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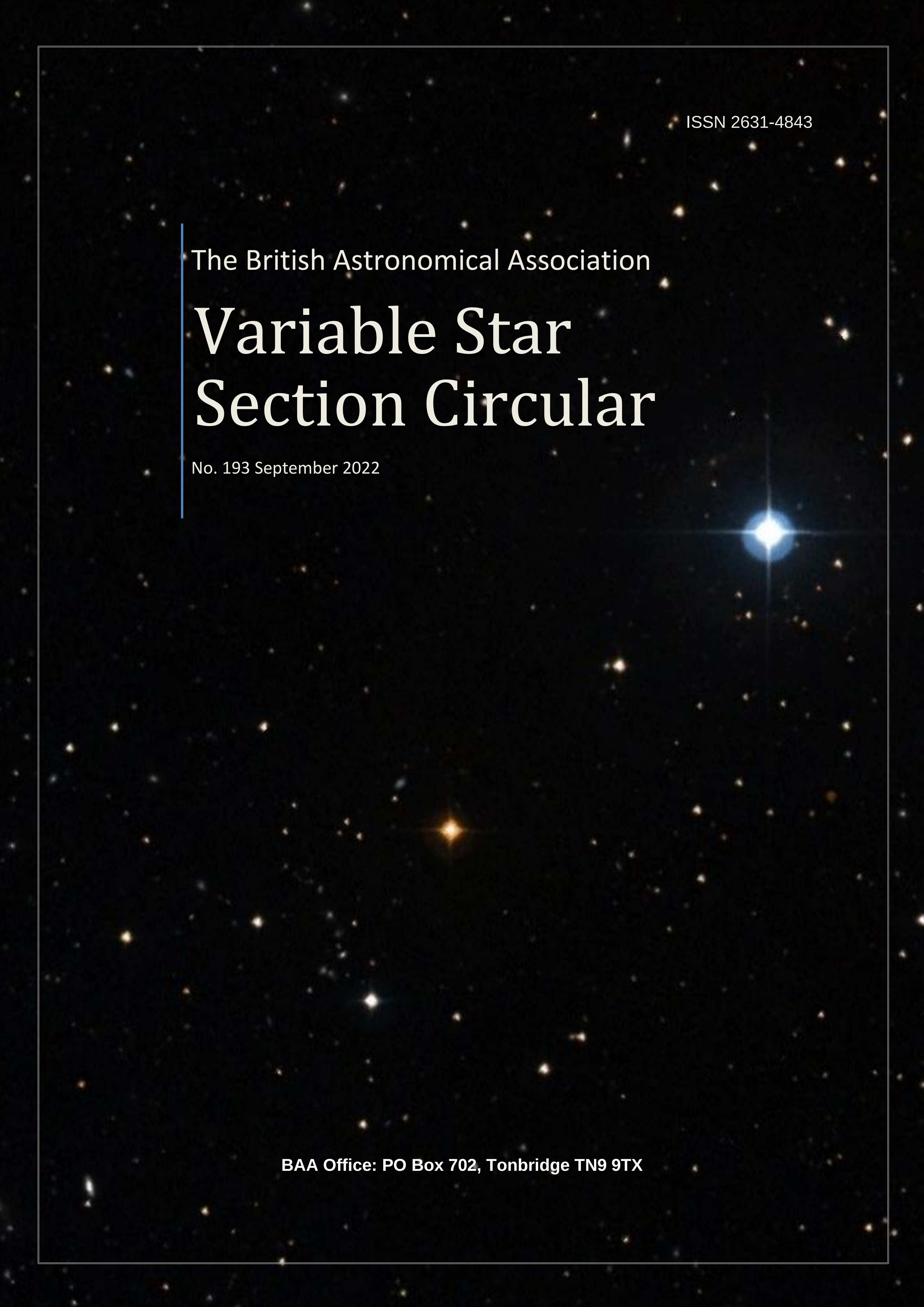
No. 193 September 2022



BAA Office: PO Box 702, Tonbridge TN9 9TX

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Cover Picture

The Mira star S Corona Borealis
Digitized Sky Survey

Aladin sky atlas developed at CDS, Strasbourg Observatory, France
2000 A&AS..143...33B and 2014ASPC..485..277B.

From the Director *Jeremy Shears*

I write this just as the UK's second heatwave of the Summer has broken. The usual rainy weather has returned, but at least the lawn is greening up. Although uncomfortable for sleeping, the August heatwave in particular has provided a good run of clear nights, at least where I live. Nevertheless, I look forward to cooler, longer nights in September, which I generally find one of the more favourable months for the number of clear nights.

One of the unexpected events of the Summer was the eruption of the recurrent nova, **U Sco,** reaching magnitude 7.8 on June 7. See the light curve in Gary's CV & E report later in this Circular. This eruption was less than a year after that of another recurrent nova, **RS Oph.** Surely **T CrB** can't be too far behind?

AUTUMN MIRAS

M = Max, *m* = min.

RW And	M=Sep
R Aqr	M=Aug/Sep
R Aql	*m*=Nov
V Cam	*m*=Nov
X Cam	M=Nov
	m=Sep
SU Cnc	M=Oct
U CVn	*m*=Oct/Nov
RT CVn	*m*=Nov/Dec
V CrB	M=Sep
W CrB	*m*=Oct
T Dra	*m*=Sep
SS Her	M=Oct
	m=Nov/Dec
R Hya	M=Oct/Nov
SU Lac	*m*=Sep
RS Leo	*m*=Oct
W Lyn	*m*=Nov
X Lyn	M=Nov/Dec
X Oph	M=Sep
R Ser	*m*=Nov
T UMa	*m*=Oct

Source BAA Handbook

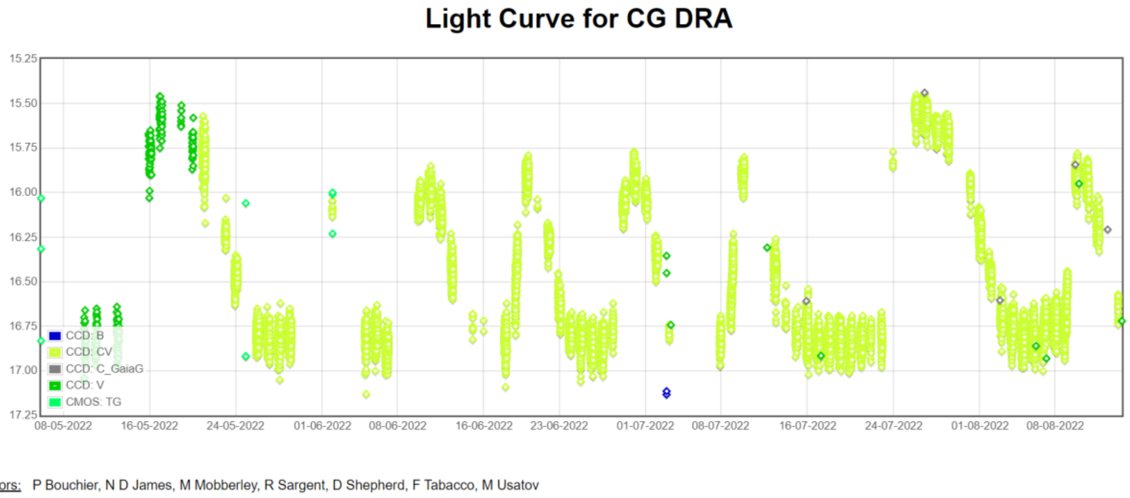
During the Summer I bought my first pair of image stabilised binoculars (Canon 12 x 32 IS III). First light was the waxing Moon low in the South. A quick look and the image looked pretty much as I'd expect in a small pair of binoculars. And then a small miracle happened. I pressed the image stabilisation button and, "ping," the Moon stood still (although there was actually no audible tone to accompany the pressing!). Gone were the usual gyrations as I tried to hold the binoculars steady. Instead, it was like I had taken a snapshot of our satellite – so much more detail was visible. I've also used them on starfields and am equally impressed. Not only is Albireo well resolved, but the colour difference of the two stars is obvious. I hasten to add I could do this without IS, but the key difference is that with IS I can concentrate on viewing, rather than straining to hold the binoculars steady. M27 was marvellous in its starfield, as was the Milky Way down from Cygnus to Sagittarius. I also used them on R CrB, again finding the steady image resulted in easier observation. I shall do some more tests under dark skies, and hopefully from more southerly latitudes, but I can already see the IS increases my limiting magnitude. I will certainly do some more binocular VS observing; I wonder if other VS observers have found benefit from IS binoculars.

Overall, using the IS binoculars is a very pleasant experience. However, I am left with the question: why hadn't I invested in a pair of IS binoculars before?

Observing Campaigns

The observational campaign of the dwarf nova, **CG Dra**, continues apace. We are building up an impressive long-term light curve of its "brief" outbursts. The campaign began last year and the light curve below shows data from the 2022 season. This reveals two longer, brighter outbursts, with 5 smaller, fainter ones between. Maxim Usatov has been doing a splendid job on time series photometry of the star. His data, obtained with his remote telescope, are exquisitely precise. They are already revealing intricacies of eclipses shape, orbital humps, etc. – do follow the ongoing thread on the BAA Forum which Max updates regularly.

Everyone's contribution to the campaign is welcome, including single observations, and I would like to thank all observers for their efforts. We will continue the campaign until at least the end of the current season (turn of the year) and review the status then.



The observing campaign on ER UMa systems continues – many thanks to Stewart Bean for continuing to highlight this. Systems under observation are **ER UMa** itself, **IX Dra**, **RZ LMi**, **V1159 Ori** and **DI UMa**. You can read Stewart's article on **V1159 Ori** in this Circular which presents evidence that super-cycle length is increasing

Copy of the Webb Society's handbook on variable stars available

As I mentioned in the June Circular, John Isles kindly gave me some pristine copies of the Webb Society's handbook on variable stars, published in 1990, which is volume 8 in their series of deep-sky observers' books. There was an excellent response from people wishing to obtain a copy such that there is only one left!

If anyone would like the final copy, please contact me. I can only post to UK addresses due to postage costs.

BAA VSS-Alert

A reminder that all observers are encouraged to join the Section's BAA VSS-Alert email group. This relays information about unusual activity in all types of variables, (such as rarer CV outbursts, nova eruptions, fades in RCB stars, and noteworthy activity in LPVs), latest news on VS topics and information about the Section (it is not used for routine reporting of VS estimates).

You can join BAA VSS-Alert by simply sending an e-mail to… baavss-alert+subscribe@groups.io or by visiting the web page https://groups.io/g/baavss-alert. The unsubscribe address is baavss-alert+unsubscribe@groups.io.

CV & E News

Gary Poyner

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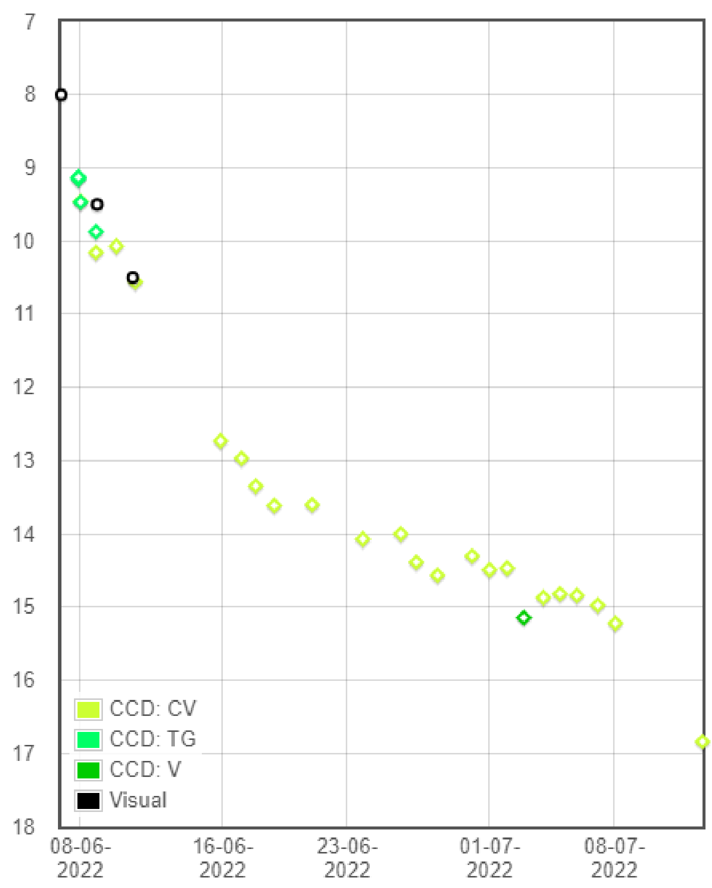
Latest news on the recent outbursts of the Recurrent Nova U Sco and the UGSU star VY Aqr, the bright state of the Symbiotic star CH Cyg and the rare fade of the RCB star V482 Cyg are discussed.

U Sco

On June 6th, 2022 the Recurrent Nova U Sco was detected in outburst by Japanese observer Masayuki Moriyama (Sasebo, Nagasaki) at magnitude 11.4C on Jun 06.720 UT, having recorded a negative observation of <17.3C on Jun 06.567 a mere 3h 45m earlier.

This was the eleventh outburst recorded (1863, 1906, 1917, 1936, 1945, 1969, 1979, 1987, 1999, 2010, and 2022). An anomalous outburst is suspected of occurring in 2016 during Solar conjunction, and there were likely outbursts missed due to the Sun in both 1927 and 1957 [1]



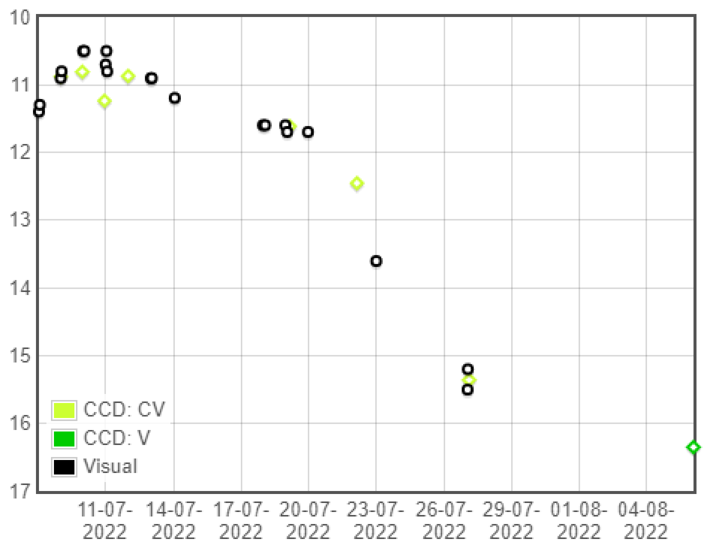
Historically, outbursts of U Sco are fast events, and by the morning of June 7, U Sco had peaked at magnitude 7.7V. There followed a steady decline for 16 days (in which U Sco lost three magnitudes in the first 3 days) to magnitude 14, before a 10 day plateau was followed by a slow continuation of decline before magnitude 17.5V was reached around August 5 – just 60 days after the outburst was detected. [2] U Sco also displays deep eclipses (~2 mags deep) with a period of 1.23 days.

Despite its low elevation as seen from the UK, four BAAVSS observers contributed to our database and managed to follow U Sco to magnitude 17. (*See left*)

BAAVSS plot of U Sco. 31 observations from: *G D Coates, G Poyner, J Toone and I L Walton*.

VY Aqr

The UGSU star VY Aqr was detected in outburst by Eddy Muyllaert (Belgium) on July 7.986 UT at magnitude 12.2 visual, and independently by John Toone on July 8.019 at magnitude 11.4 visual. This was the first outburst detected since November 2020. Both outbursts were Superoutbursts. VY Aqr peaked at magnitude 10.5V on July 10 and the outburst lasted 21 days.

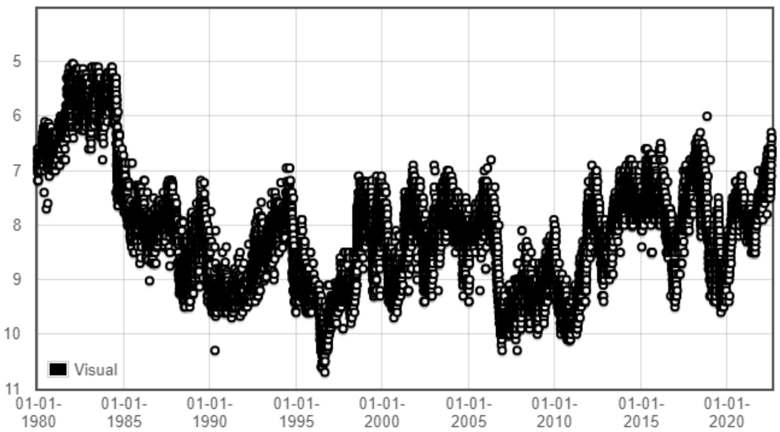


BAAVSS plot of VY Aqr. 28 observations from: *G Poyner, J Toone and I L Walton.*

Looking at the AAVSO light curve (which contains much more data than the BAAVSS), only four outbursts have been observed in detail over the past 20 years – Oct 2006, July 2008, November 2020 and the current one. Five other outbursts were reported, three of which were single visual observations and remain unconfirmed. Two can most certainly be discounted, as there are CCD measures of VY Aqr at minimum obtained at the same time as the visual observations. Compare this with the period between 1983 & 1994, where nine certain and one uncertain outbursts were detected in this eleven year period alone. Coverage is greater during recent years with 168 observers monitoring VY Aqr between 2000 and 2022 compared with 143 observers for 1983-1994. Coverage of VY Aqr at minimum magnitude is also heavier from 2000 onwards of course, with CCD's becoming ever more popular amongst some observers. Might there have been a change in the outburst interval for VY Aqr over the past twenty years or so, are outbursts occurring at Solar conjunction, or are we simply missing more outbursts these days?

CH Cyg

At the time of writing (mid-August), the Symbiotic star CH Cygni is undergoing a particularly bright phase. Reaching magnitude 6.4 mean in early August, this was the brightest CH Cyg has been seen since June 2018, when a similar brightness was reached. This in turn was the brightest recorded since the major outburst event in the early 1980's, which lasted from September 1981 to August 1984. Observers are asked to keep a close eye on CH Cyg for as long as possible to see if this is a prolonged or short duration event.



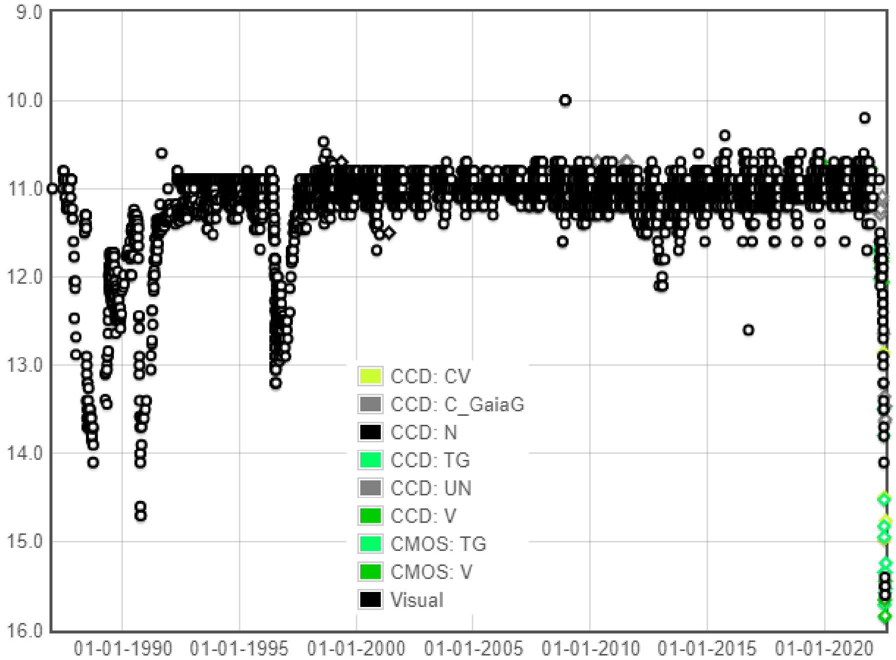
CH Cygni from 1980 to August 2022. *BAAVSS database*

CH Cygni is the brightest of the Symbiotic stars and has a unique history. Originally classified as an SR star with a 100d period and amplitude of one magnitude, a major rise in brightness in 1976 revealed the composite nature of its spectrum. We now know that the system consists of an M type giant and a hot component, very probably a white dwarf.

V482 Cyg

With just a couple of small one magnitude dips in brightness over the last 26 years, the RCB star V482 Cyg has finally entered a deep fade. First signs of activity was picked up by several observers in May, when it's brightness unusually dipped to magnitude 12.0. There then followed a slight recovery by 0.5 magnitude for 20 days before V482 Cyg dropped rapidly to 15.8V by August 6th - just 40 days. The minimum appears to be a brief event, as by Aug 23, V482 Cyg had risen to 14.2CV. & 14.4 vis.

BAAVSS data commences in 1987, and we were fortunate not to have to wait too long for a deep fade to occur. The period from 1988 to 1997 saw two fades below magnitude 14 and one below magnitude 13.0. Apart from a dip to magnitude 12.0 in early 2013, V482 Cyg has varied by just under one magnitude in 26 years. (see light curve below).

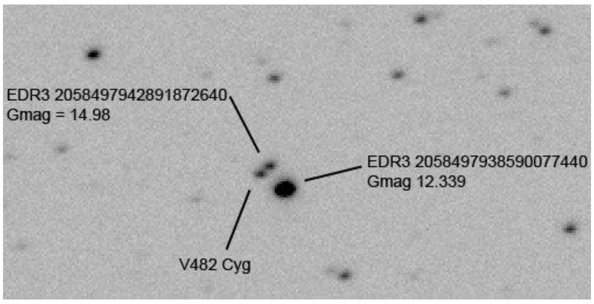


V482 Cyg - 1987-2022. 6004 observations from 28 observers. *BAAVSS database.*

A challenge to observe.

Some visual observers of V482 Cyg will know that when the star fades below magnitude 13.5, it gets trickier to estimate with telescopes of 20cm or smaller because of the presence of a 13.7 mag star just 7 arc seconds to the southwest, which is noted on the AAVSO chart which the VSS recommends for use. This 137 star can be a problem for CCD measures too if the seeing is below par, although as this fade is the first to be monitored by CCD's (the previous fades were pre-CCD), these difficulties are just being overcome by CCD users.

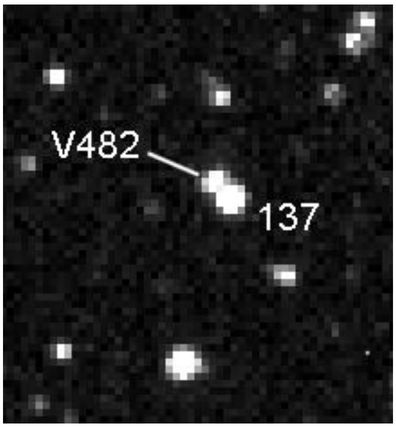
As the star faded to magnitude 15.0 and below during August, a further problem has come to our attention. During his CCD monitoring of V482 Cyg, Nick James has realised that there is also a faint star just 3 arc seconds to the NW of the variable which is not recorded on any chart currently in use. (*see left*)



Part of image captured by *Nick James* on 2022 Aug 13.944 UT with an unfiltered IMX455 camera + Celestron HD11. Scale = 0.28 arcsec/pixel.

Nick comments that his initial inspection of his binned CCD images revealed a slightly elongated V482 Cyg. Upon closer inspection of a non-binned image, he found and identified the close star as EDR3 2058497942891872640 at Gmag 14.98. A testament to the fine quality of Nicks CCD star images!

Apart from visual observations, I have been using the OU COAST telescope for V images and SLOOH for unfiltered and TG filtered images. Unfortunately, COAST images are returned very infrequently despite being of excellent quality, whereas SLOOH can be obtained nightly but are slightly inferior. The image shown on the right is a crop from a 43'x43' image taken by Canary 2 at SLOOH (CDK 17) on 2022 August 8, and with a 400% zoom in AIP4WIN. You can see that V482 Cyg appears slightly elongated in the image, and also see the obvious difficulties in measuring even a blended image so close to the 137 magnitude field star.



SLOOH C2. N top, E left. *G. Poyner*

Nick comments that it will be a very difficult exercise to de-blend the two stars from images taken by amateur telescopes. +With this in mind it might be a good idea to add a note to your observations when uploading that your image is probably blended with the 14.98 close field star. Hopefully the AAVSO will amend their charts accordingly in the not too distant future.

There is of course one further matter arising from all this which needs consideration. How has the presence of this 15th magnitude star lying so close to V482 Cyg affected the visual observations obtained during the fades of 1990 – the only one of the three in that period to approach magnitude 15.0 – and the current one? It certainly can't be discounted. Looking at the VSS database, I note that all the observations below magnitude 14.0 are my own for the 1990 event, and that the faintest I recorded was 14.7 with a 40cm reflector. I was certainly recording stars much fainter than that (plus one mag fainter) in those days, which means I probably would have noted the 15th mag companion under good seeing – so I'm tempted to say that data is good (it's a shame it happened 32 years ago so that I could remember, but I have no notes of a close field star in my observations). What is strange is that I have made five visual observations of V482 Cyg during this current fade of 15.4-15.6 with a 51cm reflector (which have been backed up by CCD V results) and not noted the close field star at all! Might it be variable?

MV Lyr

Some late news. In VSSC 192, I mentioned the recovery of the VY star MV Lyr following a deep fade during December 2021. As I write these words (Aug 23), MV Lyr has faded again (14.4CV) after reaching magnitude 13.5 during June, July and early August – one magnitude below maximum brightness. Observers are asked to monitor as often as possible for the remainder of the observing season for Lyra.

References

1. AAVSO Alert Notice 779

2. AAVSO LCG

The increasing super-cycle period of V1159 Ori

Stewart Bean

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The evolution of the super-cycle period is reviewed from 1997 to the present epoch. Between 1997 and 2010 the period was around 45 days. Since 2010 the interval between superoutbursts has been increasing. In the present observing season three superoutbursts have been observed giving 58 and 59 day cycles.

Introduction

Dwarf novae (DNe) are binary systems comprising a white dwarf with a companion star from which matter is being drawn into an accretion disc. This flow of matter leads to temperature oscillations in the accretion disc which in turn produce a series of brightening events known as normal outbursts. When the disc radius grows to a certain size, the disc becomes unstable and a long duration superoutburst, normally 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 derive P(sc) values. The super-cycle period, and its evolution, should be described by models of DNe. M. Otulakowska-Hypka and A. Olech (2) present a collection of P(sc) results for some UGER stars, including IX Dra, ER UMa, and RZ LMi (see VSSC 187, 188 and 190 respectively). The authors suggest that an increasing super-cycle period may be a feature of most UGER stars. In this note, recent results for V1159 Ori, obtained using the AAVSO database, the Variable Star Observers League in Japan (VSOLJ), Lasair (4) and ASAN-SN (5), are used to update the existing literature.

V1159 Ori has a brightness range of 12.4 to 15.2 and coordinates of RA 5 28 59.52 and Dec -3 33 52.9 according to VSX (1). The observing season starts in October and runs until the end of March based upon AAVSO database entries.

V1159 Ori literature review

Kato (3) analysed the observations made by the VSNET collaboration, including contributions from BAA VSS observers, between 1995 September and 2001 March. The quality and number of observations enabled an average supercycle period of 46.8 days to be determined, although the period did vary around this mean value. For example, the period between 1999 May and 2000 May it was 53 days which is distinctly longer.

As part of a larger study of ER UMa type stars, M. Otulakowska-Hypka and A. Olech (2) averaged individual V1159 Ori supercycle periods, extracted from AAVSO and other records, into five data points to produce the graph (reproduced from their paper) in Figure 1 below. This shows an apparent increase in P(sc) from 45 days in 1994 to 52 days in 2010.

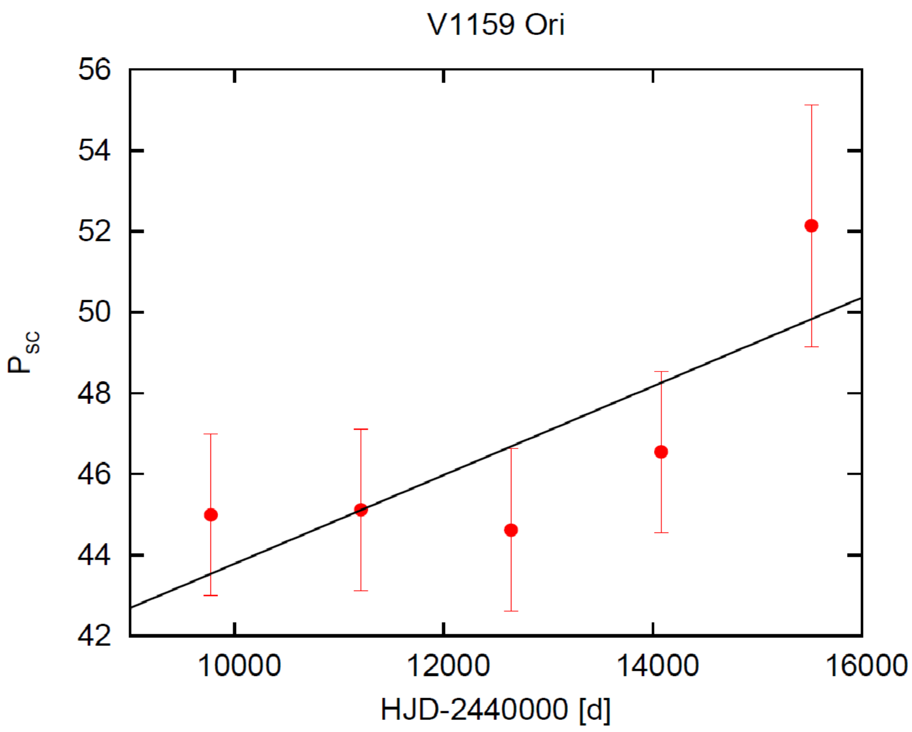

Figure 1. The averaged super-cycle period for V1159 Ori from M. Otulakowska-Hypka and A. Olech (2).

An updated analysis for V1159 Ori

An updated analysis has been made by extending the supercycle observations of Kato (2) using more recent superoutburst observations from the AAVSO, VSOLJ, Lasair and ASAS-SN records to 2022 March. The updated supercycle period graph is shown in Figure 2 with individual observing seasons identified by colour and symbol. Only those superoutbursts whose start times were clearly recorded are included in the graph. The coverage in each season did vary leading to some seasons with six identified superoutbursts and others with only two. This leads to a sparse data record and the graphical presentation in Figure 2 reflects this.

The super-cycle period does seem centred on 45 days, with notable excursions up to 57 days, to 2012. Since then, the super-cycle period has gradually increased until the most recent values of 58 and 59 days for the observing season starting in 2021. Excursions to longer super-cycle periods are also seen in the updated analysis.

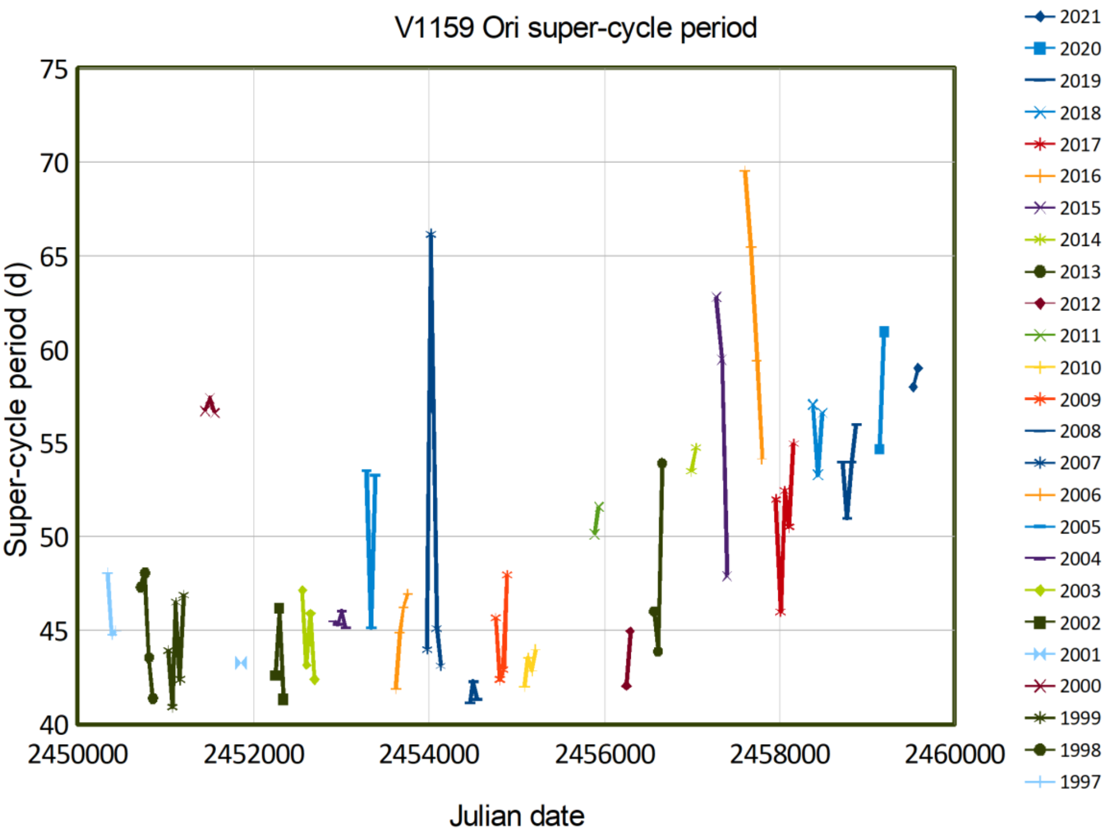

Figure 2. The super-cycle period for V1159 Ori since 1997. Each observing season is identified by colour and symbol.

Discussion

The new analysis extends the work of Kato by about 10 years and presents evidence that the super-cycle period for V1159 Ori has been increasing particularly recently. Occasional epochs when the super-cycle was quite long continue to occur. For example, the observing years beginning in 2000, 2007, 2015, and 2016 included some super-cycle periods noticeably longer than the long-term trend. The longest period reached 70 days in 2016. During the 2000-2001 observing season the three super-cycles were about 56 days long compared to 45 days in the previous and following years. Kato (3) suggests that these longer periods correspond to low rates of flow from the donor star to the white dwarf. Whatever the detailed mechanism, V1159 Ori is characterised by a lengthening super-cycle period with occasional superoutbursts separated by particularly long intervals.

UGER stars

V1159 Ori can now be compared to ER UMa, IX Dra and RZ LMi which have been discussed in previous VSSCs. The super-cycle periods P(sc) and their rate of change are tabulated below.

		Rate of change of P(sc) x 10^3		
Star	P(sc) days	VSSC	M. Otulakowska-Hypka	Notes
V1159 Ori	55	3	1	Last ten years only.
RZ LMi	25	0.55	0.5	
ER Uma	50	0-0.3	1.27	Data very sensitive to early results
IX Dra	60	0-1	1.7	Data very sensitive to early results

Table of super-cycle periods and their rates of change for four UGER stars

For RZ LMi and V1159 Ori a lengthening of the super-cycle is established. ER UMa has significant fluctuations that complicate the interpretation, although a lengthening trend does seem to be present. IX Dra may have peaked at 60 days as its recent periods have been only 56 or 57 days.

Overall, the trend towards longer super-cycle periods for UGER stars suggested by M. Otulakowska-Hypka and A. Olech (2) may be valid but with yearly fluctuations for all four stars.

Summary

V1159 Ori has shown lengthening super-cycle periods over the last ten years and is evolving sufficiently quickly for changes to be observed over only a few years. Further observations by the amateur community can contribute to the extended data set that will shed further light on the topic. To this end, AAVSO have kindly added V1159 Ori to their AAVSOnet telescopes in New Mexico and Australia to improve coverage of this star during the next observing season.

Acknowledgements

I acknowledge with thanks all BAA-VSS and AAVSO members who contributed observations referred to in this note.

References

1. The International Variable Star Index (VSX) (aavso.org)
2. M. Otulakowska-Hypka and A. Olech, MNRAS 433, 1338–1343 (2013)
3. Kato, T. Publ. Astron. Soc. Japan 53, L17–L19, 2001 August 25
4. Lasair, K. W. Smith, R. D. Williams et. al., Research Notes AAS,**3**,26 (2019).
5. ASAS-SN Sky Patrol, Shappee B.J. Astrophysical Journal, 2014, (788), Iss 1, Article 48

S Coronae Borealis – The Record Maximum of 2022

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In July 2022 S CrB attained a record maximum brightness coming within naked eye range for the first time. This article describes the 2022 maximum and also provides some background on the BAA VSS monitoring of S CrB since 1901.

S CrB is the brightest Mira type variable in Corona Borealis that was added to the official observing programme of the BAA VSS in late 1900. [1] The first BAA VSS chart was prepared by E E Markwick in June 1901 with a sequence based on Hagen's ASV series III that had been released the previous year. This was replaced by a further chart by Markwick in 1906 that adopted Harvard photometry for the sequence. Harvard photometry remained in use up to 2010 when it was replaced by Tycho and SRO values.[2]

The BAA VSS practice of recording the light estimate in addition to the calculated magnitude enables the visual light estimates to be reduced to the same photometric scale which is particularly useful when researching extreme range events over long-time intervals where the sequences have changed.

Typically, S CrB varies between magnitudes 7 and 13 in a period of 360 days. The extreme range according to re-reduced BAA VSS data is between 6.1 (in 1974) and 13.7 (in 1933). When examining the AAVSO LCG there is a solitary observation of 5.7 made on 25 June 1874 by Eduard Schonfeld which was originally reported at 6.1. [3] Without access to the original light estimate I cannot validate the re-reduced value of this observation.

The abnormality of the 2022 maximum originally became apparent when S CrB rapidly rose more than three magnitudes in the month of June. [4] It continued to rise reaching a peak in mid-July when multiple observers reported visual observations in the region of 5.5 and equal to the brightest star A (omicron CrB at magnitude 5.5) on current sequence 43.02. This excessive brightness level, within naked eye threshold for the first time, was confirmed by a measurement of 5.39V by David Boyd on the 4th July. It is reminded here that visual data is normally a few tenths of a magnitude fainter than V data when comparing red variables with non-red comparison stars

The light curve (Figure 1) from January 2018 to July 2022 illustrates the previous four maxima and the abnormality of the 2022 maximum. Note also that the 2022 minimum was brighter than normal at around magnitude 12.3, but this is not an uncommon occurrence.

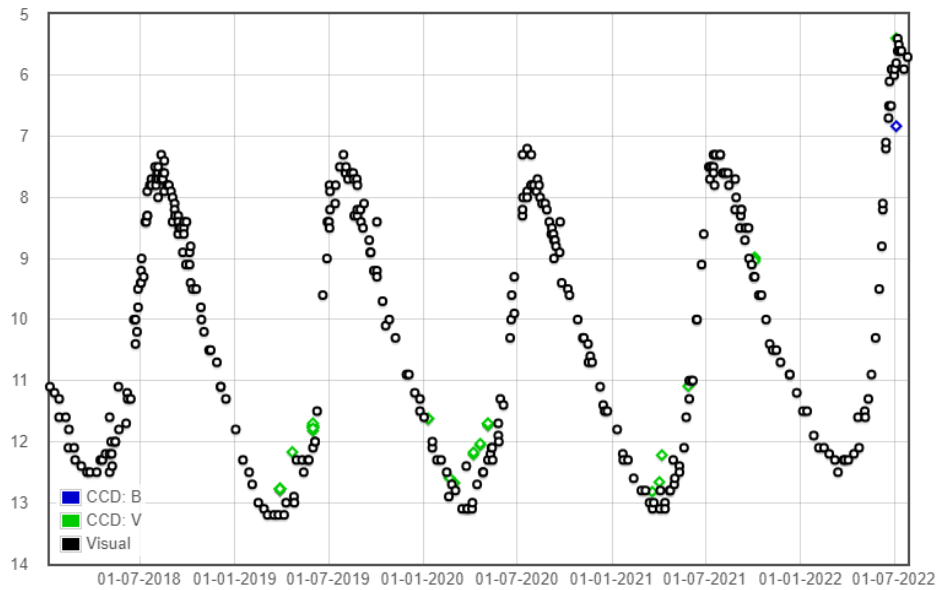


Figure 1. Light curve of S CrB since 2018 taken from the BAA VSS database illustrating the abnormal brightness of the 2022 maximum.

Images obtained show the change in appearance of the prominent portion of Corona Borealis with S CrB at minimum in April 1991 (Figure 2) and then close to peak brightness in July 2022 (Figure 3). I would venture to say that this is the first time we have had imaging opportunities of both R & S CrB at maximum with S appearing the brighter. A further close up image of S CrB (Figure 4) including comparison star E (magnitude 6.9) near maximum light is also provided. Often S CrB may only match the brightness of E at maximum.

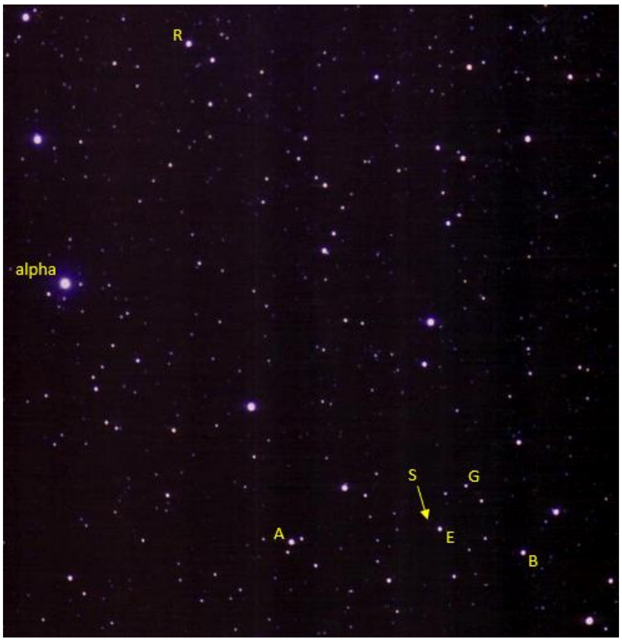
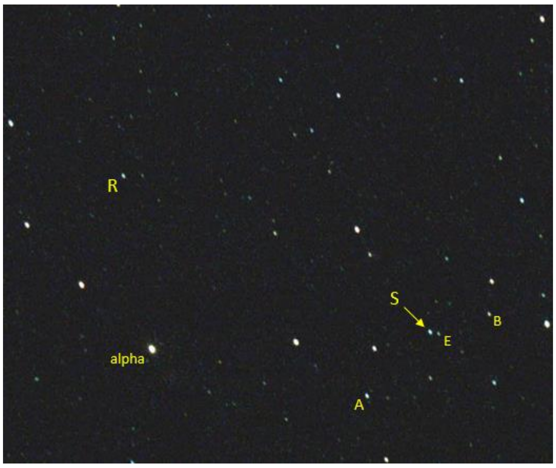


Figure 2: Corona Borealis with S CrB near minimum on 16 April 1991. Comparison stars A, B, E & G are identified in addition to the position of S CrB which is not visible at magnitude 12. Photograph taken by the author from Sedbergh, Cumbria. (*Click on image for original size*)



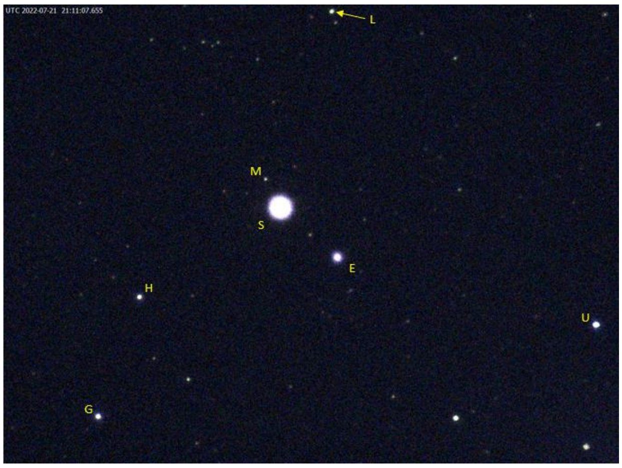


Figure 3

Figure 4

Figure 3: Corona Borealis with S CrB near maximum on 18 July 2022. Comparison stars A, B & E are identified with S CrB appearing equal to A (omicron CrB) and brighter than R CrB (also identified). Image taken by Dr Steve Arnold from Tremail, Cornwall. (*Click on image for original size*)

Figure 4: One-degree reverse field of S CrB on 21 July 2022 with a few comparison stars plus U CrB (eclipsing binary) identified. An average maximum of S CrB would not be any brighter than comparison star E. Image taken by Kevin Gurney PhD from Charente, France. (*Click on image for original size*)

The extraordinary maximum of S CrB in 2022 continues to reinforce the importance of long term and ongoing visual observations because it is the visual observers who have contributed the bulk of the data and also alerted the scientific community to this notable event.

References**:**

1. 1900 JBAA 10, 386.
2. 2010 VSSC 146, 6.
3. AN 87, 23.
4. BAA VSS Alert 20/06/2022 18:52.

The spectrum of S CrB during the July 2022 record maximum

Robin Leadbeater

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Spectra taken during the July 2022 record maximum of S CrB show a hotter spectral class and increased intensity of Balmer emission relative to spectra from a more typical maximum in 2020.

As reported by John Toone elsewhere in this edition, the Mira Variable S CrB reached a new record visual magnitude of 5.4 in July 2022. On 7th and 15th July, I recorded spectra covering maximum brightness using an ALPY600 spectrograph (resolution ~12 Å) and compared them with spectra recorded by Miguel Rodriguez also using an ALPY600 on 24th and 30th July 2020 when the star was at a more typical maximum of 7.2 [1]. (The means of the pairs of spectra were used for the comparison. The individual spectra can be found in the BAA spectroscopy database [2]).

Miras show spectral features typical of cool giant stars with a red continuum and deep molecular absorption bands. In M type stars TiO is particularly prominent. Most of the flux from these stars is in the Infra-Red, the visual brightness just representing the short wavelength tail of the energy distribution. Although the total luminosity of Miras varies during the pulsation cycle, it is largely the shift in the energy distribution from red to blue that is responsible for the large swings seen in visual brightness, while the change in brightness in the IR is much less. Miras also show various narrow emission lines in their spectra which vary with the phase, particularly the Balmer lines H gamma and delta [3]. A recent paper by David Boyd tracks the typical changes seen in the spectra of Miras during the pulsation cycle [4].

Figure 1 below summarises a preliminary analysis of the spectra for the 2020 and 2022 maxima (calibrated in relative flux and scaled to 1 at the 5500 Å visual wavelength, the two spectra displaced in Y for clarity). Overlaid in blue are template spectra from the Pickles library of spectral types [5], the best match selected based on the intensity of the TiO bands between 4500-5500 Å typically used to classify M type spectra. [6] (The good match to the underlying shape of the continuum is also consistent with the low interstellar reddening in the direction of S CrB [7])

From the literature the reported range of spectral type seen in S CrB from minimum to maximum is from M8 to M6 [8] (The lower the number the higher the effective temperature). The classification of M6.5iii for the 2020 maximum, which was slightly (~0.3 magnitudes) fainter than the long term mean maximum, is consistent with this. The spectral type at the 2022 maximum though is significantly earlier (hotter) at M5iii. The Balmer emission lines are also significantly more prominent with the flux at H gamma, delta an order of magnitude greater once the difference in brightness is taken into account and H beta, alpha present, but absent in the 2020 spectrum.

By dividing the 2022 spectrum by the 2020 spectrum and rectifying to remove the underlying difference in continuum shape any differences in the absorption features can be seen more clearly. (Note this cannot be used to quantify differences in emission line strength as quantitative comparisons of these can only be made on spectra calibrated in absolute flux). The reduction in the TiO band depth is clear. Also apparent is a reduction in the Ca I absorption line at 4226 Å, another indication in M giants of an earlier spectral class [9].

From this comparison of spectra from the 2022 and 2020 maxima it appears that the unusually bright maximum of S CrB in July 2022 was an extreme example of the normal cyclic variation rather than an indication of any different phenomena.

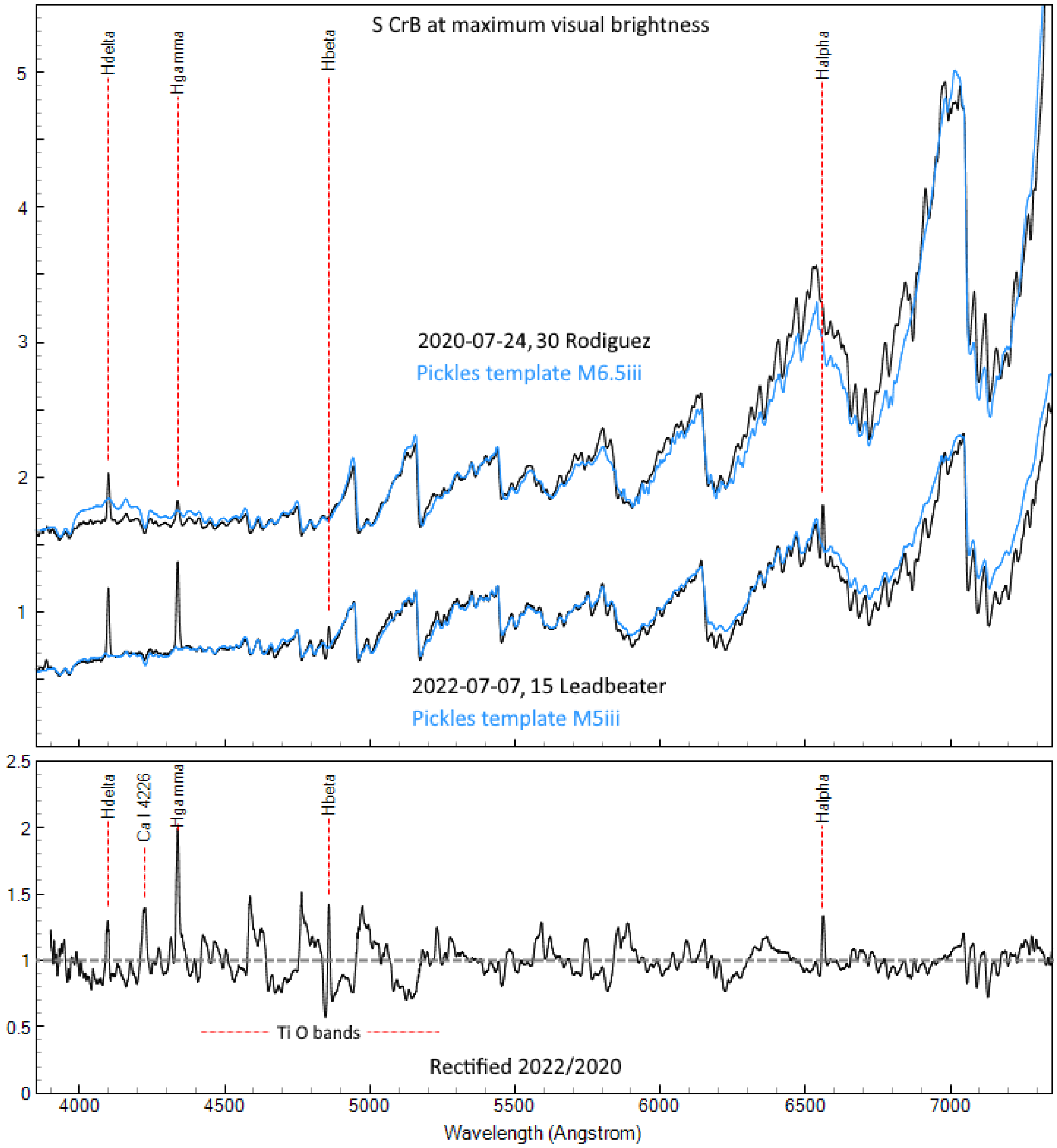

Figure 1

[1] BAA photometry database

[2] BAA spectroscopy database

[3],[6],[9] R O Gray & C J Corby, Stellar Spectral Classification 8.2

[4] D Boyd, 2021 JAAVSO, vol 49, no. 2 p. 157

[5] A. J. Pickles 1998 PASP 110 863

[7] NASA/IPAC Extragalactic Database Extinction Calculator

[8] The International Variable Star Index

Where are they now?

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A look at nine of the stars that were flagged by Mike Collins as possible variable stars during the late 1980s and 1990s.

From the late 1980s through to 2001 while carrying out photographic nova patrolling, Mike Collins spotted many suspected variables. These were reported to *The Astronomer* magazine (TA). Some were linked with objects that already had NSV designations while others gained temporary designations such as “TAV 0216+48”, “TASV 0220+48”, “TAV J1934+307“, and “Q1991/21”. Some were linked with objects detected by the IRAS satellite during the 1980s. Almost all were red objects and many were carbon stars.

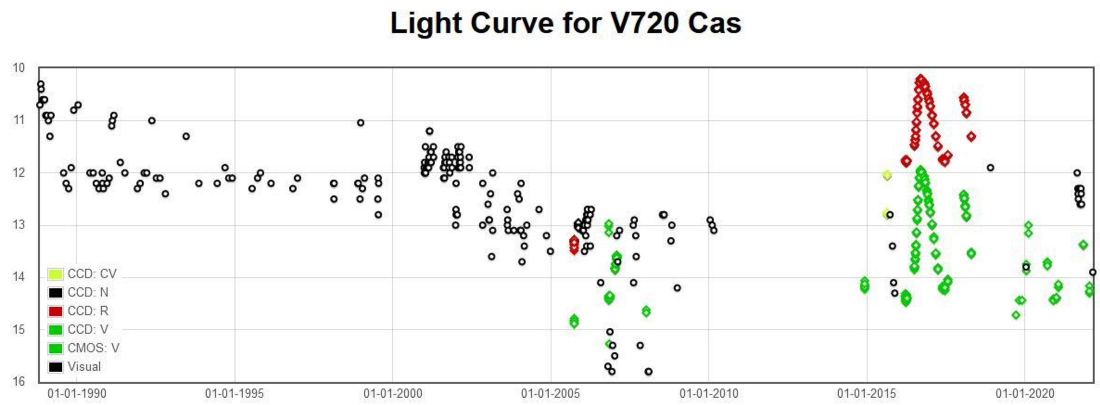
A good number now have permanent variable star designations. Here are BAA VSS light curves for a few of them.

TAV 0042+53 (=Q1990/67)

This star was noted as being bright in late 1989 and early 1990. It was originally believed to be a semi-regular variable with a range of 10.3-12.4 and a period of about 420 days and was linked with IRAS 00422+5310. A finder chart was published in the 1991 December issue of TA.

In September 1995, it was included in a target list of fifteen of Mike Collins’ stars that Gary Poyner was encouraging BAA VSS members to take on. The initial response was disappointing but later coverage was better, including particularly good coverage of the autumn 2016 maximum by David Boyd.

It now has the designation V720 Cas and is listed as a Mira type variable with a range of 11.2-15.7 V and a period of 431 days.

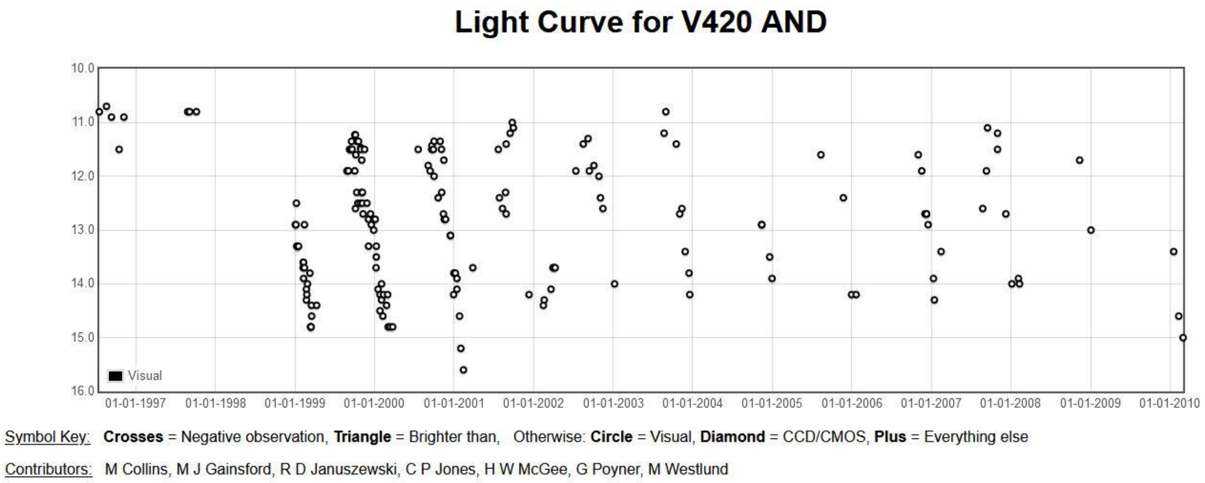


Symbol Key: **Crosses** = Negative observation, **Triangle** = Brighter than, Otherwise: **Circle** = Visual, **Diamond** = CCD/CMOS, **Plus** = Everything else

Contributors: D Boyd, M Collins, G Fleming, D Gill, K Holland, V Hull, R K Hunt, R D Januszewski, S Johnston, C P Jones, M L Joslin, H W McGee, R D Pickard, G W Salmon, R H Tremblay

TAV J0218+507 (Q1998/073)

A note on this variable appeared in the 1999 January issue of TA. The star was noted to coincide with IRAS 02150+5032. Earlier images in patrol photographs dating back to 1978 suggested that this was a Mira-type variable with a period of around 351 days and a magnitude range of 10.5 to <14. With the period being close to a year, this light curve, away from the gaps around solar conjunction, inevitably covers the same section (the fade) of the cycle each year. There are only three observations post-2010 in the database. It is now catalogued as V420 And.

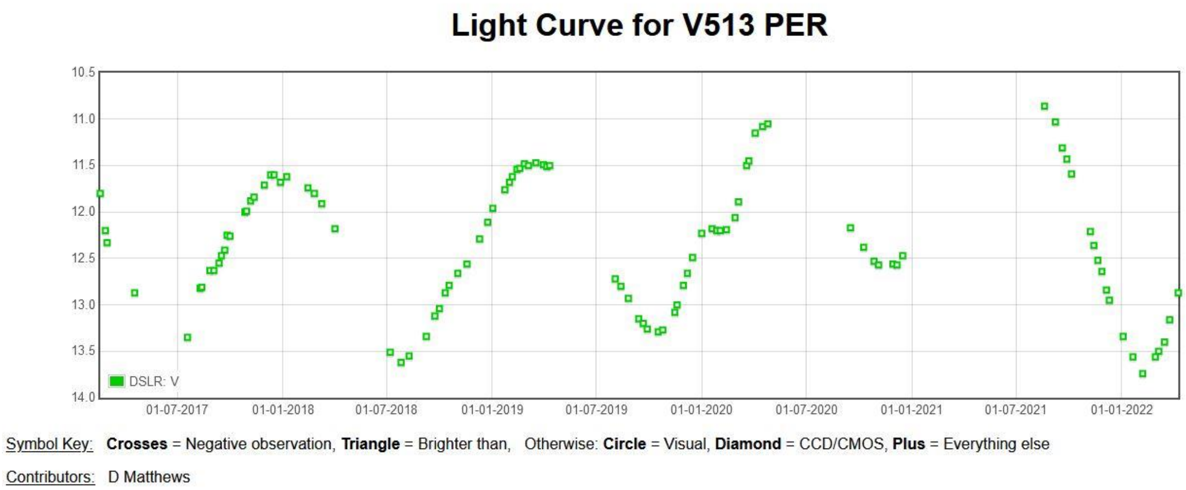


AAVSO VSX gives the range as 11.0 to <15.0V and gives the period as 355.8 days.

TAV 0329+41 (=Q1989/106)

This star was noted to be bright in February 1989. It was subsequently linked with IRAS 03291+4116 and Dearborn 9974. Dave McAdam reported that his archives suggested maxima in March 1983, October 1986 and December 1987. An early analysis suggested a period of about 423 days.

It was subsequently designated V513 Per in IBVS 3840 (71st Name-List). More recent observations by Don Matthews (see VSSC 181, 2019 September p13-15) suggest that the true period is around 423 days

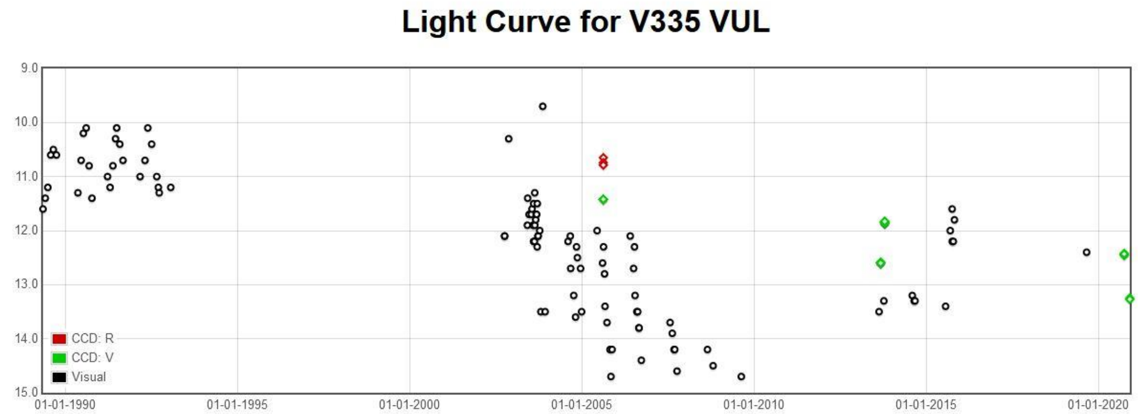


TAV 1921+24 (=Q1990/60)

This star was seen to be bright in August 1989 and August 1990. It was subsequently linked with IRAS 19211+2421. Early observations suggested a period of around 336 days.

A finder chart was published in the 1991 December issue of TA.

Mike's observations from 1989 to 1993 presumably caught the star near maximum, while observations from 2002 onwards follow it down towards minimum. It was designated V335 Vul in IBVS 3840 (71st Name-List).



Symbol Key: **Crosses** = Negative observation, **Triangle** = Brighter than, Otherwise: **Circle** = Visual, **Diamond** = CCD/CMOS, **Plus** = Everything else

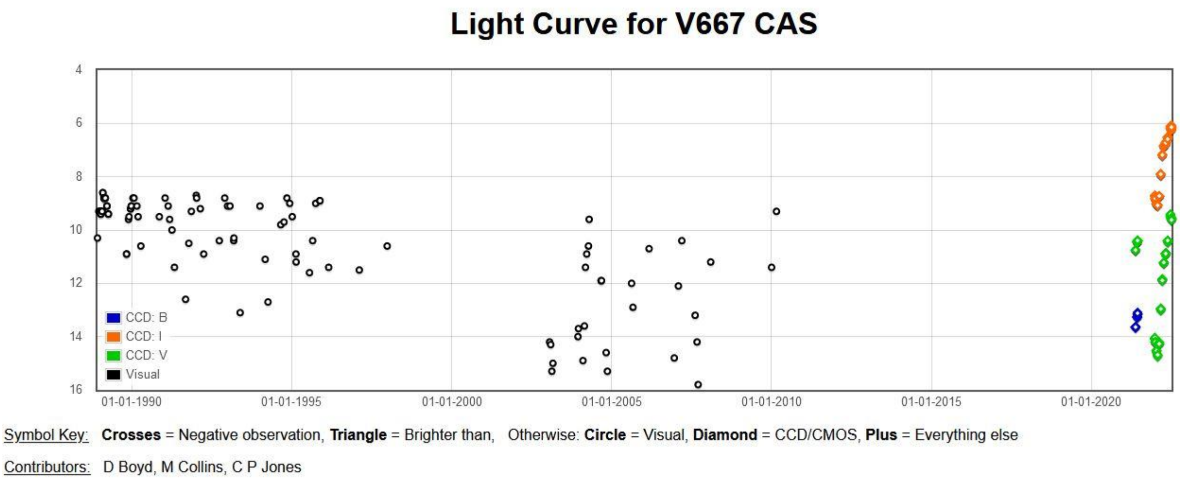
Contributors: M Collins, G Fleming, V Hull, R D Januszewski, C P Jones, R Pearce, R D Pickard, G W Salmon

AAVSO VSX now lists it as being a Mira type variable with a range of 11.5-13.9V and a period of approx. 380 days. This range does, however, seem at odds with Mike's early observations (brighter) and observations during 2006-2010 (fainter).

Q1989/1 (=BD +70 236)

This object appeared bright in December 1988 and was still bright in early 1989. Investigations revealed that it had been reported as a suspected variable by Otto Morgenroth in 1936 and was later designated as CSV 284 and then NSV 1098, the latter being coincident with IRAS 03159+7035. Inspection of images on Sonneberg plates by Dietmar Bohme suggested that it was a Mira-type variable with a period of around 347 days.

Early observations by Mike were presumably capturing the star near maximum and suggested a period of around 347 days. At the end of the light curve are David Boyd's observations of the rise towards the 2022 maximum. It was designated V667 Cas in IBVS 3530 (70th Name-List).

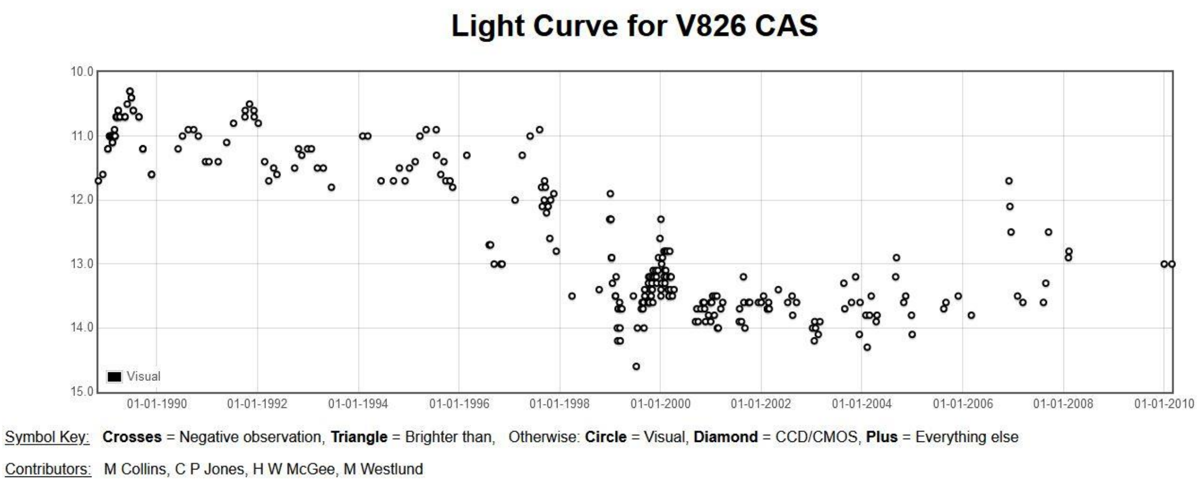


AAVSO VSX lists it as being a Mira-type variable with a range of 9.0-15.3 V and a period of 349.4 days.

<u>Q1989/51 (=NSV 203)</u>

Not all of Mike’s discoveries turned out to be Mira type variables. This one was noted to be bright in June 1989 (TA EC-318) and seemed to coincide with NSV 203, based on observations a decade earlier, although those observations placed it at 13th magnitude.

The link to NSV 203 was subsequently confirmed and it was later designated V826 Cas. Although future observations may uncover some periodicity, it is clearly not a Mira.

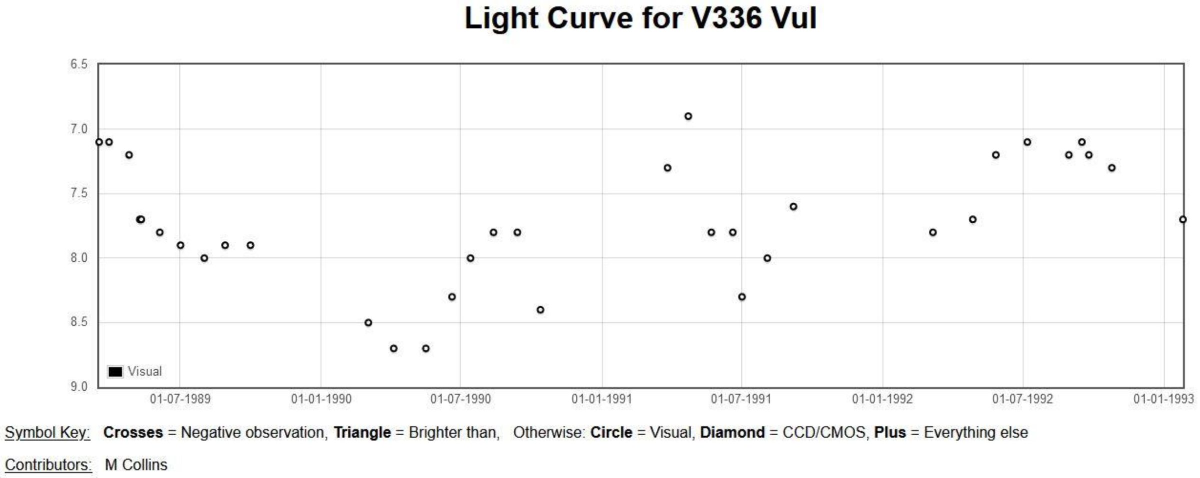


AAVSO VSX lists it as having a magnitude range of 10.5-14.6 V and being of type LB, although a period of 730 days is also quoted.

Q1990/45 (=NSV 12178)

This star was noted as being bright in March 1989 (TA EC-422). It is BD +23 3694 and also IRAS 19325+2346. A chart was published in the 1991 March issue of TA along with a comment that a Japanese study was suggesting semi-regular variations. It was subsequently designated V336 Vul in IBVS 3840 (71st Name-List) on the basis of the Japanese study.

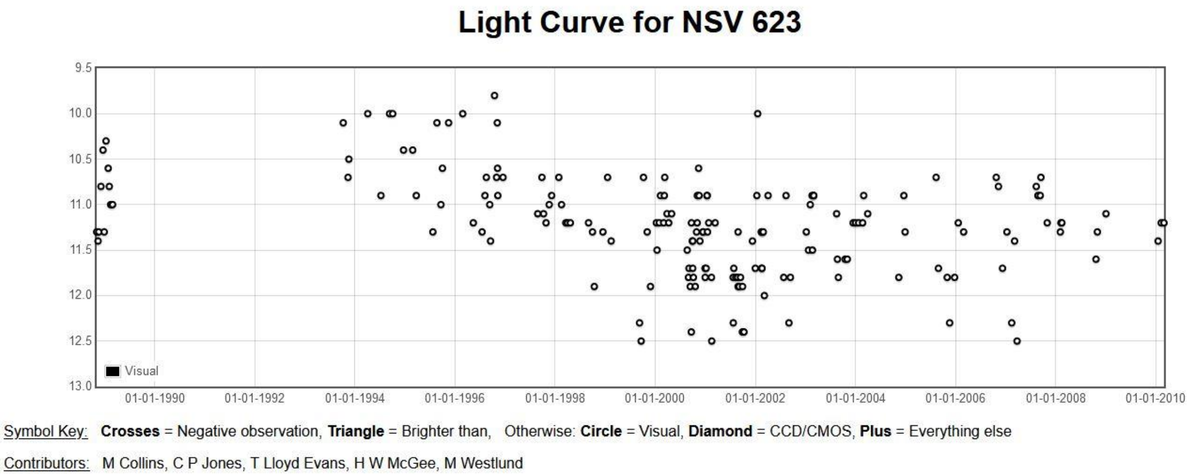
The light curve below is for the years 1989 to 1993. After that, the database contains no observations until 2020.



AAVSO VSX now lists it as being of type SRc, having a range of 7.6-9.2V and a period of 131.6 days.

Q1992/055 (=NSV 623)

This star was flagged by Mike as being bright in late August 1992. It had already been designated as NSV 623 on the basis of observations by Antoine Brun back in 1963.



The star has not yet received a permanent designation. Looking at the light curve, there seems no pattern to the observations, even when looking observer by observer or year by year.

AAVSO VSX gives it a range of 12.9-13.4p and type LB, although it also quotes a period of 70 days.

Additional observations?

If you have any observations of these or others of Mike's discoveries, please do report them to the BAA VSS database.

Maybe you could add a few of Mike's stars to your observing programme? As illustrated by Don Matthew's article, some or many of the periods suggested by the early observations will need refining and the longer the baseline over which maxima are observed, the better the periods (and magnitude ranges) can be defined. In many cases, it is not clear, for example, whether Mike happened to catch the Miras during particularly bright maxima.

A full list of Mike's variables (there are rather a lot of them!), including their positions and Guy Hurst's early notes, can be viewed here:

http://www.theastronomer.org/mikes_variables.html

Early results for the Semi Regular Variable TW Aur

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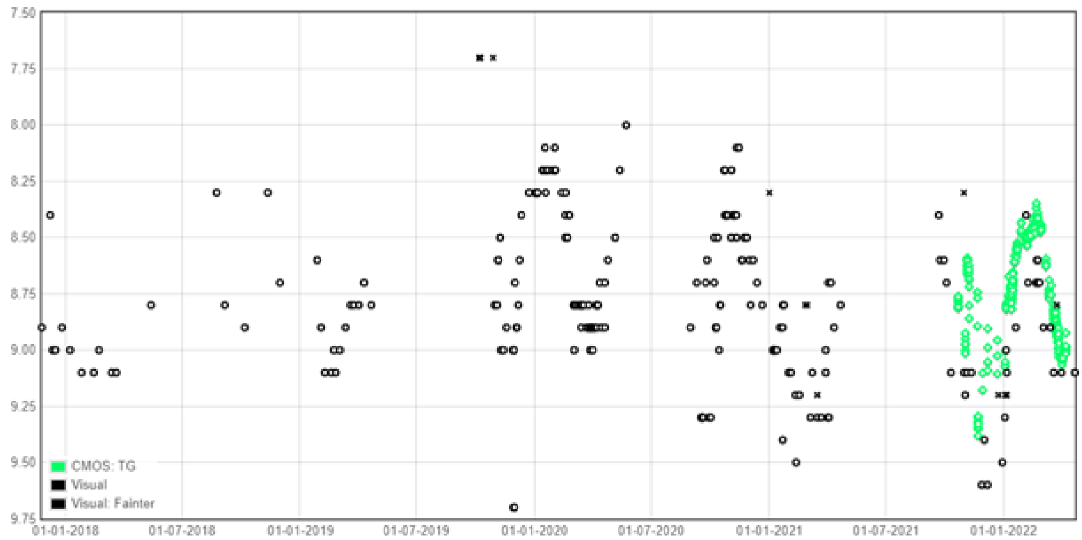
TW Aur is a poorly observed SRb variable recently added to the BAAVSS Pulsating Programme. Early results appear to confirm a main period close to the catalogued value of 150d. A visual range of 8.0-9.6 is recorded.

TW Aur is one of a number of stars recently added to the Pulsating Programme. It was selected on the grounds as having both a catalogued range in excess of one magnitude and having received very few observations (AAVSO). It can be easily found, forming a neat triangle with beta and pi Aurigae.

TW Aur was discovered in 1908 by Annie Jump Cannon. VSX lists the star as an SRb, Spec M5II, range 7.4-9.5, period 150d [1]. In addition, the GCVS has a note stating that the mean magnitude varies with P=1370 [2]. Lying at a declination of +45, one would think the star would have been actively observed, however this is not the case. There are intermittent periods, commencing in the 1920s where AAVSO records reveal that the star was followed, but by rarely more than one or two observers. Indeed, there are lengthy periods where no observations were received.

The first observations received by the BAA were in 2016, although there was no consistency until 2019, when a formal BAAVSS chart was produced. As a result, only observations since 01/01/2019 have been included in this report.

A full light curve plot is shown below. 224 visual observations and 329 CMOS observations by C. Watkins have been received, (It should be noted that in the case of the CMOS results, multiple images are measured, so the number of dates are much lower). As will be seen there is close agreement between the visual and CMOS observations. One area that does need addressing is that of over observing visually. With a period listed as 150d, observations every 5-10 days are sufficient.



Symbol Key: **Crosses** = Negative observation, **Triangle** = Brighter than, Otherwise: **Circle** = Visual, **Diamond** = CCD/CMOS, **Plus** = Everything else

Contributors: S W Albrighton, T L Heywood, R K Hunt, J Toone, C Watkins

Although only over a 3 ½ year period, analysing the results using the AAVSO V Star program [3] reveals a top hit of 152d, very close to the catalogue value. There are other lesser peaks of the order of 120d, 107d and 93d. Being a SRb star, means that there will be inconsistences in the light curve and potentially two or more periods. The period of observation is too short to analyse the longer period mentioned in the GCVS. The visual range during the period is 8.0-9.6. Whilst the minimum value is close to the quoted figure, the maximum is around 0.6 mag fainter.

Observers are encouraged to add this star to their programme, being ideally suited for 70/100mm binoculars or similar telescope. In addition, this star is suitable for observers employing DSLR cameras for their work. By doing so a more thorough examination of this interesting star may be conducted in the future. For those interested, a chart can be downloaded via the BAAVSS chart catalogue or the link https://britastro.org/vss/xchartcat/Aur%20TW%20354.01%203d.JPG

References

1 VSX Catalogue

2 General Catalogue of Variable Stars

3 AAVSO V Star program

Eclipsing Binary News

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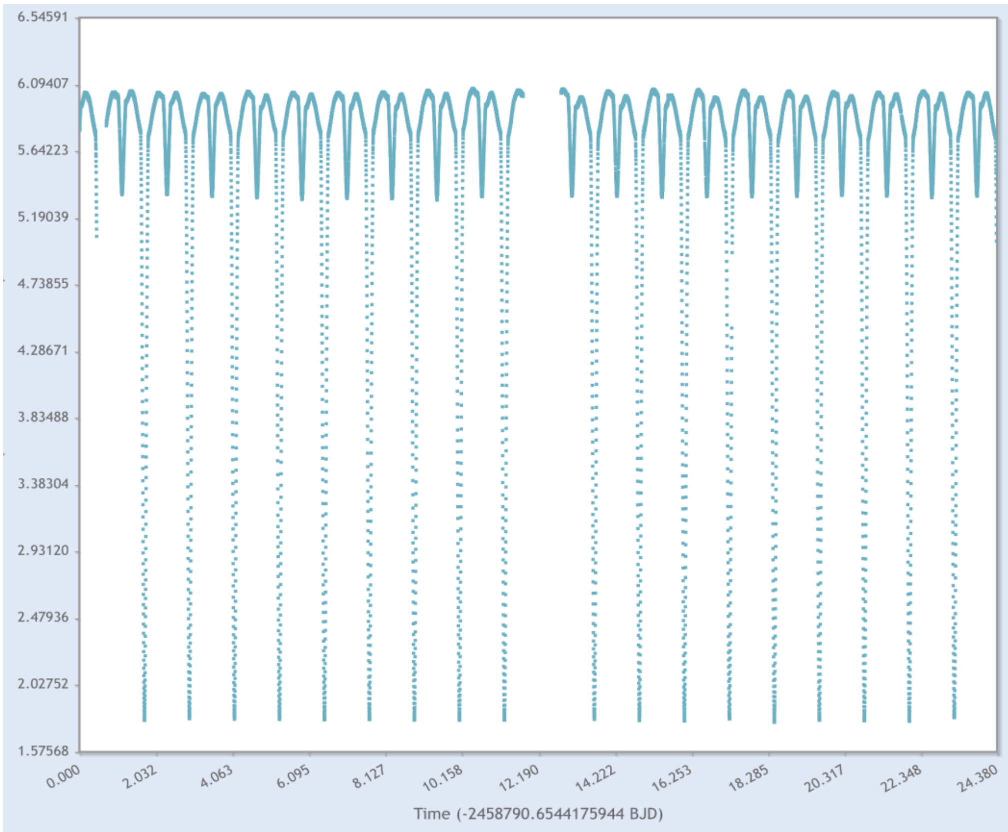
TESS: 'Transiting Exoplanet Survey Satellite"

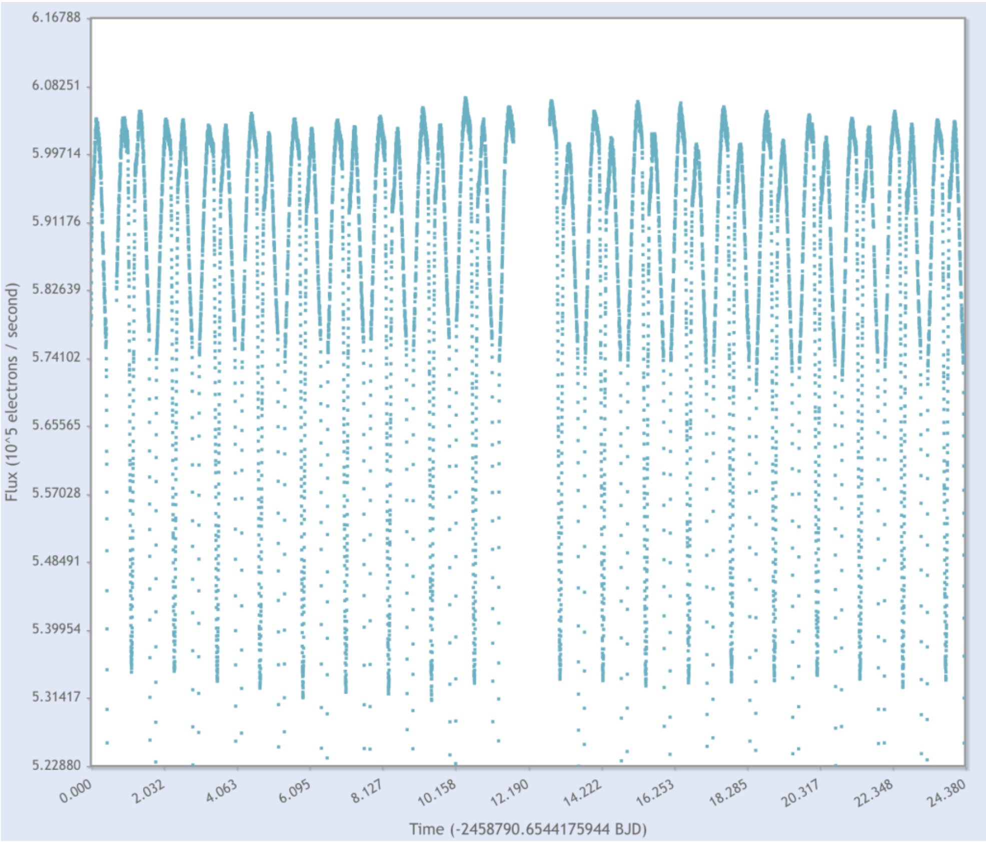
The job of this satellite, launched in 2017, was to monitor about 200,000 stars for the presence of exoplanets. In the course of this, it has monitored many eclipsing binaries (and other variable stars such as Z UMa). Some of the data and light curves are now available on <https://mast.stsci.edu/portal/Mashup/Clients/Mast/Portal.html>.

Below are light curves of RZ Cas around BJD 2458790 covering about 24 days. The time on the horizontal axis is expressed as a Barycentric Julian Date which differs from a Heliocentric Julian Date by plus or minus 4 seconds. The vertical axis is flux.

There are other sets of data for around BJD 2458816 and, for 2022, around BJD 2459718. These images show well the vast amount of data on RZ Cas that TESS has gathered. The nature of the primary eclipse as a partial eclipse is well illustrated. The secondary eclipse is less than 0.1 magnitude. With this data the period of RZ Cas will be easy to work out and see if it has changed over a three-year period. I would be interested in finding how exactly the data/light curves can be used to calculate the period.



The website allows you to zoom in to parts of the light curve so that the secondary eclipse can be studied as well as the variation in magnitude of the out of eclipse maxima. Although the differences would not be easily detectable by Earth bound methods there seems to be a regular variation in the maxima which one presumes is due to 'reflection' effects.

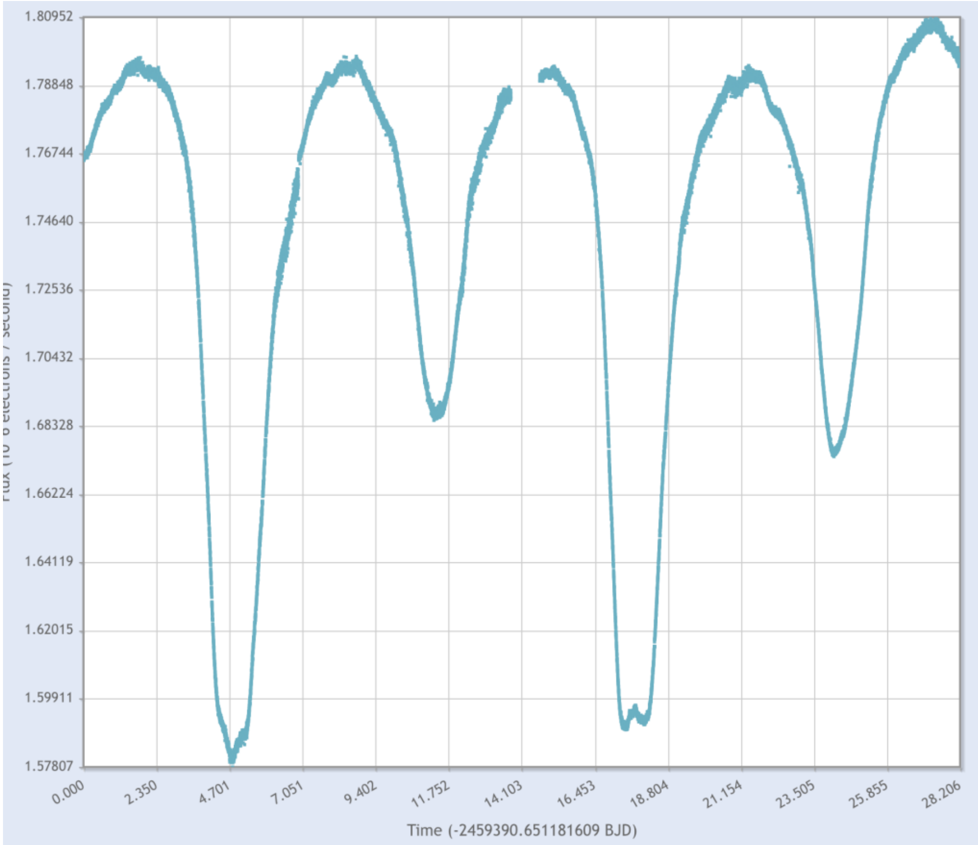


Another familiar system that has been covered by TESS is beta Lyr. There is other data for BJD 2459743. Apparently, this light curve indicates a period of 12.944 days in the middle of 2021. This light curve illustrates that there are small variations in the depth of the primary and secondary eclipse, and the shape of the eclipse and the maxima. It is presumed that this is due to the variation in the density of the cloud of dust and gas that obscures the system.

The data from TESS is being used by professionals to discover more about eclipsing binaries. Below is an abstract of a paper which looked at data regarding V375 Cas. This is a beta Lyrae class system which has an out of eclipse magnitude of 10.13V. The primary eclipse has a depth of 0.9 magnitude and the secondary 0.6.

In 2019, a survey with TESS revealed that alpha Draconis (Thuban) was an eclipsing binary star. It exhibits primary and secondary eclipses with depths of 9% and 2%, indicating that the eclipses are partial, with an inclination of slightly less than 90°. They last only six hours.

Below is the light curve it has produced for around the BJD 2459390.



V375 Cas (1)

V375 Cassiopeia (V375 Cas) is an early B-type close binary with an orbital period of 1.4734273 d. Based on high-quality and continuous light curves from the Transiting Exoplanet Survey Satellite (TESS) and new low-resolution spectra, we have determined photometric solutions of the eclipsing binary using the Wilson–Devinney method. We have found that V375 Cas is a semidetached binary where the secondary component fills the critical Roche lobe. Meanwhile, its O − C diagram was constructed with the data spanning 122 yr. An upward parabolic variation is discovered to be superimposed on a cyclic modulation with a semi-amplitude of 0.0938 (±0.0143) d and a period of 118.74 (±12.87) yr.

Both the semi-detached configuration and the period increase suggest that V375 Cas is undergoing a late case A mass transfer from the less-massive component to the more-massive component. The cyclic change is attributed to be the effect of the light travel time via the presence of a third body. The minimum mass of the tertiary companion is estimated as M3 = 4.24 (±0.87) $M_\odot$, which orbits around the central eclipsing binary with a nearly circular orbit (e = 0.184). It is detected that the light contribution of the third body is about 8.0 per cent, indicating that it is a massive main-sequence star. All the results reveal that V375 Cas is a hierarchical triple system where a massive main-sequence star accompanies a massive semidetached mass-transfer binary at an orbital separation of 60.3 au.

Eclipsing Binaries - The Primary Distance Indicator

This theme was the subject of 2007 paper (2) which stated that using the characteristics of eclipsing binaries was a more accurate way of estimating stellar distances. In the Wikipedia article on the Large Magellanic Cloud it reports that the prior method of estimating the distance to the LMC, using Cepheid variables, found in 2006,44 that the distance was 160,000 light years. In 2013 a more accurate study, using eclipsing binaries, found the distance to be 163,000 light years with an accuracy of 2.2%.

To do this type of estimation you need telescopes that can observe EBs in other galaxies or globular clusters. It is assumed that the James Webb Space Telescope will allow more of such estimations.

References

1. 2022 MNRAS 514 pp 1206-1236

2. The Seventh Pacific Rim Conference on Stellar Astrophysics, ASP Conference Series, Vol. 362, Proceedings of the conference held 1-5 November 2005 in Sejong University, Seoul, Korea. Edited by Y.W. Kang, H.-W. Lee, K.-C. Leung, and K.-S. Cheng. San Francisco: Astronomical Society of the Pacific, 2007., p.19

Is V608 Cassiopeiae really a quadruple system?

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A recent orbital solution for V608 Cas has suggested that the system contains a W UMa binary and two similarly massive, low-luminosity companions. A re-evaluation of the eclipse timings finds that a simple third-body solution fits the data equally well, with a single companion of 0.3 $M_{\odot}$ in a ~ 20-year circular orbit.

In the previous *Circular* Loughney [1] drew attention to a recent paper on the W UMa-type eclipsing binary V608 Cassiopeiae in which it was suggested that the central pair had two circumbinary companions, and that the binary itself was undergoing a secular period change (see Park & Lee [2]). Close binary stars are frequently found in multiple systems [3, 4], and according to a recent survey [5] at least 20% of W UMa binaries have close companions, and in addition *Gaia* has uncovered a population of wide-binary pairs containing a W UMa binary [6]. Systems with shorter periods, measured in the tens of years, tend to have a hierarchical structure with companions orbiting the W UMa binary individually. The masses of these companions range from low-mass ($m_3 \sim 0.15\ M_{\odot}$) third bodies, *e.g.,* AM Leo, YY Eri, through intermediate *e.g.,* V523 Cas and relatively high mass ($m_3 \sim 0.8\ M_{\odot}$) companions, *e.g.,* VW Cep ER Ori, to quadruple systems with two binaries, *e.g.,* TZ Boo, V2610 Oph.

In most systems where an eclipsing binary has a companion it is detected by the orbital motion it imparts to the binary, and this appears as a vaguely sinusoidal variation in the residuals in the O–C diagram due to the light-travel-time effect (LTTE). How sinusoidal this variation will be depends on the eccentricity of the third-body orbit, and if there are other companions then the variation can become quite complex. In addition, if there is a secular change in the period of the eclipsing binary then that will superimpose an extra parabolic term on the residuals, which in the long term will dominate the cyclical variations of any companions. In relatively short runs of data there may be some uncertainty about which effects dominate and in complex systems it can take several orbits of any companions before the true picture becomes clear.

V608 Cas is a 12th magnitude, neglected, but fairly average, W UMa system with $P = 0^{d}.38$. The first light-curves were made about 20 years ago but it has only been actively observed for the last decade. Recent photometric studies [2, 7, 8] suggest that the system is mildly overcontact, with $T_{\rm eff} \sim 5400$ K for both stars, with $m_1 = 0.9$ and $m_2 = 0.3\ M_{\odot}$. The system is potentially useful as the eclipses are total but the primary shows intermittent cool spots. Park & Lee [2] additionally suggest that the system contains two circumbinary companions with periods of ~ 20 years in very eccentric orbits, and that the W UMa binary is undergoing significant period change. The O–C diagram of V608 Cas as shown in Figure 1 and to most the obvious feature is that the variation appears almost sinusoidal with an amplitude of $\sim\pm 0^{d}.01$, on a timescale of perhaps 20+ years. Such a variation clearly suggests the presence of a third body, but there is no obvious secular trend, and in the first instance no indication of a second companion. However, it is not clear that even one cycle has been observed and only half of that is well covered.

In order to calculate the parameters of the third body orbit the observed times of minimum are fitted to a standard form of a linear ephemeris for the eclipsing binary plus an offset due to the

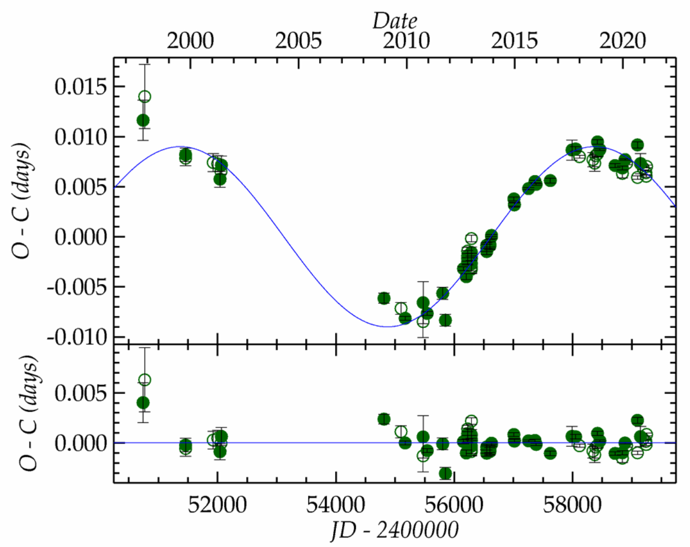

Figure 1. Top panel: The O–C diagram of V608 Cas showing the circular light-travel-time solution for a single companion. The fit for the elliptical solution is practically indistinguishable. Filled symbols are primary minima and open symbols show the secondary. Bottom panel: The residuals from the LTTE fit.

light-travel-time effect (LTTE), so

$$HJD_k = T_0 + P_0C_k + \tau_k$$

where T_0 and P_0 are the epoch zero and period of the eclipsing binary, C_k is the cycle number at minimum k and τ_k is the LTTE offset at minimum k. The LTTE expression given by Irwin [9, 10] has been used here, in which the light-travel time is given by,

$$\tau_k = A[(\cos E_k - e)\sin\omega + (1 - e^2)^{1/2} \sin E_k \cos\omega]$$

where E_k is the eccentric anomaly at minimum k, e is the orbital eccentricity, ω is the argument of periastron, and $A = a_{12} \sin i/c$ is the semi-amplitude of the light-travel time of the orbit of the close-binary pair in reaction to the motion of the third body, where $a_{12} \sin i$ is the projected semimajor axis of the orbit. The parameters fitted are the eclipsing-binary period and zero point of the linear ephemeris, P_0 and T_0, and similarly for the third-body orbit, P_3, and the time of periastron T_3, as well the eccentricity, e, the argument of periastron, ω, and the semi-amplitude of the light travel time, A.

Surprisingly the best solution is for a circular orbit with $P_3 = 7116 \pm 90$ days or 19.5 ± 0.3 which is shown in Figure 1, and despite the lack of coverage this value is robust against being pushed towards higher values. The amplitude of the light-travel time is 0.0085 ± 0.0002 days, which is typical third bodies in these systems. An eccentric orbit does fit the data equally well but it is not a significant improvement and does not justify using the additional terms in the fit. Having said that the quality of the fit is actually relatively poor with the reduced chi-squared $\chi^2_\nu = 7.98$, and for many of the high-weight points the solution passes well outside the error bars. However, this problem does seem to be a feature of O–C diagrams but may point to some distortion of the eclipses, perhaps due to spots, which have been seen here and regularly appear in W UMa systems. Despite this, the residuals from the fit, which are shown in the lower panel of Figure 1, show no obvious trends that might indicate a secular-period change or another companion. Derived parameters have been calculated from the well-known expressions for the mass function (see *e.g.,* Hilditch [11]),

$$f(m) = (a_{12} \sin i_3)^3 / P_3^2 = (m_3 \sin i_3)^3 / (m_{12} + m_3)^3$$

where m_{12} is the mass if the close-binary pair, m_3 is the mass of the third body and a_{12} is the semi-major axis of the binary pair in the third-body orbit, and the other constants have their usual meaning. Taking the total mass of the binary as $m_{12} = 1.2\ M_\odot$ [2, 7] then the minimum mass of the third body is $m_3 = 0.3\ M_\odot$, and well within the range of companions seen in similar systems.

So, how can this result be so different from the Park & Lee solution? Their starting point is the assumption that the dominant variation in the O–C diagram is due to a secular change in period of the W UMa binary. After fitting a quadratic to the O–C residuals to remove this, two apparently periodic variations with $P_3 \sim 16$ and $P_4 \sim 26$ years appear. These are treated as due to companions so they fit the LTTE parameters for both components and the linear and secular terms. In order to compare Park & Lee's complex solution with the simple one shown in Figure 1 it has been recalculated using their parameters as a starting point. The data used by Park & Lee are not identical to Figure 1 which uses individual minima where possible, and includes some additional data, but this is really only a difference in detail. The recalculated solution is very similar to their original, but it is very fragile, largely because P_4 is longer than the span of the data, but the LTTE amplitudes and the eccentricities are similarly large. The recalculated solution is shown in Figure 2 with the same data as in Figure 1. In detail the fit is rather better than the simple one resulting in a small improvement in chi-squared, however, the resulting $\chi^2_v = 8.02$, is actually marginally worse than for the simple solution, so there is no justification for using it.

The derived values that emerge from the complex solution are very different to the simple one. The

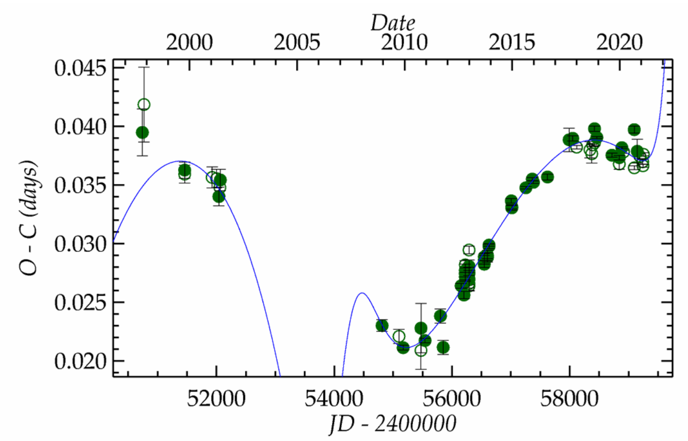

Figure 2. The O–C diagram of V608 Cas showing the recalculated complex, two component plus secular, light-travel-time solution. The data are the same as in Figure 1 and the symbols are as before.

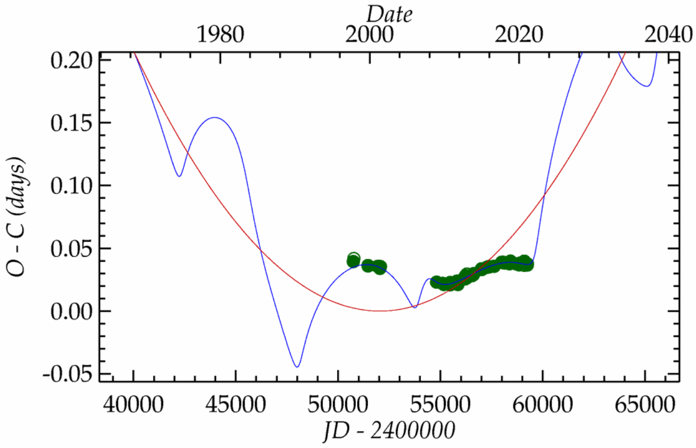

Figure 3. The O–C diagram of V608 Cas illustrating the complex LTTE solution spanning about 80 years. The blue line shows the full LTTE solution while the red one shows the effect of just the secular term.

light-travel times are large at 0.034 days for both components leading to minimum masses of 2.1 and 1.3 *M*ʘ*,* both of which are more massive than the central binary. In addition to raising dynamical and evolutionary issues both stars should add enormously to the luminosity of the system, but from their photometric modelling of the light-curve Park & Lee limit any third light contribution to 5–8%. As they point out, their two companions would have to be low-luminosity objects. Alternatively, the third body could be a 0.3 *M*ʘ star as suggested by the simple solution, which fits the data equally well, and has no other issues.

The observant will have noticed that the O–C residuals in Figure 2 are not centred, or even close, to zero, and this is due to the large LTTE amplitudes required by the complex solution, and at the extremes, the large secular term as well. Stepping back and looking at the complex solution over 80 years is shown by way of illustration in Figure 3. Locally the solution does lie near zero but exactly where depends on how the two $\pm 0^d.034$ amplitude eccentric LTTE terms combine. Over time the secular term will dominate and that can already be seen.

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Light curves and phase diagrams of three more Eclipsing Binaries

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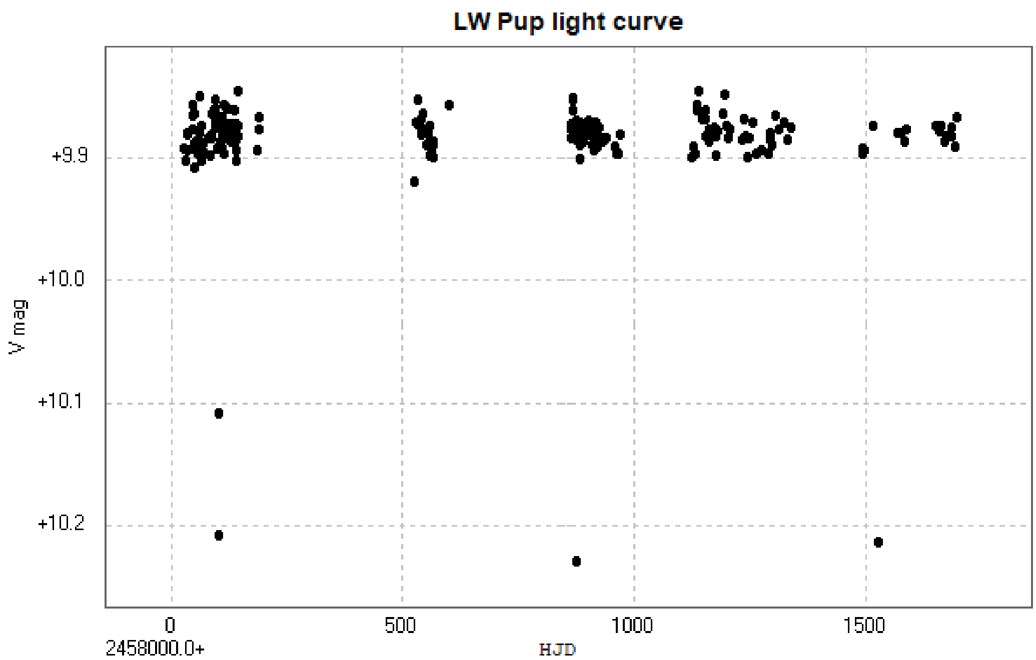
Observations of three under observed eclipsing binaries have been made over a number of years, one of which (TW Cnc) does not appear consistent with the data in the General Catalogue of Variable stars.

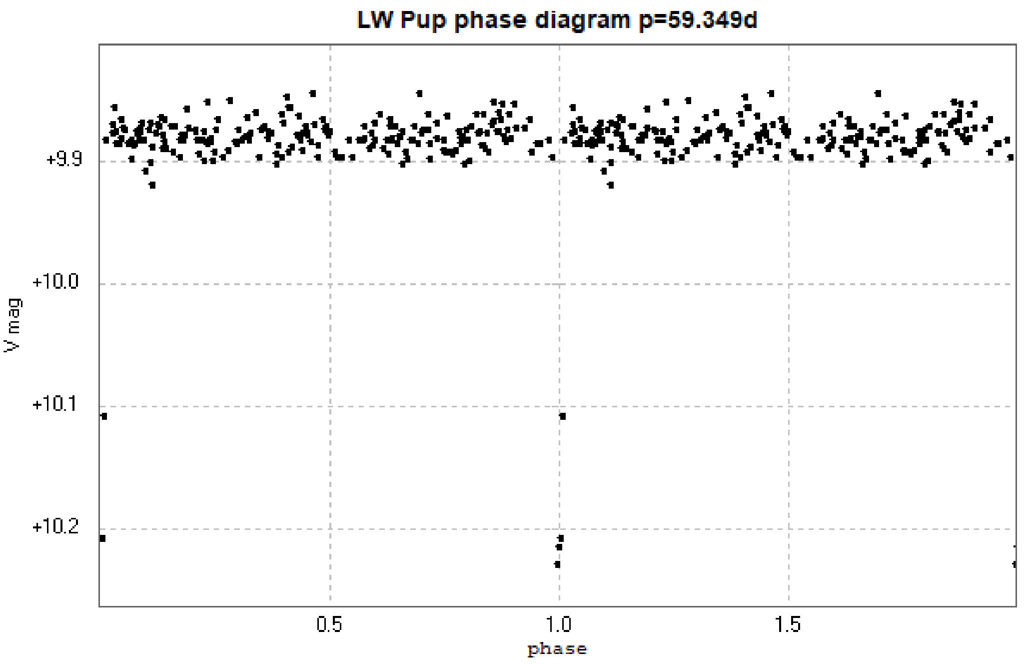
Long term light curves and phase diagrams of three EA type eclipsing binaries using photometry of images taken with online telescopes run by the Open University and, previously, by the University of Bradford. System types (in brackets) and the periods used are from the General Catalogue of Variable Stars (GCVS).

The main interest in these under-observed objects has been the acquisition of complete phase diagrams. In spite of issues with the online observatory in Tenerife used to make these observations (e.g., changes to the available instruments and poor weather) the results have been useful.

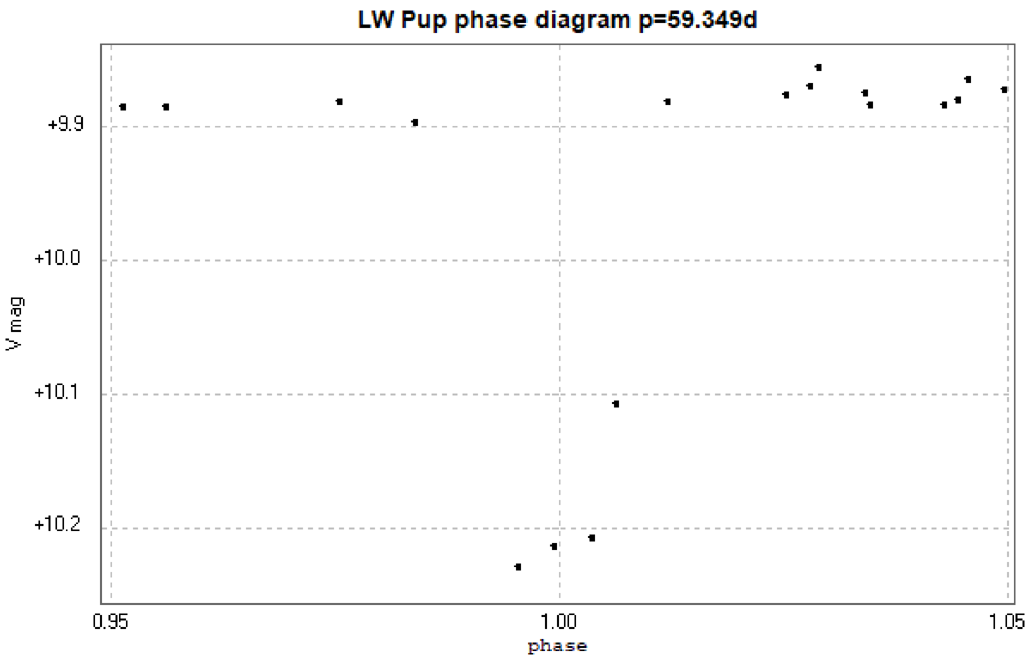
LW Pup [EA/GS]

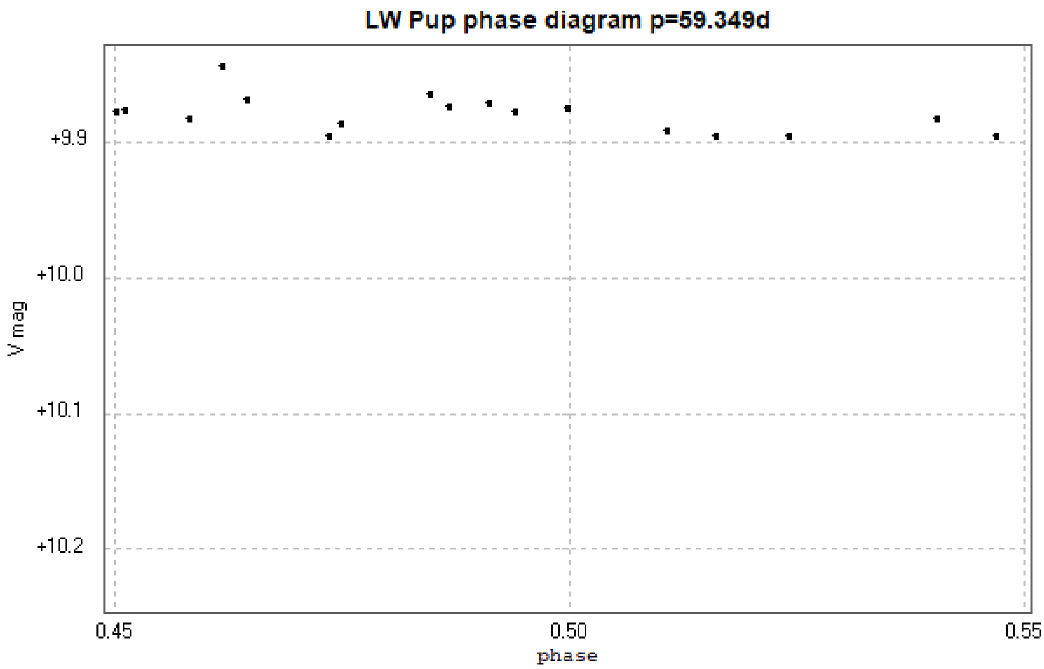
Light curve and phase diagram constructed from photometry of 207 images taken between 2017 October 2 and 2022 April 26.





Enlarged sections around phase 0 (= phase 1.0 in the diagrams) and phase 0.5 appear below.

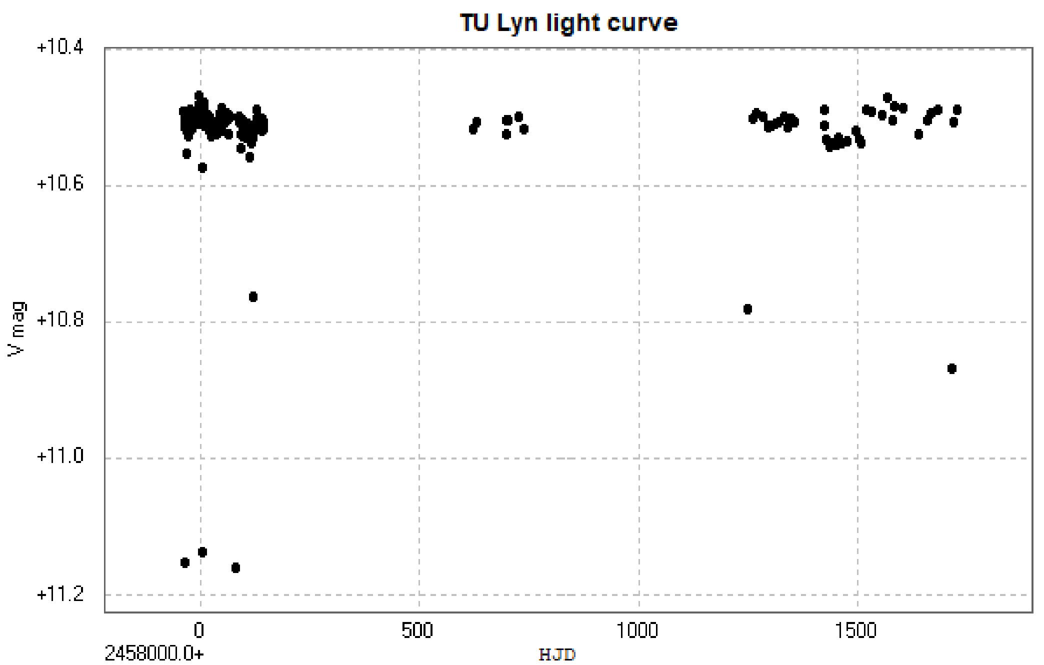




The above phase diagrams are consistent with the GCVS information, there being no detectable secondary minimum at any phase, certainly not at phase 0.5. More observations will be made to check any other gaps in the phase diagram, as well as increasing the number of data points in the primary minimum.

TU Lyn [EA/GS]

Light curve and phase diagrams constructed from photometry of 147 images taken between 2017 July 27 and 2022 May 27



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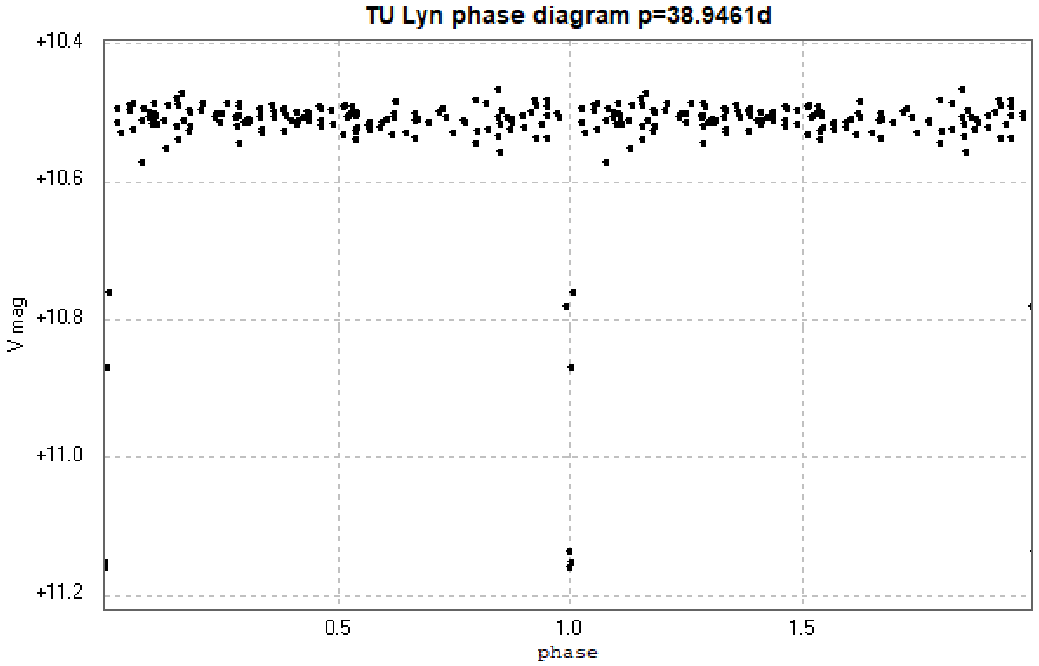

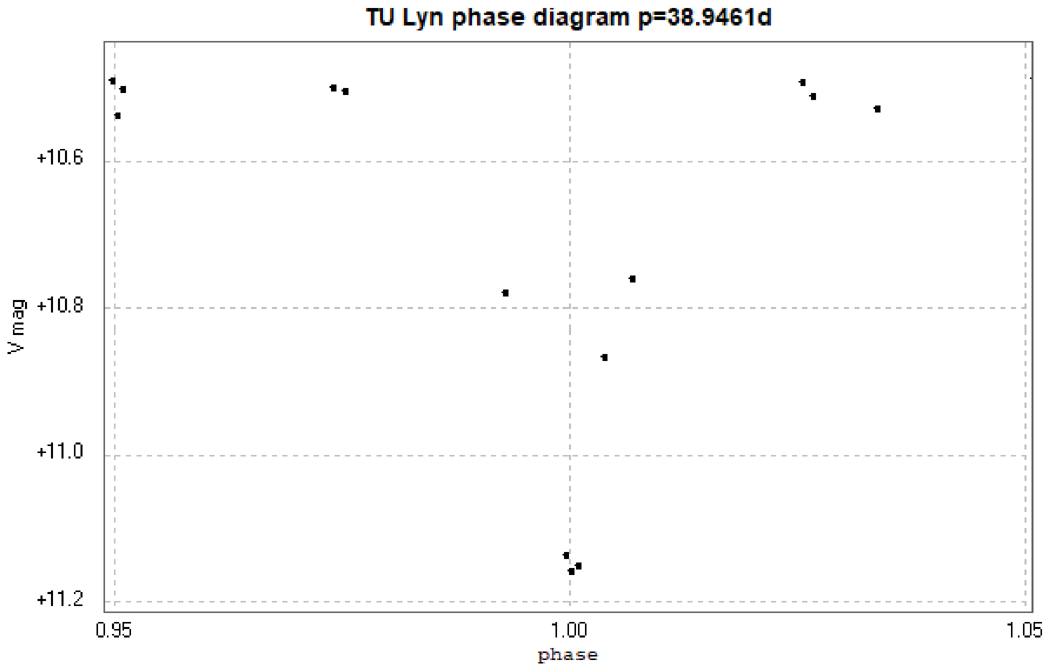

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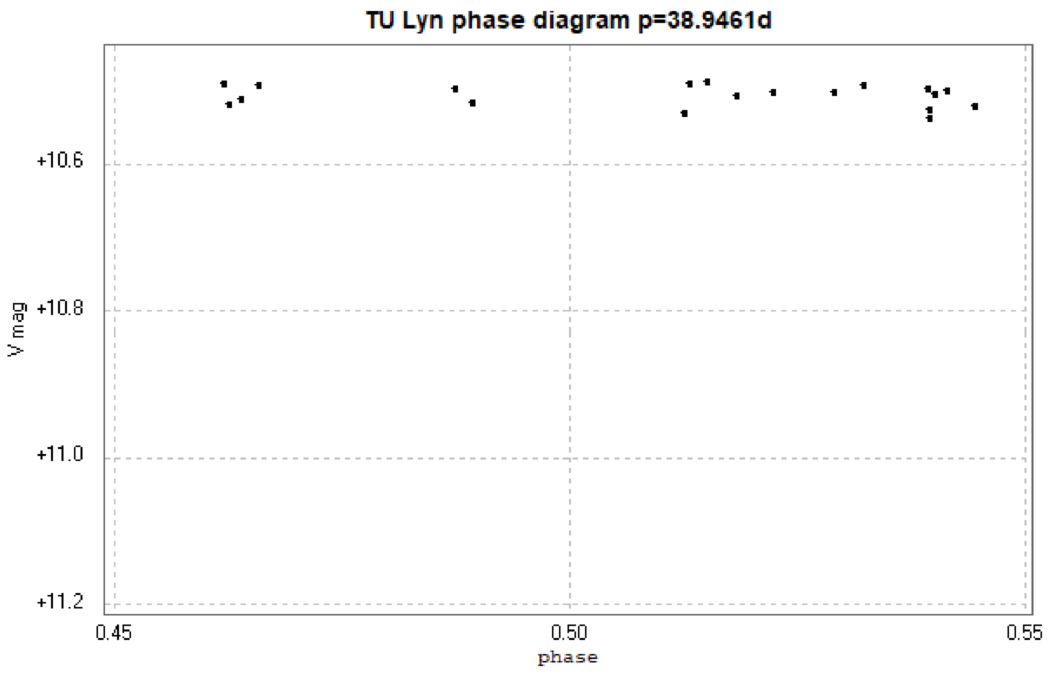
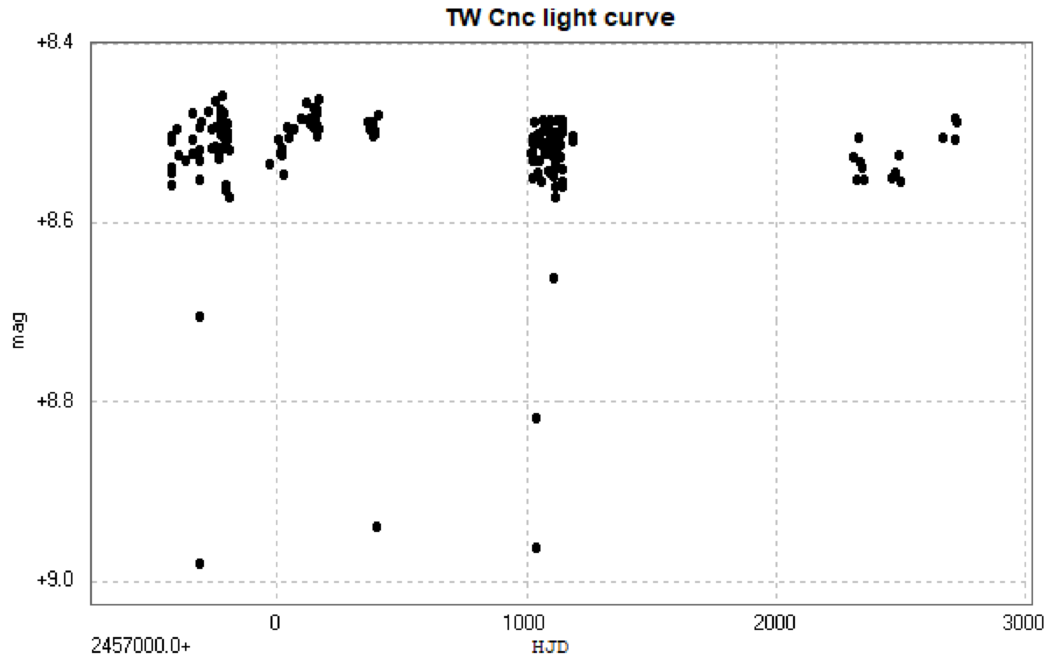
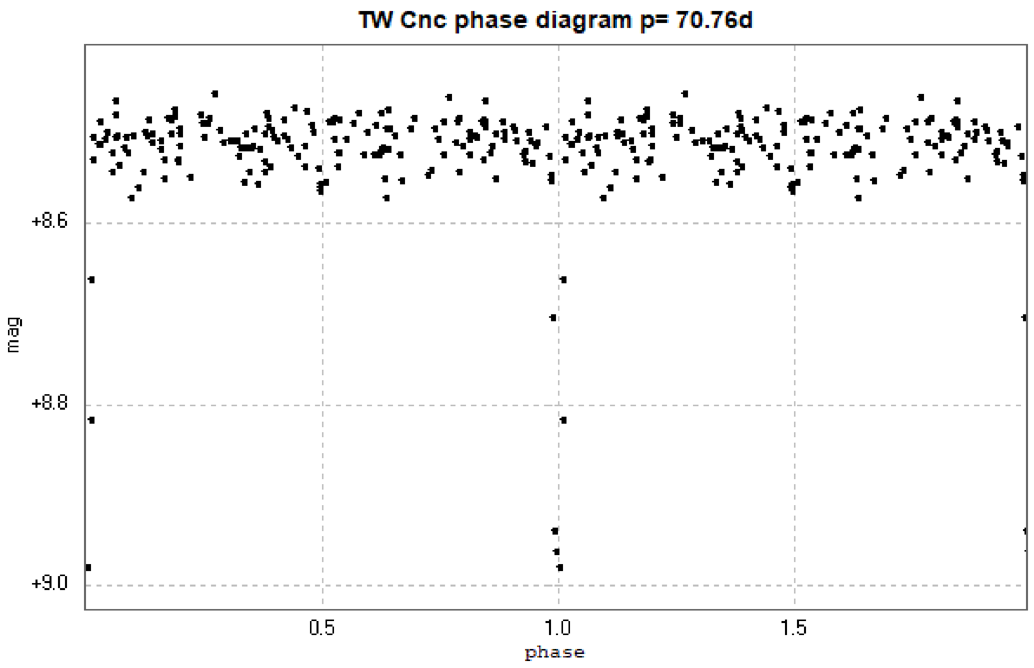


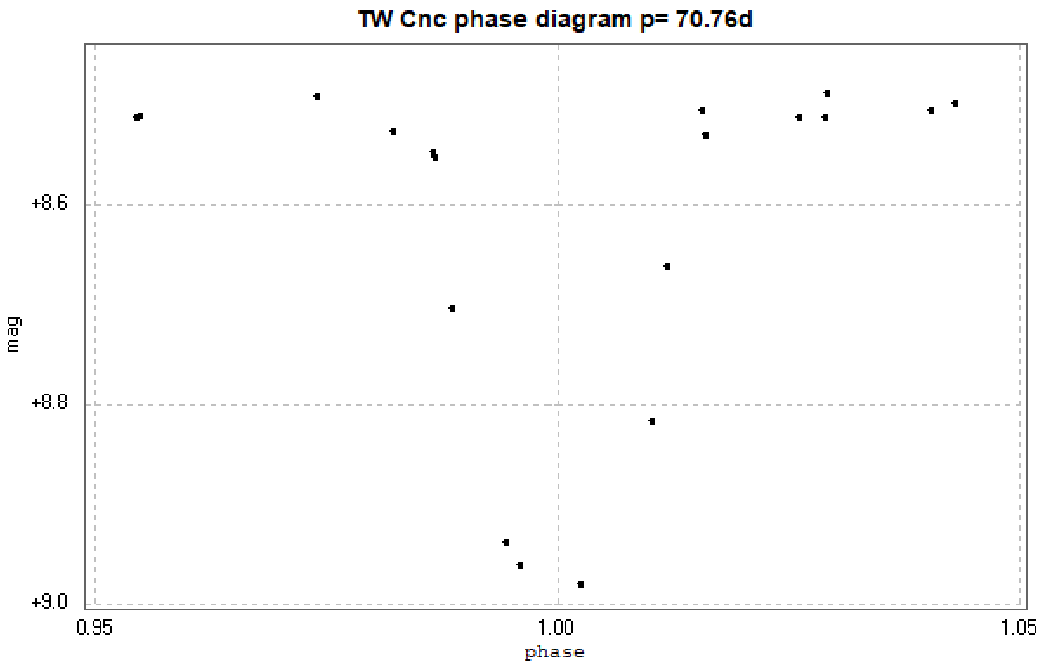
Again, the above phase diagrams are consistent with the GCVS information, there being no detected secondary minimum. However, at phase 0.5 there is a gap in the observations which do not exclude the possibility of one. More observations needed.

TW Cnc [EA]

Light curve and phase diagram constructed from photometry of 173 images taken between 2013 October 10 and 2022 May 23.




TW Cnc phase diagram p= 70.76d
+8.6
+8.8
+9.0
mag
0.5
1.0
1.5
phase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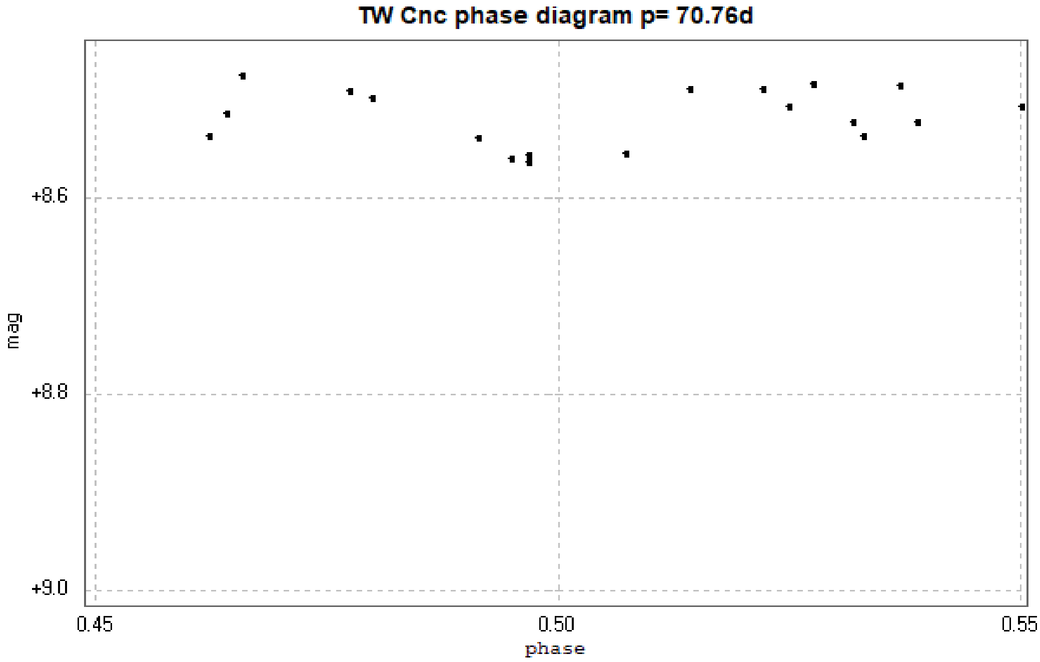
+8.8
+9.0
mag
0.95
1.00
1.05
phase



For this system, the phase diagrams are *not* consistent with the GCVS information. The GCVS says there is a shallow secondary minimum, approximately 1/3 as deep as the primary minimum. This is based on an article in the Astronomical Journal Vol 63 (Whitney 1958) which suggests one at phase 0.5 approximately. However, my observations suggest there is no realistic possibility of one at phase 0.5, or at any other phase, certainly not one as deep as suggested in the catalogue. Again, more observations are needed to test this.

All three of these systems remain in my observing program. In particular, the results to date for TW Cnc are of particular interest and require more data to check the catalogued information. More details can be found on my website David Conner's astronomy notes - Home (weebly.com).

Recent minima of various Eclipsing Binary stars

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This report lists recent timings of minima of various eclipsing binaries. The observations from which the timings were obtained have all been posted to the BAAVSS photometric database. Light curves for TU Boo and RS CVn and an O-C diagram for RS CVn are also included.

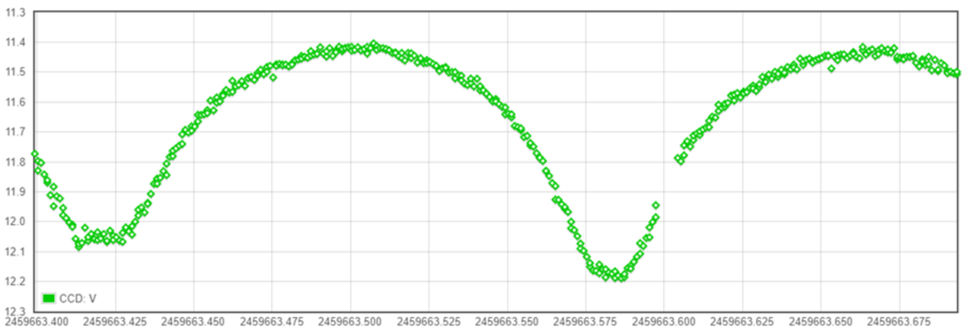
Timings:

Star	HJD of Min	Filter	Error	Type of Minimum
CD Cam	2459615.49634	V	0.00101	Secondary
IM Aur	2459621.48500	V	0.00035	Primary
Y Leo	2459633.33889	V	0.00020	Primary
Z Dra	2459661.37268	V	0.00039	Primary
TY Boo	2459657.56610	V	0.00049	Primary
TU Boo	2459663.58742	V	0.00026	Primary
RS CVn	2459658.57244	V	0.00071	Primary
TZ Boo	2459685.53663	V	0.00035	Primary
AK Vir	2459716.43003	V	0.00050	Primary
AZ Vir	2459717.39820	V	0.00030	Primary

The observations from which these timings were obtained were made from February 2022 to May 2022 using a 102mm refractor and an ASI 183MM-Pro cooled mono CMOS camera and a V band filter. The timings were extracted using Bob Nelson's Minima software.

The observations of TU Boo were made over a 7 hour period during the night of 24th to 25th March this year. There is a 13minute gap near JD 2459663.6 which was needed to carry out a meridian flip. TU Boo is classified as an EW/KW eclipsing binary of the same type as W UMa, (the meaning of the EW designation) . The components are likely to be in contact (hence KW) and tidally locked with a common envelope. The short period of only 7.8 hours and the associated high rotation speed is expected to give rise to strong magnetic activity and star spots.

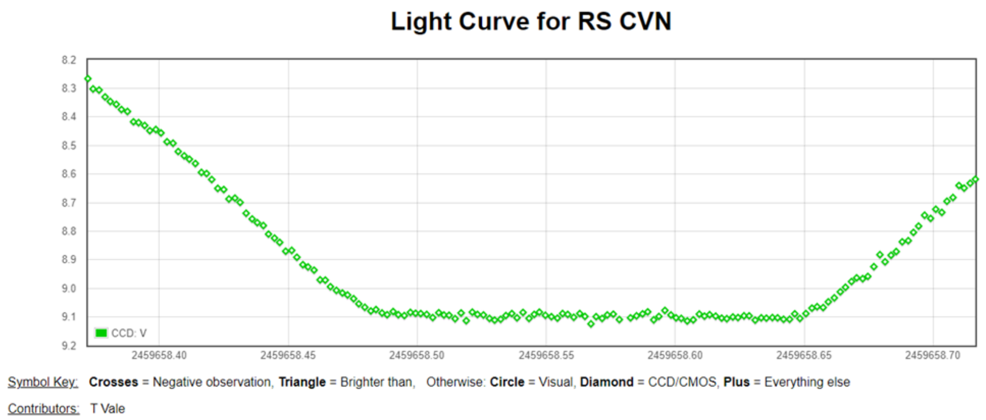
Light Curve for TU Boo



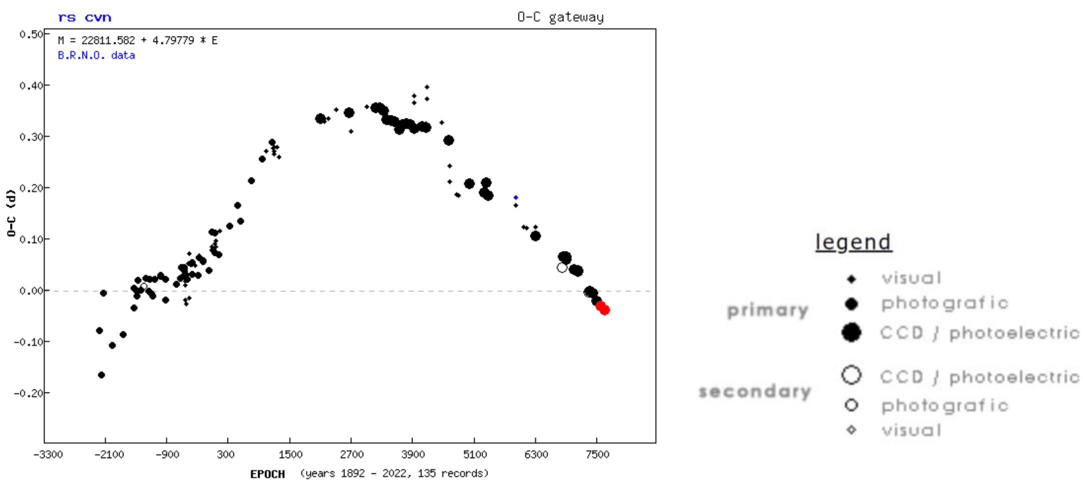
Symbol Key: **Crosses** = Negative observation, **Triangle** = Brighter than, Otherwise: **Circle** = Visual, **Diamond** = CCD/CMOS, **Plus** = Everything else

Contributors: T Vale

The observations of RS CVn were made on the night of 19th to 20th March. RS CVn is an EA/RS type eclipsing binary. EA indicates an Algol type system in which the components are relatively well separated and are circular or only slightly ellipsoidal. The periods will therefore likely be longer than the W UMa type discussed above and in the case of RS CVn the period is 4.8 days. RS indicates that the star can have large, persistent star spots. The light curve is of a primary eclipse, the duration of which is 12.7 hours. Consequently, it is difficult to observe the whole eclipse in a single night. The observations shown here took place over an 8 hour period and include a number of observations in the fade and recovery preceding and following the flat minimum. This is necessary to obtain a reasonable estimate of the time of minimum but it means that the eclipse needs to take place around the middle of the hours of darkness. This, together with the relatively infrequent minima, some of which will take place during daylight or on cloudy nights can make timing the minima of this object rather challenging and it is perhaps for these reasons that it is not as well observed as others.



An estimate of the time of minimum obtained from the light curve, together with an estimate from an earlier DSLR observation made in March 2021 (published in the June 2021 journal) are shown in red and plotted on the O-C diagram below using the O-C gateway of the Czech astronomical Society. The diagram below shows a reduction in the period over the past 60 years or so following a lengthening of the period in the 60 years before that with perhaps a hint of long period sinusoidal variation.



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The Eclipse of VV Cephei 2017-2019

Colin Henshaw

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VV Cephei was monitored using a Canon 6D camera from 2015 until 2021. The eclipse was scheduled to start in 2017, but it is possible that unusual behaviour may affect the brightness of the star both before the onset and after the end of the eclipse, so it was essential to monitor the star before the eclipse started and to continue after it had finished. VV Cephei also shows low amplitude semiregular variability that may mask the effect of the eclipse, as the eclipse itself is of low amplitude.

Introduction

VV Cephei is a hypergiant star of spectral type M2 Iab, with a B – V of 1m.82 and a radius of about 1050 R⊙ for the primary. This would make it around the size of Jupiter's orbit. Estimations of its mass range from 18.3 M⊙ to 20M⊙. The secondary has a spectral type of B0-2 V, with a B – V of 0m.36, and a mass of 8 M⊙ [1]. The system is an eclipsing binary with a period of 7,430.5 days, equal to about 20.3 years and lies within the Cepheus OB2 Association at a distance of 1.5kpc. The eclipse lasts about 650 days, starting in August 2017 and finishing around June 2019, while totality lasts for 343 days. Five eclipses have been observed since 1936, when it was discovered by Dean McLaughlin, and two more were discovered by Sergei Gaposhkin in 1895 and 1915 on blue sensitive photographic plates [2]. The primary star fills its Roche Lobe when closest to the secondary, and material is dumped onto the secondary resulting in a disc of material that causes the primary minima [1]. The secondary minima are not detectable.

Method

Images of VV Cephei were taken using a Canon 6D camera and a 135 mm telephoto lens. On each night ten dark frames were taken along with eleven images of the star. The images were processed using the single image photometry tool on AIP4Win software [3]. A new free version of AIP4Win has now appeared that is somewhat different to earlier versions, and this was downloaded from the AIP4Win website. Once this had been accomplished a new procedure for single image photometry had to be adopted. It was not certain how well this would work out, so it was tested on two other stars to ascertain as to how effective it was. The other two stars were UU Cancri (8m.68 – 9m.35), a β Lyræ star (fig 1) with a period of 96.6 days, and TT Hydræ (7m.25 – 9m.02), an Algol star (fig 2) with a period of 6.95 days. Observations of these stars were phased out according to their elements published in SkyMap Pro 12 [3]. This was not done with VV Cephei, as it has a 20.3 year period, so these observations were plotted against Julian Date.

Both light curves illustrate the characteristics of these two stars remarkably well. UU Cancri shows the characteristic light-curve of a β Lyræ star, continuously varying without any constant phase near maximum. TT Hydræ shows the characteristic light-curve of an Algol star. The primary minima are obvious, but not only that, the secondary minimum is also evident, and so is the reflection effect. The amplitudes of the two stars correspond very closely to those that are listed.

The procedure being followed was therefore considered effective, so it was decided to follow up on VV Cephei.

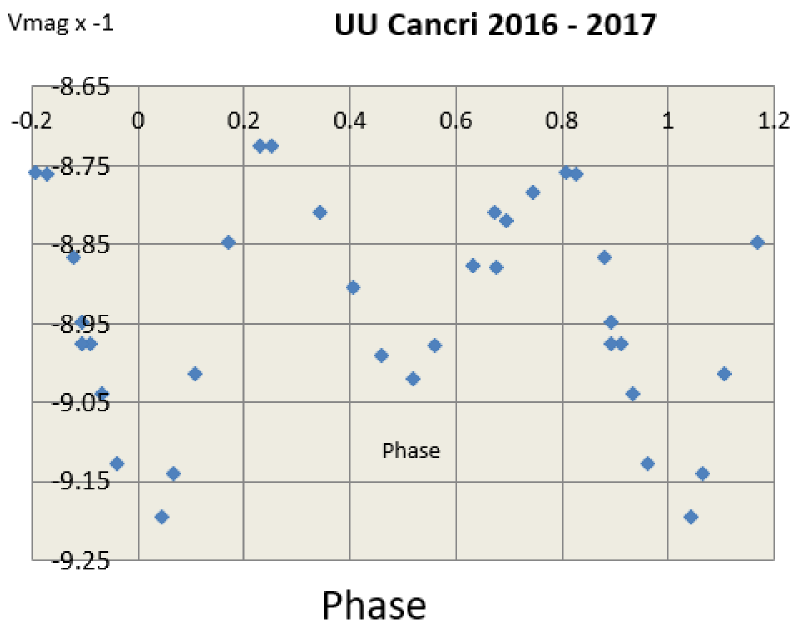

Figure 1. UU Cancri

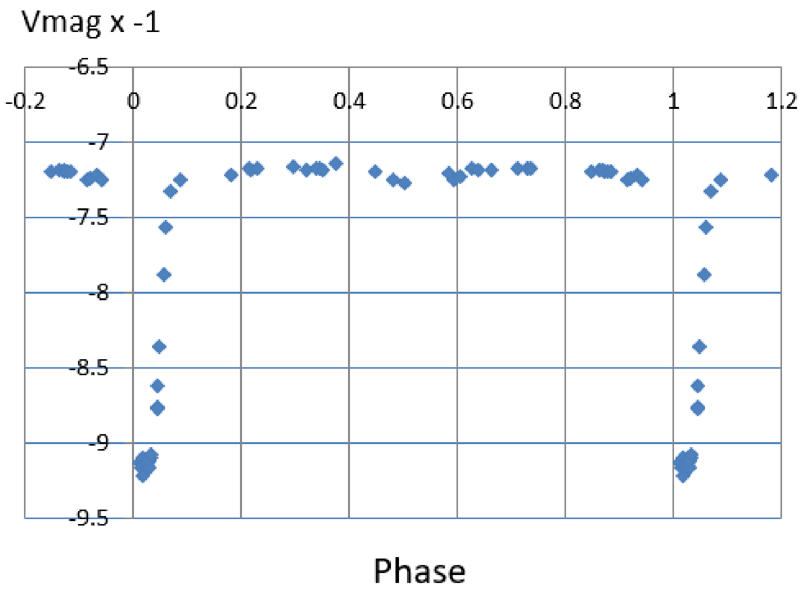

Figure 2. TT Hya

The Light-Curve of VV Cephei

The light-curve was derived from 1,151 images taken on 141 nights between July 21st 2015 and December 15th, 2021. Eleven images of the star were taken on each night along with ten dark frames. These were then measured using the single image photometry tool on AIP4Win software. Two comparison stars, FI20 Cephei (5m.28) and SAO 19621 (5m.95), were selected, the same stars as were used when the star was observed visually. The results derived from each star were then averaged.

The light-curve, fig 3, clearly shows the eclipse with an amplitude of about 0m.5, of which the eclipse amounted to about 0m.4. Out of eclipse the amplitude amounted only to about 0m.3.

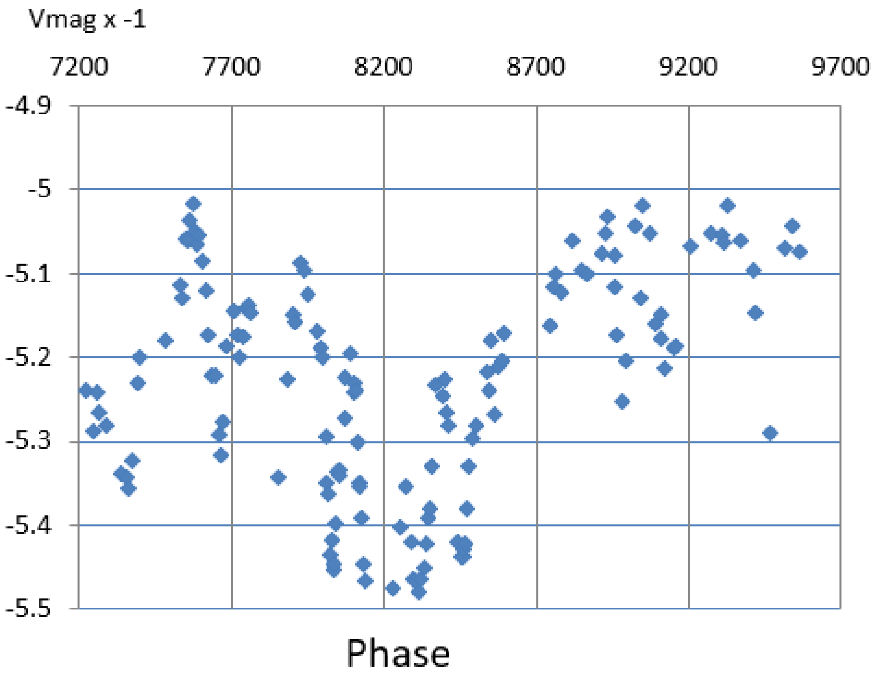

Figure 3. VV Cephei

During the eclipse the semi-regular variation was not sufficient to drown out the eclipse, which is quite obvious.

Conclusions

The latest version of AIP4Win has proven effective in detecting variability in VV Cephei and other variables. VV Cephei was found to have an overall amplitude of almost 0m.5, with the eclipse amounting to about 0m.4. With the success so far obtained, it is hoped that the procedure can be extended to exoplanets.

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