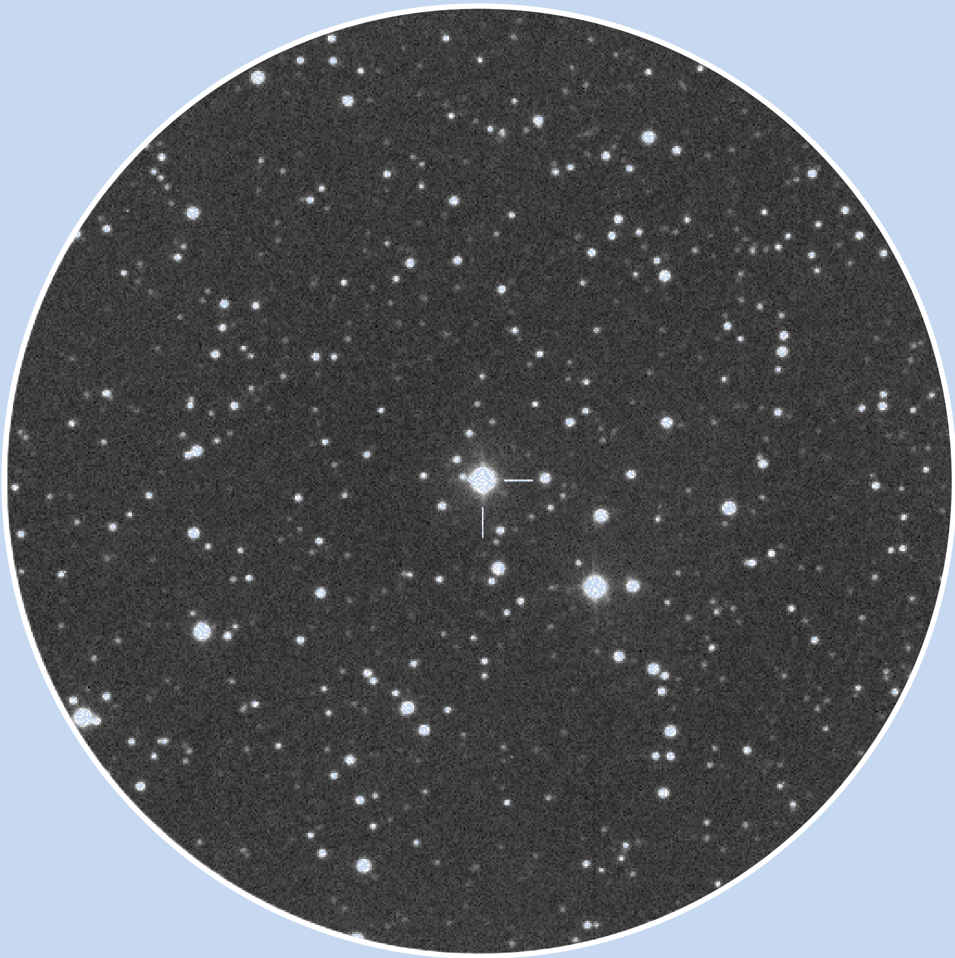
ISSN 2631-4843

The British Astronomical Association

Variable Star Section Circular

No. 187 March 2021



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Cover Picture

V1112 Per (Nova Per 2020)
November 27.176 UT 2020. iTel 0.43 DK@f4.5 + FLI-PL6303E 120s. V=9.15
Martin Mobberley, Bury St. Edmunds, Suffolk UK

I'm unusual amongst most of my family, colleagues and non-astronomical friends in that I look forward to the passing of the Summer Solstice as after that the nights begin to draw in, allowing more observing time, until Midwinter. By contrast I don't much like the period after the Winter Solstice as the nights shorten. March is especially poignant as the change in day length is very noticeable, with the familiar Winter constellations rapidly disappearing in the West. It's almost as if someone has pressed the Fast Forward button. This year is different, though. After a seemingly long Winter, with snow, ice, and plenty of floods in this corner of England, coupled with lockdown restrictions, I am very much looking forward to better weather, the Spring skies, and the emerging variable stars they herald!

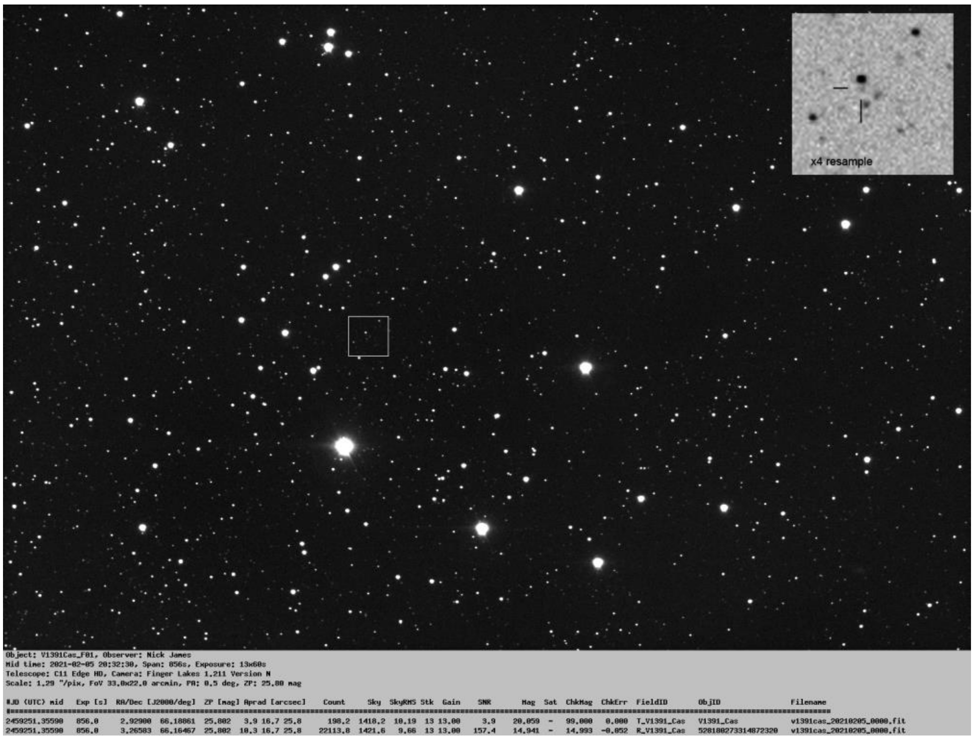
Recent novae

2020 seems to have been the year of northerly novae. Nova Cas 2020 (**V1391 Cas**) was reported on 2020 July 27. It remained brighter than 14th mag until the beginning of December when a dust fade began, plunging it to mag 19 to 20. A recent image by Nick James has it about mag 20 on 2021 Feb 5.

Then Nova Per 2020 (**V1112 Per**) was reported on 2020 Nov 25. At the time of writing, it is still 15th mag.

Please do keep observing these novae. As novae fade, the number of observations drop, so it's important to keep going as long as possible to get a full light curve of the eruption. Either of the recent novae might re-brighten if they are dust fades. Do beware the nearby field star close to **V1391 Cas**, though, which can readily contaminate photometry!

More on these novae in the 2021 February edition of the BAA *Journal*, page 9-10.



V1391 Cas on 2021 Feb 05 at 20:32, FLI6303 + Celestron HD11 (Nick James)

ER UMa stars in TESS data

As mentioned in previous Circulars, Stewart Bean and other observers have been monitoring outbursts of several UGER systems, which are also observed by TESS, to determine their supercycle length. **IX Dra**, **ER UMa** and **RZ LMi** receive good coverage from TESS, but there are large gaps in the data when the satellite is doing other things. Filling those gaps is needed to identify outbursts and keeping the clock running on future superoutbursts.

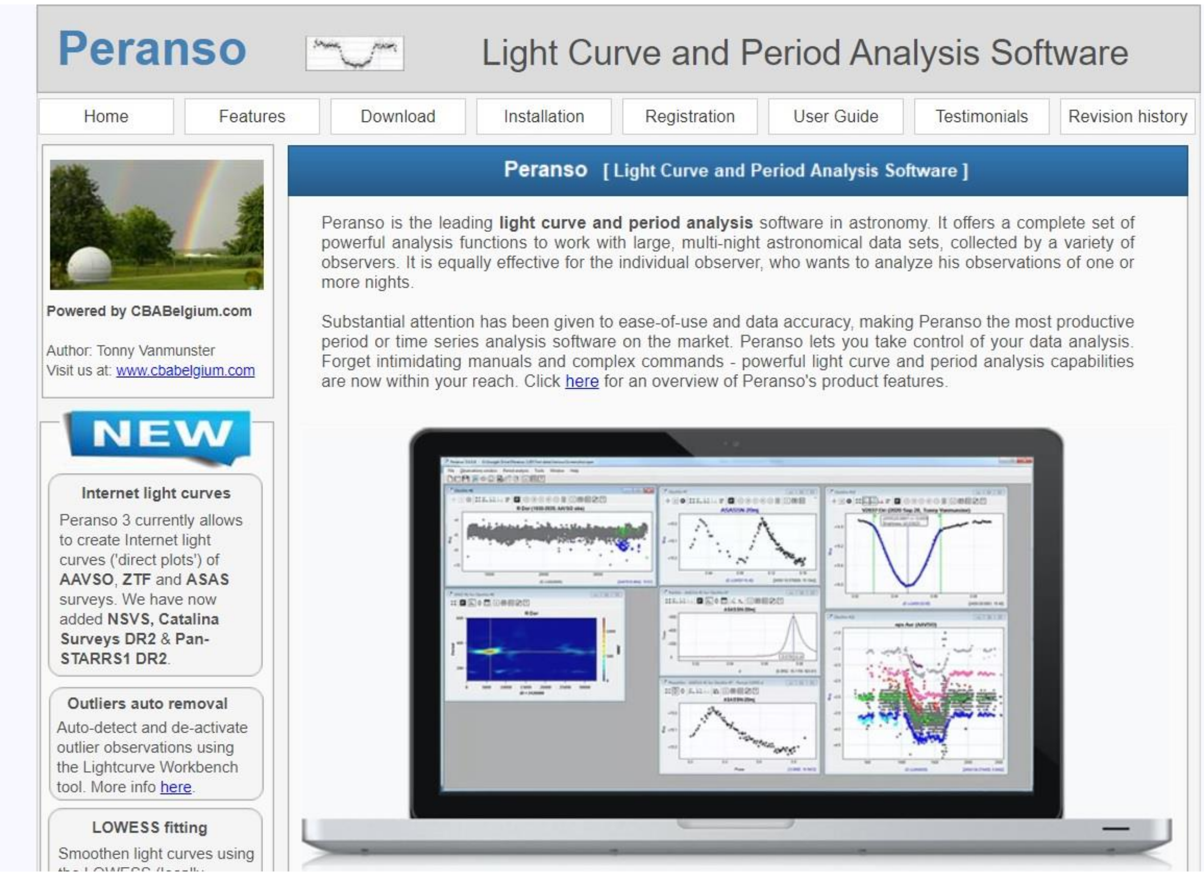
A superoutburst of **IX Dra** was detected on 2021 Jan 9 and based on measurements of recent supercycle lengths, Stewart anticipates the next around March 11.

TESS also presents good coverage on the UGSU system, **VW Hyi**, but again there are large gaps. The coverage of VW Hyi by amateurs has been decreasing in recent years, which means we are missing some normal outbursts and it has become difficult to determine accurate start times of superoutbursts. Hence a plea to our southern observes to continue to monitor this system.

Launch of Peranso 3

Like many members, I've used Tonny Vanmunster's *Peranso* light curve and period analysis software for many years. It's an easy to use programme, with an intuitive interface, but at the same time it is very powerful for period analysis, with a multiplicity of methods and algorithms incorporated. I was delighted when Tonny released Peranso 3 at the end of last year. I purchased the update and have been impressed with its performance and additional functionality.

You can download the software from the Peranso website (https://www.cbabelgium.com/peranso/). Tonny and Gabriel Christian Neagu presented a webinar on Peranso 3, a recording of which can be viewed at the website.



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Zooniverse projects on ASAS-SN and SuperWASP data

Zooniverse is perhaps best known for its Galaxy Zoo project which involves members of the public in classifying galaxies in deep space images. This is not only scientifically useful, because humans are better than computer algorithms at interpreting complex images, but it also helps to engage the public in science.

John Fairweather informs me that Zooniverse also has a project whose goal is to classify the light curves of variable stars identified in ASAS-SN g-band data (https://www.zooniverse.org/projects/tharinduj/citizen-asas-sn). "By classifying these light curves, you will help scientists better understand the population of variable stars in our Galaxy. Through your efforts, we also hope to identify unusual variables that inform us of the peculiar ways that some stars behave in". The website indicates that analysis of the ASAS-SN light curves is 4% complete, with 680 volunteers working on the project.

There is a similar project based on SuperWASP data: https://www.zooniverse.org/projects/ajnorton/superwasp-variable-stars

I wonder if this is a way of getting amateur astronomers interested in variable stars.

SPRING MIRAS

M = Max, m = min.

R And	M=May/Jun
RW And	M=May/Jun
R Aqr	m=Mar
R Aql	m=Apr
X Cam	M=Apr
SU Cnc	M=Apr
U CVn	M=Apr/May
RT CVn	M=Mar
T Cas	m=Apr
o Cet	m=Apr
R Com	m=Mar
S CrB	m=Mar
V CrB	m=May
W CrB	M=Feb/Mar
S Cyg	M=Apr/May
V Cyg	m=Apr/May
chi Cyg	M=Feb/Mar
SS Her	M=Apr
	m=Feb/Mar
R Hya	m=Apr
SU Lac	M=Apr/May
RS Leo	M=Apr
W Lyn	m=Mar/Apr
X Oph	m=Apr
U Ori	M=Apr/May
R Ser	M=Apr/May
T UMa	m=May

Source BAA Handbook

Graham Salmon (1932-2021)

It is with a heavy heart that I report the death of Graham Salmon on 2021 Jan 11. Graham has 6,256 observations in the VSS database made between 1995 and 2006. He was initially a visual observer, but later adopted CCD work. In recent years he operated a meteor video camera, contributing data to the NEMETODE meteor network.

BAA VSS-Alert

Finally, a reminder that BAAVSS-Alert email system has moved from yahoo to groups.io. It is gratifying to see that many people have signed up for the new list, the email address of which is baavss-alert@groups.io. Have you signed up yet?

Submitting CCD/CMOS/DSLR observations

Andrew Wilson

An overview of the methods for submitting CCD/CMOS/DSLR observations and a reminder not to use the visual spreadsheet.

I recently realised that not everyone is aware we have different upload file layouts for visual and CCD/CMOS/DSLR observations. It is important that only visual observations are uploaded using the visual spreadsheet, and any CCD, CMOS and DSLR observations are submitted using one of the CCD file layouts. Any CCD observations submitted using the visual spreadsheet will be recorded as visual estimates in the database even if CCD is included in the notes. This means any researchers using the data will think they are visual rather than CCD observations. We also record slightly different information on CCD observations.

There are many ways to load CCD, CMOS and DSLR observations into the database, so many that it can be a bit confusing. I give an overview of the main methods below, and please do ask if you would like advice. All of the photometry packages are free, including AIP4Win since the closure of William Bell.

1) The photometry package MuniPack will generate a file in the BAAVSS format that can be uploaded to the database.
2) The software packages AIP4Win and AIJ produce files that are loaded into the BAAVSS Photometry Excel spreadsheet, which then creates a BAAVSS format file. Although the spreadsheet adds an extra step, it produces useful graphs to help you to review and validate your results, and it can flag up erroneous comparison stars.
3) You can create a spreadsheet in one of the following 3 formats, then save it as a text and tab file to be uploaded to the database. The CCD/CMOS/DSLR format allows one variable star per file. This is the original layout and is the one created by Munipack and the Photometry Spreadsheet. If you want to include multiple variable stars in your file, then you can either use the bulk format or the slightly modified AAVSO file format. These manual methods all support fainter than estimates by putting the '[' character in front of the magnitude.
4) Finally, there is a webpage where you can manually enter your observations one at a time, though I don't recommend this as it is a bit cumbersome.

Example file formats, links to software packages, and other information can be found on the Submission Notes page of the database website:

https://britastro.org/photdb/notes_submissions.php

If you have uploaded any CCD observations using the Visual spreadsheet or have any questions, then please don't hesitate to get in touch.

Independent Comet Finds

John Toone

Visual photometry of variable stars entails star hopping and can result in occasional independent comet detections. This is an account of my experience in this respect.

One of the by-products of undertaking visual photometry of variable stars is that the observer can pick up transient events in the relative vicinity of the target object.

I learned at the start of my observing career that the observation of variable stars can accidentally lead to independent detections of comets. Aged 14 in 1975 I found a comet whilst undertaking only my second observation of chi Cyg with 12x50 binoculars. [1]

Albert Jones discovered two comets whilst monitoring southern variable stars during a 68 year observing career and actually holds the record for time elapsed (54 years) between successive comet discoveries. The second discovery also made him the oldest person (aged 80) to discover a comet. [2]

I have written previously about asteroid [3] and planet [4] detections that are mainly confined to Zodiacal constellations. To date I have detected asteroids (plus Uranus & Ceres) in Aries, Cancer, Gemini, Leo & Ophiuchus. Not being confined to the Ecliptic comets are different because they can suddenly appear practically anywhere in the sky.

The visual variable star observer is well equipped to pick up comets because variable stars are spread across the entire sky and the location technique entails star hopping to the position of the target variable. Put simply this is not unlike a basic comet & nova sweep that George Alcock perfected and systematically undertook for many years.

The instruments used by variable star observers such as binoculars with typically a 5 degree field and telescopes with a low power 0.5 degree field give plenty of scope for picking up interlopers including comets. Telescope finders are also helpful and my 6x30 finder scope on the C8 provides a 7 degree field.

Here is a list of my independent comet detections to date:

Date	Instrument	Target Object	Comet Find	Notes
18 July 1975	12x50B	chi Cyg	1975h (Kobayashi-Berger-Milon)	Discovered 2 Jul 1975
31 July 1976	12x50B	NGC6934	1851 II (de'Arrest)	BAA Handbook predicted mag 12.5
9 May 1988	12x50B	X Cam	1988a (Liller)	
26 Nov 1992	12x50B	X Oph	1862 III (Swift-Tuttle)	
1 April 2002	6x30 finder	RX And	C/2002 C1 (Ikeya-Zhang)	
17 May 2004	12x50B	RS Cnc	C/2001 Q4 (NEAT)	
16 Jan 2005	7x50 finder	GK Per	C/2004 Q2 (Machholz)	
17 Oct 2006	15x70B	V Boo	C/2006 M4 (SWAN)	
29 Mar 2013	6x30 finder	R And	C/2011 L4 (PanSTARRS)	
4 Dec 2013	15x70B	RR CrB	C/2013 R1 (Lovejoy)	
26 Jan 2015	15x70B	W Tri	C/2014 Q2 (Lovejoy)	
2 April 2017	20cmSCT	AG Peg	C/2017 E4 (Lovejoy)	Discovered 9 Mar 2017
14 May 2020	20cmSCT	Z Cam	C/2017 C2 (PanSTARRS)	

Of course, these comet finds are of no scientific use whatsoever because the closest I ever came to an actual discovery was with the first one which was originally found 16 days earlier and independently detected by 50 other observers. However, the surprise detection of a comet is pleasantly rewarding and sometimes amusing as with C/2013 R1 when I showed it to my children and their response was "is that it, not at all like the picture in the living room" (referencing a framed colour photo of Hale Bopp). Since I missed out on seeing Comet West in 1976 the first two comet's I saw were at the top of the list above. By the end of 2020 having clocked up 6452 hours observing over 45 years, I have found 13 comets, 6 asteroids (Nysa twice), 1 dwarf planet (Ceres twice) and 1 planet (Uranus) whilst mainly targeting variable stars. This together with the occasional unexpected appearances of aurora, noctilucent clouds, meteors/fireballs etc; adds to the fun of maintaining old fashioned visual astronomy because you can never be sure what you are going to see on the night.

References:

1. JBAA, 112, 245 (2002)
2. JBAA, 126, 91 (2016)
3. BAA VSS Circular, 155, 7 (2013)
4. BAA VSS Circular, 181, 27 (2019)

A recent low state in the Polar AI Tri

Jeremy Shears

The light curve of the polar AI Tri, between 2005 and 2021 is presented which shows a deep fade to mag 18.5 in 2020 Sept.

Magnetic cataclysmic variables are interacting low-mass binaries consisting of a late-type, mass donating secondary and an accreting white dwarf primary with a strong magnetic field. In the AM Her subclass, also known as polars, the rotation of the primary is locked to the orbital period and the matter is accreted along the magnetic field lines onto a small area near one (or both) magnetic poles without forming a disc.

AI Tri has one of the longest orbital periods known among polars, 0.191745d (4.6h), and emits most of its energy in X-rays. There is also the possibility that the system switches from one-pole to two pole accretion. [1] The VSX magnitude range is 14.7 - 18.2 V. Some years ago, Gary Poyner coordinated a BAA VSS campaign to observe a range of polars, including AI Tri [2]. In his report on the campaign covering the 5-year interval 2006 to 2011, AI Tri was seen to be at high or intermediate state, varying between V= 15.0 and 16.5 and displaying large orbital modulations.

The author has been following AI Tri via unfiltered CCD photometry since 2007. Initially with a 10 cm refractor, but mostly with a 28 cm SCT. He noticed that AI Tri was exceptionally faint in 2020 Sept and issued a BAA VSS Alert email to draw attention to it, citing the following measurements:

2020 Sep 13.908 17.3 C
2020 Sep 14.919 17.4 C
2020 Sep 17.910 18.5 C

The accompanying light curve (Figure 1) shows data on AI Tri from the AAVSO, BAA VSS, CRTS and ASAS-SN databases between 2005 Sep 25 and 2021 Jan 30. Note that some of the apparent scatter in the data is actually contributed by AI Tri's significant orbital modulations. The light curve shows the deep fade in 2020 Sep and, indeed, the faintest measurement was the one of Sep 17 at mag 18.5 mentioned above.

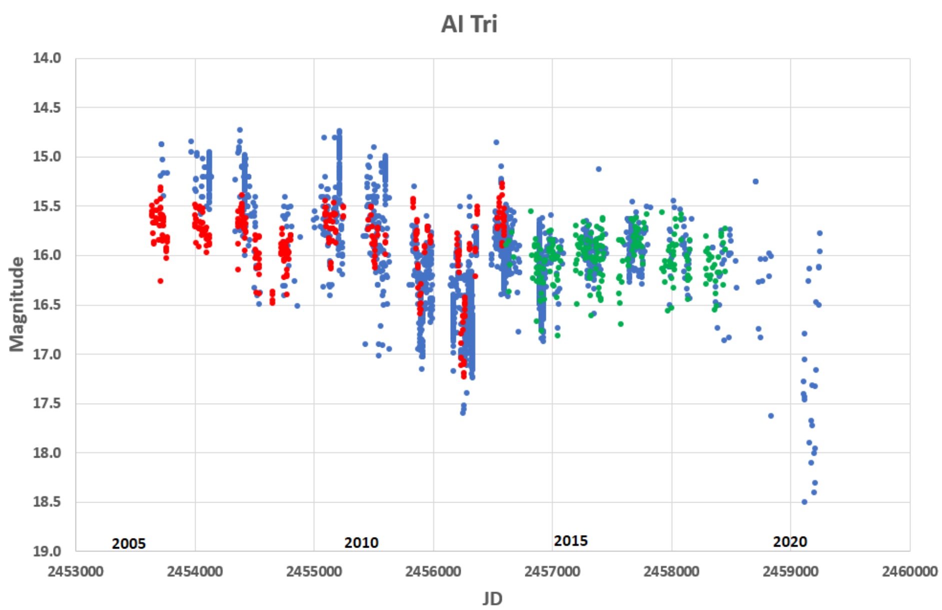

Figure 1. Long term light curve of AI Tri

However, the expanded light curve in Figure 2 reveals a more complicated story. Nine days after the mag 18.5 minimum, AI Tri had recovered to mag 16.2, where it remained for a further day before descending to mag 17.9 seven days later. There was a second fade to mag 18.4 on Dec 17, after which it rapidly brightened. The author's most recent measurement on 2021 Jan 25 has the star back to a more usual magnitude of 15.8 C.

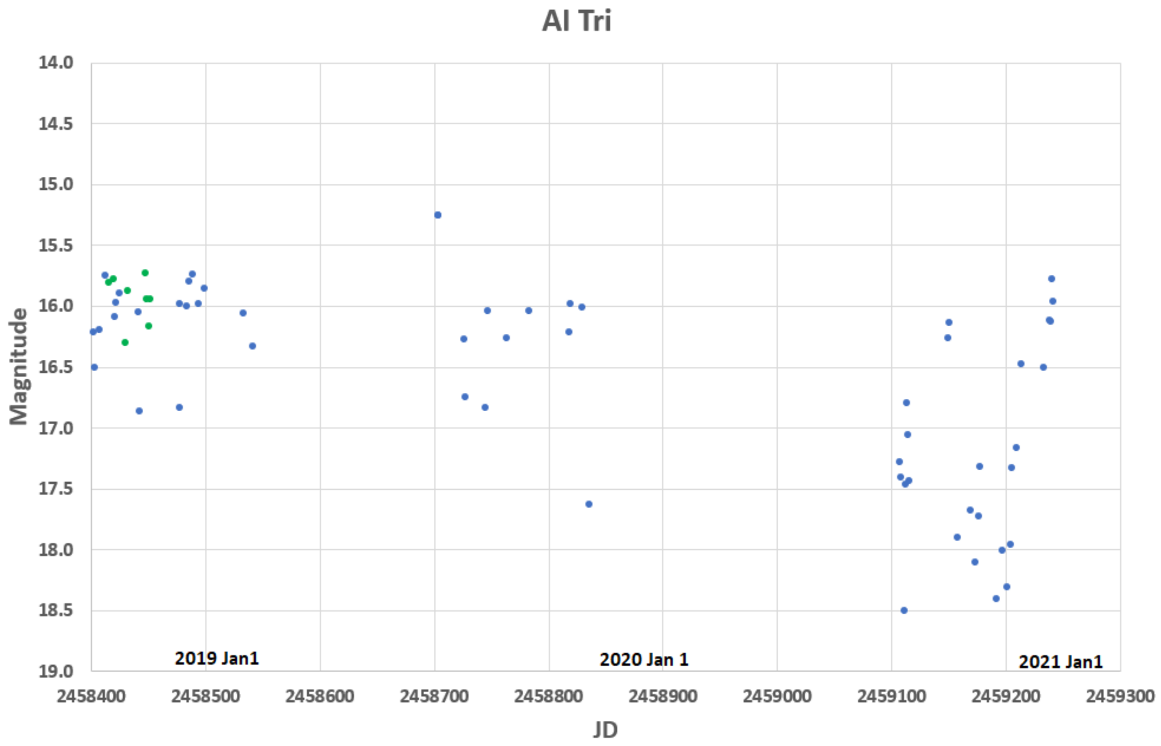

Figure 2. Light curve of AI Tri between 2019 and 2021

Thus, the fading episode lasted approximately 2 months. But it should also be noted that there is a single faint measurement at mag 17.4 on JD 2458835.4 (2019 Dec) after which the next observation was on JD 2459106.4 (2020 Sep 13) at mag 17.3. Might the fainter state have continued during this long gap?

There was also a fade in 2012 November, but this was not quite so deep as the 2020 episode, reaching mag 17.6 C.

Polars are a fascinating subclass of cataclysmic variable as they are often doing something to delight the observer. AI Tri warrants further monitoring and it is unfortunate that the intensity of observations has been low in recent years, sometimes with long gaps in the light curve. Do have a look at Gary's JBAA article for 17 other polars, in addition to AI Tri, that you might like to observe.

References

1. Traulsen I. et al., A&A, 516, 76 (2010).

2. Poyner G., JBAA,123, 108 (2013).

The super-cycle period of the UGER star IX Dra

Stewart Bean

The evolution of the super-cycle period is reviewed from discovery to the present BAA campaign.

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 P(sc) values. IX Dra is one UGER star with a super-cycle of approximately 55 to 60 days that is located close to the north ecliptic pole (NEP). One of the four cameras on the TESS satellite [2] was pointed at the NEP for 12 months starting in 2019 and so IX Dra was well observed. A more complete description of the TESS mission was given in VSS Circular 186.

The super-cycle period, and its evolution, is considered one parameter that models of DNe should describe. M. Otulakowska-Hypka‹ and A. Olech [3] present a collection of P(sc) results for some UGER stars and suggested that the super-cycle period may be increasing for most of them. In this note recent results for IX Dra, obtained both during the VSS observing campaign and collected by the TESS satellite, are compared with the historical data.

TESS started observing IX Dra (IX Dra is Tess Input Catalogue (TIC) number 236763903) from JD 2458683 (2019 July 18) to JD 2459035 (2020 July 4) and was observed in ten “Sectors” (each Sector is 27 days of observation). TESS is now observing the southern hemisphere but will return to the northern hemisphere in September 2021 to continue observations.

IX Dra

IX Dra was discovered by Klose [4] to be a variable star in 1995 during efforts to identify the optical source for a particular gamma ray burst. The study found four objects of interest of which their 'Object A' was IX Dra. This and later observations were reviewed by M. Otulakowska-Hypka et al [5] and the results are reproduced from their work in Figure 1 showing an apparent increase in P(sc) for IX Dra from 45.7 days in 1990 to 58.5 days in 2010.

This note briefly reviews the literature on IX Dra and its super-cycle period and combines the results from the recent work.

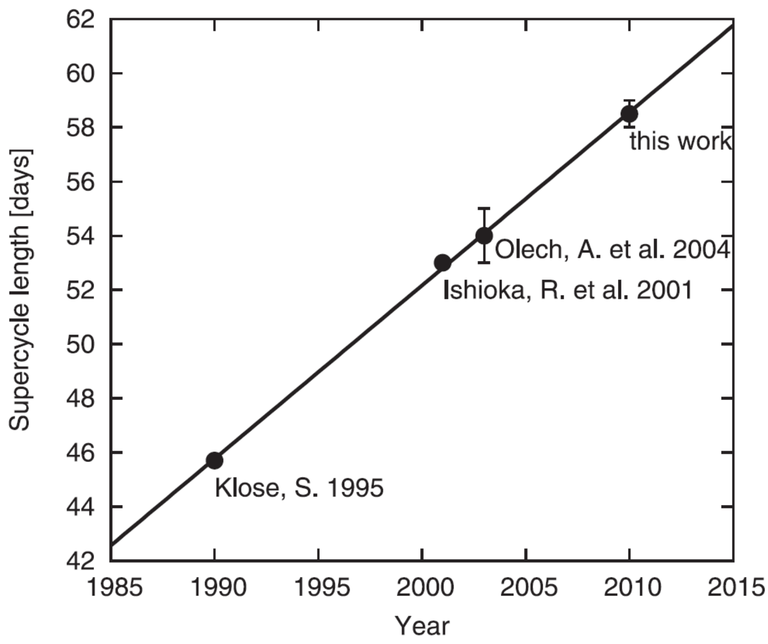

Figure 1. The super-cycle period for IX Dra from M.Otulakowska-Hypka et al (5)

The TESS and VSS campaign results.

Six superoutbursts events and numerous normal outbursts were recorded by TESS in 2019 and 2020. Figure 2 shows one such superoutburst recorded in Sector 22. The start of a superoutburst has been considered to be when the superoutburst exceeds the brightness of the preceding normal outburst and is shown by the arrow. The cadence of the TESS observations is 2 minutes permitting accurate timing of events within a fraction of one day. The vertical axis in TESS observations is flux rather than magnitude.

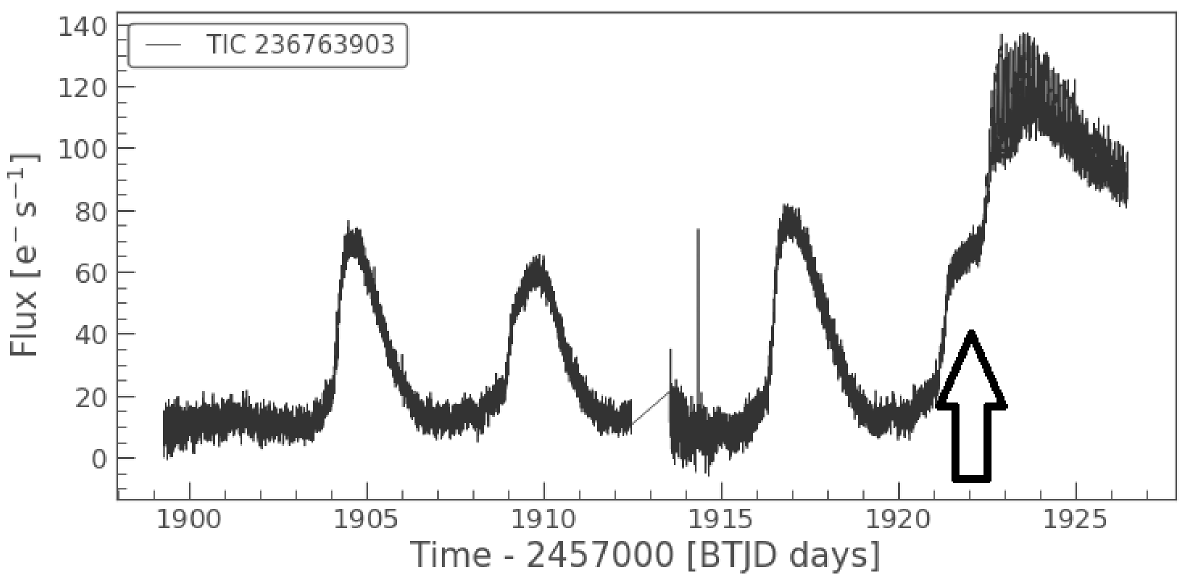

Figure 2. The superoutburst recorded by TESS in Sector 22 with an arrow indicating the notional start of the outburst.

The start of two other superoutbursts were also recorded in detail. Unfortunately, for the other three remaining superoutbursts, only the later parts of the superoutburst was recorded. Their start times can only be estimated from the shape of the superoutburst and are subject to some uncertainty and are identified with an asterix in Table 1. These three confirm that a superoutburst did occur at their approximate times during the 12 months of TESS observations and are used only to count the number of supercycles.

Coverage by the BAA VSS and AAVSO members during the period after JD 2459035 until the recent campaign started is limited and so Lasair [6] has been used to identify two superoutbursts with approximate timings. They are also presented with an asterix in Table 1.

Fortunately, the recent BAA VSS campaign, in combination with AAVSO observers, did record the November and January superoutbursts in sufficient detail to estimate their start times as JD 2459162.5 and JD 2459224.2 respectively. Figure 3 graphs the BAA VSS/AAVSO November campaign showing the six normal outbursts prior to the superoutburst. The start is indicated by an arrow.

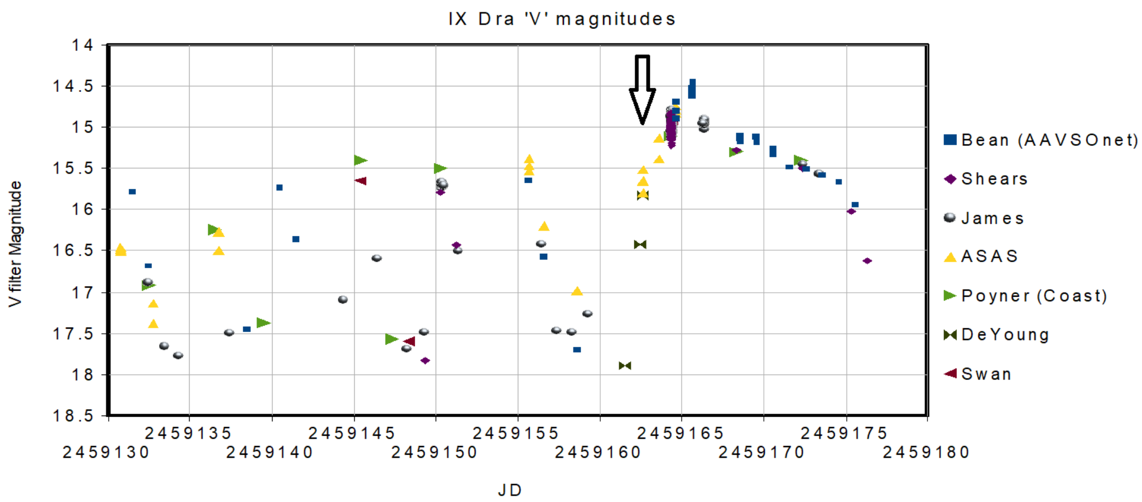

Figure 3. The 2020 November superoutburst recorded by BAA VSS and AAVSO members with a contribution from ASAS-SN observations.

Only the two superoutbursts with accurate start times (JD 2458739 and JD 2459224.2) were used to define the 484.2 day period over which eight supercycles were observed. This period yields an average P(sc) of 60.5 days centred on JD 2458982. Individual supercycles with accurate timings had lengths of 61 and 61.7 days.

Superoutburst date (JD 2450000+)	Source	Supercycle period (days)
8681*	TESS	
8739	TESS	58*
8800	TESS	61
8863*	TESS	62*
8922.5	TESS	59.5*
8984*	TESS	62*
9040*	Lasair (6)	56*
9106*	Lasair (6)	66*
9162.5	BAA/AAVSO	56.5*
9224.2	BAA/AAVSO	61.7

Table 1 lists the estimated start times for the superoutbursts, the source of observations, and the estimated supercycle period for each pair of superoutbursts. Values with uncertainties of more than one day are indicated with an asterix.

Previous work

Observations in 2010

Otulakowska-Hypka et al [5] studied IX Dra between October and December 2010 and observed two superoutbursts in detail. In combination with AAVSO observations of the next superoutburst, they determined a value for P(sc) of 58.5+-0.5 days over two supercycles. Their Figure 5 graph is reproduced below, in Figure 3, showing the two superoutbursts observed in good detail and the third superoutburst at JD 2455600. The supercycle average over two cycles was found to be 58.5 days.

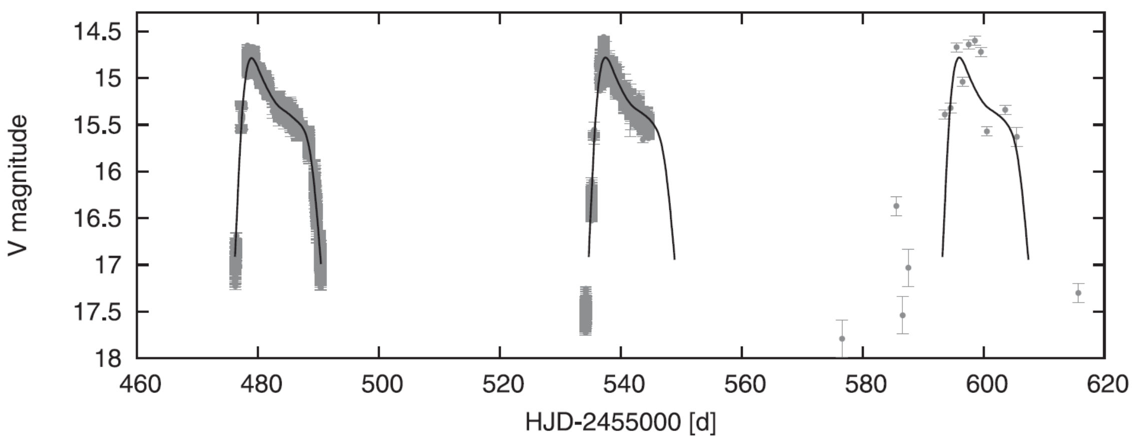

Figure 3. Light curve constructed by Otulakowska-Hypka et al (5) reproduced from their Figure 5.

Observations in 2003

A. Olech et al [7] observed IX Dra between June and November 2003 and produced a light curve, that is reproduced in Figure 4.

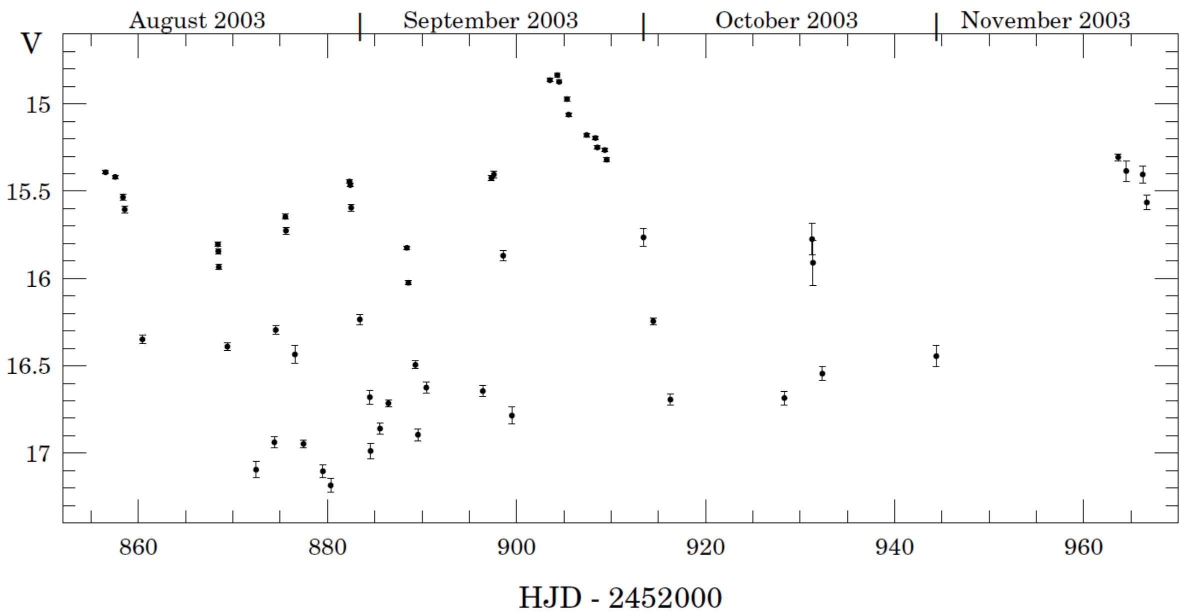

Figure 4. The light curve from A. Olech et al (7) for their 2003 campaign showing three superoutbursts identified by the authors.

They observed three superoutbursts at JD 2452856.5, JD 2452903.4 and JD 2452963.6 according to their journal of observations in their Table 2. Whilst the JD 2452903.4 superoutburst is defined by nine observations and a magnitude of 14.8, the other two superoutbursts are based upon only four observations each. In addition, these two superoutbursts do not meet their magnitude criteria of 14.8 for a superoutburst. By folding this light curve, the authors obtained a value for P(sc) of 54+-1 days.

Observations in 2000 and 2001

Ishioka et al [8] observed IX Dra between 2000 November 10 and 2001 June 17 and obtained an estimate for P(sc) of 53 days based upon the light curve reproduced below in Figure 5. The time axis is JD 2450000+. The superoutburst close to JD 2451860 only has three observations and is not as bright as may be expected for a superoutburst.

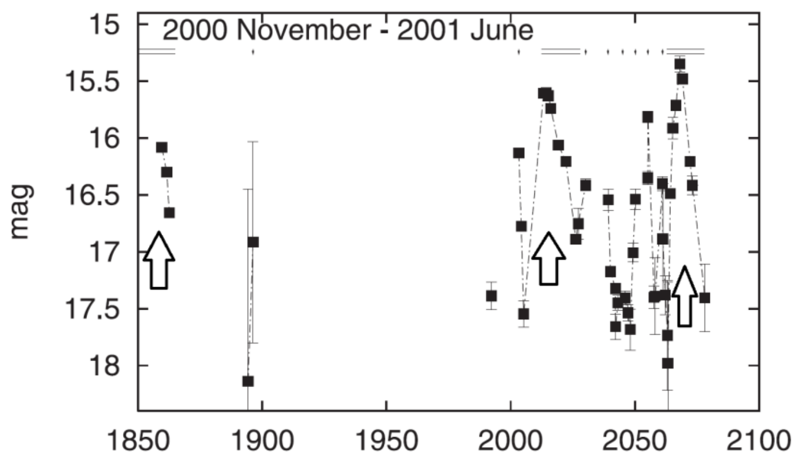

Figure 5. Light curve from Ishioka et al with the addition of three arrows to indicate their identification of three superoutbursts.

Observations from 1990 to 1992

Klose S. [4] reported observations of IX Dra during a search for the optical counterpart to a gamma ray burst from 1990 to 1992. The light curve for 'Object A' (IX Dra) is reproduced below in Figure 6 showing a superoutburst at 2448530 highlighted by their vertical line. Their periodic analysis yielded a value for P(sc) of 45.7 days whilst also stating that “This period does, however, not match all data”. In particular, the brightest outbursts at approximately JD 2448120 and JD 2448180 (separated by about 60 days) were not discussed.

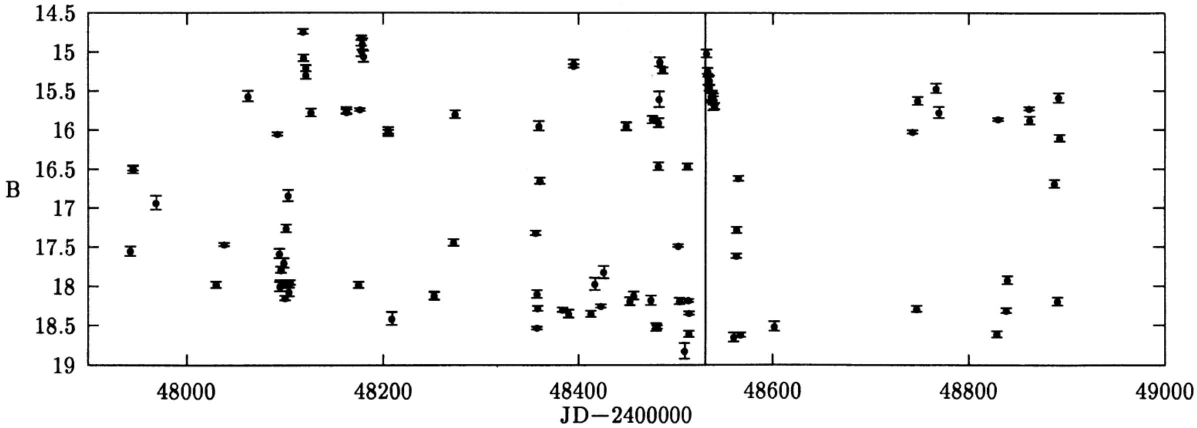

Figure 6. The lightcurve from Klose, S (4) taken from their Figure 5a.

Discussion

Following M.Otulakowska-Hypka et al [5], Figure 7 incorporates the present results to show the super-cycle period by Julian date

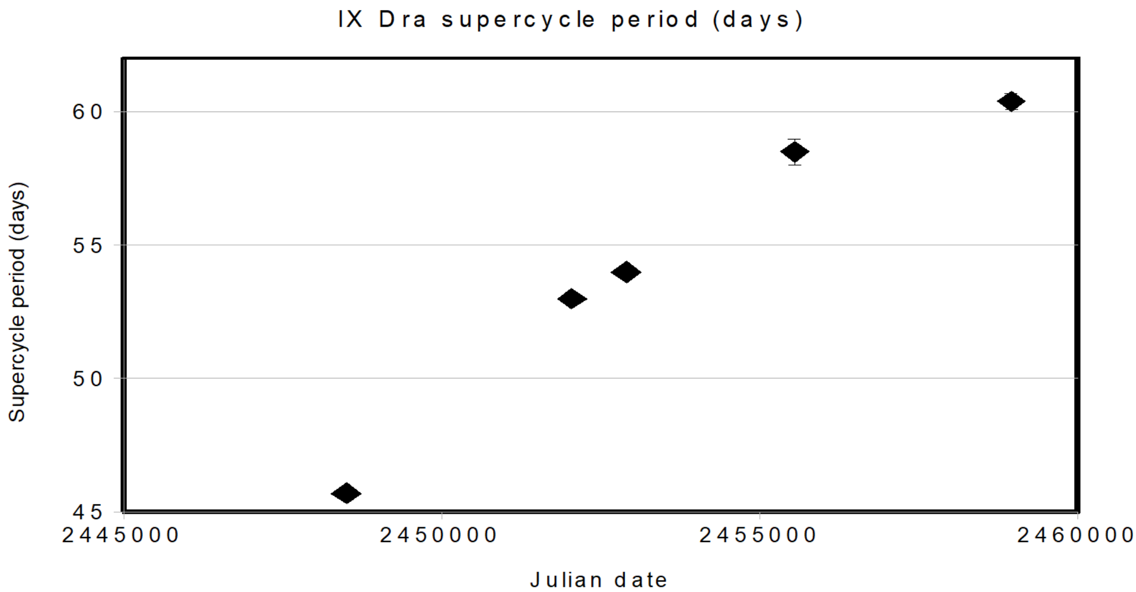

Figure 7. The evolution of the supercycle period from 1995 to the present.

The average P(sc) of 60.5 days, derived from the recent observations over eight supercycles, is similar to the 58.5 days obtained, over two supercycles, by M. Otulakowska-Hypka et al [5] in 2010, but larger than the earlier results. One interpretation is that the supercycle period did increase between 1995 and 2020 although the rate of change may have reduced in the last ten years.

Another interpretation is that the most recent results are the most reliable and that the supercycle period has always had a value of between 50 and 65 days with variations of a few days for each supercycle. This interpretation discounts earlier results on the basis that they were limited by the number of observations.

Future work

Further observations will clarify the evolution of this star. The next superoutbust is anticipated around March 11 2021. Observations of IX Dra are being continued by BAA VSS and AAVSO observers and by AAVSOnet telescopes. TESS will restart observations in September 2021 and by the end of 2022 it should be possible to present an updated report. As usual, more results are needed to describe the evolution of the supercycle period for the UGER star IX Dra.

References

1. The International Variable Star Index (VSX) (aavso.org)
2. TESS mission site: https://tess.mit.edu/
3. M. Otulakowska-Hypka and A. Olech, MNRAS 433, 1338–1343 (2013)
4. Klose, S. The Astrophysical Journal 1995, Vol 446, 357
5. M. Otulakowska-Hypka, A. Olech, E. de Miguel, A. Rutkowski, R. Koff and K. Bakowska, MNRAS 429,868–880 (2013)
6. Lasair, Lasair: The Transient Alert Broker for LSST:UK K. W. Smith, R. D. Williams et. al., Research Notes AAS, 3,26 (2019).
7. Olech A., Ke ̧dzierski P., Złoczewski K., Mularczyk K., Wi ́sniewski M., 2003, A&A, 411, 483
8. Ryoko ISHIOKA, Taichi KATO, Makoto UEMURA, Hidetoshi IWAMATSU, and Katsura MATSUMOTO, Brian E. MARTIN, Gary W. BILLINGS, Rudolf NOVAK, Publ. Astron. Soc. Japan 53, L51–L54, 2001 December 25

Acknowledgements

I acknowledge with thanks all of the BAA-VSS and AAVSO members who contributed observations.

Two active BL Lac objects

Gary Poyner

The BAAVSS Cataclysmic Variable & Eruptive star programme includes a small number of Active Galaxies. Here we report on BAAVSS observations of two active objects with contrasting trends currently showing in their light curves – BL Lac and W Com.

BL Lac was discovered in 1929 by Cuno Hoffmeister and received its variable star designation due to its irregular type variations. Few observations of it were made in the early years, but when in 1968 John Schmitt at the David Dunlap Observatory in Ontario identified a bright radio source (42.22.01) with the 'irregular variable star', interest in this unusual object 'took off'! A faint host galaxy was identified soon after, and a redshift of z=0.07 was measured, giving the distance of ~900 million light years and confirming its extra galactic nature.

The spectrum of BL Lac was seen as being very different to that of a star – its optical spectrum being virtually featureless and with the continuum rising steeply to the red and IR, quite similar in fact to the recently discovered Quasars. Improved techniques and instrumentation eventually revealed emission lines in the spectrum – all red shifted. The defining features of these 'BL Lac objects' are that they are all 'radio loud' and can be highly variable (especially in the optical spectrum) in a timescale of hours. The optical spectrum show very few broad emission lines as are seen in Quasars, and further study of these objects since discovery suggest a supermassive black hole at the centre of the parent galaxy which is showing relativistic beaming through a precessing relativistic jet.

Despite BL Lac being an extragalactic object, the high rates of variability over both short and long timescales make it an interesting target for both visual and CCD observers. Figure 1 shows an AAVSO/BAAVSS combined light curve in mv & V, with AAVSO data covering 1969-1991 and BAAVSS 1992-present. The first twenty two years of amateur coverage show a high rate of

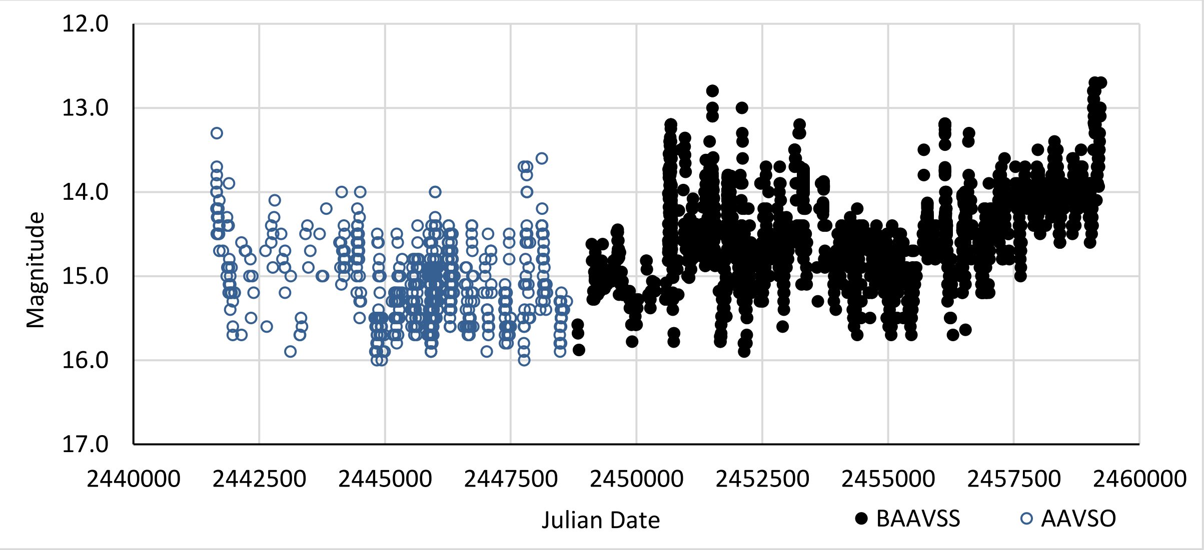

Figure 1. Combined AAVSO-BAAVSS light curve for BL Lac 1969-present.

variability, with pronounced flares occurring in 1972 and 1990 where the visual magnitude reached 13.3-13.6, and minimum values of around magnitude 16.0. An active phase during 1997-2005 saw BL Lac undergo large amplitude flare activity, reaching historically bright levels (at that time) at the end of 1999, before fading to a mean value of 15.0 during 2007-2011. During 1997 the visual 'outburst' coincided with a large X-ray outburst, and nightly observations made by the author during this period revealed short period variations approaching one magnitude in a single night! In the following years, BL Lac has been increasing in brightness steadily, rising from a mean brightness of 15.0 to around 13.5 mean during 2020. Superimposed on this rise are bright flares lasting from a few days to several weeks, and in January 2021 BL Lac reached its brightest visual magnitude since the first observations were made back in 1969 – 12.7 mv on Jan 21.7 UT.

Less popular with amateurs than BL Lac is W Com, another BL Lac object which displays high amplitude flaring and short term optical variations. Unlike BL Lac however, W Com has been showing a decline in brightness since a major optical outburst of 1998.

The outburst of 1998 reached the brightest level seen since the discovery by Wolf in 1916, peaking at a mean visual magnitude of 13.2 on April 25.9. In addition to this high brightness level, the author recorded 0.5 magnitude per hour variations visually over a number of nights. Over the next three years the mean brightness faded to 14.5 where it remained steady until the end of 2010 when a further decline over the next five years saw the lower limits of W Com reach 16.5V. Despite two minor flares seen in April-May 2018 (mean 14.4mv) and May-June 2020 (mean 15.2mv), W Com continues in its faint state through the early months of 2021. (Figure 2)

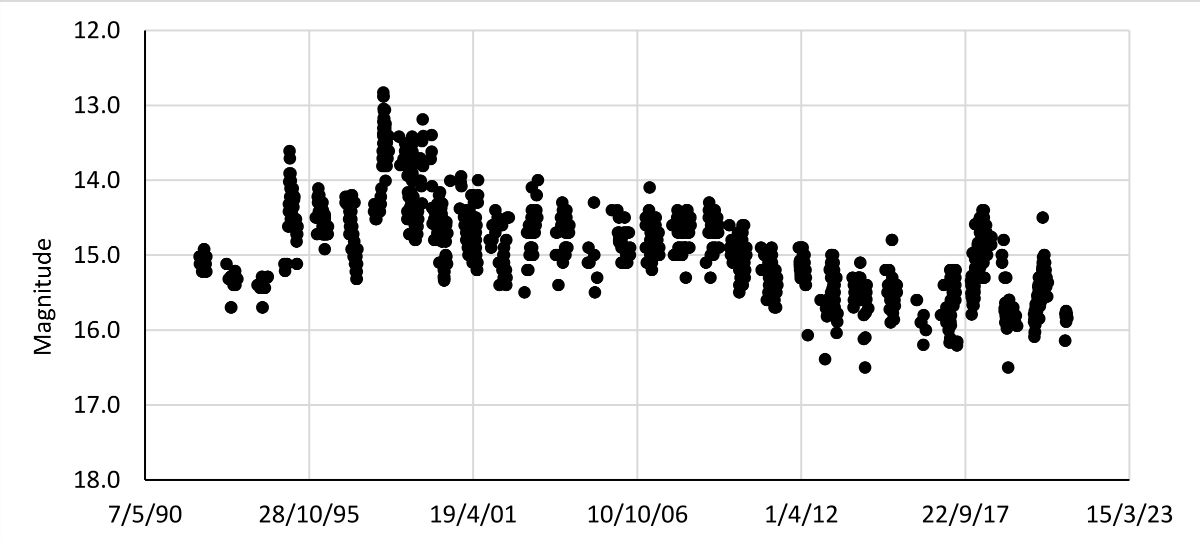

Figure 2. Combined mv & V light curve for W Com 1992-present. From BAAVSS data.

Despite the interesting nature of both objects, and the appeal of seeing an Active Galactic Nuclei display large amplitude variations over both short and long timescales, observer numbers remain surprisingly low. In the last five years W Com has 139 visual and CCD observations entered into the database (discounting time series) from just five observers (C Jones, R Pickard, G Poyner, J Toone and I Walton). BL Lac has fared slightly better with 355 visual and CCD observations from five observers (T Killestein, P Leyland, W Parkes, G Poyner and J Toone) in the same time period.

Observers are requested to add BL Lac and W Com to their observing programmes and to monitor visually or with CCD's/DSLR's as often as possible to see how this bright phase in BL Lac's light curve continues, and whether W Com maintains its current low state. Visual observers can download charts from the VSS Website (W Com, BL Lac) while CCD observers should use the photometric charts/tables from the AAVSO VSP.

Report of the Pulsating Star Programme 2020
Mira Variables, Part 1

Shaun Albrighton

This report covers the activity of 22 Mira variables currently on the BAAVSS programme, during 2020. Notes are included where stars are under observed or there appear to be issues, e.g., misidentification of variable.

R And: Fade from 10.5 in early Jan to minimum below 14.0 in Apr/May. Rise to bright max of around 6.7 in October, then fade to 9th Mag. [Additional observations around minimum are required]

W And: Near Min at 14.0 in Jan. Sharp rise during April to Max (8.2), in May, then consistent fade to below 14.0 in Dec.

RW And: Under observed. Rise from 14th to 13th Mag in Jan/Feb, then lost. Recovered late May at 8.7 (possible Max). Fade to below 14.8 in Dec. V Band estimates show star fading from, 14.0 early Nov, to 16.7 in Jan 2021.

R Aql: Good coverage. Fade from Max 6.5 in Jan to Min 11.3, late Jun. Possible standstill on ascending branch (approx. 8.5) in late Aug/early Sep, then rise to Max, 6.5 in Oct. Fade to 8.7 Dec.

UV Aur: Considerable scatter 8.3-9.2 at commencement of year, then fade to 10.3 in early May, when lost. Recovered at 10.4 late Jul, then rise to Max, 8.3-8.7 in Dec.

R Ari: Poorly observed. Max 8.5 in Feb, then fade to 9.5, when lost. V band estimates show Rise from 13.0 in Nov to 8.5 Jan 2021.

R Boo: Fade from Max 7.2 in Jan to Min 12.3 in Apr. Good coverage by V Band during Min. Rise to Max 7.3 late Jul. Fade to 8.4 in Sep, then no observations.

V Cam: Rise from 13.3 in Feb to poorly observed Max of around 8th Mag in late Jun. Slow fade to 12.5 by Dec.

X Cam: Some interesting variation in this short period Mira. Rising from 10.5 at start of year to 7.7/7.8 late Jan/early Feb. Fade to Min, 14.0 end of Apr. Then rise to fainter Max of 9.0 in early Jul, before fading to bright Min at 12.4 in Sep. Star then brightened to Max, 8.0 in mid Nov, before fading to 10.8 by the end of the year. V Band estimates match the visual observations very closely.

U CVn: V Band estimates show rise from 14.8 in Feb to 11.8 in mid Apr. Visual observations, whilst consistently fainter (expected), extend this rise to a peak around 11.0 in mid/late May. Then slow fade to 14.7 in Nov, when lost. [Additional observations required].

R Cas: Under observed. Fade from 8.5 Jan to 11.8 May/Jun. Rise to Max 5.7 in Nov, before fade to 7th mag in Dec.

S Cas: Below mag 15.0 (visually) until late May. V Band results give a Min of 16.4 in late Mar. Rise to Max of 9.5 in Nov, with hump on ascending branch at 11.5 in Aug. Fade to 10.3 by Jan 2021.

T Cas: Fascinating light curve. Star at Min 10.5 in Feb/Mar, then hump on ascending branch at 9.5 in May to mid-Jun. Double Max, 8.0 in Aug, dip to 8.7 in Sep, rise to 7.5, Nov. Fade to 9.0 by end of the year.

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T Cep: Good coverage. Rise from 8.5 to standstill at approx. 7.7 in Mar to mid Apr, then continued rise to Max, 6.7, in late May. Fade to Min, approx. 10.2 Nov.

omicron Cet: Fade from 4.7 to 7.3 in mid Mar, when lost. Recovered at 7.7 in late Jul. Rise to bright Max at about 3.2 in late Sep/early Oct. Fade to below mag 6.0 by end of year.

R Com: Fade from 13.8 to Min of around 15.5 in Mar. Rapid rise to 9.2 in mid Jul, when lost. Recovered in mid Oct at 11.3, then fade to 14.4 in mid Dec.

R Cyg: Fade from 12.0 to Min, 14.2 in Mar/Apr. Rise to Max, 7.2 in mid Aug, before slow fade to 10th mag in Dec.

S Cyg: Under observed. Negative estimates until late Feb, 14.6. Then rise to Max 9.3 in late May. Fade to below 14.7 in Sep. V Band estimates place the star at around mag 17.0 in late Dec.

U Cyg: Under observed. Fade from Max 7.7 in Jun 10 10.7, in Dec.

V Cyg: Additional observers needed. Fade from 11.3 to Min 12.6, late Mar to early May, then rise to flat Max (with scatter) around 9.8 in Sep/Oct. Fade to 11.0 by mid Jan 2021.

chi Cyg: Rise from 6.5 to Max 5.3 in early Feb. Fade to Min 13.3 in Sep. Rise to hump at 9.5, from late Nov to end of year.

T Her: No observations prior to Apr. Rise to sharp Max of 7.6 in late Apr, the steady fall to 11.5 in late Jun. V Band estimate at 12.5 in mid Jul. Gap in observations until late Sep when observed at 8.7, when approaching Max. Max 8.3 in Oct, then fade to 10.5 V Band in late Nov. [Additional observers required].

Observers are encouraged to add some of the above stars to their observing programme to enable improved study of the light curves. Some under observed stars, e.g., R Boo, R Cas and T Her are good subjects for binocular observers.

An informal look at Landolt Standard Stars and GAIA EDR3 photometry, as well as astrophysical use of GAIA EDR3 photometry

John Greaves

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A small sample of Landolt Standard Star Photometry is examined in relation to the GAIA EDR3 revised photometry for the same objects and tentative conversions noted for set magnitude and colour ranges. The ability to use GAIA EDR3 data for astrophysical interpretations is also outlined.

GAIA EDR3 consists of over a thousand million stars with some level of photometry, the release notes stating that said photometry has been fully revised and should be of a good too high standard. However, despite the immense coverage of the survey only a relative handful of 48 Landolt Standard stars were matched for the magnitude and colour ranges under investigation. The results are displayed here whilst noting this is very, very much a small number sample.

The filter transmissivity and wavelength coverage of the GAIA EDR3 passbands are plotted and detailed here: -

https://www.cosmos.esa.int/web/gaia/edr3-passbands

as can be seen the G magnitude starts within the range of the Johnson B band all the way to near the long end of the Cousins I band. Meanwhile the "blue" BP passband stretches from within the Johnson B to within the Cousins R range (thus fully encompassing Johnson V as well) and the "red" RP passband has something of an almost Near Infra-Red range including a goodly part of both Cousins R and Cousins I bands. Furthermore, both BP and RP overlap fairly significantly between roughly 600 – 700 nanometres as well as *both* fully encompassing the Hα emission line, whilst G encompasses both of them. Accordingly, the use for GAIA EDR3 photometry for colour information can be problematic for stars with strong absorption and/or emission lines, such as is the case for many kinds of variables, especially the active sort. Nevertheless, GAIA stars are currently predominantly solved for main sequence stars of F, G and K spectral types and thus may have some utility as comparison stars in first instances until better values (if any) can be obtained.

The eventual GAIA EDR3 G magnitude range involved was 8.9 to 15.7, which will be described as a rounded 9 to 16 here. Meanwhile the colour range in GAIA BP-RP was 0.02 to 1.09 which here will be rounded to 0 to 1. Comparison against the Landolt subset gave the following relations.

For simple V_J, Gmag difference the mean value was 0.114, the median 0.123 and standard deviation 0.049 magnitudes. This shows that in the first instance a simple and crude

V_J = Gmag + 0.11 (+/- 0.05) for 9<Gmag<16 and 0<BP-RP<1 [1]

Figure 1 demonstrates the comparison of these two sets of magnitudes and also shows a derived relation of

V_J = 1.0088 x Gmag (+/- 0.05) for 9<Gmag<16 and 0<BP-RP<1 [2] with the mean for this relation being 0.000, the median 0.008 but the standard deviation not much improved at 0.046. Figure 2 shows the residuals as a function of magnitude when the difference between the Landolt V_J and the GAIA EDR3 derived V_J is taken.

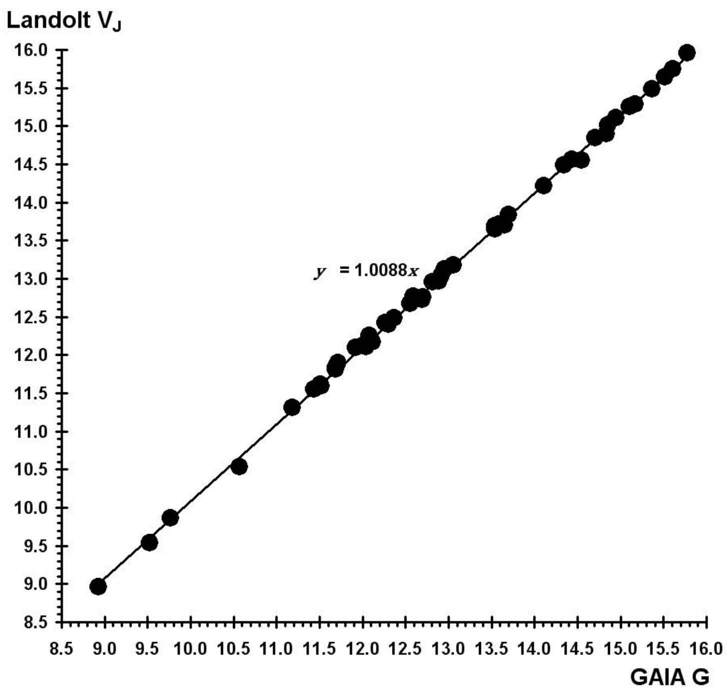


Figure 1.

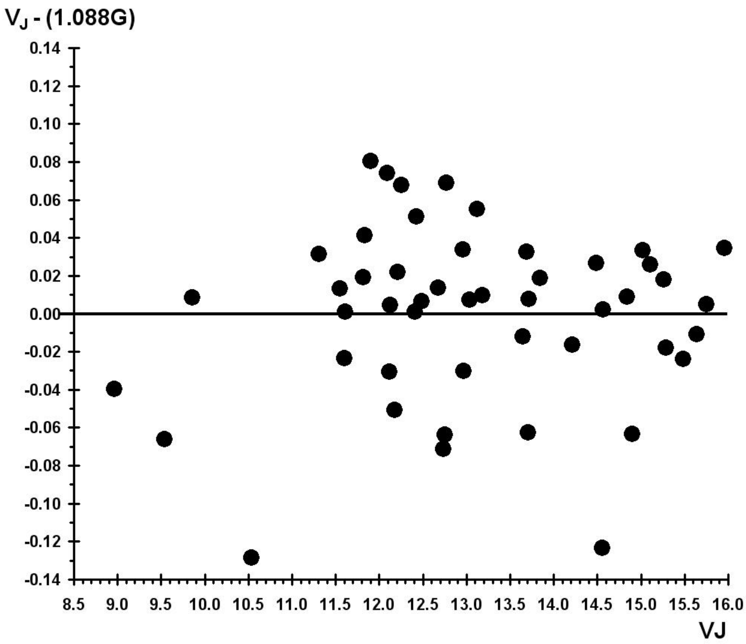


Figure 2.

Taking advantage of the full range of passbands provided by Landolt photometry the colour BP-RP was also assessed relative to each of B_J-V_J, V_J-R_C and V_J-I_C, with the spectral type for some of the individual stars being labelled for the latter as it appeared to give the most consistent relation to GAIA EDR3 BP-RP. Figure 3 shows the relation for each of these passband colours. The straight difference between V_J-I_C and BP-RP gave a mean and median of -0.08 with standard deviation of

0.03 whilst the difference between a Landolt V_J-I_C versus the GAIA EDR3 derived V_J-I_C gave a mean of 0.001, a median of 0.002 and a standard deviation of 0.020 when the following formula was used

V_J-I_C = 0.8862 x BP-RP (+/- 0.02) for 9 <Gmag< 16 and 0<BP-RP<1 [3]

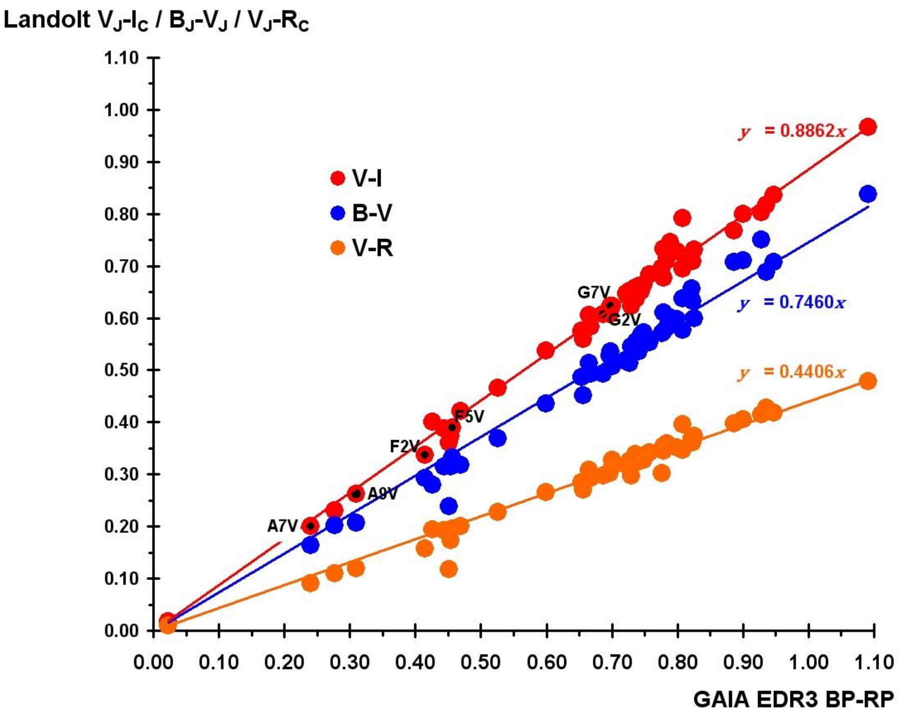


Figure 3.

Throughout it must be remembered that only a very, very, very small number of solid photometric reference stars were available for this comparison. A separate comparison of r' magnitudes from Carlsberg Meridian Catalogue version 15 for 60,000+ stars from a region in Gemini overlapping Milky Way and non-Milky Way fields did not give as good a set of matches, for instance, with nothing much better than simply using Gmag ~ r' +/- 0.15. Similar could well be the case for most red magnitudes, although objects likely to have Hα emission and/or absorption need to be excluded.

BP-RP and its proximate nature to V_J-I_C colour on the other hand can be used to crudely assess the colour or even general spectral type of a star when used in tandem with J-K_s. Figure 4 shows this for 60,000+ objects. The very sparse upward trend to the far right will consist of red giants (except for Carbon stars which would extend the main trend further to the right), whilst the more central small upward bump will constitute the red dwarfs. Between this bump and the zero point in the left to right direction will be the gradation of A to G to K spectral type stars, whilst outlier items below the main trend will be stars of a different nature (for example some exotic variable stars) and some non-stellar objects, the more rightward the latter the more likely they are to be galaxies. On the left of the main trend stars above such a sequence are usually white dwarfs including at times cataclysmic variables, but they can also include Quasi Stellar Objects. Although any interpretation is not going to be definitive on such colour diagrams at least a hint can be found of where further investigation may best lay.

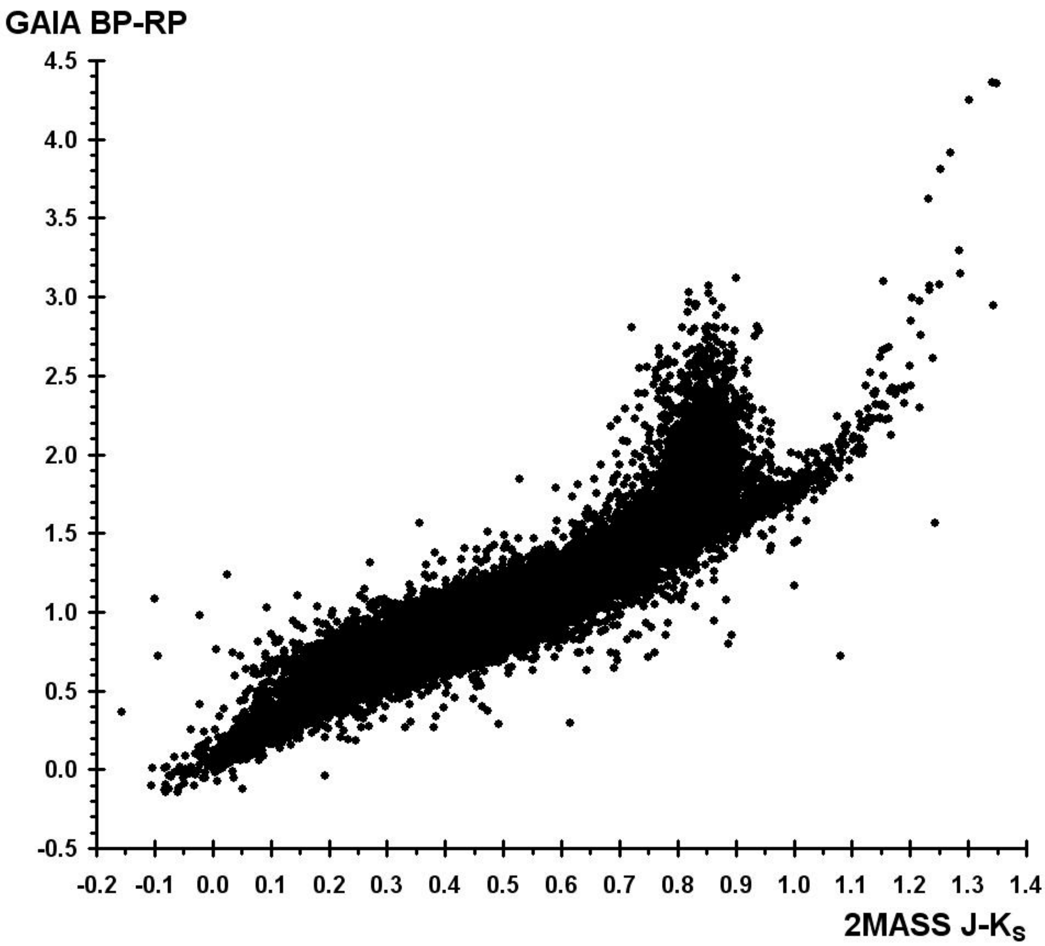


Figure 4.

However, as GAIA EDR3 is also claimed to have much improved parallax measurements and photometry a furthermore astrophysical aspect can also be applied as shown in Figure 5. Here the reciprocal of the parallax equivalent to distances up to 5 kiloparsecs is used in tandem with the G magnitude to derive an Absolute G magnitude and in combination with the GAIA EDR3 BP-RP colour be used to generate an HR Diagram. The smaller the parallax the larger the room for error and/or just plain inaccuracy but despite all this when cross linked against the GCVS just short of 16,000 intrinsic variable stars were matched in this way to give an authentic looking distribution (that is intrinsic as in not including extrinsic variables which are predominantly eclipsing stars). A major filtering was to ensure that the apparent G magnitude was within 2 magnitudes of the GCVS listed maximum magnitude as although G, BP and RP should be contemporaneous measures their measurement could have occurred nearer the minimum of a high amplitude variable's cycle and thus lead to a disparate absolute magnitude. There are likely still some instances of this in the dataset as two magnitudes is a somewhat generous range, although naturally low amplitude objects are not an issue.

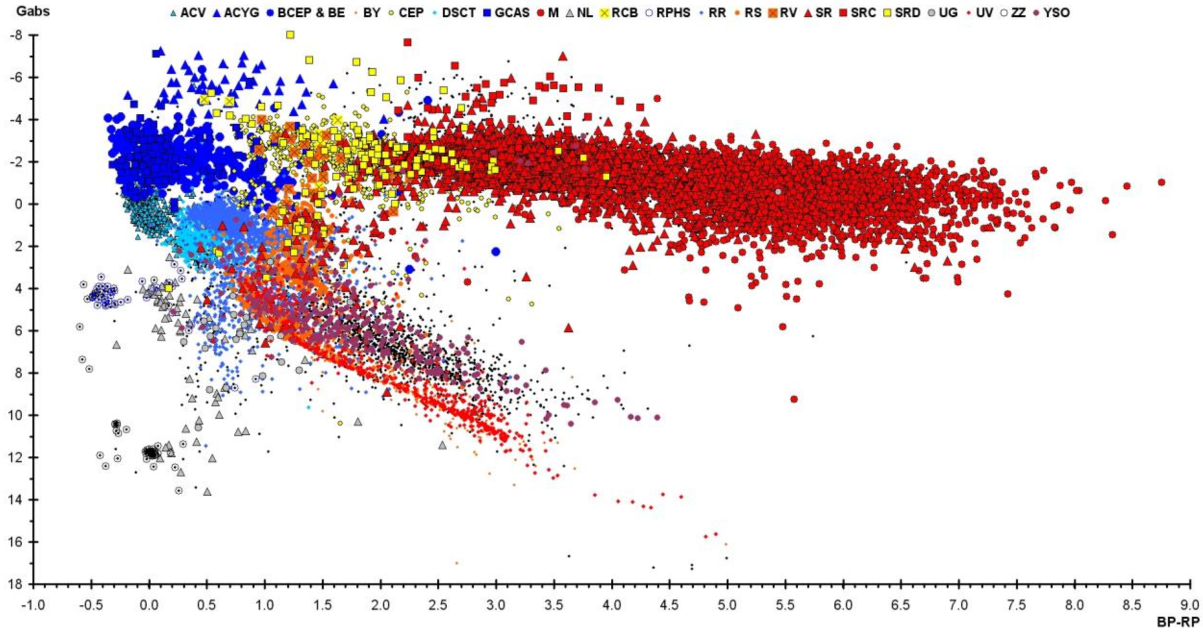


Figure 5.

All these stars are plotted in Figure 5 as small black dots with various classes of variability type being overlain denoted via a variety of symbols, with not all of the stars being included in these types as revealed by the black dot only objects. The variability types used are GCVS ones and are general such that all the types of Cepheids are lumped together whilst other types like SRa and SRb are listed as SR whilst UG includes all subtypes of cataclysmic variable listed in the GCVS other than the Nova-like variables. Similarly, the β Cep and BE variables are shown together using the same symbol. The types shown are based on a combination of how common they are or on their being types of interest. Some approximation of the colour of the stars has been attempted in the symbology when possible, whilst Figure 6 uses data listed in the GCVS to demonstrate the context of the absolute magnitude versus colour diagram in terms of spectral class.

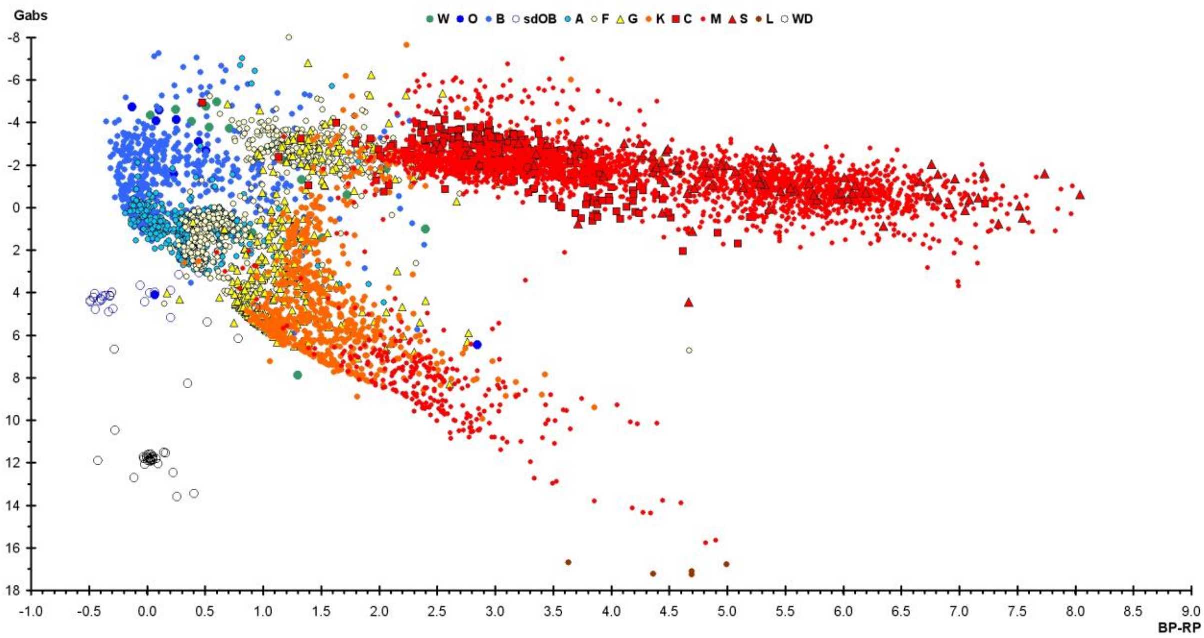


Figure 6.

Groupings in colour ranges and in certain parts of the diagram can readily be seen, which are white dwarfs (ZZ Ceti stars) away from and quite below the "main sequence" and yet still distinct from the also mostly discrete subdwarfs (RPHS). Some objects overlap but it is interesting to note that the Young Stellar Objects (YSOs, mostly T Tau stars rather than Herbig Ae/Be stars here) follow a line slightly brighter than but parallel to the mostly overlapping red dwarf BYDra and UVCet stars. Between these two trends lies a thinner line of mostly orange BYDra stars (although there are some UVCet at the redder end) and the apparently slightly higher brightness of these may be solely due to them not being single stars as opposed to any intrinsic reason as both these types can be both single and binary systems.

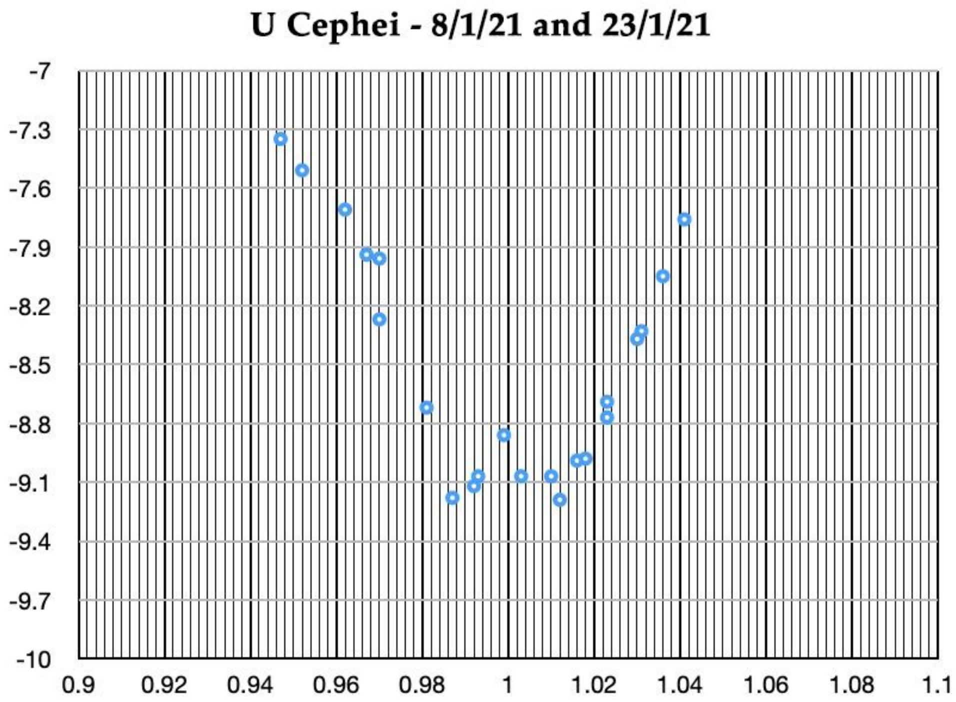
Similarly, the odd object misclassified in the GCVS can be spotted, sometimes readily. This can be a general matter such as the handful of claimed YSOs that lie in the midst of the core of the SR symbols. Sometimes it may just be one object, for instance a grey UG symbol can be seen in the midst of the upper horizontal red giant branch occupied by SR and M symbols. This is V2101 Ophiuchi which is still ranked in GCVS as a UG variable despite IBVS 3716 having shown it to be a red giant many years ago. Meanwhile in the midst of the pale blue DSCT dots lies a red triangle denoting the SR star OW Persei, which is in fact a spectral class A star according to LAMOST whilst according to TESS data has a symmetrically sinusoidal variability of at least 2.5 millimagnitudes (0.0025 magnitudes) of very roughly 0.68 day period which is not inappropriate for being the rotational signal but no evidence of any higher amplitude of variation. In other words, the star is likely constant and most certainly not a red LPV. Other objects may not be incorrect but slightly different from the norm, such as the lone red Mira symbol lying alone around BP-RP 5.5 and between Absolute G 9 and 10 which turns out to be the low amplitude Carbon Star V370 Aurigæ. Further, more subtle instances can be seen but Figure 5 is busy enough to hide this fact due to the many overlapping symbols. Accordingly, a copy of the Excel spreadsheet is made available so that types of stars can be removed and at times added for clarity or regions zoomed in upon to make hidden aberrant position symbols visible.

Eclipsing Binary News

Des Loughney

U Cephei

On two nights in January 2021, it was possible to make measurements of eclipses of U Cephei. The measurements are illustrated on the diagram below.



The vertical axis is V magnitude, and the horizontal axis is an extract from a phase diagram based on the current Krakow period of 2.493093 days. '1' is the predicted point of primary mid-eclipse. All the measurements were made in very good conditions. The methodology was DSLR photometry. The measurements are combined from eclipses observed on two nights - the 8/1/21 and 23/1/21.

The phase diagram shows that eclipses are currently occurring as predicted by Krakow.

The phase diagram shows that both eclipses exhibit a flat bottom and were therefore total with a duration of about 2 hours. This is the characteristic U Cephei eclipse. As related in VSSC 184 'Eclipsing Binary News', eclipses can vary and may illustrate the light curve of a partial eclipse.

The measurements do however illustrate other features which, from the literature mentioned in VSSC 184, are due to variations in the brightness of an accretion disk. There is a variation in the depth of totality. The eclipse on 8/1/21 showed totality at 9.1 magnitude with a spike during totality when it brightened to about 8.8 magnitude. The GCVO database has the depth of the eclipse at 9.24V. The eclipse on the 23/1/21 bottomed out at about 9.2 magnitude. During the eclipse on 23/1/21 there was a pause as the system faded which is illustrated by the measurement of about 7.9V at around 0.97 of the phase diagram.

The measurements of the two eclipses show that they continue to show small variations due to changes in the accretion disk. It is a system of active, varying, mass transfer.

HS Hydrae

This is an eclipsing binary system which is included in the Krakow database. It is described as having an out of eclipse magnitude of 8.12V, an eclipse depth of 0.6 magnitudes, and as being an EA/D system. Its period is apparently 1.5680413 days. It has recently been revealed that it will cease to be an eclipsing binary this month (February 2021) and may not return to be an EB until the year 2195 [1].

"*There is a historical record of observations of HS Hydra that essentially spans modern astronomy – starting with photographic plates in the late 19th century up through satellite images taken in 2019. By diving into those records, we documented the complete rise and fall of this rare type of eclipsing binary*," team leader James Davenport, from the University of Washington, said in a statement.

The two stars continue to orbit each other every 36 hours or so. What is changing is the orientation of their orbit with respect to our line of sight, and the cause of that is probably a third star in the system, quite distant from the eclipsing pair. The object, reported in the 2012 paper, is slowly but surely tugging at the dancing duo, changing the inclination of their orbit.

If the pull of this star stays the same as it has been for the last century, we will be able to start seeing the system eclipsing again from the year 2195. However, this might not be the case, as we don't know enough about the dynamics of the system.

"*We won't know for sure unless we keep looking*," concluded Davenport. "The best we can say right now is that HS Hydra has been changing constantly over the course of modern astronomy."

AAVSO Eclipsing Binary Ephemeris 2021

See:<https://www.aavso.org/node/85892>.

Sextuple Star System

Astronomers studying data from NASA's Transiting Exoplanet Survey Satellite, or TESS, have found a remarkable sextuple star system featuring three gravitationally bound eclipsing binaries.

The system, known as TYC 7037-89-1, is located about 1,900 light years from Earth in the constellation Eridanus. It is the first known example of six stars making up a trio of eclipsing binaries, known as A, B and C.

The primary stars in all three binaries undergo periodic eclipses, passing in front of each other as viewed by TESS. The changing light curves show all three primary stars are slightly more massive than the sun, but about as hot. The secondary stars are roughly half the size the Sun.

The two stars making up the A binary orbit each other every 1.3 days while the stars in binary C orbit each other every 1.6 days. The A and C binary systems, in turn, orbit each other every four years. The two stars in the B system orbit each other every 8.2 days, but they take about 2,000 years two complete an orbit around the sextuple system's center of gravity.

TESS was launched to look for exoplanets by measuring the slight change in a star's brightness when a planet moves in front of its host. It has also "*dramatically improved our ability to discovery multiple star systems*," a team led by Brian Powell and astrophysicist Veselin Kostov wrote in a paper accepted by The Astronomical Journal." [2]

Recent Minima of Various Eclipsing Binary systems by Tony Vale

Timings of minima of various eclipsing binaries are presented below. These were derived from observations made by Tony Vale from February to December 2020 using a Startravel 102mm Skywatcher refractor telescope and a Canon 600D DSLR camera. The observations have all been uploaded to the BAAVSS photometric database. Precise times of minima were obtained from the light curves using Bob Nelson's Minima software. All times listed are Heliocentric Julian Day.

Timings:

Star	HJD of Min	Filter	Error	Type of Minimum
TT Aur	2458885.34413	TG	0.00044	Primary
DO Cas	2458900.34141	TG	0.00038	Primary
UV Leo	2458912.36570	TG	0.00039	Secondary
UV Leo	2458920.46680	TG	0.00034	Primary
UV Leo	2458950.47173	TG	0.00029	Primary
UV Leo	2458962.47273	TG	0.00028	Primary
AG Vir	2458968.55075	TG	0.00077	Primary
W Uma	2458990.50621	TG	0.00017	Secondary
TX Her	2459024.52335	TG	0.00091	Primary
TX Her	2459025.55217	TG	0.00023	Secondary
CW Cas	2459050.48130	TG	0.00025	Secondary
SW Lac	2459065.47550	TG	0.00022	Secondary
SW Lac	2459068.52270	TG	0.00014	Primary
IR Cas	2459102.46659	TG	0.00065	Secondary
AB Cas	2459118.46174	TG	0.00052	Primary
IM Aur	2459157.48996	TG	0.00059	Primary
TV Cas	2459179.31423	TG	0.00044	Primary
EO Aur	2459208.57730	TG	0.00089	Primary

1. https://www.iflscience.com/space/two-binary-stars-will-stop-eclipsing-each-other-after-a-century-next-month/

2. https://astronomynow.com/2021/01/29/sextuple-star-system-fascinates-with-three-eclipsing-binaries/

Examples of Eclipsing Binaries where stellar eclipses are not the whole story

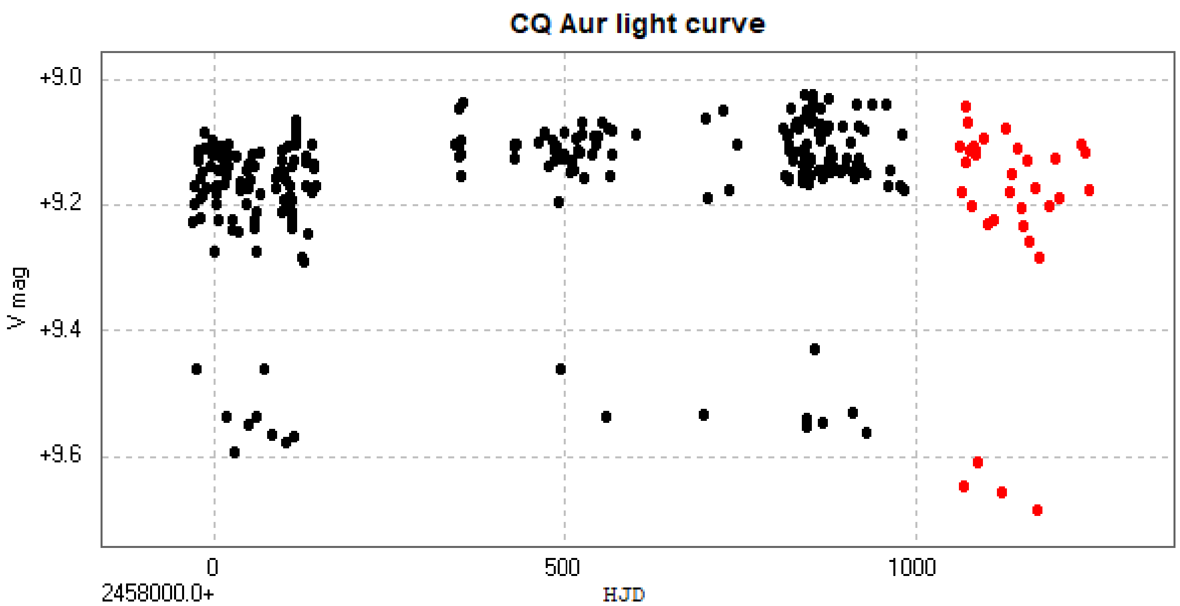
David Conner

Light curves of three variable stars which are catalogued as eclipsing binaries but where the variability is caused, at least in part, by factors other than one star eclipsing another.

Three more light curves of stars which are catalogued as eclipsing binaries (GCVS types in brackets), but where their apparent magnitude is affected by factors other than just simply eclipses by a stellar component. All the data are from photometry of images taken with the Open University COAST telescope using a V filter, and the observations have been uploaded to the VSS database.

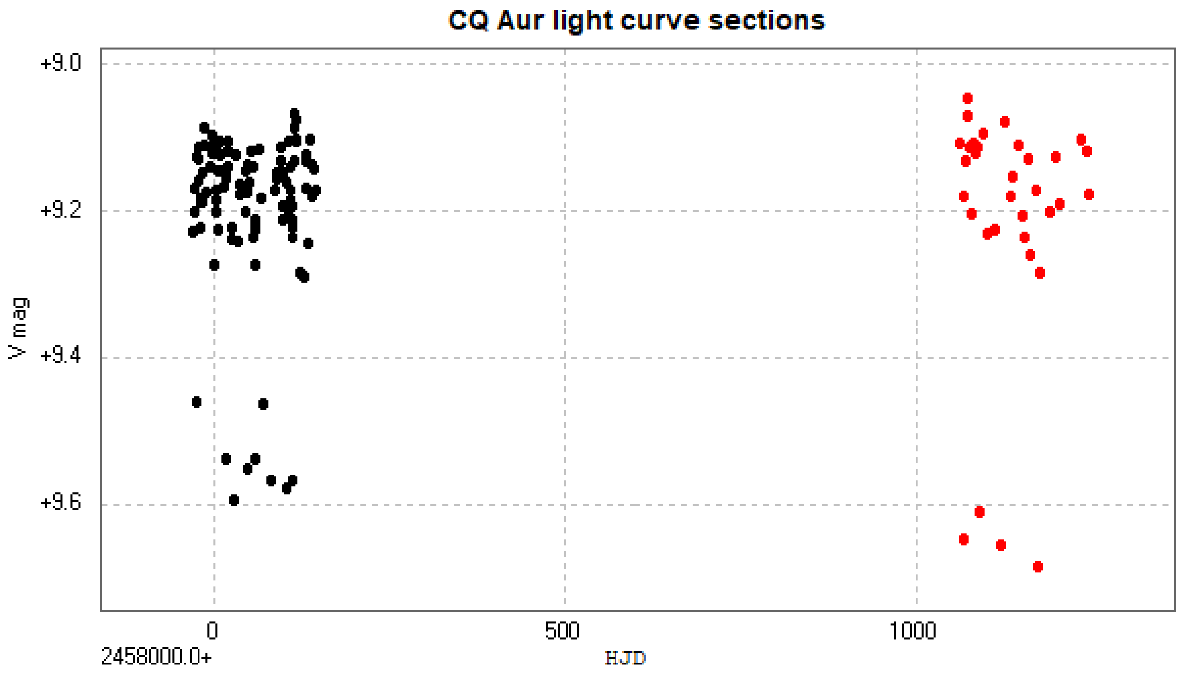
CQ Aur – revisited (type EA/RS)

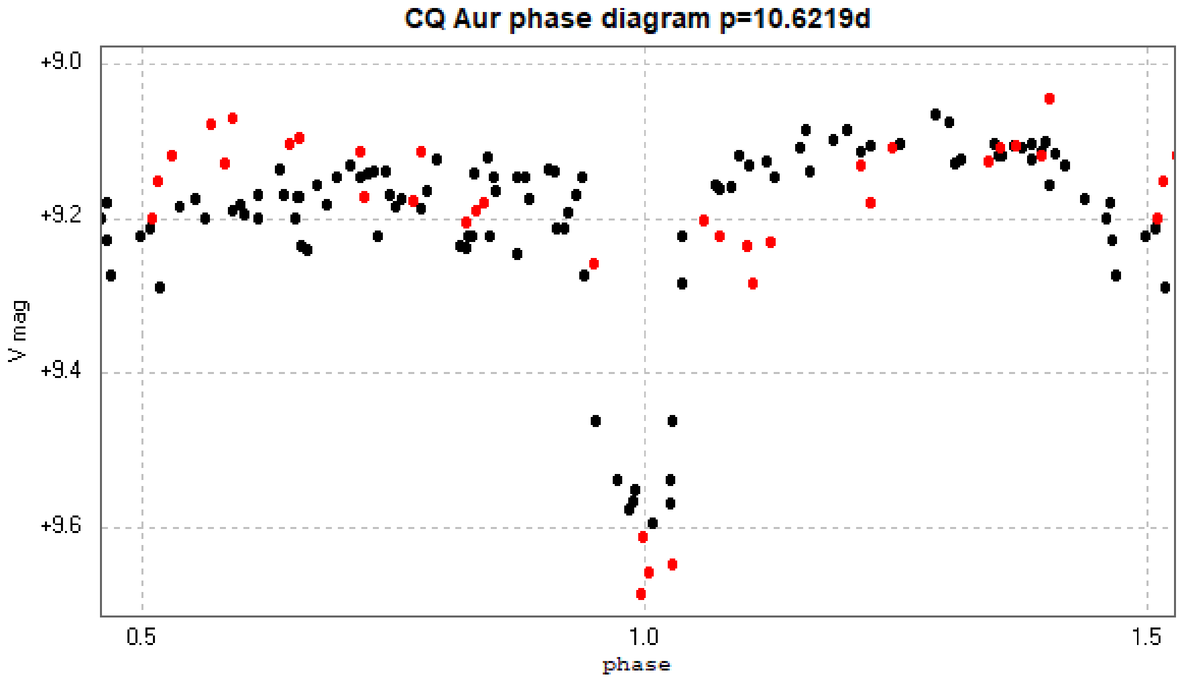
This follows on from my article in circular 183 (March 2020). Since then, a further 61 images were obtained between 2020 February 12 and 2021 February 1, which are included in the following light curve. The last 33 observations from this group (from 2020 July 31) are highlighted in red. For this latter section of the light curve, both the maxima and minima would appear to have faded consistently before showing a slight increase again, at least for the maximum where data was available. The four points at minimum are from different minima, and the 'maximum' part of the light curve also covers several cycles.



To see what might have changed in more detail, the light curve was divided into the two fainter sections (below) and the associated phase diagram plotted.

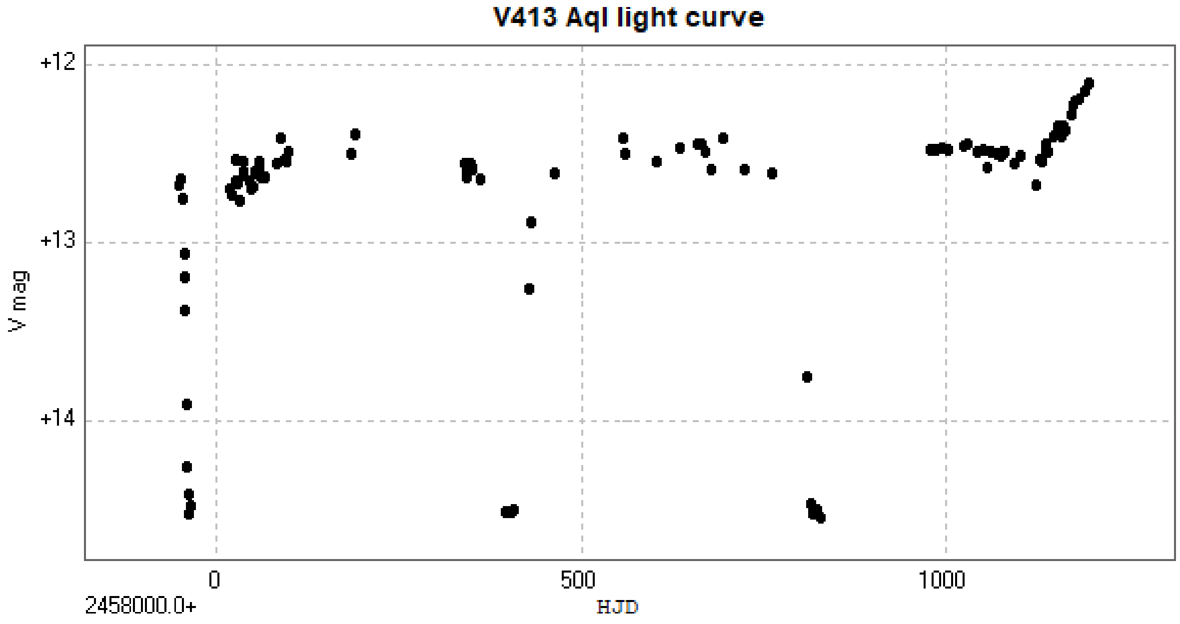
As well as being deeper than the earlier primary minima, the recent primary eclipses are a little wider near to maximum. There is also a *suggestion* of a possible sinusoidal type variation of the envelope of the maximum of the light curve, with a period of very approximately 1160 days. As mentioned in the previous article, this could be due to variability of the RS CVn component of the binary.

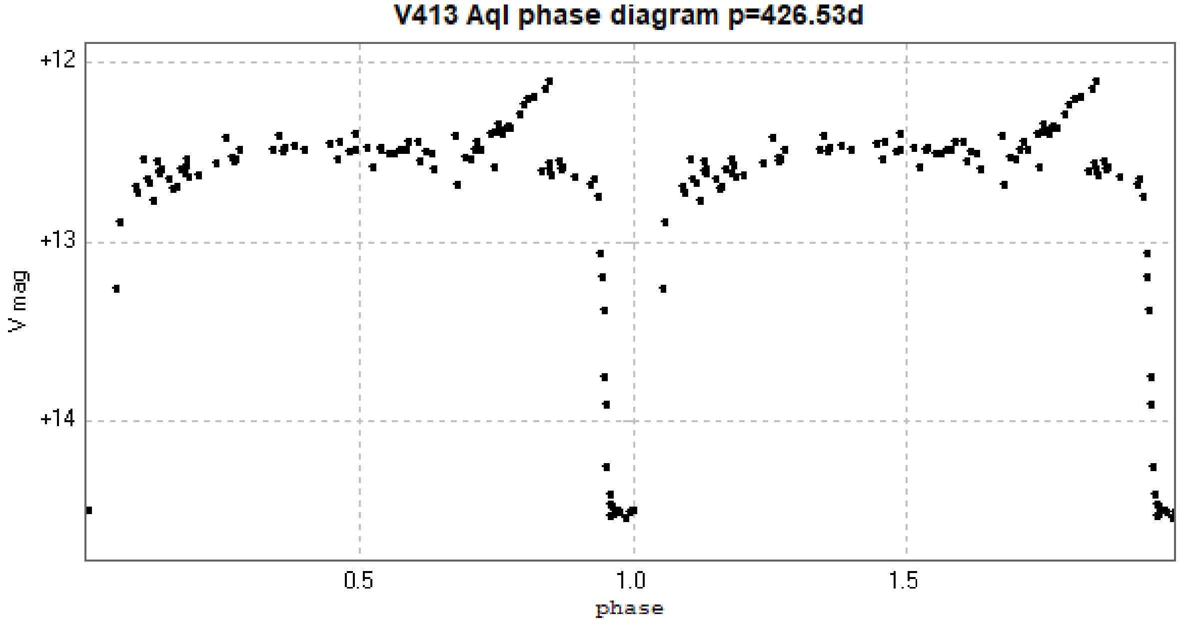

CQ Aur light curve sections
V mag
+9.0
+9.2
+9.4
+9.6
0
500
1000
2458000.0+
HJD


CQ Aur phase diagram p=10.6219d
V mag
+9.0
+9.2
+9.4
+9.6
0.5
1.0
1.5
phase

V413 Aql (type EA)

The period of this star is about 425 days, and the light curve covers the period from 2017 July 12 to 2020 December 10.

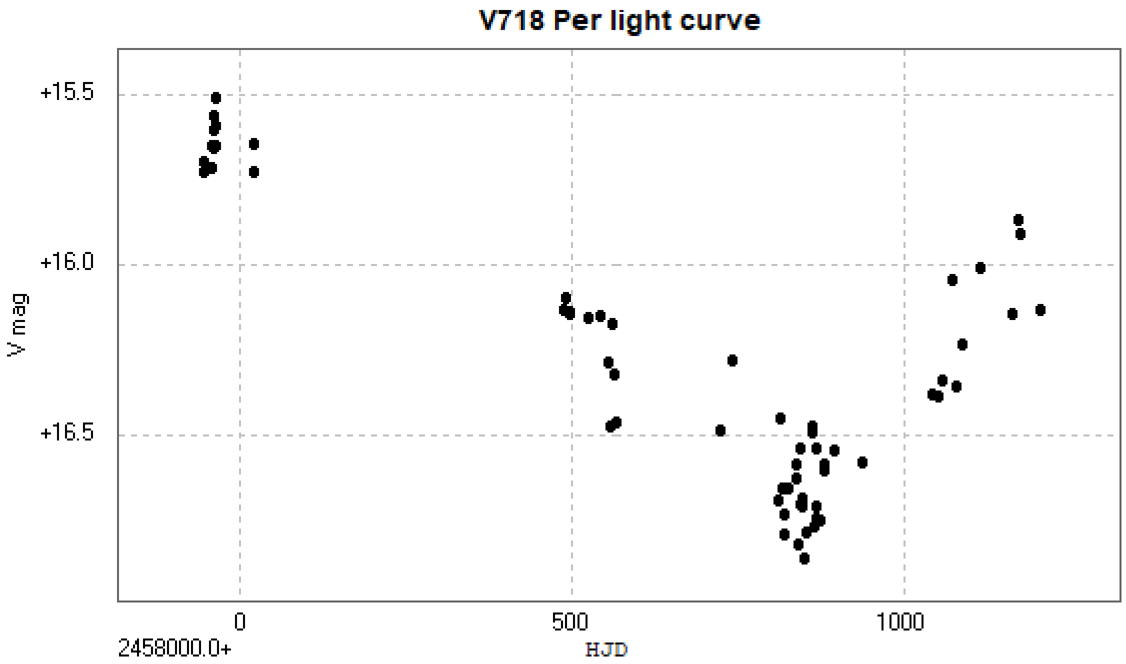


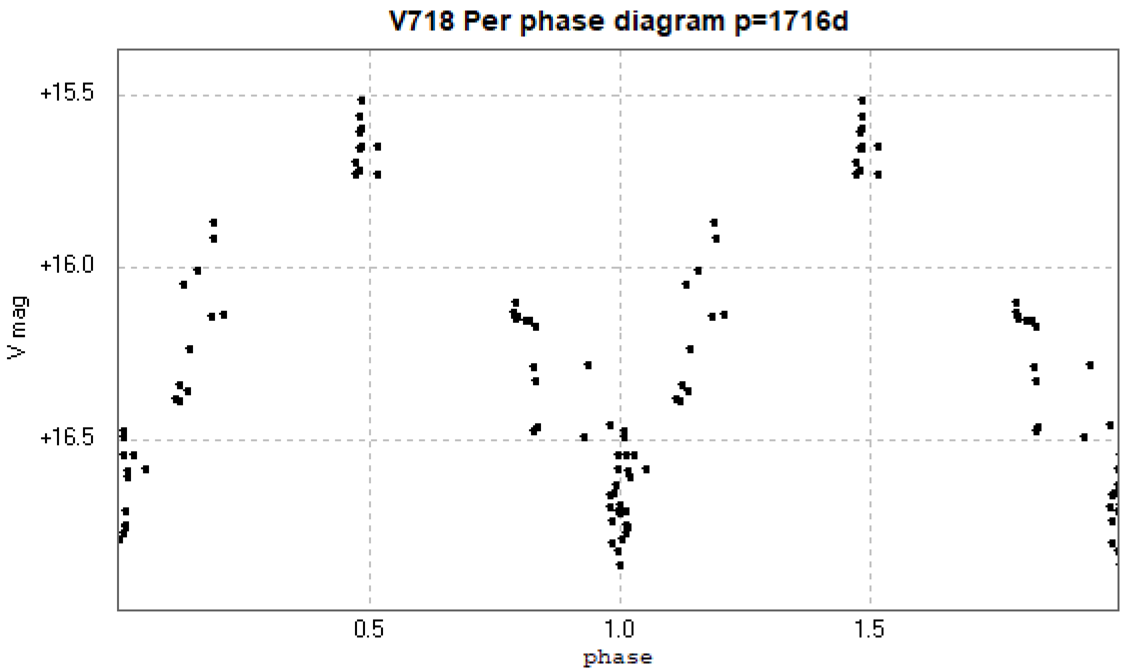


The obvious stand out feature is the 0.5 magnitude increase in brightness which starts at about 2020 October 9 (JD 2459132). This system is listed in the AAVSO VSX as an EA+ZAND type variable. This spike can be attributed to Z AND type activity within the system, a previous outburst having been observed in 2006 (vsnet-alert 10534).

V718 Per (type E)

Light curve and phase diagram of the long period (~1716 day) variable observed during the period 2017 July 9 to 2020 December 21. Note that the maximum exposure available with COAST is 3 minutes, which is probably responsible, at least in part, for some of the scatter in the light curve of this mag 16 object.





The 'E' classification is defined as 'eclipsing binary system' (GCVS). However, this is a pre main sequence object, and research suggests that the light variations in this system are caused not by the passage of one star in front of another, but by periodic obscuration of a single star by an edge-on circumstellar disk consisting of an uneven distribution of dust (Grinin *et al* 2008). There might also be some spot activity occurring.

As ever, these objects remain in my current observing program and more results should become available in due course.

The Constantly Changing Period of beta Lyrae

Christopher Lloyd

A modern quadratic ephemeris is derived for beta Lyrae, which represent a small improvement on previous solutions. The cubic fit to the data did not yield a significant cubic term and did not improve the other parameters, so there is no evidence to support any change in the rate of period change.

Few stars can claim to be the prototype of a major class of variable stars but *β* Lyrae is one of them, which along with Algol and W Ursae Majoris represent the three main types of eclipsing binaries. As a class *β* Lyrae stars are defined by their continuously varying light curves where the onset of eclipses cannot be seen directly. The same is also true of W Ursae Majoris stars, but these are essentially contact variables while the *β* Lyrae stars can be detached, semi-detached or in contact. The *β* Lyrae stars can also contain a wide range of components from supergiants to main-sequence stars, and these are more massive stars with spectral classes of O, B or A, as opposed to the later types of W UMa systems. The vast majority, if not all, *β* Lyrae systems have either undergone, are undergoing, or will undergo mass transfer.

As for *β* Lyrae itself, it has a period of 12.9 days, which is increasing at the prodigious rate of 19 seconds per year, and the eclipses are $0^{m}.8$ and $0^{m}.4$ deep. The primary component is classified as a bright giant with a spectral type of B6-8II, but the secondary has long been something of a mystery. Spectroscopically it is peculiar and although it superficially resembles an A- or F-type star it is 4.5 times the mass of the primary. The reason for the confusion is that the star is completely obscured by a deep accretion disc, and it is the filtered radiation from this that gives the impression of a cooler star. The system has obviously undergone substantial mass transfer. For a recent review see Mourard et al. [1]

In close binary systems mass transfer begins when the primary evolves to the extent that it fills its Roche lobe and material pours through the inner Lagrangian point (L1) on to the secondary. The mass transfer is usually so rapid that the recipient cannot absorb the incoming material, so whether the accretion stream falls directly on the surface of the star or not, an accretion disc will usually form. As the mass transfer proceeds the mass ratio of the system ($q = m_2/m_1$) will slowly increase and the Roche lobe of the primary will shrink, accelerating the process with positive feedback. During this time, the period of the system will shorten dramatically. Rapid evolution of the system will continue until the components have the same mass ($q = 1$), and then from this point the period will lengthen, and the Roche lobe of the original primary will begin to increase in size. With the system now in negative feedback the mass transfer rate will reduce, and rate of period change will also slow down, but q will continue to increase. It is thought that *β* Lyrae is at this stage. The process will continue until the original primary detaches from its Roche lobe or until other evolutionary forces begin to dominate, which for massive stars might not be very long. While this idealized scheme is appropriate for some stars, mass and angular momentum loss from the system can be important, and this appears to be the case for *β* Lyrae (see *e.g.,* van Rensbergen & De Greve [2] and the discussion in Mourard et al.[1] For *β* Lyrae, once the accreted material has been incorporated into the new primary the system will probably present as a massive Algol, with an early B-type primary, possibly still with the remnants of an accretion disc, and semi-detached secondary.

The period of *β* Lyrae was famously found by John Goodricke from a series of observations made during the last few months of 1784. He was also the first to postulate the eclipsing binary mechanism, although this idea was not widely accepted until spectroscopic binaries were discovered over a century later. Some early observations were also made by Sir William Herschel but there was little interest in variable stars at this time and the star was observed only spasmodically until about 1840, then it began to be monitored extensively by Argelander, Baxendell, and others. By this time it was clear that the period was changing and has been observed more or less continuously ever since. Now, with nearly 240 years of eclipse timings available, the period change can be examined in unprecedented detail.

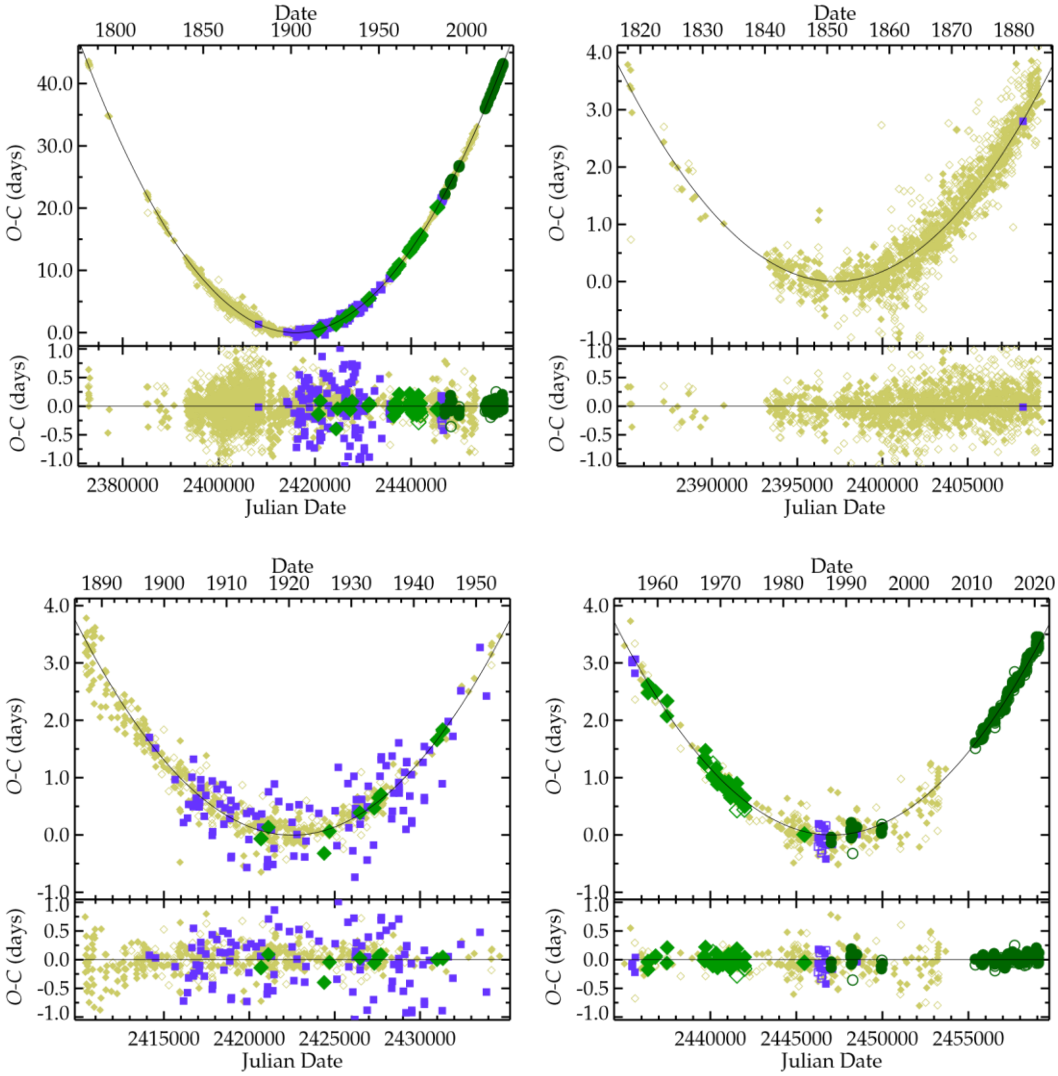


Figure 1. The four panels show the O-C diagram of *β* Lyrae for four different time frames. In each panel the upper pane shows the residuals from an arbitrary linear ephemeris together with the fit of the weighted least-squares quadratic ephemeris given in Equation 2. The lower pane of each panel shows the residuals from the quadratic fit, at a larger scale. A few points lie outside the plot limits but the vast majority are clustered around zero. The different observation methods are identified so; visual (small diamonds), photographic (squares), photoelectric (diamonds), and CCD/CMOS (circles). Open symbols indicate secondary minima.

(Top left) The complete O-C diagram of the observations from 1784 to 2020. The three other panels each show about 65 years starting from 1815 when more regular observing began, after Goodricke and Herschel. There are no coherent runs of residuals that would suggest any departure from the linear period change, although they are very unevenly distributed.

The times of minima have been taken from the O-C gateway which is maintained by the Czech Astronomical Society. For the times from JD = 2455000 (2009) minima have been calculated from selected V, B, R, and TG observations from the AAVSO archive. The vast majority of observations are visual with a small number of photographic, and relatively few photoelectric, and more recent CCD/CMOS timings. The entire period history of β Lyrae is shown in varying detail in the four panels of Figure 1. It is clear that the data are very inhomogeneous, with long sections dominated by either visual, or more recently CCD/CMOS data. The bulk of the photographic data overlap both visual and the early photoelectric measurements. The coverage is also very patchy with a particular lack of accurate measurements between 1975 and 2010. There is also considerable variation in the accuracy of the timings, with the PEP/CCD/CMOS data, not surprisingly, being much more consistent.

The initial quadratic fit was made using equal weights and the residuals for the primary and secondary minima were examined for each of the observing methods. The photographic minima and the visual secondary minima were the least reliable with $\sigma \sim 0^{d}.4$, while the visual primary minima were slightly better with $\sigma \sim 0^{d}.3$. All the PEP/CCD/CMOS data gave $\sigma \sim 0^{d}.1$. The unweighted fit is given in Equation 1.

$$HJD_{MinI} = 24000010.531(10) + 12.908895(13) \times E + 3.8598(34)\times10^{-6} \times E^{2} \qquad (1)$$

For the weighted solution, the general uncertainties given above have been applied to the data as these reflect the real-world situation, and lead naturally to the reduced chi-squared, $\chi^{2}_{v} = 1.00$. Any other weighting scenario could lead to large differences in weights with possible distortion of the fit given the distribution of the various data sets, and inevitably lead to $\chi^{2}_{v} >> 1$. The weighted fit is given in Equation 2.

$$HJD_{MinI} = 24000010.537(9) + 12.908862(10) \times E + 3.8693(23)\times10^{-6} \times E^{2} \qquad (2)$$

The value of the quadratic component has a slightly lower uncertainty than recent major determinations, but of course has the advantage of a longer time base. The solutions from Ak et al. [3], Wilson et al.[4], Harmanec & Scholz [5], and the earliest ones of the modern epoch, Klimek & Kreiner [6,7] are all consistent with Equation 2. Klimek & Kreiner [6] also used a cubic fit to test if the rate of period change was constant, and although the value of the cubic term was nominally significant at the 3σ level it made no improvement to the other parameters, so was deemed to be not significant. The cubic fit to the current data is given in Equation 3 using the same weighting scheme as before, and the cubic term is not significant, so the rate of period change appears to be constant.

$$HJD_{MinI} = 24000010.540(9) + 12.908880(14) \times E + 3.8539(77)\times10^{-6} \times E^{2} + (2.6\pm1.5)\times10^{-12} \times E^{3} \quad (3)$$

Also, examination of Figure 1, particularly the residuals from the quadratic fit in the lower panes, show no coherent runs that might suggest constant period sections or any other departures from a constant, linear period change.

Although the period is constantly changing it is useful to have a linear ephemeris that is simple to calculate and sufficiently accurate. The following ephemeris provides times of primary minima within $\pm0^{d}.2$ of the quadratic ephemeris until 2035. The times are slightly late until 2030 and then slightly early.

$$HJD_{MinI} = 2459227.3 + 12.945272 \times E$$

References

1. D. Mourard *et al.*, *A&A*, **618**, A112, 2018
2. W. Van Rensbergen & J. P. De Greve, *A&A*, **592**, A151, 2016
3. H. Ak *et al.*, *A&A*, **463**, 233, 2007
4. R. E. Wilson & W. van Hamme, *MNRAS*, **303**, 736, 1999
5. P. Harmanec & G. Scholz, *A&A*, **279**, 131, 1993
6. Z. Klimek & J. M. Kreiner, *Acta Astron.*, **23**, 331, 1973
7. Z. Klimek & J. M. Kreiner, *Acta Astron.*, **25**, 29, 1975

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Terzian, Y (ed.) Interstellar Ionized Hydrogen. W.A.Benjamin inc., NY & Amsterdam, 1968.
Menzel, DH. (ed). The Radio Noise Spectrum. Harvard University Press, 1960.
Bracewell, RN (ed) Paris Symposium on Radio Astronomy. Stanford University Press, Stanford. 1959.
Bishop, O. Practical Electronic Timing. Bernard Babani (pub) ltd., 1993.
Atledge, D. Digital Astrophotography : the state of the art. Springer, London. 2005.
Mobberley, M. The New Amateur Astronomer. Springer, London. 2004.
Berry,R. & Burnell, J. The Handbook of Astronomical Image Processing (includes AIP4WIN software). 1st edition, Willmann-Bell inc., Richmond, VA. 2002.
Frank, J., King, A., Raine, D. Accretion Power in Astrophysics. 3rd ed. Cambridge University Press, 2002.
Smith, HA. RR Lyrae Stars. Cambridge University Press, 2003.

Also, a Philosophical Transactions of the Royal Society (vol. 366, no. 1884, pp 4357-4500, 13 Dec. 2008). Astronomy papers of a triennial issue compiled and edited by J.M.T.Thompson. It has 12 articles on a wide variety of topics including Black Holes, gamma ray bursts, Mira, magnetic fields extrasolar planets and space weather.

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