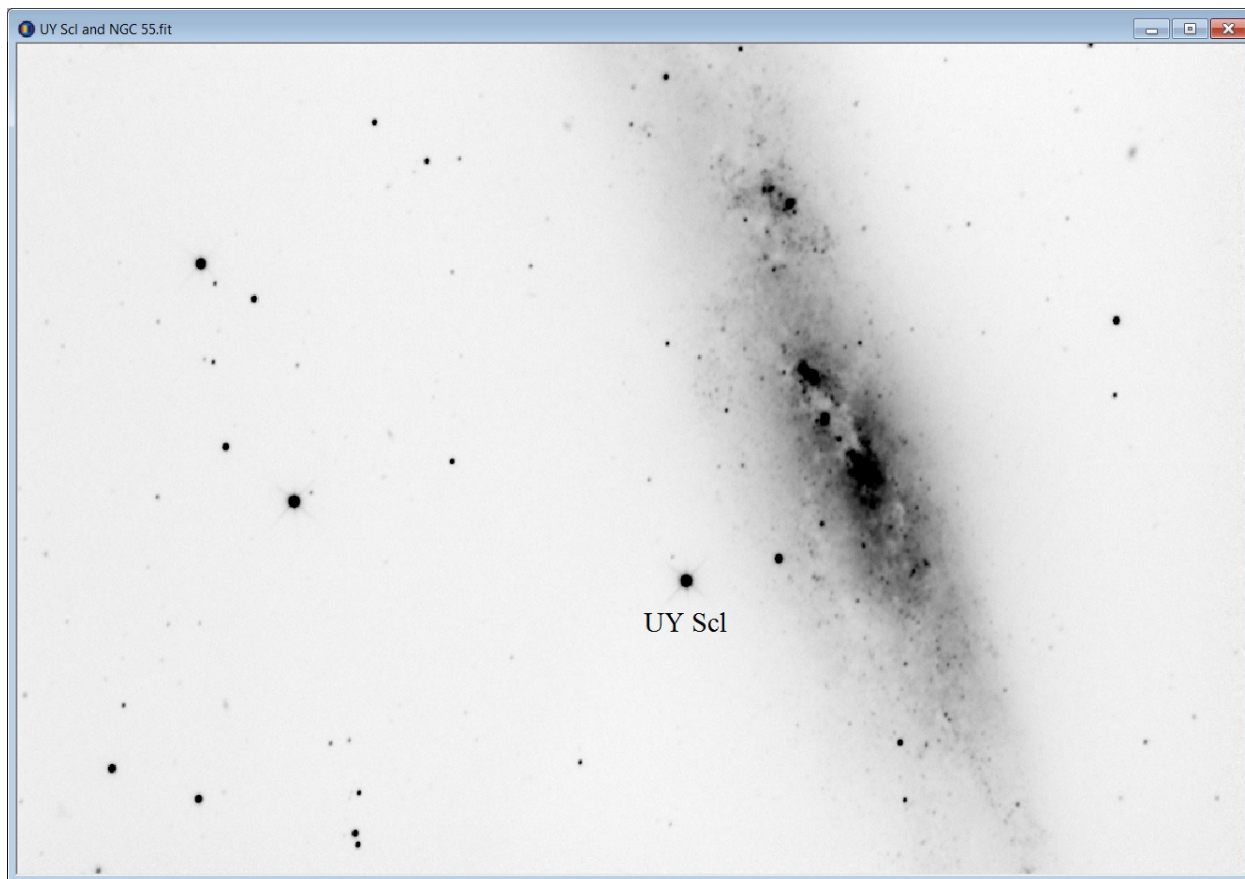




NGC 55 photobombs Mark Blackford's study of the EW binary UY Sculptor. See page 7 for the story.

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From the director – *Mark Blackford*

Welcome to our final VSS newsletter for 2019. I hope you find the various articles interesting and informative. I'd like to thank the authors for their excellent contributions. As always, we would welcome more content so please consider contributing to future newsletters.

Recently David Benn, William Goltz and I participated in a teleconference with AAVSO director Stella Kafka and president Gordon Myers. The AAVSO is consulting its members on the future shape of the organisation and wished to get an antipodean perspective. Several topics were discussed, including some interesting new initiatives that Gordon and Stella expect to be unveiled at the AAVSO Annual Meeting at about the time you receive this newsletter. One thing that seems inevitable is that the numerous automated professional surveys will have a significant impact on amateur variable star studies so AAVSO, VSS and similar organisations will need to adapt.



The Sixth Variable Stars South Symposium will be held on Friday April 10th, 2020. Details appear on the next page. At the same venue immediately following VSSS6 is NACAA 2020, the National Australian Convention of Amateur Astronomers, April 10th to 13th. And just one month later, May 8th to 10th Wellington, NZ will host the RASNZ conference celebrating 100 years of the Royal Astronomical Society of New Zealand. Certainly a very busy time coming up, but all three meetings will provide excellent social and scientific interactions with fellow astronomy enthusiasts. I'll be attending all three and hope to see many other VSS members at each meeting.

I hope there's room in your observing schedules for one or more of the following targets. Eta Carinae exhibits small scale oscillations that are important in interpreting the complex structure of this system. Steve Kerr and I made observations as often as possible up until eta was lost in evening twilight. It is now emerging from conjunction and accessible before morning twilight. So please start monitoring this fascinating southern binary as its component stars approach perihelion on February 17th, 2020.

Peter Williams urges observers to monitor the long period eclipsing binary BL Telescopii which will be undergoing an eclipse over the coming months.

The southern symbiotic variable R Aquarii, is another fascinating target. It is believed to be a binary system containing a white dwarf and a large Mira type variable. The dwarf is surrounded by an accretion disc and a large dark cloud, all of which orbit the larger star in a 44 year orbit. R Aqr is apparently entering into a period where the Mira type component is being occulted by the dark cloud. As you can imagine, the long term light curve is quite complex. See Richard Roberts post on the AAVSO Long Period Variable forum (<https://www.aavso.org/r-aqr-0>).

Since the previous newsletter I've had a fair run of favourable observing conditions at Congarinni Observatory, mixed with periods of cloud and bushfire smoke. But, like many other places, not nearly enough rain. My small photometry system has been out of action for much of that time due to the failure of the CCD's Peltier cooler. While it was away for repairs I took the opportunity to strip down and clean the mount. It should be back in operation by the time you receive this newsletter.

Wishing you all clear skies,

Mark Blackford

Sixth Variable Stars South Symposium – *Mark Blackford*

markblackford@outlook.com

VSSS6 will be held on Friday, April 10th, 2020 in Parkes NSW, just prior to the NACAA meeting. The symposium will have a single stream of presentations as well as a poster display.

The VSSS6 Programme Committee (David O'Driscoll and I) is now calling for presentations for the Friday sessions. Oral presentations are the main focus of our symposia, and we are inviting amateur and professional astronomers with an interest in variable stars to consider making a contribution, individually or as part of a group. Membership of Variable Stars South is not necessary, indeed we welcome anyone with a shared interest in this fascinating field of study.

A poster display will also be available for those who prefer to present their work in that manner. These will be in place for the entire weekend giving delegates to the NACAA conference and other satellite meetings the opportunity to view them.

There is no particular theme for this symposium; presentations on any topic related to variable stars may be accepted, so long as the contribution is significant and interesting. These include, but are not limited to short and longer period pulsating stars, eclipsing binaries, cataclysmic variables, exoplanets, equipment, techniques, visual and electronic observing.

We are looking for addresses on topics such as:

- an observational (or desk-bound) research programme you are involved in;
- an interesting development in instrumentation and tools: optical, spectroscopic, computational, imaging, electronic, etc.;
- your progress with a significant project or programme, national or worldwide;
- an entertaining address aimed at promoting the enjoyment of variable star astronomy;
- an interesting piece of variable star history.

The usual duration for presentations is 30 minutes. We may be able to accommodate shorter or longer talks, but that will depend on the number of submissions we receive. The NACAA Welcome Reception on the Friday evening will limit how late our symposium can run. We anticipate including a short question and answer session where delegates can pose questions or suggestions regarding our hobby or Variable Stars South.

Paper submission and registration for the symposium will be through the NACAA 2020 website. The VSSS6 Call for Presentations webpage (<https://nacaa.org.au/2020/vsss6/cfp>) is live and the registration page will come online toward the end of 2019.

The deadline for proposals is **January 31st, 2020**. Late proposals may be accepted, depending on venue restrictions, scheduling, etc. But please submit your proposals as soon as possible to allow us to start putting the programme together. It will also help with planning our resource requirements for the venue, etc.

If you are considering making a presentation, but are not sure what's expected, whether your topic meets the requirements, or any other issue, please [contact the Programme Committee](#). A member of the PC will get back to you to assist.

On the Thursday evening before the symposium we'll have an informal VSS gathering at a local pub or restaurant, like we did before the Sydney 2016 symposium. I was in Parkes in July and scoped out a couple of options that aren't too far from the VSSS6/NACAA venue.

Abstract

By the use of digitized archival images, four old novae in the SMC region, from 1897 to 1952, have been identified. Charts and more precise positions are published for each SMC nova.

Introduction

Four SMC novae were reported 1897 and 1952. It appears that the original plates have not been closely examined in recent times, and only approximate positions exist. This paper extends similar work done on old LMC novae (Morel 2019), with the same methods. The SMC novae are as follows:

- Nova Tuc 1897 = HV 849 = SMC V1691.
- Nova Tuc 1927 = VZ Tuc = HV 6334 = SMC V0177.
- Nova Tuc 1951 = SMC V0182.
- Nova Tuc 1952 = SMC V0491.

Source material

Direct images were found on Harvard archival plates for each nova. Digitized plates were downloaded from the *DASCH* server. Nova Tuc 1951 was captured 24^d after maximum, at ~15.0p.

Reference stars

Following previous practice, four or five reference stars on each old plate were identified and their precise positions taken from Gaia DR2 (CDS cat I/345), or UCAC4, noting their proper motion. The pm values were used to determine the precise position of each reference star, at the respective epoch of each plate. These reference stars enabled me to determine the exact orientation and scale of each DASCH plate. Knowing the exact scale one could interpolate the exact position of the target star. Alternatively, one could precisely match an enlargement of the DASCH plate to a UKS/ESO plate. The limiting factor was the quality of the old plates, which were usually inferior, often due to trailing.

Results

Nova Tuc 1897 = SMC V1691.

From literature, first listed as variable star HV 849 by Leavitt in 1908 (HA60) but recognized as a nova by McKibben Nail in 1951. My four measurements are in good agreement, estimated from DASCH plate X8937 and Gaia DR2 reference frame, pm adjusted. See also SMC Atlas by Hodge & Wright (1977). See Figure 1.

Plate: **X8937** (1897-10-20) 13-in. Boyden telescope, Excellent resolution; sharp images.

Astrometric position: **01^h02^m11.40^s ±2" -70°02'56.0" ±2"** Equinox J2000, Epoch 1897.79

Nova Tuc 1927 = VZ Tuc = SMC V0177.

See literature refs. Shapley, H. & Hughes, E.M. (1935) and Prager, R. HA 111 (1941). An accurate chart was published by Tsessevich & Kazanasmas (1971)

Plates: **MF11148** (1927-11-12) Used for measurement. See Figure 2.

MF11227 (1927-12-12) Id. clear, but too much annotation. Not used.

Astrometry: Five measurements, referred to Gaia DR2. RAs range is 0.65 to 1.16; Dec range is 5.6" to 8.5". A rough position in HA 111 was the only one for many decades, but too far east by ~8". Recently Downes et al (2001) have refined the position to within a small error circle, but still uncertain. My improved position falls within their error circle, but a little NE. I am north of their coordinates by 9".

Mean position: $00^{\text{h}}34^{\text{m}}00.93^{\text{s}} \pm 2''$ $-73^{\circ}16'06.8'' \pm 2''$ Equinox J2000, Epoch 1927.89

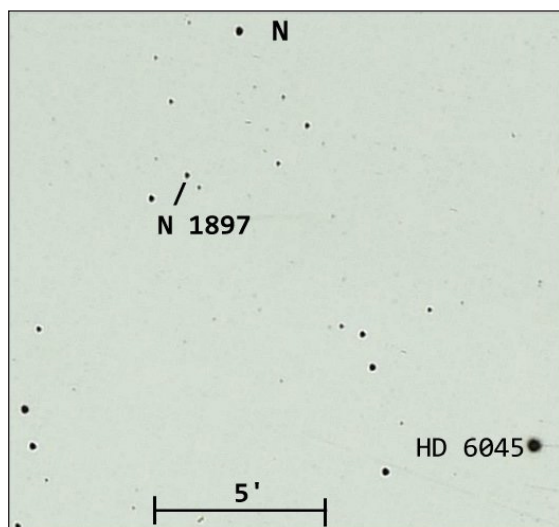


Figure 1. *Nova Tuc 1897 (SMC V1691). From DASCH plate X8937 (1897-10-20).*

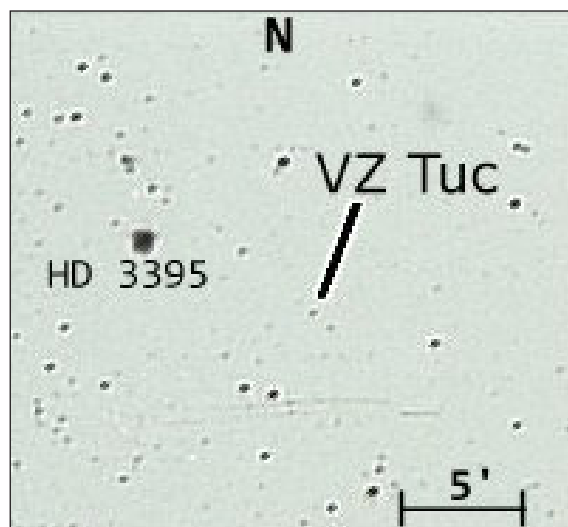


Figure 2. *VZ Tuc = SMC V0177. From DASCH plate MF11148 (1927-11-12).*

Nova Tuc 1951 = SMC V0182

Discovered 1951-08-04 at 11^{mag}, (IAUC 1323). Faded to ~15p Aug. 28.

Chart ref: Position is shown by tick marks on small scale chart by Henize (1956). Enlargement of two DASCH plates enabled a careful comparison with six surrounding Gaia DR2 stars. These plates are

Plates: **MF39647** (1951-08-28, T 21:26:43.6, 45.0min exp.) Image distinct; heavy annotation.

RB16950 (1951-08-28, T 21:31:12.9, 60.0min exp.) Used for measurement. See Figure 3.

At least six measurements of the DASCH plates were made, and at least 3 from Henize's chart. Henize's chart proved to be consistently about 5.6 RAs westwards of plate measurements. This is not surprising as the tick marks were placed there by hand, probably on the basis of a rough position. Finally a precise enlargement of a DASCH plate cut-out was matched to a 15' red print from SuperCOSMOS..

Mean position: $00^{\text{h}}35^{\text{m}}22.30^{\text{s}} \pm 3''$ $-72^{\circ}58'11.5'' \pm 3''$ Equinox J2000, Epoch 1951.67

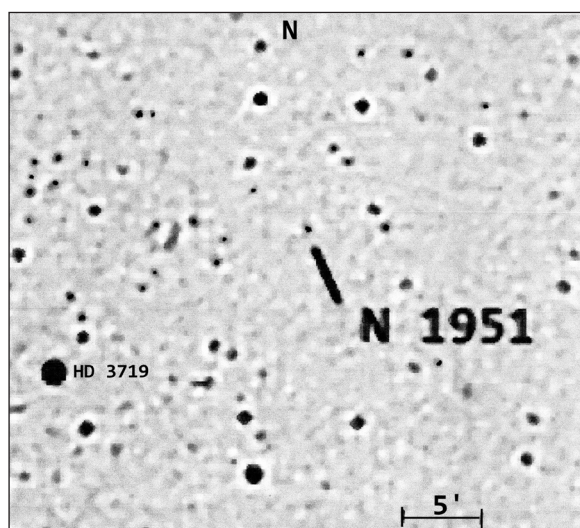


Figure 3. *Nova Tuc 1951 = SMC V0182. From DASCH plate RB16950 (1951-08-28).*

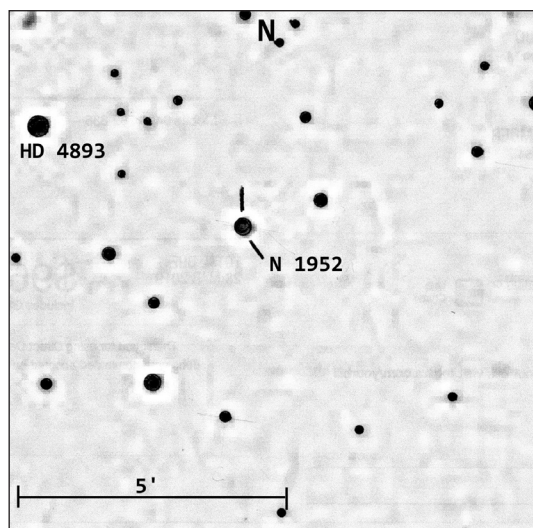


Figure 4. *Nova Tuc 1952 = SMC V0491. From DASCH plate B76511 (1952-12-19) Lies ~73 arcsec NE of cluster NGC 269.*

Nova Tuc 1952 = SMC V0491

Literature: Smith, Henry G. (1954)

Plate: **B76511** (1952-12-19), exp. 2.0min. 5 measurements. At max. on JD 2434366 (1952 Dec. 19). At least 16 plates were taken on that date, and all were of very short exposure, only 2.0min, using 8-in Bache telescope. The aim was to look for rapid short term variations. This meant that even bright stars impressed only tiny images on the plate. Just one plate was selected for measurement. Five measurements were made, relative to UCAC4 stars, included one very good match-up with a DSS IR plate. All end figures, both RA and Dec. are internally consistent, within $\pm 2''$. See Figure 4.

Mean position: **00^h48^m29.27^s $\pm$ 2.0" -73°30'46.4" $\pm$ 2.0"** Epoch 1952.97

My position lies about 8s west of the position given by Smith, and is almost exactly midway between UCAC4 stars, mag 16.8 and 16.0. Upon zooming in one finds two faint Gaia stars, closer in to my measured position. These Gaia stars have the following positions.

00 48 28.810 -70 30 46.66 Ep. 2015.5 Equ. J2000 Mag. G = 19.97

00 48 29.732 -70 30 46.14 Ep. 2015.5 Equ. J2000 Mag. G = 20.57

Concluding remarks

This paper concludes a programme to determine more precise positions for 9 old novae in both Magellanic Clouds, 5 in the LMC and 4 in the SMC, based on original plate material.

Table 1: Summary of New Positions for 4 SMC Novae.

No.	Name	(J2000)	Epoch
1.	N 1897	01 02 11.40 -70 02 56.0	1897.79
2.	N 1927 = VZ Tuc	00 34 00.93 -73 16 06.8	1927.89
3.	N 1951	00 35 22.30 -72 58 11.5	1951.67
4.	N 1952	00 48 29.27 -73 30 46.4	1952.97

Acknowledgement

I gratefully acknowledge the use of DASCH plates in this research..

References.

- DASCH (Digital Access to a Sky Century @ Harvard) <http://dasch.rc.fas.harvard.edu/project.php>
Downes R.A. et al 2001. PASP 113,564. [2005JAD....11....2D]
Henize, K. G. 1951 IAUC 1323
Henize, K.G., Hoffleit, D. and Nail, V. McKibben 1954. Proc. Nat. Acad. Science 40, 365
Henize, K.G. 1956 Astrophys. J. Suppl. 2,315
Hodge, P. & Wright, F.W. 1977 'The Small Magellanic Cloud', Univ. of Washington Press.
Leavitt, H.S. 1908 Harv. Ann. 60,4,87
Morel, M. 2019 VSS Newsletter, July (2019-3, p3)
Nail, V. McK. 1951 Harv Bull. 920, p13
Prager, R. 1941. Harvard Annals 111, 134, -208 (remark for VZ Tuc)
Shapley, H. & Hughes, E.M. 1935 Harv. Bull. 898, p8
Smith, Henry G. 1954 Proc. Nat. Acad. Science 40,372
SuperCOSMOS Sky Survey. <http://www-wfau.roe.ac.uk/ss/pixel.html>
Tsesevich, V. P. & Kazanasmas, M. S. 1971. 'Atlas of Finder Charts for Variable Stars', Moscow.

As photo bombs go this one's a beauty – *Mark Blackford*

(markblackford@outlook.com)

It isn't unusual to see faint background galaxies near variable stars, but the EW type eclipsing binary UY Sculptor has a rather imposing neighbor. NGC 55 is a Magellanic type irregular dwarf galaxy in the local group of galaxies. It lies some 6.5 million light years beyond UY Scl. Figure 1 is a stacked image from 350 frames recorded over some 6 hours in early October 2019.

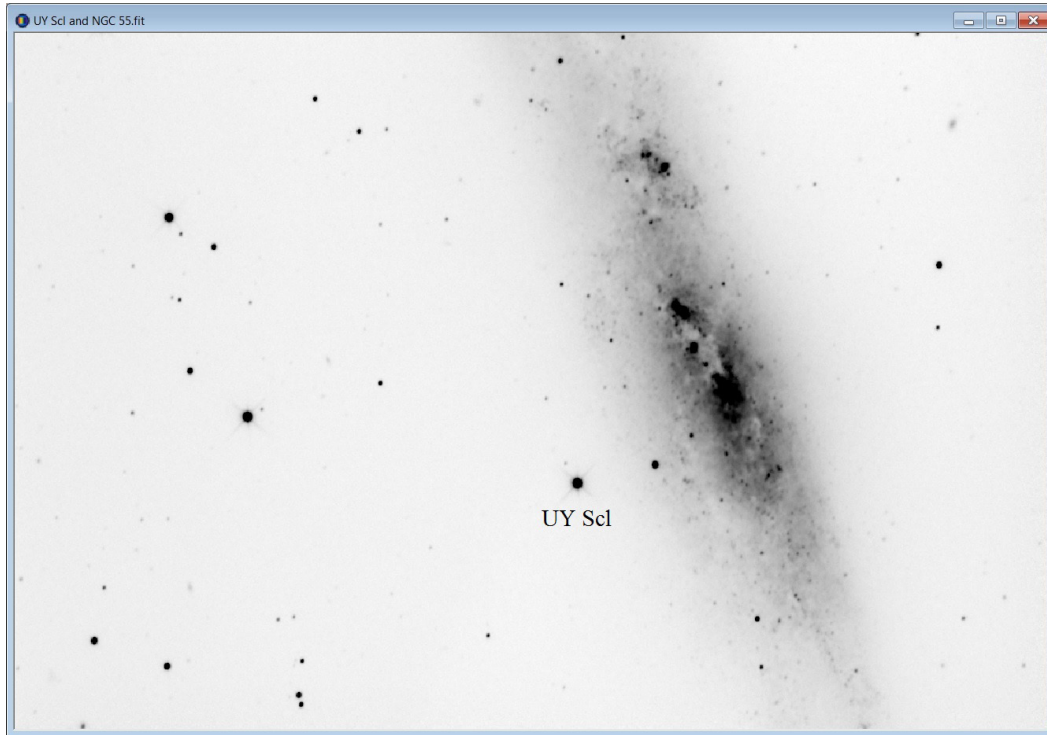


Figure 1. NGC 55 dominates this image of the UY Sculptor field (FOV 18x12 arcmin).

But NGC 55 wasn't the reason for imaging this field; I was interested in recording the light curve and measuring Times of Minimum of UY Scl. The AAVSO Variable Star Index (VSX) lists its period as 0.364356 d and epoch 2451869.77 HJD which I presume are derived from All Sky Automated Survey (ASAS) data. My V band light curve phased to the VSX light elements is shown in Figure 2. The two maxima are significantly different in brightness. This so-called O'Connell effect is not uncommon but not fully understood either.

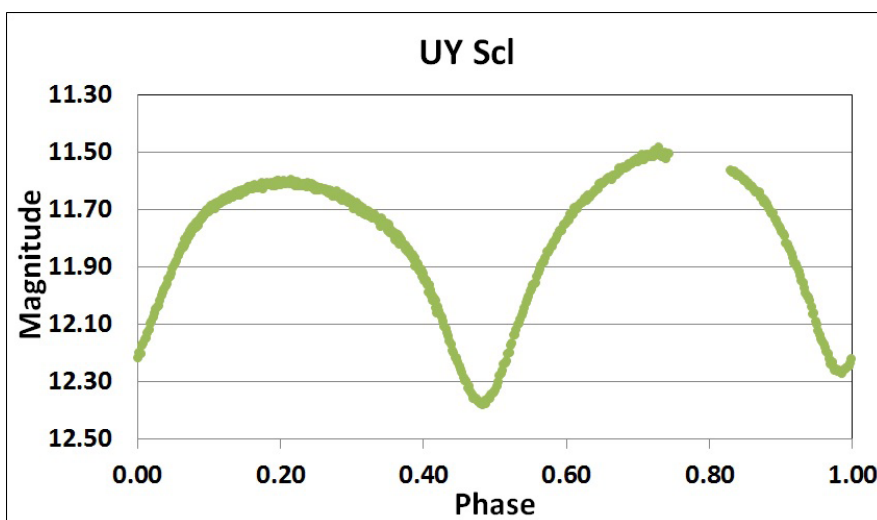


Figure 2. UY Sculptor V band light curve using VSX light elements.

Note also that the deeper eclipse is close to phase 0.5, so whoever derived the original light elements got the two eclipses mixed up or the period is in need of serious revision.

Linearity, and high precision time series photometry

Introduction

The ZWO ASI1600MM-C00L is a cooled monochrome CMOS astronomical camera, fitted with the Panasonic MN32430ALJ chip (according to the Version 1.3, 2018-03 manual). It has 4656 x 3520 pixels, each 3.8 μ m square, giving an image area of 17.6 x 13.3mm. Analogue to digital conversion operates in 12 bit or 10 bit mode. When the latter is selected, a faster frame per second rate can be achieved. As the current testing was done on series of single images, only 12 bit mode was used.

Let us revisit what is meant by ‘12 bit mode’. Analogue to digital converters (ADC) transform an analogue voltage to a binary number (a series of ones and zeroes) and finally to a digital number (to base 10) which is displayed or recorded in some manner. The number of binary digits (bits) in the binary number determines the ADC resolution. Thus, an n-bit ADC has a resolution of one part in 2^n . For a 12 bit ADC, that is one part in 2^{12} or one part in 4096. By way of comparison, for a CCD with 16 bit ADC, the corresponding resolution is one part in 65,536 which is 16 times greater.

Gain and full well capacity

Figure 1 is part of a graphic taken from the camera manual, and shows the FW (full well) in electrons (e-) and gain (e-/ADU) (e-/Analogue-to-Digital Units) at various gain settings. The latter (0 to 300 in units of 0.1dB) is user selectable within the camera control dialog, which can be called from your imaging software. Note that 139 dB units is unity gain: there is no amplification of the signal.

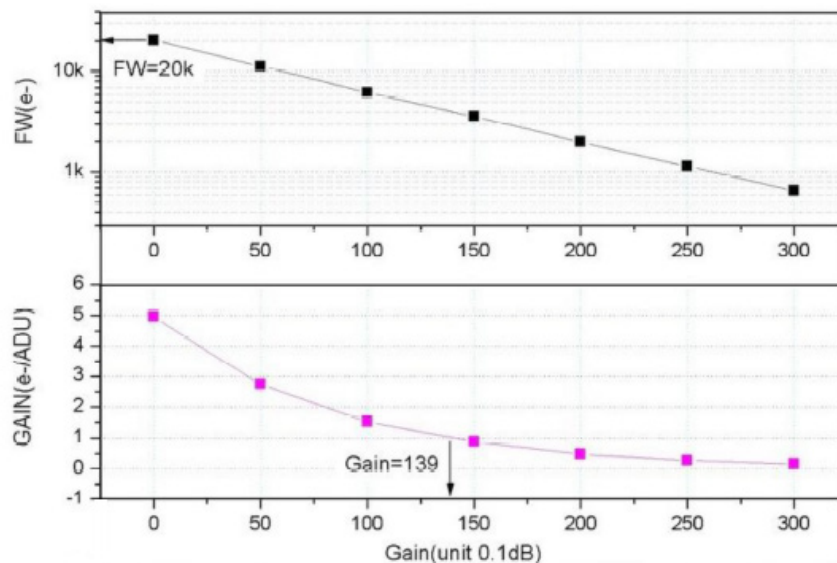


Figure 1. Gain and full well capacity of the camera, versus the gain setting (0 to 300) in dB units. These graphs are part of a figure in the ZWO ASI manual.

At unity gain the full well capacity (FWC) is 4096 in 12 bit mode (this data is not shown in Figure 1), whereas at gain levels less than 139 dB units, it is greater than 4096. The manual states that it reaches a maximum of 20,000 only at zero gain (noted on the upper panel of Figure 1).

Linearity of the camera's response

Flat frames were taken at exposures from 5 – 90 seconds at zero gain setting, and 5 – 80 seconds at unity gain in increments of 5 seconds. The mean pixel count was determined for each frame in AstroimageJ. It was planned initially to dark subtract the flat frames, but after a preliminary inspection of the linearity data, it was decided not to take darks. The two linearity tests were done on two consecutive days. The ambient temperature each day was 23°C, and the temperature of the sensor was set to -10°C, (ie 33°C below ambient).

The graphed results of the tests are illustrated in Figures 2 and 3. Note that the mean counts/pixel plateau below 60,000 when the gain is set to zero, whereas the plateau at unity gain (gain setting 139) is precisely 65,504. The latter figure represents true FWC (as displayed in AstroimageJ). The highest mean count/pixel in the linear range is 62,312.

The display of such a high average count per pixel (65,504) for a saturated image from a camera with a 12 bit ADC occurs because the camera driver multiplies the binary number that represents the data in each pixel by 16. For a full well, $4096 \times 16 = 65,536$ which is a little larger than the count of 65,504 displayed when the pixels are saturated. After this is done, each binary number ends in four zeroes.

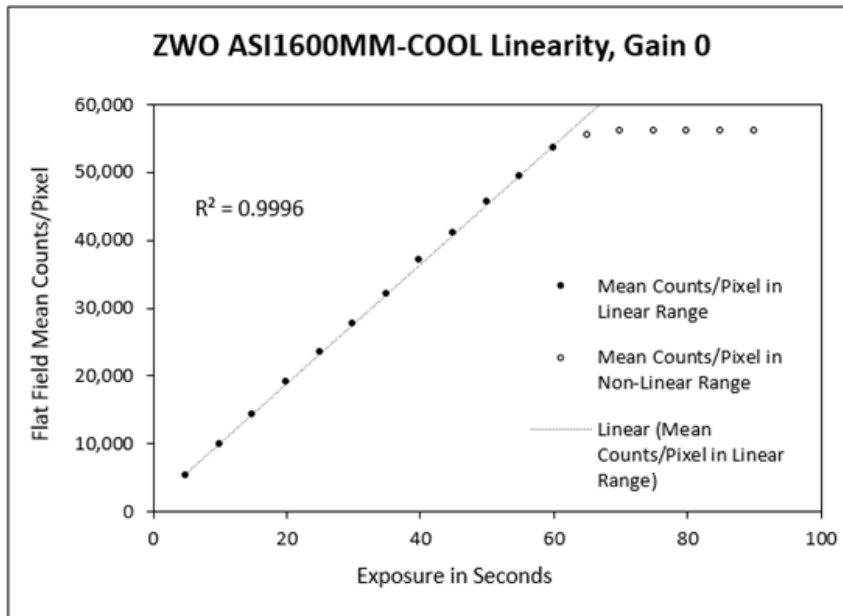


Figure 2. Linearity plot with the gain set at zero dB units (5e-/ADU). Note that the data plateaus below 60,000 counts. Although it cannot be seen in the plot, even at the plateau the counts are increasing at a slow rate with increasing exposure times.

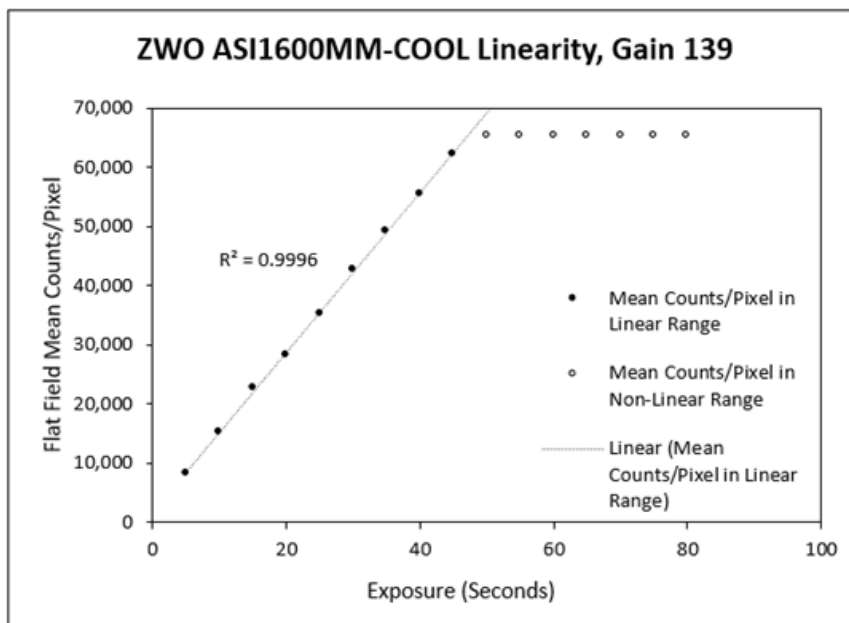


Figure 3. Linearity plot with the gain set at 139 dB units (1e-/ADU). The data plateaus at precisely 65,504 counts. The highest data point in the linear range has a count of 62,132.

Formal determination of non-linearity was based on regression analysis of the data at unity gain up to full well capacity (Table 1 and Figure 4).

Exposure in Seconds	Mean Counts/Pixel	Predicted Linear Range	Residuals
5	8,196	9,034	-838
10	15,158	15,578	-420
15	22,739	22,122	617
20	28,308	28,666	-358
25	35,268	35,211	57
30	42,656	41,755	901
35	49,127	48,299	828
40	55,564	54,843	720
45	62,312	61,388	924
50	65,501	67,932	-2,430

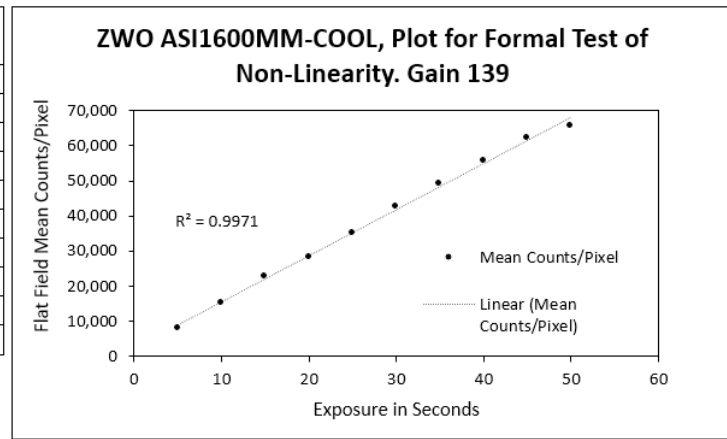


Table 1 and Figure 4. Data and plot for the formal calculation of non-linearity.

Non-linearity % = (Max Positive Deviation + Max Negative Deviation) x 100/Max Signal

Residuals, minimum value (maximum negative deviation) -2,430

Residuals, maximum value (maximum positive deviation) 924

Non-linearity % = (Max Positive Deviation + Max Negative Deviation) x 100/Max Signal

= (924 - 2,430) x 100/65,501

= -2.3

High-precision time series photometry of the delta Scuti star RS Gru

RS Gru was imaged during two consecutive nights in August 2019. Exposures of 150 seconds were taken with a Johnson V photometric filter through an 80mm f/7.5 refractor. Importantly, images were de-focused. They were pre-processed in AstroimageJ with dark and flat frames. Non-transformed magnitudes in V were calculated. The variable, comparison and check stars are listed in Table 2.

Star	V	B-V
RS Gru	8.264	0.267
Comparison Star HD 206442	8.485	0.490
Check Star HD 206584	8.451	0.950

Table 2. Values of V and B-V for the variable, comparison and check stars accepted for this study. The values for RS Gru are indicative only, since both V and B-V would vary during the cycle.

Light curves of RS Gru and the check star obtained during the two nights are shown in Figures 5 and 6. The high precision is evident, and encouragingly there is no shift in magnitude of the check star after the meridian flip.

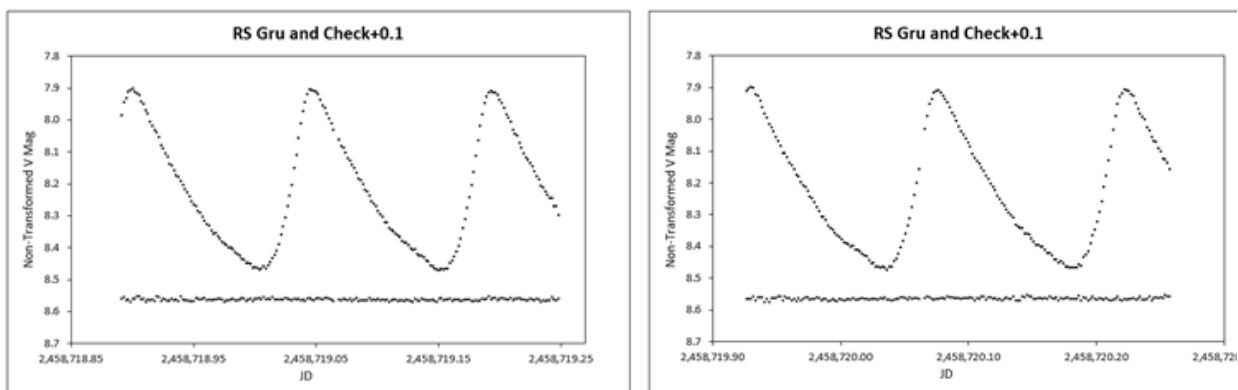


Figure 5 & 6. Light curve of RS Gru and check star (+0.1 Mag) for the night of 23-24 August 2019 (left) and for the night of 24-25 August 2019 (right).

Date	Mean of 10 consecutive check star V magnitudes	Standard deviation
23-24 Aug 2019	8.5651	0.0029
24-25 Aug 2019	8.5655	0.0020

Table 3 lists the means and standard deviations of 10 consecutive check star observations chosen randomly near the middle of each night's observing run. The means differ by only 0.4 millimagnitude.

Line profile of RS Gru

Figure 7 shows the line profile of RS Gru from an image taken at the first peak of the light curve on the night of 23-24 August, as displayed in AstroimageJ. The broad stellar profile reflects the fact that the image was defocused. Note that the peak value of 62,192 is just above the highest mean count/pixel of 62,132 in the linear range of the data displayed in Figure 3. The exposure should thus be regarded as too long. However, the great majority of the signal from the star in this exposure is within the range of the linear response of the sensor. According to AstroimageJ, the SNR for RS Gru at the first peak of the light curve on 23-24 August is 3,276 but I do not know what algorithm is used to calculate this value. However, for the check star near the middle of each night's observing run, the SNR would appear to be greater than 1,000 since the means of 10 observations on each night differ by less than one millimagnitude.

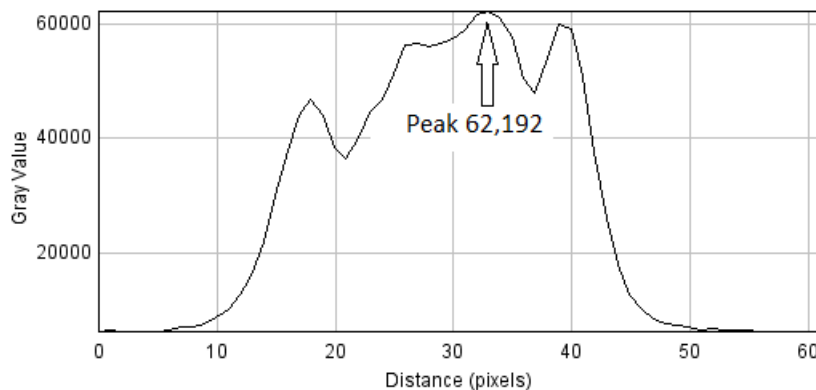


Figure 7. Line profile of RS Gru from an image at the first peak of the light curve on the night of 23-24 August. The peak value of 62,192 counts has been added as an annotation to the graphic. The software (AstroimageJ) lists all values at each of the approximately 60 (in this example) pixels crossed by the line.

Summary

The ZWO ASI1600MM-COOL camera is described briefly, its linearity is graphed at gain values of 1e-/ADU and 5e-/ADU, and its precision for time series photometry is demonstrated. The response of the sensor is linear to nearly full well capacity at the former of these gain settings. Formal determination reveals non-linearity to be -2.3% at unity gain (setting 139 in 0.1 dB units, 1e-/ADU). Time series photometry of the 8th magnitude delta Scuti star RS Gru and an 8th magnitude check star performed on two consecutive nights reveals excellent precision when the exposure and degree of defocus of the image are optimized so that the maximum signal is very close to the top of the linear response range of the camera.

The inconstant eclipsing binary BO Indus – *Mark Blackford*

(markblackford@outlook.com)

What started as a routine measurement to refine the orbital period and epoch of BO Indus has uncovered a somewhat more complicated situation than first appeared.

The eclipsing nature of BO Ind was identified from observations by the Hipparcos satellite in 1990-1993. The AAVSO Variable Star Index (VSX) lists its period as 0.405054 d and epoch 2448500.33 HJD which were derived from the satellite data. Hipparcos' light curve is shown in Figure 1; note that primary and secondary eclipses are of similar depth.

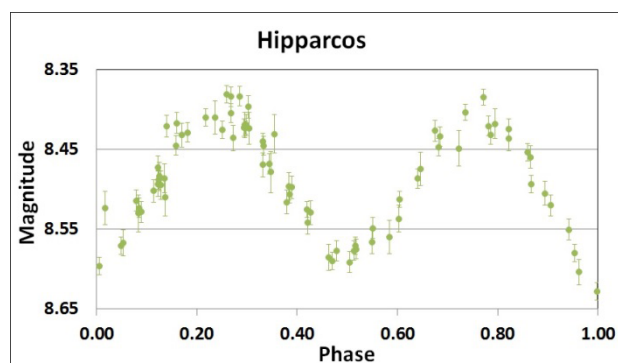


Figure 1. *Hipparcos light curve using VSX light elements.*

As far as I could establish there have been no subsequent period measurements since its discovery. So in August/September 2015 and July 2019 I recorded time series images of BO Indus (up to 9.7 hrs on several nights) with the aim of measuring primary and secondary eclipse Times of Minimum for the VSS Eclipsing Binaries project.

My 2015 and 2019 light curves phased on the VSX light elements are shown in Figure 2. Magnitude offsets are due to Hipparcos' filter having a different spectral response to my DSLR camera (2015 data) and CCD with Johnson V filter (2019 data), as well as different sets of comparison stars used for the 2015 and 2019 measurements. These offsets do not affect Time of Minimum (ToM) determination.

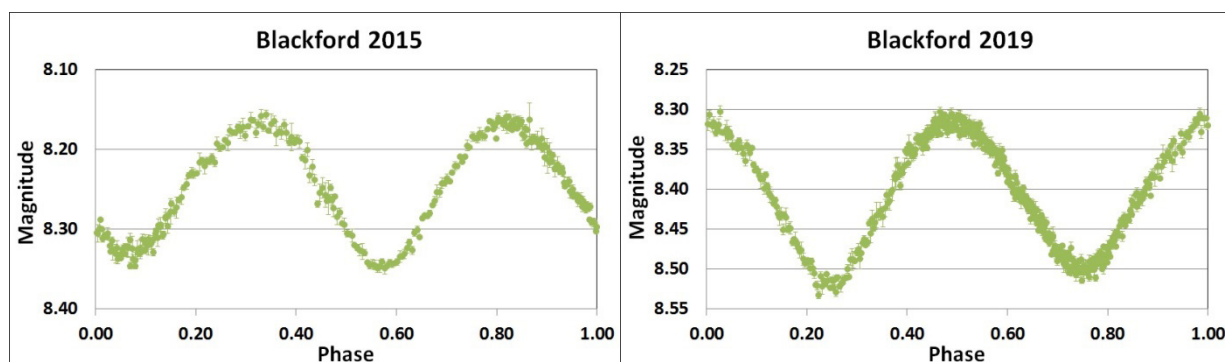


Figure 2. *2015 (DSLR) and 2019 (CCD) light curves using the VSX light elements.*

The 2015 primary eclipses occur at phase 0.57, whereas the 2019 primary eclipses are at phase 0.24, or about 3.2 hours earlier than the VSX period would predict. This is a third of the orbital period which is quite a large deviation over a relatively short time frame of 4 years.

My first thought was that the 0.405054 d period derived from Hipparcos observations may have been incorrect. The 82 observations were made over a time frame of 1078 days, long enough that a small error in assumed period would result in significant smearing of the light curve, but that is not evident in Figure 1. I derived a period of 0.405058 d using Jeff Byron's PeriodFinder software (described in VSS newsletter 2019-1), which amounts to less than a second difference from the VSX period. So I am confident the VSX period was correct at the time Hipparcos data was collected.

Two and a half decades separate my 2015 measurements from the Hipparcos epoch. For a short period

eclipsing binary such as BO Ind a period change of a few seconds per cycle could easily accumulate in that time to the point where determining the true number of completed orbits becomes uncertain. So I looked for published ToM's or observations in the intervening years. The only data available was from the All Sky Automated Survey (ASAS) database, accessed through the VSX webpage.

A total of 553 A and B grade ASAS measurements, recorded between 2000 and 2009, were used in the following analysis. These are shown phased to the VSX light elements in the left panel of Figure 3. The smeared light curve indicates the VSX period was not appropriate for the 2000 to 2009 time frame. A more appropriate period of 0.4050258 d was found by PeriodFinder (Figure 3 right panel). Evidently the period had reduced by 0.000028 d or 2.4 s per cycle in the years between Hipparcos and ASAS surveys.

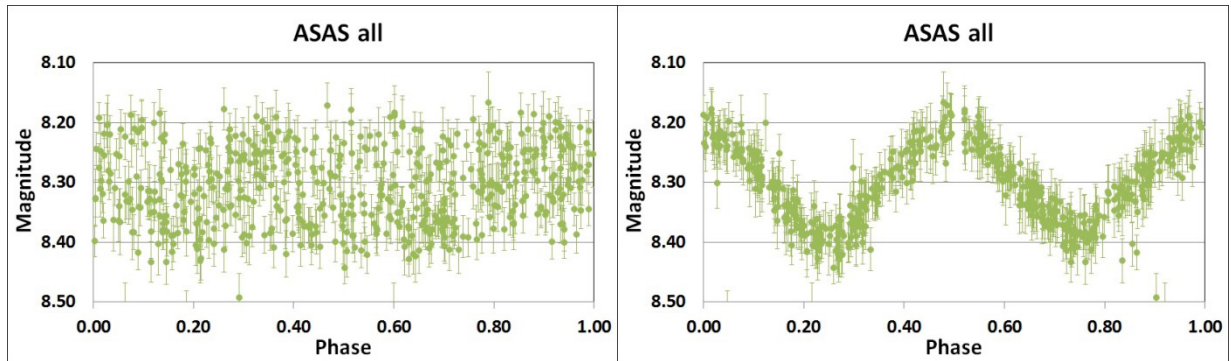


Figure 3. ASAS light curve using the VSX period (left) and period 0.4050258 d (right).

ASAS data were divided into three groups, 2001 (Nov 2000 - Jun 2003), 2005 (Jul 2003 - May 2007) and 2008 (Apr 2007 - Sep 2009), from which light curves in Figure 4 were constructed. Primary eclipses occur at essentially the same phase for all three groups which implies the orbital period had not changed significantly during the ASAS survey period. An epoch of primary minimum was determined for each group:

2001 epoch = 2452213.7060 (0.0054)

2005 epoch = 2453474.1438 (0.0054)

2008 epoch = 2454615.9113 (0.0049)

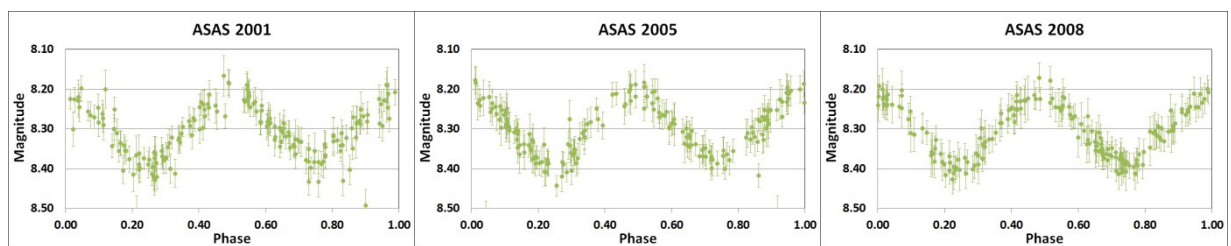


Figure 4. 2001, 2005 and 2008 ASAS light curve using the VSX epoch and period 0.4050258 d.

So at this point I was confident of the orbital periods applicable at the time of the Hipparcos mission (0.405054 d) and during the ASAS survey (0.4050258 d). The next step was to determine the orbital period at the time of my 2015-19 observations.

PeriodFinder couldn't be used with my original 2015 and 2019 observations due to the differing magnitude range and offset as seen in Figure 2. However, the observations could be homogenized by adding a zero point correction to the 2015 measurements and scaling them to the same range as the 2019 measurements. PeriodFinder found 0.4050167 d to be the best fit to the homogenized 2015 and 2019 measurements. Figure 5 shows the light curve folded on this period and using a measured 2015 primary ToM as the epoch.

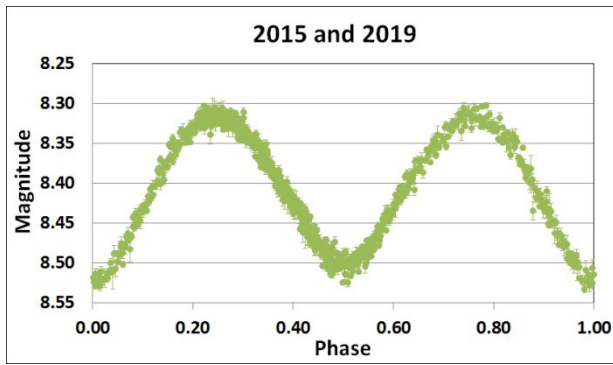


Figure 5. Combined 2015 and 2019 light curve using a 2015 primary ToM and period 0.4050167 d.

An Observed–Calculated (O-C) diagram, Figure 6, was constructed using the Hipparcos and ASAS epochs and observed ToM’s from my 2015 and 2019 measurements. The ASAS period (0.4050258 d) and 2008 ASAS epoch were used to generate calculated values.

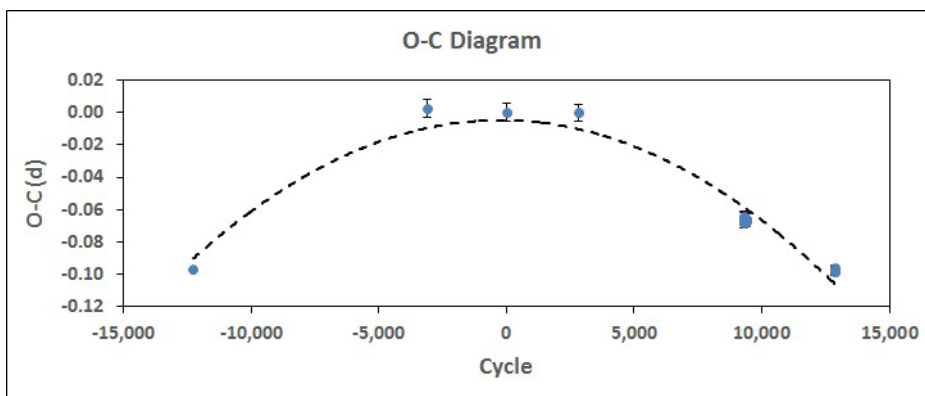


Figure 6. BO Indus O-C diagram showing all available data.

If the period was constant we would see the O-C data lie along a straight line, which is not the case in Figure 6. The downward parabolic curve of best fit indicates the period is shortening. I’ll leave it to others to determine the exact mechanism of the period change. Two possible causes are mass transfer between the two stars or light travel time effect due to the binary pair orbiting a third star in a wide orbit.

So in conclusion, the orbital period of BO Indus has decreased from 0.405054 d in the early 1990s to 0.4050258 d in 2000s and 0.4050167 d currently. Continued measurements of Times of Minimum in coming years will be crucial in understanding this interesting system.

Introduction

As with BL Telescopii it's good to revisit some of the more interesting stars in our particular field of interest - rather like an old popular book on astronomy, Russian in origin, I think, called '*Astronomy for Entertainment*'. Perhaps with everything online these days we hardly get to look at the target as it appears in the telescope! Maybe we're too result oriented. After a night's observing at Auckland Observatory we often finished off with a look at a few of the more interesting objects in the sky. So I've always had an interest in VW Hydri - even if the present research seems aimed at ideas we wouldn't even have dreamed of 50 years ago.

This also brings to mind another aspect of the changes over fifty years of astronomy. In those days all calculations were pencil and paper assisted by slide rules and logarithm tables. So finding periodicities was a major operation. I remember we were delighted when Emilia Belserene who attended the '*Small Telescope Conference*' in Christchurch about 1985 provided the essential algorithms for a period search software which we modified and used extensively for decades. I still use it on occasions. The great advantage was that we developed a real in-depth understanding of simple astrophysics which many of today's so-called astronomers lack. But back to VW!

VW Hydri was one of the first variable stars we looked at after the new Auckland Observatory was opened in early 1967. It is the closest dwarf nova and one of the most interesting. We also included BV Centauri and EX Hydrae, two other DNs interesting in their own right: BV Centauri has an exceptionally long period of 16.7 hours whereas EX Hydrae, a well studied eclipsing binary at that stage, turned out to be an intermediate polar. BV Centauri comprises a white dwarf component of ~ 1.18 solar mass and a main sequence G star of 1.05 solar mass, both much more massive than the average DN system. EX Hydrae was special - a well known 98 minute eclipse period, but also a mysterious 67 minute period. Later this was found to be the rotational period of the white dwarf component with a very strong magnetic field and we were watching direct accretion onto one of that star's polar regions.

VW Hydri has become perhaps the most closely studied DN in the sky and over recent years a considerable number of electronic measures have been published on the International Database, maintained by the AAVSO. So let's give in to curiosity and see what these observations show.

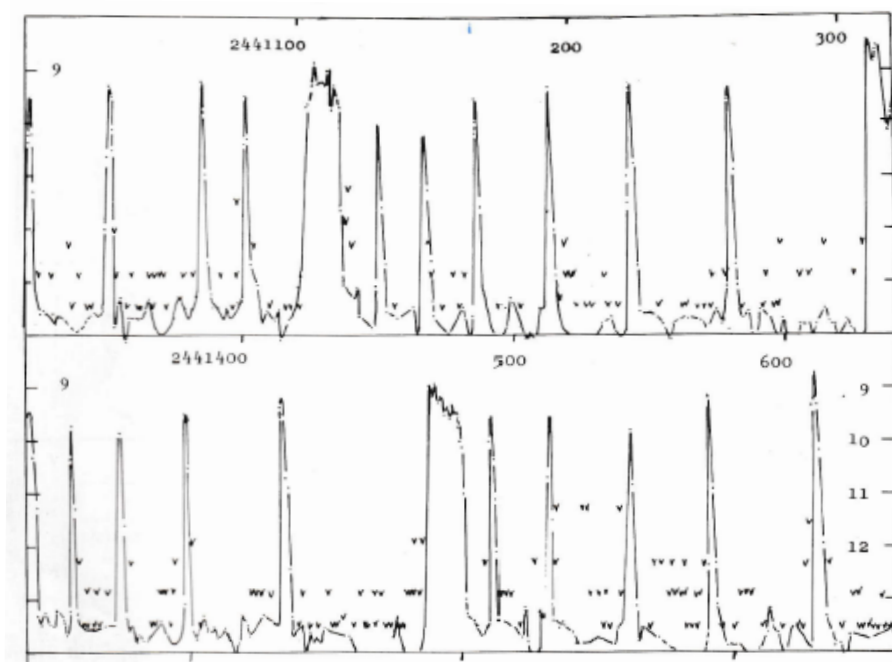


Figure 1. This illustrates the type of activity which was attracted many observers back then. This comes from Bateson, 1977, Figure 1.

The visual scene

Unfortunately the number of recent visual measures is less than it was 50 years ago and probably some of the outbursts have been missed. This is not good. Its visual range is from mid-thirteenth magnitude to around 8.7 during the longer superoutbursts. So if your skies are reasonably dark it's visible to the eye at minimum in the standard 203mm telescope which many of our members use.

There are two types of outburst: the more frequent short term brightening which appears to be the result of an abrupt collapse of part of the disc around the white dwarf causing accretion brightening as it impacts the surface of that star - but also the longer and brighter superoutburst, a composite and more prolonged event triggered by a normal outbursts, as discovered and explained by Marino & Walker, 1978.

Table 2 of Bateson's 50 page summary of 7500 days of observations showed all the outbursts during that period: 248 normal outbursts and 44 superoutbursts. Possibly 6 to 8 normal outbursts were missed. This indicates an average of about 6 ordinary outbursts between each superoutburst. The actual numbers range from 3 to 8. A variety of researchers have attempted to show trends dependent upon the time since the last supermaximum or the time to the next but to all appearances intervals and amplitudes of the ordinary outbursts are random and probably governed by the rate of mass flow from the donor star.

The superoutbursts are different. They occur twice yearly and there are suggestions that like many other stars the O-C curve of these superoutbursts varies between two extreme values. Bateson used maximum brightness to derive an average period of 179.35 days with a scatter of 12.1 days from 44 outbursts. But if the beginning of the superoutburst is used the scatter is far less and a wavy O-C can be imagined. Since that analysis there have been around 100 of these bright maxima and an updated analysis might be interesting. But defining the true start date requires a well observed event as will be clear from some of the following illustrations. Perhaps someone has already tried this?

More recent CCD measures

A perusal of the International Database of Variable Star Observations shows a gradual decline in visual observations but also two intervals of heavy CCD monitoring undertaken in response to the request of various investigators with much more detailed goals in mind. But it's interesting to see how earlier ideas match up with this much more comprehensive cover.

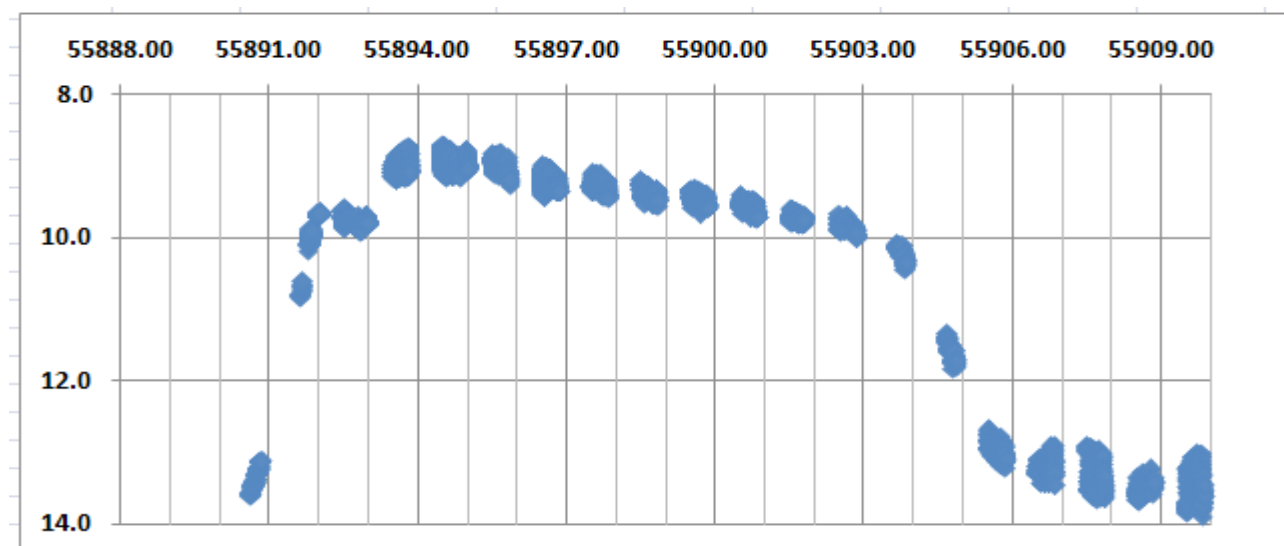


Figure 2. CCD measures by Josch Hamsch and Terry Bohlsen. The vertical axis is from $V = 8$ to 14. The spread of measures each night is real, being caused either by orbital humps, or superhumps during the long outbursts.

The above graph shows a number of features which are examined in detail. The superoutbursts of VW Hydris are triggered by a normal outburst, or precursor, which declines in the normal manner until the triggering interaction begins to take place. Indicative of the commencement of this is the development of enhanced orbital humps as shown in Figure 3. Figure 2 shows that the rise to supermaximum occurred at

about MJD 55893.0.

The beginning region is shown in more detail in Figure 3 which uses the recently determined ephemeris of JD 2440128.0222 + 0.07427104. This starts at cycle 201267 which in MJD is 55892.4218. The third block of measures were by Terry Bohlson in V, the others all by Josch Hambsch in CV.

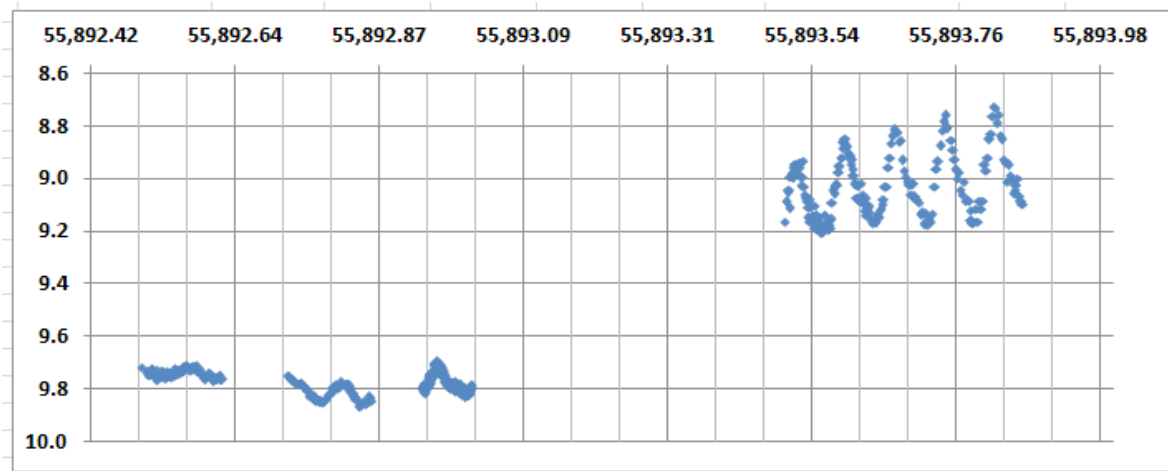


Figure 3. This clearly shows the beginning of the development of a series of brightenings or humps. The horizontal scale increments are one orbital cycle of 0.07427104 days from the current epoch.

Unlike the ordinary outbursts supermaxima are an event which carries on for more than a week. In the paper presented at Colloquium 46 of the IAU in Hamilton it was shown that the level at which these anomalous humps were occurring required that they were 30 times brighter than the normal orbital humps, probably indicating a dramatically increased mass flow into the disc. This appears to continue for ~11 days and provides the ongoing energy to drive the superoutburst for that period. In Figure 3 the light curve is very disturbed but still close to the normal orbital period. By the next night, however, the period has lengthened to 0.07747 but will gradually become shorter as the outburst proceeds.

The disc around the white dwarf star does not remain unaffected. It becomes distorted into an ellipse which precesses at a rate governed by the relative masses of the two stars in the system. It also appears to become larger as a result of the increased flow. This then leads to the light curve of Figure 4.

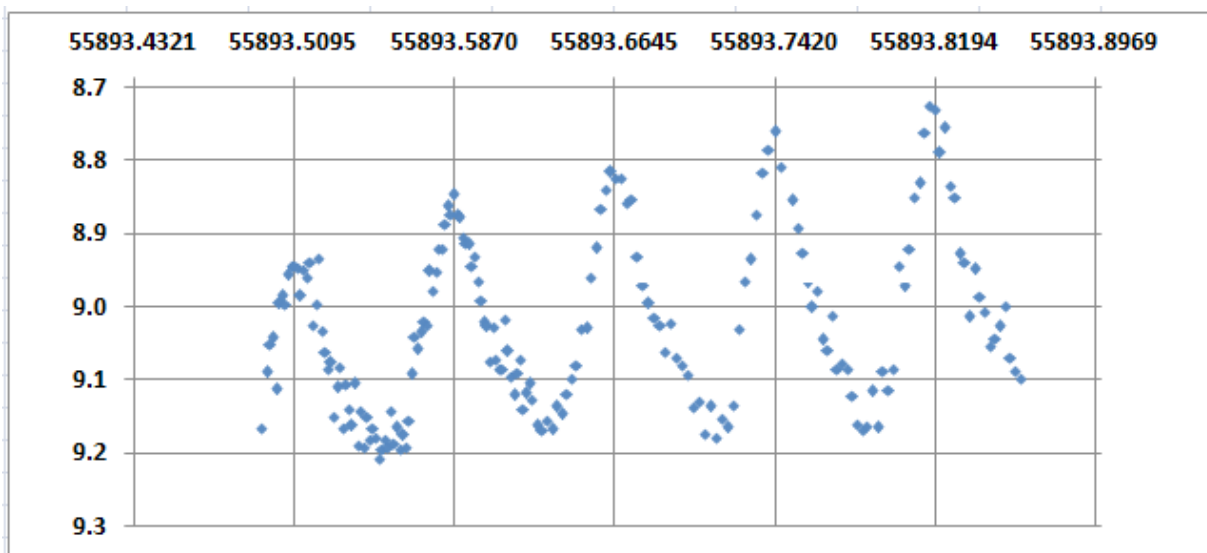


Figure 4. This illustration begins about 11 hours after the first three blocks of Figure 3. The superhump epoch is shown with the vertical divisions 0.0774 apart. VW Hydri has doubled in brightness from $V = 9.75$ and continues to brighten. The other major change is that the period of the humps is now 0.0774 and the epoch has also shifted. Maximum brightness is still associated with the hot spot on the accretion disc but the period now includes a precession component.

All of this is a beautiful illustration of the development of superhumps in the initial stages of the super-outburst. Over an interval of ~8 hours the system has brightened by 0.25 magnitudes and the superhumps have increased in amplitude from 0.25 to 0.45 magnitudes. Warner, 1995, in his monumental review of cataclysmic variables, drew attention to an interesting feature of these curves, namely that they were slightly redder or cooler at maximum, indicating a greater area of emission. Hence the concept of an elliptical disc with a temperature gradient. This provides one peak per orbit but later in the outburst the expected double peaks are often seen.

Orbital Humps and Superhumps

All of this takes us back to determining the orbital period of the star. The conventional method was by timing eclipses but in the absence of eclipses how do you do this? Not knowing better, Brian Marino and I timed the orbital humps and began searching for periodicities. Not an easy task - this was 1968 so all calculations were with pen and paper. Then we fell into a trap - during superoutbursts the star also showed humps and these were much easier to measure. But nothing made sense. If a period was derived from the humps at minimum it didn't match the humps during superoutbursts. A naive interpretation is that the orbital period had changed - but a 3% increase in a few hours is physically impossible.

After collecting dozens of humps - maybe hundreds - we finally published a paper, Marino and Walker, 1974, providing an ephemeris for the star based on the humps at minimum: $JD\ 2440128.0222 + 0.0742711$ and listed the anomalous humps as unexplained. Brian Warner of the SAAO resolved the problem by producing a model in which an elliptical disc caused the longer period with the slow change in this superhump period being caused by a precession effect on the elliptical disc. So there were two different types of hump.

These two papers appeared to unblock a series of problems in the CV field. Edwards, 1976, presented a further address on our behalf at a symposium in Paris, 1976, and reported its reception back to Auckland. A succession of papers from then on saw dramatic progress in the field.

What has changed in 50 years?

Variable star astronomy is now much more largely based upon period changes. Is this due to the ease of use of CCDs with extremely good collection and analysis software? The CCD has its limitations and is much more suited to cool red stars than the hot CV objects. U is very slow and tedious to obtain, even B requires careful transformation and rather longer exposures than V. So the classical method of monitoring in B, V or unfiltered 'white' light with a UBV set at intervals is no longer used. The astrophysical aspects are much poorer because of this.

Perhaps all of the gross astrophysical values such as colours and colour changes as outbursts develop are so well known as to not need revision. But one interesting aspect of VW Hydri is that there is a new photometric sequence with B-V colours published by AAVSO with its charts and now used by most observers. Using this VW seems to be a few tenths fainter than 40-50 years ago. Is this change real?

Similarly, we now have an improved period. But is this the result of the far longer baseline or is it a real change? Has the period remained constant for the last 50 years? An O-C diagram would answer these questions.

What of the visual observers?

In the earlier days of the Variable Star Section dwarf novae were a important part of our operations. The only problem was their faintness so that only a dozen or so were observable. But most of the major discoveries in the field were based upon these visual observations. As regards outbursts and the major features this is still the case today. Figure 1 illustrates this clearly - much the same presentation could be made from the International Database covering a similar period of roughly two years at a more recent time.

Those measures clearly defined two types of outbursts in some of the stars. With typical parochialism the IAU allotted them a northern hemisphere name, SU Ursae Majoris. In VW Hydri's normal outburst the visual measures show a pause at around $V = 12.5$ or so - later UBV measures showed that this was

real and accompanied by substantial B-V colour changes from an early A spectrum colour to a mid-F colour. This was attributed to the white dwarf star being obscured to a large extent by material from the partially collapsing disc before accretion caused everything to brighten and reach a B-V colour equivalent to mid or late B.

Similarly with the major outbursts. Bateson classified these into more than a dozen different types but it was clear that the true astrophysical model should be much more simple. Hence the concept that superoutbursts were triggered by a normal outburst at a time when the donor star had reached some critical level. This resulted in a dramatic increase in the mass flow into the disc and the prolonged superoutburst. Many other stars show this feature including Z Chamaeleontis, the brightest eclipsing DN in the southern hemisphere. Also due to visual monitoring, Alan Plummer has recently drawn attention to apparent changes in the outburst frequency of another of the brighter southern DN stars, V442 Centauri from memory.

Observing possibilities

VW Hydri is due to begin a supermaximum within the next few weeks. It's unlikely that anything dramatic will be discovered by observing this but it deserves attention. Not just in V, but a colour set every hour or so is useful. Measures should be sent to the AAVSO for inclusion in the International Database.

The same applies to other less well observed stars. One which could usefully be measured for a season or so is EX Hydrae, an intermediate polar as mentioned before. Here there are two periods involved: the 67 minute spin period of the white dwarf which is slowly changing, see Walker & Allen, 2000, and the normal eclipse period which appears to oscillate over a decade long time scale.

V442 Centauri is probably worth measuring through an outburst cycle every few years but these are harder to catch. This was the faintest star ever measured at Auckland Observatory using conventional PEP - the star was positioned in the focal plane aperture and we followed it through a minimum at around $V = 16.2$ to 16.5 .

There are many others which the Centre for Backyard Astrophysics monitors and to the observation of which many of our members contributed and still do. It would be good to see the occasional report from some of these in our newsletter.

References

- Bateson, F M. 1977 NZ Journal of Science **20**, 73-122
- Marino, B F and Walker, W S G. 1978 I A U Colloquium **46**, 29-38
- Edwards, P. 1976 Private communication.
- Walker, W S G and Allen, W H. 2000 Southern Stars, **39**, 2, 29-35
- Warner, B. 1995. Cataclysmic Variable Stars, Cambridge University Press.

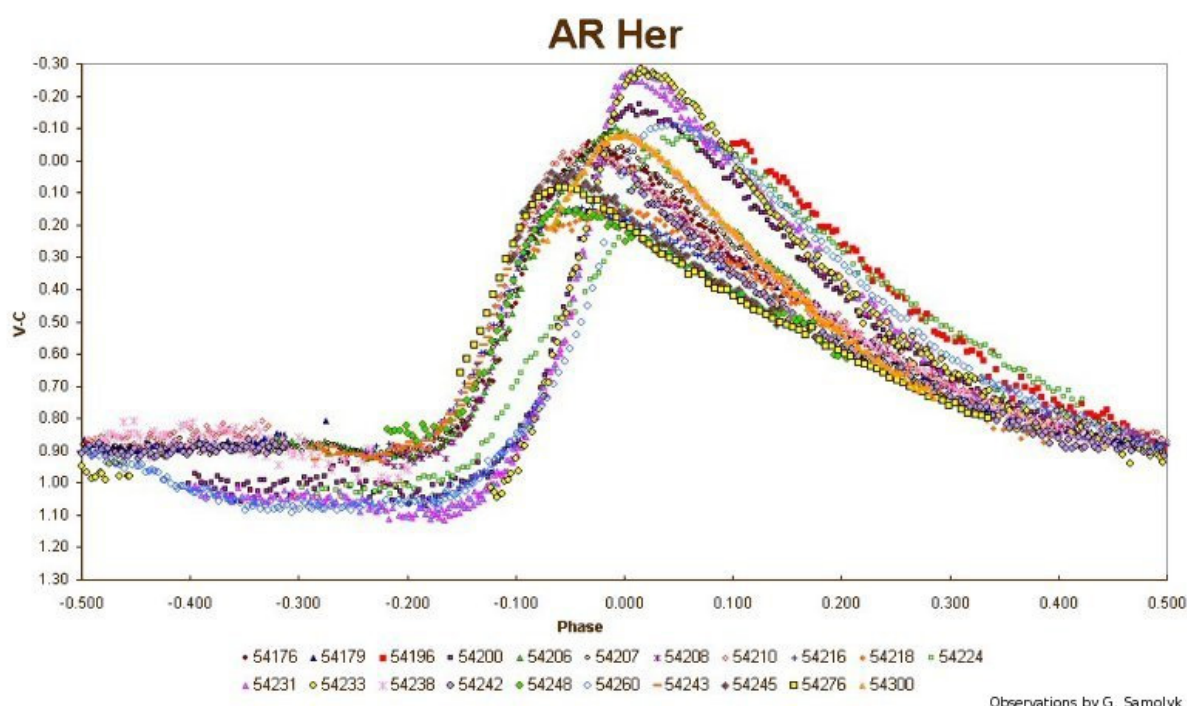
Short period pulsators at AAVSO – *Alan Baldwin*

a.hbaldwin@inspire.net.nz

The AAVSO is setting up a new section covering observations of short period pulsators under leaders Gerry Samolyk, Melanie Crowson and Eric Hintz.

A short period pulsator (SPP for short) is a star that varies in brightness on the timescale of a few hours up to tens of days as it grows and shrinks in size. These changes often follow a very regular pattern, repeating over and over from cycle to cycle. Short period pulsators include a number of different variable star types, including Cepheids, RR Lyrae stars, and delta Scuti stars.

In some cases poorly understood processes affect the regular pattern, causing the light curve to vary in height and shape from cycle to cycle. This variation in light curve, called the Blazhko effect after its discoverer, can become very large in some stars. AR Herculis is an RR Lyrae star that shows a large Blazhko effect. The graph below shows the shape of the light curve around maximum brightness on 21 different nights, phased with the average pulsation period. Notice how the height and broadness of the curve changes, and how the time of maximum brightness shifts.



Some short period pulsating stars have more than one period. These additional pulsation period(s) alternately interfere and reinforce each other, resulting in a very complex light curve. Multi-periodic stars like these must be observed frequently over weeks or months to provide enough data to measure the periods involved. There is also some evidence that the pulsation periods and amplitudes change over the span of years.

The AAVSO Short Period Pulsator Section targets all pulsating variable stars with periods in the range of hours to several weeks. This period range includes several important variable star classes like the Cepheids and RR Lyrae stars. More information about some types of short period pulsating stars is given on the SPP Star Classes page. Observations of all short period pulsating stars are welcome, but consult the SPP Programme page or click the link to the AAVSO Target Tool below for a list of interesting targets where additional observations are especially useful.

For information on the SPP group go to <https://www.aavso.org/aavso-short-period-pulsator-section>. Visit AAVSO SPP Program page if you are interested in choosing observing targets.

Publication watch

Carl Knight and Phil Evans are both named as co-authors in a new paper on exoplanet transit timings.

Baluev, R. V., Sokov E. N., Jones, H.R.A. et al. *Homogeneously derived transit timings for 17 exoplanets and reassessed TTV trends for WASP-12 and WASP-4.* MNRAS Sept 2019.

Abstract

We homogeneously analysis $\sim 3.2 \times 10^5$ photometric measurements for ~ 1100 transit lightcurves belonging to 17 exoplanet hosts. The photometric data cover 16 years 2004-2019 and include amateur and professional observations. Old archival lightcurves were reprocessed using up-to-date exoplanetary parameters and empirically debiased limb-darkening models. We also derive self-consistent transit and radial-velocity fits for 13 targets. We confirm the nonlinear TTV trend in the WASP-12 data at a high significance, and with a consistent magnitude. However, Doppler data reveal hints of a radial acceleration about (-7.5 ± 2.2) m/s/yr, indicating the presence of unseen distant companions, and suggesting that roughly 10 per cent of the observed TTV was induced via the light-travel (or Roemer) effect. For WASP-4, a similar TTV trend suspected after the recent TESS observations appears controversial and model-dependent. It is not supported by our homogeneous TTV sample, including 10 ground-based EXPANSION lightcurves obtained in 2018 simultaneously with TESS. Even if the TTV trend itself does exist in WASP-4, its magnitude and tidal nature are uncertain. Doppler data cannot entirely rule out the Roemer effect induced by possible distant companions.

Surjit S. Wadhwa published a paper on V633 Virginis on the Journal of the American Association of Variable Star Observers.

Wadha, S. S. 2019. *Photometric Analysis of V633 Virginis.* JAAVSO, Volume 47 No 2 (2019)

Abstract

Photometric analysis of the ASAS-SN V-band photometry of V633 Virginis is presented. The results show an A-type system with an extreme low mass ratio of 0.14 and mid-range contact of 33%. There is good thermal contact between the components. Some astrophysical qualities are examined, and some absolute parameters of the system determined.

And Roy Axelsen also published in the same issue of the JAAVSO but on a new delta Scuti star he has observed and investigated.

Axelsen, R.A., A New Candidate δ Scuti Star in Centaurus: HD 121191. JAAVSO, Volume 47 No 2 (2019)

Abstract

During a study of the δ Scuti star V1393 Centauri by digital single lens reflex photometry, it was found that two of the chosen comparison stars were variable. This paper reports the subsequent investigation of one of them, the class A star HD 121191, which revealed that it is a candidate δ Scuti star with a period of 0.046282 d and an amplitude of 0.048 magnitude in V.

Mark Blackford, Stan Walker, Edwin Budding, Greg Bolt, Dave Blane and Terry Bohlson have submitted an article to JAAVSO on the double binary QZ Carinae.

Blackford, M., Walker. S. et al *QZ Carinae - Orbit of the Two Binary Pairs.* Submitted to JAAVSO

Abstract

We present an updated O-C diagram of the light time variations of the 5.99857 day period eclipsing binary in this system as it moves in the long period orbit of the two pairs. This includes new Variable Stars South members' measures from 2017 to 2019, BRITE satellite observations in 2017 and 2018 and 100 previously unknown measures made at Auckland Observatory from 1974 to 1978. Measures in 2017-

19 indicate a rather longer primary total eclipse period of 0.295 ± 0.02 days (7.08 ± 0.48 hours) than the earlier models. We conclude that QZ Carinae has not yet completed one orbit of the two pairs since discovery in 1971. Other observational features include the duration and shape of primary and secondary eclipses and small scale short term brightness changes.

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

Visit our website to see a list of our area advisers, and to find out about our projects and how to contact their leaders

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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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