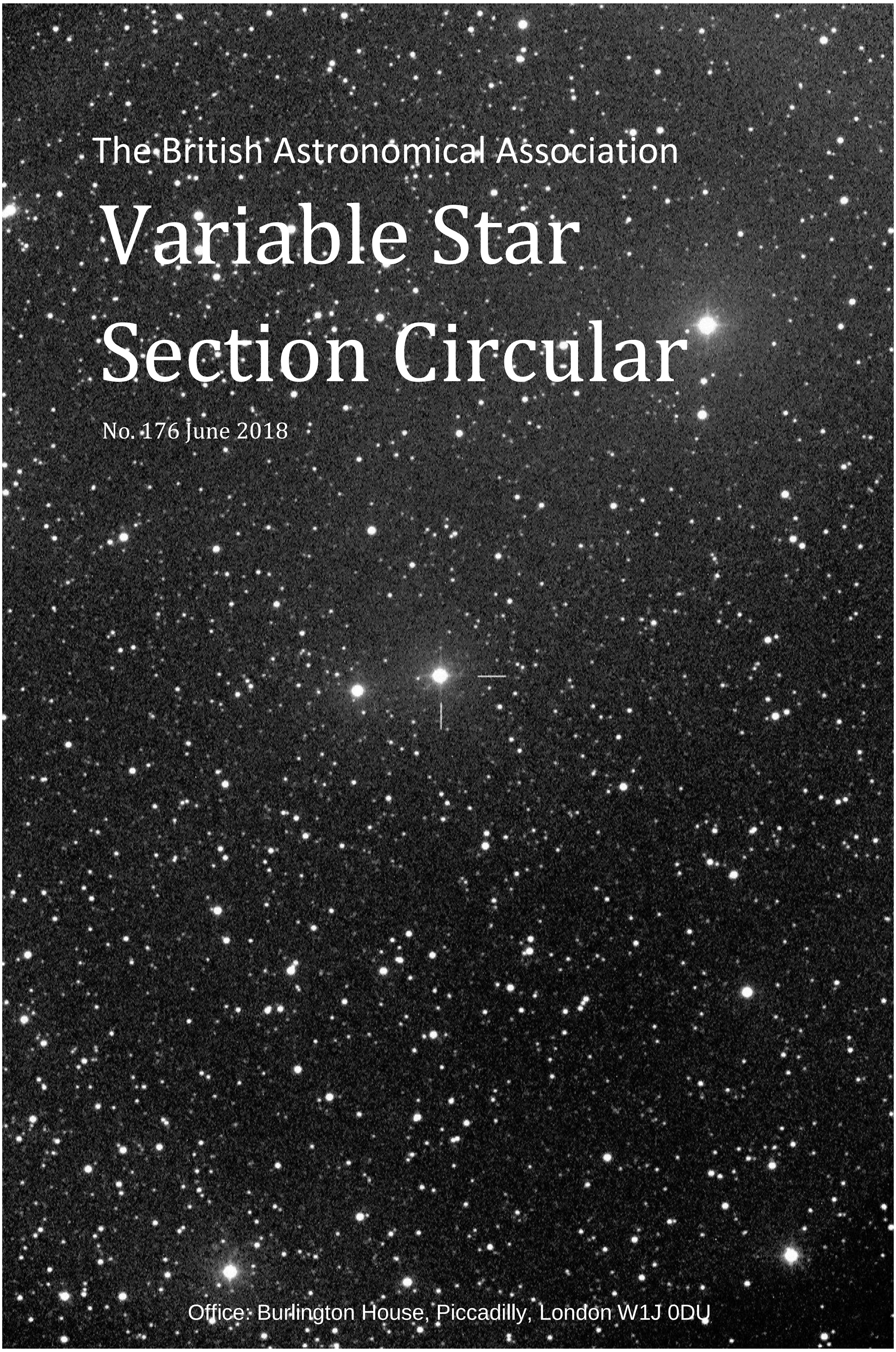
The British Astronomical Association

Variable Star Section Circular

No. 176 June 2018



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Contents

Cover image V392 Per (Nova Per 2018)
May 6.129UT iTelescope T11 120s.
Martin Mobberley

Joint BAA/AAVSO Meeting on Variable Stars
Warwick University
Saturday 7th & Sunday 8th July 2018

Following the last very successful joint meeting between the BAAVSS and the AAVSO at Cambridge in 2008, we are holding another joint meeting at Warwick University in the UK on 7-8 July 2018. This two-day meeting will include talks by

Prof Giovanna Tinetti (University College London)
Chemical composition of planets in our Galaxy
Prof Boris Gaensicke (University of Warwick)
Gaia: Transforming Stellar Astronomy
Prof Tom Marsh (University of Warwick)
AR Scorpii: a remarkable highly variable star discovered by amateur astronomers
Prof Christian Knigge (University of Southampton)
Cataclysmic Variables as Universal Accretion Laboratories
Dr Guillem Anglada Escude (Queen Mary, University of London)
Red Dots Initiative: science and opportunities in finding planets around the nearest red-dwarfs
Dr Dirk Froebrich (University of Kent)
The HOYS-CAPS Citizen Science Project
Francois Teyssier (Astronomical Ring for Access to Spectroscopy)
Observing Symbiotic Stars
Francois Cochard (Shelyak Instruments)
Starting in Spectroscopy

plus, talks by Mike Poxon, Andrew Wilson, John Toone, David Boyd, Josch Hambsch, Robin Leadbeater, Andrew Smith, Gordon Myers, Lukasz Wyrzykowski, David Pulley, Geoff Chaplin, Kristine Larsen, Thomas Morris, Des Loughney and Mario Motta.

All speaking slots are now filled but if you would like to present a poster please contact Roger Pickard at roger.pickard@sky.com

More information about the meeting and online registration are available at https://britastro.org/summer2018

General Data Protection Regulation (GDPR) or more simply, changes to the law regarding the sending of email messages

This came into effect on May 25 and the new law now includes small hobby clubs, such as astronomical societies etc.

For relativity close-knit groups such as the VS Section Officers we won't go to the bother of sending one another messages via the "Blind Copy" route as we all know one another's email addresses anyway.

However, for larger groups like the VSS Circulars mailing list I shall continue to send it out bcc as I always have done. I also sent an email to all those who receive the Circulars inviting them to contact me if they no longer wished to receive them. In case you missed that email, you can still contact me if you no longer wish to receive them.

"Far-infrared photometry of OJ 287 with the Herschel Space Observatory"

The above paper appeared in a recent issue of Astronomy & Astrophysics

(https://www.aanda.org/articles/aa/abs/2018/02/aa32142-17/aa32142-17.html)

and featured the names of Mark Kidger, who I'm sure is well known to many of you, especially those reading The Astronomer magazine and those attending their AGM. It also featured the name of Gary Poyner who added he was also delighted that it gave a mention for the VSS in the author list!

Recent Papers on the Classification of Variable Stars

John Fairweather kindly sent me links to the following papers and I thought some other members may be interested and so I've copied the links below: -

The first is "Unsupervised Classification of Variable Stars" (https://arxiv.org/pdf/1801.09723.pdf) and the second is "Automatic Survey-Invariant Classification of Variable Stars" (https://arxiv.org/pdf/1801.09737.pdf).

Enjoy!

SUMMER MIRAS

M = Max, *m* = min.

R And	*M*=Jly/Aug
R Aqr	*M*=Jun/Jly
R Aql	*M*=Aug
V Cam	*m*=Jly/Aug
X Cam	*M*=Jly
SU Cnc	*M*=Aug
	m=May/Jun
U CVn	*M*=Jly
S Cas	*m*=Jun
T Cas	*M*=Jun/Jly
omicron Cet	*m*=Jly/Aug
R Com	*M*=Aug
S CrB	*M*=Aug
W CrB	*M*=Jly
chi Cyg	*m*=Jun/Jly
S Cyg	*M*=Aug
T Dra	*M*=Jly/Aug
RU Her	*m*=Jun
SS Her	*M*=Aug/Sep
	m=Jly
SU Lac	*m*=May/Jun
RS Leo	*M*=Jun/Jly
X Lyn	*M*=May/Jun
X Oph	*m*=Aug/Sep
R Ser	*M*=Jun/Jly
T UMa	*m*=Jly

Source BAA Handbook

Charts

A couple of reminders when using either VSS or AAVSO charts.

Firstly, VSS charts. When quoting a VSS chart reference you should always use the latest chart (the date is given at the bottom right) with the latest number (top left). For example, X Leo has charts with reference of 010.01 and 010.02 and so you can use the former to help you find the variable and the later when estimating its brightness and therefore quote 010.02 when entering your observation, it being the latest chart. The point being here is that the latest chart will quote the better magnitudes and therefore the ones you should use.

Also, if you have the choice of using a VSS chart or an AAVSO one, we would prefer you use the VSS one! This is especially the case if you have the choice of using one of our charts with the reference in the form ***.** because all these charts are in the database which allows the checking software to do its job when you enter your observations. This it can't do using the AAVSO charts because these charts change their reference *every* time you, or someone else, looks at one and it's impossible to keep up with this.

That said, if you do have difficulties with any particular charts do let John Toone and myself know and we can look into it.

Data

As you will read elsewhere in this Circular, Alex Pratt and Len Entwisle are continuing to do a splendid job in sorting out the old observations found in Melvyn Taylor's files. So much so indeed, that the Director still wishes to increase the number of "Data inputters" to help with this task. Basically, Alex and Len scan the old paper records and send them to me where appropriate and I then send them on to my small band of helpers who enter the observations into the Excel spreadsheet and return it to me.

BVRI Filters

I was contacted early last December by Tex Moon who is an experienced observer based in Tasmania, Australia.

In his email he said, "In particular I have been exploring CMOS cameras for low-cost photometry in the hope of getting more people involved in measurement of variable stars rather than visually estimating magnitudes." Interesting, I thought. Anyway, soon after that he sent me his paper which I then forwarded to Norman Walker (he of the article "CCD Photometry"), as Norman knows more about these things than I do and has already supplied a number of us with filters in the past. Norman felt it was an excellent article and suggested one or two minor changes and so we have now placed it on the same webpage as above for your enjoyment. You can read it here.

It would be interesting to know how many people might be interested in having a go at producing their own filter sets.

I sent out an alert (OK, it's not really an alert, but we don't have another way to do it) but have not heard whether anybody is going to give it a try.

Introduction to AstroImageJ Photometry Software

Richard Lee who was previously unknown to me, contacted me earlier this year about submitting CCD observations and added that his software of choice would be AstroImageJ.

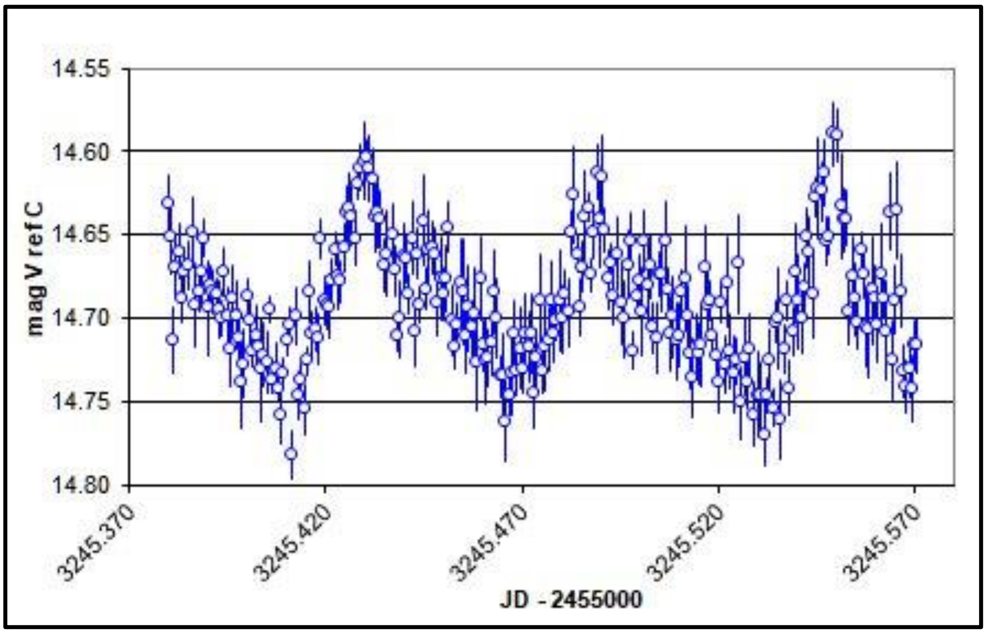
This software is favoured by the AAVSO exoplanet-section and Richard had already written some software to allow CCD data to be entered into the VSS Database.   Richard has also written an introduction to this software which you will find included with this Circular. I've not yet had the opportunity to try it myself but hope to very soon.

And finally, I'll end my '*From the Director*' report with an observation of ASASSN-18iq…

Ian Miller reported new observations of this star on vsnet-alert 22098 on April 20 when he recorded it at magnitude 13.9. The light curve showed clear superhumps with a period of 0.0606(3) days and an amplitude of 0.032 mag. The alert added that the object was a new SU UMa-type DN.

Sadly, due to the poor weather I was unable to observe it until April 30 when I had it at 14.9 magnitude and recorded one superhump. However, my best run was on May 6th when it was a tad brighter and I recorded several superhumps as can be seen on the light curve below.

I continued to monitor it during the remarkable clear spell we experienced at the beginning of May and observed it a further 7 times by which time it had faded to 17.3 mag and the next night it was not visible to mag 17.3 and has not been seen since.



Unfiltered observation by Roger Pickard on 2018 May 06
356mm Meade LX 200 and Starlight Xpress CCD.

V392 Per – Nova Per 2018

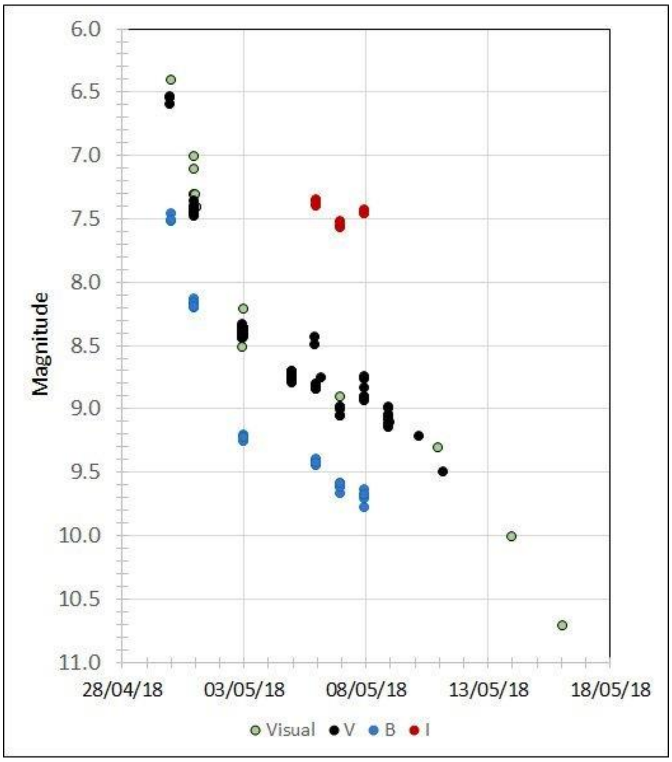
Gary Poyner & Robin Leadbeater

On 2018 April 29.474 UT, Yuji Nakamura, Kameyama, Mie, Japan reported his discovery of a transient object in Perseus at magnitude 6.2 using a 135mm f4.0 lens and CCD. A report was made to CBAT and appeared on the 'Transient Object Follow-up Report' page as TCP J04432130+4721280. It soon became clear that a known Dwarf Nova (originally classified as UGZ) V392 Per is to be found at this position.

An optical spectrum was quickly obtained with the 2.4-m Hiltner telescope of the MDM observatory on Kitt Peak and announced on Atel #11588. The spectrum revealed a classical nova in the early stages of outburst which had not yet reached maximum light. Previously this phenomenon had occurred in just one other *classical* dwarf nova – V1213 Cen (Nova Cen 2009, which in its pre-nova state had been a very faint outbursting dwarf nova with a maximum of I=19.5 with a ~3 magnitude amplitude (Mroz et al)

V392 Per has been monitored regularly by both visual and CCD observers since 2004, with several outbursts being reported to the AAVSO international database. The range before the nova outburst was given in VSX as 14.1-16.9 with the last outburst reported in 2016 Feb/Mar, where the brightness peaked around 13.5. A quick inspection of the AAVSO light curve will show that the last three well defined outbursts (2011, 2013 & 2016) had been increasing in amplitude before the nova outburst of 2018.

Observations from the BAAVSS database during the first three weeks of the outburst reveal a fast nova with an initial 2 magnitude decline in three days, slowing somewhat after May 3 to a further 2.2 magnitudes in a further thirteen days.



Precise astrometry has been received from Denis Buczynski who reveals the position to be RA 04 43 21.39 +47 21 25.9.

Several observers have sent the editor images, and my thanks go to Denis Buczynski, Nick James, Martin Mobberley (cover image) and David Swan for taking the time to do this.

BAAVSS data, Apr 29 to May 16, 2018.
145 observations from…

D. Boyd, T. Heywood, J. H. Mallett, I. Miller, M. Mobberley, R. Pickard, G. Poyner, J. Toone & T. Vale

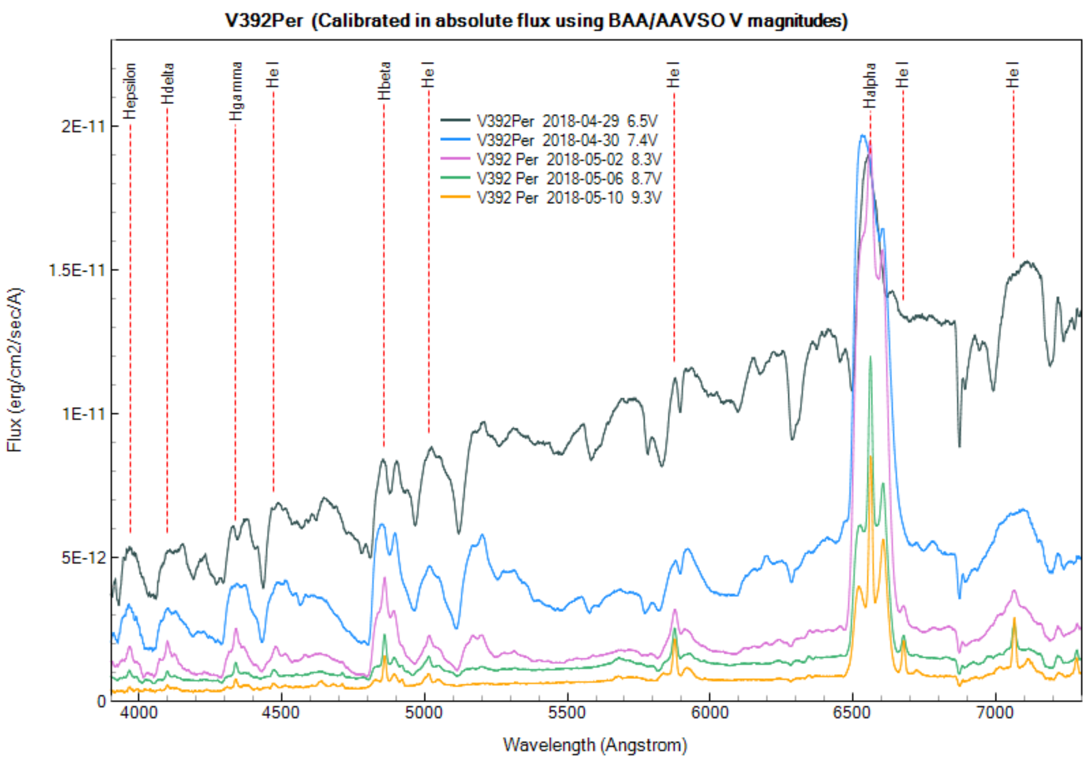
Robin Leadbeater

The low resolution (~12A) spectra (shown below) were recorded at Three Hills Observatory using an ALPY600 spectrograph. They track the evolution over the first two weeks of the nova outburst of V392 Per. They have been calibrated in absolute flux using photometric V magnitudes from the BAA and AAVSO databases and thus show the true change in intensity of the spectrum features over time.
http://www.britastro.org/vssdb
Kafka, S., 2018, Observations from the AAVSO International Database,
https://www.aavso.org
The spectra are also available to view and download from the BAA Spectroscopy Database
https://britastro.org/specdb

The first spectrum was taken 10 hours after the discovery and shows a red continuum with many broad emission lines from H, He and Fe, resembling a classical nova near maximum, significantly reddened by interstellar extinction. The velocity of the ejected material (as measured at H alpha by the blue shift of the P Cygni absorption component relative to the emission component) was estimated at 2600 km/s. This was confirmed by a spectrum taken 5 hours later at the MDM observatory Kitt Peak and announced on Atel #11588

As the nova faded rapidly over the following 3 days, the spectra show the continuum falling away leaving the strong H alpha line dominating the spectrum. This then also starts to fall in intensity after 2018-05-02.

There is significant structure in the H alpha line profile (also seen in the other H Balmer and He lines) This is evidence of asymmetry in the explosion with clumps of material ejected in different directions both towards and away from us, seen at different velocities along our line of sight. Discussions with Prof. Steve Shore, University of Pisa, suggest that the sharp central peak in the profile (at the H alpha rest wavelength) may be an indication that the accretion disk survived the explosion.
http://www.spectro-aras.com/forum/viewtopic.php?f=5&t=2015&start=60#p10688



High cadence measurements of the Symbiotic star V648 Car using a CMOS camera

Steve Fleming, Terry Moon and David Hoxley

Introduction

V648 Car (CPD -57 2768; TYC 8607-22-1) is one of only a handful of hard-X-ray-emitting symbiotic stars (SySt). Angeloni *et al*. [1] reported large-scale variability in its *U*-band light curve over timescales of minutes noting that there appeared to be no significant periodicity to this 'flickering'. During a 4½-hour observing session they measured variations of 0.5 magnitude or more; the timescales being less than 15 minutes. The cadence for the CCD camera they used was approximately 2 minutes.

CMOS cameras designed specifically for astrophotography are inexpensive and readily available. They have some clear advantages over CCD cameras including high quantum efficiencies and low noise but, importantly, dramatically faster image processing and download speeds. By using a CMOS astrocamera, flickering in stars like V648 Car can now be studied on timescales of seconds rather than minutes. Through studying such flickering, we hope to gain a better understanding of the physical processes present in these complex stellar laboratories; processes in the accretion disc surrounding the white dwarf component.

On the night of 14 February 2018, we observed V648 Car continuously for about 7 hours using a ZWO ASI1600MM cooled CMOS camera attached at the f/4 Newtonian focus of the Mount Burnett Observatory (MBO) 18-inch telescope (URL: http://mtburnettobservatory.org/). The field-of-view for this configuration of telescope and camera was 33x25 arc-minutes, well suited to finding then continuously measuring this 10th magnitude symbiotic star. Measurements were made relative to comparison and check stars that were close by and of similar magnitude. Such differential photometry not only suited our program of continuous monitoring but enabled us to gather useful data even when the seeing was less than ideal.

We settled on an exposure time of 4 seconds as it provided sufficient signal-to-noise while delivering a sampling rate almost 30x faster than that of Angeloni et al. [1]. More than 5,000 images were collected over the 7-hour observing session. A median dark frame was subtracted from each 4-second image then an average flat field image applied. SharpCap 3.0 was used for image capture with subsequent batch photometry of the 5000+ images undertaken using Astroart 6.0.

Photometric Band for Measuring Flickering

The measured amplitude of flickering in SySt is greater in the U band than the B or V bands. For example, Cieslinski *et al.* [2] measured short-duration brightness variations for RT Cru on timescales of 10-30 minutes. They found that the amplitude measured in the V band (~ 0.04 magnitude) increased to ~ 0.09 magnitude for measurements in B band. Angeloni *et al*. [3] also note that the amplitude increased for the shorter wavelength bands and chose to measure V648 Car in U band only.

Unfortunately, the sensitivity of CMOS and CCD sensors is substantially less in U band than B or V. To maximise the amplitude of the flickering, we decided to develop a broadband bespoke filter by cementing a planetary #47 (violet) to a Schott BG39 filter. Taking the published response of the Sony IMX174 as representative of CMOS detectors, we customised an 'F band' with a central wavelength

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of 399 nm. This has a significantly shorter central wavelength than B band and is in a spectral region where the flickering amplitude is expected to be higher while the CMOS detector remains relatively sensitive. (See Figure 1 for comparison of standard U and B bands with the bespoke F band. The responses shown have been normalised.)

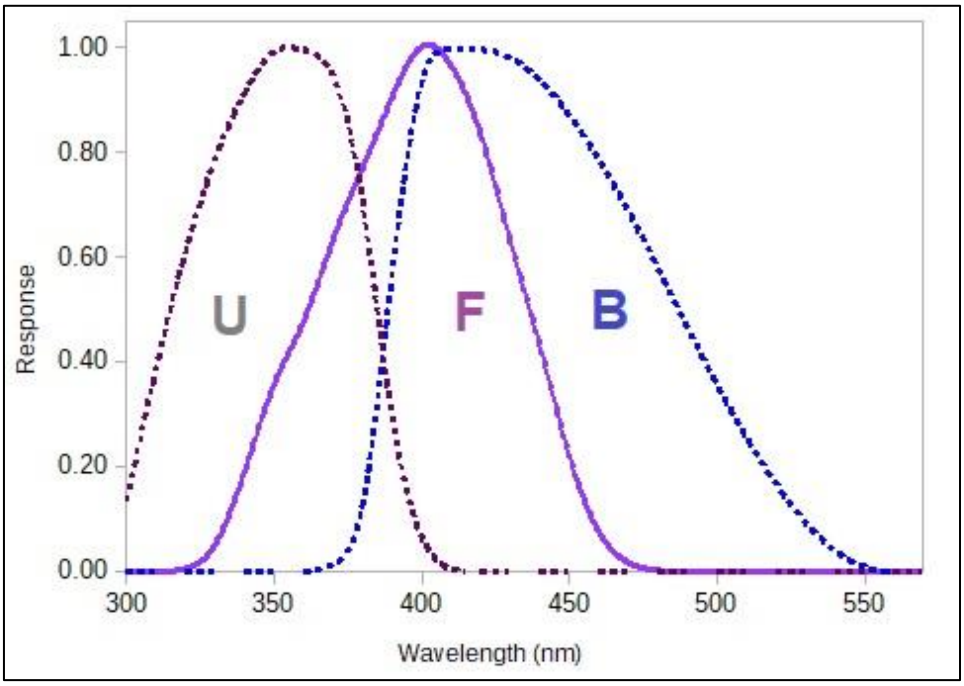

Figure 1: Normalised response of the new F band compared to Johnson U and B bands.

Currently, our F-band measurements are simply the instrumental-magnitude differences between the variable and comparison and check stars selected. To standardise the F band would require establishment of a suitable F-V colour index with a set of standard stars where F-V is set to 0.00 for unreddened A0V stars. The open cluster IC 2602 has a group of bright stars around A0 that are essentially unreddened. A customised colour index, F-V, could then be readily established by setting the average F-V for this selection of A0 stars to 0.00. Further work to establish a 'standard' F-V index for specifically studying flickering with CMOS cameras is being considered as it would enable photometric measurements from different observers or equipment to be combined.

F-Band measurements of V648 Car

Measurements of V648 Car for the 14 February 2018 are shown in Figure 2. The comparison (TYC 8607-276-1) and check stars (TYC 8607-345-1) were of a similar magnitude to V648 Car and close by (separated by 1½ and 5 arc-minutes respectively). The signal-to-noise was thus similar for variable, comparison and check stars. The standard deviation of the differences between the comparison and check stars for the 7-hour observing session was ±0.050 magnitude and, as shown in Figure 1, this magnitude difference remained constant while V648 Car varied by several tenths of a magnitude.

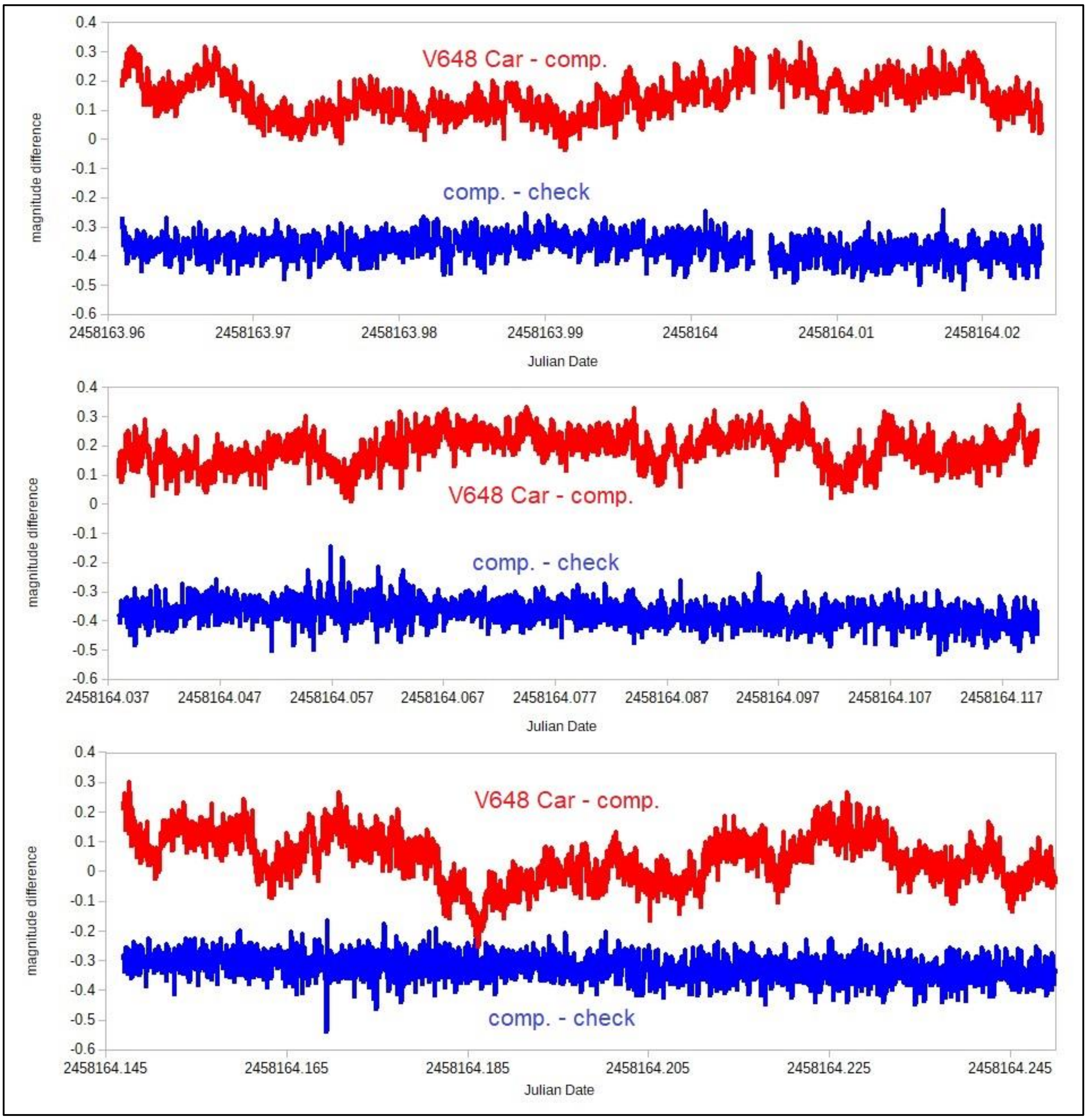

Figure 2. Measurements of V648 car relative to comparison and check stars for 14 February 2018.

Using the software package PerSea [4, 5] a search was undertaken for periodicity in the light curve of V648 Car over a range of frequencies defined, at the upper end, by the cadence of our measurements (4 seconds) and, at the lower end, by the timescale of variations reported in the literature (20 minutes). Subsequently the search range was extended to explore the aliasing effects arising from the collection of the data.

In Figure 3 there is an aliasing peak at the frequency related to the length of the observing run (~ 0.29 day) and a smaller peak at a frequency defined by the cadence (4 seconds). Although variations in the order of several tenths of a magnitude were clearly observed during the observing session, there is no evidence from the period analysis that they are periodic.

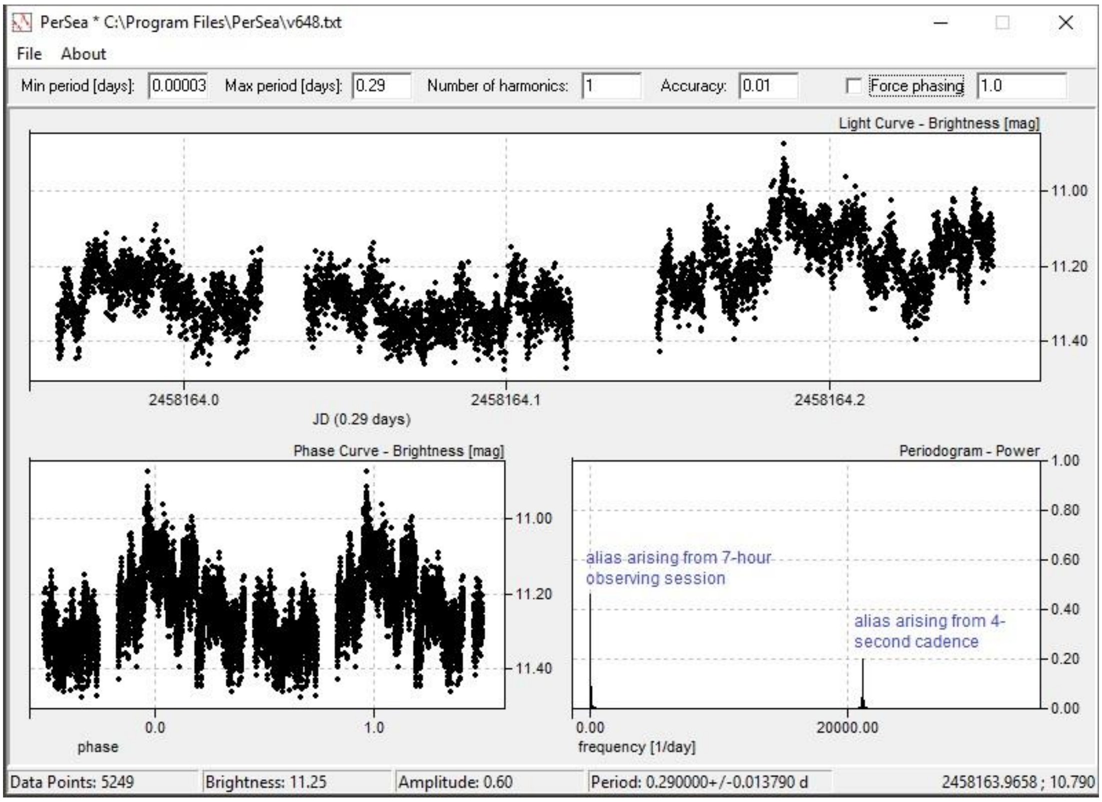

Figure 3: Periodogram for measurements of V648 Car taken on 14 February 2018. There was no evidence of periodicity over the range of 0.00005 to 0.0010 days. When the range is extended to 7 hours (length of observing run) an alias appears at 0.29 day as shown on the LHS of the periodogram. The alias at around 0.00005 day arises from the cadence of 4 seconds.

Conclusion

Flickering in the light curve of the symbiotic star V648 Car (reported by Angeloni *et al*.) was confirmed along with its non-periodic nature.

Continuous measurement of V648 Car over a 7-hour observing session demonstrated that inexpensive CMOS astrocameras enable such flickering to be studied at a higher cadence (seconds rather than minutes) than that attained previously using CCDs. Coupled with their high quantum efficiencies, low noise and fast image download and processing times, CMOS astrocameras appear ideally suited to studies of such short-duration variability in SySt enabling physical processes associated with disc accretion to be further explored. Further studies of the optical variations in selected SySt are planned.

References

[1] Angeloni, R., Di Mille, F., Ferriera-Lopez, C.E. and Masetti, N. 2012, *Astrophys. J. letters*, 756:L21.
[2] Cieslinski, D., Elizalde, F. and Steiner, J.E. 1994, *Astron. Astrophys. Suppl. Ser*. **106**, 243.
[3] Angeloni, R. 2011, 'A Systematic Search for Flickering in Southern Symbiotic Stars', *Pontificia Universidad Católica de Chile (PUC) Seminar*, 23 November. URL: http://www.rodolfoangeloni.net/uploads/6/0/7/8/6078320/puc_seminar_23nov11.pdf [accessed 16 March 2018.]
[4] Maciejewski, G. 2009, PerSea 2.6,
[accessed 1 December 2009.]
[5] Schwarzenberg-Czerny, A. 1996, Astrophys. J. **460**, L107-L110.

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Analysis of two semi-regular variables in Draco

Shaun Albrighton

This report highlights observations made by members of the BAAVSS of the two SRb variables, TX Dra and AH Dra. Both of these stars are circumpolar from British latitudes, which leads to complete coverage of the stars during the period since 1970. The AAVSO V Star program has been used for the purposes of analysis.

TX Dra is listed in the VSX database as a SRb variable, spectral type M4II/IIIe-M7, mag range 6.8 – 8.2 and period 78d. An additional note gives a second longer period of 645d.

Figure. 1 shows the full BAAVSS light curve which clearly shows a longer period for the variable. In addition, the maximum range is approx. 6.7 -8.5.

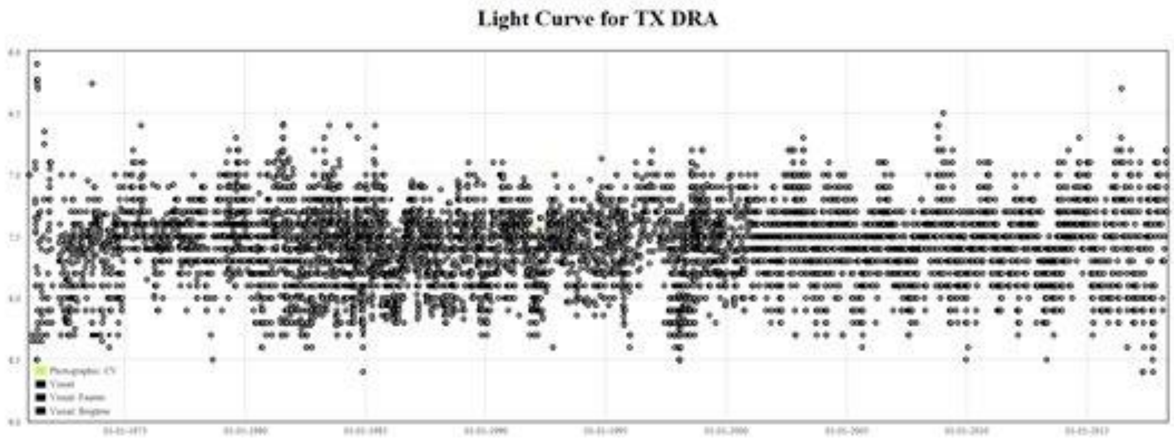

Figure. 1

When we conduct a period analysis for TX Dra we see that the dominant periods are 713d and two peaks of 76.6d and 77.5d. These later two periods may be due to fluctuations over time in this shorter period.

Frequency	Period	Power	Amplitude
0.001402	713.46d	448.57	0.148
0.013061	76.57d	241.34	0.108
0.012901	77.51d	219.77	0.133
0.007231	138.29d	118.22	0.076
0.007836	127.61	83.21	0.060

Figure. 2 shows the light curve for the period 1980 – 1985, clearly shows typical SRb type variations. The 77d period is very distinct between autumn 1980 and Jan 1984, either side of this variations are less distinct. Figure. 3 clearly shows the longer period of around two years.

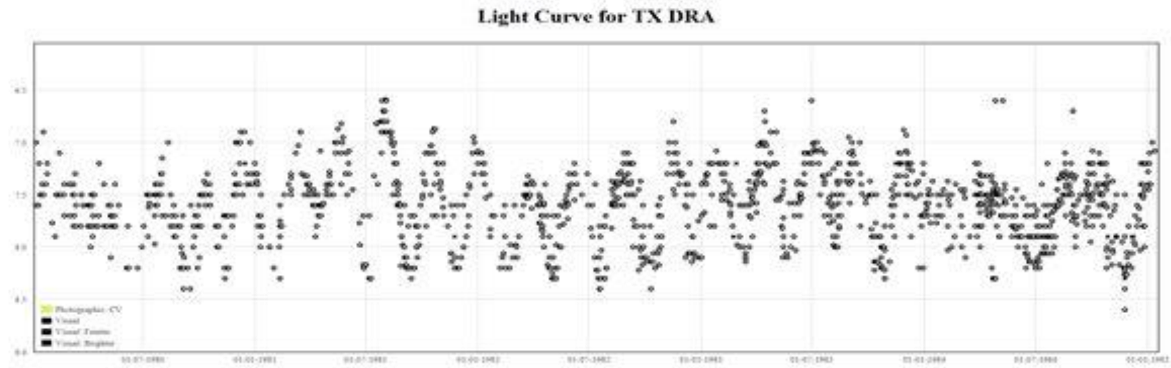

Figure 2

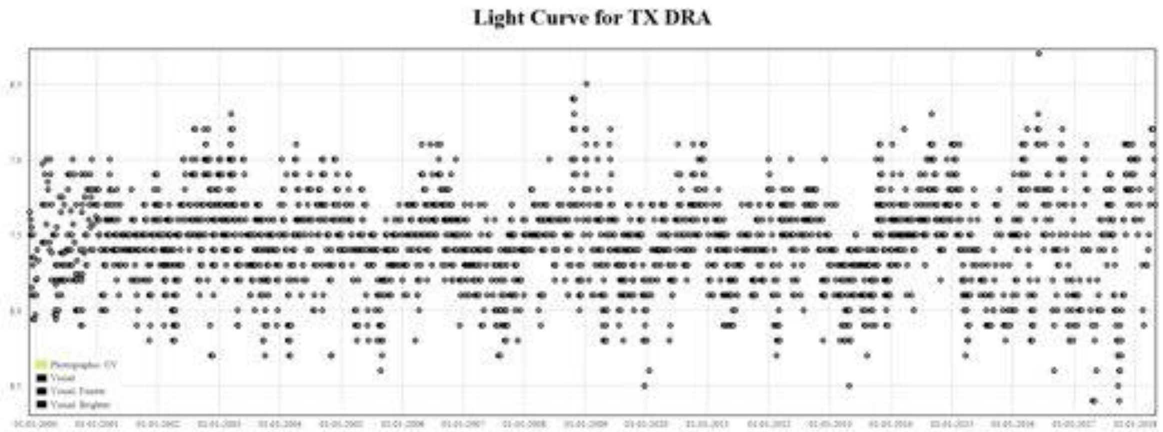

Figure 3

To sum up, observations confirm the VSX range and that there are two clear periods. Whilst we find the shorter period 77d close to VSX (78d), the secondary longer period appears longer than the quoted 645d, being 713d. Continued observations of this excellent binocular variable should help us to confirm/refine this longer period.

AH Dra appears on the same BAAVSS chart as TX Dra, whilst we have good coverage of the star, TX Dra appears to be the more popular object. The VSX lists AH Dra as a SRb variable, spectral class M5-M7, mag range 6.4-8.6 and period of 158d. No secondary period is listed.

Figure. 4 below shows the full light curve of AH Dra for the period since 1970. We do find the max range for the star to be slightly fainter than the quoted range, being approx. 6.8 – 8.8, but this can be possibly attributed to variations in comparison star magnitudes. It should be noted that during the periods 1980 -1985 (in particular) and again from 1996 – 2002 the range appears reduced.

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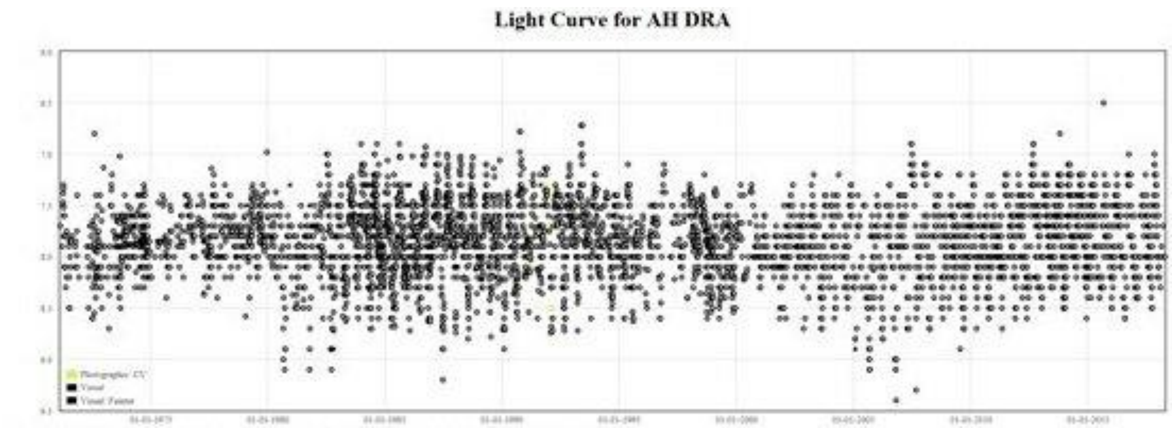

Figure. 4

As will be seen period analysis reveals a clear period of 190d for AH Dra (Figure 5). A secondary peak of 186d and two further weaker periods of 194d and 197d may again be due to slight fluctuations of this period. This is clearly longer than the stated period of 158d. To date there is no evidence for a longer period as in the case of TX Dra, however there is a peak corresponding to 105d which may benefit from further investigation.

Frequency	Period	Power	Amplitude
0.005259	190.15	552.06	0.240
0.005367	186.31	252.76	0.164
0.009528	104.95	128.97	0.117
0.005166	193.57	113.41	0.109
0.005089	196.51	66.94	0.083

Figure. 5

It is hoped that observers will continue to monitor both of these variables, as these results demonstrate the value of a long time series of observations.

BAAVSS charts for AH Dra & TX Dra

V720 Cas and its close companions *David Boyd*

Background

At the VSS meeting at Northampton in March 2016, Chris Jones reviewed the current position of several stars in the ICCE programme for which there remained an unresolved issue. These included V720 Cas (aka GSC 3655 1254) which at the time was listed in the AAVSO VSX as a semi-regular variable. There are three stars of similar magnitude within a circle of radius 22 arcsec at the location of V720 Cas, the other two stars being GSC 3655 1011 and GSC 3655 1455. Because of the difficulty of resolving these stars in wide field images, there had been a question about which star of the three was actually variable. Chris reported that this had now been resolved and that the variable was probably a Mira. However, its range remained uncertain and Chris commented that it seemed likely that one of the other two stars was an eclipsing variable.

There are relatively few references to V720 Cas in the published literature. The star was first catalogued as IRAS 00422+5310 in the IRAS infrared survey (Olnon et al. 1986). Little-Marenin et al. (1987) classified it as a carbon star based on a low-resolution spectrum. Carbon stars are pulsating red giants showing strong absorption bands of carbon-rich molecules in their spectra.

The variability of the star was discovered by Mike Collins in the course of his nova patrol using Kodak 2415 film and was reported in The Astronomer magazine in December 1991.

Rudolph (1993) at Sonneberg Observatory reported the pulsation period as 420d between 1971 and 1986 and 456 d after 1988. The *Catalog of Red Variables in the NSVS* (Wozniak et al. 2004) gave the variability type of V 720 Cas as SR+L (semi-regular and irregular) and the period as 357 days. The GCVS lists its variability type as SR (semi-regular …. sometimes interrupted by various irregularities) and its period as 456 days. From a period analysis of data collected in 2013-2014, Rocchi et al. (2017) reported the period of V720 Cas as 455 days. The AAVSO VSX currently gives the period of V720 Cas as 425 days and lists its variability type as Mira.

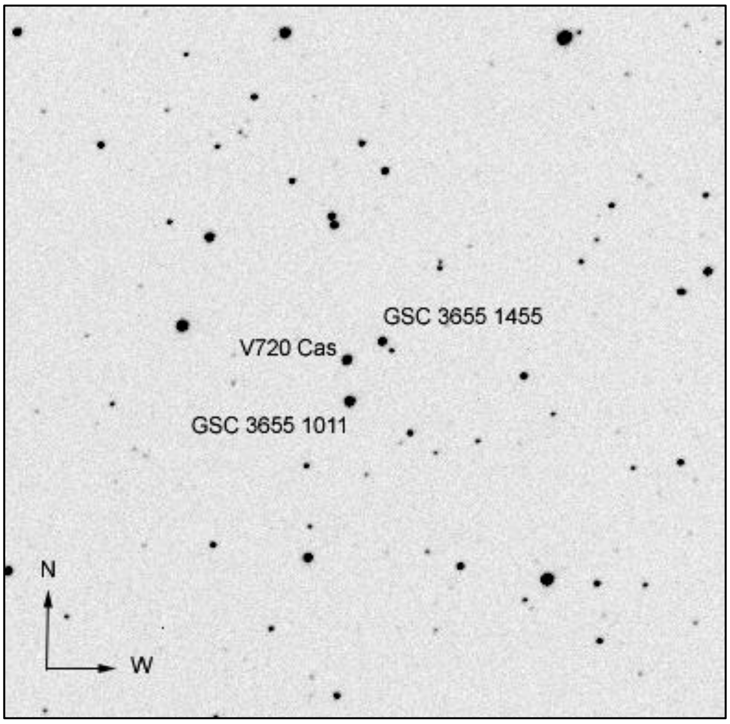

Figure 1: 19 x 9 arcmin field centred on V720 Cas

Comparing the data for V720 Cas in the AAVSO and BAAVSS databases, it appears that the majority of the data in the AAVSO database originated from the BAAVSS. There is little data on V720 Cas in either database prior to 1998 and between 2010 and 2015. Magnitudes of V720 Cas in the BAAVSS database from 1998 to the present range between 11 and 15.8. The AAVSO VSX gives the range as 11.2 to 15.7 V. However closer examination shows that the star's annual mean magnitude fell steadily from 1998 to 2009 while the range of variation at any point in that time was only about 2.5 mag.

Period analysis of the BAAVSS data from 1998 and 2009 using the ANOVA technique in Peranso gives a period of 452±12 d.

New observations

Prompted by Chris's talk to investigate, I imaged the field with a 0.35m SCT and SXVR-H9 CCD camera using V and Rc filters approximately every two weeks between March 2016 and July 2017 and again occasionally between January and April 2018. Fig 1 shows a 9 x 9 arcmin field centred on the group of three stars. Using V and Rc magnitudes of three nearby comparison stars from the APASS catalogue, I measured mean V and Rc magnitudes of each of the group of three stars by differential aperture photometry on 40 nights between March 2016 and April 2018.

Fig 2 shows the V magnitude light curves of the three stars over this time. V720 Cas varied between V = 11.95 and V = 14.4. This amplitude of around 2.5 mag is consistent with previous observations and places V720 Cas on the rather arbitrary borderline in amplitude (2.5 mag) between Mira and semi-regular variables. The mean V magnitude of GSC 3655 1011 was 12.740±0.008 and of GSC 3655 1455 was 13.444±0.007. These two stars therefore appear to be constant and it is unlikely that either of them is an eclipsing variable.

Fig 3 shows how the V-Rc colour index of V720 Cas varies with its V magnitude indicating the star is hottest when at maximum brightness and coolest when faintest as expected for a pulsating giant star. The mean V-Rc colour index of GSC 3655 1011 is 0.542±0.007 and of GSC 3655 1455 is 0.414±0.009 indicating they are probably main sequence stars with K3 and G8 spectral types.

To determine the mean pulsation period of V720 Cas between March 2016 and April 2018, I carried out separate period analyses of my V-band and R-band data using the ANOVA technique in Peranso. This gave periods of 412±13 d and 406±11 d respectively. Assuming these periods are actually the same, this gives a mean pulsation period between those dates of 409±3 d. This represents a reduction in pulsation period compared to recent years of about 9%. Whether this is an indication of a progressive period reduction as has been seen in some long period variables (e.g. T UMi) or simply an example of its semi-regularity, remains to be seem.

References

Olnon F.M. et al., Astronomy and Astrophysics Supplement Series, 65, 607 (1986)
Little-Marenin I. R. et al., Astronomical Journal, 93, 663 (1987)
Collins M., The Astronomer, 28, 332, 182 (1991)
Rudolph E., Mitteilungen über Veränderliche Sterne, 12, 9, 165 (1993)
Wosniak P. R. et al., Astronomical Journal, 128, 2965 (2004)
Rocchi G. et al, IBVS 6199 (2017)

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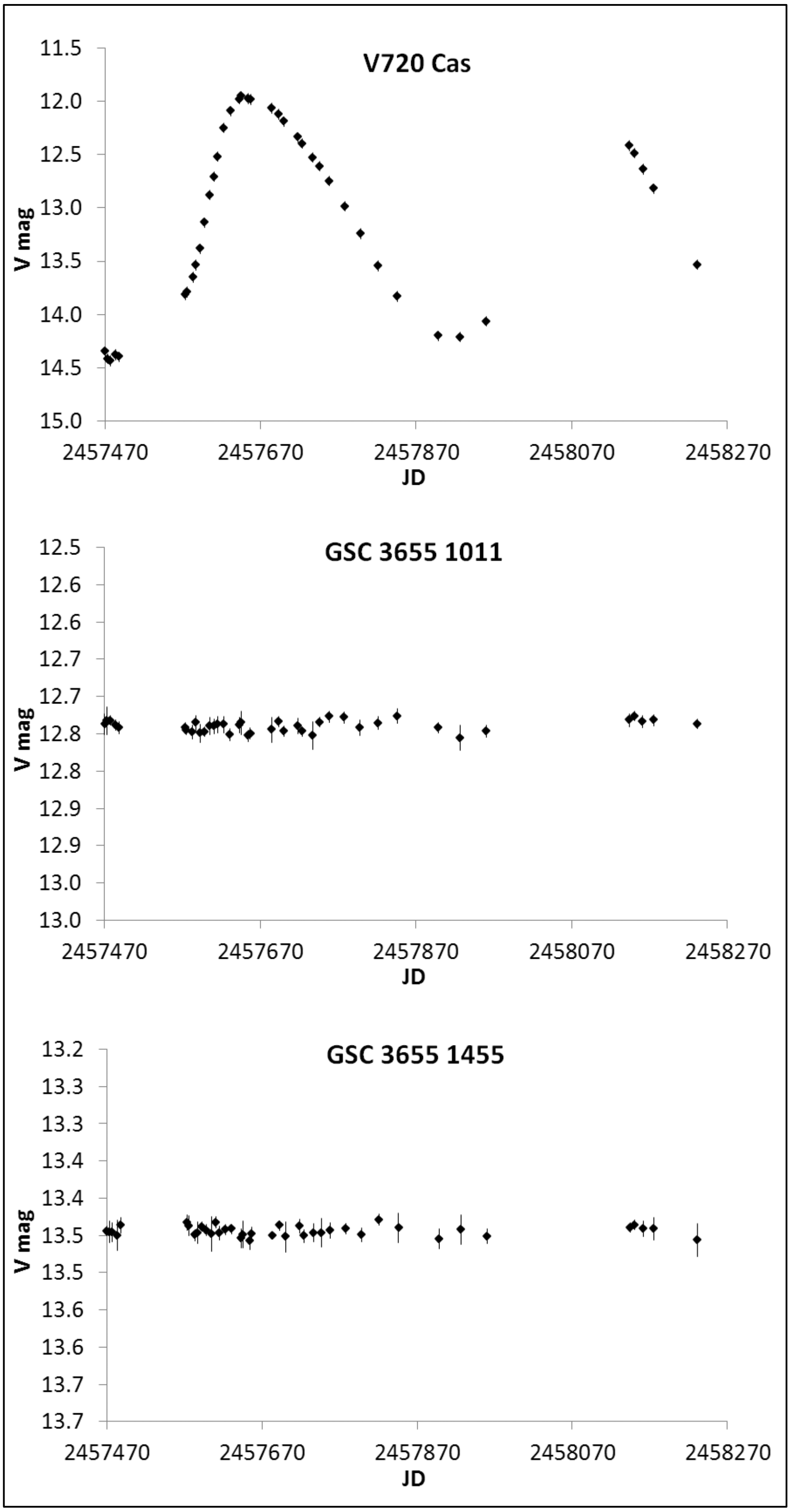


Figure 2: V magnitude light curves of V720 Cas, GSC 3655 1011 and GSC 3655 1455 between March 2016 and April 2018.

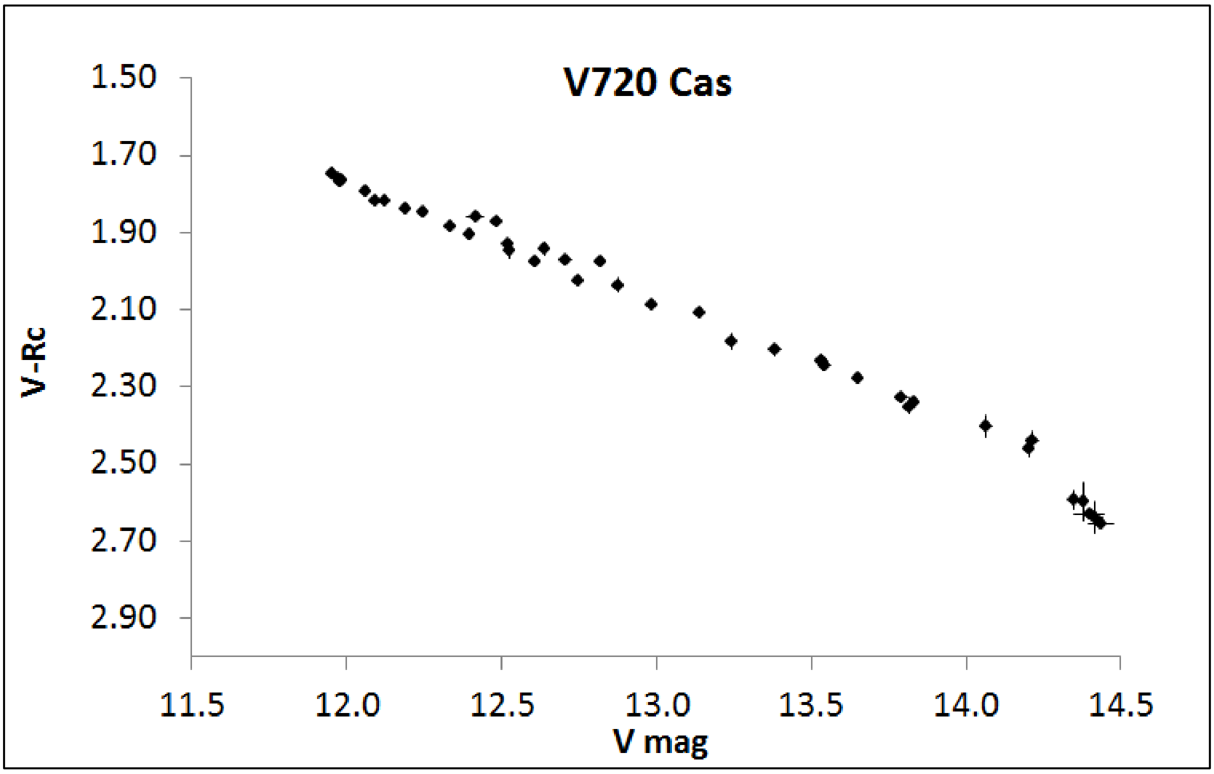


Figure 3: Variation of the V-Rc colour index of V720 Cas with its V magnitude.

BAAVSS Chart

Introduction to AstroImageJ Photometry Software

Richard Lee

AstroImageJ (AIJ) is open source photometry software, developed and maintained by researchers at the University of Louisville as an astronomical extension to ImageJ NIH image analysis software. In Collins et al 2017, the authors describe the software as:
" .. *AIJ is streamlined for time-series differential photometry, light curve detrending and fitting, and light curve plotting, especially for applications requiring ultra-precise light curves (e.g., exoplanet transits)."*
Possible users of AIJ include:

- Observers new to stellar photometry – AIJ is free to down-load with several sets of example data on the AIJ home page and other sites
- Photometry of exoplanet transits - AAVSO recommend AIJ for exoplanet photometry
- Asteroid light curve photometry – Multi-plot Main function to create Minor Planet Center formatted data.
- More experienced observers considering AIJ as an alternative to AIP4WIN, for example.

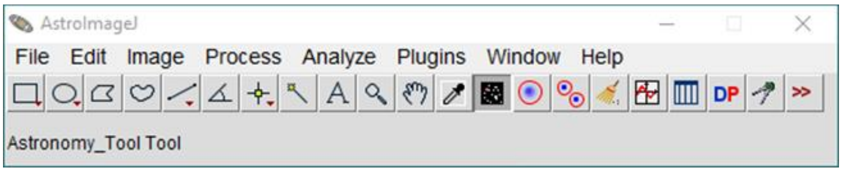
In this article, I'll cover some of the main features of AIJ, including the Image Display Interface and sub-sets of other dialogs, deferring detailed discussion of the complex Multi-plot dialogs to the AIJ User Guide etc. The section "Generating VSS Submission Files" outlines Excel spreadsheets developed to convert AIJ measurements results into BAA VSS compatible formats.

Download and Install

AstroImageJ software, example files and User Guide can be accessed through AIJ Home page: http://www.astro.louisville.edu/software/astroimagej/. For Windows, download AstroImageJ v3.2.0 java7 x32 or x64 (approx. 50M), open the downloaded zip file and copy the AstroImageJ folder to local hard-drive e.g. C:\AstroImageJ. The Java Runtime Engine (jre) and all support files are contained in this folder.
To download example files, select the zip-format Wasp-12b raw calibration files and uncalibrated image files. The total file size unzips to about 15 GB.

First run:

Double-click on AstroImageJ.exe to open the AstroImageJ toolbar, with Astronomy Tool Tool icon pre-selected.



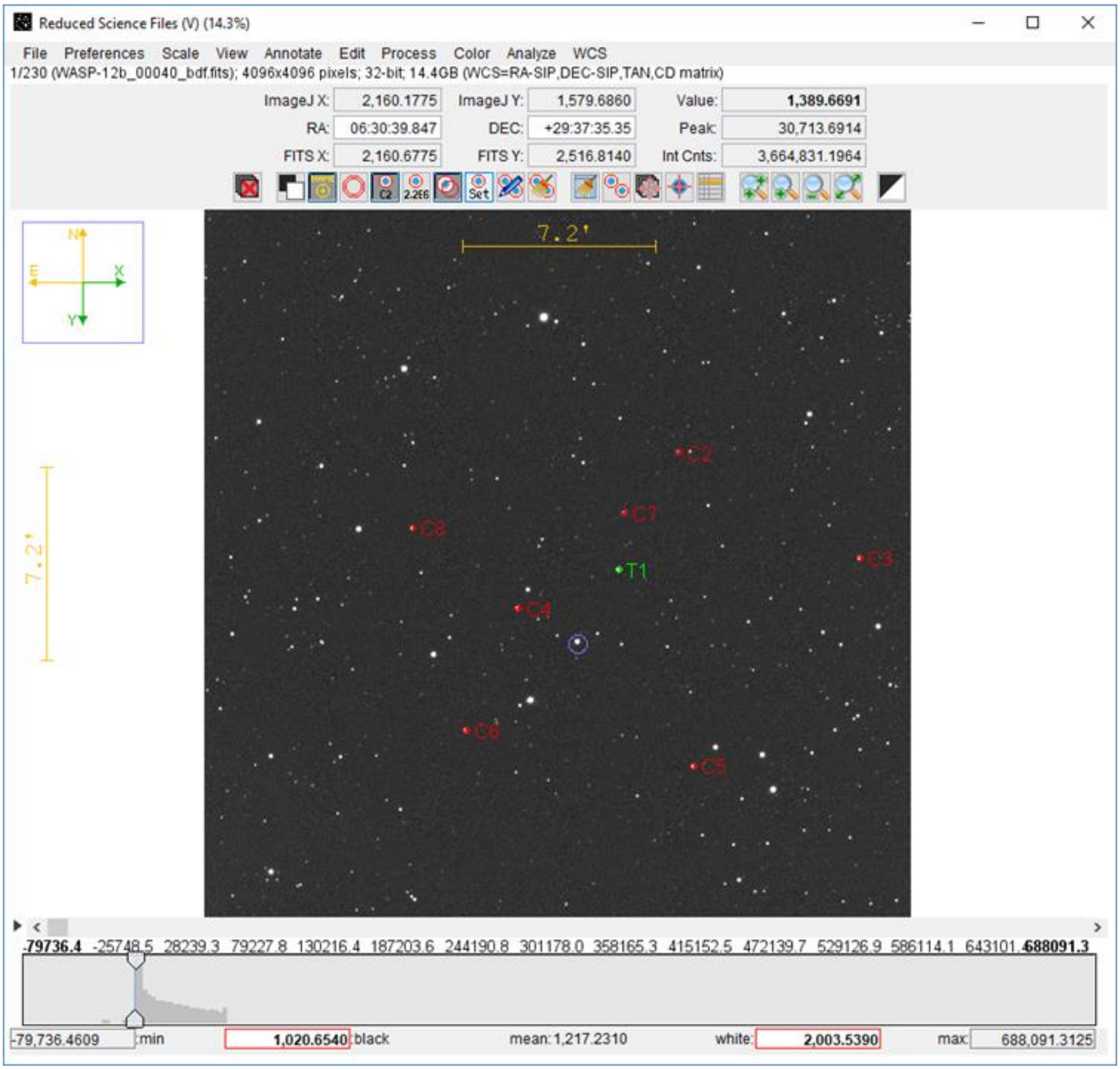
AstroImageJ Toolbar

The first run sets up configuration files and may trigger Windows Firewall warnings. On subsequent runs AIJ should open without warnings. To update to the latest version, select Help | Update AstroImageJ. select "daily build" from the drop-down and click OK to run upgrade.

Icons to right of Astronomy Tool invoke AIJ functions.  opens the CCD Data window (see below) and several other icons can also be accessed from AIJ windows.

To import a set of reduced image files for processing, from the toolbar select File | Import | Image Sequence ... navigate to and select the first image file in the folder. In the Sequence Options dialog, confirm Use virtual stack option is checked then click OK to import the first image into the AIJ image display interface. The screenshot below shows image #1 in a stack of 230 WASP-12b images from the example files set. The marked apertures T1 (green) and C2 to C8 (red) mark the target and comparison or reference stars used in the User Guide tutorial.

AstroImageJ Image Display Interface



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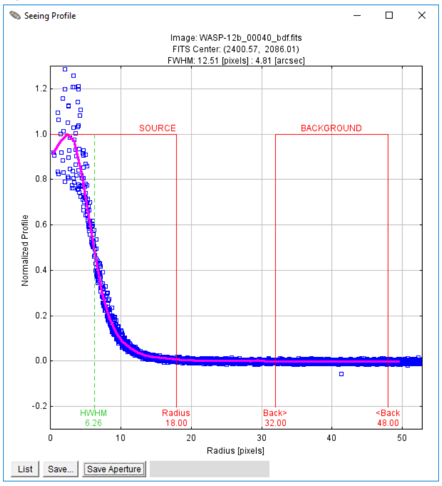
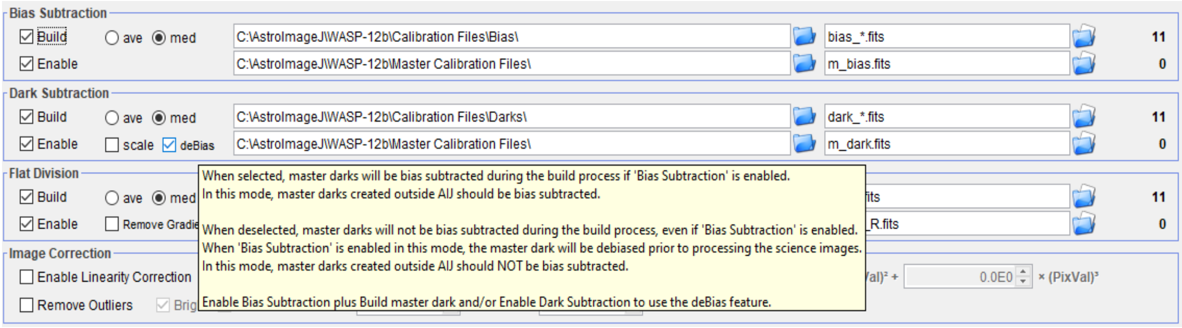
AstroImageJ Image Display Interface Features

<table>
<tr><td>Top line (below menu options)</td><td>File and image information and plate solve data (if applicable)</td></tr>
<tr><td>Header section</td><td>Photometric and coordinate values for the blue circle ‘live’ data cursor, indicated by the yellow arrow.</td></tr>
<tr><td>Icons</td><td>Range of icons for common functions including aperture size and display options, zoom and image contrast, FITS header editor etc. Hover mouse over icon to display tool-tip.</td></tr>
<tr><td>N/E X/Y indicator (box upper left)</td><td>X/Y pixel coordinate axes and N/E celestial compass orientation yellow / red indicates image plate solved / not solved respectively</td></tr>
<tr><td>Image</td><td>Intuitive mouse wheel zoom and left-click pan actions.
Alt-right click on star image to open Simbad web page for that object (requires plate solved image)
Alt-left click on star to open Seeing Profile window with suggested aperture sizes.

</td></tr>
<tr><td>Apertures</td><td>Aperture sets can be saved and re-loaded with RA/DEC centre coordinates to track star centroids over full stack, including meridian flip (requires plate solved images)</td></tr>
<tr><td>Histogram</td><td>Bottom section displays image histogram with standard controls</td></tr>
<tr><td>Image animation</td><td>Left click the small triangle highlighted in AIJ Display screenshot to start / pause image animation. Right click opens a dialog to set animation speed (fps).
Toolbar icon  removes the current image from the processing stack</td></tr>
</table>

Master Calibration Files and Image Reduction

Click 

in AIJ toolbar to open the CCD Data Processor and DP Coordinate Converter dialogs. The Coordinate Converter dialog collates UTC and JD-based times, observatory location and Simbad Object celestial coordinates. The CCD Data Processor manages Build of Master Calibration files and reduction of Science Image files.



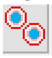
Processing Calibration Files in the CCD Data Processor Window

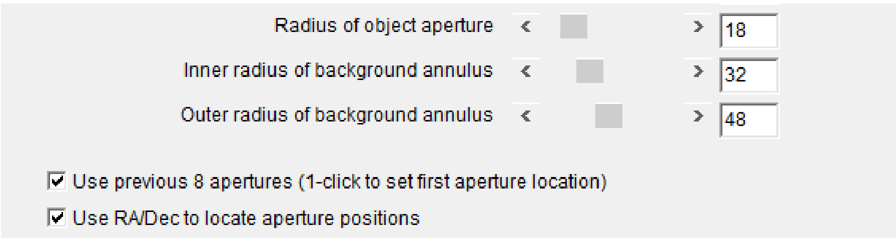
The screenshot shows bias, darks and flats calibration files selected for median combining into respective master calibration files. The lengthy tool-tip details deBias option in the Dark Subtraction section. Files are selected by folder then matched by pattern – for example 11 bias files matching bias_*.fit are selected for combining into m_bias. fits master bias file. Reduction of Science Image files follows the same pattern. Reduced files can be saved to a new subdirectory with an optional file suffix to indicate image reduction history.

Plate Solving using the Astrometry.net Web Portal

Click toolbar icon  to open the Astrometry Settings dialog. Section 7 of the User Guide covers "plate solving" FITS images using Astrometry.net web portal with WCS updates to FITS header. A stack of images can be plate solved automatically, although for a large image set the process will be slow (full disclosure, I prefer to use TheSkyX Image Link to plate solve FITS images).

Multi-Aperture Photometry

Click  to open the Multi-Aperture Measurements dialog, the first of three dialogs to configure measurement apertures and set-up items to log in the measurements table. The extract below shows aperture radii and option to use RA/Dec to locate aperture positions.

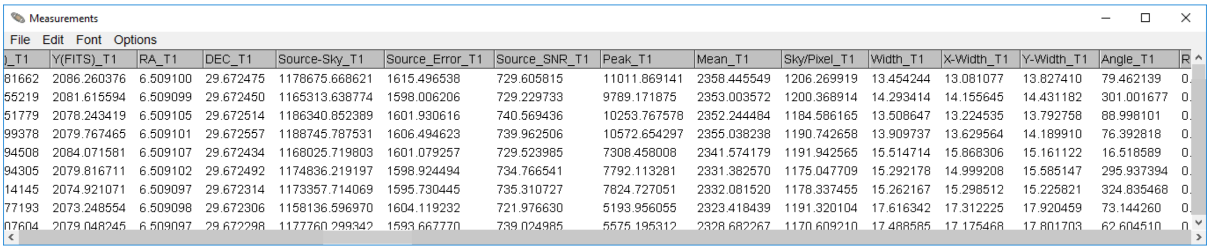


Extract from Multi-Aperture Measurements dialog

Click [Place Apertures) in Multi-Aperture Measurements window to open Multi-Aperture Help dialog which lists options for adding/deleting target or reference star apertures. Press <Enter> to start processing.

Measurements table

On completion of Multi-Aperture processing, AIJ generates a leaderless measurements table for the selected parameters which can be saved as a text file for importing data into Excel.


Measurements

File Edit Font Options

)_T1	Y(FITS)_T1	RA_T1	DEC_T1	Source-Sky_T1	Source_Error_T1	Source_SNR_T1	Peak_T1	Mean_T1	Sky/Pixel_T1	Width_T1	X-Width_T1	Y-Width_T1	Angle_T1	R
81662	2086.260376	6.509100	29.672475	1178675.668621	1615.496538	729.605815	11011.869141	2358.445549	1206.269919	13.454244	13.081077	13.827410	79.462139	0.
55219	2081.615594	6.509099	29.672450	1165313.638774	1598.006206	729.229733	9789.171875	2353.003572	1200.368914	14.293414	14.155645	14.431182	301.001677	0.
51779	2078.243419	6.509105	29.672514	1186340.852389	1601.930616	740.569436	10253.767578	2352.244484	1184.586165	13.508647	13.224535	13.792758	88.998101	0.
99378	2079.767465	6.509101	29.672557	1188745.787531	1606.494623	739.962506	10572.654297	2355.038238	1190.742658	13.909737	13.629564	14.189910	76.392818	0.
94508	2084.071581	6.509107	29.672434	1168025.719803	1601.079257	729.523985	7308.458008	2341.574179	1191.942565	15.514714	15.868306	15.161122	16.518589	0.
94305	2079.816711	6.509102	29.672492	1174836.219197	1598.924494	734.766541	7792.113281	2331.382570	1175.047709	15.292178	14.999208	15.585147	295.937394	0.
14145	2074.921071	6.509097	29.672314	1173357.714069	1595.730445	735.310727	7824.727051	2332.081520	1178.337455	15.262167	15.298512	15.225821	324.835468	0.
77193	2073.248554	6.509098	29.672306	1158136.596970	1604.119232	721.976630	5193.956055	2323.418439	1191.320104	17.616342	17.312225	17.920459	73.144260	0.
07604	2079.048245	6.509097	29.672298	1177760.299342	1593.667770	739.024985	5575.195312	2328.682267	1170.609210	17.488585	17.175468	17.801703	62.604510	0.

Sample of AIJ Measurements Table

Multi-plot

The Plot of Measurements window is configured with two complex dialogs, the Multi-plot Main and Y-data dialog. Plot titles, default X-data, scaling etc are set-up in Multi-plot Main, and the user can select number and type of data sets to plot in Multi-plot Y-axis. In a second section of the Y-axis dialog, there are a wide range of dataset trend functions used in exoplanet transit photometry. There are a couple of other dialogs detailed in the User Guide and other documentation listed in Resources section.

Generating VSS Submission Files

VSS Photometry Excel spreadsheet
Currently, this spreadsheet is limited to importing AIP4WIN data files only. An adapted version has been developed which imports AIJ measurement data, although at time of writing, this version should be considered “demonstration” standard.

AIJ_VSS_Photometry
I have developed a second Excel application to import AIJ photometry data into VSS-compatible report files. Pending a released update to VSS_Photometry software, AIJ_VSS_Photometry will enable members of BAA VSS section (and possibly other BAA sections ...?) to import AIJ photometry data into the BAA database.

Tutorials

Chapter 10 in the User Guide is a step-by-step guide to differential photometry in AIJ with WASP-12b FITS files downloaded from AIJ homepage (see Resources). A Practical Guide to Exoplanet Observing also has detailed instructions including navigating various Multi-plot dialogs.
A short user guide / tutorial for AIJ_VSS_Photometry is planned, to walk users through importing and converting the WASP-12b data set into a VSS report file.

Resources

Tooltip provide the primary source of application help, tooltips are liberally distributed throughout AIJ.
On-line resources include:
AIJ homepage: . http://www.astro.louisville.edu/software/astroimagej/, with links to software downloads, example files and AIJ user guide.
Dennis Conti’s Guide to Guide to Exoplanet Observing From section 8, *“...this Guide was intended as a practical, step-by-step approach to image calibration, differential photometry, light curve plotting, and exoplanet transit modelling using AIJ.”*

Link to the AIJ user forum, supported by Karen Collins lead author of AIJ. The forum link How to accomplish specific tasks in AstroImageJ contains information not covered in the user guide.

For more information on Multi-plot functions, download the AstroImageJ Open Access article (extended version); the Guide to Exoplanet Observing also has detailed Multi-plot instructions.

References

Collins, K. A., Kielkopf, J. F., Stassun, K. G. & Hessman F. V. 2017, AJ, 153, 78
BAA VSS Guide to CCD & DSLR Observation Submission File Layout (23 April 2017)

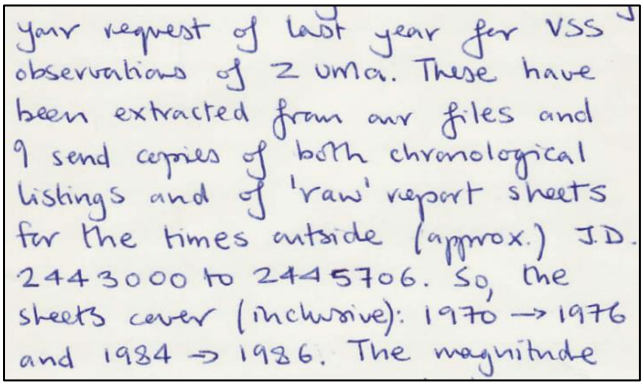
Project Melvyn – 2018 May update

Alex Pratt

As mentioned in VSSC175 (2018 March) Len Entwisle and I found hundreds of VS report forms in Melvyn Taylor's document archives containing thousands of unrecorded visual estimates of Binocular Programme stars from the 1970s to the 1990s. I'm scanning these to PDF files and they are being added to the VSS database either by the original observers or a small team of volunteers.

A notable exception is the data for 1982. In almost all cases observers' report sheets for this year are not in Melvyn's folders, they have previously been logged in the database.

Neither the VSS Committee nor his fellow observers were aware that Melvyn had retained such a treasure trove of VS data. There are some large gaps in Binocular Programme light curves for those years and the missing observations could not be found. I think I can throw some light on how they came into Melvyn's possession. He served in various roles in the VSS, including a term as Section Secretary, during which time he received many observers' report forms. These were analysed by him when preparing Section reports, for example, in his Journal paper on 'The semiregular variable RX Bootis' [1] covering the period 1968 to 1984. He also used them when replying to requests for observations, such as in this letter to the RGO in March 1987 concerning VSS data on Z UMa. The original forms were then stored on Melvyn's bookshelves.


your request of last year for VSS observations of Z UMa. These have been extracted from our files and I send copies of both chronological listings and of 'raw' report sheets for the times outside (approx.) J.D. 2443000 to 2445706. So, the sheets cover (inclusive): 1970 → 1976 and 1984 → 1986. The magnitude

I've now finished working through the contents of his RS And, RX Boo, V CVn, AR Cep, ST Her, RV Mon and SX Mon, and Z UMa folders. So far this has recovered 9,893 unrecorded observations on 1,008 report forms submitted by 103 observers. The 5 most prolific contributors were: Ian Middlemist (1,587), Shaun Albrighton (808), Melvyn Taylor (725), Bill Worraker (587) and Rhona Fraser (577).

In addition to these paper records I found more of Melvyn's unrecorded estimates in doc and txt files stored on his USB flash drives and external hard drives. These were forwarded to Tracie Heywood whose sterling efforts have added 22,000 of Melvyn's observations to the database, bringing his tally to over 58,000.

The hard work of Tracie and other inputters is improving our coverage of Binocular Programme stars during the 1970s to 1990s, shown by the following 'before' and 'after' 1970s VSS database plots of V CVn and Z UMa. Future Circulars will include more examples of how Project Melvyn is filling the gaps in these light curves.

Reference

[1] M. D. Taylor, 'The semiregular variable RX Bootis', *J. Brit. Astron. Assoc*., **97**(5), 277-279 (1987)

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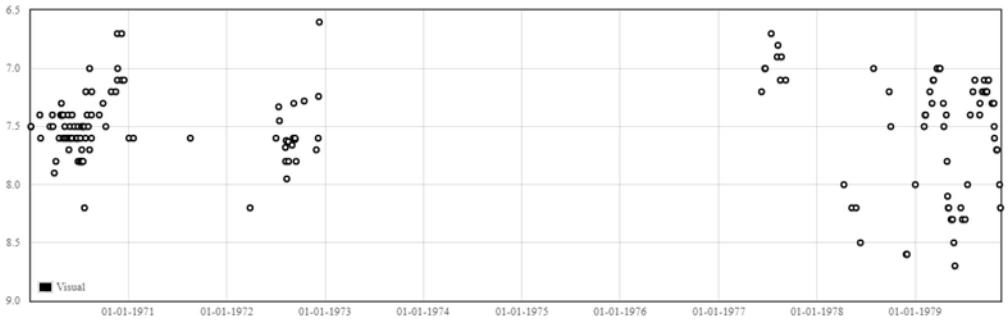
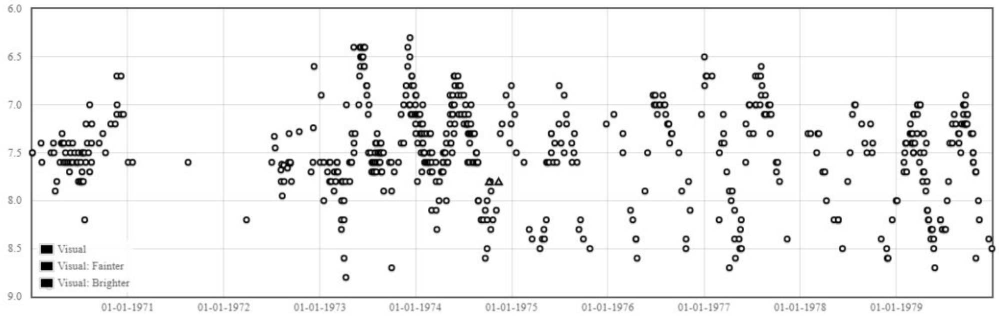
Light Curve for V CVN (2018 Mar 3)



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

Contributors: J Bingham, M Currie, A E J Forno, T Gough, C Henshaw, J E C Hern, P W Hornby, J E Isles, D E Jackman, D J Northwood, R D Pickard, D A Pickup, P Quadt, F A Roper, J Toone, E J Voss

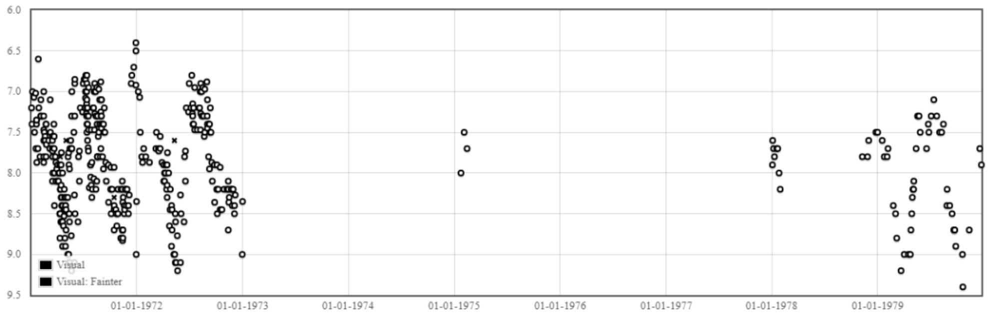
Light Curve for V CVN (2018 May 13)



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

Contributors: G W E Beekman, J Bingham, M Currie, A E J Forno, T Gough, C Henshaw, J E C Hern, A J Hollis, P W Hornby, D Hufton, G M Hurst, J E Isles, D E Jackman, B Jobson, D J Northwood, R D Pickard, D A Pickup, P Quadt, F A Roper, M D Taylor, J Toone, E J Voss, E J W West, D Young

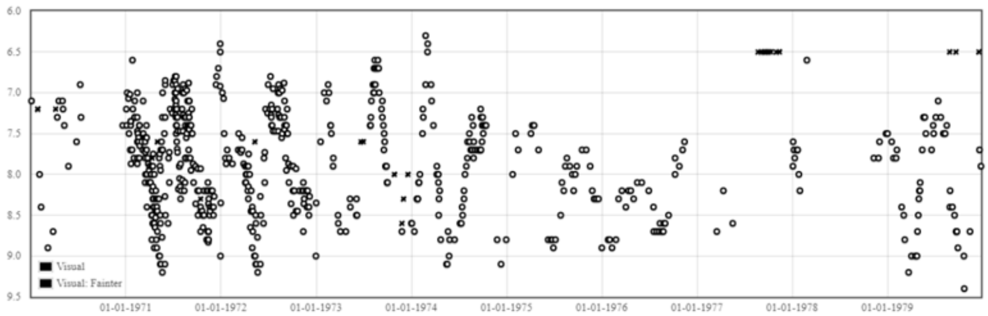
Light Curve for Z UMA (2018 Jan 19)



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

Contributors: A Brown, P R Clayton, M Currie, A E J Forno, V J Freeman, T Gough, P J Harpur, C Henshaw, P W Hornby, I D Howarth, G M Hurst, J E Isles, B Jobson, T Markham, I Miller, D A Pickup, M Poxon, P Quadt, D W Robinson, A L Smith, J Toone, H Wildey, J W Wilson, J D Wise, D Young

Light Curve for Z UMA (2018 May 13)



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

Contributors: M Beach, G W E Beekman, B J Beesley, A Brown, P R Clayton, M Currie, A E J Forno, V J Freeman, T Gough, P J Harpur, C Henshaw, P W Hornby, I D Howarth, G M Hurst, J E Isles, B Jobson, T Markham, I Miller, D A Pickup, M Poxon, P Quadt, D W Robinson, A L Smith, M D Taylor, J Toone, H Wildey, J W Wilson, J D Wise, D Young

The Applegate Mechanism and Post Common Envelope Binaries

Two 'new' terms appeared in a recent paper "The Applegate Mechanism in Post Common Envelope Binaries": Investigating the role of rotation.

The name 'Applegate Mechanism' derives from a paper (1) that was published in 1992. It states that most striking example of orbital period modulation is Algol. It apparently has two modulations. One has a period of around 200 years and another of around 30 years. It has only been possible to describe such modulations because there have been so many observations of Algol and determinations of its period. The 30-year modulation has an amplitude of 0.06 days or 1.44 hours. The paper illustrates how careful measurements of the period of a system such as Algol can build up knowledge of the internal structure and evolution of a star or a system.

The paper describes how the modulations observed in Algol and other stars are plausibly related to the long term magnetic activity of the star. The 30-year cycle of Algol may be similar to the 11-year sunspot (magnetic) activity of the Sun.

A Post-Common-Envelope (Eclipsing) Binary is explained in the paper referred to at the beginning of this article.

"Post-common-envelope binaries are systems that consist of a low-mass main-sequence secondary and a white dwarf (WD). Their evolution starts when the more massive component evolves up to a stage where its surface goes beyond the outer Lagrangian point, thus engulfing its companion. At this point the less massive star experiences friction as it orbits and thus loses orbital energy and angular momentum to the common envelope, spiraling inwards until enough energy is transferred to the envelope for it to be expelled. This leaves a close binary consisting of an M dwarf (dM) or a subdwarf and a white dwarf, with a binary period of normally less than 3 hours."

KIC 9832227 - Predicted Red Nova in 2022

This, according to Wikipedia, "is a contact binary star system in the constellation of Cygnus located about 1,800 light-years away. It is also identified as an eclipsing binary with an orbital period of almost 11 hours. The system is predicted to result in a merger in 2022.2±0.6, producing a luminous red nova reaching an apparent magnitude 2. The luminous red nova should remain visible to the naked eye for roughly a month. The merger of the two stellar cores is predicted to give birth to a new, hotter, more massive main-sequence star.

The period of the variations in KIC 9832227 has been observed to be growing shorter since 2013. It is expected that the period will continue to get smaller at an ever-increasing rate, and end in the merging of the two cores. This will release a very large amount of energy, a process which occurred before in the system V1309 Scorpii, a nova which erupted in 2008, and was later found by a team led by Romuald Tylenda to have been the result of a stellar merger".

EE Pegasi

This is an EA/DM system which is on the BAAVSS observing list. There are some examples of its light curves which can be found on the internet which suggest that it a straightforward Algol type system. Over the years there does not seem to have been much change in its period which the GCVS has as

2.62821423 days and which Krakow has, as the latest period, 2.6282169 days. The question is - why should it be on our observing list? A literature search shows that nothing much has been written about the system for some time.

The system has some attractive features. It is bright and observable with binoculars. It is easily found very near Epsilon Pegasi - Enif. It has a bit brighter than usual secondary minimum (for an Algol system) of 0.13 magnitude (GCVS) or 0.2 magnitude (Krakow). This should just be possible to pick up with DSLR photometry even in UK skies. It has frequent eclipses and, being relatively bright, could be a good target for those who want to make a start studying Algol systems.

Out of eclipse the system is of 7.0 magnitude. The primary eclipse is 0.58 magnitude in depth (GCVS) or 0.7 magnitude in depth (Krakow). The primary and secondary eclipses each last about six hours altogether. Predicted times of both eclipses are given on the Krakow website. The primary star is A3mV spectral type and the secondary F5V spectral type. There seems to be evidence that there is a third star in the system which orbits the main pair every four years. I presume that this has been discovered due to perturbations of the period or the orbit of the secondary star being not quite circular. This will be shown by the middle of the secondary eclipse not occurring at half way through the period defined as half way between the middle of primary eclipses.

A case can be made for continuing to observe the system given the accuracy of CCD/DSLR observations. Systems where the stars are so close will be subject to change and perhaps the perturbations can be picked up. Profiling the secondary eclipse will be a nice challenge for DSLR observers.

Algol Predictions for 2018

These were published in the BAA Handbook for 2018. In November last year it was discovered that there was a systematic error in the predictions from May 2018 onwards. The predictions have been corrected in an amended electronic version of the Handbook. The new version can be downloaded from the BAA website. If you contact me at the email address below I can forward a file that contains just the corrected variable star predictions.

1. J H Applegate 'A mechanism for Orbital Period Modulation in Close Binaries' The Astrophysical Journal, 385:621-629,1992 February 1

For EB predictions and where to find them, see here

Summer Eclipsing Binaries

Christopher Lloyd

The BAAVSS has a recommended list of 85 eclipsing binaries that are accessible to observers with small telescopes or DSLR cameras, or even binoculars. For the listing see elsewhere in this issue. Most of the stars have magnitudes of 7 – 10 with a handful of bright, well-known classics and a few fainter stars. The periods are short, half have P < 2 days with the shortest at 0.27 days and only 8 have P > 5 days, again with a few long-period curiosities. Many of the stars have eclipses that are short enough to be observed in a single night – and this is the preferred way to make timings – but others may need the light curve or at least the eclipse to be built up over some weeks or even the whole observing season.

There are many issues to consider when selecting a target beyond the obvious visibility, detectability and signal to noise etc. Clearly the short-period systems are the easiest to observe because there are many more opportunities of catching an eclipse and these will also be short. But they are also likely to be the best observed, so they may not need extra observations. Periods close to an integral number of days are potentially difficult to observe from one longitude because the same phase of the light curve is visible for some time. If that happens to coincide with the minimum, then all well and good but if not then it may be a season or two or many before the eclipse becomes visible. If possible make observations at the beginning and end of the observing season as this will close the seasonal gaps and help reveal subtle details in the O-C diagram that might otherwise be missed.

There are many resources for eclipsing binary observers available on the internet. Potentially the most useful is access to O-C diagrams which will instantly give an idea of the period behaviour of a star. The most widely used are the Krakow database, run by the Cracow Pedagogical University, the O-C Gateway run by the Czech Astronomical Society, the Lichtenknecker-Database of the BAV and Bob Nelson’s O-C files hosted by the AAVSO. The Krakow database is widely regarded as the most “official” and it probably has the most complete listing of stars. It is largely a matter of personal choice which is preferred but they do not all cover the same stars and while they generally contain the same observations for a particular star they are updated at different intervals. The first three sites allow an O-C diagram to be plotted in the browser, but Bob Nelson’s files are just that, MS Excel files that have to be downloaded but they do contain more information on likely period changes. Data can also be downloaded from the other sites. Care must be taken with the ephemeris used to plot the O-C diagrams as these can sometimes be out of date and are not necessarily useful for eclipse predictions. See the cautionary tale in one of the previous Circulars (Lloyd 2017, VSSC 171, 5).

The purpose of this article is to provide some information about the period changes of these systems – in this case for stars selected from the RA range 18 – 0 hours that come to opposition during the summer – and also to provide a current working ephemeris to enable useful predictions of minima. The intention is not to make a period analysis of the stars. The stars were selected in order the show a range of behaviour, systems that are probably constant, simple or complex, or illustrative in some way.

It is clear from the plots that there has been a marked reduction in the number of visual observations since ~2000 and while that may seem appropriate for the digital age it has not been matched by an equivalent take up of CCD and DLSR observations. Obviously where these observations exist they significantly improve the quality of the O-C diagrams, but it should be remembered, and this also comes through in some of the plots, that for many years the only observations were visual.

AD And 23 36 45.01 +48 40 15.6

AD And has long established period changes but their nature has only become clear in the past decade or so. The O-C diagram (see Figure 1) is dominated by CCD observations in recent years while prior to 2000 the observations were almost exclusively visual. It provides a stark contrast between the accuracy of the visual and CCD timings. The system shows an approximately sinusoidal variation with a range of nearly ±0.02 days and a period of ~12 years, caused by the orbit of an unseen companion. The system is near the positive peak of its excursions in the O-C diagram, so the residuals will decrease rapidly over the next 5 or 6 years. The ephemeris of primary minimum is

$$HJD_{MinI} = 2438999.0137(33) + 0.98619323(22) \times E$$

and this should be reliable to < 0.005 days for the next two years or so. Given the activity in the O-C diagram this system should have a high priority.

CW Cep 23 04 02.22 +63 23 48.8

CW Cep is a relatively bright system showing apsidal motion (see Figure 2). The apsidal period is close to 50 years and barely one complete cycle has been observed so far. As both minima move in anti-phase both should be observed if possible. The ephemeris of primary and secondary minimum is

$$HJD_{MinI} = 2435368.0044(43) + 2.7291409(8) \times E$$

$$HJD_{MinII} = 2435367.9536(43) + 2.7291409(8) \times E$$

The system is relatively well observed but given the variation it should have high priority.

EG Cep 20 15 56.83 +76 48 35.8

EG Cep has been observed sporadically for nearly a century and recent observations with modern detectors have revealed an approximately sinusoidal variation with an amplitude of <0.01 days and a period of about 50 years (see Figure 3). The current ephemeris of primary minimum is

$$HJD_{MinI} = 2454067.40063(35) + 0.54462141(11) \times E$$

and this should be reliable to <0.005 days for the next few years.

BR Cyg 19 40 54.74 +46 47 05.6

Extensive visual observation over the past century has failed to show any clear variation in period of BR Cyg and that is confirmed by recent CCD observations. The O-C diagram in Figure 4 clearly demonstrates the difference in precision and the recent uptake of CCD observations. The current ephemeris of primary minimum is

$$HJD_{MinI} = 2433458.7949(9) + 1.33256427(7) \times E$$

and the best data show no evidence of any change. Coverage has improved in recent years, but it is a low-priority system. The secondary eclipses should be avoided.

V367 Cyg 20 47 59.59 +39 17 15.7

Observations in recent years suggest that V367 Cyg has an approximately sinusoidal variation with an amplitude possibly as large as 0.1 days and a period of perhaps 60 years (see Figure 5). The observations are very sparse and quite noisy, even the modern ones, and that is because despite being bright the system has a period of 18.6 days and so times of minimum are difficult to obtain. The ephemeris of primary minimum is

$$HJD_{MinI} = 2436051.718(41) + 18.59783(7) \times E$$

Given the possibly large variation and that it is poorly observed this should be a high priority if difficult target. If possible both eclipses should be observed as there is some discordance.

V453 Cyg 20 06 34.97 +35 44 26.3

Despite over a century of observations the nature of the variation of V453 Cyg remains unclear and surprisingly the modern data do little to clarify the situation (see Figure 6). Part of the problem is that the eclipses are shallow and relatively wide so measuring the minimum is difficult. The ephemeris for primary minimum is

$$HJD_{MinI} = 2439087.274(7) + 3.8898168(26) \times E$$

It is not clear if the period is variable, but the large variations could conceal some real movement. This is a low priority object, but it would be helpful to get some reliable timings over the next few years.

BH Dra 19 03 39.54 +57 27 25.9

Observations of BH Dra go back to the early 1900s but it is only in the past decade or so that its lack of variation has been shown (see Figure 7) and the discussion in the previous circular (Lloyd 2018, VSSC 175, 24). The current ephemeris of primary minimum is

$$HJD_{MinI} = 2440019.7988(25) + 1.81723803(33) \times E$$

using just the primary eclipses and there is no indication of any period change. Coverage has improved in recent years, but it is a low-priority system. The secondary eclipses should be avoided.

AR Lac 22 08 40.82 +45 44 32.1
Observations of AR Lac go back to the beginning of the last century and over that time it has shown large and complex period changes. Since 1970 (see Figure 8) the O-C residual has changed by nearly 0.2 days in a slow and continuous fashion and for the past decade the period has been effectively constant. The current ephemeris of primary minimum is

$$HJD_{MinI} = 2452941.4403(47) + 1.9832112(35) \times E$$

however, recent observations are sparse, so this system should be a high priority.

CM Lac 22 00 04.45 +44 33 07.7

CM Lac is another system with over a century of photographic and visual observation with no indication of any period change (see Figure 9). Good coverage recently and earlier more sporadic PEP observations confirm the lack of variation to a high level. The ephemeris of primary minimum is

$$HJD_{MinI} = 2433871.92929(28) + 1.604691434(30) \times E$$

It is a low-priority system and the secondary eclipses should be avoided.

beta Lyr 18 50 04.79 +33 21 45.6

Beta Lyr is one of the brightest and best-known eclipsing binaries and of course gives its name to a class of continuously variable stars. The earliest observations by John Goodricke date from the 1780s and since that it has shown a prodigious change of some 40 days in the O-C diagram. The variation is well modelled by a continuous change in period but in detail some segments appear constant. The recent detail (see Figure 10) shows a change of period just before 2000. The ephemeris of primary minimum since then is

$$HJD_{MinI} = 2455434.94(5) + 12.94187(49) \times E$$

Despite its brightness, V = 3.3 at maximum, or perhaps because of it, beta Lyr is not an easy object to observe and its long period makes observing a minimum on a single night all but impossible as the variation at minimum is about 0.1 magnitudes in 24 hours. There have been no visual timings for over a decade. This is an object that requires a particular technique and as the O-C diagram shows it has been ignored by CCD observers in the past although this has improved in recent years.

V451 Oph 18 29 14.04 +10 53 31.4

V451 Oph is another bright system that shows apsidal motion with an amplitude of ~0.01 days and a period in excess of 120 years (see Figure 11). The primary and secondary minima are beginning to separate so the next 40 years will be important in establishing the nature of this system! This should be a high priority target both for the primary and secondary minima which have given discordant timings recently. The mean ephemeris for primary minimum is

$$HJD_{MinI} = 2434165.4890(18) + 2.19659715(28) \times E$$

and this will be within 0.01 days of the primary and secondary (with the appropriate P/2 offset) minima for many years.

Z Vul 19 21 39.10 +25 34 29.5

The long-term behaviour of Z Vul over the past ~120 years shows a small but clear change in period which could be continuous or sinusoidal or more complex. The recent data (see Figure 12) apparently shows very little change but it is nevertheless part of a long-term evolution of the period. This plot also illustrates the almost instantaneous secession of visual observations ~2000 and the start of more continuous CCD monitoring. The ephemeris for primary minimum is

$$HJD_{MinI} = 2440362.4354(9) + 2.45493203(17) \times E$$

and on past behaviour this should be reliable to < 0.01 for many years. Although this does not merit a high priority it does deserve regular monitoring.

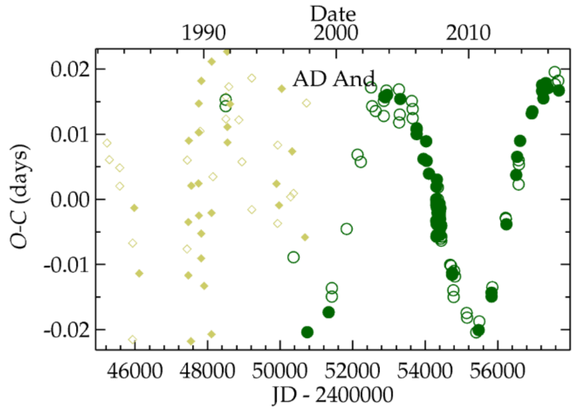


Figure 1

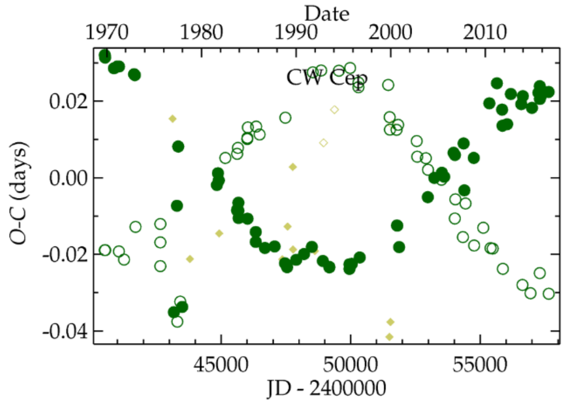


Figure 2

Figure 1: AD And showing PEP, CCD and DLSR (circles) and visual (diamonds) observations for the past ~35 years. Filled symbols are primary minima open symbols are secondary. The light time effect with a period ~12 years due to an unseen companion can clearly be seen.

Figure 2: CW Cep showing the apsidal motion with a period of ~50 years.

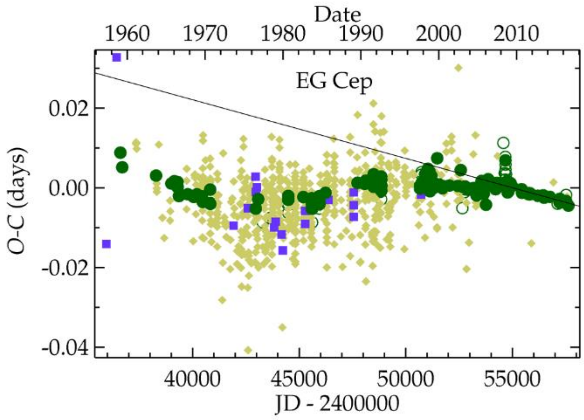


Figure 3

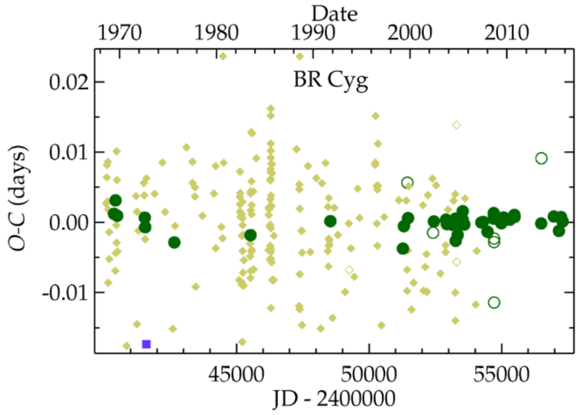


Figure 4

Figure 3: EG Cep showing a low-amplitude oscillation with the current ephemeris indicated by the line. Photographic data are shown as squares.

Figure 4: BR Cyg showing very little sign of any period variation.

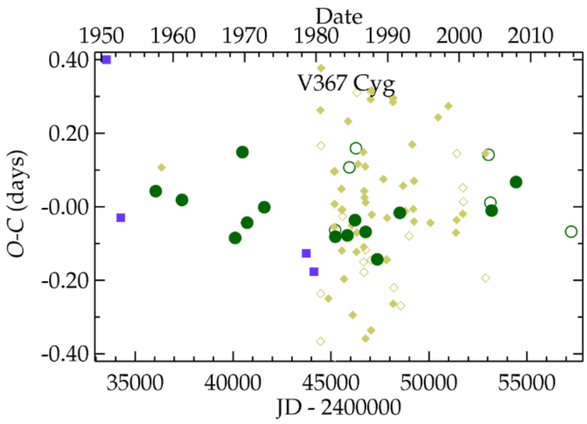


Figure 5

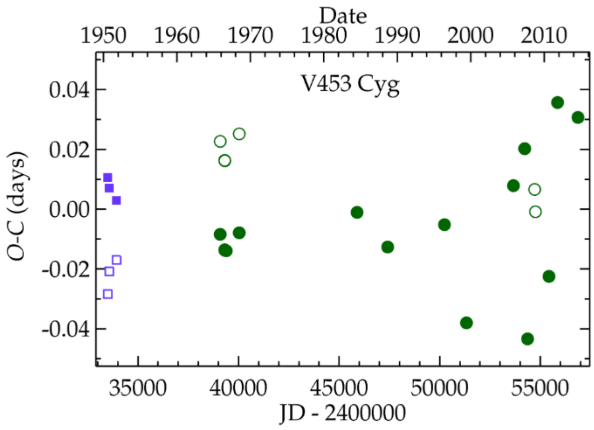


Figure 6

Figure 5: V367 Cyg showing large scatter with a suggestion of some change. More observations are needed.

Figure 6: V453 Cyg showing sparse and inconsistent data.

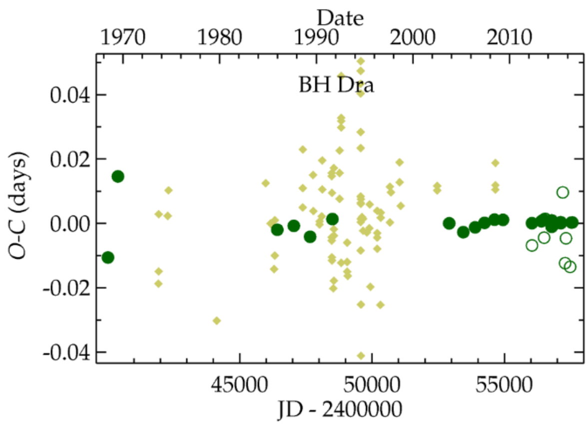


Figure 7

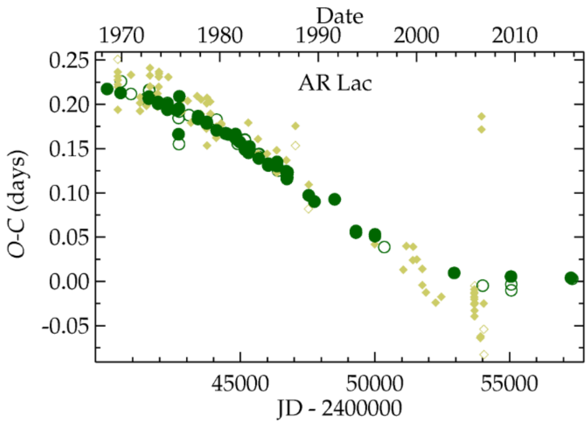


Figure 8

Figure 7: BH Dra showing very little sign of variation.

Figure 8: AR Lac showing the recent part of the star's prodigious variation in the O-C diagram. The variations are well covered up to ~1990 but since then the star has become more neglected and is now in need of more continuous monitoring.

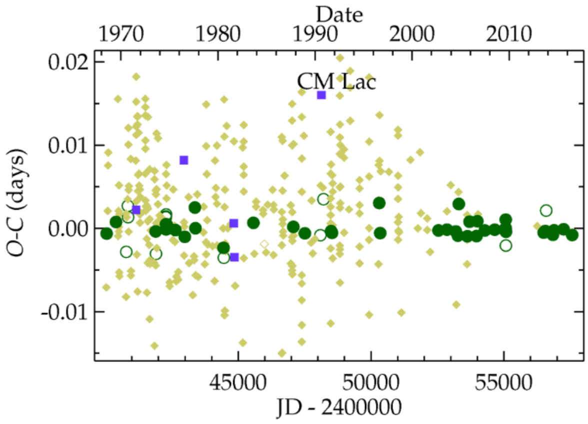


Figure 9

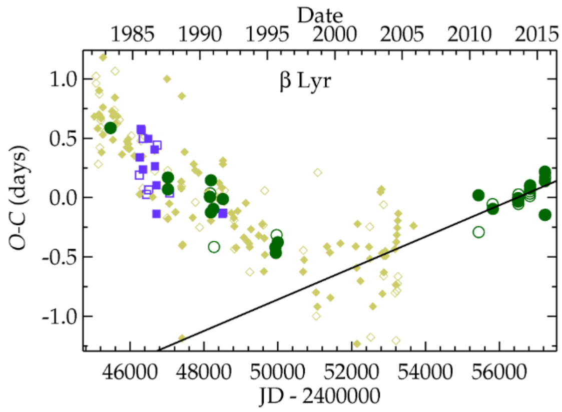


Figure 10

Figure 9: CM Lac showing a lack of variation.

Figure 10: beta Lyr showing the recent part of its enormous variation in the O-C diagram. Even in the past ~30 years the residuals have changed by over one day and this is part of the continuous change that has been seen for over 200 years. This part suggests that the variation is comprised of constant segments.

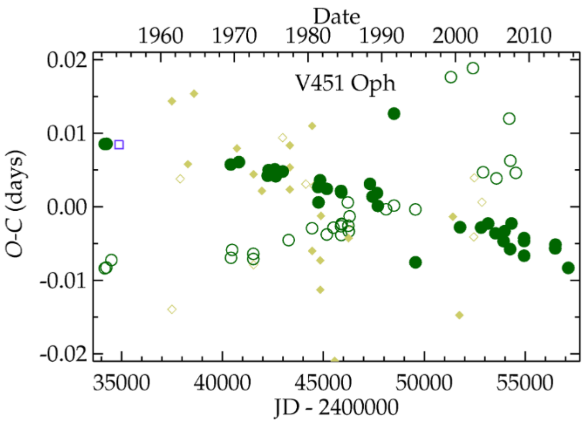


Figure 11

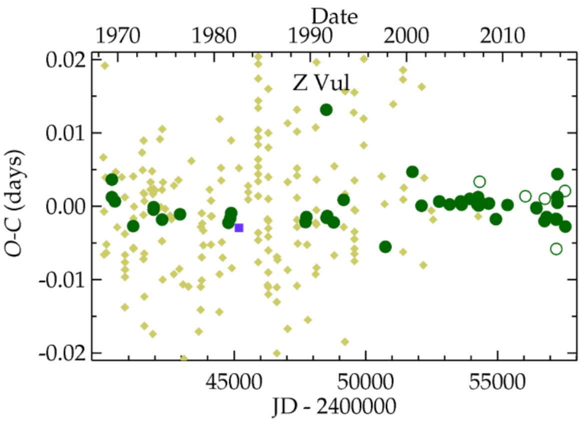


Figure 12

Figure 11: V451 Oph showing the long-period apsidal motion.

Figure 12: Z Vul showing the recent part of its long, slow and potentially complex variation.

68u Herculis *David Conner*

In response to the article by Des Loughney in the previous circular regarding the eclipsing binary 68u Herculis (VSSC175), I would like to contribute a series of observations of this star that I obtained in the 2012 and 2013 seasons.

The original observations are in the VSS database under '68 HER'. They were made with the 'Constellation Camera' (a 16mm f2.8 lens with a 40-degree square field) of the now obsolete Bradford Robotic Telescope (BRT) located in Tenerife. 118 images were obtained in 2012 and a further 52 images in 2013. The images were unfiltered.

Photometry of the images was performed with AIP4Win using comparison stars from an AAVSO chart for this star. Note that the star is referred to as both "u. Her" and "U. Her" (with a full stop) on the AAVSO website and 68 HER in the VSS database.

The following light curve and phase diagrams were constructed using Peranso. The BRT returned approximately one image per night, so it was not possible to observe any eclipse in its entirety. It was therefore not possible to determine the times of minima - and hence the period - directly, so the period had to be determined by constructing phase diagrams. The 'best fit' periods were calculated using Peranso's ANOVA function with a resolution of 20 000 over the interval 2.044d to 2.056d and using 11 harmonics.

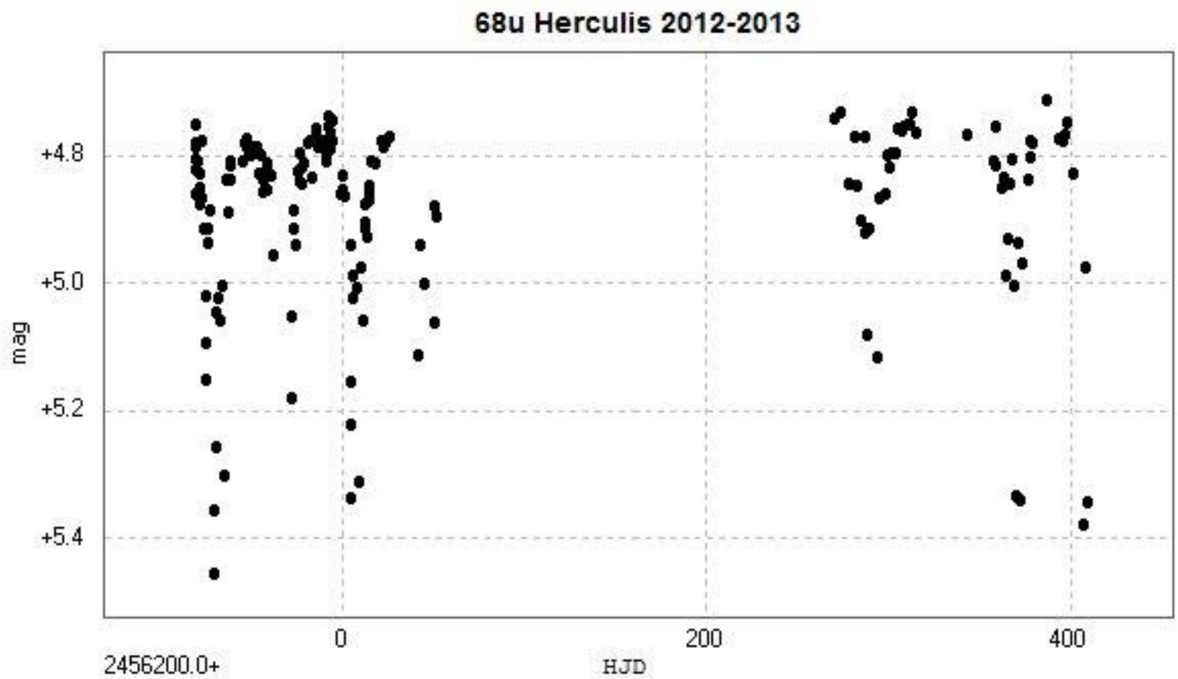


Figure 1: Light curve of 68u Herculis constructed from photometry of BRT Constellation Camera images.

The appearance of a 'ghost' EB light curve in figure 1, particularly in the 2012 data in the left-hand side of the diagram, will be noted. This artefact is due to the frequency that the images were returned from the BRT beating with the period of 68u, which is itself close to an integer number of days.

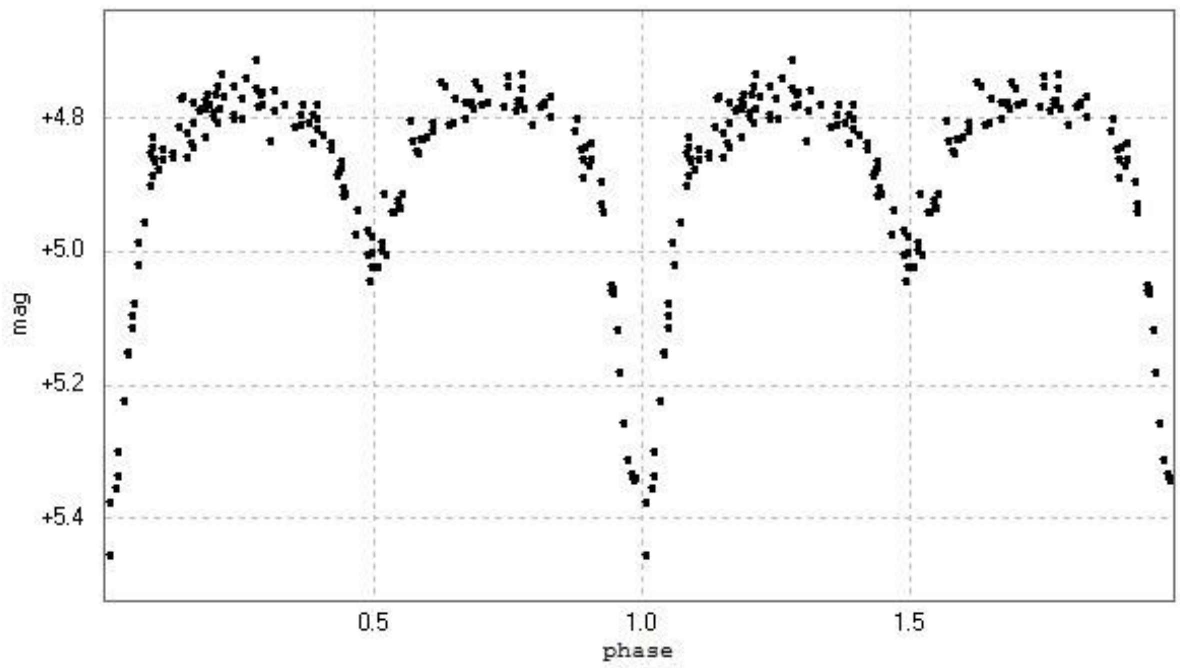


Figure 2: Phase diagram, using 2012 and 2013 observations, with p = 2.051013d

The separate phase diagrams for 2012 and 2013 are included below, although there are probably insufficient data points for 2013 for too much credence to be given to the quoted 6 figure precision of the period.

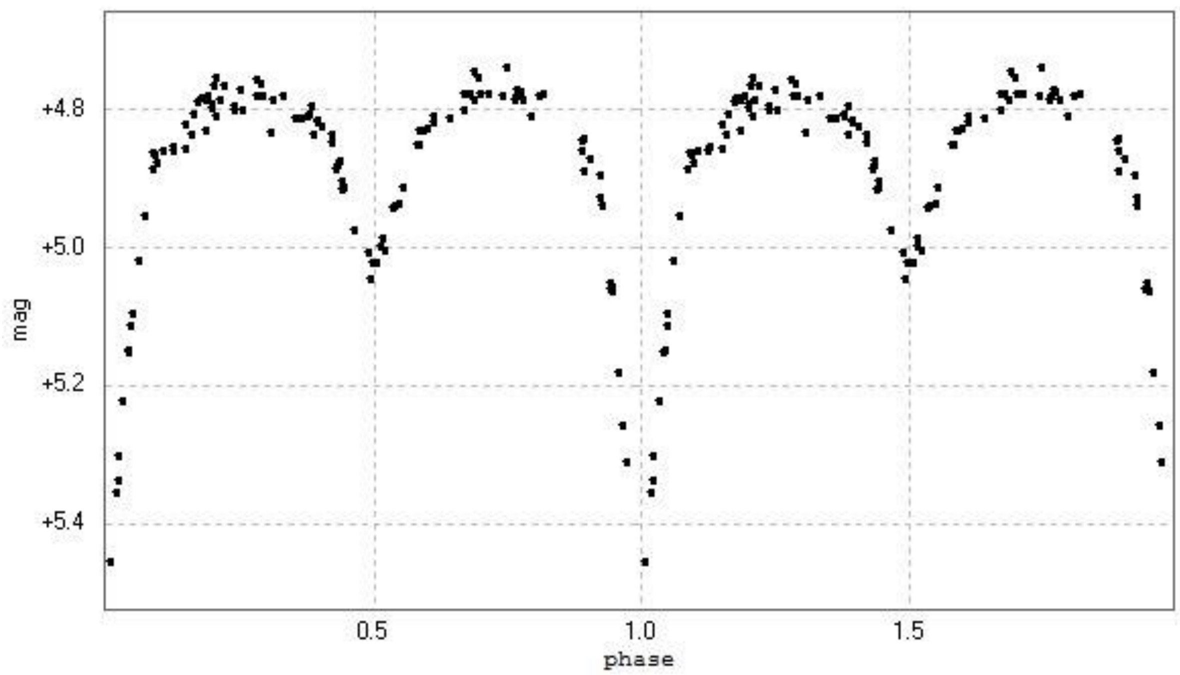


Figure 3: Phase diagram, using 2012 data only, with p = 2.051059d

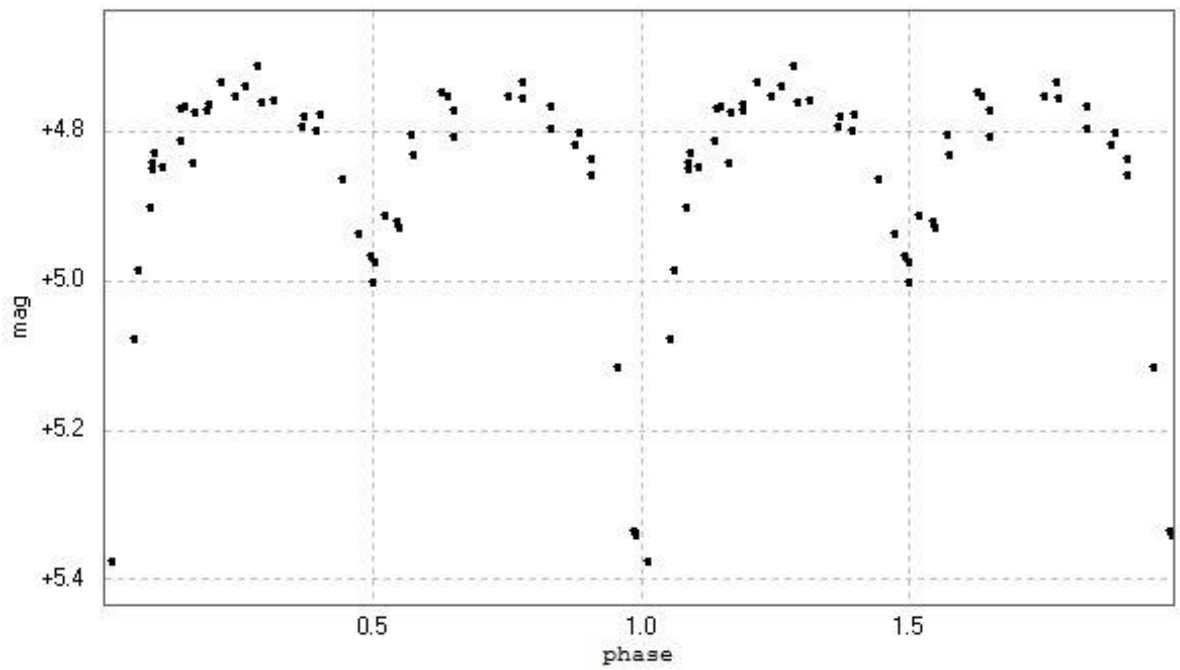


Figure 4: Phase diagram, using 2013 data only, with p = 2.05087d

Notwithstanding the small number of observations, the above results suggest a period of 2.051059d best fits the 2012 observations, while a period of 2.05087d best fits the 2013 observations. Approximate epochs were indirectly determined from the phase diagrams, using Peransos extremum function, as follows.

2012 HJD 2456129.4221 +/- 0.0005
2013 HJD 2456607.307 +/- 0.001

VSX

https://davidsconner.weebly.com/

The BAAVSS Eclipsing Binary Programme Lists

Christopher Lloyd

The BAAVSS Eclipsing Binary Programme comprises 76 stars, mostly with magnitudes of 7 – 10 and short periods, half have P < 2 days and all but 8 have P < 5 days. The list as it stands at present can be found on the eclipsing binary page of the web site along with links to other resources such as the Eclipsing Binary Handbook and Des Loughney's paper (2010, J.BAA 120, 157) on photometry with a DSLR camera. The EB Handbook identifies a subset of 29 “Priority stars” and also an additional list of 10 short-period low-amplitude stars selected by Loughney (2014, VSSC 160, 4) as being particularly suited to DLSR observers. One of these was already on the main list. Most of the stars from the main list were probably selected originally for binocular observers and all will also now be amenable to DLSR or CCD observation. There has been a distinct movement away from visual timings of eclipses towards CCD and DSLR timings in recent years and while this has improved the quality of the O-C diagrams it has led to a significant drop in the number of observations. What is needed is for the visual observers to pick up their DSLRs.

The purpose of this article is to update and re-present the list providing more information about the stars and links to other archives. The original list and the additional low-amplitude DLSR stars are combined into one list with the DSLR stars highlighted in yellow and the “Priority stars” highlighted in green. The list is in variable star designation order by constellation. One star, NSV 4031 in Lynx is not an eclipsing binary as described and is probably not variable at all.

The columns of the table are 1: The variable name with a link to the Simbad database. From here data about the stars can be found together with links to other archives and the bibliographic database. Simbad may list the star under another name but the alternative names are also given.
Columns 2 and 3: J2000 co-ordinates from VizieR.
Column 4: The AAVSO VSX number with a link for that star. VSX provides basic data for the star and a potted history together with the main photometric references and links to other resources.
Column 5: The variability type from VSX which provides a more detailed classification of the variation than the basic EA, EB and EW. The description can be found on the variability type designations page and an old-school more graphical presentation of the eclipsing types can be found here and linked pages.
Columns 6, 7 and 8: the maximum, primary minimum magnitudes and magnitude range.
Column 9: The photometric band.
Column10: The period in days.
Column 11: The **full** duration of the eclipse in hours for stars where this has some meaning taken from the original table, and other light curves, and finally
Column 12: The finding chart name with a link to the VSS charts where they exist. The shorter non-date numbers refer to older AAVSO charts. Comparison sequences and finding charts can also be found on the **Sequence** link on the VSX page for each star.

Name	RA	Dec	VSX	Var type	Max	Min	Range	Band	Period	D	Chart
TW And	00 03 18.23	+32 50 45.1	30	EA	8.98	11.04	2.06	V	4.122834	13	122901
AD And	23 36 45.01	+48 40 15.6	58	EB	11.2	11.82	0.62	V	0.986202	EB	1984Dec22
DS And	01 57 46.05	+38 04 28.4	141	EA	10.44	10.93	0.49	V	1.0105188	EB	1984Dec22
OO Aql	19 48 12.65	+09 18 32.4	1441	EW / DW:	9.2	9.9	0.7	V	0.506792	EW	0801
epsilon Aur	05 01 58.13	+43 49 23.9	4299	EA / GS	2.92	3.83	0.91	V	9892		316.01
SX Aur	05 11 42.93	+42 09 55.3	3786	EB / KE:	8.38	9.14	0.76	V	1.2100802	EB	1984Dec23
WW Aur	06 32 27.18	+32 27 17.6	3807	EA / DM	5.79	6.54	0.75	V	2.5250192	6	122901
AR Aur	05 18 18.90	+33 46 02.5	3833	EA / DM	6.15	6.82	0.67	V	4.134695	7	283.01
EO Aur	05 18 21.07	+36 37 55.3	3920	EA / DM:	7.56	8.13	0.57	V	4.0656372	12	283.01
HL Aur	06 19 13.04	+49 42 06.9	3974	EB / SD	10.8	11.9	1.1	pg	0.6225058	EB	1984Dec23
IM Aur	05 15 29.74	+46 24 21.4	3992	EA	7.9	8.51	0.61	V	1.247296	6	1972Feb04
IU Aur	05 27 52.40	+34 46 58.3	4000	EB / SD	8.19	8.83	0.64	V	1.8114754	EB	1984Dec24
LY Aur	05 29 42.65	+35 22 30.1	4035	EB / SD	6.66	7.35	0.69	V	4.0024932	EB	283.01
ZZ Boo	13 56 09.52	+25 55 07.4	4357	EA / DM	6.79	7.44	0.65	V	4.991744	7	252.01
RS CVn	13 10 36.91	+35 56 05.6	5028	EA / AR / RS	7.93	9.14	1.21	V	4.797887	13	252.01
RZ Cas	02 48 55.51	+69 38 03.4	6348	EA / SD	6.18	7.72	1.54	V	1.195247	5	236.02
TV Cas	00 19 18.74	+59 08 20.6	6359	EA / SD	7.22	8.22	1	V	1.8125997	8	1982Aug16
TW Cas	02 45 54.82	+65 43 35.0	6360	EA	8.32	8.98	0.66	V	1.428324	5	273.01
TX Cas	02 52 16.19	+62 46 57.5	6361	EB / DM	9.16	9.8	0.64	V	2.92687	EB	1985Jun08
YZ Cas	00 45 39.08	+74 59 17.1	6383	EA / DM	5.71	6.12	0.41	B	4.4672224	8	
AB Cas	02 37 31.51	+71 18 16.3	6386	EA+DSCT	10.1	11.85	1.75	V	1.3668738	6	0801
AO Cas	00 17 43.06	+51 25 59.1	6398	ELL / KE	6.07	6.24	0.17	V	3.523487	ELL	
BM Cas	00 54 45.95	+64 05 05.2	6420	EB / GS	8.78	9.31	0.53	V	197.28	EB	1986Jul05
CC Cas	03 14 05.34	+59 33 48.5	6434	EB / DM	7.06	7.3	0.24	V	3.368753	EB	
DO Cas	02 41 24.16	+60 33 11.8	6468	EB / KE	8.39	9.01	0.62	V	0.6846661	EB	1986Jul05
U Cep	01 02 18.44	+81 52 32.1	8356	EA / SD	6.75	9.24	2.49	V	2.493087	9	279.01
VW Cep	20 37 21.54	+75 36 01.5	8393	EW / KW	7.31	7.71	0.4	V	0.2783089	EW	1972Mar21
AH Cep	22 47 52.94	+65 03 43.8	8414	EB / DM	6.78	7.07	0.29	V	1.7747505	EB	
CQ Cep	22 36 53.95	+56 54 21.0	8469	EB / DM / WR	8.63	9.12	0.49	V	1.641249	EB	
CW Cep	23 04 02.22	+63 23 48.8	8475	EA / DM	7.6	8.04	0.44	V	2.72914	9	
EG Cep	20 15 56.83	+76 48 35.8	8503	EB	9.31	10.21	0.9	V	0.5446218	EB	0801
EI Cep	21 28 28.21	+76 24 12.6	8505	EA / DM	7.54	8.06	0.52	V	8.439334	12	1972Mar21
GK Cep	21 30 59.15	+70 49 23.6	8545	EB / KE	6.89	7.37	0.48	V	0.936157	EB	1971Dec02
U CrB	15 18 11.35	+31 38 49.4	10603	EA / SD	7.66	8.79	1.13	V	3.4522013	12	254.01
Y Cyg	20 52 03.58	+34 39 27.5	10928	EA / DM	7.3	7.9	0.6	V	2.9963328	7	1986Jul06
SW Cyg	20 06 57.93	+46 17 58.2	10943	EA / SD	9.24	11.83	2.59	V	4.5731341	13	0801
BR Cyg	19 40 54.74	+46 47 05.6	11015	EA	9.85	11	1.15	V	1.3325645	6	0801
V367 Cyg	20 47 59.59	+39 17 15.7	11287	EB / GS / SD:	6.67	7.6	0.93	V	18.59773	EB	1986Jul06
V448 Cyg	20 06 09.95	+35 23 09.6	11368	EB / SD	7.9	8.72	0.82	V	6.5197162	EB	1986Jul06
V453 Cyg	20 06 34.97	+35 44 26.3	11373	EA / D	8.29	8.72	0.43	V	3.8898128	14	1986Jul06
V477 Cyg	20 05 27.69	+31 58 18.1	11397	EA / DM	8.5	9.34	0.84	V	2.3469906	4	1972Feb05
V1425 Cyg	21 11 01.78	+55 19 56.0	12345	EB / KE:	7.7	8.15	0.45	V	1.252387	EB	
Z Dra	11 45 29.21	+72 14 58.4	13681	EA / SD	10.8	14.1	3.3	pg	1.357456	5	1993Jan10
TW Dra	15 33 51.06	+63 54 25.7	13702	EA / SD	8	10.5	2.5	pg	2.806847	11	274.01
AI Dra	16 56 18.15	+52 41 54.4	13735	EA / SD	7.05	8.09	1.04	V	1.1988146	5	284.01
BH Dra	19 03 39.54	+57 27 25.9	13758	EA / SD:	8.38	9.27	0.89	V	1.8172386	5	285.01
S Equ	20 57 12.84	+05 04 49.4	13954	EA / SD	8.35	10.4	2.05	V	3.436106	11	286.01

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eta Gem	06 14 52.66	+22 30 24.5	14666	SRA+EA	3.15	3.9	0.75	V	232.9		326.01
RW Gem	06 01 28.06	+23 08 27.5	14309	EA / SD:	9.53	11.76	2.23	V	2.8654972	10	1994Mar12
68 u Her	17 17 19.60	+33 06 00.0	15899	EA / SD	4.69	5.37	0.68	V	2.051027	14	1971Aug27
Z Her	17 58 06.98	+15 08 21.9	14820	EA / AR / RS	7.3	8.18	0.88	V	3.9928077	11	1972Feb06
RX Her	18 30 39.26	+12 36 40.4	14827	EA / DM	7.28	7.87	0.59	V	1.7785724	6	1972Jun12
SW Lac	22 53 41.66	+37 56 18.6	16612	EW / RS	8.51	9.49	0.98	V	0.3207152	EW	1987Nov
AR Lac	22 08 40.82	+45 44 32.1	16660	EA / AR / RS	6.08	6.77	0.69	V	1.983192	7	1971Feb13
CM Lac	22 00 04.45	+44 33 07.7	16702	EA / DM	8.18	9.15	0.97	V	1.6046916	4	1987Nov
UV Leo	10 38 20.77	+14 16 03.6	17066	EA / DW	8.9	9.56	0.66	V	0.6000873	3	1987Nov
AP Leo	11 05 05.02	+05 09 06.4	17100	EW / KW	9.32	9.91	0.59	V	0.430358	EW	1987Nov
delta Lib	15 00 58.35	-08 31 08.2	17591	EA / SD	4.91	5.9	0.99	V	2.3273543	13	1987Nov
NSV 4031	08 22 58.65	+45 27 23.6	42655	EA:	8	8.8	0.8	V			275.01
beta Lyr	18 50 04.79	+33 21 45.6	18631	EB	3.3	4.35	1.05	V	12.9406171	EB	328.01
TZ Lyr	18 15 49.67	+41 06 38.1	18073	EB / D	10.87	11.85	0.98	V	0.5288268	EB	1987Nov
V505 Mon	06 45 49.98	+02 29 57.4	19333	EB / GS / D	7.15	7.65	0.5	V	53.7805	EB	1971Aug22
U Oph	17 16 31.72	+01 12 38.0	20490	EA / DM	5.84	6.56	0.72	V	1.6773462	6	1971Dec12
V451 Oph	18 29 14.04	+10 53 31.4	20937	EA / DM	7.87	8.42	0.55	V	2.1965962	6	1972Jun12
V566 Oph	17 56 52.41	+04 59 15.3	21052	EW / KW	7.46	7.96	0.5	V	0.4096457	EW	1972Jun11
ER Ori	05 11 14.50	-08 33 24.7	23224	EW / KW	9.28	10.01	0.73	V	0.423406	EW	1987Nov
EE Peg	21 40 01.88	+09 11 05.1	25271	EA / DM	6.93	7.51	0.58	V	2.6282142	6	245.01
beta Per	03 08 10.13	+40 57 20.4	26202	EA / SD	2.09	3.3	1.21	V	2.86736	10	327.01
Z Per	02 40 03.24	+42 11 57.7	25533	EA / SD	9.7	12.4	2.7	pg	3.0563066	10	1994Mar12
DM Per	02 25 58.01	+56 06 10.0	25659	EA / SD	7.86	8.59	0.73	V	2.7277427	11	1972Apr09
IQ Per	03 59 44.67	+48 09 04.5	25758	EA / DM	7.72	8.27	0.55	V	1.7435701	5	246.01
IZ Per	01 32 05.49	+54 01 08.3	25767	EA / SD	7.83	9.15	1.32	V	3.687673	11	1972Feb14
SZ Psc	23 13 23.79	+02 40 31.6	26422	EA / DS / RS	7.18	7.72	0.54	V	3.965665	10	1972Jun11
U Sge	19 18 48.41	+19 36 37.7	27345	EA / SD	6.45	9.28	2.83	V	3.3806193	14	287.01
lambda Tau	04 00 40.82	+12 29 25.3	36240	EA / DM	3.37	3.91	0.54	V	3.9529478	14	1993Oct22
RW Tau	04 03 54.31	+28 07 33.5	35032	EA / SD	7.98	11.59	3.61	V	2.768804	9	1984Dec18
BV Tau	05 38 34.73	+22 54 44.8	35116	EB / KE:	11.7	12.4	0.7	pg	0.930453	EB	1985Jan31
CD Tau	05 17 31.15	+20 07 54.6	35122	EA / D	6.77	7.34	0.57	V	3.435137	7	1972Feb04
HU Tau	04 38 15.83	+20 41 05.0	35238	EA / SD:	5.85	6.68	0.83	V	2.0562997	7	247.01
V1061 Tau	04 58 52.76	+24 29 44.5	36078	EB / KE	7.95	8.45	0.5	V	1.385217	EB	
X Tri	02 00 33.74	+27 53 19.2	36600	EA / SD	8.55	11.27	2.72	V	0.9715352	4	1982Jan01
W UMa	09 43 45.47	+55 57 09.1	37110	EW / KW	7.75	8.48	0.73	V	0.3336375	EW	248.01
TX UMa	10 45 20.50	+45 33 58.8	37135	EA / SD	7.06	8.8	1.74	V	3.063295	9	288.01
AW UMa	11 30 04.32	+29 57 52.7	37180	EW / KW	6.83	7.13	0.3	V	0.4387299	EW	
Z Vul	19 21 39.10	+25 34 29.5	38184	EA / SD	7.25	8.9	1.65	V	2.454934	11	255.01

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