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Variable Star Section Circular

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Contents

Cover Picture

V1405 Cas (Nova Cas 2021)
May 08.418 UT 2021. iTel Takahashi FSQ 106ED apo +STL 11000M. 120 seconds. V=5.87
Martin Mobberley, Bury St. Edmunds, Suffolk UK

From the Director *Jeremy Shears*

Spring has been a mixed bag for me, with sleet, hail, and sub-zero temperatures in early May and yet April was my best observational month ever (22 nights, patrolling over 2000 cataclysmic variable fields). We've also had the enjoyment of Nova Cas 2021 (**V1405 Cas**) which has received considerable attention from non-VS observers too, as it has been visible in binoculars for many weeks. The first report of a naked eye observation was a VSnet posting by Filipp Romanov observing from near Nakhodka, Russia (nr Vladivostok, 42degN) who had it at 5.1 vis on May 10.75. This was around the time of maximum brightness (see light curve below).

I believe this makes it the first naked eye nova since Nova Del 2013 (**V339 Del**), at least from these latitudes. This is a slow nova and certainly worth keeping an eye on over the next few weeks. Might we see another brightening episode, similar to what was observed with HR Del?

And don't forget the other two recent novae: Nova Cas 2020 (**V1391 Cas**) and Nova Per 2020 (**V1112 Per**).

SUMMER MIRAS

M = Max, m = min.

R And	M=May/Jun
W And	M=Jun/Jly
RW And	M=May/Jun
R Aqr	M=Aug
R Aql	M=Aug
UV Aur	m=Aug
V Cam	m=Jun
X Cam	M=Aug
	m=Jun
SU Cnc	m=Jly
RT CVn	m=Aug
o Cet	M=Aug
R Com	M=Jly/Aug
S CrB	M=Jly
W CrB	m=Jly
R Cyg	m=Jly
T Dra	m=Jly
RU Her	M=Aug/Sep
SS Her	m=Jun
W Lyn	M=Jly/Aug
X Lyn	m=Aug
T UMa	M=Aug/Sep

Source BAA Handbook

VSS observing campaigns on CG Dra and ER UMa systems

May I draw observers' attention to a new VSS campaign on **CG Dra** which is described later in this Circular? This was once on the VSS "Recurrent Objects Programme" of rarely outbursting cataclysmic variables. However, as the campaign in 2005 revealed it is actually one of the most active dwarf novae, going into outburst every 11 days or so. Unfortunately, since then CG Dra has been largely neglected, so the aim of the campaign is to check on what it is up to now. We'll run the campaign until the end of the current observing season and review.

Members have indicated to me that they like to engage in campaigns of this nature as a focus for their work – often people will add a campaign star to their existing programme. A paper on a recent campaign target, the nova-like variable **HS 0229+8016**, has been submitted to the BAA *Journal*.

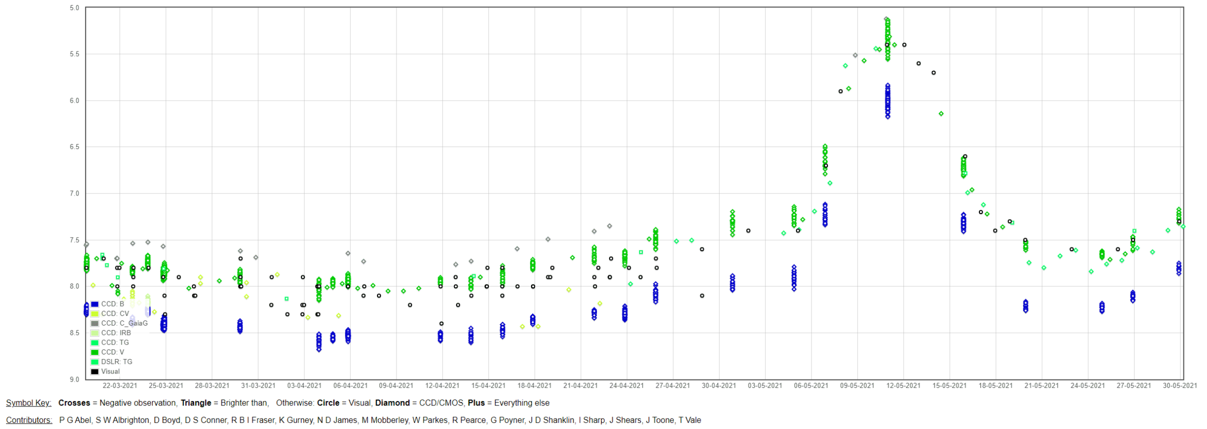
Another campaign ongoing presently is on the supercycle lengths of ER UMa dwarf novae including **IX Dra** (https://britastro.org/node/24529), **ER UMa & RZ LMi** (https://britastro.org/node/25052). Nightly measurements enable us to determine the onset times of outbursts and superoutbursts.

AFOEV Centenary

On behalf of the Variable Star Section of the BAA, I had the pleasure to send hearty and fraternal congratulations to the members of the Association Française des Observateurs d'Étoiles Variables (AFOEV) on their centenary. The AFOEV was formed on 1921 April 16. John Toone's article in this Circular provides further context.

Back numbers of the VSS Circular

A number of people that have joined the Section recently have enquired about obtaining back numbers of this Circular. The are available for download at https://britastro.org/vss/VSSC_archive.htm



Light curve for V1405 Cas (Nova Cas 2021); Mar 19 to May 30. Data from VSS database

V1405 Cas. 2021 March 29 and May 19, indicating a shift to red. Skywatcher Quattro 200mm f/4 Newtonian, ZWO ASI 294MC-Pro. Exposure: 90 frames of 60 sec (Mazin Younis, Hale Barnes, Manchester)

The Centenary of the AFOEV

John Toone

Following the lead set by the BAA VSS in 1890 the next sustainable variable star organisation to be formed was the AAVSO in 1911. Then there were a cluster of national variable star groups that were formed in the 1920's. Most like the BAA VSS were sections within nationwide astronomical associations/societies that were set up in Australia, Denmark, Japan, New Zealand and South Africa. France also formed a group, but they were different in that they were autonomous and more like the AAVSO supported by a professional observatory. This group was the AFOEV, and they formed following a meeting held on 16 April 1921 at Lyons Observatory with AAVSO founder member Stephen Crasco Hunter in attendance. Their first observations were published the following month in the Lyons Observatory Bulletin and the initial name adopted by the group was "Groupement Francais d'Observateurs d'Etoiles Variables". The name changed to Association Francaise des Observateurs d'Etoiles Variables (AFOEV) once it was officially registered as an association in 1927. Henri Grouiller, Jean Mascart and Antoine Brun formed the leadership of the group in the early days.

The AFOEV rapidly expanded in the late 1920's and 1930's and published the observations in the AFOEV bulletin. They received observations from up to 20 countries including contributions from Charles Butterworth who submitted his observations of variable stars that were not on the official observing programme of the BAA VSS. During 1932–1938 the AFOEV collaborated with the AAVSO and BAA VSS under the Joint Committee of Variable Star Associations to improve and unify variable star sequences with the assistance of the McCormick and Strasbourg Observatories.

Unfortunately, World War II severely disrupted the work of the AFOEV and it took until 1969 to recover when the Association was officially relaunched and the bulletins resumed.

Like the BAA VSS the AFOEV shares its observational data with the AAVSO and has amassed approximately five million observations that are stored at its HQ at Strasbourg Observatory. Today the AFOEV continues to be a focal point for variable star work within Europe and French speaking countries worldwide. On the 16 April 2021 the AFOEV celebrated its centenary, the third major variable star organization to do so.

Campaign to observe the (very) frequently outbursting Dwarf Nova CG Dra

Jeremy Shears

CG Draconis was discovered by Hoffmeister in 1965 (1) and he later classified it as a dwarf nova (2). Rather little was known about its outburst frequency until an intensive monitoring campaign was conducted during 2005, the results of which were published in the BAA *Journal* (3). This revealed that the star has frequent outbursts every 11 days or so and the star spends very little time at quiescence. Two types of outburst were detected: short outbursts lasting about 4 days and long outbursts lasting about 8 days. The range is mag 14.1 to 17.4 as shown in the VSS light curve below.

A subsequent paper presented evidence for very shallow (~0.16 mag) eclipses with a duration of about 18 min (4). The times between the eclipses were consistent with an orbital period of 0.18864(4) d, or 4h 31m 38 +/- 3s.

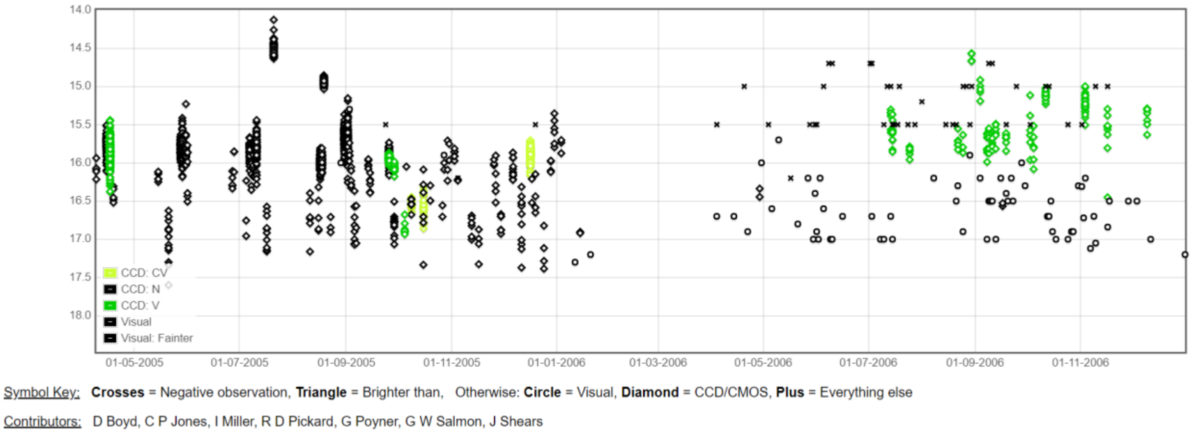
Rather few observations of this star have been made since 2008, according to the BAA and AAVSO databases. Hence the intent of the present campaign is to rectify that situation and check on CG Dra's current behaviour. Has it changed in the last 15 years?

Two kinds of observation are requested. The first is nightly "snapshot" observations to determine the overall light curve of CG Dra, thus its outburst frequency and duration. These can be digital or visual (if you have a sufficiently large telescope). Secondly, some long runs of time series photometry would help to verify, and time, eclipses. Unfiltered photometry is very suitable for this.

Charts and sequences are available from the AAVSO Variable Star Plotter (e.g., chart https://app.aavso.org/vsp/chart/X26515JI.png). CG Dra is located at RA 19 07 32.63 Dec +52 58 28.1 (J2000.0). The campaign will run until the end of the current observing season, likely early 2022 depending on latitude.

Given that this star undergoes frequent outbursts, it provides much interest for those that decide to follow it, as it is always doing something! Please submit your data to the VSS Database and help us to shed new light on this neglected dwarf nova.

1. *Hoffmeister C., Mitt. Veranderl. Sterne 2, 96 (1965).*
2. *Hoffmeister C., Astron. Nachr. 289, 139 (1966).*
3. *Shears J., Pickard R. and Poyner G., J. Br. Astron. Assoc., 117, 22-24 (2007).*
4. *Shears J., Boyd D., Brady S. and Pickard R. J. Br. Astron. Assoc., 118, 343-347 (2008).*



Light curve of CG Dra from VSS database

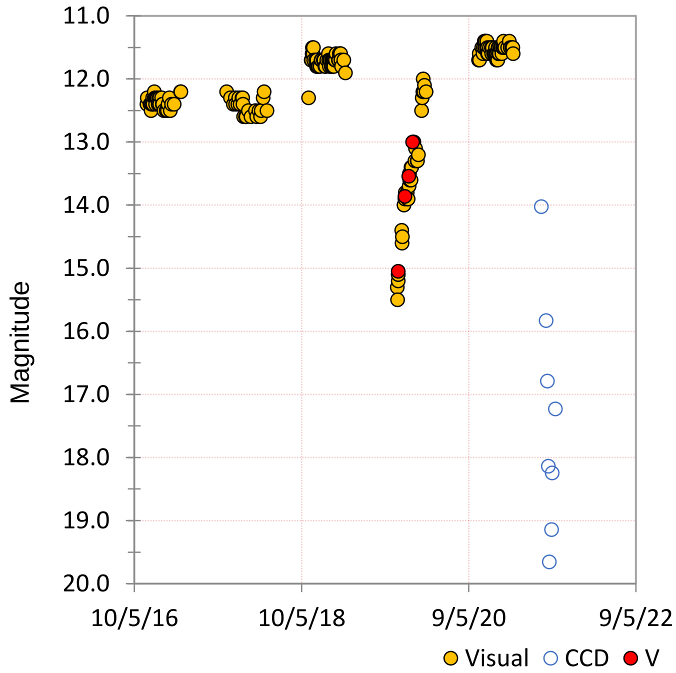
CV & E News

Gary Poyner

Recent activity in five objects on the BAAVSS Cataclysmic Variable & Eruptive Star programme are discussed – ES Aql, DO Dra, YY Her, V742 Lyr and DV UMa.

ES Aql:

Recent observations of the RCB star ES Aql reveal an historic low state occurring in late April. The BAAVSS DB reports that the final observations of 2020 show the star at maximum brightness of 11.6 visual on November 19. Unfiltered CCD observations on March 23 2021 reveal ES Aql had faded to 14.03CV, and one month later the decline had reached 19.66CV by April 26. A recovery to magnitude 17.2CV by May 22 has followed, with ES Aql spending just ten days at minimum brightness. The previous faintest level ES Aql has been recorded is 18.4V in 2011 (from *AAVSO IDB*).



Observations of ES Aql began as recently as 1999, yet in those 22 years no fewer than twelve fades below magnitude 15 have been recorded. Each one of those fades have been of short duration, with a recovery occurring within a month of minimum brightness. Not really classic RCB behaviour. With this unusual high activity seen in an RCB star, one wonders why there are so few BAAVSS observers – eight in total, and just three in the last decade.

The light curve above right shows the current historic fade, and the previous fade which occurred in March/April 2019. *(BAAVSS database*).

DO Dra:

Intermediate Polars can be strange beasts. A magnetic white dwarf leading to a truncated accretion disc is a good recipe for an interesting time to be had for any observer who follows these fascinating CV's – and DO Dra is proving that as I write these words.

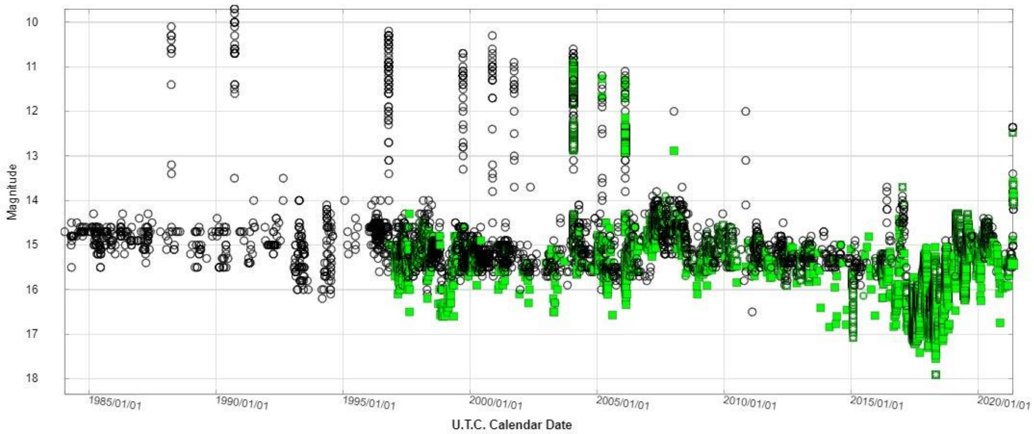
Since 1985 there have been eleven outbursts reported to brighter than magnitude 12, and three between magnitudes 12 and 14. Minimum can vary between magnitudes 14 and 18, and the period between 2016-2020 showed lots of activity in these lower levels. Outbursts tend to be short duration events – around 2 to 4 days at most, with the occasional rare outburst lasting longer. With such a short outburst duration, one wonders just how many outbursts in IP's are being missed entirely! A

Back to contents

visual inspection of the light curve below shows a lack of any outbursts being detected between May 2011 and May 2016.

The amplitude of the outburst has also been decreasing over the last 30 years or so. The brightest yet seen occurred in September 1990 peaking at magnitude 9.8, with subsequent outbursts each fainter than the previous one. The last 'bright' outburst occurred in November 2010 which peaked at magnitude 12.0. (*AAVSO IDB*).

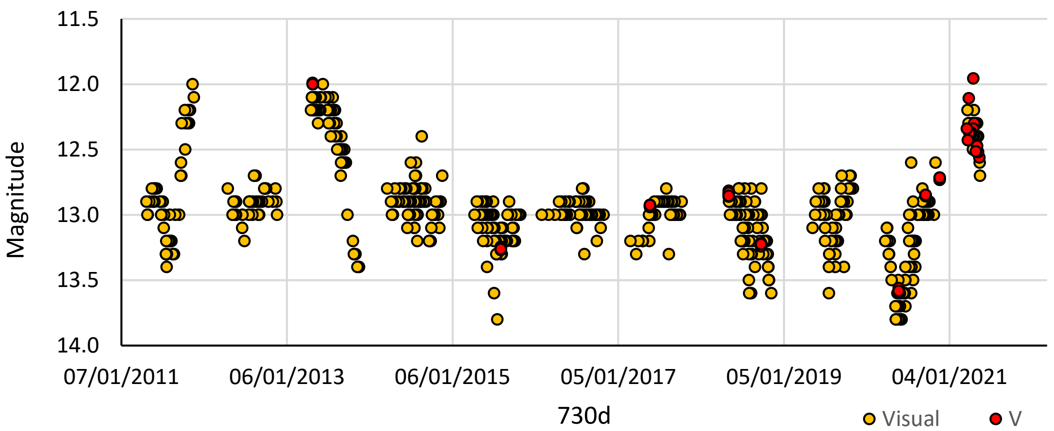
The current outburst (still ongoing as I write these words on May 23), has been quite unusual for a couple of reasons – the duration (14 days so far), and the occurrence of a rebrightening. Having peaked at magnitude 12.4 on May 9, DO Dra then faded back to magnitude 15.0 by May 11. The rebrightening occurred two days after on May 13, which peaked at 13.6V on May 16. By May 22, DO Dra could still be seen bright at magnitude 13.9C. The AAVSO have the most complete data on DO Dra available, with no historic outbursts having shown a rebrightening.



DO Dra 1984-2021. AAVSO International Database.

YY Her:

The Symbiotic variable YY Her entered its first outburst since 2014 during March 2021. The outburst appears to have peaked around magnitude 12.0 on April 19, and slowly faded to its current level (May 23) of 12.6V. This event has followed a deep minimum recorded in June 2020 when YY Her reached a magnitude of 13.8 at minimum brightness – the faintest seen since July 2015. The outburst was first announced on ATel 14458.

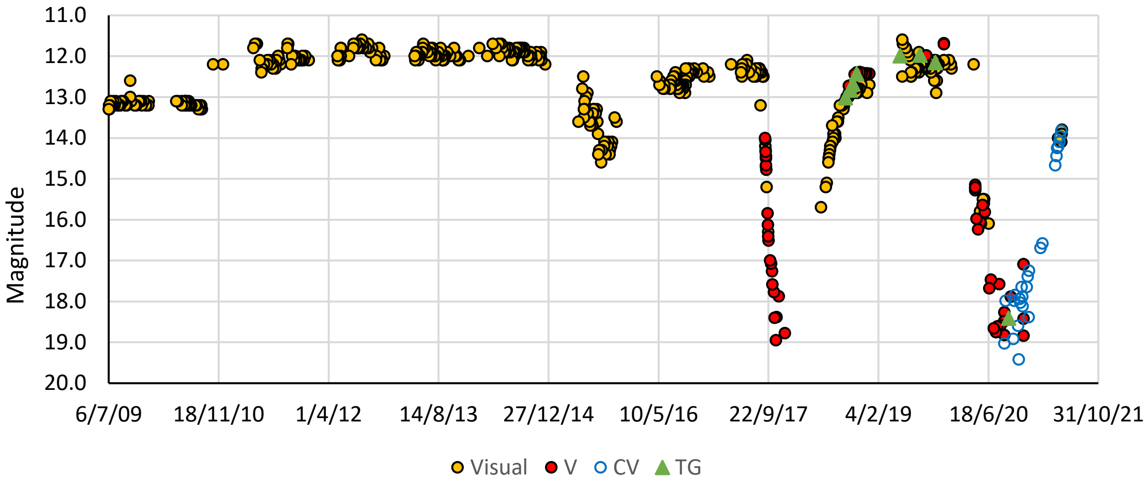


YY Her, 2011-2021. Visual and V date from BAAVSS Database

V742 Lyr:

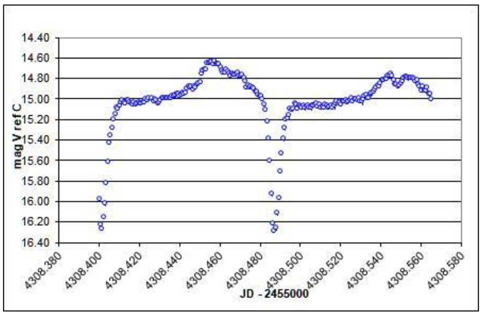
Rather like the aforementioned ES Aql, V742 Lyr is another RCB star which is apparently being ignored by both visual and CCD observers alike, with just five observers reporting data to the database since monitoring began in 2009 (first identified as NSV 11154). This is rather unfortunate, as V742 Lyr is proving to be an interesting classical RCB star with an amplitude in excess of seven magnitudes. Recently, the star has just seen its deepest minimum yet, bottoming out at magnitude 19.4C in November 2020 before rising slowly to its current level (at time of writing, May 23) of 13.8 visual on May 20. A rise of 5.5 magnitudes in five months. The previous deep minimum was seen in October 2017 when the star reached magnitude 19.0V at minimum.

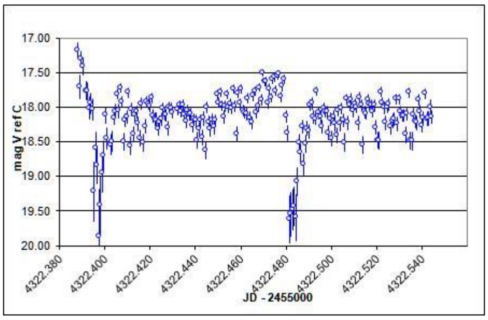
With a magnitude range of 11.5V-19.5CV, V742 Lyr is an excellent target for both visual and CCD users who have an interest in the unpredictability of RCB stars.



V742 Lyr (NSV 11154) 2009-2021. BAAVSS database

DV UMa:





The eclipsing UGSU star DV UMa was detected in outburst on March 29.9 at 15.2CV by Jeremy Shears. This was the first outburst observed since April 2020, and the first superoutburst seen since February 2014. The outburst lasted 19 days.

Roger Pickard observed several eclipses (see right) on the nights of April 3 (top) and April 17 (bottom).

The times of mid eclipse in Roger's observations have allowed me to compare with the ephemeris given on the BAAVSS eclipse page (under CV's). It was quite apparent that the ephemeris given for DV UMa was incorrect, and both John Greaves (who wrote the CV eclipse program) and I suspected that other timings might be out too, as the data to calculate the mid timings were old. With this in mind, the CV eclipse predictions have been removed from the BAAVSS web page. Mid eclipse timings for selected (but not all) eclipsing CV's can be found in VSX.

V1391 Cas, V1112 Per, V1405 Cas – three very different Novae

David Boyd

B and V band photometry and spectroscopy of three recent northern hemisphere novae reveals their different behaviour.

Observations

Northern hemisphere novae are like buses. You wait ages for one then three come along at the same time. I have tried to observe all three as regularly as weather conditions and their visibility has allowed. I obtained photometry with a 0.35m SCT, SXVR-H9 CCD and B and V filters and spectroscopy with a 0.25m SCT and LISA spectrograph. They have all gradually become lower in the north-west over recent months making observation increasingly difficult because of obstruction by trees and buildings. Using comparison stars from the relevant AAVSO charts, I measure B and V instrumental magnitudes on each image and use the B-V colour index to transform V magnitudes to the Johnson V photometric standard. At their brightest, exposures had to be very short and therefore suffered from atmospheric scintillation. This was mitigated by averaging magnitudes measured on many consecutive images. At their faintest I switched to a clear filter to maintain a reasonable signal to noise ratio. Spectra have been calibrated in absolute flux using concurrently measured V magnitudes.

I show below for each nova, using my own measurements, how their V (and C) magnitudes and B-V colour indices evolved over time, and the paths they have followed in a V vs B-V colour-magnitude diagram. I have also included a spectrum of each nova recorded close to the point where it reached maximum brightness shortly after discovery. The most prominent emission lines in the spectra at this stage in the outburst are the lines of the hydrogen Balmer series and, in V1112 Per and V1405 Cas, lines of He I. These emission lines often show P Cygni type absorption dips on their blue side caused by absorption in the ejecta of the explosion which is moving towards us. The different behaviour of each nova is clear from these results.

More data on each nova from many observers can be found in the BAA photometry and spectroscopy databases.

Nova Cas 2020 = V1391 Cas

Discovered on 2020 July 27 at unfiltered magnitude 12.9 by Stanislav Korotkiy in the course of the New Milky Way Survey [1], Nova Cas 2020 was reported on the CBAT Transient Objects Confirmation Page (TOCP) as TCP J00114297+6611190. It rose to a maximum V magnitude of 10.6 on August 10 before experiencing a series of flares as it faded slowly and erratically until December 2020. It then faded rapidly to below magnitude 20 and its B-V colour index became much redder. This was attributed in ATel 14267 to the formation of optically thick dust in its ejecta. Because there was a star 5 arcsec to the north and of similar brightness to the now very faint nova, it became difficult to perform reliable photometry of the nova for several weeks. Eventually in March 2021 it started to brighten, and I was able to begin measuring it again using a clear filter. It has continued to brighten slowly and now appears to have reached a plateau at magnitude 16.3. V1391 Cas has been classified spectroscopically in ATel 13905 as an Fe II type nova suffering from extensive interstellar reddening with E(B-V) = 1.39. This explains the steep downward slope of the spectral continuum towards shorter wavelengths.

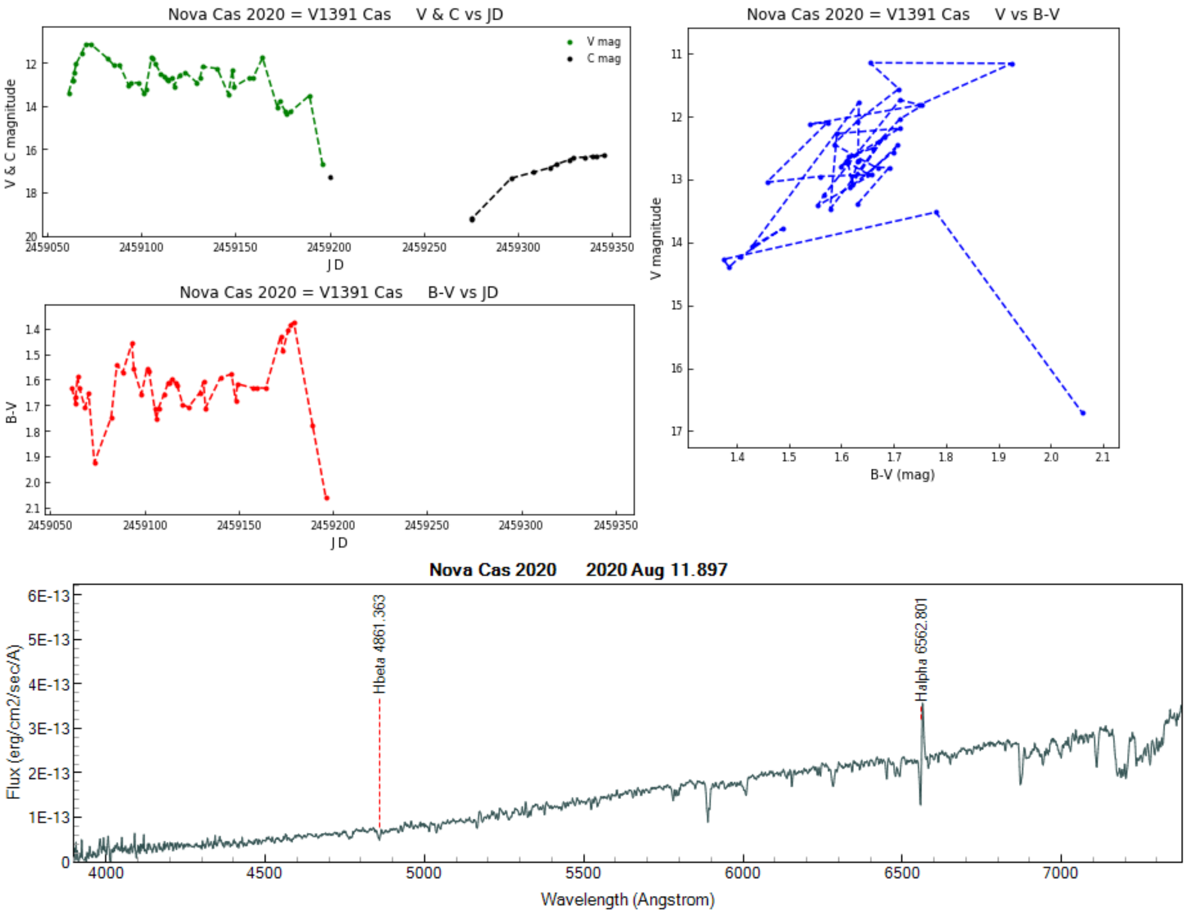


Figure 1. Photometry and spectroscopy of V1391 Cas.

Nova Per 2020 = V1112 Per

Discovered by Seiji Ueda at unfiltered magnitude 10.6 on 2020 November 25 using a DSLR camera, Nova Per 2020 was reported as TCP J04291884+4354232 on the TOCP. It rose to V magnitude 8.2 over the next 2 days and varied over a half magnitude range for 9 days before starting to fade slowly reaching magnitude 11 on 2021 January 5. It then began a rapid decline coupled with a sharp reddening of the B-V colour before eventually bottoming out at magnitude 16 around the middle of February. This fade was confirmed in ATel 14338 as also being due to the formation of dust. The B-V colour index recovered some 6 weeks later but the V magnitude only increased slowly and now appears to have plateaued at V magnitude 14.3. V1112 Per was classified an Fe II type nova in ATel 14229 with interstellar extinction estimated in the range E(B-V) = 0.6 - 0.8.

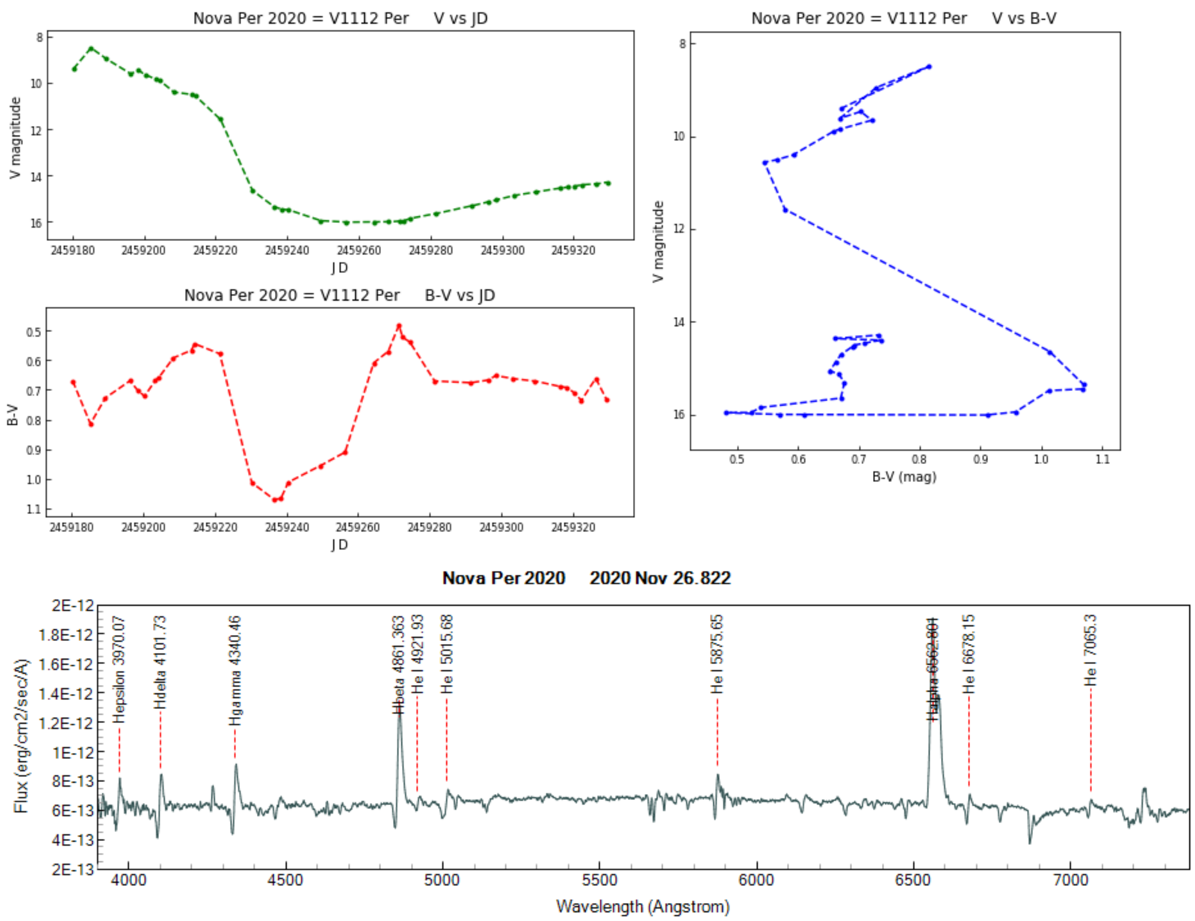


Figure 2. Photometry and spectroscopy of V1112 Per.

Nova Cas 2021 = V1405 Cas

Nova Cas 2021 was discovered on 2021 March 18 by Yuji Nakamura with a CCD camera and 135 mm lens at unfiltered magnitude 9.6. It was reported on the TOCP as PNV J23244760+6111140 and appears to be coincident with the known eclipsing variable CzeV3217 (according to ATel 14530 this is possibly a nova-like variable misclassified as a W UMa-type binary). The nova rose rapidly to V magnitude 7.5 two days later then faded slowly over 20 days to V magnitude 8.1 around April 7 before starting to brighten again. This rise continued until it reached V magnitude 7.2 on May 5. Over this period, the B-V colour index was gradually becoming redder. After May 5 it brightened more rapidly with a further reddening in colour reaching V magnitude 5.3 five days later. It then started to fade reaching 6.7 on May 15 and the colour became bluer again suggesting that there was still no formation of dust. This is its current state at the time of writing. ATel 14577 reports the presence of Fe II emission lines in the spectrum for the first time on April 6 on the basis of amateur spectra submitted to the ARAS spectroscopic database, finally revealing V1405 Cas as another Fe II type nova. ATel 14476 reports reddening with E(B-V) = 0.55.

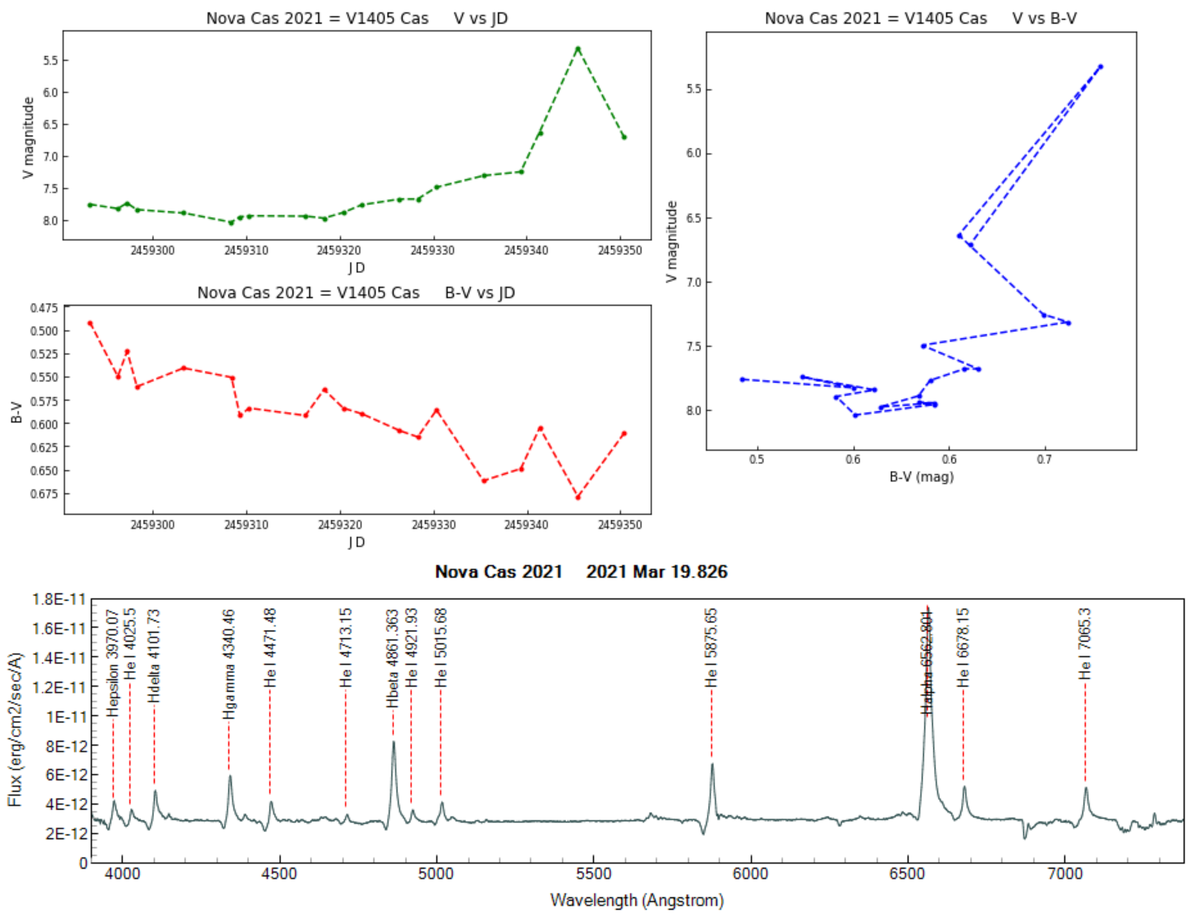


Figure 3. Photometry and spectroscopy of V1405 Cas.

References

[1] Sokolovsky K. et al. ASPC, 490, 395 (2014)

Is the supercycle period of ER UMa really increasing?

Stewart Bean

The evolution of the super-cycle period is reviewed from 1992 to the present epoch. The conclusion is that as more data is obtained over a longer epoch the smaller the rate of change of the supercycle period.

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, 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. ER UMa itself has a super-cycle of approximately 45 to 60 days. The super-cycle period, and its evolution, is considered one parameter that models of DNe evolution should describe. M. Otulakowska-Hypka and A. Olech (2) present a collection of P(sc) results for some UGER stars, including ER UMa and IX Dra (see VSSC 187). The authors suggest that the super-cycle period may be increasing for most UGER stars. In this note, recent results for ER UMa, obtained using the AAVSO database, the Variable Star Observers League in Japan (VSOLJ), Lasair (4) and ASAN-SN (5) results are used to update the existing literature.

ER UMa has a brightness range of 12.4 to 15.2 and coordinates of RA 09 47 11 and Dec +51 54.08 according to VSX (1). The observing season starts in November and runs until June based upon the reports to the AAVSO database.

ER UMa literature review

As part of a larger study of ER UMa type stars, M. Otulakowska-Hypka and A. Olech (2) averaged individual ER UMa supercycle periods, extracted from AAVSO and other records, into five measurements to produce the graph, reproduced from their paper, in Figure 1. This shows an apparent increase in P(sc) for ER UMa from 43 days in 1994 to 51 days in 2010 which the authors suggested was a trend for UGER stars as a whole. The daily rate of change of the supercycle period was estimated to be $12.7 \pm 1.9 \times 10^{-4}$.

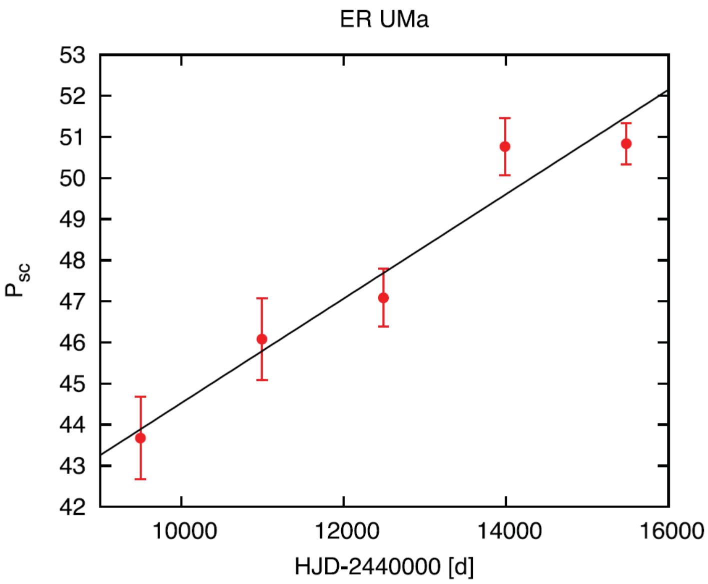


Figure 1. The super-cycle period for ER UMa from M.Otulakowska-Hypka and A. Olech (2) .

A more detailed analysis was then almost immediately published by Zemko et al (3) in 2013 using the same databases and almost the same time period of 1992 to 2012. They avoided any averaging and this article's Figure 2 shows a more complex behaviour taken from their Figure 6 . The first supercycle dates from 1992 and the last from 2012 with E as the number of superoutbursts since JD 2448740. The different symbols refer to the number of normal outbursts between the superoutbursts and can be ignored. The authors fitted a line to the data to derive an estimate for the daily rate of change of the supercycle period of 6.7 x 10^{-4} . This rate is approximately half that reported by M.Otulakowska-Hypka and A. Olech using the same data. Zenko et al also commented that "*Supercycle lengths (Ts) appeared to change discontinuously and show oscillations superimposed on a secular increasing trend.*"

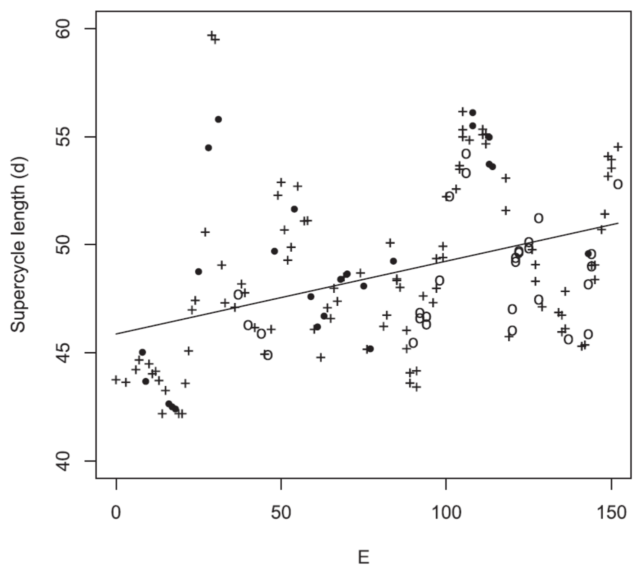


Figure 2. Variation of the supercycle lengths measured by a linear fitting of the O - C diagram. The solid line shows the secular increasing trend. Taken from Figure 6 of Zemko et al (3).

An updated analysis for ER UMa

An updated analysis has been made by extending the results of Zemko et al (3) using results from the AAVSO, VSOLJ, Lasair and ASAS-SN sources to 2021 January. Observations have also been undertaken by one of the AAVSOnet telescopes (BSM NM in New Mexico) under their observing program number #163 which started in 2020 November. Observations by Beech, Coates, Henderson, Hull, Johnson, Leyland, Miller, Pickard, Poyner, Poxon, Rock, Rodda, Walton and Withers from the VSS have all contributed to the period covered by the updated results. The new supercycle period graph is shown in Figure 3. The blue symbols represent the data presented by Zemko et al (3). The black symbols are this author's interpretation of the more recent observations. Only those superoutbursts whose start times were clearly recorded by the observations are included in the graph.

The behaviour over the last 50 cycles since 2012 continues to be unpredictable. The supercycle period appears to be centred on a value of 50 days but with gradual changes, over about 10 cycles, to extreme values of 42 and 61 days. If a linear line is fitted to all of the data (using OpenOffice spreadsheet tools) the daily rate of change of the supercycle period is 3.3×10^{-4}. This result is highly dependent upon the range of data used. If the early data with supercycle periods of less than 45 days is ignored, the linear fit becomes close to zero!

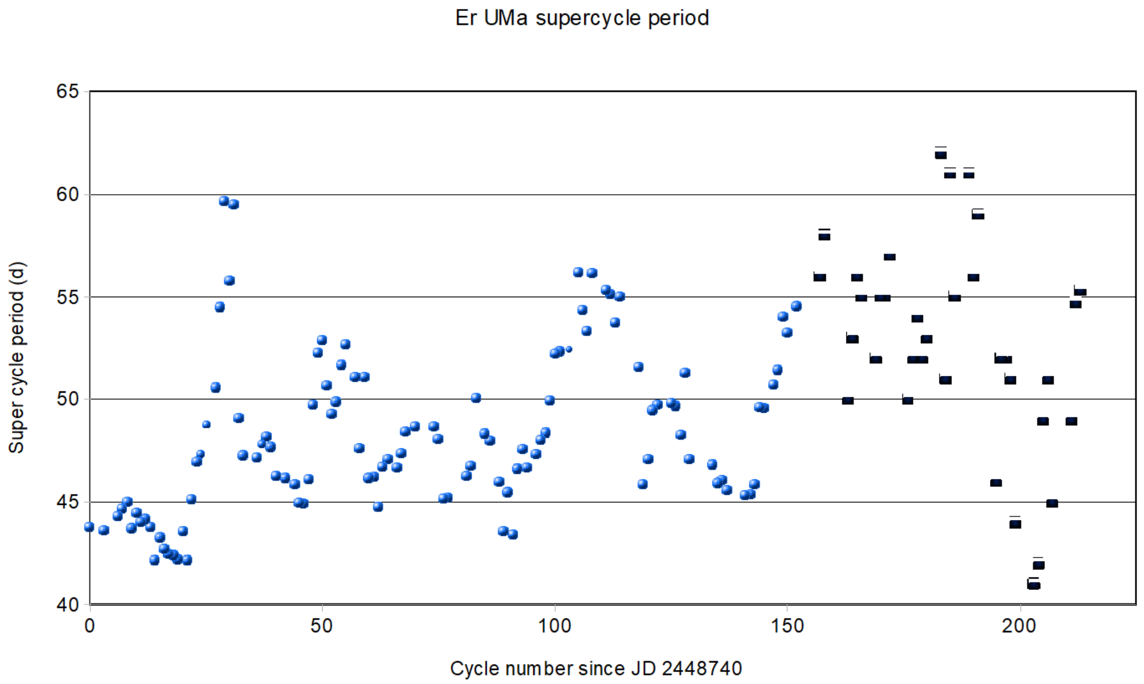


Figure 3. The updated graph of the supercycle period against cycle number following Zemko et al (3)

Discussion

The new analysis extends the work of Zemko et al (3) by about 8 years and suggests the rate of change of the supercycle period has halved compared to their result. The sensitivity of the result to the starting point of the analysis suggests that the data set is not sufficient to distinguish whether the supercycle period is either increasing gradually or is actually zero. The three analyses are summarised below.

12.7×10^{-4}	M. Otulakowska-Hypka and A. Olech (2)
6.70×10^{-4}	Zemko et al (3)
3.30×10^{-4}	This analysis

This update shows that the rate of change of the super-cycle period for ER UMa is smaller than reported by both of the earlier reports. The actual rate of change may even be zero, but the present data covers too short a time period to be confident of such a conclusion. Only many years of observations, led by the amateur community, can provide the extended data set that can shed further light on the topic.

References

1: The International Variable Star Index (VSX) (aavso.org)

2: M. Otulakowska-Hypka and A. Olech, MNRAS 433, 1338–1343 (2013)

3: Zemko, P., Kato, T. and S. Yu. Shugarov, Publications of the Astronomical Society of Japan, Volume 65, Issue 3, 25 June 2013, 54

4: Lasair, K. W. Smith, R. D. Williams et. al., Research Notes AAS,**3**,26 (2019).

5: ASAS-SN Sky Patrol

Acknowledgements

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

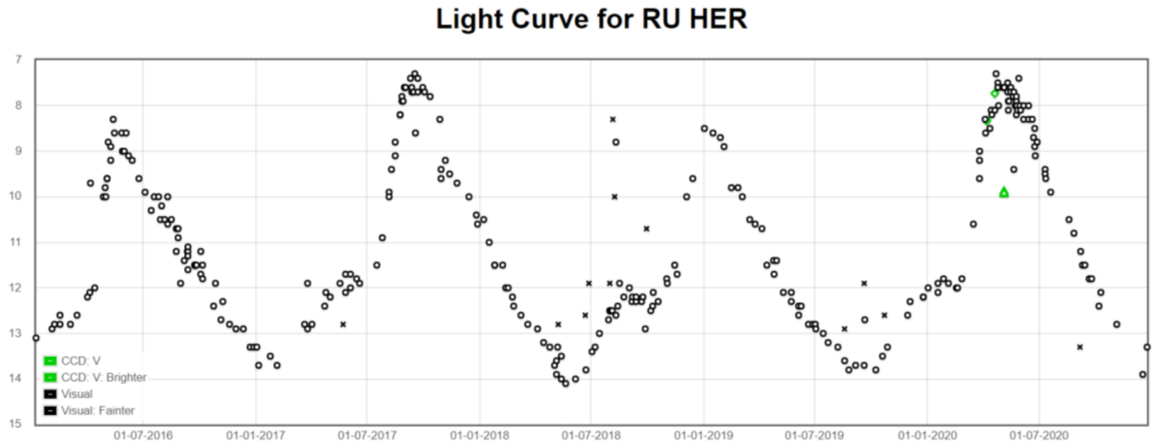
Mira Variables 2020 Part II

Shaun Albrighton

This report covers the activity of a further selection of Mira variables during 2020. All estimates are visual, unless stated otherwise.

T Dra – Fade from 11.5 in Jan to Min of around 13.5 in May/June. Rise to 11.5 in Nov/Dec.

RU Her – At standstill near to mag 12 until late Feb, then rapid rise to bright Max, 7.5 in May. Fade to 13th mag by end of year. Below is a light curve of RU Her, covering the years 2016 – 2020 inc. A hump/standstill is readily seen at around mag 12 on the last three ascending branches.

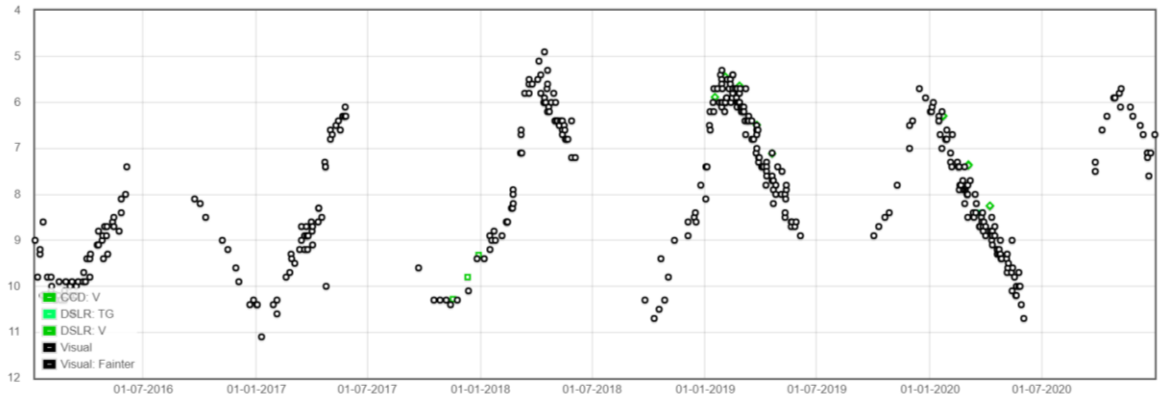


SS Her – No observations until Apr when at 12.6. Rise to Max near 8.5 in late May. Fade to Min 13.0 in late Jul, then rise to poorly observed Max, around 8.9 in early Sep. Fade to 10.7 by Oct. No further observations.

SU Lac – Poorly observed. At Mag 15 (V Band) in Jan, then rise from 14.5 (Vis) to Max, 11.4 in Jul. Fade to 13.8 Nov, with further fade to 15th mag (V Band) by end of year.

R Leo – Fade from near Max at approx. 5.8 in Jan to 11.0 in Jun., then lost. Recovered in Sep at 7.5. Then rise to Max 5.8 in early Nov before fade to around mag 8 in Jan 2021. Below is a 5-year light curve for R Leo, covering 2016-2020.

Light Curve for R LEO



RS Leo – Poorly observed. Fade from possible Max 11.2 in early Mar to 13.7 in mid-May. Only two further estimates during remainder of year.

R Lep – Poorly observed. Possible Max around 7.2 in Dec.

W Lyn – Poorly observed. Fade from Max 10.5 in Dec 2019 to Min of 15.8 in Apr. Rise to 13.5 in May, then lost. Recovered at/near Max of 10.3 in Sep, then fade to 13.3 (V Band) in Dec.

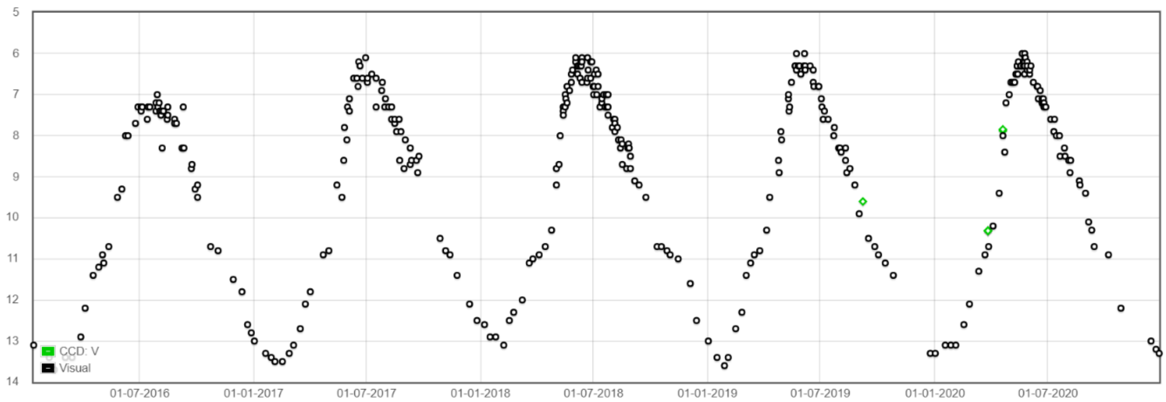
X Lyn – Poorly observed. Rise in V Band from 15.2 in Jan to Max 9.8 in Apr. Visual observations near max agree closely with V Band results. Lost in Jun, with only two sightings during remainder of year, 13.8 Sep, and 15.6 (V Band) Dec.

X Oph – At Max 6.9 at start of year. Fade to long flat Min 8.4 from May to late Jul. Rise to 6.6 in Nov, with slight fade to 7.0 by end of year.

U Ori – Rise from 13.2 to Max 7.5 in early May, then lost. Recovered in Sep, around 10.2, before fade to bright Min of approx. 12.3 in Dec 2020/Jan 2021.

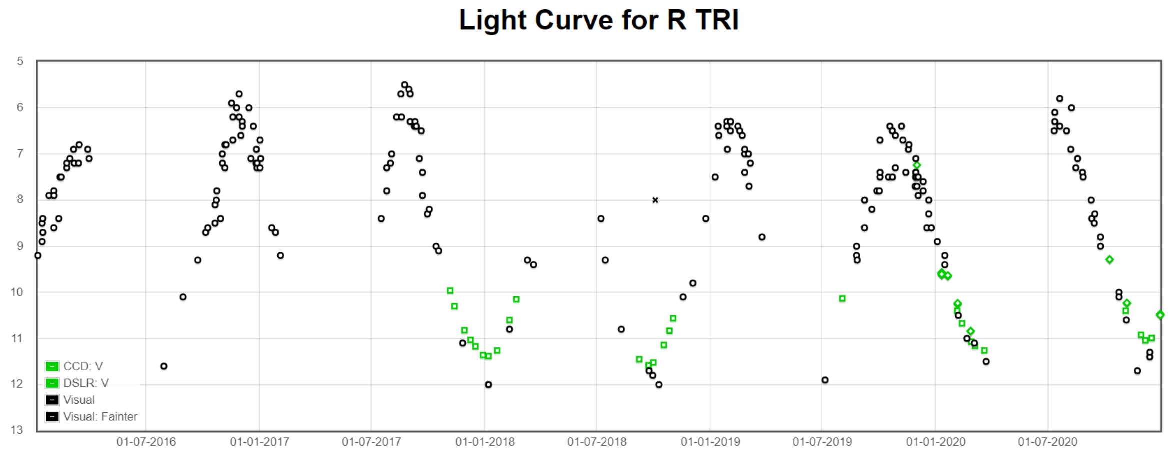
R Ser – Rise from Min, 13.2 in Jan to Max 6.0/6.3 in May. Fade to mag 13 by end of the year. A 5-year light curve (2016-2020 inc.) is shown below.

Light Curve for R SER



Back to contents

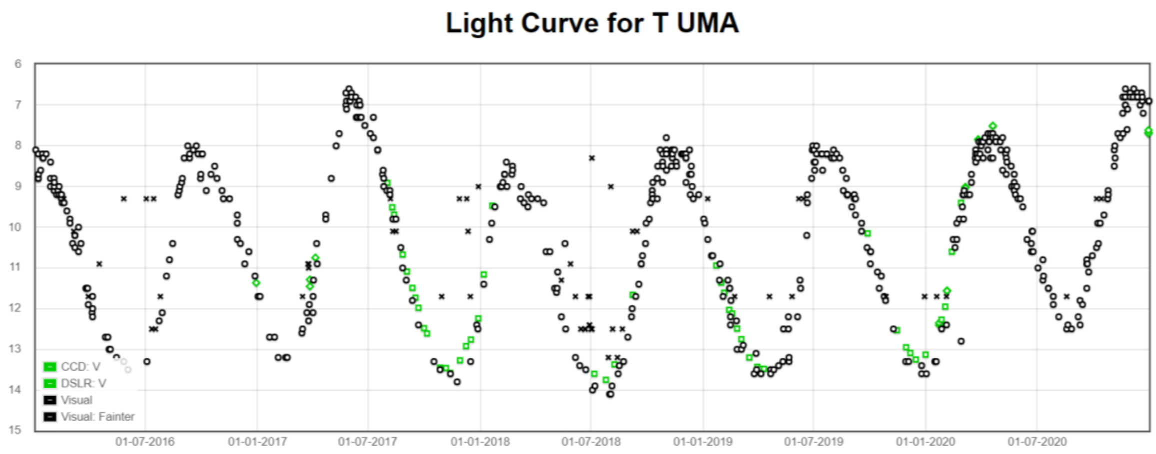
R Tri – Fade from 7.5 towards Min, 11.6 in Mar, when lost. Recovered at/near Max, approx. mag 6.0 in late Jul. Fade to Min, 11.0 (V Band), 11.4 (visual) in Dec. A five year light curve is shown below.



R UMa – At Max 7.3 in Jan, then fade to poorly observed Min, approx. 12.8 in Jun. Second Max approx., 7.9 Oct/early Nov. Fade to 9.5 by end of year.

S UMa – Large scatter. Rise from mag 9 in Jan to Max mag 8 in Mar. Sharp fade to 11.8 in Jul. Second Max observed in Sep/Oct around 8.5, fade to 10.9 by end of year.

T UMa – Well observed. Rise from 12th mag in Jan to fainter Max, 7.8, in Apr. Fade to Min,12.5 in Sep. Rise to brighter Max 6.7 in late Nov/Early Dec. A five year light curve is shown below.



S UMi – Max 8.2 (V Band) in Feb, then fade to 11.3 by end of Jun. A second broader Max was observed in Dec, 8.4 (vis), 8.1 (V Band).

R Vul – Very poorly observed. Max at 6.8 observed in Jan.

Back to contents

A shallow minimum of Betelgeuse in April 2021 in agreement with the recent 430 day period

Mark Kidger
ESA/ESAC

Predictions based on recent behaviour of Betelgeuse led to the speculative suggestion that a new minimum to magnitude +1.0 approximately should occur around 2021 April 12, with a possible error of around ±10 days. Photoelectric photometry and visual estimates show a minimum to magnitude +0.9 on 2021 April 23±5, in reasonable agreement with predictions. A new study supports the core-collapse supernova end-of-life model for Betelgeuse, but suggests that it is much further from supernova explosion than previously assumed.

Interest in Betelgeuse remains high. No fewer than 6061 visual estimates have been submitted to the AAVSO database since the start of 2019 (3880 for the 2019/20 observing season, 1716 for 2020/21, compared to an average of 780 for the ten years prior to 2019 and an average of 320 per year over the full 125 years of lightcurve coverage). This interest has provoked numerous recent studies of the star. For example, Joyce et al. (2020, ApJ, 902, 63) added nine years of high-accuracy photometric data from the Solar Mass Ejection Imager (SMEI) instrument aboard the Coriolis satellite, obtained from 2003-2011 to the AAVSO record since 1928. They find a pulsation period of 416±24d and a long secondary period 2365±10d (6.48 years), although they note that neither strictly cyclic. When these periods were removed from the lightcurve, a further pulsation period of 185.5±0.1d remains in the modern, photometric data. Such excited oscillation modes take as long as 150 years to build up in a star of 19 Solar Masses, around the suggested current mass of Betelgeuse.

They also suggest that there are suggestions of a 35-40 year dimming cycle in the full lightcurve, similar to the estimated rotation period of 35 years. From a combination of datasets with multiple simulations of evolution and oscillations, they concluded that the distance of Betelgeuse is 548 light years, with a range of uncertainty from 499-634 light years, similar to the "traditional" value for the distance and smaller than recent determinations from radio data. Finally, they conclude from the pulsation periods in the lightcurve that the mass of Betelgeuse is in the range from 16.9-19 Solar Masses and that it is early in the helium-burning phase, rather than half-way through, or late in it, as has been assumed typically previously. Betelgeuse is heading for a death as a Type IIp supernova, but maybe not for another half a million years.

Joyce et al. (2020) find that the low amplitude variability of Betelgeuse is due to a combination of short-lived pulsation modes and the effects of giant convection cells in the photosphere. However, deep minima, such as that of 2020, require other causes, such as dimming by dust clouds. Among the more intriguing suggestions is the conclusion that the high measured rotational velocity of Betelgeuse (15km/s) giving a rotation period of 31±8 years (Kervella et al. 2018, A&A, 609, A67) is extremely difficult to account for by standard stellar evolution models. Wheeler et al. (2016, MNRAS, 465, 2564) had suggested that the star absorbed a 1 Solar Mass companion as it expanded, leading to spin-up of the rotation of the primary. Chatzopoulos et al. (2020, ApJ, 896, 50) examined this and concluded that a merger with a 1-4 Solar Mass companion would explain the fast rotation; they also suggest that the runaway nature of Betelgeuse requires the binary to have been ejected from the parent cluster where it formed some millions of years ago and to have merged with its companion after ejection.

Based on the 430 day period (Guinan, Wasatonic & Calderwood, 2020, ATel#13365) and the timing of the 2020 minimum, a prediction was made that a new minimum would occur in early April 2021 (Dupree, Guinan & Thompson, 2020, ATel#13901). However, this was predicted to be a shallower event than the great minimum of 2020, expected to reach magnitude +1.0.

Photometry from the STEREO satellite (Dupree, Guinan & Thompson, 2020, ATel#13901) and photoelectric photometry reported to AAVSO, some of it taken in daylight, shows a fade down to magnitude +1.0 in mid-August 2020, although Betelgeuse had recovered to +0.75 a week and a half later, with the rise missed in an inconvenient gap in data. From late August to the end of October the magnitude oscillated over a small range from +0.60 to +0.82. A systematic fade started in mid-February, with a rate of 0.026 magnitudes/week, reaching a flat minimum of +0.88 around April 23rd, after which, the very scarce data suggests that a recovery has started (Figure 1).

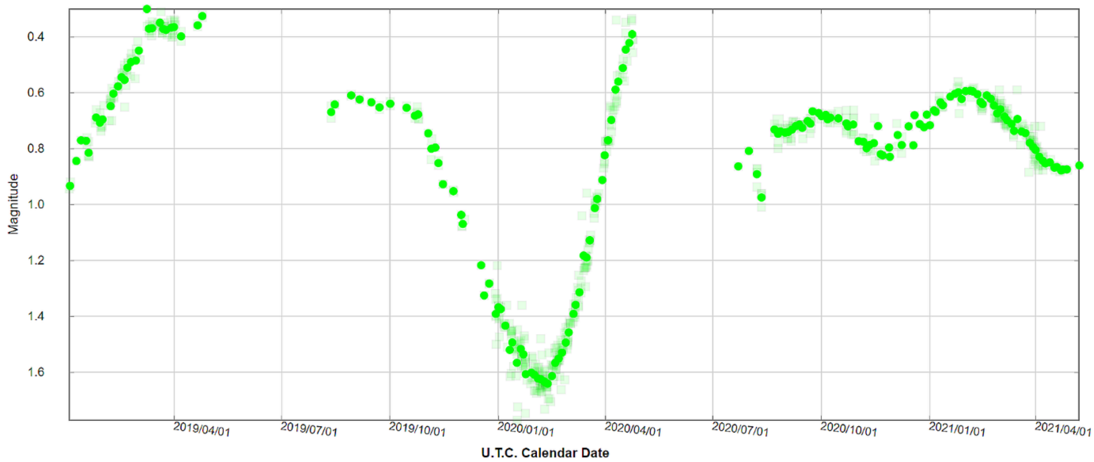


Figure 1: Three day means of photoelectric photometry in V reported to AAVSO from 2019 January 01 to date. A small minimum is seen at 2021 April 23±5 days, but the contrast with the Great Minimum of 2020 is stark.

The apparent date of minimum is in good agreement with the predictions of the 430 day pulsational model, although once again showing that the periodicity is only approximate. This is also consistent with the findings of Joyce et al. (2020, ApJ, 902, 63) who find that the mean period since 1998 is 416±24d whereas, if it were an exact period, we would expect it to be very strongly constrained after 32 years of observation.

Did visual observers detect this predicted April 2021 minimum? A range of 0.3 magnitudes is generally thought to be below the level of visual detectability. The raw lightcurve is, predictably, noisy (Figure 2). There is a hint of a fade, in early 2021, but it is far from clearly above the noise. We see also that in early April 2021, when the mean was magnitude +0.8, magnitudes as faint as +1.5 and as bright as +0.1 were being reported.

Back to contents

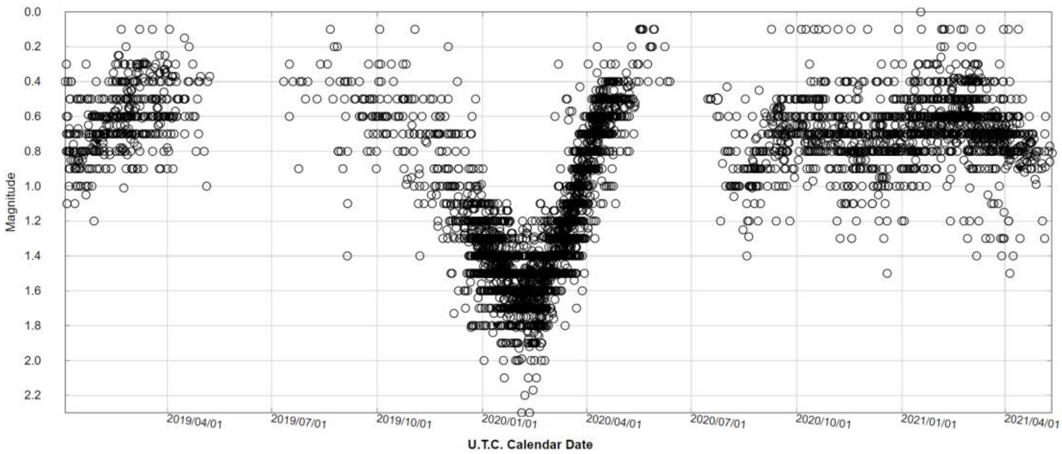


Figure 2: The raw AAVSO visual lightcurve for the same range of dates as Figure 1. There is a hint of a turn-down, but it is far from obvious in the data. Note that some observers are giving magnitudes as faint as +1.5 and as bright as +0.1 when the mean was +0.7.

However, if we take 3-days means of the visual estimates (Figure 3) the fade in early 2021 is obvious and even the small November dip seen in the photoelectric data seems to be present. The very large quantity of estimates does seem to allow relatively low-amplitude variations to be distinguished, following the well-known "gobstopper theorem", whereby if a large number of people estimate the number of sweets (or gobstoppers) in a jar, while the individual estimates will show a large range of variation, the mean of the estimates will be close to the correct number.

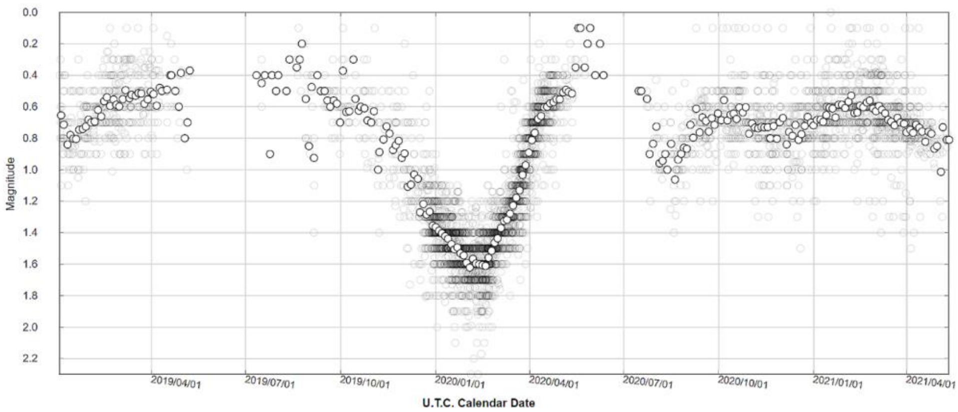


Figure 3: 3-days means of the AAVSO visual data from Figure 2. The fade to the April 2021 minimum is seen clearly in the data.

Conclusions

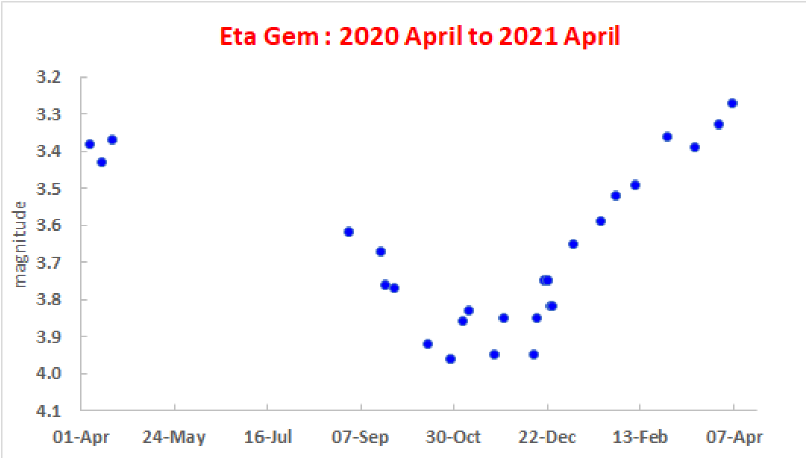
A lightcurve minimum of approximately the time and of the depth predicted from the 430d period is duly observed in the lightcurve of Betelgeuse. This is consistent with models of Betelgeuse as a star of approximately 18 Solar Masses that is in an early phase of helium burning and generating semi-stable pulsational modes. While the low-amplitude variations are due to a mix of pulsations and of variations caused by convection cells, there is even some evidence of rotational modulation of the lightcurve with a period of 30-35 years, while the deep minimum seen in 2020 is still, most likely, due to dust absorption, although some authorities dissent from this view and suggest other models such as superstarspots.

eta Geminorum and VZ Cancri

Tracie Louise Heywood

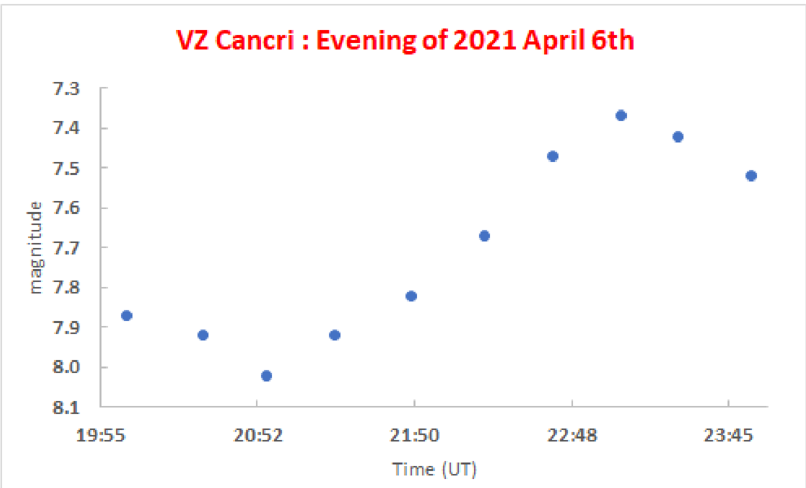
My visual observations of the autumn 2020 eclipse of eta Geminorum, and VZ Cnc: A delta Scuti type variable that can be followed using binoculars.

eta Gem is usually quoted as having a magnitude range of about 3.0-4.0. Half of this range is due to semi-regular variations with a period of about 233 days. The other half is due to eclipses that occur approx. every 2984 days (8.17 years). Based on observations of previous eclipses, I was expecting mid-eclipse to occur around late November 2020. Totality normally lasts for about a month, but the presence of the semi-regular variations can make it difficult to be certain as to the duration of the partial phase.



Looking at my light curve, which includes naked eye and 10x50 binocular estimates, it seems likely that mid-eclipse actually occurred in early November. The star was most likely fading into a semi-regular minimum when it emerged from August's morning twilight, but my best guess would be that that partial phase started in late August and that after totality the partial phase lasted until mid-January.

VZ Cancri is a delta Scuti type variable. Most stars of this type have brightness ranges that are too small to be followed accurately using visual observations. VZ Cancri is a notable (and welcome) exception, having a range of 0.7 magnitudes and a period of approx. 4.3 hours. The light curve shows my observations, using 11x80 binoculars, during the evening of 2021 April 6th.



Observations ended when the star disappeared behind my neighbour's house!

Back to contents

V572 Cam: Period calculation from a single cycle, preliminary analysis

Geoff Chaplin

High frequency CCD data for HADS variable V572 Cam obtained on a single night is used to calculate the period. Analysis of many data sets then gives an indication of possible variation. A description of further research, and what further data is required, is included.

This note examines high frequency observations of the HADS variable V572 Cam (GSC 4556-1113) made by the author on 2 May, 15 Jun, 11 Jul, 9 Oct, 5 Nov, 5 Dec 2020, and 26 Feb 2021 using T21 on the iTelescope network (43cm CDK with FLI-PL6303E camera, 2000m elevation in New Mexico), and by D W G Smith on 2 Mar and 5 Apr 2020 using a C11 telescope with Atik 460EX camera based in the UK. The T21 observations have a reported average accuracy of 0.003mag, and the C11 0.010 mag.

Observations are mostly made at a constant time cadence (1 minute exposure, plus time to download data etc giving 1.375 minutes in the case of Chaplin, shorter for Smith) with occasional long gaps (up to several minutes) when the telescope drive is resetting. Different equipment set-up, as well as different exposure times, can give rise to a different time difference.

Several methods were used to reduce the data noise before analysis. Figure 1 shows data and a 9-point centred moving average (CMA). A 7 point CMA, and also a non-parametric curve using singular spectrum analysis (SSA) were also used with essentially the same results throughout. Both methods required some preliminary data manipulation: for CMA the occasional gap was filled by linear interpolation, and SSA required data at constant time differences, again obtained by linear interpolation.

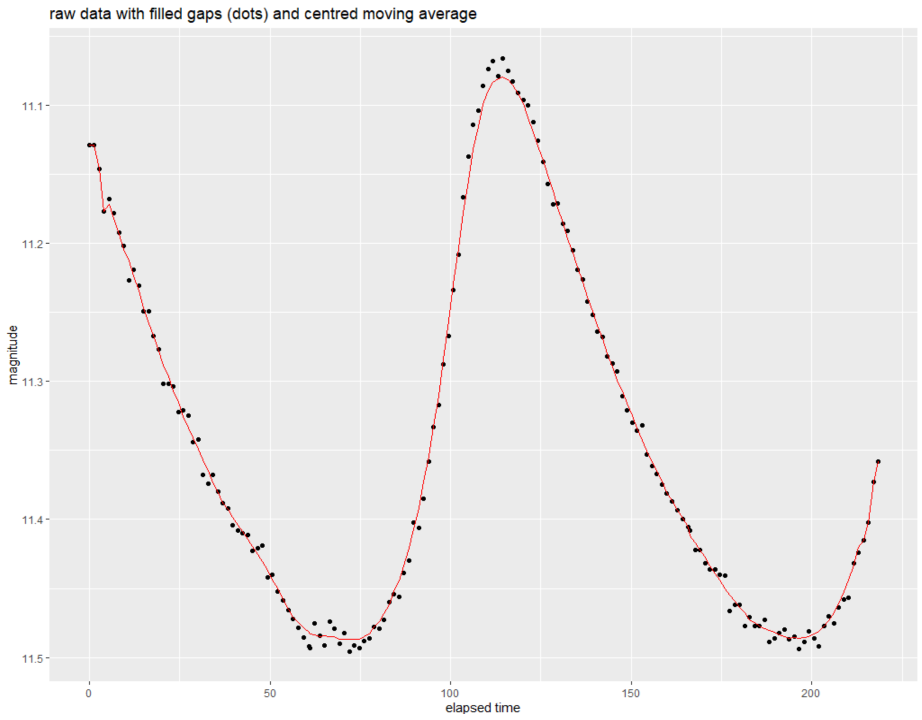


Figure 1: V572 Cam, 6 Nov 2020

The star is known to be a binary – the abstract to the paper by Wils et. al. (IAU Inform. Bull. Var. Stars, 6049, 1 (2013/February-0), “Photometry of high-amplitude delta Scuti stars in 2012.”) says “The binary nature of GSC 4556-1113 has been confirmed” referring to a 164 day period companion, however period variation arising from the binary nature will not be apparent during a single night’s observations.

Apart from the obvious roughly 0.4 mag variability, there appears to be more short-term variability at the fainter magnitude and looking closely at the falling brightness [=rising magnitude] phase there is at least a hint of several steps down, one step sideways. Figure 2 below shows some data from 15 Jun 2020 of the rising magnitude phase and this pattern appears more evident. This and similar noise in the data cause slight high-frequency variation in a smoothed curve which persists when we calculate the period below.

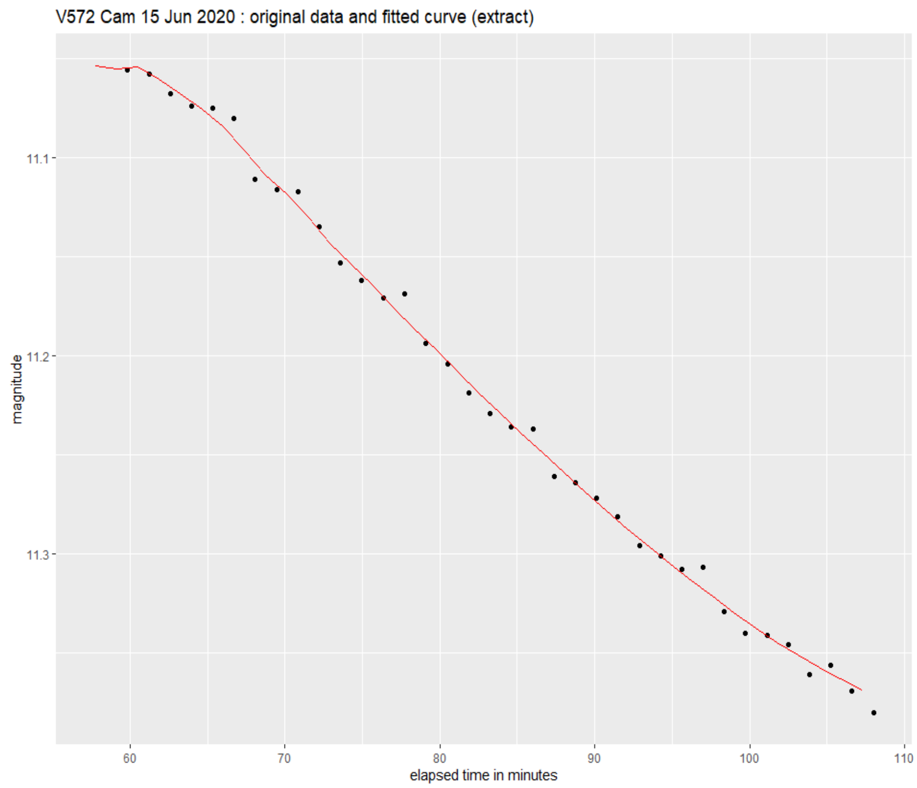


Figure 2:

Figure 3 below shows the data and curve used for Smith’s observations on 2 Mar 2020. In this case the time difference between observations is approximately 0.75 minutes and the curve is defined at these time steps.

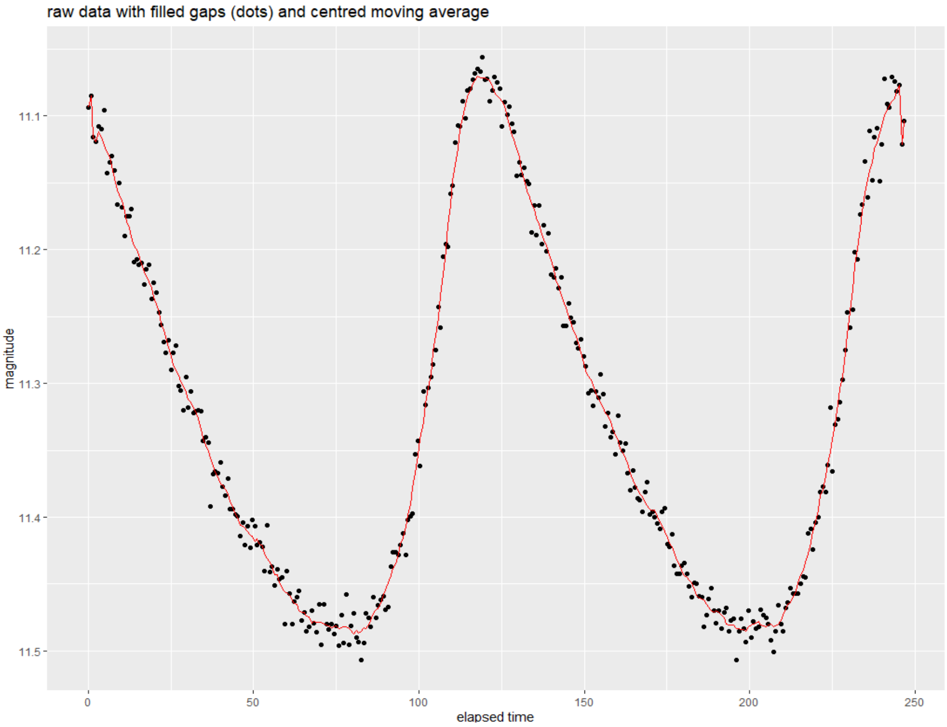


Figure 3: V572 Cam 2 Mar 2020

To calculate the period, we adopt the following procedure. For a rising leg, for each point on the curve we search for the corresponding point [same magnitude] on the following rising leg (which generally requires interpolation between two points at which the curve is defined). A similar procedure is followed for a falling leg. This generates – depending on the smoothing method and observation frequency – between 23 and 90 values for the period in cases where a complete rise or fall are observed. The mean and the standard deviation of these observations is then calculated and shown in table 1.

date	Period (minutes)	stDev	leg
6 Nov 2020	123.86	0.52	rising
	123.97	1.62	falling
6 Dec 2020	124.39	0.28	falling
	124.09	0.40	rising
3 May 2020	124.70	0.69	rising
2 Mar 2020	124.73	0.69	rising
	123.88	0.57	falling
5 Apr 2020	127.64	1.79	rising
	124.20	1.43	falling

Table 1:

Based on these figures there is no significant difference between the periods in these legs and dates. All of these period observation were then amalgamated into a single file one for each observer. Outliers were generally in clusters and were removed and the period recalculated – this gave a period of 124.13 minutes (2 hours 4 minutes 8s) with a standard deviation of 26s – close to the AAVSO quoted period of 2h 4m 20s.

Available data comprises 116 high-frequency CCD series of observations of which about 25 cover more than a full period. These were analysed by the same processes described above and the mean and standard deviations of the periods are shown in Figure 4 below.

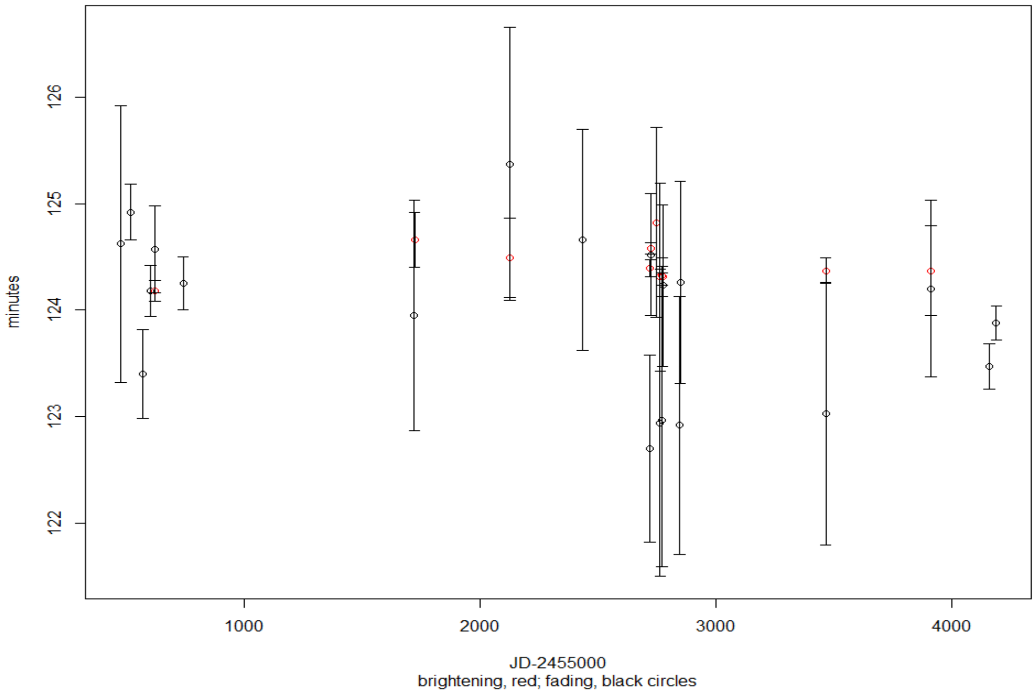


Figure 4: Mean and standard deviation of periods based on a single night's data

The results suggest – but with low confidence – a tendency for the period to shorten or be periodic in the longer term but with short-term variations.

Further research will cover improvement to the noise reduction process and refinements to the interpolation method, but we will also analyse differences between magnitudes recorded on different nights. Different observers with different equipment, comparison stars and reduction software lead to surprisingly large differences in magnitude level and in the range of variability (which at least in part can be corrected by shifting and stretching data) both of which will add uncertainty to final results. However, if comparable sets of observations are, say 30 days apart, this amounts to 360 periods and assuming the period is actually constant over the interval this should lead to a dramatic reduction in standard error – to below a few seconds. Period variation would then become more apparent but is hampered by the clumping of observations over time. Regular – monthly observation – would be ideal, and the star is circumpolar so well placed to observe round the year and without moonlight interference.

The author wishes to thank Patrick Wils for very helpful comments on an earlier version of this paper, and for copies of relevant research material.

Eclipsing Binary News

Des Loughney

Krakow Atlas of O-C Diagrams

The Mount Suhora Observatory have made the following statement on their website.

"*The Atlas of O-C Diagrams has been superseded by newer data available online at http://www.as.up.krakow.pl/ephem. The books are no longer available, and this online version is kept for historical reference only. Please use the new data in any research*."

Recent minima of various Eclipsing Binary stars from Tony Vale

Timings of minima of various eclipsing binaries are presented here. These were derived from observations made by Tony Vale from February to April 2021 using a Startravel 102mm Skywatcher refractor telescope and a Canon 600D DSLR camera. The observations have all been posted 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.

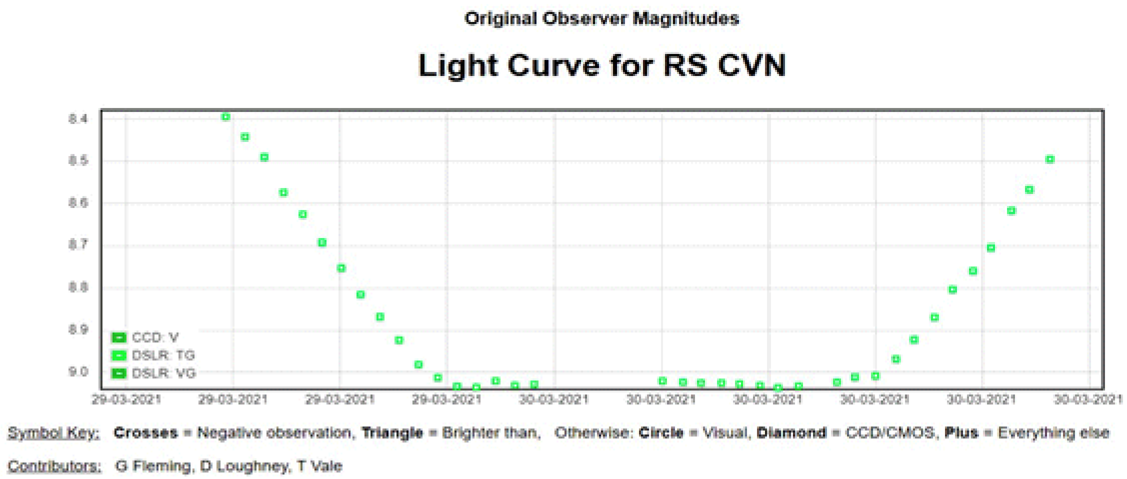
Timings:

Star	HJD of Min	Filter	Error	Type of Minimum
AD And	2459258.35579	TG	0.00122	Secondary
CD Cam	2459264.35862	TG	0.00123	Primary
SV Cam	2459272.40012	TG	0.00025	Primary
AW Uma	2459281.37996	TG	0.00095	Primary
SV Cam	2459291.37768	TG	0.00109	Primary
RS Cvn	2459303.54428	TG	0.00043	Primary
TU Boo	2459308.49690	TG	0.00089	Primary
AG Vir	2459310.43684	TG	0.00017	Primary
AI Dra	2459317.42285	TG	0.00022	Primary
TZ Boo	2459327.45799	TG	0.00022	Primary

References:

Software by Bob Nelson – Variable Stars South

Here is an illustration of the work Tony is doing using DSLR photometry with a 4”refractor and a Canon 600D camera. He has constructed a light curve of RS CVN which illustrates very well a primary eclipse. It is perhaps worth noting that the light curve shows no evidence of the starspots on the magnetically active secondary that are a feature of the RS CVN class of eclipsing binaries. The eclipse took place on the 29th/30th March 2021.

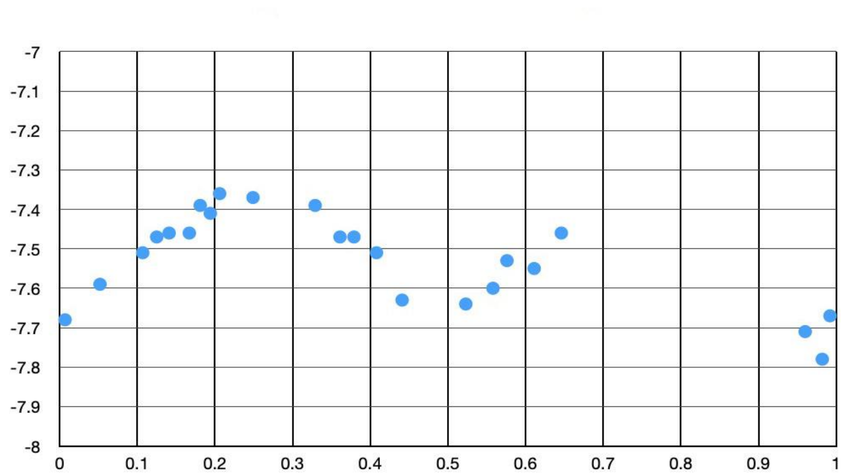


The camera was set to an ISO 100 and an exposure time of 50s. 460 raw images with these settings were obtained. IRIS software was used to reduce these images and to stack them in groups of 12. Each datapoint therefore represents 10 mins of integration time. AstroimageJ was used to perform photometry.

VW Cephei

Starting in April 2021 I have been studying VW Cep. It is an easy system to study as it is bright, is near Polaris and is visible all year round. It is always high up. This is an EW/KW system which is on our observing list of Low Amplitude Eclipsing Binaries. It is a suitable target for DSLR photometry. It varies from 7.38 to 7.78 magnitude. On our list it is described as having a period of 0.2783089 days. However, in constructing my phase diagram I used the latest Krakow period which is 0.2783094 days.

As an EW system it can be observed at any time. It varies quickly going through its whole cycle in 6.67 hours. The Canon 550D settings were ISO 800, exposure 5 seconds. 20 images were taken for each point on the phase diagram. The images were stacked and analysed with AIP4WIN. I used three comparisons which were HIP 100504 (7.79 magnitude), HIP 101824 (7.07 magnitude) and HIP 102982 (7.26 magnitude). On the phase diagram below the vertical axis is V magnitude and the horizontal axis is the phase. The measurements were obtained between 15th and 21st of April 2021.



Back to contents

I have referred to the 2018 paper written by T.Mitnyan et al which is entitled ‘The contact binary VW Cephei revisited: surface activity and period variation’ (1). This paper indicates that measurements of the system can show asymmetry in the light curve. On page one of the paper, it states:

“*A lot of contact binaries show asymmetry in the light curve maxima (O’Connell effect), which is likely caused by starspots on the surface of the components as a manifestation of the magnetic activity. The difference between the maxima can change from orbit to orbit because of the motion and evolution of these cooler active regions. This phenomenon may indicate the presence of an activity cycle similarly to what can be seen on our Sun*.”

The measurements can contribute to studies of period variation which is referred to on page 10 of the paper:

“*Nevertheless, the available data suggest that mass transfer from the more massive primary to the less massive secondary star (with a slowly decreasing mass transfer rate) is the most probable explanation of the observed period variation of VW Cep*.”

My studies of this system will continue with a goal, later on in the year, of measuring a whole cycle in one night.

Reference:

(1) The contact binary VW Cephei revisited: surface activity and period variation. T. Mitnyan et al

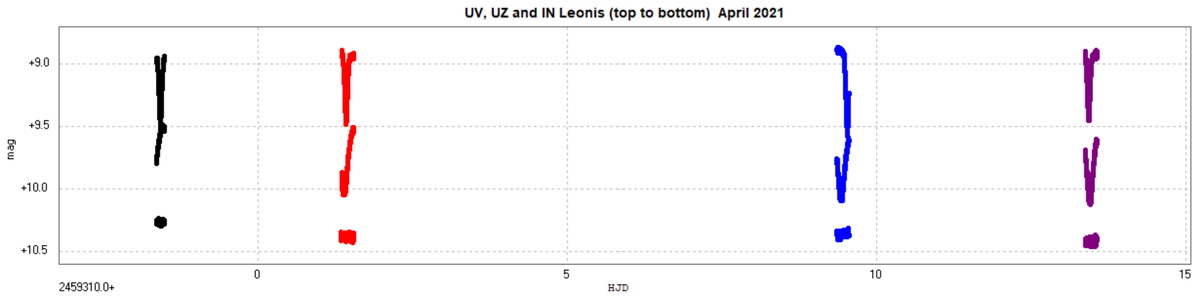
Three for the price of one

David Conner

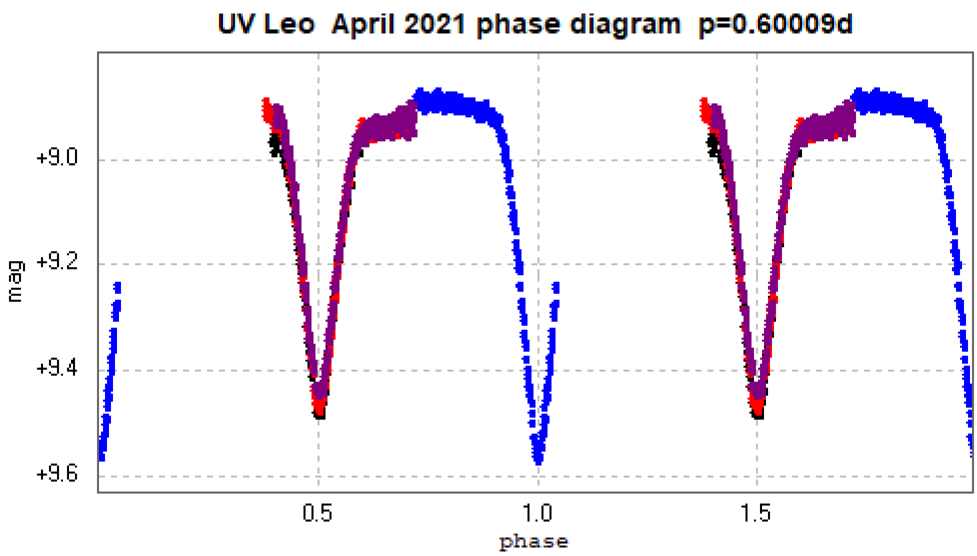
Three variable stars in Leo fall within one field of view of my camera; UV, UZ and IN Leonis. These are the results from a number of observing runs during April 2021.

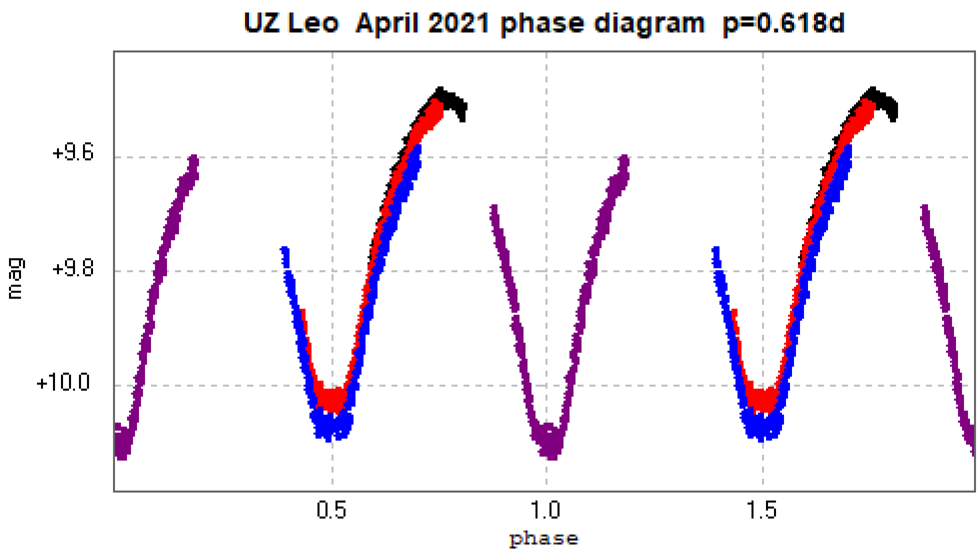
April 2021 had several clear nights which I used to make observations of the eclipsing binaries UV Leonis and UZ Leonis, hoping to generate complete phase diagrams. These objects are less than a degree apart and both will fit into the same field of view of my set-up (Atik Titan camera with 50mm aperture ~f4 objective lens). As an added bonus, the RS type variable star IN Leonis is also in the field of view. All observations used in this article were made without a filter.

The combined light curves appear below (UV top, UZ middle, IN bottom), with black being the night of April 3-4, red April 6-7, blue April 14-15, purple April 18-19.

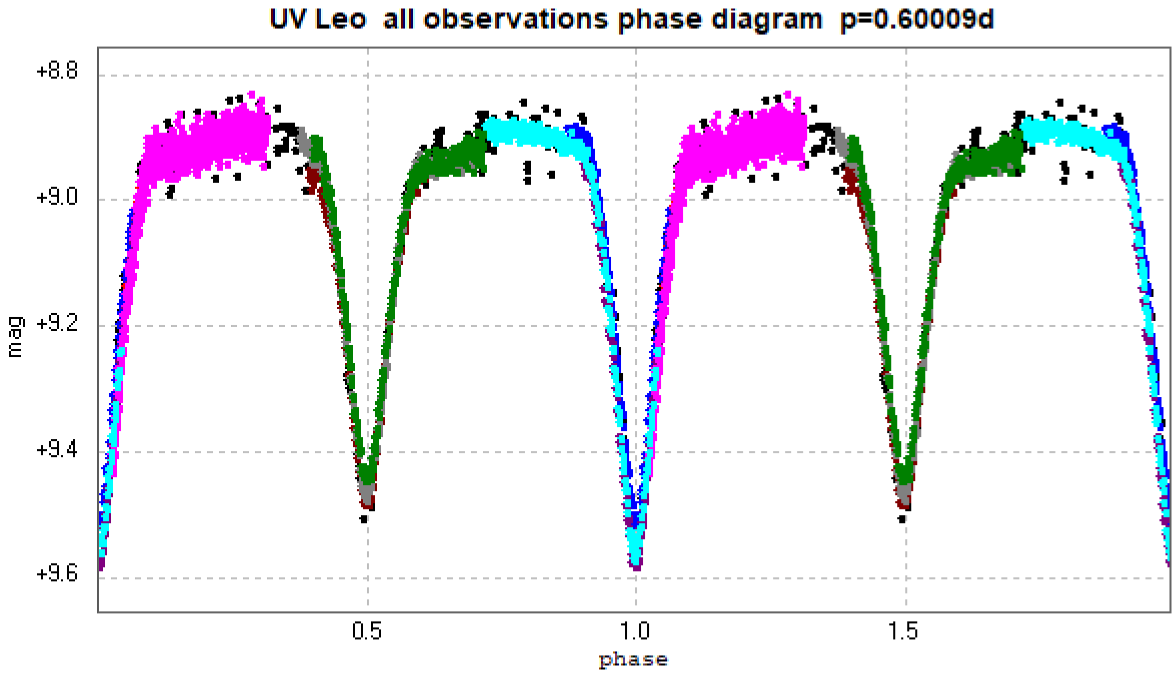


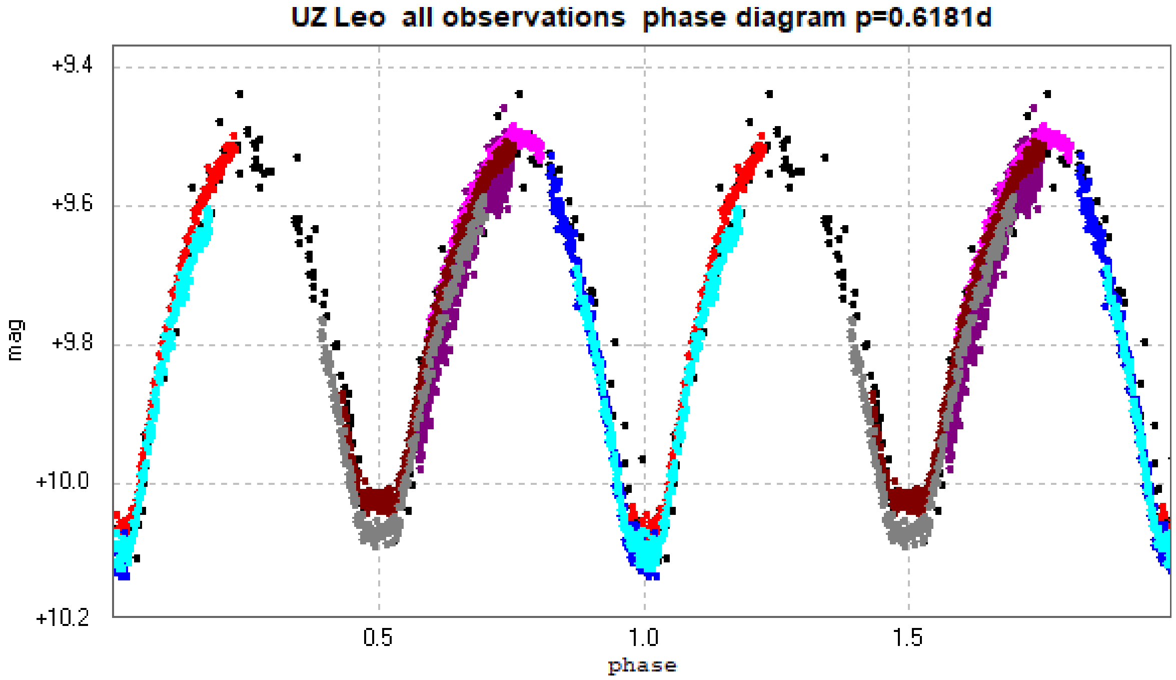
The resulting phase diagrams of the UV Leo and UZ Leo systems are below.





There are gaps in the phase diagrams of UV and UZ, but when combined with historic observations from Somerby and the [Bradford Robotic Telescope Cluster Camera] (BRT) then more complete phase diagrams are possible.



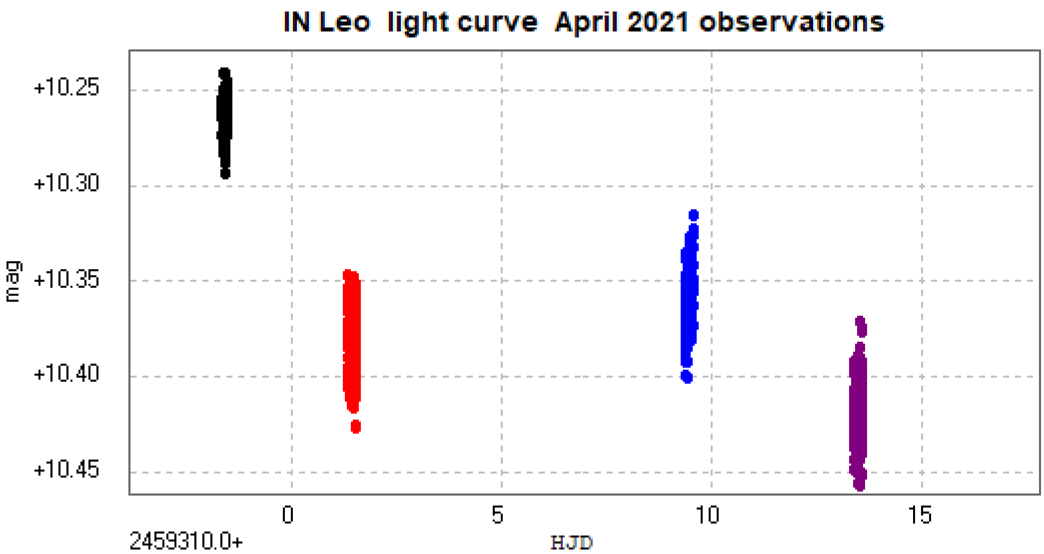


Given the short time over which the observations were made, the inequalities of the minima and maxima on different nights are quite possibly due to observational/photometry issues of some kind. More observations and further analysis needed.

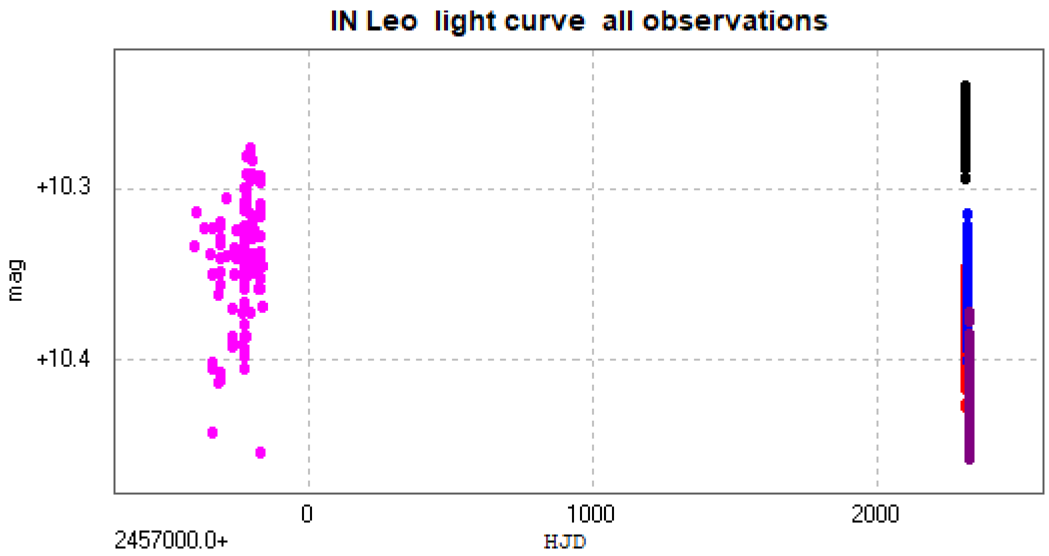
Times of minima obtained from these observations, using Peranso/ANOVA, are as follows.

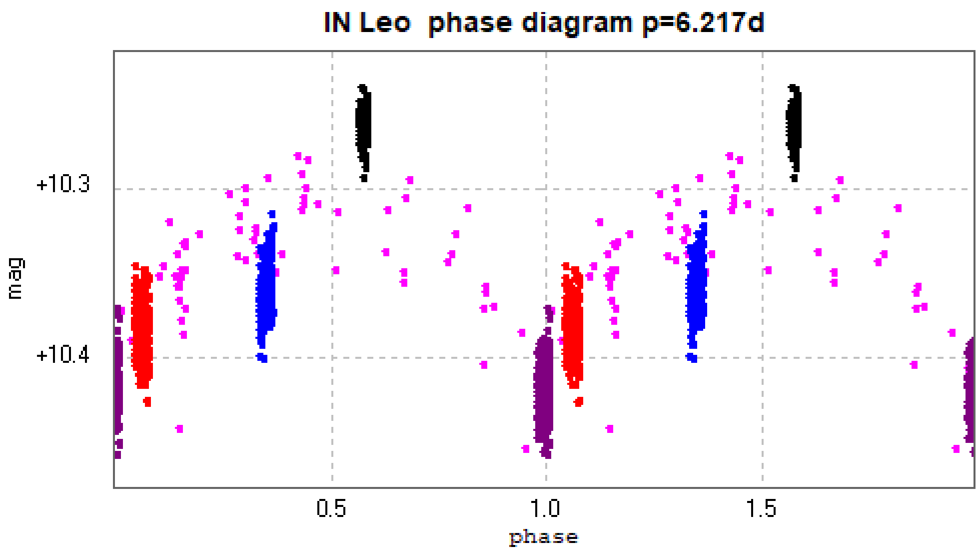
Star	HJD of minimum	Filter	Error	Type of minimum
UV Leo	2459308.42353	CV	0.00005	Secondary
UV Leo	2459311.42411	CV	0.00005	Secondary
UZ Leo	2459319.42586	CV	0.00009	Secondary
UV Leo	2459319.52475	CV	0.00007	Primary
UV Leo	2459323.42589	CV	0.00006	Secondary
UZ Leo	2459323.44466	CV	0.00006	Primary

The field star IN Leonis is catalogued as an RS type variable (i.e. non-eclipsing, as opposed to, e.g., EA/RS type) with a period of 6.217 days (GCVS, AAVSO VSX accessed 2021 May 13). This is a little fainter than both UV and UZ, and the exposures are not ideal for this star. As before, black is the night of April 3-4, red April 6-7, blue April 14-15, purple April 18-19.



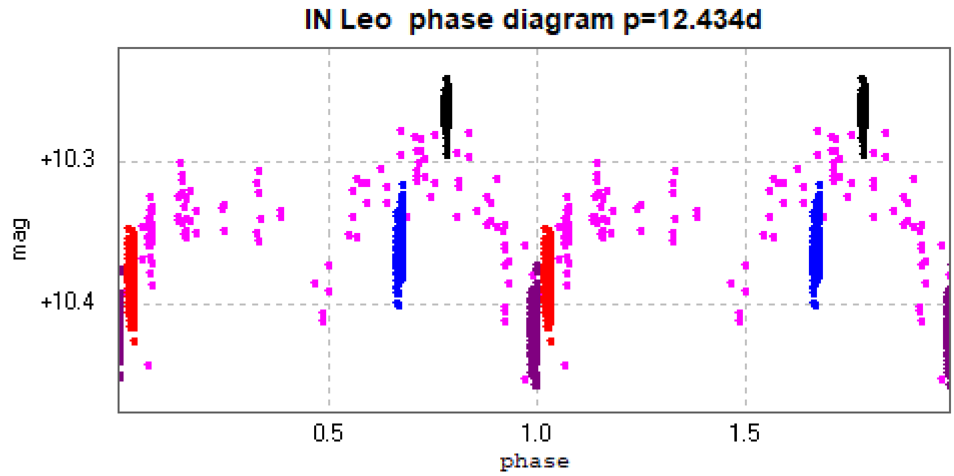
Adding photometry from Bradford Robotic Telescope Cluster Camera images of UV Leo and UZ Leo (2014 January 1 to 2014 June 28, in magenta) generated the following light curve and phase diagram.



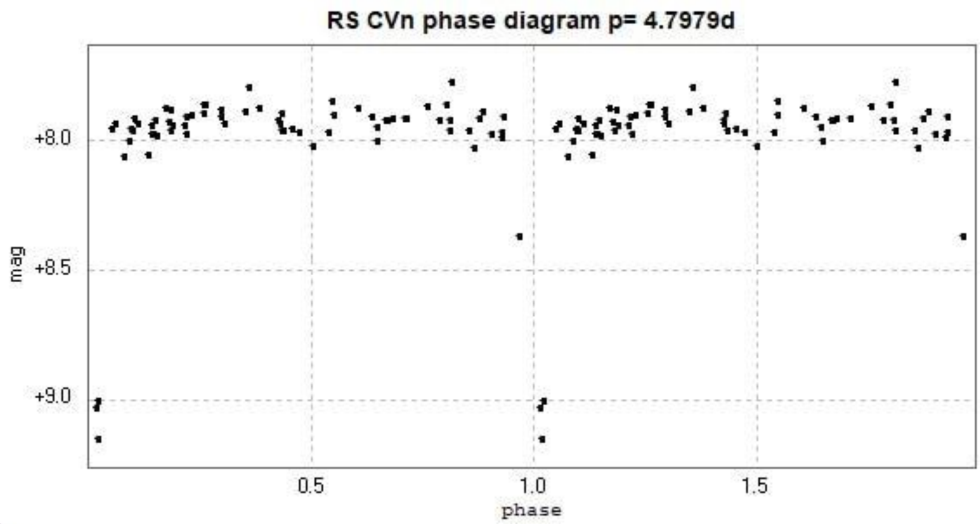


It will be seen that the BRT data generates a moderately symmetrical phase diagram, but the April 2021 observations are not a good fit to this, particularly those of April 14-15 and 18-19. As well as possible observational 'glitches', this could be due to chromospheric and/or spot activity within the system, together with nonsynchronous rotation of one or both components (*op cit).*

A slightly improved fit can be obtained by using a period of 12.434d, i.e. double the catalogue period, as below. This generates two minima per cycle of different depths. Additionally, with this data at least, the two maxima are also different magnitudes, consistent with spots and/or chromospheric activity within the system.



EA/RS type variables do have phase diagrams with these characteristics, e.g. Conner (2018) and Li-yun Zhang and Sheng-hong Gu (2007).



Whether or not eclipses occur in this particular system is another matter, and this feature of the phase diagram could simply be an artefact due to gaps in the data at the relevant phases of 0.25 and 0.5 for a period of 12.434 days.

It should be noted that a similar exercise using ASAS data does *not* generate minima of alternating depths, or maxima of alternating heights, using either of the two periods (6.217d and 12.434d). [The link allows you to plot phase diagrams of ASAS data with selected periods. It can also be accessed via AAVSO VSX website – select *ASAS Light Curve* in the External Links 'Location' box.]

This system would benefit from more observations and analysis, and has now been added to my ongoing COAST observing program with optimised exposures using a V filter.

More information about these and other observations can be found on my website.

Follow up observations of
GSC 03421-01402 aka UCAC4 709-047369

James Screech

This article describes the process followed to determine the period of the recently discovered eclipsing binary star UCAC4 709-047369 (GSC 03421-01402). The observations used were the work of Walter F. (Štefánik Observatory, Prague, Czech Republic) and the author.

Having reported on the discovery of GSC 03421-01402 as an EA eclipsing binary in the March 2020 edition of the circulars, this is a follow-on report on an investigation and subsequent discovery of its period.

The initial minimum was discovered timed at approximately 2458847.39 (the evening of 29th December 2019) see figure 1. Further observations during the 2019-20 observation window failed to discover any further minimum, however during the next window a second minima was discovered at 2459208.35 figure 2 (the evening of 24th December 2020). The time between minima being 360.96 days, thus the period must be this or a sub-multiple of this time. A computer application was written by the author to help determine the period by discounting possible sub-multiples of 360.96 days by the use of negative observations.

Then while searching the internet I came across observations of this star by [1]Walter F. (Štefánik Observatory, Prague, Czech Republic) showing a possible minimum at 2458532.52 figure 3. When this timing was added to my period finder application together with my first minimum and negative observations the possible periods (in days) were determined are listed in table 1. My own observed minima gave the possible periods shown in table 2.

When the two tables are cross referenced the best matching periods are 7.6798 & 7.6800 days, a difference of about 17 seconds. Using a period of 7.68 days I made a prediction that there would be an observable minimum at approximately 2459323.55, a few days in the future and the weather forecast was looking promising for once. Observations were made at the appropriate time and another minimum found at the predicted time, figure 4.

When this timing was combined with my second minimum the possible periods calculated is shown in table 3, again the only close period is 7.6797 days.

In conclusion I believe that this proves that the period of this eclipsing binary is approximately 7.68 days. Figure 5 shows a phase diagram of all my observations plotted with this period. Although there are several gaps, where no observations have been obtained and a few outliers (possibly due to cloud) the observations fit this period well. The minima's observed are all of a similar depth (0.15m) and as there is no sign of a second minimum it looks like these are observations of primary eclipses and that the system may not have secondary eclipses, or they are of very small brightness reduction. However, it is possible that a second eclipse could be hidden in the missing gaps in the phase diagram if the star's orbit is non-circular.

[1] Walter F. (Štefánik Observatory, Prague, Czech Republic) http://var2.astro.cz/EN/obslog.php?obs_id=1305470210&projekt=%25&star=GSC%2003421-01402%20Lyn&lang=en&shv=Lyn

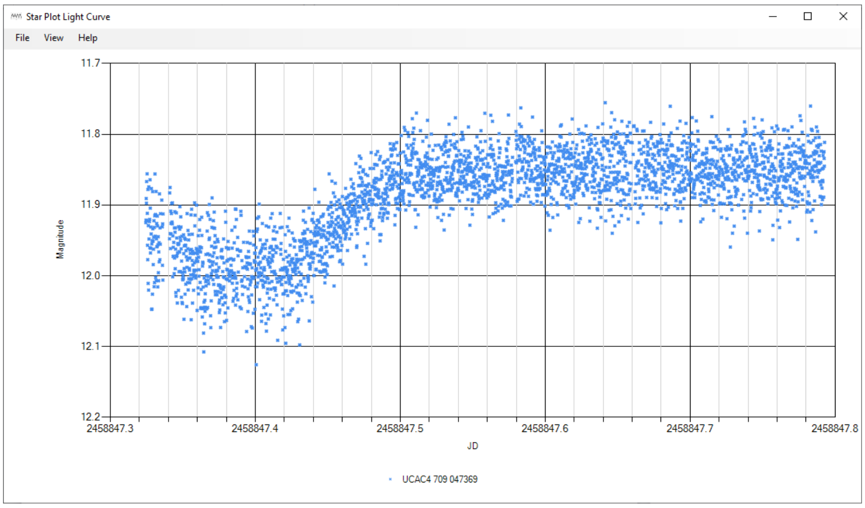


Figure 1

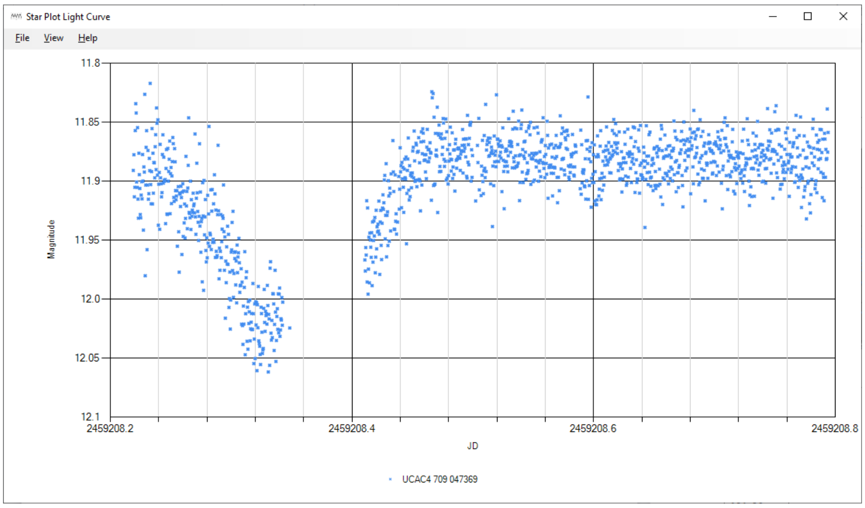


Figure 2

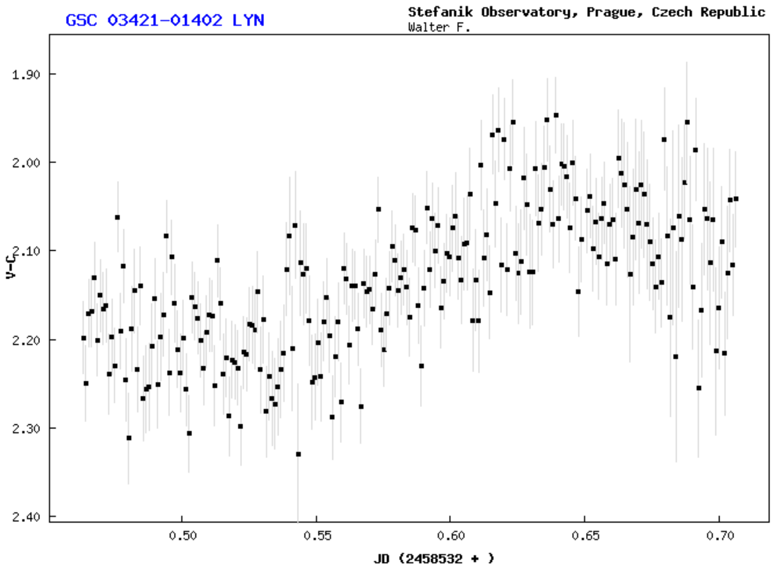


Figure 3

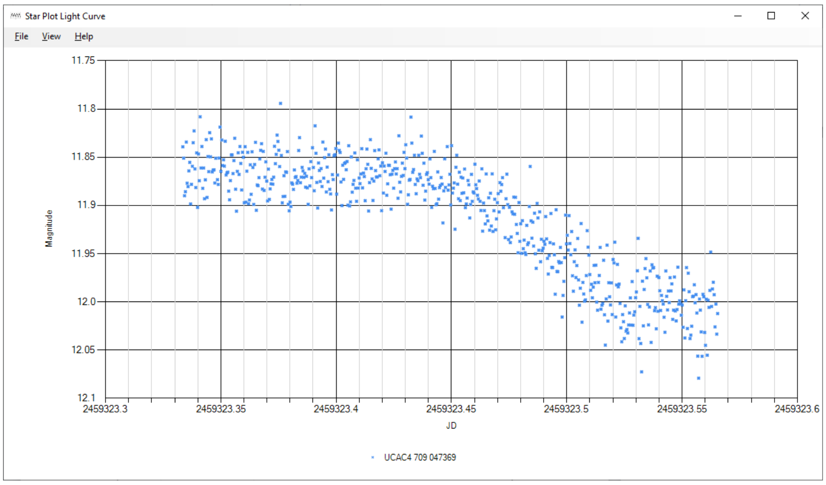


Figure 4

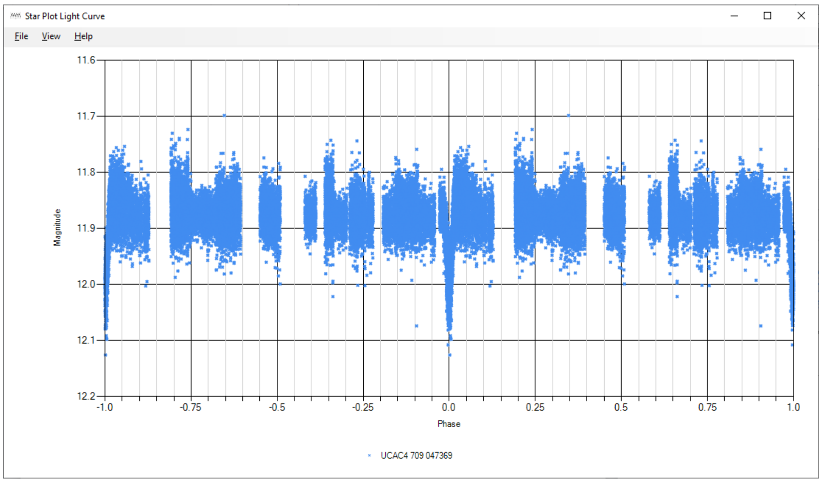


Figure 5

Table 1: (*days*)	Table 2: (*days*)	Table 3: (*days*)
314.87	360.96	115.20
157.44	180.48	57.597
104.96	72.192	38.398
78.718	51.566	28.799
62.974	40.107	23.039
52.478	36.096	19.199
44.982	32.815	16.456
34.986	25.783	14.399
28.625	18.998	11.520
26.239	16.407	8.8612
24.221	15.694	7.6797
22.491	14.438	7.1997
16.572	13.369	6.7762
14.312	11.644	6.0629
12.595	7.6800	5.4855
11.662	6.1179	4.4306
11.245		2.4510
8.8996		
7.6798		
5.9410		

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Back to contents