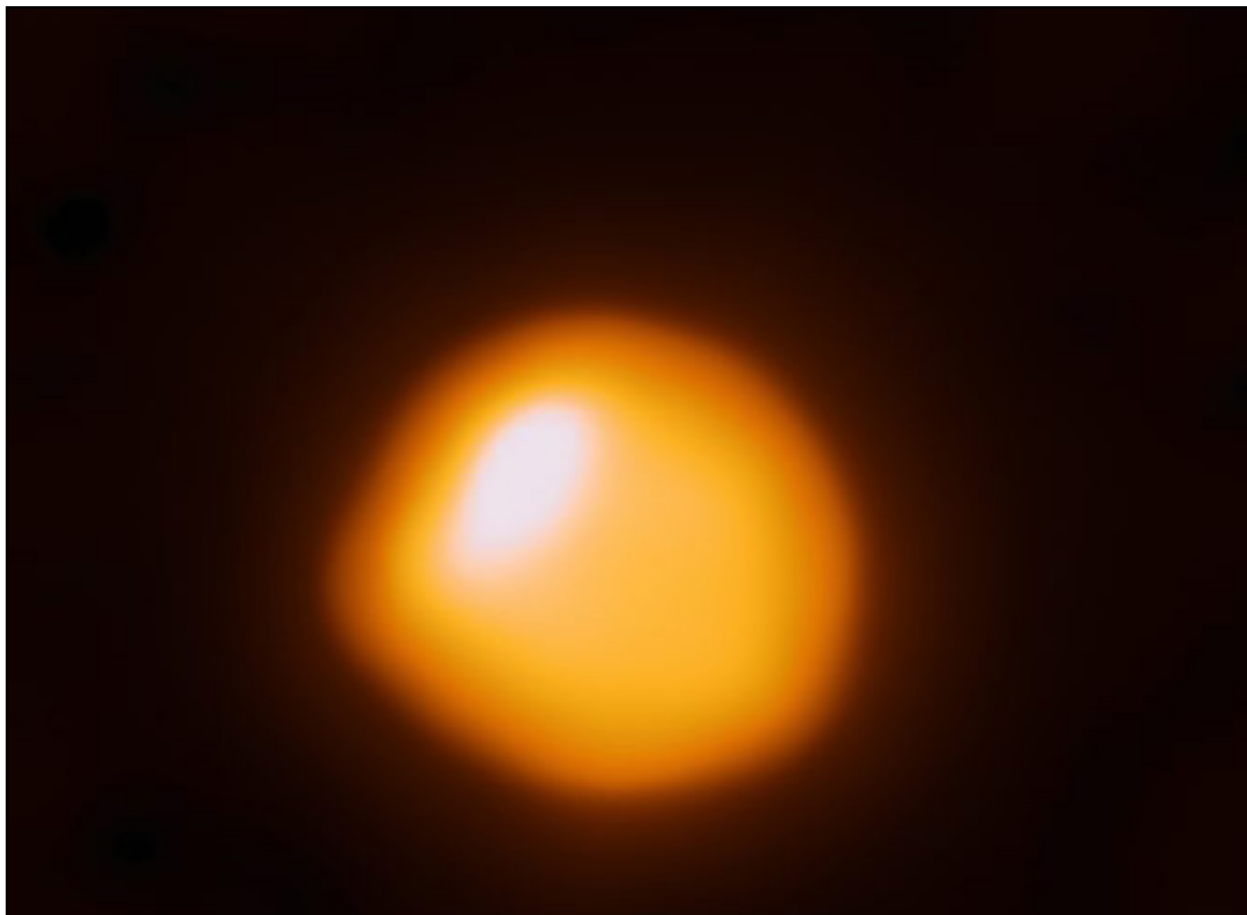




Betelgeuse, a red giant star, has been in the news lately for an unexpected dimming. Some have speculated that it will soon explode in a supernova, however it seems that the dimming may have been induced by a dust cloud. Stan Walker has an interesting article on colour photometry of Betelgeuse on p 13. (Image Credit: ALMA (ESO/NAOJ/NRAO) /E. O’Gorman/P. Kervella)

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From the Director – *Mark Blackford*

Welcome to the third Newsletter of 2020. I hope you've been happy and healthy despite continuing restrictions to our normal lives. One positive has been the opportunity to participate in on-line astronomy meetings. Personally I've enjoyed several of Fred Watson's Cosmic Relief webinars, as well as monthly meetings of the Astronomical Society of Queensland and the Astrophotography Section of the Astronomical Society of NSW.

The Society for Astronomical Sciences and AAVSO held a joint virtual meeting over 5 days in May and June. For a modest registration fee we were treated to a programme of high quality presentations by professional and advanced amateur astronomers and enthusiastic students. People from all around the world participated. The downside for those of us in Australia was the very early morning start (4am for me on the east coast).

AAVSO Observing Sections have also run webinars; including one by the Long Period Variables Section featuring our very own Stan Walker entitled "Miras from an Astrophysical Standpoint". The talk was originally planned for the cancelled VSS Symposium in Parkes. Instead, over 30 people from the US, UK, South Africa, Australia and New Zealand (and possibly elsewhere) enjoyed Stan's talk at the much more civilized time of 8am for me. Links to a PDF of Stan's PowerPoint slides and to a recording of his presentation can be found of the LPV forum (<https://www.aavso.org/lpv-webinar-miras-astrophysical-standpoint>).

More webinars are planned by astronomy groups globally and I encourage you to try them out if you haven't already. Often these are recorded, with many being freely available for anyone to view while others may require membership of the respective societies.

In early June I announced on the VSS Google Group a new collaboration with a group of amateur and professional astronomers in the Middle East, led by Atila Poro. The initial aims of the Binary Systems of South and North (BSN) Project were set out in my post; however Tom Richards suggested some very reasonable changes to enhance the collaboration. I will be discussing these with Atila over coming weeks and hope to finalise project details before the next newsletter.

July has seen the appearance of a very bright nova in Reticulum discovered by Rob McNaught at Siding Spring Observatory and a fainter nova in Sagittarius. See the AAVSO Time Sensitive Alerts forum (<https://www.aavso.org/forum/5012>) for details.

Since the last Newsletter observing conditions at Congarinni have been fair. Both my photometry telescopes are operational again after installing a Skywatcher EQ6-R Pro mount for the ED80 refractor. I observed 14 different targets multiple times over 35 nights, recording in excess of 32,000 images.

Wishing you all clear skies and good health,

Mark Blackford



Updated positions for the LMC II 4801 GCVS stars – *Mati Morel*

mmorel7@bigpond.com

Abstract

I present here the 2nd part of a review of 4801 LMC variables, as listed by the GCVS team (1995, Samus, N.N. ed.). My aim is to provide J2000 positions, accurate to within <1", for the majority of stars, taken from Gaia DR2 (2018). An additional 34 astrometric positions from other sources lifts coverage to >98% of the GCVS stars. A small number of stars (78) could not be identified with certainty, and hence their placeholder GCVS positions are copied in.

Method

Every effort was made to locate and examine original published charts from a wide range of journals and other works. Preliminary positions, where possible, were then compared with previously available positions, from GCVS and SIMBAD. A number of typos were thus found and corrected. Images from DSS were widely used, while additional matches with other catalogues, such as WOH G, WOH S and ASAS, have been noted. The final catalogue uses positions from Gaia DR2 for about 98% of stars. Guide9© software was used, supported by VizierR.

Sources of Positions (column ‘S’)

I give a summary of the astrometric catalogues used, their code letters, and number used.

A	USNO-A2.0 (1998USNO.C.....0M, I/252)	1 star
g	GSC2.3 (Guide Star Cat. v2.3, I/305)	2 stars
G	Gaia DR2(2018yCat1345....0G, I/345)	4690 stars
M	2MASS (2006AJ....131.1163S, II/246)	2 stars
R	Recent literature, usu. for old novae (Morel 2019)	27 stars
U	UCAC3	1 star
X	GCVS Vol. V. II/214A.	[Placeholder, pending]

Type of Magnitude (column ‘FIL’ = Filter)

C CCD-V

V V band

B B band

R R band

G Gaia-G (midway between V and R).

I IR

J J band

K K band

P Photo-blue

Final Table. LMC_VARS_4801.DAT

The format closely follows the catalogue of 4801 LMC variables by the GCVS team (1995, 2002 Samus, N.N. ed.). Their numbering is retained, but all records are now sorted in order of J2000, rather than B1950. I have inserted an extra column, “Mag~V”, to indicate the visual magnitude, roughly. Most values here are Gaia-G, but sometimes they are V or B, and are really for internal use by Guide9.

Other cross-identifications and remarks (not in GCVS) are included in the final column.

Many matches to ASAS variables have been found, from VSX, but I cannot guarantee completeness. All coordinates are for equinox J2000, but epoch 2015.5 for positions from Gaia DR2. True members of

the LMC have vanishingly small proper motion, so can be taken as essentially the same as epoch 2000.

Naming conventions & adopted prefixes

To try to clearly separate the aliases cited by the GCVS team, the following prefixes are used consistently. Additional identifiers have been included where possible from recent surveys such as ASAS-3, but completeness cannot be guaranteed..

CV	Landi Dessy, J., Laborde, J.R. 1966. Bol Inst. mat. Astr. Fis., Univ. Nac. de Cordoba 2, No. 6. [273 LMC variables; Charts unavailable].
DV	Butler, C.J., Wayman, P.A. 1974. Dunsink Publ. 1, No.7.
HD	Nesterov, V.V. et al 1995. The HDE Stars, HA 112. 1995A&AS..110...367N CDS III/182.
Hsusp	Shapley, H., Mohr, J. 1933. HA90, No.1, pp19-20. [82 suspected variables].
HV	Hodge, P., Wright, F.W. 1967. List of Harvard Variables, in Atlas, "The Large Magellanic Cloud" 1967SAOP.4699....1H
LMV	Gaposchkin, S. 1971. SAO Special Report 310. [1850 LMC variables].
SHV	Hughes, Shane M.G. 1989. Astron. J. 97, 1634. 1989AJ.....97.1634H
Sk	Sanduleak, N. 1970. Contr. Cerro Tololo Inter-American Obs., No.89 1970CoTol..89....1S. CDS III/113A.
WOH G}	Westerlund, B.E. , Olander, N. and Hedin, B. 1981. Astron. Astrophys.
WOH S}	Suppl. 43,267-295. 1981A&AS...43..267W.

Bib. codes are given in the final (Remarks) column, referencing papers with published finder charts. Sources with rather long lists of stars are not referenced in this way, to avoid much repetition particularly CV, DV, HV, LMV and SHV.

DV (Dunsink Variable) stars

A list of 307 suspected objects (1974, Butler and Wayman) was studied using the published charts. Accurate positions and G-mags are now available, where none previously existed. Many of the DVstars are very sparsely plotted, creating problems in rich LMC fields. It was necessary to go over the list at least three times, to ensure correct interpretation of each chart. It is stated by Butler and Wayman that their charts were "hand-drawn", implying that some of them used free-hand sketches. It is quite possible, as on many occasions some plotted stars could not be identified on deep DSS images. On the other hand it was not uncommon to find relatively bright stars on the DSS images which were inexplicably missing on the DV charts. One had to be mentally nimble to allow for these quirks, when attempting an eyeball match with the DSS. In the original paper, positions are given in equatorial coordinates, and X, Y coordinates (Harvard system) as well as finder charts. All three methods were used when appropriate.

CV (Cordoba Variable)

Numbered CV334 to CV606, published by J. Landi Dessy (1966) with charts. Charts are not readily available and identification relies on published coordinates. Many CV stars are matched provisionally with stars in astrometric catalogues, but others cannot be identified. Agreement within 1" to 2" is taken as a match, but the reader should be alert to the possibility of the published position being inaccurate, leading to a false identification.

Hsusp stars

This list of 86 suspected variables was reported by Shapley and Mohr (1933). Some appear to be identical with known stars, from positional coincidence, while others are not identifiable. Most of these stars currently lack original photos or charts for verification.

Short list of problems encountered, and resolved

In a long list such as this you would expect to find a number of discrepancies between different sources, especially SIMBAD and GCVS. In fact, minor disagreements were many, too many to list here. Here is a list of **major** problems encountered, and how they were resolved.

- **LMC V0024 = DV38.** Misprint of position in *Dunsink Publ.* 1,7,1974. For RA min 46 read RA min 56 (Equ, 1875).
- **LMC V0088, 0089, 0090.** Three variables grouped together in cluster NGC 1712. The X,Y coordinates for stars 1 & 2 appear to be confused, and hard to reconcile with the chart. I follow the ordering given by GCVS; corrected coordinates now in increasing RA. .
- **LMC V0640 = HV 12506.** GCVS typo. Dec. deg. is -66°, not -69°.
- **LMC V1018 = HV 11978 =LMV 1114.** Positional error. Is really further south by 1.75'. Confirmed in Hodge & Wright, and SAO Spec. Rep. 310.
- **LMC V1729= HV 5704.** Wrong position in SIMBAD, which probably refers to a star 25.24^s following, 1'52.4" S. Hodge & Wright position adopted.
- **LMC V3889 = HV 13001.** Gaposchkin (SAO Spec. Rep. 310) mixes up HV 13001 and 13003. The former star lies 6" NE of TYC 9167-0333 (V=11.14) and is unstudied. He studied the Cepheid LMC V3933 = LMV 1680 = HV 13003. Both HV stars are clearly marked by Hodge & Wright. Appropriate corrections are made in my table.
- **LMC 2454 = LMC V4180.** Is star V22 in *1985MNRAS.214..405G*. The coordinates given are badly in error, and do not match the published finder chart. With perseverance, and a bit of luck, the star in the finder chart was proved to be LMC 2454, an independent discovery. The inferred error in RA is about 18.15min.

Acknowledgements

I acknowledge the use of the VizieR service of CDS, Strasbourg, and also SIMBAD database, without which this work would hardly have been even contemplated.

This work presents results from the European Space Agency (ESA) space mission Gaia.

Gaia data are being processed by the Gaia Data Processing and Analysis Consortium (DPAC).

Funding for the DPAC is provided by national institutions, in particular the institutions participating in the Gaia MultiLateral Agreement (MLA). The Gaia mission website is <https://www.cosmos.esa.int/gaia>. The Gaia archive website is <https://archives.esac.esa.int/gaia>.

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In support of this paper, the full catalogue, LMC_VARS_4801.DAT is now on the Databases & Catalogues page: <https://www.variablestarssouth.org/member-contributed-catalogues/>

Abstract

I report observations of the super-outburst of VW Hyi in October/November 2019, using the Spirit-2 17" (432 mm) Planewave instrument operated by ICRAR/UWA at the University of Western Australia in Perth, supplemented with observations using 2 similar instruments at Siding Spring in NSW. Results were contributed to the AAVSO database and also analyzed in conjunction with data from other contributors to AAVSO.

As VW Hyi brightened to over magnitude 10, I was able to make photometric measurements with a cadence as short as 3 minutes. The observed ‘superhumps’ had a period of 112 minutes, which appears to indicate a continued slight increase in the superhump period from 109.5 minutes seen in 2004.

The measurements also revealed shorter period variations of 35 and 15 minutes, which have not been noted earlier in the literature, and these were partly confirmed by analysis of an excellent data set contributed by another observer in 2011. The signals are most likely due to processes in the accretion disk. I strongly recommend further study of these features using a combination of high cadence observation and computer modelling.

Introduction

Type 1A supernovae are important objects in modern astronomy, as ‘standard candles’ used to provide the distance scale which underpins our estimates of the Hubble Constant, one of the key cosmological parameters describing the evolution of the universe. They occur when a white dwarf star is fed material from a close secondary, and its mass reaches the Chandrasekhar limit (approximately $1.4M_{\odot}$). At this point the star detonates, and becomes very luminous due to thermonuclear reactions in the resultant expanding cloud.

We know that these explosions are not actually standard, there are a number of empirical corrections such as for the duration of the light curve, the metallicity and colour of the supernova, and there is a suspicion that not all detonations are symmetric, so there may be a viewing angle effect. For all these reasons there is scientific value in studying the precursor systems, the cataclysmic variable stars, UG type variables.

Dwarf nova UGSU (SU Uma) systems

The UG dwarf novae systems are binaries consisting of a medium K-M type star which fills its Roche Lobe and spills material via an accretion disk onto a white dwarf (AAVSOWebA). They are characterised by periods of sudden brightening which can last for several days. The system VW Hyi is an example of the sub-type referred to as UGSU (also called SU UMa). In this system there are two distinct types of brightening, a short period ‘normal outburst’ variation with a duration of up to a few days, and a long-period ‘super-outburst’ with a duration greater than 10 days (AAVSOWebA).

Figure 1 shows the key features: the Roche-lobe filling secondary, a stream of material passing through the L1 Lagrange point, the luminous “hot spot” where the stream impinges on the accretion disk, and the accretion disk around the white dwarf.

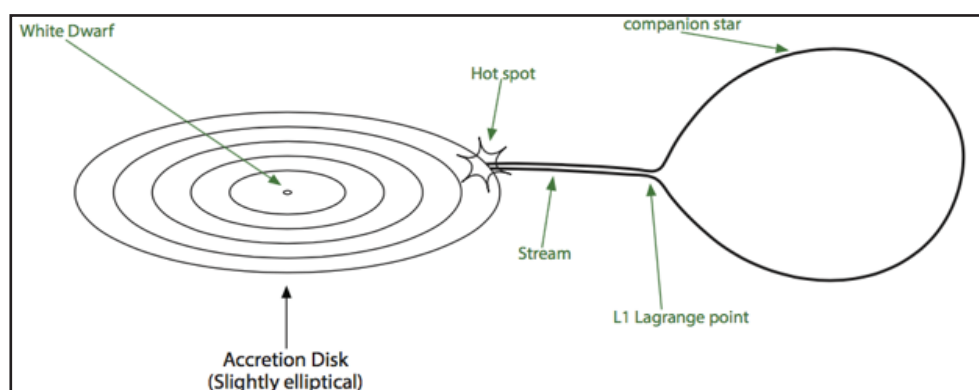


Figure 1. Features of a UGSU Catalytic variable system.

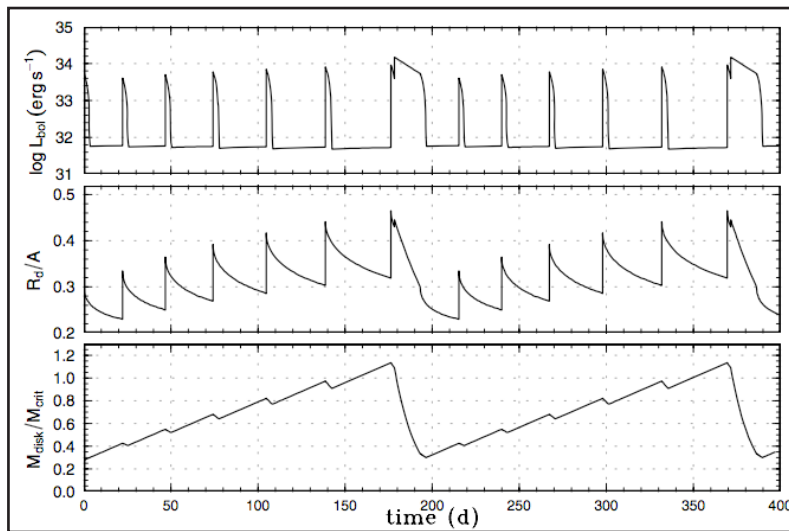


Figure 2. Computer simulation of the behaviour of VW Hyi. Upper: light curve; Mid: radius of accretion disk (as a proportion of the primary-secondary separation); Lower: mass of the accretion disk. From Osaki & Kato (2013)

Figure 2 upper (from Osaki & Kato 2013) shows a computer simulation of the light curve of the VW Hyi system – illustrating the normal- and super-outbursts. There are three sources of luminosity: the white dwarf, the accretion disk, and the ‘hot spot’ where the infalling stream meets the accretion disk. This modelling, and spectral analysis (Long et al. 2009), suggest that during a super-outburst most of the luminosity arises from the accretion disk, whereas the hot spot & WD dominate the radiation during quiescence. The lower two panels show the disk radius and mass.

The current consensus model is that the outbursts are due to instabilities in the accretion disk. As material falls into the accretion disk, the temperature rises until it reaches around 10^4K , at which point hydrogen gas ionizes, greatly increasing the viscosity and reducing flow of material onto the white dwarf (quiescence). The disk grows and cools – when it is below the transition temperature the viscosity suddenly drops and there is a cascade of material onto the WD – an outburst. This cycle repeats, with the disk growing slightly larger at each cycle.

When the accretion disk grows to more than about half the separation of the two stars, tidal forces force the disk into an elliptical shape, and the ellipse begins to precess. This deformation of the disk means that the next outburst is prolonged and a much greater fraction of the disk is able to fall into the white dwarf – a super-outburst.

During the super-outburst, we can observe a periodic variation in brightness, referred to as a ‘super-hump’ (Patterson et al., 2000) – see Figure 3, further apparently random variations referred to as ‘flicker’.

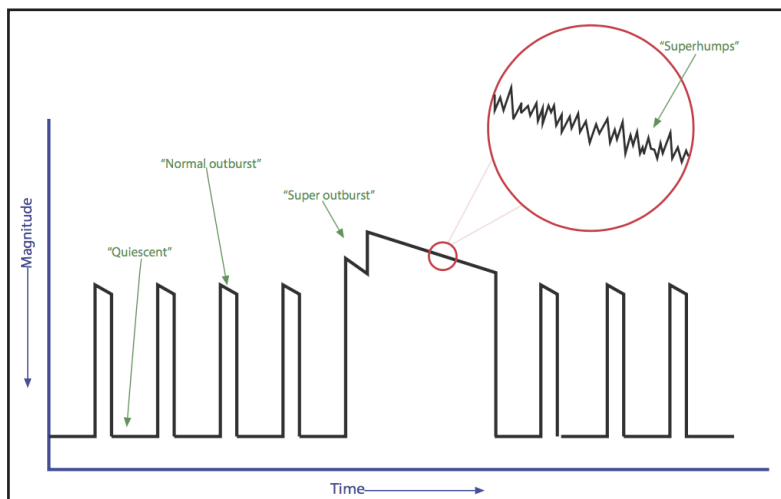


Figure 3. Schematic showing components of the light curve (based on Osaki & Kato 2013)

The superhump period is slightly greater than the orbital period and is believed to be caused by the motion of a tidally-induced pressure wave in the accretion disk. It is common to analyse the periodic behaviour using Fourier analysis, however due to differences in phase between the system orbit and the pressure wave, the peak period from Fourier analysis may not be equal to the observed superhump period.

Target details and experimental methods

In the current study the system VW Hyi was observed from 24 September to 7 November 2019. VW Hyi is of interest, being a relatively well-studied UGSU variable in the southern sky.

The primary instrument used for observations was the Spirit 2 telescope housed at the University of Western Australia (managed by ICRAR/UWA) (SpiritWeb), supported by observations using T30 & T31 in the iTelescope network at Siding Spring (managed by CSIRO). All three instruments are 17" Plane-wave reflectors with automated pointing, focus and image calibration (iTelescopeWeb). All observations were made with the V filter.

Data processing was based around the toolset and observation database of the AAVSO (AAVSOwebA), and data were uploaded to the AAVSO database (AAVSOwebC). Photometry was carried out in the usual manner with 2 comp stars and one check star – different sets were used for quiescence and outburst. The exposure time in quiescence was 3 minutes, during the super-outburst 10 seconds. The shorter exposure time permitting a cadence down to 3 minutes (ie 3 minutes between exposures).

Errors in the measured magnitudes were estimated as:

$$Err = \sqrt{Err_{std}^2 + \left(\frac{1}{SNR}\right)^2}$$

in which Err_{std} is the error in the magnitude of the check star, ie the difference between the catalogue magnitude and that calculated using the comparison stars; and SNR is the signal to noise ratio of the target star. The errors are represented as +/- error bars on the magnitude observations in the next section.

Results

The super-outburst of VW Hyi commenced on 18 October (JD 2458775), and lasted until 1 November. Observations for the entire period are plotted in Figure 4, combined with results from other observers in the AAVSO database using green filters. It can be seen that the super-outburst follows a pattern of rapid increase, plateau/drop off followed by a rapid return to quiescence, at a brighter magnitude than before the super-outburst.

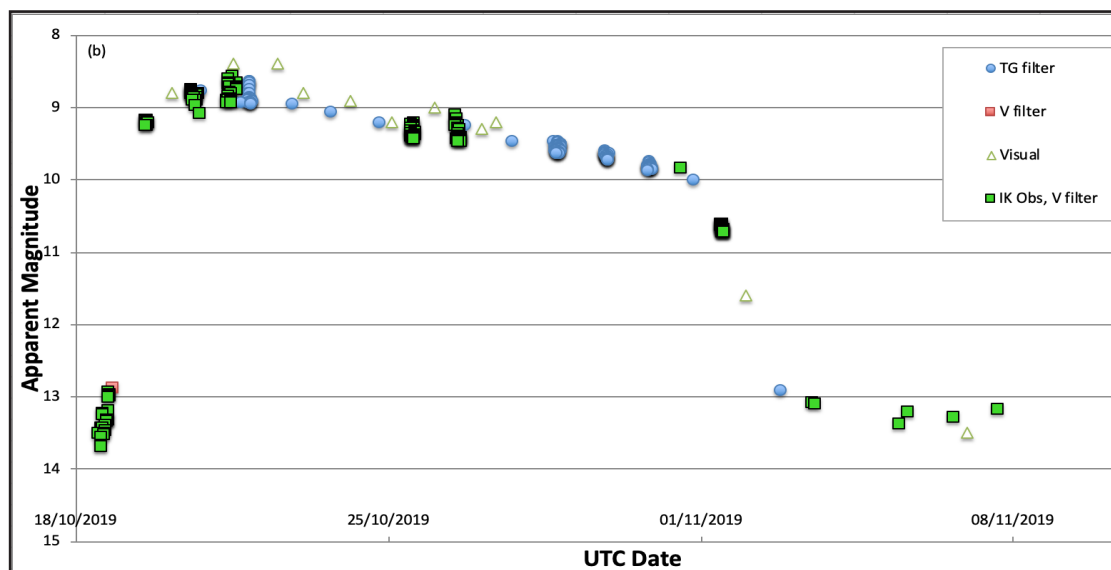


Figure 4. light curve of VW Hyi during the super-outburst of October 2019. Observations in the current work (solid green squares) combined with Green/V filter measurements by other observers (sourced from AAVSOwebC)

Figure 5 shows results of high-cadence observations over several nights showing the superhumps. It is clear that various periodicities are apparent in the curves, and the hump shape itself varies from night to night. This is consistent with earlier analyses indicating that the humps are the superposition of processes with different fundamental periods (for example Patterson et al., 2000).

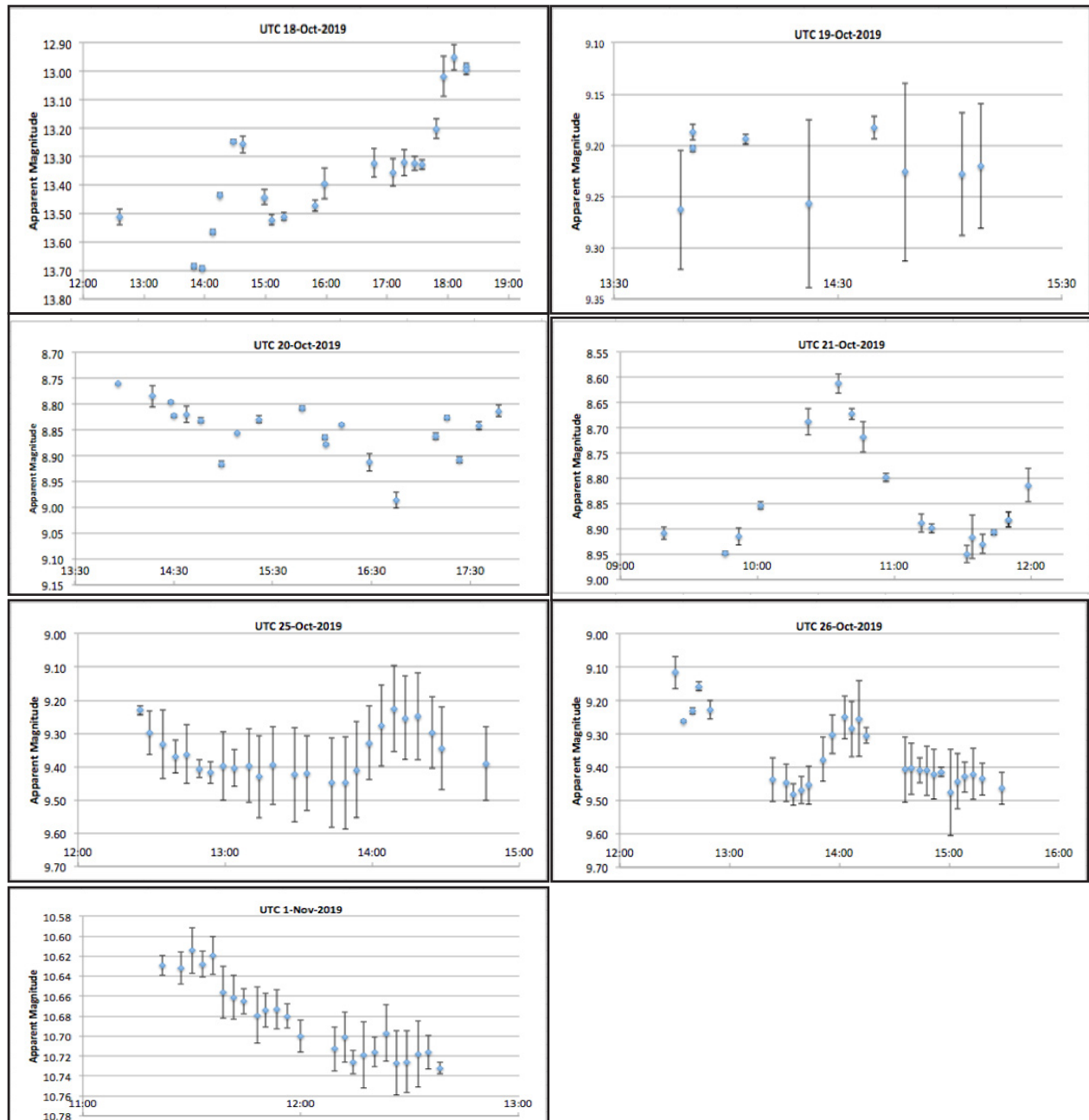


Figure 5. These show results of high-cadence observations over several nights showing the superhumps.

The SNR (reflected in the size of the error bars) varied from night to night due to variations in the seeing conditions, primarily the presence of medium to high cloud. The results of UTC 19 October are marginal due to rapidly moving bands of high cloud.

Analysis and discussion

The data in Figure 5 confirms some of the basic features of the super-outburst of VW-Hyi – the brightening from 14.2 to a peak of around 8.5 is completely consistent with the AAVSO summary of this target (AAVSOwebA). The 30-day quiescent period before the super-outburst is also consistent with a typical ~34 day gap between a super-outburst and the preceding normal outburst (Osaki & Kato 2013). Finally, the fall to magnitude 13.2 following the outburst is consistent with heating of the white dwarf surface immediately following the collapse of the accretion disk (Long et al. 2009).

To gain further information on the system we performed period analysis of the superhumps. To analyse the curves, the AAVSO VStar tool was employed, using the Date Compensated Discrete Fourier Transform (DCDFT) algorithm, which allows periodicity information to be extracted from non-continuous data (Ferraz-Mello 1981) – which is appropriate for this data set which contains large gaps between discrete periods of data collection. Unfortunately with only 175 observations our data proved to be of insufficiently high cadence for this method to reveal the short periodicity clearly visible by inspection at around 90 minutes in Figure 6. The DCDFT method produced a power spectrum dominated by long-period components fitting the overall rounded shape of the super-outburst.

To proceed, periodicity was estimated by extracting the times between minima in the discrete observing periods shown in Figure 6. For example the curve for 20 October UTC shows minima at 14:58 and 16:45 corresponding to a period of 107 minutes (0.074 days). A shorter period, lower amplitude variation can also be seen, for example from 16:45 to 17:23 – a period of 38 minutes (0.026 days) – see Figure 11. No attempt was made to interpolate between data points.

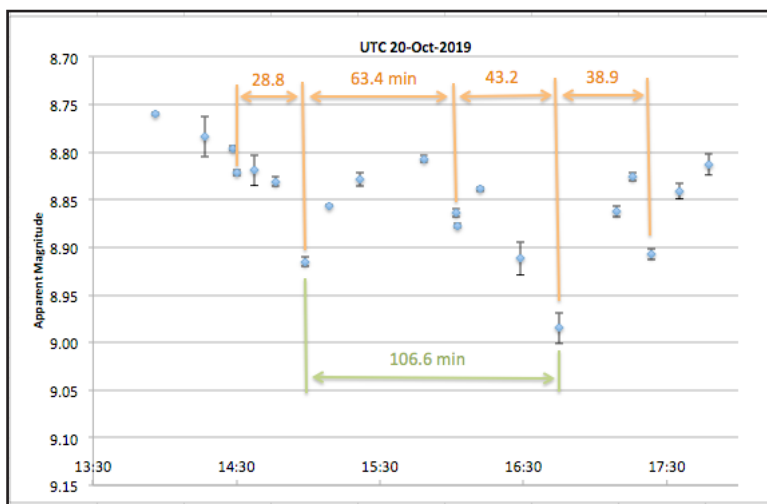


Figure 6. *Example of extraction of periods*

Using this method, periods were extracted by listing successive local minima, plotted as a simple sequence in Figure 7. The results indicate three periodicities, at approximately 112 minutes, 35 minutes and 15 minutes. The two highlighted data points are assumed to be 2x the relevant period and included in the averages.

The 112 minute cycle is the normal superhump period, which represents the rotation of the density wave in the accretion disk, and is slightly longer than the system orbital period of 107 minutes (Pandel et al. 2003). The two shorter period features appear to be in phase with the main superhump and so may be related to activity in the accretion disk.

Many authors have reported short period features detected by Fourier analysis (power spectrum analysis) – and referred to them as harmonics of the fundamental superhump signal; for example Osaki & Kato's (2013) detailed report on V1504 Cyg. These harmonics exist because the superhump wave form is not sinusoidal. However, our work shows that in addition there is a true modulation in the light curve at periods approximately 1/3 and 1/7 of the superhump period. Examination of data in the prior literature show similar features in UGSU systems, but no authors have analysed them as real physical phenomena and offered an explanation.

In the case of VW Hyi, there is an excellent high-cadence data set relating to a 2011 Super-Outburst, contributed to the AAVSO database by Josch Hamsch - Figure 8 (AAVSOwebC). The early part of this data set uses a 6-second cadence and is seen to contain short period variations. In the current work Hamsch's 2011 data was downloaded and analysed using VStar. The power spectrum shows a number of periodicities which are listed in Table 1 along with the results from the current study.

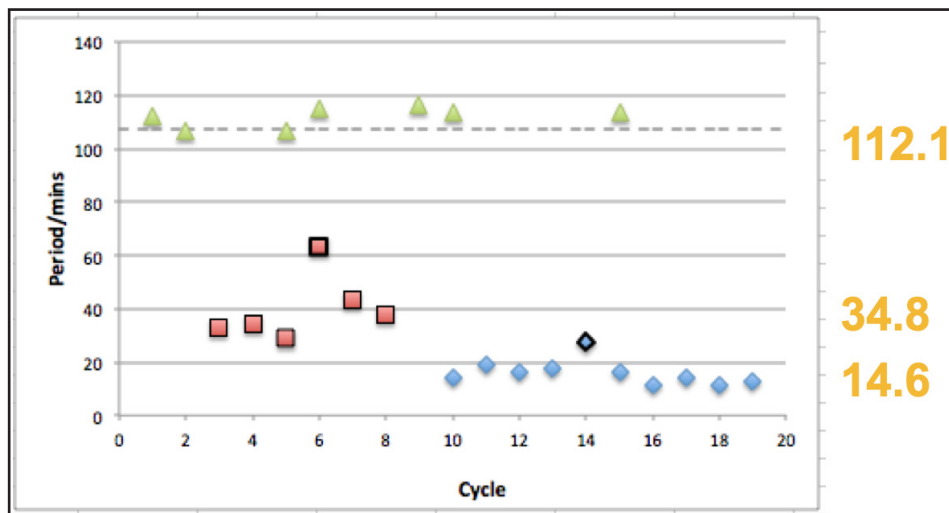


Figure 7. Periods of cycles observed. Dashed line is the 107 min orbital period (Pandel et al. 2003)

It should be noted that the columns do not quite compare like with like, as the first column lists direct observations whereas the second lists periods abstracted from the Fourier analysis. However, of interest is that Hambsch's data appears to show a 35 minute signal agreeing with the current work, a 43-minute signal which was not evident in the current work, and does not display the 15 minute signal obtained in 2019.

The existence of short-period variations in the data in both cases suggest there is more to learn about the behaviour of the accretion disk. These types of periods were not generated in the modelling work of Osaki & Kato (Figure 2) and therefore, if real, relate to more complex phenomena in the system.

Turning now to the superhump period itself, we extracted the average superhump period from Long (2009) and Kato et al. (2014), Hambsch (2011) and combined this with the current measurement (Figure 8). This compilation strongly suggests a long term increase in the superhump period.

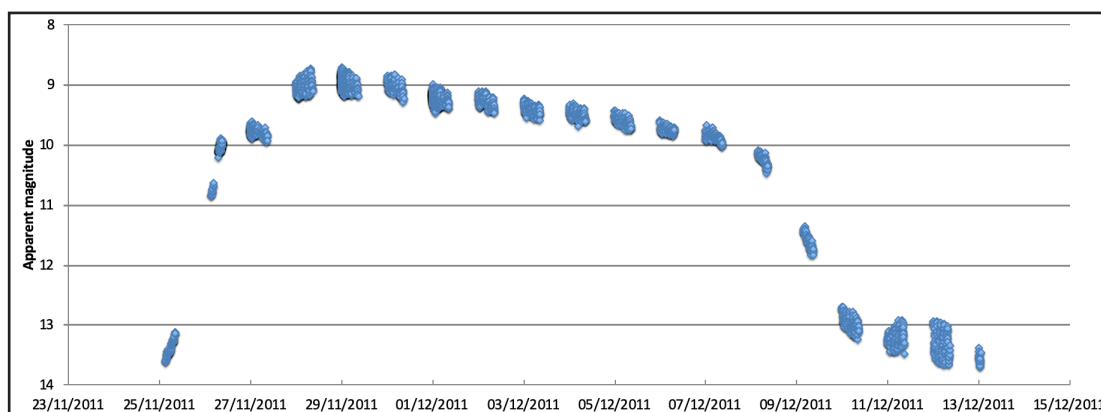


Figure 8. Overview of observations of Hambsch 2011

Periodicities in 2019 data & 2011 Data		
IK Obs	HMB 2011	
Obs periods	From power spectrum	
112.1	111.0	Superhump
	(55.5)	Harmonic
	(999.2)	Camel hump
34.8	35.7	35 min signal
	43.4	43 min signal
14.6		15 min signal

Table 1. Periodicities in current data & HMB's 2011 data

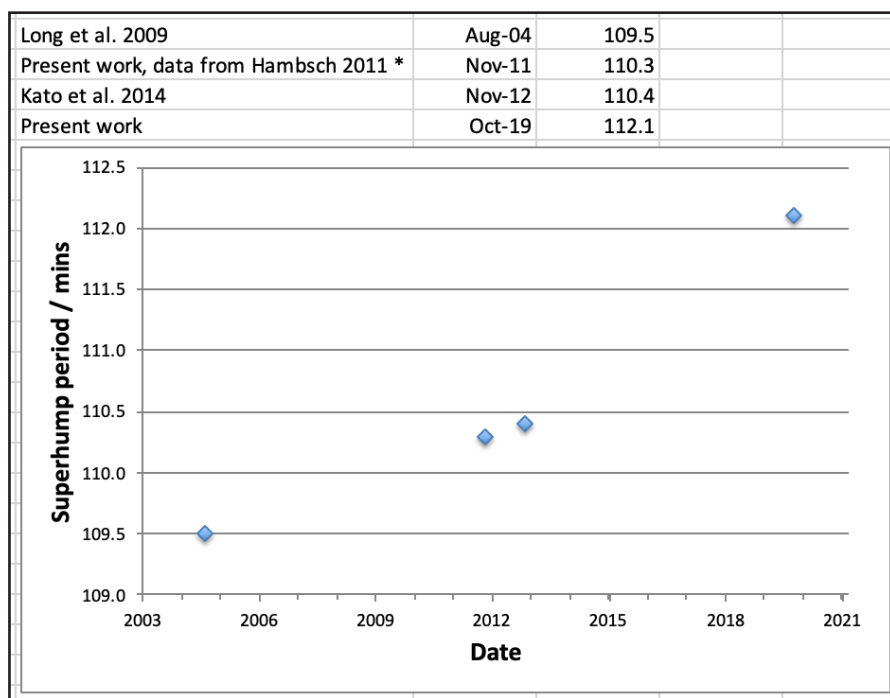


Figure 9. Long term observations of the superhump period.

Conclusion

I have reported observations of the 2019 super-outburst of the UGSU cataclysmic variable system VW Hyi, using 17" telescopes with cooled CCD imagers based in Perth and Siding Spring. Photometric data obtained using the V filter was contributed to the AAVSO database and analysed in conjunction with historical data at the same repository.

The extensive data set included magnitude measurements with cadence down to 3 minutes. The 112 minute superhump period appears to be a continuation of an increase over the last 15 years.

In addition, a shorter period variation in the light curve, averaging 35 minutes in the early part of the super-outburst, and 15 minutes in the later part, was seen. Re-analysis of other observers' data from 2011 supported the 35 minute cycle, and suggested the presence of a 43 minute cycle rather than 15 minutes. These shorter period signals do not appear to have been reported before in the literature on VW Hyi, although Patterson noted a similar feature in the system IY Uma. The only short-period signal discussed for VW Hyi has been the 2-minute variation due to rotation of the white dwarf itself (Woudt & Warner, 2002).

I strongly suggest ongoing observation of future super-outbursts of VW Hyi, specifically at high cadence (<1 minute) to allow for confirmation or rebuttal of these shorter period signals. There is also an opportunity for computational modelling to investigate mechanisms which could cause such periodic signals from the accretion disk.

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Woudt, P. A. & Warner, B., 2002, MNRAS, 333, 411

Back in time

A long time ago, back in 1967, I participated in a flare-star programme to measure UV Ceti. This was prior to the Auckland Observatory setting up its photometric system and we used to make estimates at 30 second intervals. I used an 8" Newtonian and to rest the eyes between measures amongst other things I would estimate the brightness of Betelgeuse - alpha Orionis - using these values - Aldebaran 0.87 or 0.989, Procyon 0.40 or 0.461, Bellatrix 1.64 or 1.655 and Rigel 0.18 or 0.284 - all dependent upon whether you use Allen's Astrophysical Quantities (AAQ) or Guide 9. Then of course Wikipedia will give you some other choices. Oddly enough the 1985 edition of the GCVS does not list beta Orionis as variable. All of which illustrates that not everything is known about the brightest stars - they're very hard to measure accurately. The AAVSO does not even provide any comparisons or values.

Forward to 2020

Over our summer Betelgeuse has been in the news with an unexpected fading to about magnitude $V = 1.6$. This has seen a dramatic increase in measures by many observers using a variety of detectors. Some of these measures are shown in figure 1 below covering an interval from JD 2458200 to 59000 by which time it was too close to the Sun to observe.

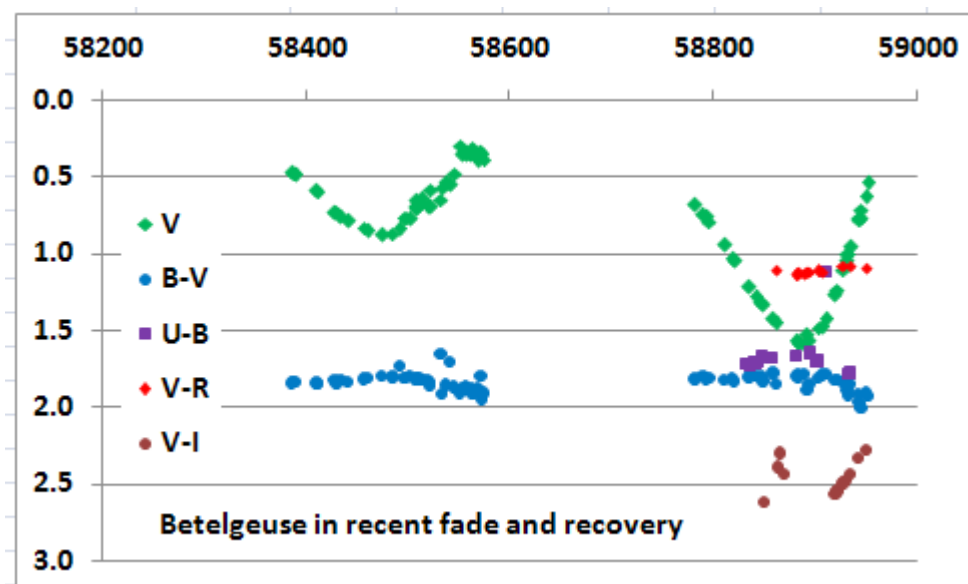


Figure 1. Measures of Betelgeuse from March 2018 to May 2020

This unexpected event caused me to add it to a recent webinar for the LPV section of the AAVSO in which some of our members were involved. Since the webinar was about the astrophysical aspects of Mira stars - smaller cousins of supergiants like Betelgeuse - this graph is along the same lines. It presents UBVRI measures in the manner that the system was designed for, a V magnitude to follow the brightness changes and B-V, U-B, V-R and V-I colours to provide some physical information about the star.

For those unfamiliar with colour photometry let's explain what the colours tell us. B-V is a reasonably good indicator of temperature. As the value of the B-V colour increases, the temperature is becoming cooler. V-R is something of an orphan in this application but the R filter or something close to it in wavelength is widely used to measure minor planets and similar objects where colour changes do not occur. R is a good match to reflected sunlight. The two extreme colours, U-B and V-I do, however, provide information about any shell or halo of ejected material. U-B will detect emission from a gas cloud, V-I a hot shell of dust.

AAQ suggests a temperature of ~ 3300 for Betelgeuse's M2 spectrum, with $B-V = 1.71$, $U-B = 1.95$, $V-R = 1.34$ and $V-I = 2.44$. These are quite close to those measured so this indicates that Betelgeuse does not have the very extensive gas and dust halo typical of its smaller cousins, the Mira stars. Digressing a

little, I'm very interested in obtaining radial velocities of the surface pulsations of R Centauri but the real problem is in deciding which spectral lines emanate from the 'surface' as measured by eye or the V filter and which from atmospheric layers above that.

An important difference

In a variable star such as a Mira the B-V colour would follow the V light curve showing that as the star dimmed it was becoming cooler. But in this case the opposite is the case which indicates that as the star has faded its temperature has increased. U-B has decreased, indicating something similar. In contrast, the V-I value has increased which at a shorter wavelength is suggestive of some dust around the star.

But why should the apparent temperature increase? It is suggestive of a companion, a point which I mentioned casually in passing but not with any belief. So I was more than a little startled when Tom Calderwood drew my attention to two papers by Karovska et al., 1986 and 1992 presenting evidence that Betelgeuse appears to have one or even two companions. Calderwood also mentioned periods of 420 and 2100 days. V filter measures strongly support the first, the latter only occasionally. Visual measures have a spread of 1.5 magnitudes so are probably of little value.

Like L² Puppis Betelgeuse has a dust and gas shell or halo and it is difficult to determine what is being measured or seen. The L² Puppis colours of B-V ~1.6 and U-B of ~1.0 indicate a much larger and denser halo than whatever surrounds Betelgeuse. There have been no definite conclusions about whether the discordant Betelgeuse colours indicate a halo or companion - either for or against - in a variety of papers published over the intervening two and a half decades.

One of the brightest and well known Miras in the south is R Carinae. It has a twelfth magnitude companion at a separation of 2.1" and position angle of 138°. These probably don't change very quickly. Even at the Mira star's minimum this companion contributes at most 10% of the combined light, hence the combined light curve is not flattened at minimum. The colours, however, are much more affected. The B-V colour curve is about 0.4 magnitudes too bright and the U-B curve two magnitudes too bright at around phase 0.3. It reaches close to zero U-B colour at that time.

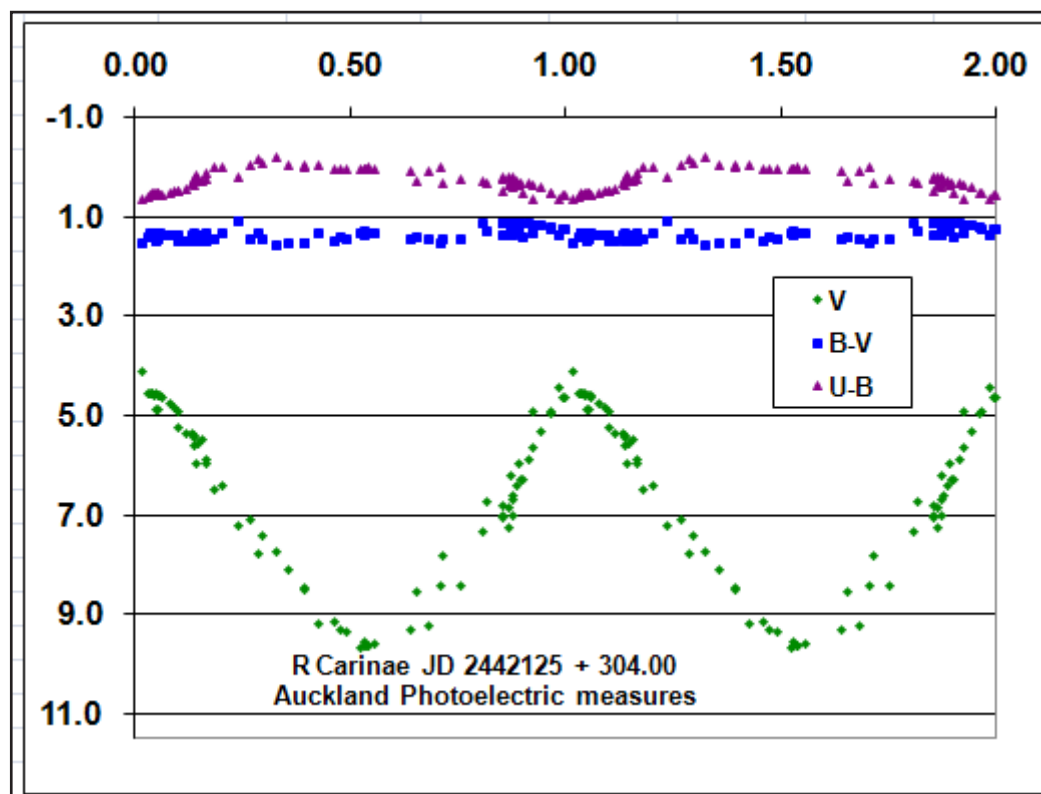


Figure 2. Phase curve of R Carinae from data taken in 1974.

Unfortunately we cannot decide from these measures whether the companion is contributing all of the ultraviolet flux or whether much of it originates in a gas shell around the Mira star. The B-V light curve is not inverted to any extent which suggests that the U emission is largely from this shell. Maybe some

observer with a UBV photometer, say a good SSP5, might like to obtain a few measures at minimum of R Car. Measure both stars and then R Car and the companion alone. The differences will be the hotter star with some contamination but it is possible to derive some idea of what it is. We did this with an EB with a 5" separation and derived very good results.

Measuring Betelgeuse

So back to alpha Orionis. How do we measure this? Perhaps the difficulty is shown by the fact that more than half of the bright stars in the area have NSV numbers and the spectral types are predominantly O and early B which are often variable at a low level. More stable stars are in the spectral range A0 to G5. The following are possibilities as comparison and checks.

Star	Name	R A	Dec	Spec	V	Err	B-V	U-B	Comments
alpha Ori	Betelgeuse	05 57 39	+07 02 36	M2lab	0.08 v		1.850	2.060	Variable
pi3 Ori	Tabi	04 49 55	+06 55 27	F8	3.172	0.004	0.484	0.000	NSV 1731
eps Mon		06 23 26	+04 34 48	A5	4.404	0.016	0.215	0.140	
gam Gem	Alhena	06 37 48	+16 25 30	A0	2.024	0.004	0.001	0.137	
xi Gem	Alzir	06 45 16	+12 52 43	F5	3.331	0.004	0.443	0.060	NSV 03193
gam Ori	Bellatrix	05 25 00	+06 22 37	B2	1.655	0.006	-0.224	-0.860	NSV 1972

Table 1. *Brightness and colours of neighbouring stars to Betelgeuse (from Guide 9).*

The coordinates are only approximate and the V magnitude and B-V colours vary dependent upon the source. These are all from Guide 9. U-B colours are from Wikipedia. The error column reports on the Hipparcos scatter. The very low scatter in most cases seems to suggest that the NSV labels are due to poor photometry and not true stellar variation. There is little physical reason for F stars to vary unless they undergo Cepheid pulsations or are EBs and there is no reason that these could be overlooked in such bright stars.

Selection of a main comparison is difficult. Epsilon Mon is probably the best or xi Gem. Do not use ensemble techniques. These give you no indication of accuracy. Accuracy is obtained by measuring the divergence from the comparison of the other three stars which are used as checks. Undoubtedly your measures treated in this manner will not agree with the catalogued values which are very doubtful but the divergences should be constant for each check star over long intervals.

Finally, Betelgeuse, for the purposes of finding evidence of a companion star, is best measured in UBV. This probably means an SSP5 photometer as there are few of the old custom built PEP systems still in use. This allows the derivation of V, B-V and U-B which indicate the presence of a hotter companion as seen in the graph of R Carinae. BV provides V, B-V, which may be useful if any companion is brighter than it seems at present. Betelgeuse measures are not suited to DSLR cameras. In most case the transformation, or scale factor, is around 2.1 or so. This means that the separation of the B and G detectors is only 1/2.1 of the normal 112.4 nm giving a true filter separation of only 53.5 nm and probably the B is much redder than normal. Even the G may be displaced toward the blue a little.

So in conclusion, if any of our readers have photoelectric equipment which can provide good V, B-V or even U-B at this level it's worthwhile measuring Betelgeuse at fortnightly intervals. Someone in the future may be very pleased with the results.

References

- Karovska, M, Nisenson, P and Noyes, R. 1986 *Astrophysical Journal*, **308**, 260
 On the Alpha Orionis Triple System
 Karovska, M 1992 *ASP Conference Series*, Vol 26 *Imaging of the Surface of Alpha Ori*

With NASA's TESS satellite moving from observing the southern hemisphere sky to the northern sky there have been fewer opportunities for me to observe exoplanets candidates over the past year. Fortunately, after a request to observe a particular known southern exoplanet from a University College, London astronomer, I was invited to join a new programme of exoplanet observing in preparation for the launch of the European Space Agency's Ariel satellite. 'Ariel' has nothing to do with biblical angels or Shakespearean spirits but is an acronym built from "*A*tmospheric *R*emote-sensing *I*nfrared *E*xoplanet *L*arge-survey".

Ariel will be tasked with the characterisation of atmospheres of exoplanets around stars from a target list of about one thousand stars in both hemispheres. For this very accurate transit times and durations need to be known for each planet as well as monitoring for stellar variability.

The Ariel Ephemerides Working group has set up a project, [ExoClock](#), to allow professional or amateur astronomers operating small or medium sized telescopes to contribute transit data to the project.

Many of the target stars are easily visible to southern hemisphere observers and have R magnitudes between 6 and 15 with mag 10-12 being the largest group.

To be part of this project you need to sign up on the Exoclock web site and register a few personal details such as name, email, affiliation and time zone, and your telescope(s) and observatory site(s).

Once you have been accepted you will be able to see what transits are available to you each day under the 'MySchedule' tab (Figure 1)

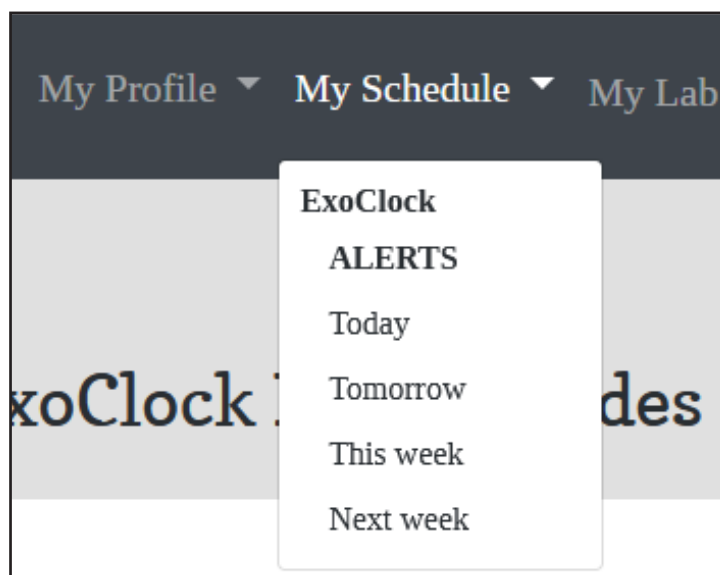


Figure 1. Your schedule for the next few days. ALERTS for are high priority stars

It is important to put in your offset from UT under your profile so that the schedule can give you correct time for your location and you need to change it when your location switches to or from daylight saving.

Figure 2 shows a typical output from the scheduler. You will notice that the magnitudes given are R magnitudes. This is because many of the target stars are cool so a red filter such as Rc is best for your observations.

Once you are ready to analyze your data you can use the project's custom software called HOPS – *H*olomon *P*hotometric *S*oftware – written by Angelos Tsiaras of UC London. I think the Holomon part refers to Angelos's Greek heritage and Mount Holomon in particular.

HOPS requires Python on your computer. Full instructions for installing HOPS (and Python) are provided along with the user manual at <https://www.exoworldsspies.com/en/software/>

My Schedule									
El Sauce - Planewave CDK14 - SBIG STT 1603-3									
Latitude: -30.471°, Longitude: 289.235°, Telescope size: 14.0"									
Showing results for 24 hours, starting from: 2020-07-20T21:09:41 (UTC-4.0)									
For a more generic scheduler visit the ExoWorlds Spies Scheduler									
Planet & ExoClock status	Star RA/DEC J2000	Magr mag	Depth mmag	Duration hours	Observing times [UTC-4.0] and target position				
					1h Before Ingress	Transit Start	Mid Transit	Transit End	1h After Egress
WASP-123b Priority: MEDIUM Total obs.: 0 Last obs.: - O-C (min): -	19:17:55.0316 -32:51:35.954	10.667	13.69	3.11	2020/07/20 19:46 36° E	2020/07/20 20:46 48° E	2020/07/20 22:20 68° E	2020/07/20 23:53 87° SE	2020/07/21 00:53 79° W
Max counts increase during observation : R:7% V:14% Moon illumination: 0.3%, Moon distance: 161.8°									
CoRoT-2b Priority: MEDIUM Total obs.: 9 Last obs.: 2020-06-24 O-C (min): 4.01 ± 0.2	19:27:06.4944 +01:23:01.357	12.204	36.99	2.28	2020/07/20 22:18 48° NE	2020/07/20 23:18 56° NE	2020/07/21 00:26 58° N	2020/07/21 01:35 53° NW	2020/07/21 02:35 43° NW
Max counts increase during observation : R:2% V:3% Moon illumination: 0.4%, Moon distance: 151.9°									
HATS-24b Priority: MEDIUM Total obs.: 1 Last obs.: 2020-04-19 O-C (min): 2.8 ± 0.9	17:55:33.7673 -61:44:50.367	12.82	22.23	2.45	2020/07/21 00:19 55° S	2020/07/21 01:19 50° SW	2020/07/21 02:33 41° SW	2020/07/21 03:46 33° SW	2020/07/21 04:46 26° SW
Max counts increase during observation : R:0% V:0% Moon illumination: 0.5%, Moon distance: 131.7°									

Figure 2. A portion of a recent daily schedule for the author.

Use of HOPS proceeds in three stages:

1 Reduction of your raw data

HOPS 2.6.1
Copyright (c) 2017-2020
Angelos Tsiasaras
atsiasaras@star.ucl.ac.uk

MY PROFILE

HOPS UPDATES & USER MANUAL

Reduction & Alignment

Directory: **2020-07-08/HOPS**

Name identifier for observation files	Wasp	132 files found
Name identifier for bias files	bias	No files found
Name identifier for dark files	dark	No files found
Name identifier for flat files	flat	No files found
Bin fits files (reduced only)	1	

Show files

Detected target RA DEC: 03:43:44.0 -65:11:32.0 ☒ Use detected values

Manual target RA DEC (hh:mm:ss +/-dd:mm:ss): Coordinates accepted

Exposure time header keyword: Keyword found

Observation date header keyword: Keyword found

Observation time header keyword: Keyword found

☐ If the time stamp in your fits files refers to the mid-exposure instead of the exposure start, please tick this box.

Show header

Extra tools:

OBSERVATION PLANNER

RUN REDUCTION & ALIGNMENT

PROCEED TO PHOTOMETRY

PROCEED TO FITTING

Figure 3. The first of three stages of HOPS is the reduction and alignment module.

There is no need to do your own reduction as HOPS can do it all for you as long as you tell it where the calibration files are kept. Having completed this step you can then move onto the photometric measure-

ments for your target and comp stars

2 Photometry of the target and comp stars

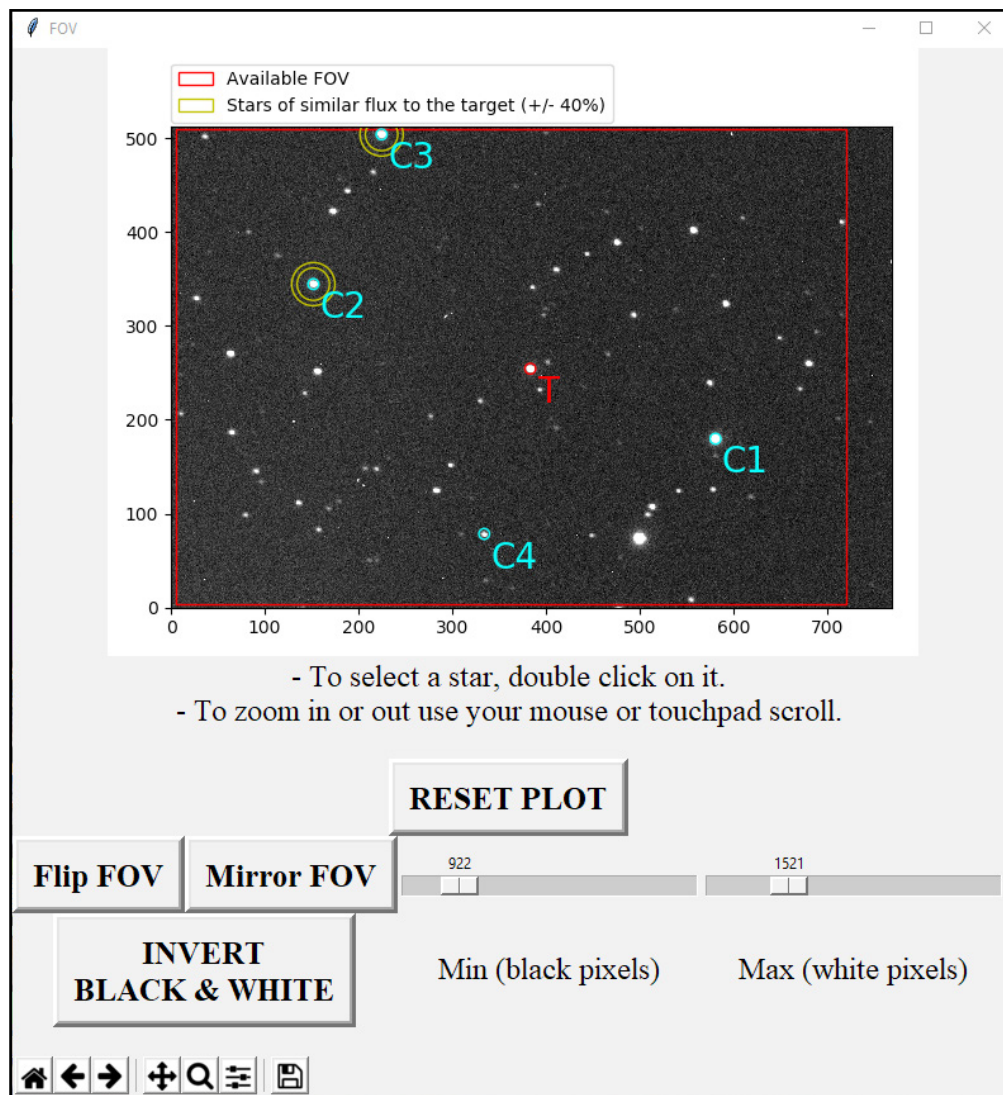


Figure 4. The second module of HOPS where you select the target and comparison stars.

HOPS will select stars that are approximately the same magnitude as your target but it is up to you to check if they are variable or not. A link is given to SIMBAD for this. You need not use its recommendations. HOPS will also warn you if you select a comp that it considers to be either too bright or too dim (Figure 4).

When you run the photometry you will get light curves for each of your selections with separate points for aperture photometry and PSF (point-spread-function) photometry. If you don't like what you see you can go back and change comps or aperture size. You don't need to select anything just yet. Close the graphs and HOPS will produce two files, one based on aperture photometry and the second based on PSF photometry. You can use either in the fitting module.

Once you have your photometry you can move to the final stage of Monte Carlo fitting.

3 Curve fitting using Markov Chain Monte Carlo iterative method.

You will be presented with an initial least-squares fit with a rough idea of your final curve and O – C for the transit mid-point (T_c). In my sample in Figure 5 there is a considerable difference between what was expected and what was observed.

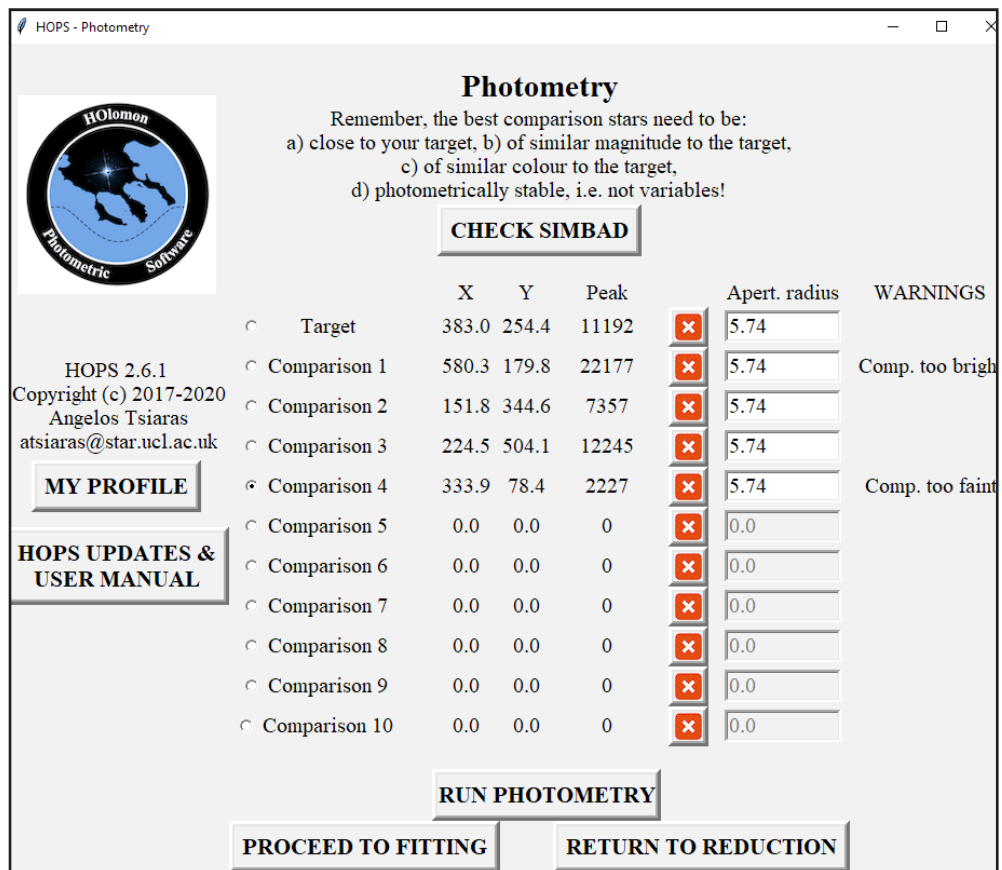


Figure 5. HOPS will automatically select the best photometry aperture and will also tell you if the star you have selected is either too bright or too dim. It won't flag variables though so it is up to you to check your selections via SIMBAD.

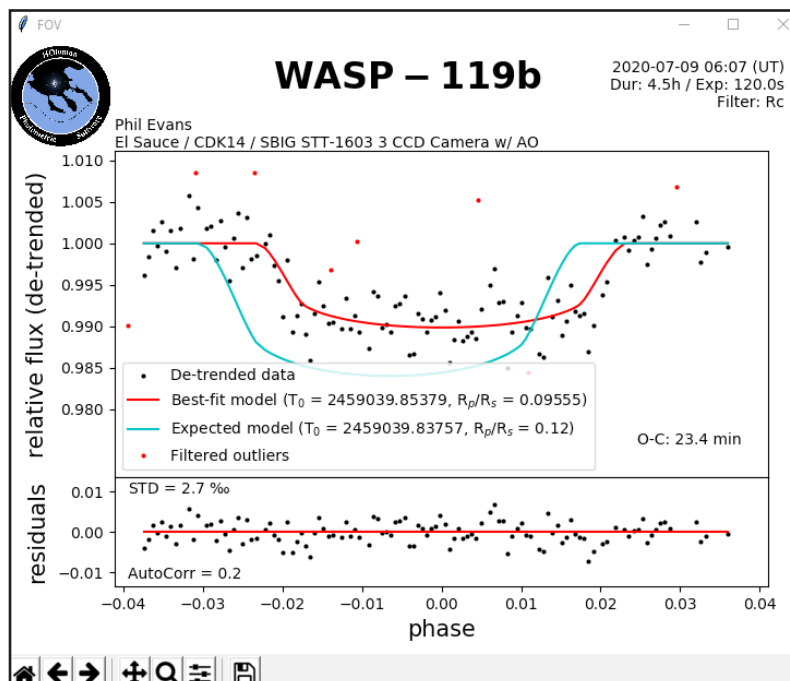


Figure 6. An initial fit to your data based on least-square deviations.

For the MCMC fitting you generally will not need to alter any of the options and you can just let it run the 300,000 iterations it suggests, discarding the first 30,000 runs which will likely be a long way from a decent fit to your data (Figure 6).

HOPS - Fitting

Light-curve file:

Fitting

Planet: ☐ Use detected planet param. ☐ Enter param. manually

Planet	Planet RA DEC (hh:mm:ss +/-dd:mm:ss)	Coordinates accepted
WASP-119b	03:43:44.0213 -65:11:37	03:43:44.0213 -65:11:37

Scatter limit: MCMC Iterations: MCMC Burn-in:

Period [days]: Mid-time [BJD_TDB]:

Filter: Camera: Telescope: Observatory: Observer:

Rp/Rs: a/Rs: Inclination [deg]: Eccentricity: Periastron [deg]: M* [Fe/H, dex]: T* [K]: log(g*) [cm/s^2]:

RUN FITTING

RETURN TO PHOTOMETRY **RETURN TO REDUCTION**

MY PROFILE

HOPS UPDATES & USER MANUAL

Figure 7. The MCMC fitting module. The program will get the planet parameters automatically but you may alter any.

The output will be a new light curve with O – C, Tc and also the ratio of the planet’s radius to that of the parent star.

Now you are ready to upload your data to the website. Look first in your target star’s photometry folder on your computer. There you will see a file called `ExoClock_info.txt` plus several others. Open this file and it will tell you what file to upload to the ExoClock.space web site.

<< Photometry > Ariel > Wasp-119 > 2020-07-08 > HOPS > PHOTOMETRY

Name	Date modified	Type	Size
ExoClock_info.txt	13/07/2020 4:27 pm	Text Document	1 KB
FOV.pdf	13/07/2020 4:27 pm	Adobe Acrobat D...	668 KB
log.yaml	13/07/2020 4:27 pm	YAML File	5 KB
PHOTOMETRY_a.txt	13/07/2020 4:27 pm	Text Document	51 KB
PHOTOMETRY_APERTURE.txt	13/07/2020 4:27 pm	Text Document	7 KB
PHOTOMETRY_g.txt	13/07/2020 4:27 pm	Text Document	74 KB
PHOTOMETRY_GAUSS.txt	13/07/2020 4:27 pm	Text Document	7 KB
photometry_output_description.txt	13/07/2020 4:27 pm	Text Document	3 KB
RESULTS.pdf	13/07/2020 4:27 pm	Adobe Acrobat D...	27 KB

Figure 8. HOPS will put its output into a single folder labelled ‘Photometry’. The ‘photometry_output_description.txt’ file tells you what each file contains.

Once you know what file to upload then go to the MyLab option on the ExoClock.space website, fill in the details on the page and send it off. You should get an acceptance from the team within a few days of submitting.

Whilst it's a bit late in the year for this star - the Covid-19 problem made astronomy take a back seat - Dave Blane has responded admirably to our call for measures. These are presented in the illustration below (figure 1) - which also shows how we cope with this multiple system's unfortunate eclipse period of 5.99857 days with totality lasting seven hours or more.

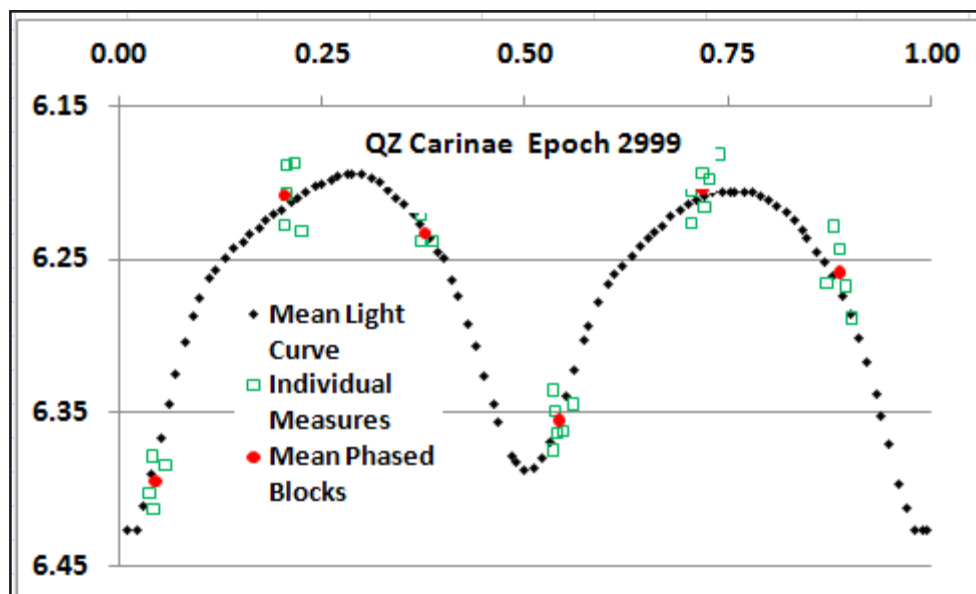


Figure 1. *Phased light curve for epoch 2999 of R Car showing individual measures and their means.*

Our recent measures usually fall into 6 blocks which allows the derivation of the means of each block of individual measures. These mean points can be fitted much more accurately.

We'd welcome any more measures from observers with a good western horizon. Observing will be possible for another month or so in such locations. Don't do monitoring, just make one or two measures a night. Dave is using a DSLR camera from South Africa so any measures from Australia or NZ will put mean points at other places on the graph and improve the fit.

At some stage during the next few years the O-C curve will begin to flatten and thus, finally, we will be able to determine both the long period orbit of the two pairs and the true period of the eclipsing pair.

“Discovery” of an EB in the field of BF Pavonis – *Mark Blackford*

(markgblackford@outlook.com)

In August 2019 I observed the eclipsing binary BF Pavonis on 4 separate occasions to determine Times of Minimum (ToM) of primary and secondary eclipses. These will be published elsewhere; this article will instead report the serendipitous “discovery” and subsequent period determination of another eclipsing binary within 6 arcmin of BF Pav.

The AAVSO does not currently have any comparison stars selected for BF Pav in the 18.1 x 12.2 arcmin field of view of my RC14+SBIG STT3200ME photometry system. Therefore I used the AAVSO’s SeqPlot program (<https://www.aavso.org/seqplot>) to choose nine nominally constant stars, one to use as a check star and eight for an ensemble of comparison stars. Using a comparison ensemble can improve the signal-to-noise of the check and target star light curves. Improved SNR allows more precise ToM determination. Figure 1 is a finder chart for these stars and BF Pav.

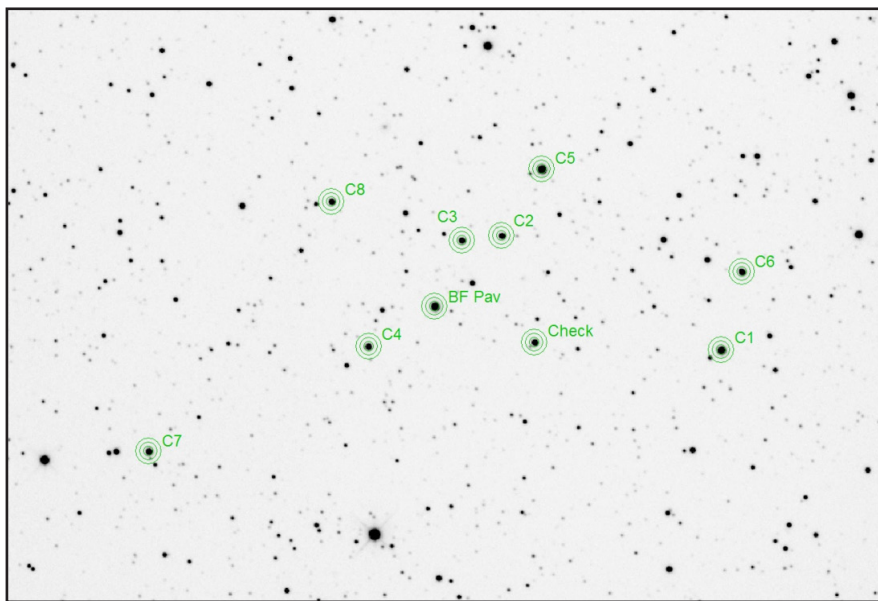


Figure 1. *BF Pavonis finder chart showing potential check star and comparison stars.*

Analysis of images recorded on August 15th, 2019 showed the star marked C1 in the finder chart had undergone an eclipse. This star was therefore removed from the comparison ensemble and instead analysed as a target star. Figure 2 shows the light curve. Analysis of the other three nights of observations did not detect any variation in brightness.

SeqPlot did not identify this star as a known variable and neither did the AAVSO’s Variable Star Plotter. A search of the AAVSO’s Variable Star Index (VSX) also failed to find a known variable at the position of star C1. So, had I found a new eclipsing binary? Well – no.

Before trying to observe future eclipses I needed to determine the period, and to do that I needed long term, high quality photometry. A check of the All-Sky Automated Survey for Supernovae (ASASSN) Sky Patrol database (<https://asas-sn.osu.edu/>) found a known variable, ASASSN-V J184530.00-593235.0, at the position of star C1. They tentatively identified it as a Rotational variable with mean V magnitude of 12.29, however there were very few observations during eclipse and no period was reported. The ASASSN light curve is shown in Figure 3.

I next looked for earlier observations in the All Sky Automated Survey (ASAS) All Star Catalog (<http://www.astrouw.edu.pl/asas/?page=aasc>), however the data quality was much poorer (Figure 4). So for period analysis I used the ASASSN observations with Jeff Byron’s PeriodFinder software (described in VSS Newsletter 2019-1). A period of 8.15128d resulted in the least scatter in the phase plot.

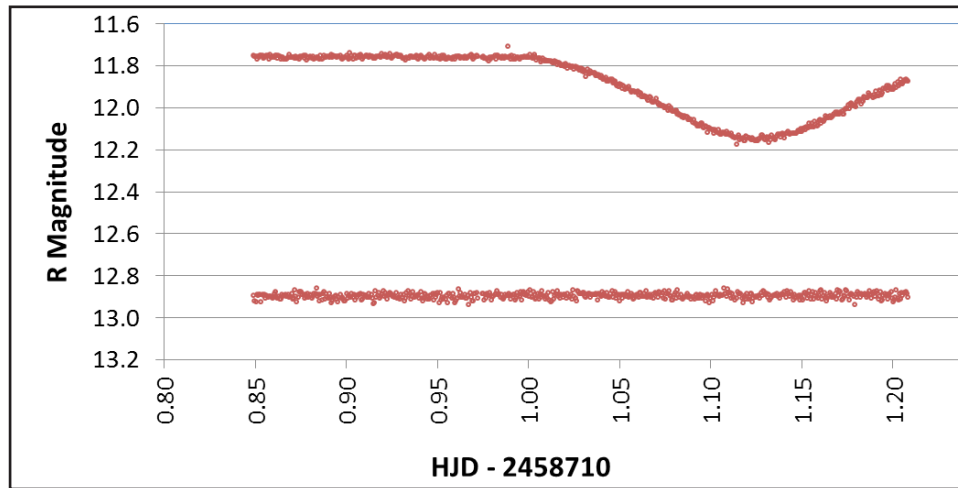


Figure 2. *R* filter light curve of star C1 (top) and check star (bottom) on the night of August 15th, 2019

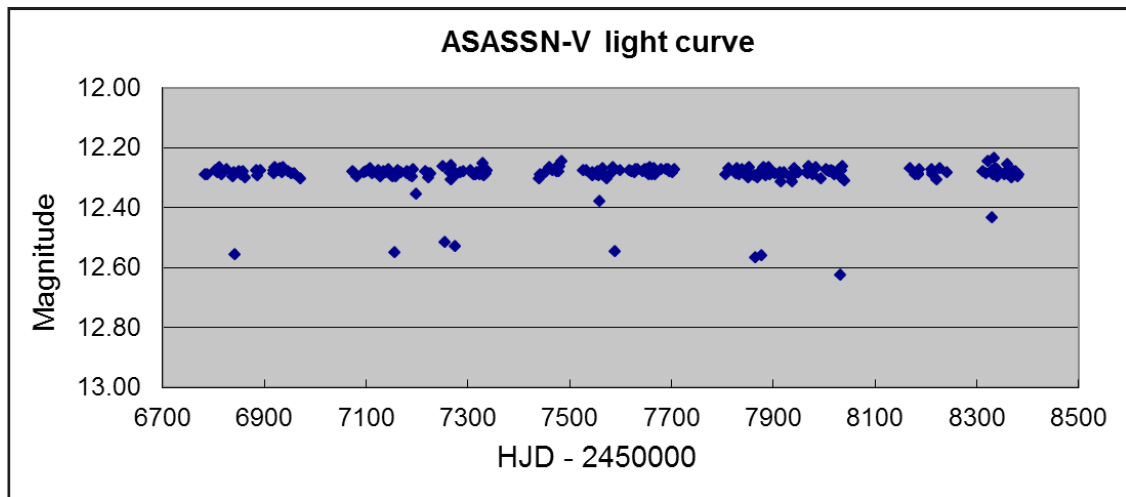


Figure 3. *ASASSN-V J184530.00-593235.0 V* light curve from *ASASSN Sky Patrol* database.

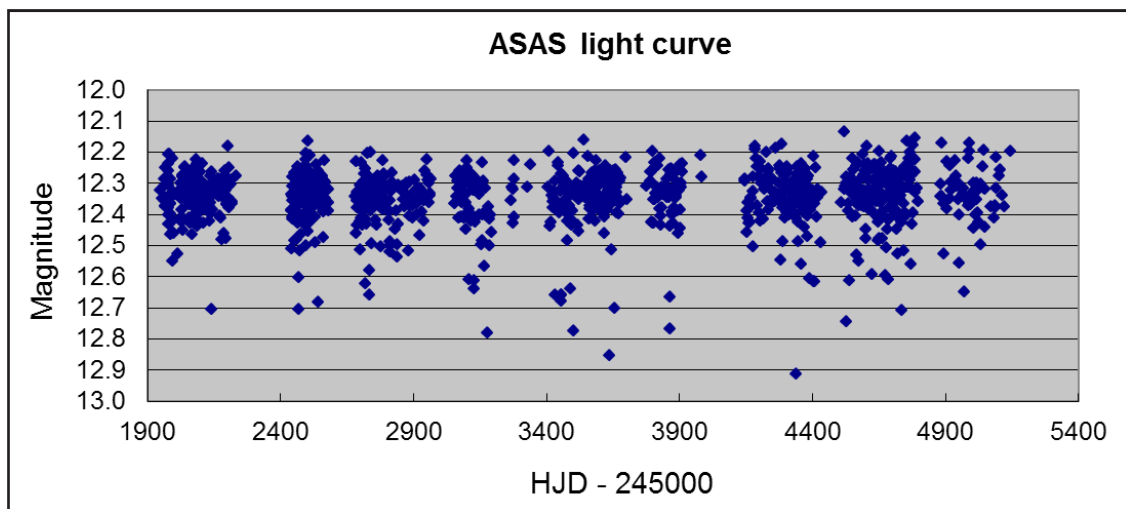


Figure 4. *ASASSN-V J184530.00-593235.0 V* light curve from *ASAS All Star Catalog* database.

The next step was to determine a pseudo-epoch for the ASASSN observations, which spanned a total of 1600 days with a median HJD of 2457595.66412. This was a bit subjective because only 5 observations were recorded during primary eclipses. In the end I adopted a value of HJD 2457594.464 (close to the median HJD) which put the primary eclipse at phase 0.

The final step was to refine the period using the Time of Minimum determined from my 2019 observations. There were 137 cycles between the adopted ASASSN epoch and the eclipse I observed. Using the 8.15128d period found by PeriodFinder I calculated the primary eclipse for cycle 137 should have been at HJD 2458711.18936 whereas the observed time was HJD 2458711.1287 (0.0019). Linear regression of the adopted ASASSN epoch and my measured Time of Minimum leads to a refined period of 8.15084d. Figures 5 show a phase plot of the ASASSN observations using this refined period and my ToM as the epoch. The secondary eclipse is displaced from phase 0.5 indicating an elliptical orbit.

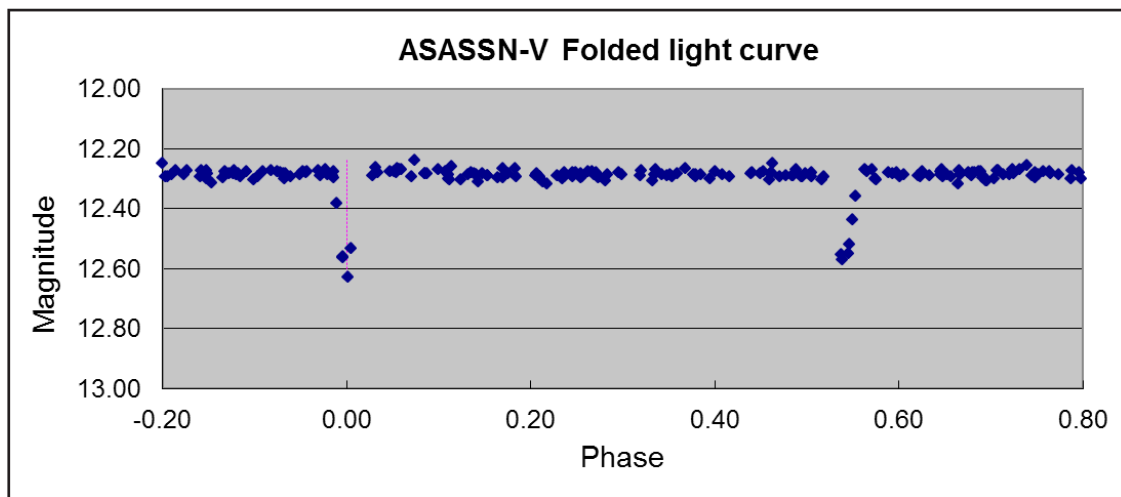


Figure 5. *ASASSN-V J184530.00-593235.0 V phased light curve from ASASSN observations.*

More Times of Minimum are required to further refine the period and determine confidence limits.

Publication watch

Phil Evans has been listed as a co-author on exoplanet observations published recently in the MNRAS

Billy Edwards et al. 2020. *Original Research By Young Twinkle Students (ORBYTS): Ephemeris Refinement of Transiting Exoplanets:* <https://doi.org/10.1093/mnras/staa1245>

Abstract

We report follow-up observations of transiting exoplanets that have either large uncertainties (>10 minutes) in their transit times or have not been observed for over three years. A fully robotic ground-based telescope network, observations from citizen astronomers and data from TESS have been used to study eight planets, refining their ephemeris and orbital data. Such follow-up observations are key for ensuring accurate transit times for upcoming ground and space-based telescopes which may seek to characterise the atmospheres of these planets. We find deviations from the expected transit time for all planets, with transits occurring outside the 1-sigma uncertainties for seven planets. Using the newly acquired observations, we subsequently refine their periods and reduce the current predicted ephemeris uncertainties to 0.28 - 4.01 minutes. A significant portion of this work has been completed by students at two high schools in London as part of the Original Research By Young Twinkle Students (ORBYTS) programme.

About

Variable Stars South is an international association of astronomers, mainly amateur, interested in re-searching the rich and under-explored myriad of southern variable stars.

Renamed from the Variable Star Section of the Royal Astronomical Society of New Zealand, it was founded in 1927 by the late Dr Frank Bateson, OBE, and became the recognised centre for Southern Hemisphere variable star research.

VSS covers many areas and techniques of variable star research, organised into projects such as Beginners' Visual Observations and Dual-Maxima Miras. The goal of each project is to obtain scientifically useful data and results. These may be published in recognised journals, or supplied to international specialist data collection organisations.

VSS is entirely an internet based organisation, working through our website <http://www.VariableStars-South.org> and its e-group <http://groups.google.com/group/vss-members>. It also encourages members to work in with major international organisations such as the British Astronomical Association, the Center for Backyard Astrophysics and the American Association for Variable Star Observers.

To find out more, please visit our website, where, incidentally, you will find PDF copies of all our newsletters. Our website has a great deal of information for VSS members, and for anyone interested in southern hemisphere variable star research. All VSS project information and data is kept here too.

Who's who

Director Mark Blackford

Treasurer/Membership Bob Evans

Newsletter Editor Phil Evans

Webmaster David O'Driscoll

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After you've joined and received your membership certificate, you will be signed up to the VSS-members egroup (see above), and you will also receive a password to access the members' areas of our website.

Newsletter items

These are welcomed and should be sent to the Editor (phil@astrofizz.com). I'd prefer Microsoft Word (or compatible) files with graphics sent separately. Don't use elaborate formatting or fancy fonts and please do not send your contribution as a fully formatted PDF file.

Publication dates are January, April, July and October, nominally on the twentieth day of these months and the copy deadline is the thirteenth of the month though earlier would always be appreciated.

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