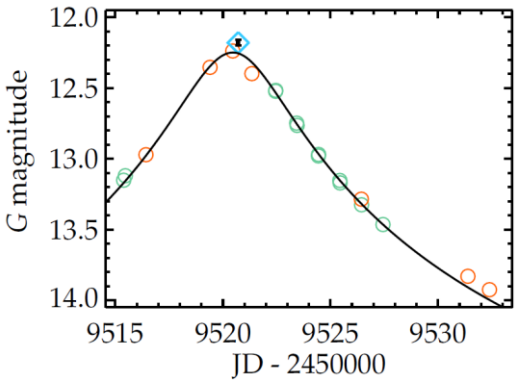

Figure 2 The peak of the microlensing event covering the first half of November showing the Gaia *G*-band data and the recent *V* and *CV* time-series data. The line is the current best fit single event solution but may evolve as new data become available. The symbols and the fit are the same as Figure 1.

do not exist and given the observing season of the star it seems likely that observations will only be possible some way down the descending branch. Having said that, the functional form of the event is quite stiff, so it is possible to rely on that to help tie the data sets together. Although Gaia detected the event it has very few observations through it, there are two in the wing and one at the peak. Nevertheless, Gaia has been used to provide the framework and the other datasets have been aligned to it. Initially this was through offsets of the historical magnitudes and then through systematic offsets of sets of residuals from the fit.

The event has been fitted using the point source approximation lensing model, which is suitable for wide encounters when there are no caustic crossings that produce almost instantaneous increases in brightness - see Gould [5] for the relevant theory and other references. There are only four parameters that define the profile of the event. These are the time of maximum t_0, the Einstein time t_E, which defines the width or time scale of the event, the amplification or magnification of the event *a*, which is the peak increase in flux at t_0 over the base level, and the unlensed magnitude m_z. It is possible to include a fifth parameter that allows for additional unlensed light, either from the lens itself if it is sufficiently bright or from the background, which will be relevant for the ASAS-SN data.

The time-series data typically contain runs of 100-200 points but occasionally this can drop to as few as one, and it was found that the solution was sensitive to this divergence in weighting. Consequently, the runs were replaced by their means, which reduced the problem, but the solution was still sensitive to the offsets between the individual *V* and *CV* data sets. The main parameter that was affected was t_E, which is mostly defined by the peak of the event. The major part of the event is shown in Figure 1, with the detail around the peak shown in Figure 2. The line is the best fit single-event solution but may

change as new data become available and the weighting scheme is improved. From this initial fit maximum occurred at *JD* =245920.46 or 2021 November 2.0, and the amplification was 25.4 or $3^{m}.5$.

The ASAS-SN g-band data are shown in Figure 3 together with a fit that includes a background light contribution. The blending has the effect of reducing the apparent amplification, in this case from $3^{m}.5$ in Figure 1 to ~$2^{m}.5$ for the ASAS-SN data, and preferentially brightening the wings of the event. Although the ASAS-SN data set covers the whole event and is likely to continue gathering data for the rest of the season, the contamination means that they cannot be directly compared with other data. When the background light contribution is taken into account the true base level is found to be g = 17.16, which compares very well with g = 17.27 from the ZTF data, and the amplification becomes consistent with the rest of the data as shown in Figure 1.

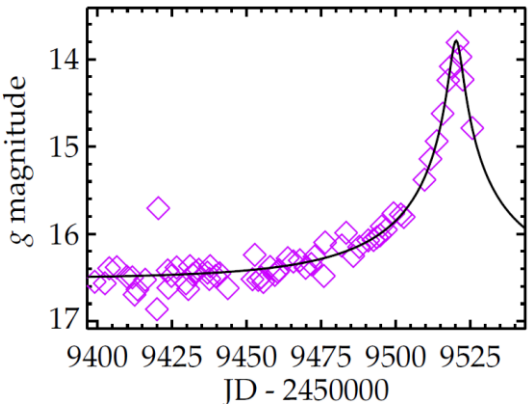

Figure 3: The microlensing event from 2021 July to mid-November (same range as Figure 1) showing the ASAS-SN g-band data. The line is the best fit single event solution including a background light component.

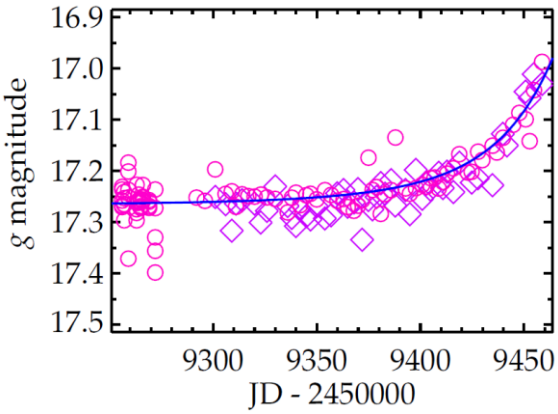

Figure 4: The merged ZTF g- and r-band data. The g-band data (diamonds) are shown at their correct level while the r-band data (circles) have been aligned for the fit. The line shows a slightly different fit compared to Figure 1 where the width of the profile has been optimised to the ZTF data.

The ZTF data unfortunately cover less than $0^{m}.3$ of the rise in the early part of the event but they do help to define this period, which is poorly covered by the Gaia data. In Figure 4 the ZTF r-band data have been aligned with the g-band data and the fit has allowed the width of the event, t_E, to float while fixing t_0 and a at the values for Figure 1. The result is a slightly narrower event and reflects the small systematic offset of the early data. The inclusion of more data in the general solution may help to resolve this but even so there is nothing at present to suggest any complications.

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Observing from the Atlantic Wall

John Toone

During August 2021 I underwent a two-week family holiday to Jersey in the Channel Isles. I had previously visited the island in 1997-1998 for business purposes and I had always intended to return so that I could observe from the British Isles most southerly point. My plan prior to travelling in 2021 was to pinpoint a dark & elevated position giving an unobstructed view of the southern horizon. Two candidate sites were identified on the southern coast, Noirmont Point and Green Island Common. Noirmont Point had greater elevation and was further away from St. Helier the island capital, so that became my primary target. On the 16th August I loaded up the car with the C8 telescope & binoculars and took a four-hour ferry transfer from Poole to St Helier. I then drove to Bouley Bay on the north coast where we were based for the holiday. On the following day I drove to Noirmont Point and was pleased to find it was uninhabited with no local lighting, so it became my primary observing site during the holiday. Noirmont Point was at latitude 49.17° N some 0.8° south of Lizard Point on the British mainland.

Noirmont Point also happened to be the site of “Batterie Lothringen” a coastal artillery battery constructed by the German occupation forces during 1941-1944 and forming part of the so called “Atlantic Wall.” Since the battery never saw action, it was remarkably well preserved with gun emplacements, bunkers & even a restored gunnery range-finder. Although I never saw the underground elements (the entrances were securely locked) I understand they are extensive including a well-protected command bunker for the Kriegsmarine personnel who had manned the battery. The reinforced concrete base and walls of Gun Emplacement No 2 provided an advantageous platform to observe from. The 15cm naval gun barrel dating from 1917 was still in position (Figure 1) but didn’t obstruct the sky. The only disadvantage of the gun emplacement was exposure to wind, so when that became an issue, I observed from the side of the structure using it as a wind break. On each clear night I drove my BMW to the gun emplacement to observe with Zeiss binoculars and wondered (only fleetingly) why I was submitting my observations to the BAA VSS and not to the BAV!!

Figure 1. The interior of Gun Emplacement No 2 facing east with St Helier in the distance. Although the gun had a much longer length the telescope had the edge on aperture. At the time of this photo, the age of the concrete structure was twice the operational age of the telescope. Photo taken by Alexander Toone.

I was fortunate to have eight consecutive clear evenings at Noirmont Point from 22nd to 29th August. The first clear evening coincided with full moon in Aquarius but on the last evening the moon was at last quarter in Taurus. In-between the harvest moon rose on successive nights above the lights of St. Helier towards the east. As anticipated, the southern horizon was dark and unobstructed (Fig 2).

Figure 2. An external view of Gun Emplacement No 2 facing south. An excellent observing platform that allowed me to see the northern part of Corona Australis for the first time from the British Isles. Photo taken by the author.

When the moon was absent from the sky, I could clearly see alpha, beta, gamma & epsilon CrA with 12x50 binoculars. Beta CrA was at declination -39° and at the limit of what I could see, with delta CrA at declination -40.5° not visible. I had not expected to see Corona Australis otherwise I would have brought a chart to attempt to observe V CrA, an RCB star at declination -38° that I saw in 1999 from Australia. Lying within the Milky Way, Corona Australis has a good number of interesting variable stars including R CrA located within a reflection nebula. Consequently, I am not aligned with Patrick Moore's dismissive description of Corona Australis in Naked Eye Astronomy that includes the statements: "it is never seen in Britain" and "it contains nothing of note." (although I fully acknowledge that Patrick was writing from a naked eye perspective).

I secured observations of RY Sgr on each clear evening which represented my third best continuous nightly run of data for this star. I have only exceeded this with 14 nights in Portugal (2017) and 9 nights in Corfu (2019). Whilst the moon was full, I required the C8 to pick up RY Sgr but later as the moon waned, I could make observations with 15x70 binoculars and eventually 12x50 binoculars. This was the first instance that I had seen RY Sgr with binoculars from the British Isles. Over the eight nights of monitoring, RY Sgr faded from mag 6.6 to 6.8 as part of its maximum light pulsation. During the same period its northern hemisphere counterpart R CrB faded from mag 6.2 to 6.3 during its less pronounced pulsation cycle.

Both RS Oph and V1405 Cas were fading from recent nova outbursts. RS Oph faded steadily from mag 8.0 to 8.5 whilst V1405 Cas continued to fluctuate up and down over a similar range.

SS Cyg at mag 11.7 on the 22nd August was at the faintest level I have seen it since June 2020 as it appeared to be gradually returning to more normal activity following its reduced range spell that began back in January 2019.

Z Cam was at mag 11.7-11.8 until the 26th August but then it suddenly dropped on the next three nights to mags 12.1, 12.7 & 13.5 respectively. This signalled the end of its near three-year long standstill and I put out an alert message in the early hours of 29th August.

Already lost from the latitude of Shropshire, I managed to secure observations of R, RR & V818 Sco. FY Lib was still visible in binoculars as were Y & Z Ser which are becoming a challenge back home.

When the moon was below the horizon the Milky Way was an imposing sight right down into Sagittarius. I took some time out of observing variables to gaze at various southern deep sky objects. I got splendid views of M4, M8, M16, M17, M20, M22, M25 & M30 with the C8. Although well past the meridian, M6 & M7 were still impressive in binoculars.

Two days after returning from Jersey I was in Dundee, and it was striking the difference in altitude that Jupiter & Saturn presented in Capricornus due to being located 7.5° north of Jersey. Also evening twilight faded later in Dundee, but after considering the impending autumnal equinox, I put that down more to the 1° difference in longitude between the two locations. At the time of the autumnal equinox, I was in the UAE where Venus was seen against a dark sky whereas from Jersey it had been low down in twilight and from Dundee it was not readily visible. Astronomical objects really do attenuate the effect of latitude and I saw plenty of evidence of that during the period 23rd August to 23rd September 2021.

In summary I was very pleased with the observing conditions experienced on Jersey. I also felt that the Atlantic Wall gun emplacement served some positive scientific purpose eighty years after it was constructed for distinctly non-scientific reasons.

Accessing the Circulars through the ADS

Christopher Lloyd

A programme is under way to index all the VSS Circulars on the NASA ADS which will enable them to be searched by various criteria. In this brief guide the relationship between the ADS, VizieR and Simbad is outlined together with an introduction to accessing the Circulars.

The Variable Star Section Circular is the primary means – although these days not the only means – of communicating with section members, and some sort of document fulfilling this need has been in circulation since the beginning of the section. It is clear that from the very start there were discussions and advice on target lists and comparison stars, and much of this appeared in the early volumes of the *BAA Journal* and the *Memoirs*. The first known circulars were issued by E.E. Markwick, who was Director from 1900 – 1910 (see Shears [1] for a review of his life and times), but apparently none of these documents survive (see Toone [2]).

The *Circulars* as presently understood first appeared over a decade after Markwick in 1922, with eleven being issued up to 1935 by the Director Félix de Roy, who was an internationally recognised Belgian observer based in Antwerp (see Shears [3]). These early *Circulars* are based on the work of pioneers of variable star astronomy such as E.E. Markwick [1], A.N. Brown [4], C.L.Brook [5], A.A.

Nijland and others, and provide a unique insight into the development of variable star astronomy at the time (see also Toone [2] [6] and Kelly et al. [7]).

There was then a long hiatus until 1972 when *Circular* No. 12 appeared under then Acting Director John Isles. Over the next two decades the *Circulars* appeared slightly irregularly with generally 3-5 issues per year, but in 1994 the current regular quarterly pattern was established. Over the years there have been various changes in format and method of production depending on the technology available, and the role of editor has separated from the section Director (see e.g., Isles [8] and Dunlop [9]. The most notable changes were the transition from the larger format to the A5 booklet with – mostly – the 'Old Gold' covers from No. 53, and more recently, and significantly the change to the purely electronic version from No. 173 in 2017 with navigation and embedded links, masterminded by Roger Pickard and Gary Poyner.

In addition to the changes in format and style there has also been an evolution in content. The *Circulars* still have the necessary articles on the management and administration of the section and regular features like the CV & N and Eclipsing Binary News, Chart Updates etc., but the *Circulars* are now dominated by articles with unique pieces of work that deserve to be treated as *papers*. Many of these contain results that do not reach the wider community and that was the primary motivation for indexing the *Circulars* on the NASA Astrophysics Data System (ADS).

The ADS is one of the corner stones of the astronomical information and data system and enables authors and researchers to access papers and articles through an index of all the major, and not so major, astronomical journals and publishing streams, including some articles that are not formally published. The other side of the coin is data access and this is provided through the *Centre de Données astronomiques de Strasbourg* (CDS), which gives access to information on individual stars, and combined objects like clusters and galaxies (and radio, X-ray sources etc.) through the object database query tool Simbad. Although Simbad does provide some basic data its most useful function is identifying papers that contain information on the star in question and provides the appropriate link to the ADS. Access to catalogue data on specific objects is provided through another CDS tool, VizieR, which can be used to search all or a subset of CDS catalogues. In addition to increasingly detailed catalogue data VizieR also provides bibliographic data on the papers providing the catalogues and a link to the ADS. Similarly, the NASA/IPAC Extragalactic Database (NED) provides a more specific search of extragalactic catalogues, but again links to bibliographic data in the ADS.

Every article in the ADS is identified by a 19 character string called the bibcode which is built up from the year of publication, the bibliographical abbreviation of the journal, the volume or issue number, the page number and the first initial of the lead author's surname. These are padded as necessary with dots to make 19 characters. So, for example, the Gaia collaboration paper reporting the DR1 data in 2016 has the bibcode 2016A&A...595A...1G and is the primary identifier of this paper, which can appear anywhere on the internet from Google searches (others are available) to Wikipedia. Special cases can occur when there is no author information, or the page number is meaningless, but the basic format remains the same and is still 19 characters.

Access to the ADS is through https://ui.adsabs.harvard.edu, which by default points to the so-called "Modern Form" as opposed to the legacy "Classic Form," or the more specialist "Paper Form." An enormous range of possible search terms is available under "All Search Terms," but the most widely used fields are available through the 'QUICK FIELD' tabs above the search box, and the required formats of the fields are given in the example's underneath. The field names can be typed directly in the search box and auto-complete suggestions will be offered. Numerical fields do not need quotes.

To limit any search to the *Circulars,* select 'bib abbrev' from the drop-down list and type 'BAAVC' between the quotes. For a general search of all journals and publications ignore this field. The

'Fulltext' search term is useful for searching for words or phrases that appear in the title, abstract or keywords of any papers. For the *Circulars* the keywords field contains variable star names of stars that are *significantly featured* in the article, so not stars that are mentioned in passing. Stars that are given new or updated charts also appear in the keywords. The 'body' search term will search the body of the text for a word or phrase in major publications, but currently this is not enabled on the *Circulars*.

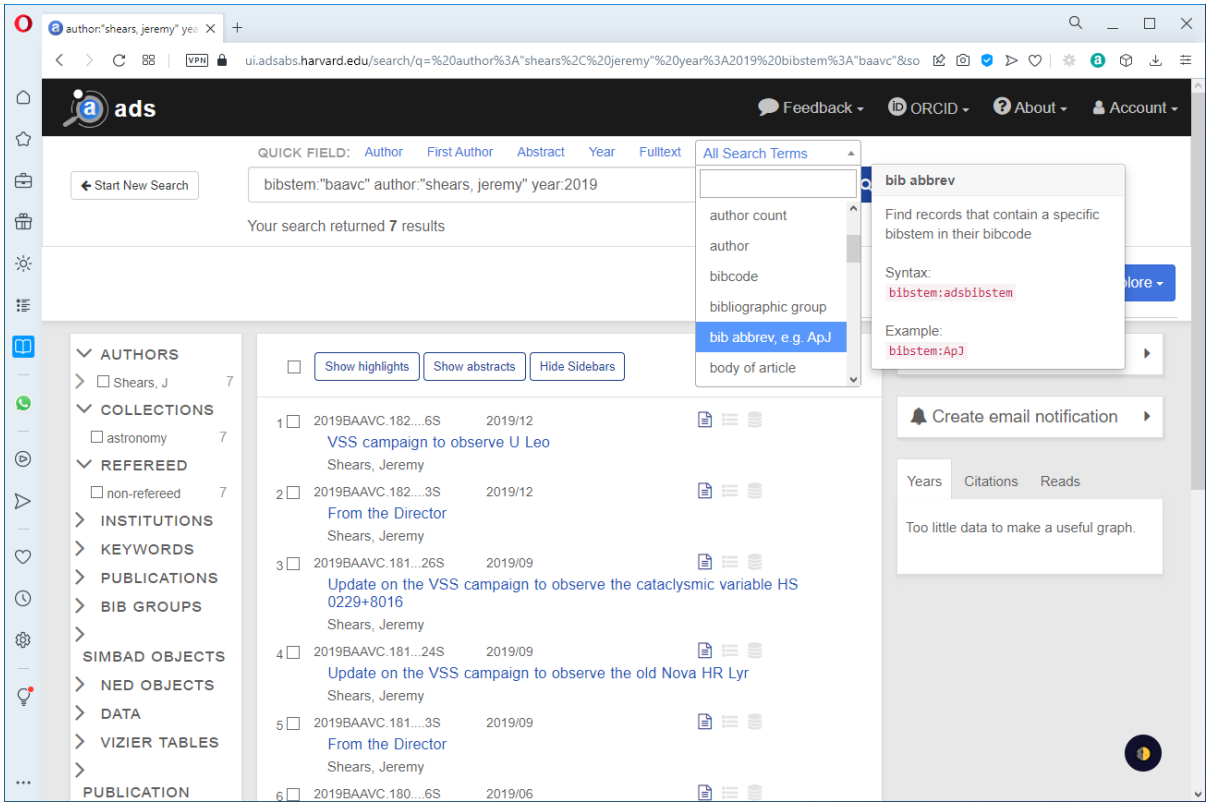

Figure 1. The result of a simple author and year search of the *Circulars* showing the 'bib abbrev' field in the drop-down box and the help information.

The results page (see Figure 1) gives a list of articles meeting the search criteria showing the bibcode and title, and author information, with the most recent at the top. The three icons alongside each article provide direct access to [1] a PDF or scanned article, [2] a list of references and citations for the article in question, and [3] a link to related data in (typically) Simbad, the CDS and NED. If nothing is available these symbols will be greyed out, and that will initially be the case with all the *Circulars* until the whole system catches up with the articles being indexed. The link on the bibcode and title leads to the abstract page (see Figure 2) which not only shows the abstract but also in turn provides links to the other information such as the citations to the article and references in the article, and for users of *LaTeX* a very useful bibtext formatted citation. Below the abstract further meta data about the publication are given including the Digital Object Identifier (doi), if it exists, and this usually links to the journal web site.

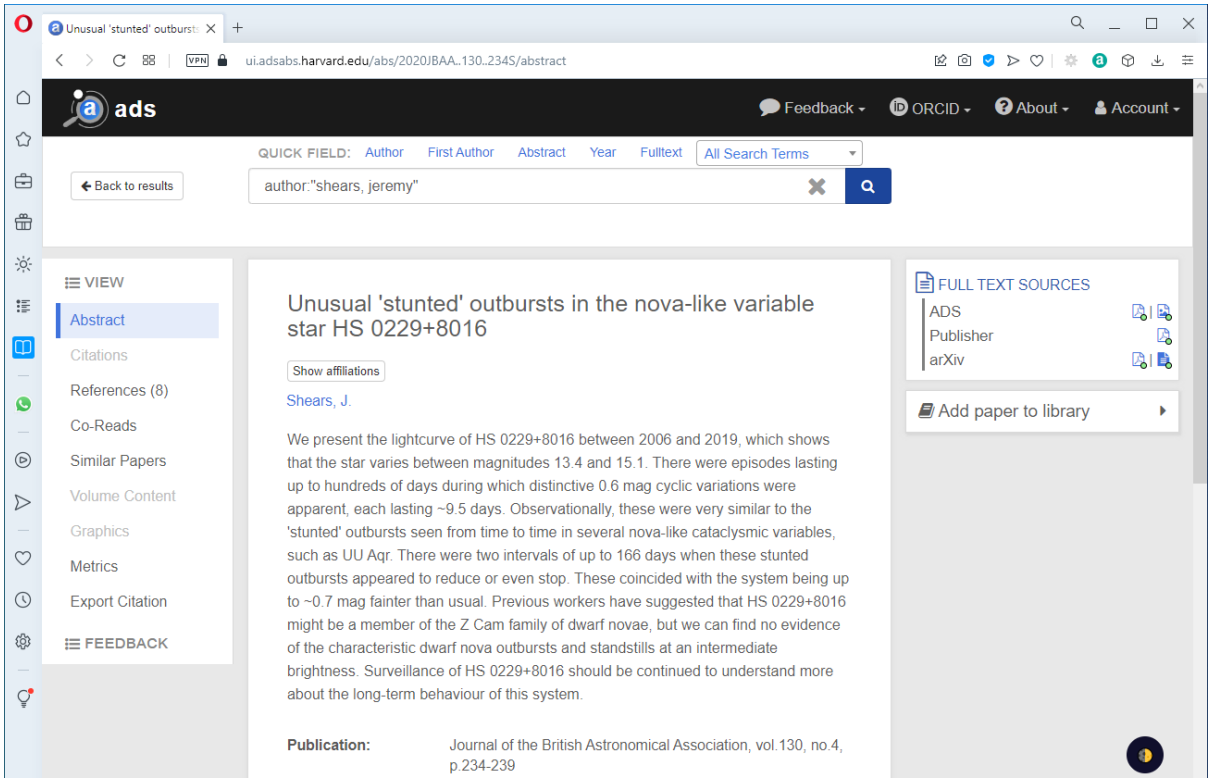

Figure 2. The ADS abstract page which as well as showing the abstract of the article provides access to other information and different sources of the full-text article.

On the right hand side there is access to various full-text sources and there is usually a maximum of three sets. The ADS provides access to the paper as published either as a PDF document or a scanned file. Hovering on the icons provides more details. The publisher may also provide free access to a PDF document or an html source, usually through the doi (digital object identifier), but the full article may be behind a paywall, and this is usually indicated by the 'login required' message, although it is not always correct. The third full-text source is the astro-ph preprint archive maintained by Cornell University and this provides either direct access to the PDF document or the relevant *arXiv* page, which in turn may provide access in a variety of formats, including the full *LaTeX* file set. The *arXiv* is a very important source of hard-to-get papers but it should be remembered that they may not be identical to the published versions.

When available, the abstract page also provides access to various data products associated with the article (see Figure 3). The most common is the link to Simbad which provides access to data and publications on specific stars mentioned in the paper (as given in parentheses). If there are any catalogues associated with the paper, then these can be accessed through the CDS or NED link. In addition, links to specific data sets used in the paper may be available through individual mission archives. Finally, at the bottom of the column there may be a link to associated works, which generally point to related papers in a well-defined series or source papers for catalogues.

When writing a paper for the *Circulars* there are a few points to bear in mind that make the indexing more useful. The first is a short but descriptive title that gives the direction of the paper. The second is a short abstract which increases the visibility of the paper and provides the basic details, and conclusions. Thirdly, it is very helpful to include the name of the star, or stars being discussed in the title or abstract, if there are not too many of them, as they will be automatically searched by the ADS without having to rely on them being included in the keywords during the indexing process of the *Circulars*

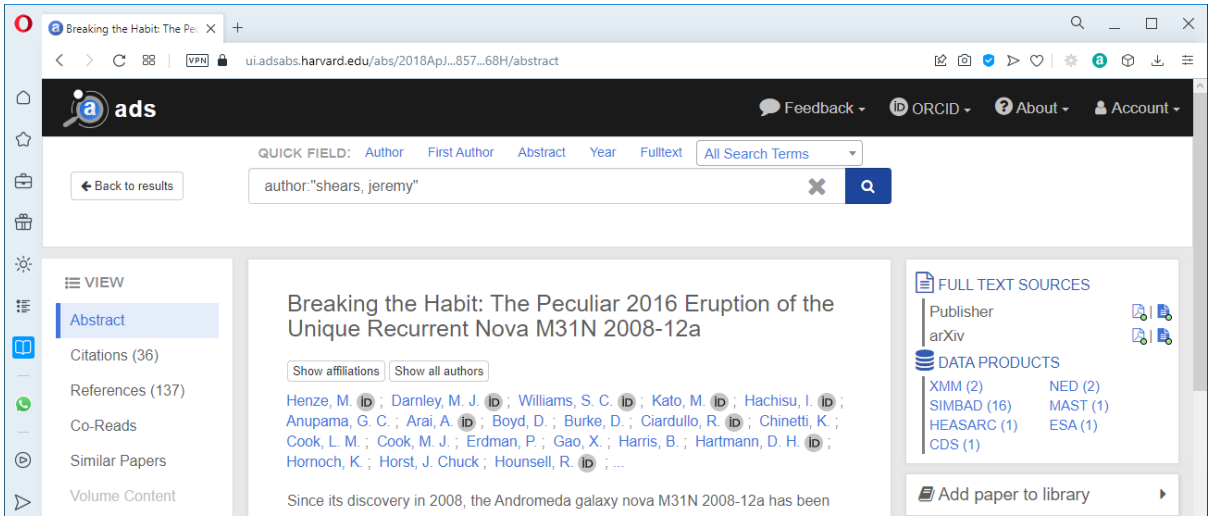

Figure 3. The ADS abstract page of a paper showing links to several data products. These are most commonly to Simbad but may include links to catalogues held by the CDS and NED, other portals, and data sets in specific mission archives.

The *Circulars* has a flexible approach to references, but the editor would prefer authors to link to the ADS rather than directly to the PDF files of the *Circulars* on the BAA web site. In this way any links are future proofed against changes on either site, and it enables the full power of the ADS to be utilised. Although all the Circulars are not indexed on the ADS yet, it is possible to anticipate what the link will be by knowing how the bibcode is constructed. The direct link to the article abstract page is https://ui.adsabs.harvard.edu/abs/*bibcode* where the bibcode for example Storm Dunlop's article in *VSS Circ.* 100, page 7 from 1999 will be 1999BAAVC.100….7D, but for the moment this page does not exist.

Currently the *Circulars* indexed by the ADS cover issues 1 – 11 from the Félix de Roy years, which were imported as part of an earlier exercise, and issues 139 – 184 from 2009 – 2020. Indexes have been created for issues 115 – 138, and these will be sent to the ADS for processing shortly, along with those for 2021. Some of the earlier issues have also have indexes but the majority from 13 – 114 need some work before they can be sent to the ADS. If any corrections or omissions are found, then please send them to the editor.

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Eclipsing Binary News

Des Loughney

Eclipsing Binary Observing Guide - Second Edition

The second edition has been printed and can be obtained from the BAA Shop. It costs £6.00 for BAA members and £7.50 for others.

AAVSO Eclipsing Binary Webinar

This webinar was held on 11th July 2020 and was attended by 300 people from all over the world. The webinar is now on YouTube. It lasts just over two hours. If you click on the image below it will take you to the YouTube site. The webinar has been viewed by another 400 people since 11/7/20. It is part of a series of 15 AAVSO webinars on variable star themes including another one on Eclipsing Binaries, with a more specialist theme, which is titled: '**How to plan observing of eclipsing binaries when ephemerides are out of date.**

I would recommend that everyone that has an interest in Eclipsing Binaries looks at the webinar. It has much interesting information and useful suggestions. I was not sure how useful will be the 'Phoebe 2.3: a binary simulation and fitting programme', which was presented by Bert Pablo, to BAA VSS members. However, I would welcome views on that. Gerry Samolyk and Gary Billings are the joint chairs of the AAVSO's Eclipsing Binaries Section.

I watched carefully Gerry Samolyk's contribution. He referred to the work of the Finnish astrophysicist Lauri Jetsu of which I had not been aware. Later on in this article I quote an abstract of a paper by him published this year, and also include a reference to a news article on the paper. The paper illustrates the ongoing research on the very familiar Algol system.

Gerry illustrated the light curve of UX UMa which has been monitored by AAVSO observers since 1984. It varies between magnitude 12 and 14.5. On the AAVSO website is a paper on the system <https://www.aavso.org/vsots_uxuma>. It is regarded as a system of interest because it is both a cataclysmic variable and an eclipsing binary. It can be observed any time because it only has a period

of 4.7 hours! It has never been on our list of recommended systems to observe possibly because it is too faint to be followed by most of our observers.

Legacy Programme

Gerry described the AAVSO Legacy Programme which is a different way of organising EB observing compared with the UK. They have determined that some systems should be monitored long term in order to check period change. The Programme works to ensure that two or three times a year the EBs in the list have the time of mid-eclipse determined.

Visual/Binocular Observations

Gerry's presentation and examples of light curves seemed to be only those that have been obtained by CCD photometry. There were no examples of good estimates of mid eclipse obtained by visual or DSLR methodology. There was no mention of the special role of DSLR photometry in measuring brighter EBs with low amplitude variation.

Gary Billings gave an interesting presentation which included 'The science of O/Cs' and 'Planning EB Observations'. At one point he referred to data mining and the use of the ASAS-SN database <https://asas-sn.osu.edu/variables>, which I was not aware of. This is the only survey to monitor the entire visible sky every night. It apparently has made 238,752 discoveries of variable stars of which about 25% are eclipsing binaries.

Gary commented on the use of packages of software called Peranso 3 and Binary Maker 3.0.

He emphasised the importance of time series photometry in determining the midpoint of a primary eclipse though he was only referring to CCD data. He made a useful explanation of the use of Observed/Calculated Diagrams (O/C Diagrams) in determining the influence of non-eclipsing third bodies within an EB system.

He referred to his paper on V1103 Cas: "The Apsidal Motion Analysis of the Eccentric Eclipsing Binary V1103 Cassiopeiae". The abstract is:

"The Algol-type eclipsing binary system V1103 Cas was discovered by Otero et al. (2006) and identified as an eccentric system with period 6.1772 days. I observed it on multiple nights from 2012 to 2017 and found the primary and secondary eclipses to be of unequal depth and duration. The secondary eclipse is displaced from phase 0.5, and that displacement is slowly varying. Differential V-filtered lightcurves were modeled (using binarymaker3) to determine the eccentricity (0.27) and inclination (87.5 degrees) of the system. These parameters, and 10 times of minima, were used to determine the apsidal rotation period (748 years), using the method described by Lacy (1992). The presentation will include material showing how the eclipse widths and timing will vary through the apsidal period." [2].

Gary was quite correct to emphasise the importance of light curve analysis as well as determining the mid-point of eclipses.

I think that I will have to look at his presentation several times in order to fully understand the use of O/C diagrams after obtaining data from DSLR photometry. It will be a useful exercise.

Say Hello to Algol's New Companion Candidates' - Lauri Jetsu

Abstract

"Constant orbital period ephemerides of eclipsing binaries give the computed eclipse epochs (C). These ephemerides based on the old data cannot accurately predict the observed future eclipse epochs (O). Predictability can be improved by removing linear or quadratic trends from the O − C data. Additional companions in an eclipsing binary system cause light-time travel effects that are observed as strictly periodic O − C changes. Recently, Hajdu et al. estimated that the probability of detecting the periods of two new companions from the O − C data is only 0.00005. We apply the new discrete chi-square method to 236 yr of O − C data of the eclipsing binary Algol (β Persei). We detect the tentative signals of at least five companion candidates having periods between 1.863 and 219.0 yr. The weakest one of these five signals do not reveal a "new" companion candidate, because its 680.4 ± 0.4-day signal period differs only 1.4σ from the well-known 679.85 ± 0.04-day orbital period of Algol C. We detect these same signals also from the first 226.2 yr of data, and they give an excellent prediction for the last 9.2 yr of our data. The orbital planes of Algol C and the new companion candidates are probably coplanar because no changes have been observed in Algol's eclipses. The 2.867-day orbital period has been constant since it was determined by Goodricke." [1]

There is an article on this paper here

1: Lauri Jetsu 2021 *ApJ* **920** 137

2: Gary Billings 2019 JAAVSO 47,1,p130.

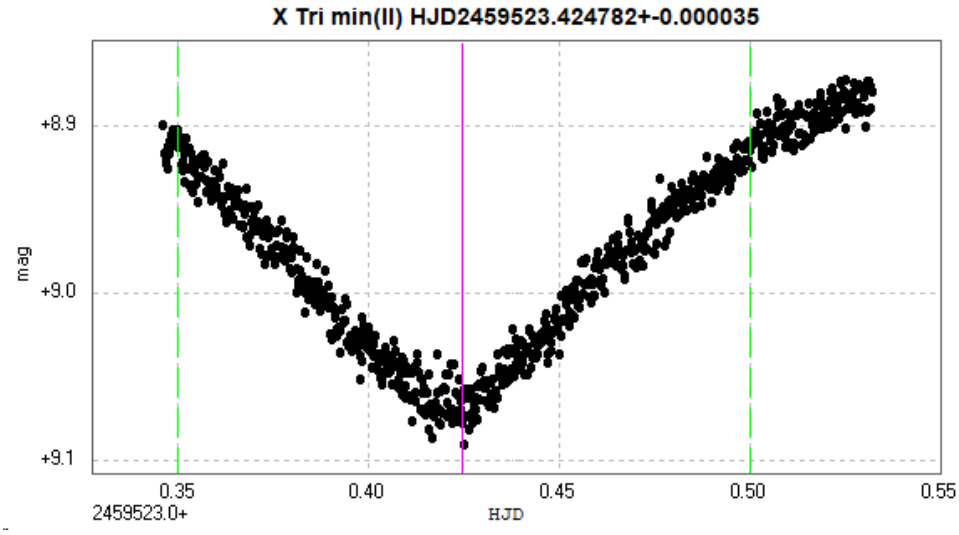
Some observations of the eclipsing binary X Trianguli

David Conner

X Trianguli is an eclipsing binary with a complex o-c curve. One primary and two secondary minima have been recently observed which are consistent with this curve, and possible explanations for its complexity are briefly discussed.

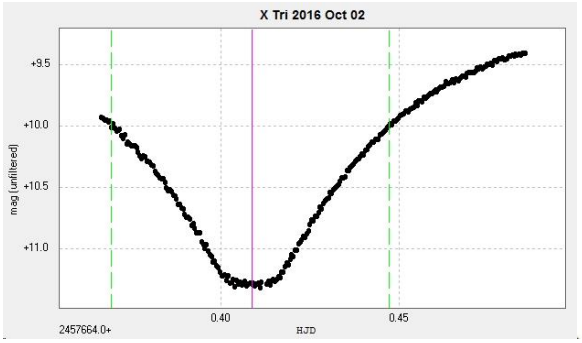
X Trianguli is an EA/SD type eclipsing binary. I have recently made a number of observations of its minima whose timings are consistent with the complex o-c curve of this system. Possible explanations for this complexity, which have been discussed elsewhere (links below), include mass transfer, some form of magnetic activity and a possible third body.

The following is a secondary minimum of the EA type eclipsing binary X Tri made from Somerby Observatory on 2021 November 4 using the '2" Titan'. The 756 images used for the photometry were unfiltered and the results have not been transformed.

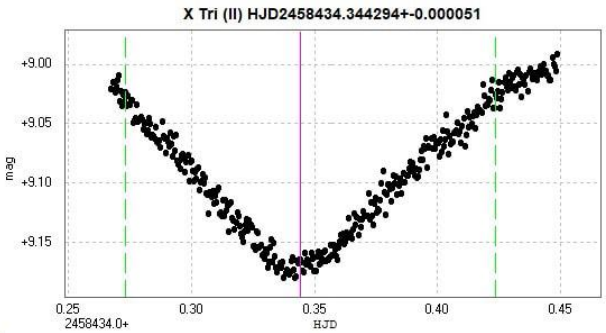


The time of this secondary minimum as calculated in Peranso was HJD 2459523.424782 +/- 0.000035.

Previous observations of this system from Somerby include a primary minimum on 2016 October 2, and a secondary minimum on 2018 November 11. Both are shown below, together with their calculated times of minima (both of which have been forwarded to Krakow, unlike the 2021 result).

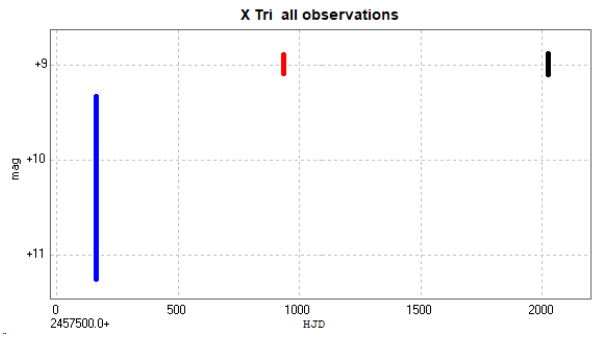


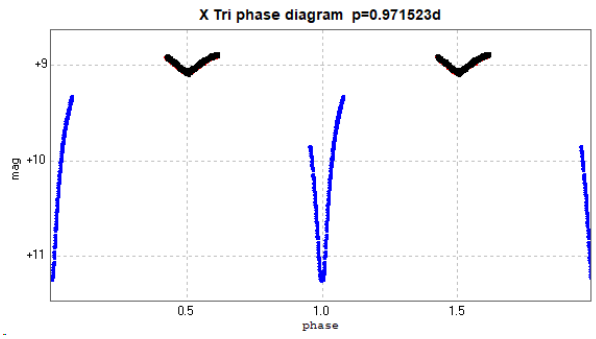
2016 October 2 time of primary minimum = HJD 2457664.408705



2018 November 11 time of secondary minimum = HJD 2458434.344294

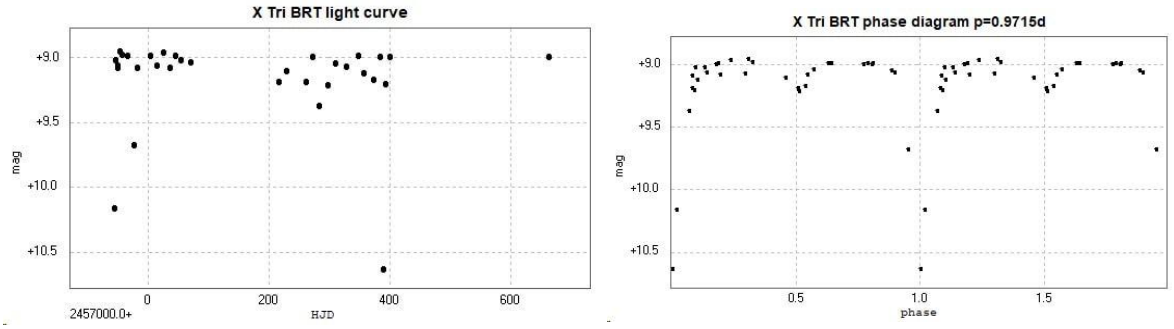
The three sets of observations were plotted in the following light curve and phase diagram.





The 2016 observations are in blue, 2018 in red and 2021 in black. The 2018 results are obscured by those of 2021 in the phase diagram.

Previously, 32 images had been obtained from the Bradford Robotic Telescope (BRT) between 2014 October 13 and 2016 October 1 through the tri-colour green filter, resulting in the following light curve and phase diagram.



Discussion.

1) The o-c value for the 2021 November 4 secondary minimum was calculated to be -0.054096 days, using the epoch and value for the period used by Kreiner to generate the o-c curve. (37879.5 cycles had elapsed since the epoch.) This value is consistent with Kreiner's o-c curve, which shows a decreasing value of o-c due to the current period of the system being slightly shorter than that used to generate the curve.

2) It has been suggested that the changes to the o-c curve over the last century or so might be due to the presence of a third body and/or internal magnetic activity of one of the components affecting its internal angular momentum. Additionally, the magnetic activity might also be responsible for changes to the range of variation of the brightness of the system *Rovithis-Livaniou et al Astronomy and Astrophysics 2000*. The possibility of mass transfer between the components has also been discussed as a possible cause of the irregular period changes, *Mallama, Acta Astronomica 1975*.

3) More details of these observations can be found on my website.

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