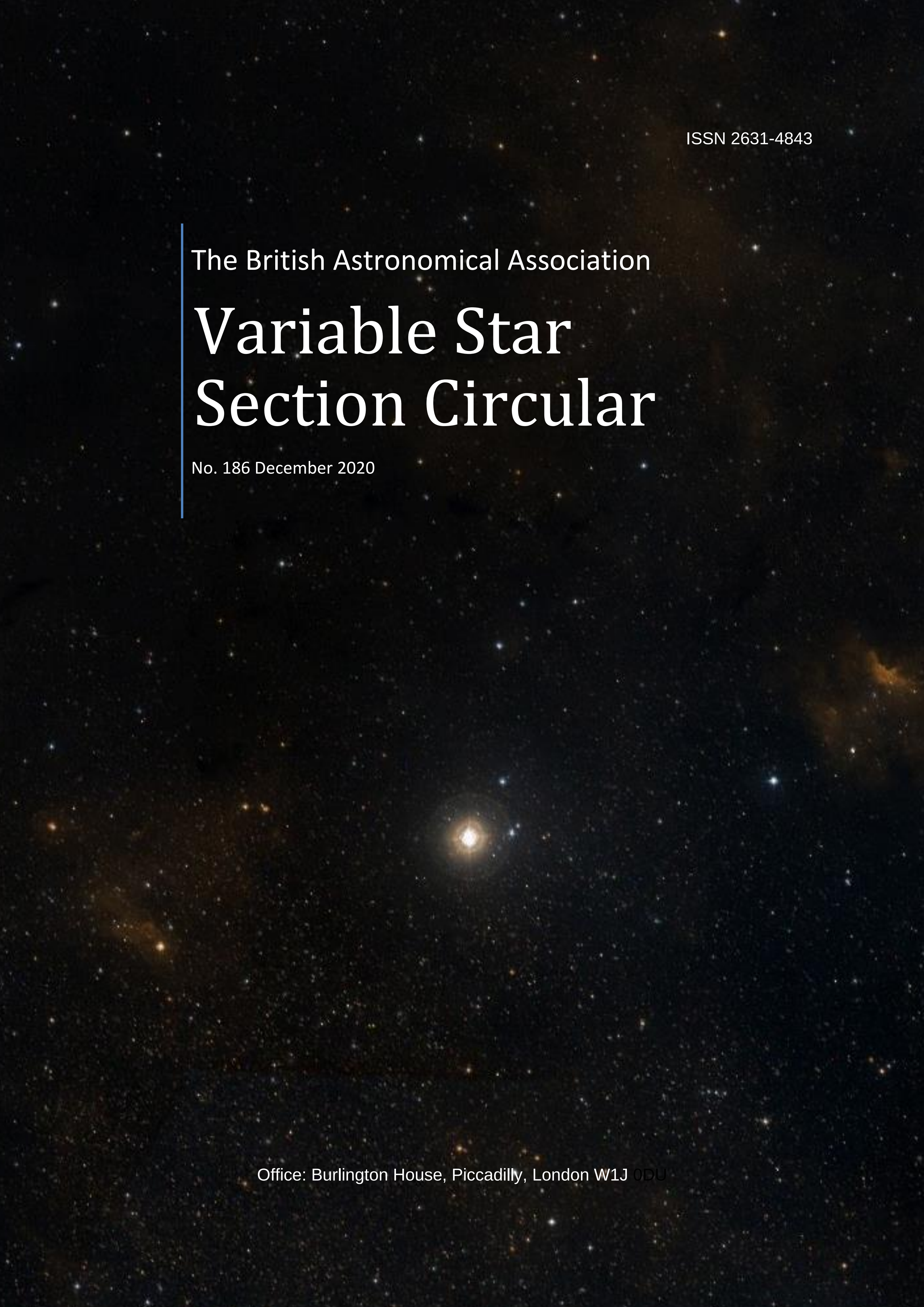

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The British Astronomical Association

Variable Star Section Circular

No. 186 December 2020

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Cover Picture

delta Cephei
Digitised Sky Survey 2, ***C**entre de **D**onnées astronomiques de **S**trasbourg.*
Aladin Interactive Sky Atlas

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From the Director *Jeremy Shears*

Welcome to the December 2020 Variable Star Section Circular. As I write this, England is experiencing Lockdown 2.0 and many other parts of the country are under other restrictions. One of the few constants, at least for me, during this strange year has been, somewhat counter-intuitively, the variable stars. I've certainly appreciated the distraction that VS work has provided, and a travel ban by my employer has also resulted in more observing opportunities. We've also been treated to a number of interesting VS events including the rare outbursts of **PQ And** (still detectable in recent CCD images), **AY Lac** and, more recently, **VY Aqr**. Unfortunately, I missed the eruption of the recurrent nova **M31N 2008-12a**, which holds the record for the shortest recurrence time among RNe, as its brief appearance coincided with a spell a bad weather.

WINTER MIRAS

M = Max, m = min.

W And	m=Dec/Jan
RW And	m=Jan
R Aql	M=Nov/Dec
UV Aur	M=Jan
X Cam	m=Jan
SU Cnc	m=Dec/Jan
W CrB	M=Feb/Mar
chi Cyg	M=Feb/Mar
T Dra	M=Nov/Dec
RU Her	m=Jan/Feb
SS Her	M=Jan
	m=Feb/Mar
SU Lac	m=Jan
RS Leo	m=Feb
X Lyn	M=Jan/Feb
X Oph	M=Nov/Dec
U Ori	m=Dec
R Ser	m=Dec/Jan
T UMa	M=Dec

Source BAA Handbook

Astronomy in general has experienced a boom this year as people have spent more time at home pursuing other interests. Some people have invested cash that they might have spent on holidays on upgrading their equipment. I hear that some UK equipment retailers have experienced record sales, with stocks getting low in the run up to Christmas, not helped by the logistical challenges of long supply chains and manufacturers unable to keep up with global demand. Let's hope that some of the owners of these new instruments will take up VS observing.

Winter, of course, provides an opportunity to introduce friends and family to **Betelgeuse**, which underwent a deep fade last season. Apart from the dust event, the star exhibits variations with a number of different periods. In an article in this *Circular*, Dr Mark Kidger considers the possibility of a minimum to around magnitude 1.0 next April 2021. What will it do over the new few months? There is only one way to find out! A chart is available on VSS website:

I hope that 2021 will be a better year for everyone and the news of vaccines gives reasons to be positive. The Variable Star of the Year is the dwarf nova **RU Peg**. Do read Gary Poyner's article in the 2021 *BAA Handbook*, which was delivered with the October *Journal* and also available online at the VSS website: https://britastro.org/vss/vsoty2021.pdf

VSS campaign on IX Dra

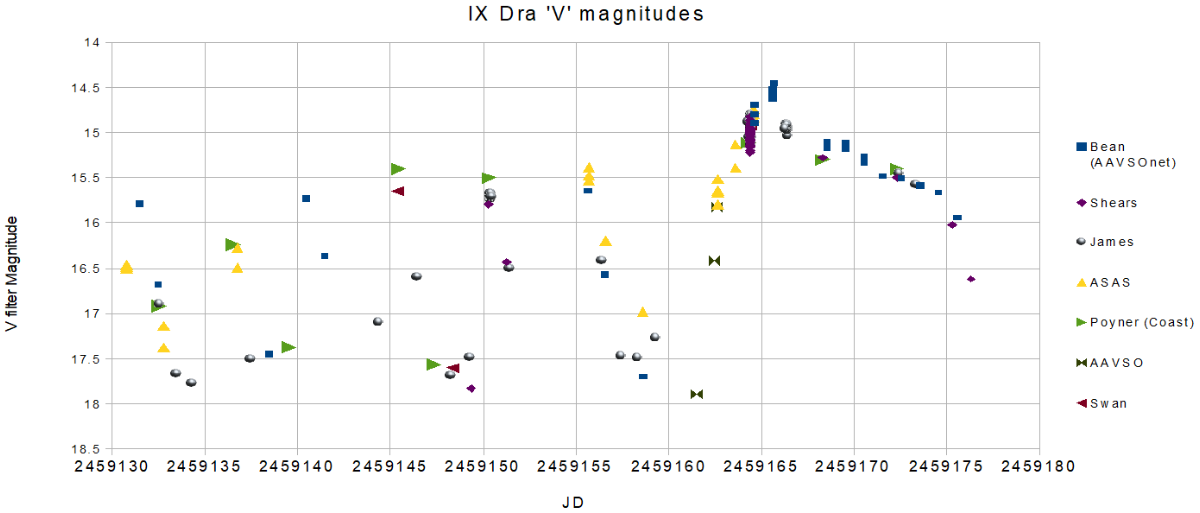
During the autumn, the VSS has been running a campaign to detect outbursts of the UGER-type dwarf nova, **IX Dra** (see Forum discussion: https://britastro.org/node/24529). This star has a magnitude range of 14.6-18.2. It undergoes very frequent "normal" outbursts, every 3 to 5 days, which last a couple of days. Then, every 60 days or so, it undergoes a longer "superoutburst". Recent data from the TESS satellite have revealed the light curve of IX Dra in exquisite detail - see the article in this VSSC by Stewart Bean about variable stars in TESS data.

For a few months IX Dra will not be monitored by TESS. In the meantime, we are keen to continue to get timings of the start of the next superoutbursts, to check if the supercycle length is evolving, hence this campaign which was launched in October. Stewart provides regular updates of the star's light curve on the BAA Forum. The November superoutburst started on November 9/10 with Nick James's time series photometry revealing characteristic superhumps on the (UK) evening of the 10th. Many thanks to all observers who have contributed data.

Following the detection of the latest superoutburst, Stewart notes "The timing of this superoutburst gives an average period for the last 8 outbursts of 59.5 days. This value is close to the last reported value of 58.5 +/-0.5 from 2010 and suggests that the super outburst period has not really changed in ten years. I will stick my neck out and suggest that the next outburst will start near January 7".

We'd also like to determine the start time of the January superoutburst, so please do add IX Dra to your target list. As ever, other observers are welcome. We are requesting one observation per night to get a light curve which will enable us to spot the normal and superoutbursts. Observations can be visual or CCD. It's a fascinating star to monitor as it's always doing something!

There are other UGER systems available during the winter/spring including **ER UMa** itself, **RZ LMi**, **V1159 Ori**, **YZ Cnc** and **DI UMa**. A BAA forum thread on ER UMa and RZ LMi can be seen here.



Light curve of IX Dra prepared by Stewart Bean (mags are V or CV).

LISA spectrograph available for loan

The LISA spectrograph is once again available to loan to budding spectroscopists. This instrument was kindly donated by BAA member Andrew Smith in support of our initiative to encourage members to take up spectroscopy. Perhaps you already have some experience using the Star Analyser for spectroscopy and would like to explore the next step. Or you might have been doing CCD photometry and want to see what spectroscopy is like. The instrument is capable of a wide range of variable star projects and we can provide advice and support on using it.

The LISA comes complete with a guide camera, but no imaging camera. Do contact me if you would like to discuss borrowing it. We'd like to get it into the hands of a member who would like to experience spectroscopy.

BAAVSS-Alert: time to sign up for the new list!

As a result of the forthcoming demise of Yahoo Groups, we have decided to move BAAVSS-Alert to groups.io

Please see Gary's note below on this important subject. We are unable to transfer members from the old list, so please do sign up for the new list. The new email address will be baavss-alert@groups.io

AIP4WIN 2.0 software available

It was announced in early November that the astronomical publisher Willmann-Bell is shutting up shop. This is a sad development as the company has published many useful books over the years at remarkably affordable prices. The AIP4WIN software, which accompanies Richard Berry's book "Astronomical Image Processing", has been used by many people for photometry. Output from the software can be readily imported into the VSS photometry spreadsheet for further analysis. The second edition, including AIP4WIN version 2, has been out of print for many years. According to Willmann-Bell, they are making a non-registered version available for download from their website: https://www.willbell.com/aip4win/aip.htm , specifically stating "AIP4Win2.0 no longer requires online Registration". Richard Berry comments in an AAVSO forum that it is now essentially freeware. There is some uncertainty how long the Willmann-Bell website will remain active.

BAA advertorial in the *Astronomy Now Yearbook 2021*

The BAA has placed an "advertorial" in this Yearbook, promoting reasons for joining the BAA. The piece emphasises the Association's observing sections and naturally the VSS gets a mention, saying how amateurs can participate by using simple equipment, or none at all, all the way through to high tech approaches. An eye-catching image of spectra of **δ Cep** by VSS member Hugh Allen illustrates the piece. Coincidently, Hugh has an article in this *Circular*.

Best wishes for a Merry Christmas and a peaceful, healthy & safe New Year!

BAAVSS-Alert group is on the move.

Yahoo have announced that they will be shutting down 'Yahoo Groups' from December 15 2020, and all emails sent to any existing group on Yahoo will be returned to sender undelivered after that date.

A new BAAVSS-Alert group has been set up with 'groups.io', and will become active on December 15. **All current subscribors to the Yahoo BAAVSS-Alert group will have to re-join the new group** to receive VS alerts and news. You can do this by simply sending an e-mail to…

baavss-alert+subscribe@groups.io or by visiting the web page https://groups.io/g/baavss-alert

the unsubscribe address is baavss-alert+unsubscribe@groups.io

Some BAAVSS members also subscribe to CVnet-Outburst and CVnet discussion groups. These too will be moving over to groups.io, and as with BAAVSS-Alert, current subscribors to CVnet lists will have to rejoin.

cvnet-outburst+subscribe@groups.io or by visiting the web page https://groups.io/g/cvnet-outburst

cvnet-discussion+subscribe@groups.io or https://groups.io/g/cvnet-discussion

I have set up all three groups so that the first post will be moderated, after which your messages will be accepted without moderation. If you don't see your first post appear in your mailbox immediately, it just means that I haven't had a chance to moderate it. The message archive is available from the groups web page, and e-mail addresses will be hidden to non members. Attachments to messages are NOT allowed as before. It goes without saying that any transgressors will be removed immediately.

Gary Poyner

Books offered from the late Ian Miller's estate.

Only postage required apart from the first one as it includes software. Sue Miller is asking £20 plus postage for that one.

AIP4WIN Vol 2 - The Handbook of Astronomical Image Processing, Brilliant for anybody with a CCD or DSLR etc and not necessarily just for VS. Also, comes complete with lots of copied notes etc. (Also Vol 1)
Discover the Universe 4th Ed, by Kaufmann and Comins
Sky Cat 2000.0 vols 1 and 2.
Understanding VS, Percy, 2007
An Introduction to the Study of VS, 1915 (Yes, 1915) Caroline E. Furness
Cataclysmic VS, How and Why they Vary, 2001, Coel Hellier
Norton's Star Atlas, Sixteenth ed 1973.
Millennium Star Atlas, 1997
Smithsonian Star atlas of reference stars and nonstellar objects
W.Tirion - Sky Atlas 2000
A.Becvar - Atlas of the Heavens : Atlas Coeli 1950.0
W.Peck FRAS - Observer's Atlas of the Heavens 1898
A Practical Guide to CCD Astronomy, Martinez and Klotz
Light curves of VS, Sterken and Jaschek
Introduction to Astonomical Photometry, Budding and Demircan
Variable Star Observers Handbook, Glasby
Observing Variable Stars, Novae and Supernovae, Gerald North

Enquiries through me please.

Roger Pickard

Erratum VSSC 185

In VSSC 185, the details given for the cover image taken by Martin Mobberley were incorrect. The correct time and magnitude for the image of PQ And at maximum is 2020 June 4.45UT at magnitude 11.71V. The error was corrected not long after uploading to the web page, but those who receive the Circular by e-mail will have the incorrect details on page 2. My apologies to Martin for the error.

Gary Poyner

Project Melvyn – update 2020 November

Alex Pratt

Melvyn Taylor, one of the Section's most active visual observers and experienced Officers, passed away in August 2017. He left a large archive of unrecorded estimates, including many submitted to him by Section members. The aim of this project is to add them to the VSS database.

This work has been underway for 3 years and this report summarises the progress made so far. It is worthwhile describing my process of sorting through Melvyn's archive of VSS Binocular Programme documents, mainly from the 1970s and 1980s.

He maintained a card folder for each variable star's visual report forms, grouped into years, which is most helpful, although many additional forms were also found in between his bundles of charts, letters, and hand-drawn light curves. Each form is checked for any missing star name, date, or observer's name. Surprisingly, several forms are deficient in this respect and some detective work is required to identify the missing information which wasn't supplied by the observer and not resolved by the Section recorder on receipt of the form.

The estimates on each form are checked to see if they are already in the VSS database; if not, they are scanned to a PDF, per star, per observer. In some cases, the date and reduced magnitude are in the database, but the estimate field is '?', in which case the form is scanned so that the record can be updated.

The card folders also contain bundles of report forms which had previously been added to the database, but on checking their entries some of them have data input errors. Other checks revealed blocks of duplicate entries in the database and a small number of spurious entries which distort the light curves. All these are reported to Bob Dryden. In rare cases, there is confusion over an observer's alias in the database. Roger Pickard and Bob are notified of these.

A computer archive is maintained containing a directory for each star with sub-directories for the PDFs for each observer. A screen shot of each star's database light curve, taken before uploading the unrecorded estimates, is stored in its respective folder. A spreadsheet is updated which contains the numbers of forms and estimates of each star per observer. Lastly, an e-mail containing the PDFs of observers' unrecorded estimates of a star, with my comments on any findings from the archive search, is submitted to either Tracie Heywood (for Melvyn's estimates) or to Roger or Bob (for all other VSS observers). After Tracie notifies me that she has uploaded the estimates I check the entries in the database.

In the first year or so of this project I was sending PDFs directly to some of the Section's experienced observers, including Rhona Fraser and John Toone. Rhona commenced checking her records and is uploading her estimates which weren't in the database. John was already undertaking a comprehensive review and a reprocessing of his observations. [1]

In their articles in VSSC 184, Mark Kidger ('Betelgeuse: the expected recovery happens') and Christopher Lloyd ('Betelgeuse – A Century and more of Variation') discussed the extent of coverage in its light curve, particularly mentioning a gap for the years 1906-1920. [2],[3] We have added 290 estimates by Alphonso King for the period 1920-1932. [4] Richard McKim (BAA Archivist) informed me that King's observing logbook has now been professionally rebound and is in a slipcase with lettering down the spine. [5]

As of November 2020, the following numbers of observations have been added to the database:

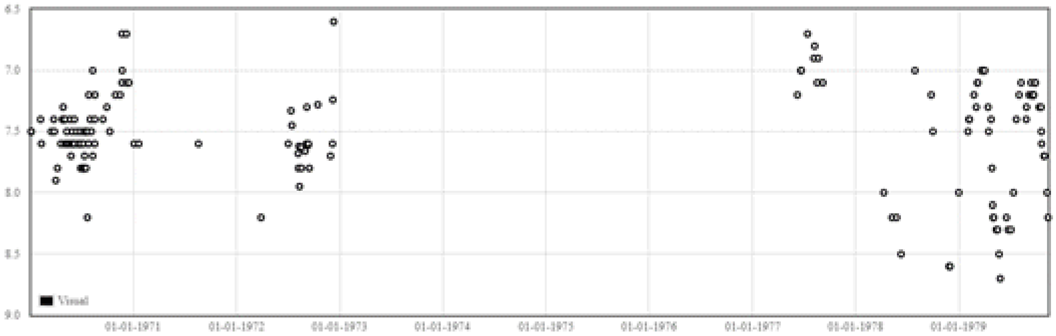
Melvyn Taylor - 39,074

Other observers - 23,209

Grand total - 62,283 estimates on 2,631 report forms of 244 stars by 104 observers

(These don't include all the observations entered by Rhona and John).

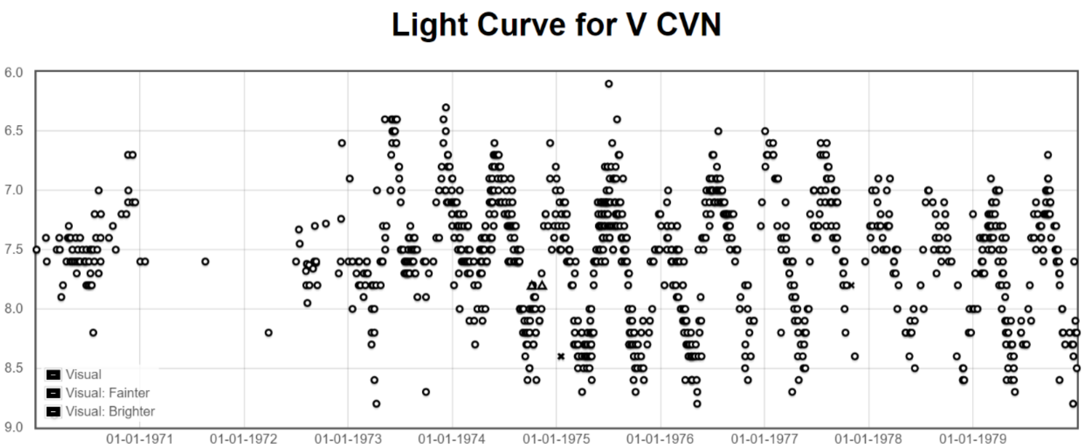
Many thanks also go to Tracie, Roger, Bob, and the data input volunteers John Fairweather, David Griffin, Don Matthews, and Terry Miles, plus Alex Menarry, Matt Jenkins, Hazel McGee, Astrid Ohlmeier and Ray Pearce for all their help and commitment to this non-trivial task. As an example, to illustrate the benefits of everyone's efforts, the plots below show the improvements in VSS coverage of V CVn during the 1970s and 1980s.



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

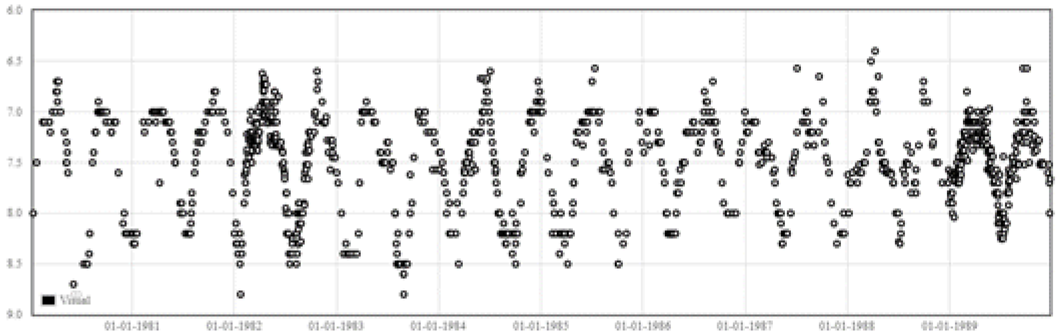
V CVn during the 1970s, from estimates available up to 2017 Nov 10.



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

Contributors: G W E Beekman, B J Beesley, J Bingham, T Brelstaff, J S Bullivant, M Currie, S R Dunlop, A E J Forno, R B I Fraser, 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, G J Kirby, L R Matthews, I A Middlemist, D Miles, D J Northwood, M Peel, R N Pennell, R D Pickard, D A Pickup, A K Porter, P Quadt, N Reid, F A Roper, D A Rothery, J D Shanklin, M D Taylor, J Toone, E J Voss, E J W West, D Young, D L Young

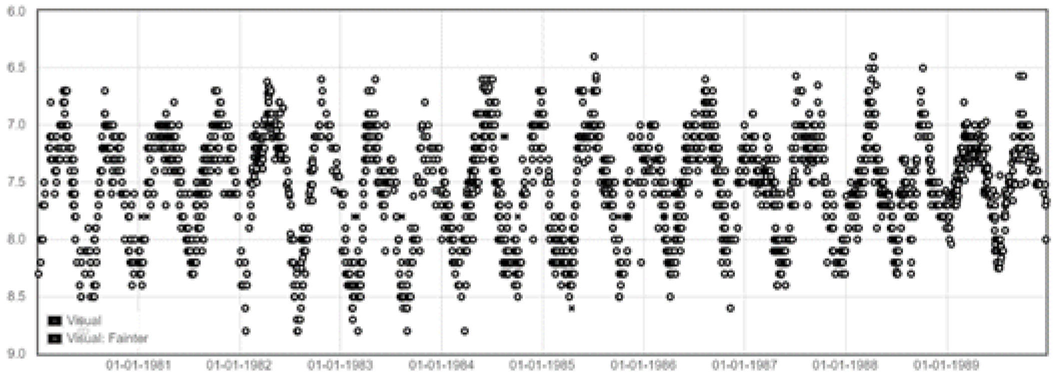
V CVn during the 1970s, from estimates available up to 2020 Nov 9.



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

Contributors: S W Albrighton, C M Allen, N M Bone, E H Collinson, R C Dryden, R W Fleet, R B I Fraser, M A Hapgood, S Hoste, G F Kellaway, T Markham, I A Middlemist, I P Nartowicz, G Ramsey, T G Saville, D R B Saw, J D Shanklin, F W Smith, R M Steele, M D Taylor, J Toone, , W J Worraker

V CVn during the 1980s, from estimates available up to 2017 Nov 10.

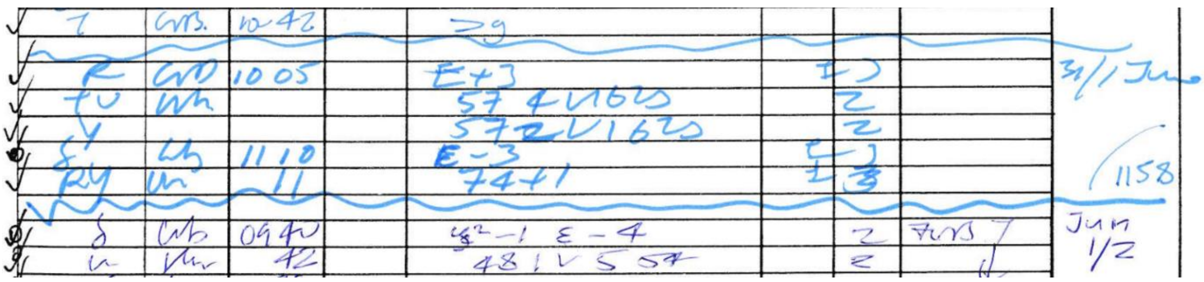


Symbol Key: **Crosses** = Negative observation, **Triangle** = Brighter than, Otherwise: **Circle** = Visual, **Diamond** = CCD, **Square** = Everything else

Contributors: S W Albrighton, C M Allen, N M Bone, T Brelstaff, E H Collinson, D S Conner, R C Dryden, R W Fleet, R B I Fraser, R J Geddes, M A Hapgood, M A Hather, D Herbert, S Hoste, D Hufton, A Hutchings, J E Isles, G F Kellaway, R A Kendall, T Markham, I A Middlemist, I P Nartowicz, M J D Price, G Ramsay, T G Saville, D R B Saw, J D Shanklin, A Smeaton, F W Smith, J S Smith, E Spooner, R M Steele, D M Swain, M D Taylor, J Toone, , K West, W J Worraker

V CVn during the 1980s, from estimates available up to 2020 Nov 9.

We have processed almost all of Melvyn's archive of observers' Binocular Programme estimates. There are some folders labelled 'CSV' and 'NSV', although they mainly contain comparison charts and letters, rather than bundles of unrecorded report forms. Tracie remarked that Melvyn's database totals for certain years, e.g. 1997, are significantly low and I confirmed that his corresponding folder for that year contains many more estimates. We are slowly working through these, it's quite a laborious task for Tracie, she's finding problems with some of his comparison stars which means those estimates cannot be used, and Melvyn's handwriting would challenge the skills of Young and Champollion:[6]



His database tally now stands at 75,468 and there's about 15,000 of his estimates yet to be uploaded. It's unlikely we'll fully achieve this because of the reasons given above and I can find very few of his estimates made after 2014. His family asked him why he was hoarding so much 'junk'. He replied: "It's valuable stuff!" It certainly is.

References

[1] Toone, J., 'Missing data from 1980-1995', VSS Circ., 184, 6

[2] Kidger, M., 'Betelgeuse: the expected recovery happens', VSS Circ., 184, 15

[3] Lloyd, C., 'Betelgeuse – A Century and more of Variation', VSS Circ., 184, 24

[4] Pratt, A., 'The Variable Star Observations of Alphonso King', VSSC Circ., 180, 24-25

[5] McKim, R., personal communication, 2020 March 20

[6] Decipherment of ancient Egyptian scripts, Wikipedia, https://en.wikipedia.org/wiki/Decipherment_of_ancient_Egyptian_scripts

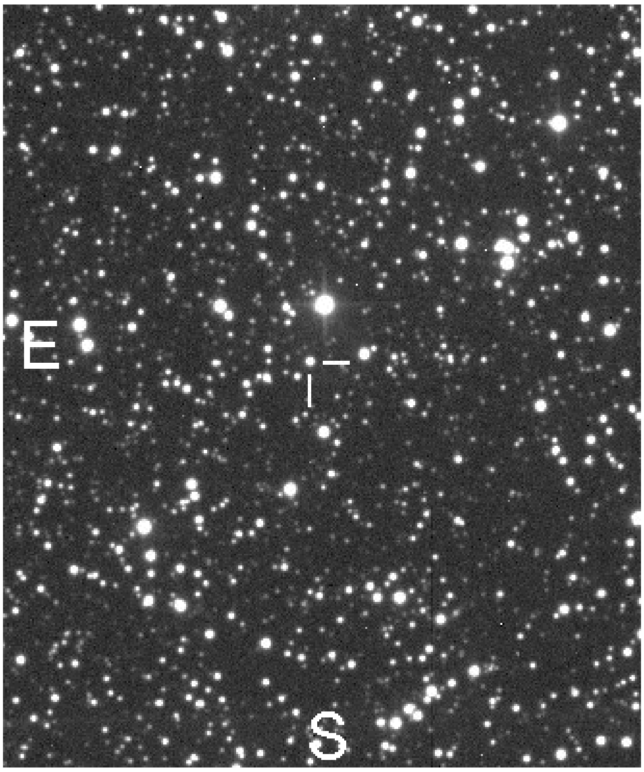
CV & E News

Gary Poyner

News of the long awaited outburst in AY Lac is reported, along with a light curve of BAAVSS data. The early stages of the November 2020 outburst of VY Aqr is also covered.

Rare outburst of AY Lac

Discovered by C. Hoffmeister in 1927, AY Lac was detected on Sonneberg Observatory photographic plates during August and September 1927 at about 15.0mpg (photographic magnitude), and fainter then 16.5mpg on plate searches at other times. Hoffmeister speculated that the star could be a long period variable (Mira type), U Gem variable or a Nova. A second outburst was detected by H. Geßner, again from Sonneberg plates in 1966.   She found that AY Lac was again in outburst between August 11 and August 29, 1962 fading from 14.5mpg to 16.5 mpg by the 29th. A further search recorded AY Lac at the plate limit of 17.5-18.0mpg on September 26, indicating that this second recorded outburst lasted at least 46 days. P Kroll et al conclude in IBVS 5441 (2003) that AY Lac is definitely a CV, most probably a Recurrent Nova, but that a dwarf nova classification of UGWZ cannot be ruled out.



After an interval of some 58 years, AY Lac was again recorded in outburst on 2020 October 8 by both Patrick Wiggins and the ASAS-SN patrol at magnitude 13.83g (on Oct 08.283UT). The first observations from the UK were obtained on the evening of October 8 by J. Shears, G. Poyner & S. Johnston at magnitudes 13.8CV, 13.9 vis. and 14.1V, respectively.

The first indications of superhumps present in the light curve came 10 days into the outburst, when on October 19, Tonny Vanmunster reported to vsnet-alert (24819) that he had detected superhumps of amplitude 0.22 mag during observations obtained on October 18, and that the delay in the superhumps developing established AY Lac as a new UGWZ type dwarf nova. Further time series observations by Vanmunster and Kyoto University on Oct 19/20 suggest a P_{sh} of 0.0568-0.0595d (vsnet-alert 24825).

Figure 1. A rare opportunity to ‘see’ AY Lac in outburst.
An image (cropped from original) taken by Martin Mobberley on Oct 09.170UT recording AY Lac at magnitude 14.11V.
iTel New Mexico 0.43-m CDK f/4.5.

The outburst received good coverage from BAAVSS observers N James (CV), S Johnston (V), D. Mathews (V), Martin Mobberley (V), R Pearce (Vis), G. Poyner (Vis.V&CV) & J. Shears (CV), who contributed 406 observations to the database from Oct 08 to November 10.

Figure 2 shows the light curve from BAAVSS observations. After slowly fading from magnitude 13.0 on Oct 8 to magnitude 16.7CV by Nov 02, a rapid decline set in with a fade of over three magnitudes in two days. The last recorded magnitude of 20.8CV by Nick James on Nov 10 gives a duration of 33 days for the 2020 outburst.

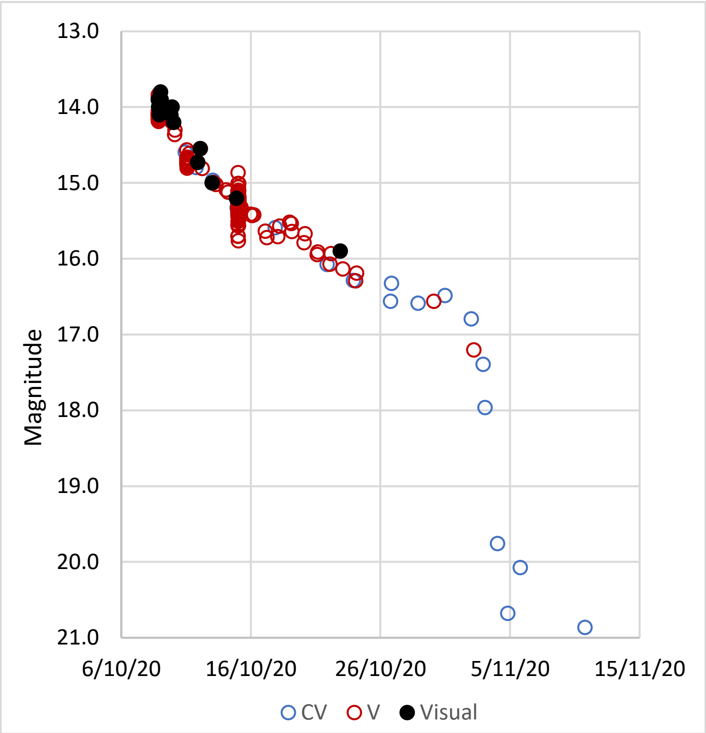


Figure 2. AY Lac outburst. BAAVSS database.

It is likely that one or more outbursts have been missed during the 58 years of apparent quiescence between 1962 and 2020 as coverage has been very sparse. An examination of the AAVSO international database light curve does indeed show five instances where outbursts do seem to have been recorded – Sep 2003, Nov 2004, Sep 2006, Aug 2009, and July 2010. However, these cannot be validated as the positive datapoints on the light curve (all CCD) are surrounded by deeper negative CCD observations. The times between these outbursts are also much too short for the recently 'confirmed' UGWZ classification of AY Lac. A case of mis-identification in a very difficult, crowded field? These 'outburst' data should, in my opinion, certainly be queried with the observers to give the historic light curve any credibility.

VY Aqr

This UGSU star was first reported to be in outburst by Patrick Schmeer on November 6.741UT at magnitude 11.2 visual – the first outburst detected since March 28, 2015 (Stubbings). In response to Patrick's alert message, other reports from E. Muyllaert, G. Poyner and J. Toone quickly followed and which suggested a fast rise to maximum. The AAVSO light curve suggests maximum occurring on Nov 07/08 at mean 9.5 visual magnitude (~0.3 mag fainter in V). Developing superhumps appeared on the light curve on Nov 8.4UT, and by Nov 14 revealed an amplitude of ~0.3V. At the time of writing (Nov 15), VY Aqr had faded to magnitude 10.8V.

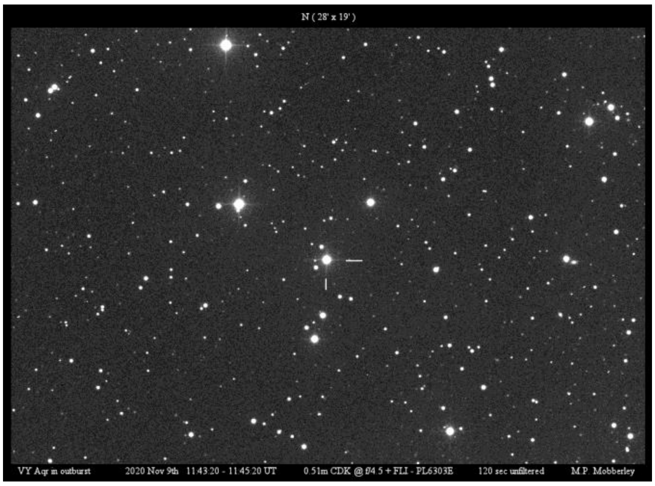


Figure 3. VY Aqr in outburst. Nov 9.487, V=10.09. iTel SS 0.51-m CDK f4.5. Martin Mobberley.

Brief further update on PV Cephei

David Boyd

In the March 2020 VSS Circular I gave an update of the behaviour over the last 10 years of the Herbig Ae star PV Cephei and the associated Gyulbudaghian's Nebula which it illuminates. In that time the star had never faded below Rc magnitude 17.2. As if to show that the star had been listening, in September it suddenly faded to Rc magnitude 19.3. This resulted in a reciprocal fading of the nebula almost to the point of invisibility. Since then the star has started to brighten and had reached Rc magnitude 18.7 on 3rd November.

This behaviour generated considerable professional interest with Bo Reipurth (Hawaii), Lynne Hillenbrand (Caltech) and Brian Skiff (Lowell) all exchanging emails with me to discuss it. Lynne tried to get an IR spectrum with Keck, but her attempt failed with equipment issues. Brian has since been getting deep photometry of the star with one of the telescopes at Flagstaff. The general consensus is that the current fading is probably caused by dense clumps of gas and dust passing in front of the star. This is common behaviour for these objects which are embedded in a very dusty environment out of which they originally condensed.

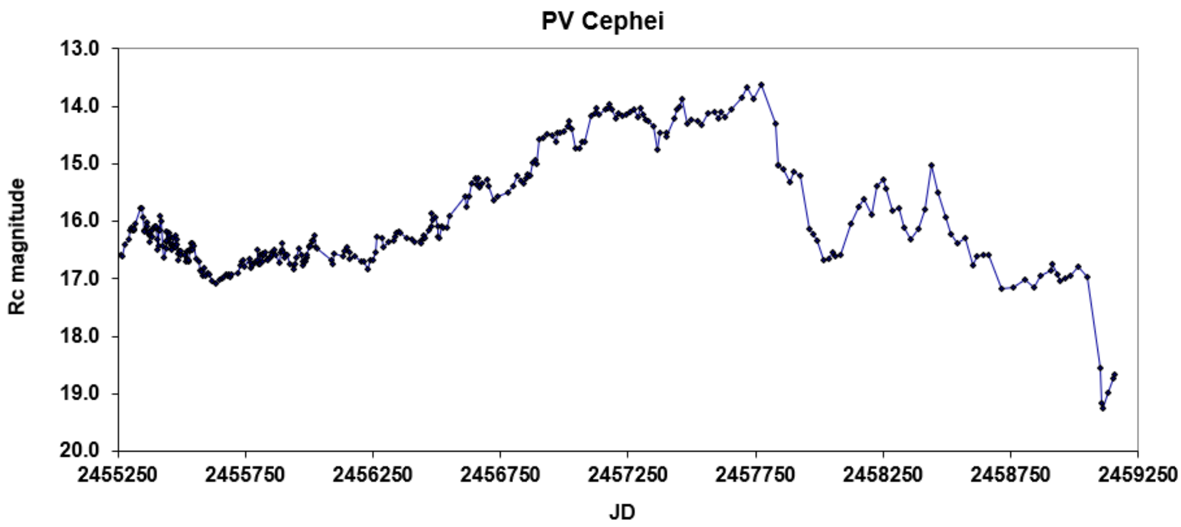


Figure 1 Updated 10-year Rc-band light curve of PV Cep showing recent deep fading.

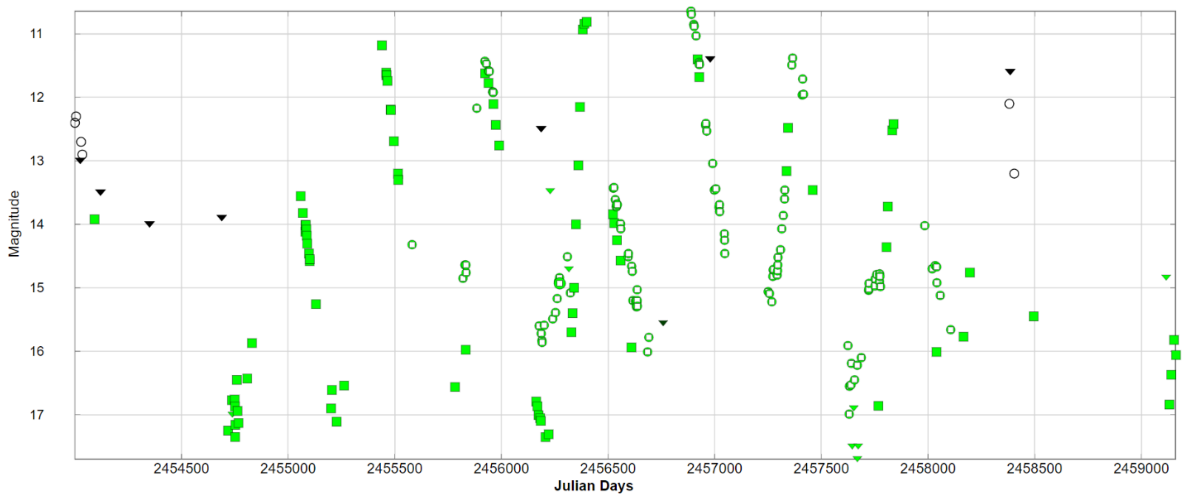
Provisional analysis of four Mira variables

Shaun Albrighton

In the previous circular (VSSC 185, September 2020) a 10 year project into interesting/under observed Mira variables was discussed. In this report we take a provisional look into results submitted to the AAVSO for four of these stars – AH And, VY Aur, AU Aur and QS Ori.

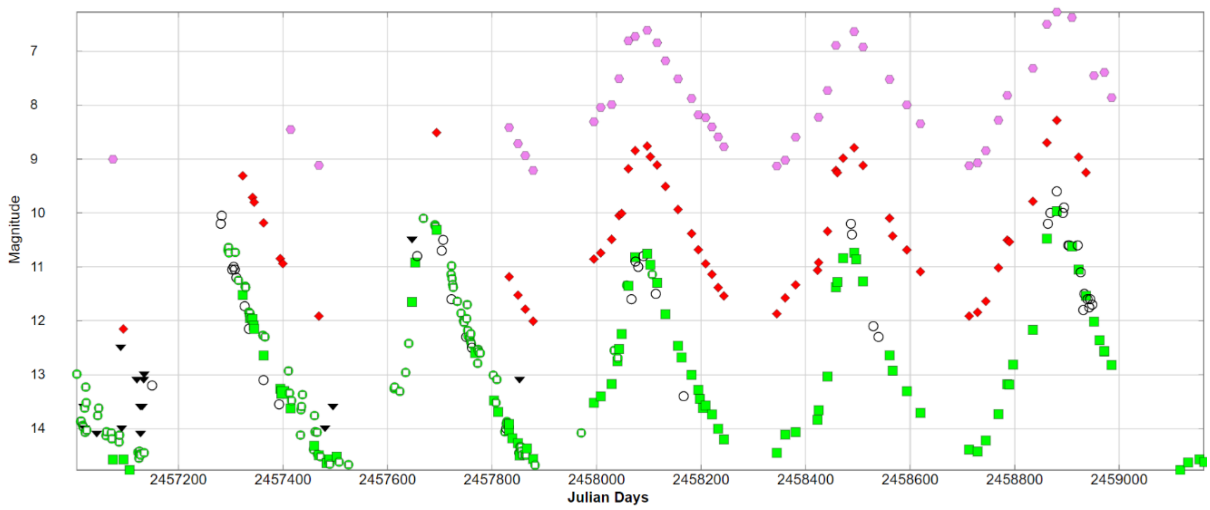
AH And

AH And is listed in VSX as a M type variable, spectra M4-M5e, with a range of 9.3-<14.5V, period 480.2d. Whilst this star is very poorly observed, older visual estimates support a maximum in the order of mag 10.0 and fading to below 15.0, more recent V mag estimates (shown below) have the range in order of 10.8 – 17.5. Period analysis of the fragmented data yields a period of around 489d.



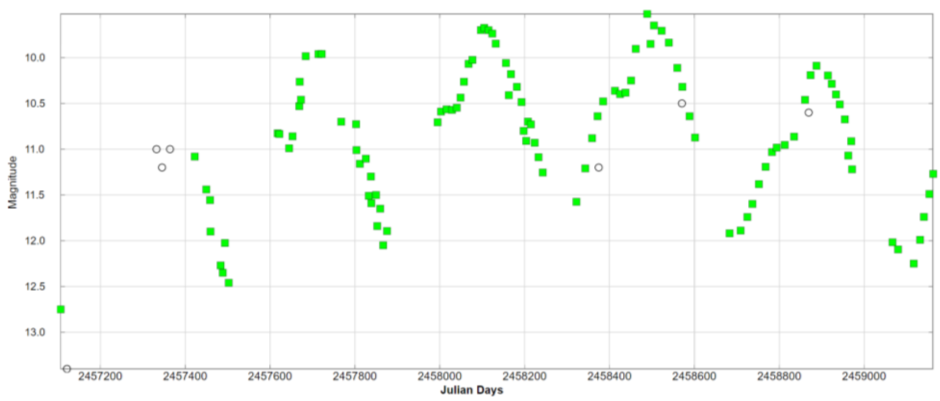
VY Aur

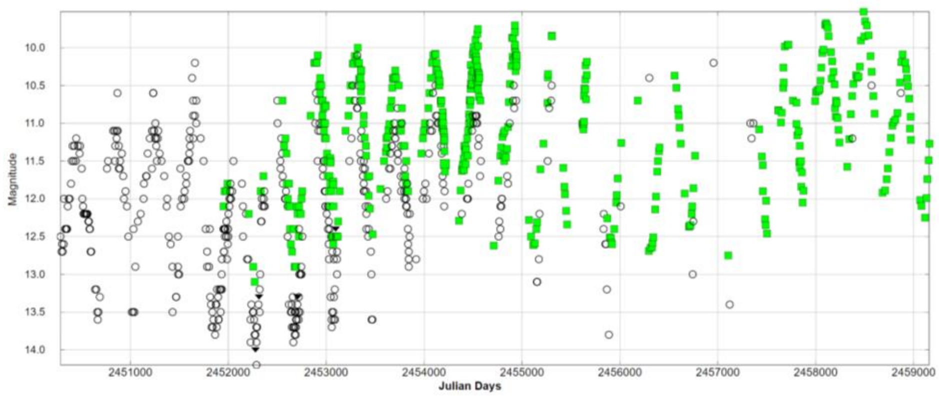
Below is shown the light curve for VY Aur in multiple wavelengths, visual (open circle), V mag (green), red light (red) and Infrared (purple). As will be seen the visual and V mags confirm the range of 9.3-15.3. The longer run of scattered visual mags (not shown) yield a period of 402.1d, whilst more recent V mags give 399.7d. Please note there are hints of a hump visible in all wavelengths on the ascending branch.



AU Aur

For our third star we take a look at AU Aur, which is listed as a Mira star with class C6-7,3e(N02), with a range of 10.0-14.00V, period 400.5d. Looking at the light curve confirms the extreme range of 9.5-14.2, however each individual cycle has a range of less than 3 magnitudes. In addition, there appears to be a pronounced hump on the ascending branch (see plot below). The most interesting aspect however is what appears to be a secondary period (see 2nd plot). Whilst there are insufficient observations a period in the range of 3,900 to 4,320d is hinted at. If this is the case, in view of this fact and small range, is AU Aur actually a SR type variable?





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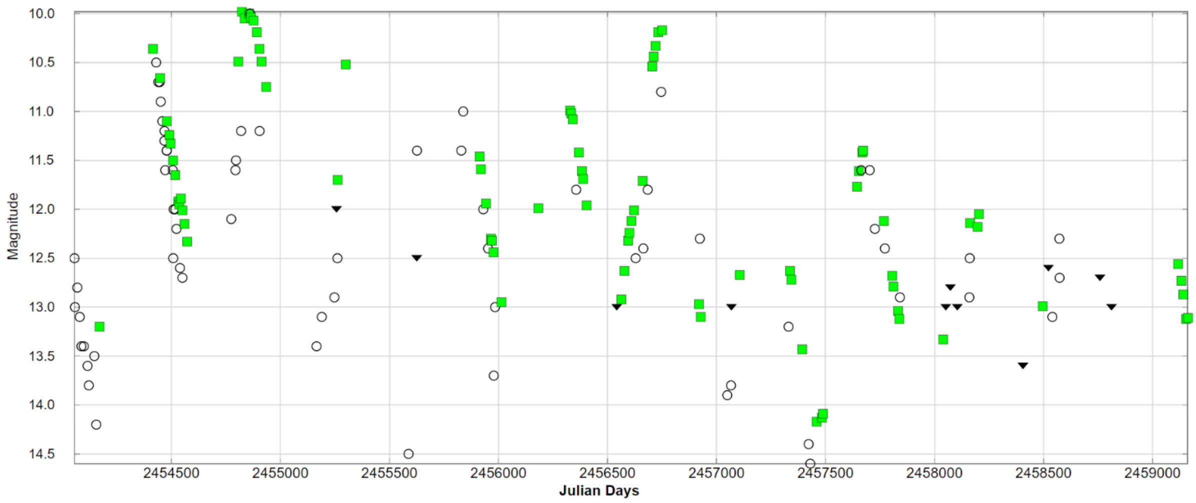
QS Ori

For our final star we take a look at the under observed star QS Ori which is also listed as a carbon star. Provisional results confirm the max magnitude listed in VSX of 9.8 however the minimum appears to be fainter than the listed, 13.7, at approx. 14.5. Despite the shortage of observations, period analysis yields a period of 475.9d close to the VSX catalogue result of 473d.



It is hoped that observers will take on board some or indeed all of these stars thereby enabling more meaningful analysis. Charts for all four stars are available via the AAVSO, Variable Star Plotter program.

All analysis and light curves are produced from the AAVSO VStar program.

Is Betelgeuse Heading into Another Deep Minimum?

Mark Kidger

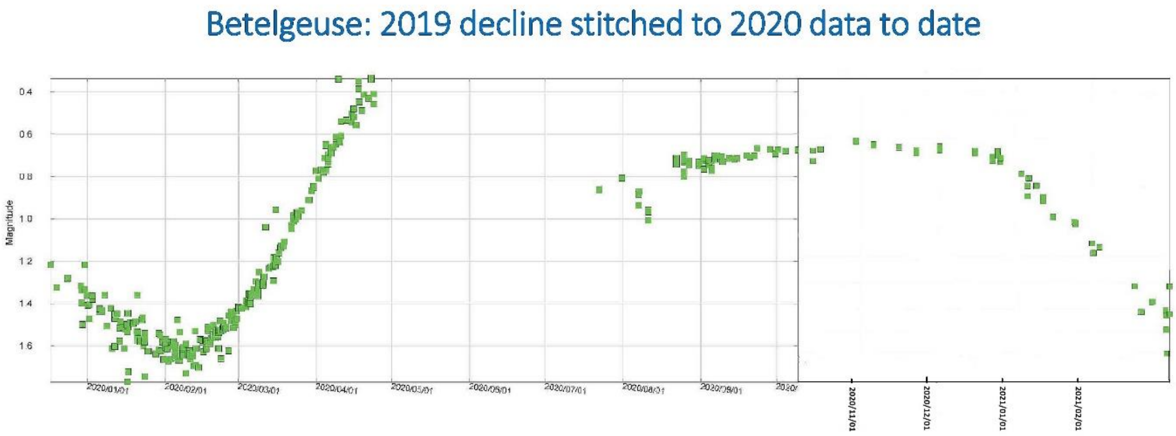
ESA/ESAC

Predictions based on recent behaviour of Betelgeuse have led to the speculative suggestion that a new minimum to magnitude +1.0 approximately should occur around April 12th 2021, with a possible error of around ±10 days. The value of any putative periodicity is only as great as its predictive power: what would we expect to see were Betelgeuse to repeat its behaviour from 2019/20?

Interest in the future behaviour of Betelgeuse remains high as it starts to move into the evening sky, especially as, if the recent ~430 day pseudo-periodicity is respected, there is the tantalising prospect of another deep maximum in early to mid-April 2021. Even though such periods have the annoying habit of disappearing as rapidly as they have appeared, the test of their validity is always to see what behaviour they predict and contrast it with reality. However, I will say up-front, that I have little faith in the predictive power of such periodicities and it is evident that even the recent light curve, in which the 430-day period is evident, is far from purely periodic.

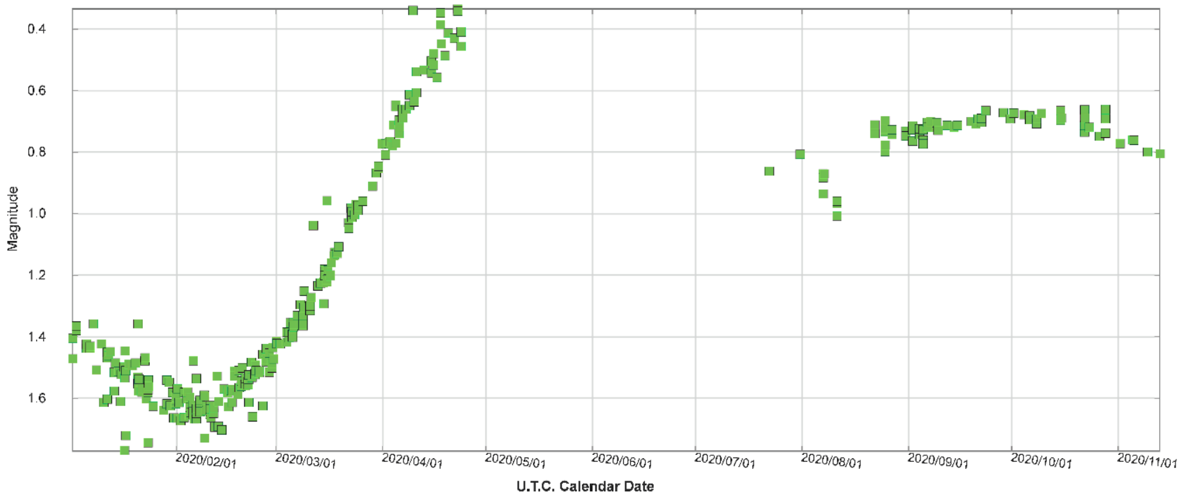
Let's try a *Gedankenexperiment* – a thought experiment and look at what we would expect from Betelgeuse were it to repeat recent behaviour.

If we take the V-band, photometric lightcurve of Betelgeuse up to mid-October 2020 from the AAVSO archive and just stitch the data for 2019/20 onto it, assuming that it will repeat exactly, 430 days later, we would expect something like the following.



V-band photometric data is best for this, as the dispersion is much smaller than for visual estimates, so we can see fine detail more easily. In 2019, there was a slow, post-conjunction brightening, followed by what appears to be an initial small fade and a short stabilisation and then a fade at increasing rate into the deep minimum. If these data were to repeat in 2020, we should see the first signs of a fade in early November, followed by a bigger decrease in brightness that would start in mid-December and accelerate around New Year.

If we update the AAVSO lightcurve to date – i.e. an extra month of data compared to the lightcurve above – we see the first signs of fading in the last two weeks. This appears to be quite rapid compared to the corresponding phase of the lightcurve in 2019. We can see also that there are some discrepancies between the data from the different observers, even though the dispersion is quite small.



While there is justified scepticism about the possibility of a further, deep minimum, produced by the current pseudo-periodicity occurring in April 2021, it would be of enormous interest if one were to occur. Such an event would imply that Betelgeuse may have developed a temporary, pseudo-stable mode of oscillation. However, given that there is no significant evidence of such a period in the historical light curve, one would expect the periodicity to break down in the near future and to have little, true predictive power.

Variable star observing and TESS satellite lightcurves

Stewart Bean

The contribution of the TESS satellite to variable star observations is described using TX UMa and IX Dra as examples.

Introduction

The TESS (Transiting exoplanet survey satellite) is an instrument designed to observe the light curves of the closest bright stars in both the northern and southern hemispheres to detect small dips associated with planetary transits. The satellite mission is led by MIT on behalf of NASA and details are available at the mission website (1). Of interest to Variable Star Section members are the lightcurves that can be viewed and downloaded from the MAST website (2). Targets are described by a TESS Input Catalogue (TIC) number. Python (3) in combination with Lightkurve (4) is used to present data, fold, and plot the observations.

Observing strategy

TESS is pointed at a fixed location for a period of about 27 days with each of the four cameras viewing a 24 x 24 degree field of view (FOV). The observed field stretches from the ecliptic pole towards the ecliptic equator. Each 27 day period is called a sector. During each sector, images of the FOV are collected with a 2 minute cadence and stored on board. Every 13 days the satellite is pointed towards Earth and the data downloaded. During download no observing is possible and this period appears as a gap in the centre of each lightcurve. The four cameras have a 100 mm clear objective with a transmission between 600 nm and 1000 nm that has been optimised for planet transit detection. Owing to the design of the mission those stars closest to the ecliptic north and south poles are observed most frequently, whilst stars closer to the equator will be observed only in one sector. Stars within a few degrees of the equator will be missed entirely.

TESS has now completed its primary mission to observe both hemispheres and has won an extension to again observe both hemispheres over the next two years. In order to illustrate the opportunity for VSS members, data from an eclipsing binary (TX UMa) and a CV star (IX Dra) are presented.

TX UMa (TIC 406758816)

TX UMa has been observed only in TESS Sector 21 as it is relatively distant from the ecliptic plane. The data can be observed at the MAST site using the “enter target” panel at the top of the screen. Fortunately, the MAST does recognise “TX UMa” as a valid description of a target of interest. However, MAST does not yet recognise newly discovered objects such as V1391 Cas (Nova Cas 2020). The TX UMa lightcurve has been downloaded and processed within the Python environment using “Lightkurve”. The sector 21 lightcurve for TX UMa is shown in Fig 1.

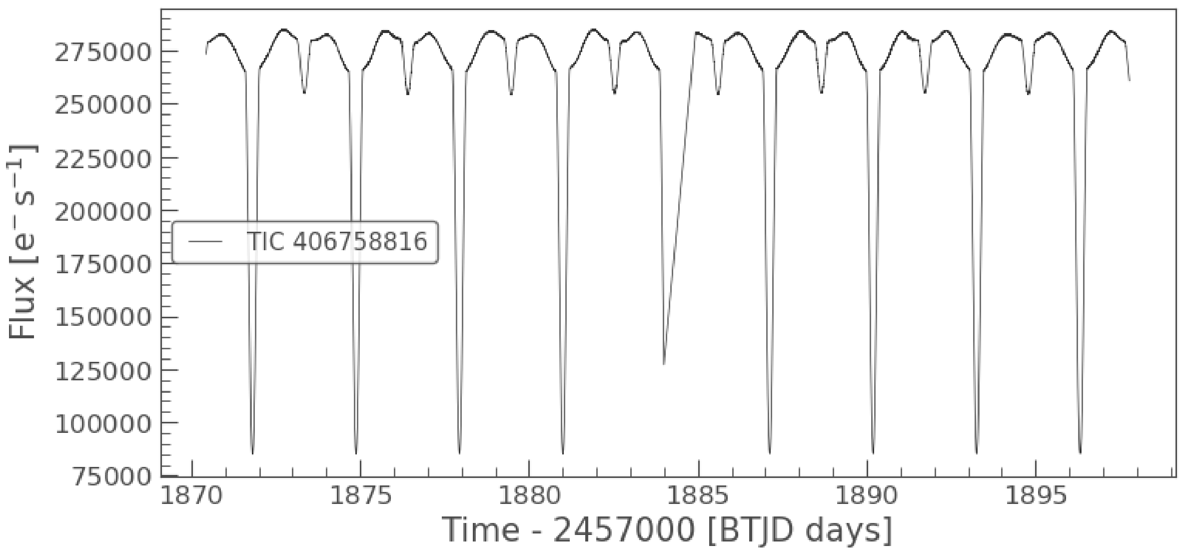


Figure 1. Lightcurve for TX UMa for TESS Sector 21.

The major and minor eclipses are clearly observed together with the missing day around JD 1884 in the middle of the lightcurve. The periodicity of the system can be examined within Lightkurve and yields an estimate of 3.063 days that is consistent with published data. The phase plot is shown in Figure 2. In addition, it is possible for the raw data to be converted to CSV files for analysis outside Lightkurve.

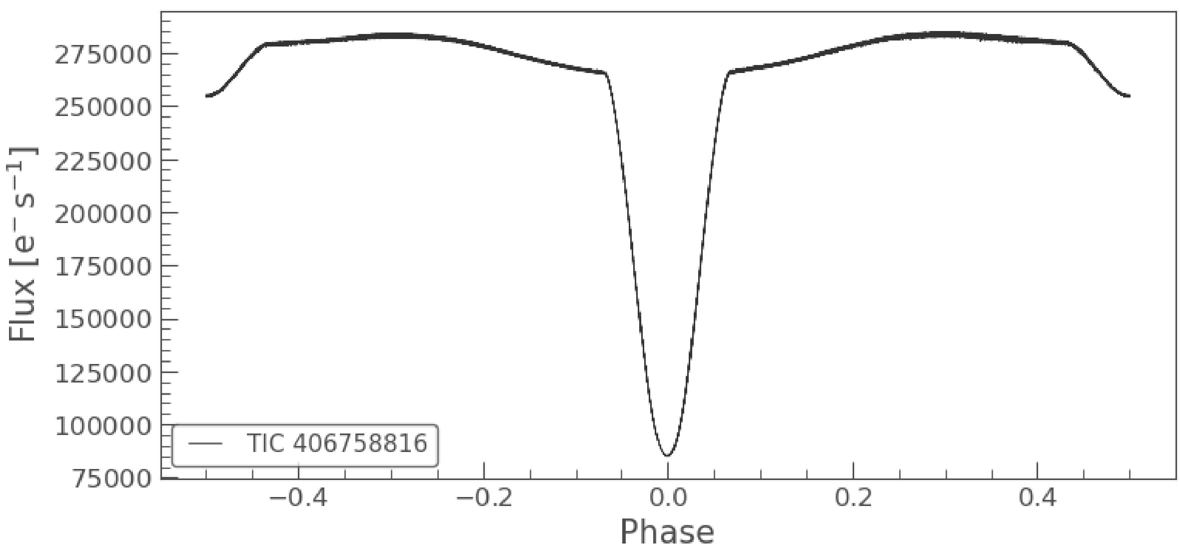


Figure 2. The folded lightcurve for TX UMa using a period of 3.063 days produced using Lightkurve

IX Dra (TIC 236763903)

IX Dra is a CV system that has been observed during ten sectors as it is close to the north ecliptic pole and this permits a fairly complete light curve to be created. Figure 3 shows a stitched and binned light curve over the period of one year.

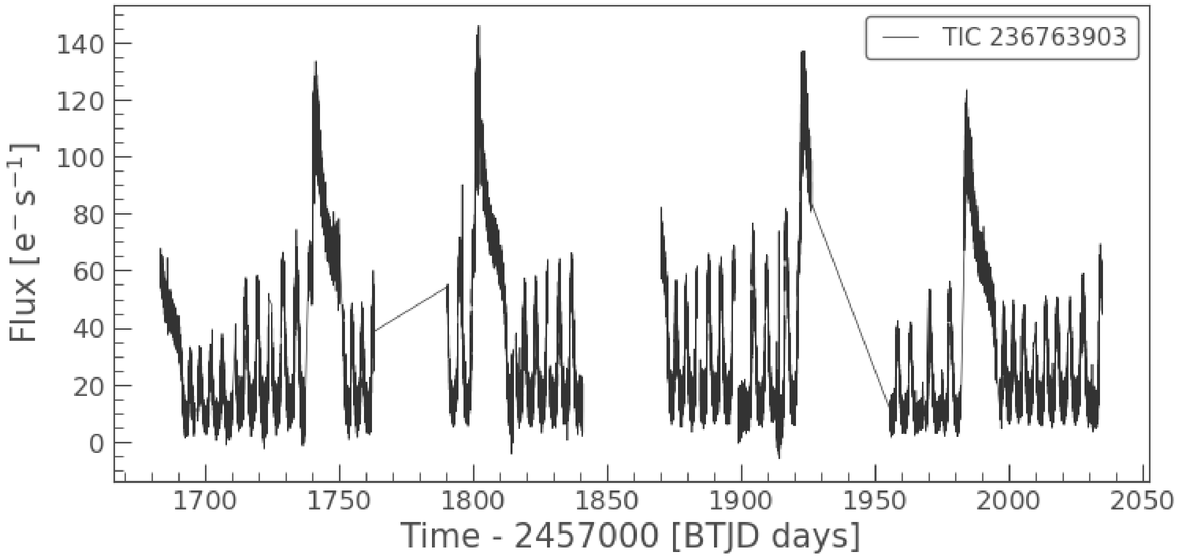


Figure 3. The stitched and binned lightcurve for IX Dra for TESS Year One observations

The outbursts occur about every 4 days. For greater clarity, the stitched lightcurve for Sectors 14 and 15 is shown in Figure 4 below (with x5 binning).

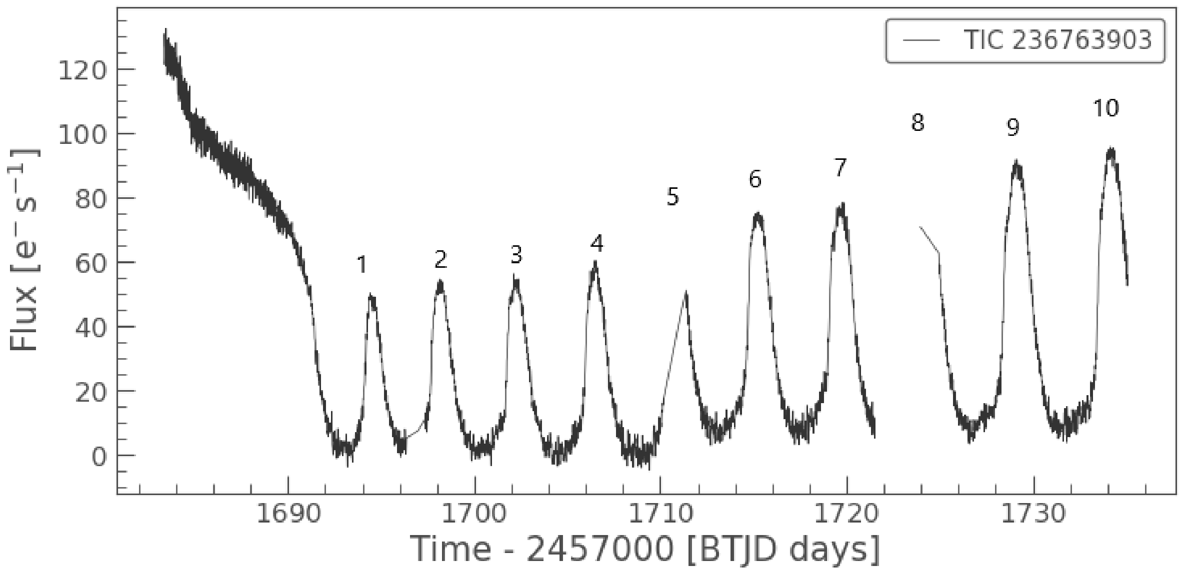


Figure 4. The stitched and binned (x10) lightcurve of IX Dra for Sectors 14 and 15

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Following a long and bright outburst that began before JD 1685, ten gradually more intense outbursts follow. Outbursts 5 and 8 are only partially recorded owing to download gaps in the data. The outbursts 1 to 10 appear to be gradually increasing in peak light flux, outburst duration at half height, and the time between outbursts.

Summary

TESS provides 27 day observations for many variable stars of interest to VSS members, with extended views over a whole year for some stars close to the ecliptic poles. The MAST site provides an easy means to check if a target has been observed by TESS and to review the lightcurve. Lightkurve, within Python, allows more detailed analyses.

References

1.TESS mission site: https://tess.mit.edu/

2.MAST site: https://mast.stsci.edu/portal/Mashup/Clients/Mast/Portal.html

3.Python site: https://www.python.org/

4.Lightkurve site: https://docs.lightkurve.org/#

ASASSN-V J112615.94+370728.3 may well be a DY Per star

John Greaves

ASASSN-V J112615.94+370728.3 is listed at its source website as an irregular variable of unknown type (type 'L') and on AAVSO VSX as a YSO. It is in fact a Carbon star with a lightcurve profile possibly suited to it being a type DY Per star.

The lightcurve source for the variability type 'L' ASASSN-V J112615.94+370728.3 Ursæ Majoris (Jayasinghe *et al* 2018) can be found here

whilst the lightcurve from the Catalina Realtime Transient Survey, CRTS, (Drake *at al* 2009) can be seen here

meanwhile AAVSO VSX lists the following details inclusive of a variability type of 'YSO' (Young Stellar Object) here

This star is in fact the Carbon Star CGCS 6447 which can be confirmed via examination of the LAMOST DR5 spectrum (eg Zhao *et al* 2012) here where absorption bands due to C_2, the "Swan Bands", can be clearly seen leftward of the plot and with there being any evident indication of Hα in either absorption or emission at around 656 nanometres.

The ASAS-SN lightcurve could be interpreted as a multiperiodic Semiregular or Irregular variable which are usually of low amplitude and long periods with the multiple periods interfering with each other to give varying maxima and minima values and sometimes a consequent varying mean magnitude. The variable width of cycles is somewhat large, however, and the greater dips are to some extent analogous to those of DY Per itself, albeit of less amplitude. That is, a more or less normal Carbon Star long period pulsation period (or mix thereof) with the occasional relatively deep dip that is not as deep or precipitous as that for an RCB star. Nevertheless, this still does not preclude a simple long period pulsating Carbon Star.

The CRTS lightcurve whilst near general maximum is also appropriate for either a low amplitude Semiregular, although DY Per stars (and for that matter some RCB stars) can also show such variation in between fading events. However, an additional ghost of a deeper dip showing a more gradual and potentially more symmetrical profile can be seen around MJD 54260, admittedly with a sparse number of points (also note that despite both lightcurves purportedly being V magnitude the CRTS has a brighter maximum magnitude as well as greater magnitude range in comparison to the ASAS-SN one). Although the points are few and the dip of lesser amplitude the skeleton of a symmetric profile akin to those occasionally seen in DY Per can be imagined.

Whether this is just another Semiregular Variable or a true DY Per or any sort of variable only future monitoring will show, the star is a little faint however with a mean maximum magnitude very roughly 12.5 V or between that and nearly 13 in various red magnitudes, it being red but not very red with a 2MASS J-K_s of 1.0, with the amplitude of the CRTS potential dip not having exceeded much more than half a magnitude in V plus the star spending most of its time exhibiting Semiregular like variations of barely 0.2 – 0.3 magnitude in amplitude.

References

Drake, A.J. et al, 2009, ApJ, 696, 870
Jayasinghe, T., et al, 2018, MNRAS, 477, 3145
Zhao, G., et al, 2012, RAA, 12, 723

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Observing Cepheid Variable Stars with an Alpy 600 Spectroscope

Hugh Allen

A method is described for monitoring classical Cepheid variable stars with a low resolution Alpy 600 spectroscope (resolving power R = 600 at 6500Å). Absorption line strengths in spectra of delta Cephei and X Cygni are converted to temperature, expressed as B-V colour index by using similar measurements in the Pickles reference spectra of supergiant stars. The resulting temperature-phase curves closely match light curves available from the AAVSO database, suggesting the method could successfully be extended to other classical Cepheids. Such spectroscopic temperature measurements also provide a means to estimate interstellar reddening.

Introduction

Classical Cepheid variable stars are of fundamental importance in astronomy. They are supergiant stars thousands of times the luminosity of our Sun and so are visible even in nearby galaxies with large professional telescopes. In 1912 Henrietta Swan Leavitt working at the Harvard Observatory published her discovery that the period of variation of Cepheids in the Small Magellanic Cloud was proportional to their brightness (Leavitt's Law).[1] They have since become a crucial rung on the cosmic distance ladder, allowing the measurement of the scale and age of the Universe. There are a number of nearby bright examples with well documented periods which make popular targets for visual and photometric variable star observers.

Classical Cepheids represent a particular late stage in the evolution of more massive stars. Pulsations in the outer layers of the star produce regular changes in both size and surface temperature which in turn lead to a regular variation in brightness. The change in surface temperature also produces changes in the spectrum of the star, presenting a different way for amateurs to monitor their variability. Surprisingly, amongst the 7127 spectra in the BAA Spectroscopy Database (as of 2020 Oct 25), only three Cepheids have been observed totalling just 14 spectra (excluding the author's observations). This paper describes a spectroscopic method for monitoring the variability of classical Cepheids using a low resolution Alpy 600 spectroscope from Shelyak Instruments (resolving power R = 600 at 6500Å).

Setting the scene

Delta Cephei is the prototype classical Cepheid after which the entire class is named, and its variability was first observed by the English astronomer John Goodricke in 1784. Although to the naked eye it appears as a single star, it is actually a visual binary whose total brightness is dominated by the classical Cepheid component del Cep A (Fig. 1).

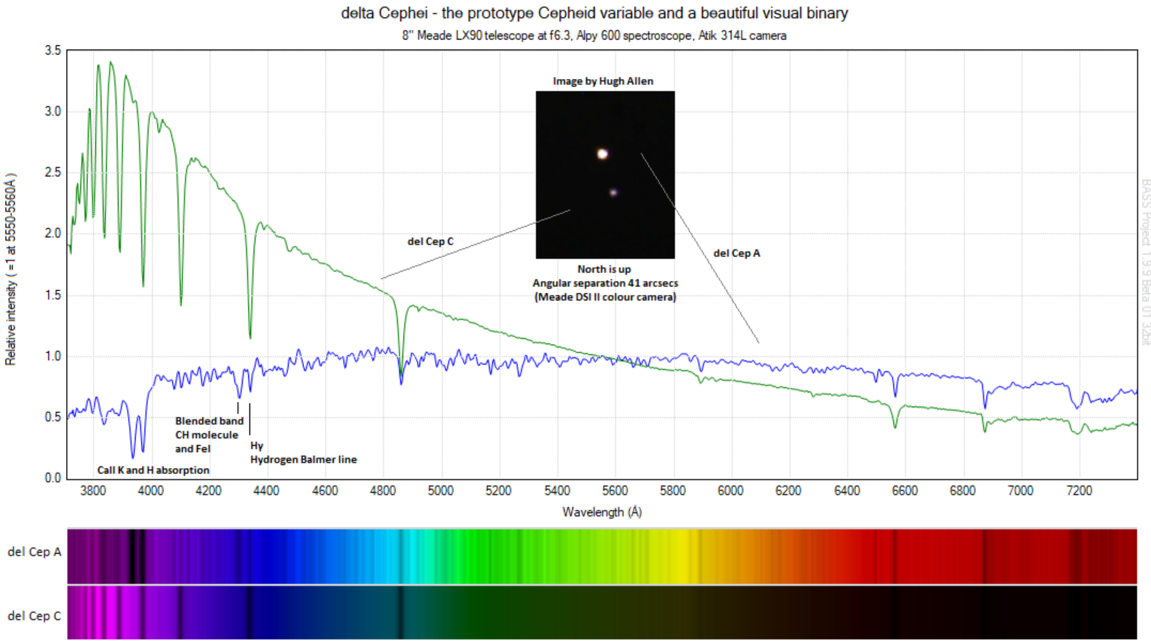

Figure 1: Photographic and spectroscopic comparison of the two visual components of delta Cephei (del Cep C has a constant apparent magnitude = 6.3)
In a telescope the two components make a beutiful gold - blue colour contrast

Del Cep's overall apparent magnitude varies between 3.5 and 4.4 with a period of about 5.4 days. The associated change in surface temperature of del Cep A can be observed in the Alpy 600 spectrum in two ways: a change in the profile of the spectrum (colour of the star) and a change in strength of the absorption lines in the spectrum (Fig. 2).

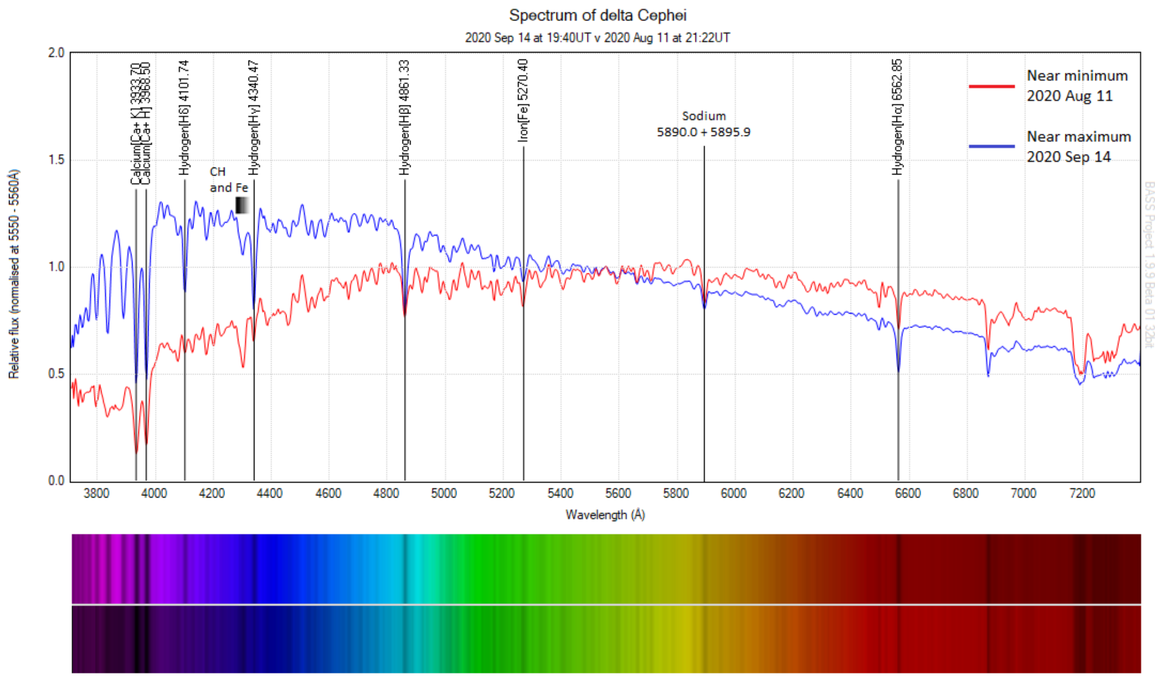

Figure 2 : Comparison of the relative flux calibrated spectra of del Cep near maximum and minimum brightness.
Some of the atomic absorption lines are labelled along with the CH molecular absorption band

The relationship between absorption line intensities and temperature is typically used to assign a spectral type to stars. Classical Cepheids are known to vary within early F to early K supergiant spectral types (Fig. 3). [2]

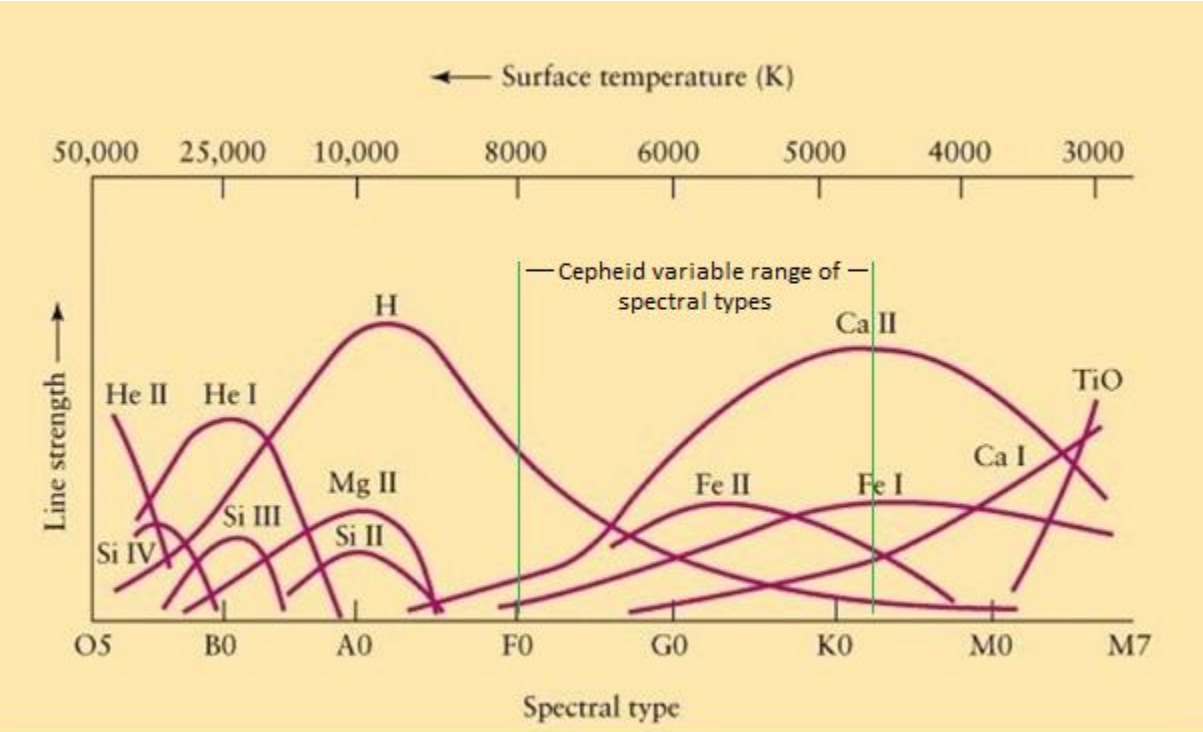

Figure 3: Variation of some example absorption line strengths with temperature.
Figure courtesy of The Curious Astronomer blog by Dr Rhodri Evans
https://thecuriousastronomer.wordpress.com/

Cepheid variable annotation added by Hugh Allen

Measurements of absorption line strengths can therefore provide a different way of monitoring variation in classical Cepheids, provided a method can be found to calibrate the line strength scale.

Calibrating the variation of absorption line strength with temperature

At the resolution of the Alpy 600 spectroscope most of the absorption lines in the spectra of classical Cepheids are blends whose variation with temperature may not therefore match the pure curves in Figure 2. Fortunately, the set of Pickles model spectra are made with a similar resolution to the Alpy.[3] The relationship between temperature and line strength in classical Cepheid spectra can therefore be modelled by measuring the strength of absorption lines in the Pickles spectra of supergiant stars that span the Cepheid spectral types: F5I, F8I, G0I, G2I, G5I, G8I and K2I. The author’s measurements of the strengths of several prominent absorption lines are given in Table 1, expressed as their Equivalent Width in Å (see Appendix for the measurement method).

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Pickles Spectral Type	Temperature (B - V Colour Index)	Measured absorption line strengths (Equivalent Width, Å)				
		CaII K	CH band	Hγ	Hβ	Hα
F5I	**0.27**	11.661	3.222	5.4533	7.843	3.751
F8I	**0.60**	12.342	5.238	3.9198	7.287	3.461
G0I	**0.78**	10.849	5.627	3.2339	6.711	2.921
G2I	**0.90**	13.103	7.610	2.9934	5.895	2.857
G5I	**1.07**	10.942	7.565	2.3509	6.366	2.246
G8I	**1.21**	11.240	7.122	0.9654	4.527	2.229
K2I	**1.50**	12.797	7.529	0.3310	4.189	1.933

Table 1: The author's measurements of Equivalent Widths in the Pickles Spectra of supergiant stars (see Appendix). The temperature is given as the B – V colour index (magnitude difference in a B and V filter) [3]

In this study, a plot of the Hγ absorption line strength against B – V gave the strongest fit with a linear equation $y = -4.2433x + 6.5868$, where y = Hγ Equivalent Width and x = B – V Colour Index (Fig. 4).

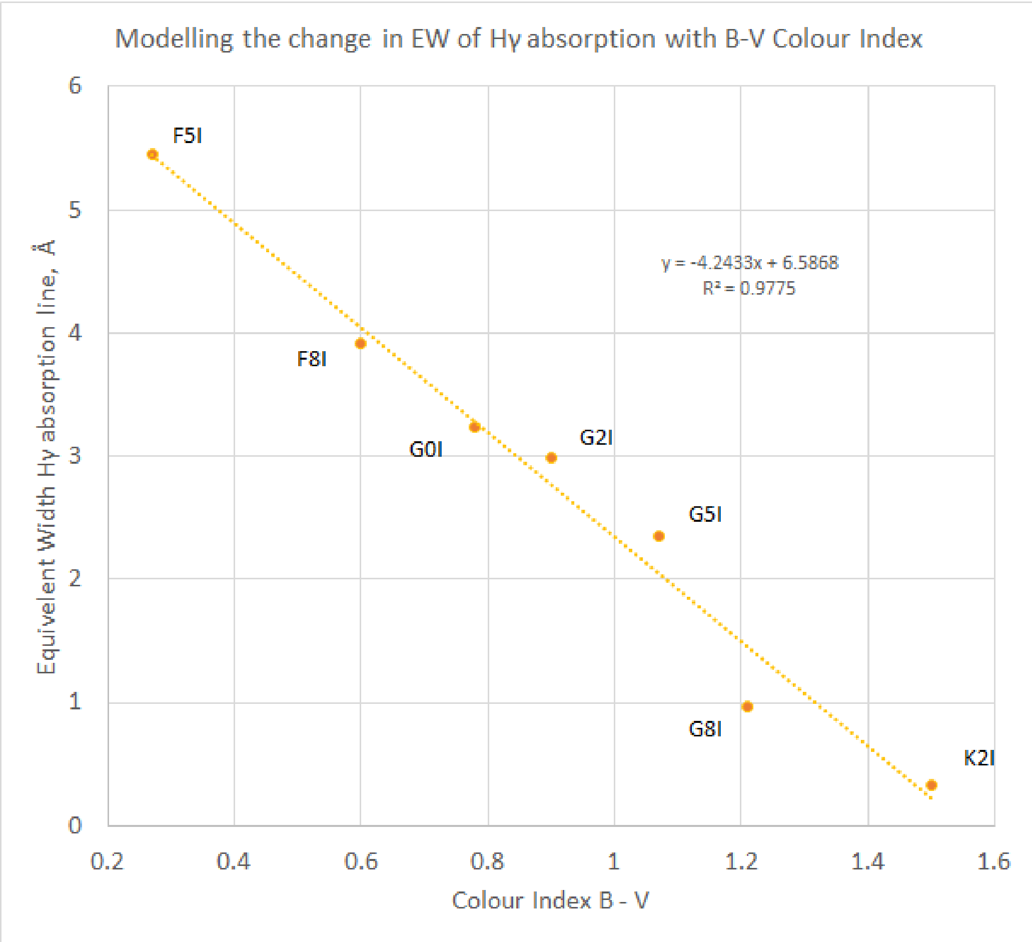

Figure 4: Equivalent width v Colour Index plot made in Excel with associated best fit equation. The relationship is strong ($R^2 = 0.9775$) and the residuals appear randomly distributed

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The temperature (B – V colour index) of any classical Cepheid can now be estimated by measuring the Equivalent Width of the Hγ absorption line in the Alpy 600 spectrum.

Testing the model on delta Cephei

The spectrum of del Cep A was taken on 14 nights to provide a reasonable coverage of the star's 5.366341 day period. Using JD2436075.445 as the Phase = 0 point, the modelled B – V Colour Index was assigned to a folded phase (Table 2).

Calendar date	Time UT	Julian date	Folded phase	Hγ Equivalent Width	Modelled Colour Index B - V
30/07/2020	22:00	2459061.417	0.360	3.0201	0.841
03/08/2020	22:11	2459065.424	0.107	4.5867	0.471
06/08/2020	21:57	2459068.394	0.660	2.7165	0.912
08/08/2020	21:48	2459070.408	0.036	5.0315	0.367
11/08/2020	21:22	2459073.390	0.591	2.6417	0.930
09/09/2020	19:51	2459102.327	0.984	5.5250	0.250
13/09/2020	19:46	2459106.324	0.729	3.0081	0.843
14/09/2020	19:40	2459107.319	0.914	5.6615	0.218
21/09/2020	19:08	2459114.297	0.214	3.5000	0.727
24/09/2020	19:00	2459117.292	0.772	3.1494	0.810
25/09/2020	18:55	2459118.288	0.958	5.8155	0.182
27/09/2020	18:52	2459120.286	0.330	2.9888	0.848
11/10/2020	18:12	2459134.258	0.934	5.7581	0.195
15/10/2020	18:00	2459138.250	0.678	2.7280	0.909

Table 2: Author's spectroscopic observations of del Cep

The modelled B – V Colour Index values were used to plot a temperature – phase curve which can be compared to a folded light curve of V magnitude photometric observations downloaded from the AAVSO database (Fig. 5).

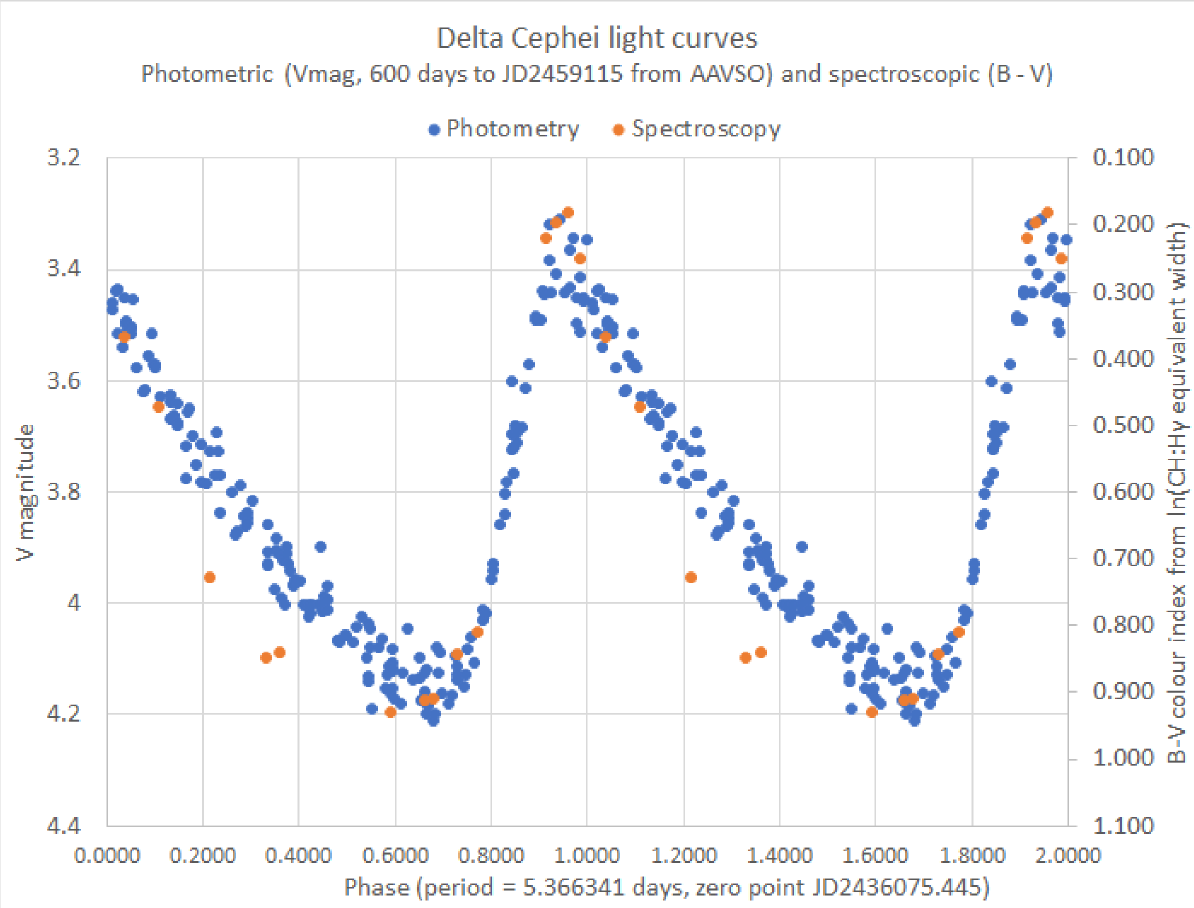
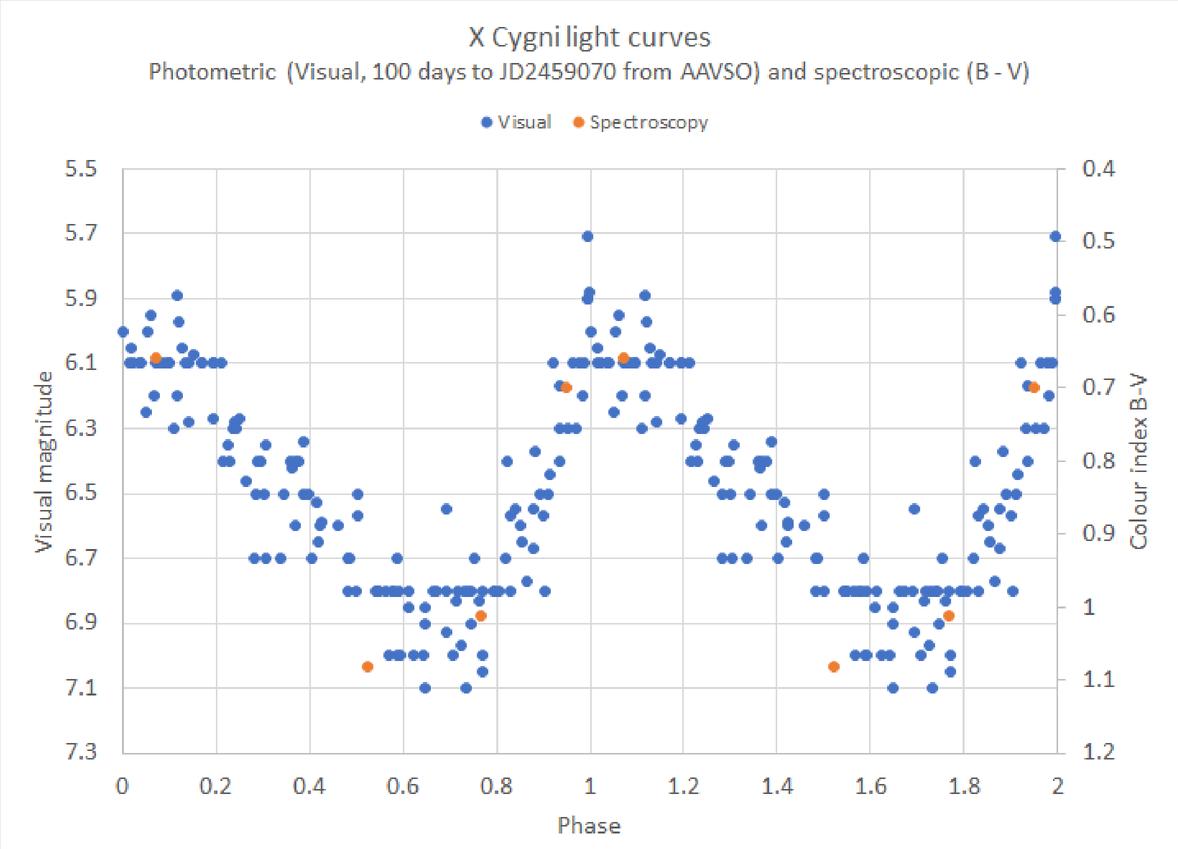


Figure 5: A comparison of the author's spectroscopic temperature-phase curve with the photometric light curve generated from Vmag data in the AAVSO database

The B – V temperature-phase curve closely follows the photometric light curve, confirming the potential of the spectroscopic method. The temperature-phase curve shows a steeper declining profile which is also seen in photometric B – V measurements in the literature. [2]

Extending the method to other classical Cepheids

Four observations were made of the classical Cepheid star X Cygni (16.386332 day period). The comparison of temperature-phase and visual light curves is given in Figure 6, based on a zero point of JD 2458970.896.



Calendar date	Time	Julian date	Folded phase	Hγ Equivalent Width	Modelled Colour Index B - V
30/07/2020	21:30	2459061.396	0.523	1.9973	1.082
03/08/2020	21:44	2459065.406	0.768	2.2891	1.013
06/08/2020	21:27	2459068.394	0.950	3.6229	0.698
08/08/2020	21:21	2459070.390	0.072	3.7898	0.659

Figure 6: Light curve comparison for X Cygni. The data available from the AAVSO database is by visual observation which leads to more scatter compared to the photometric Vmag data available for del Cep

Although the spectral data points are sparse, their position relative to the visual light curve is consistent with the del Cep profiles suggesting that the technique can be extended to other classical Cepheids. It is interesting to note that X Cygni's colour index range 0.66 – 1.08 is significantly cooler than del Cep's 0.20 – 0.93.

A final comment - interstellar reddening

A by-product of these measurements is the possibility to estimate interstellar reddening caused by extinction from intervening gas and dust. On 2020 July 30, the modelled colour index of X Cygni was 1.082, close to the colour index of a G5I star. However, X Cygni appears noticeably reddened when the profile of the spectrum is compared to the profile of the G5I Pickles reference. A much closer match is obtained by dereddening the X Cygni spectrum using a colour excess E(B-V) of 0.27 (see Fig. 7). This value is in near agreement with E(B-V) measurements in the literature. [4]

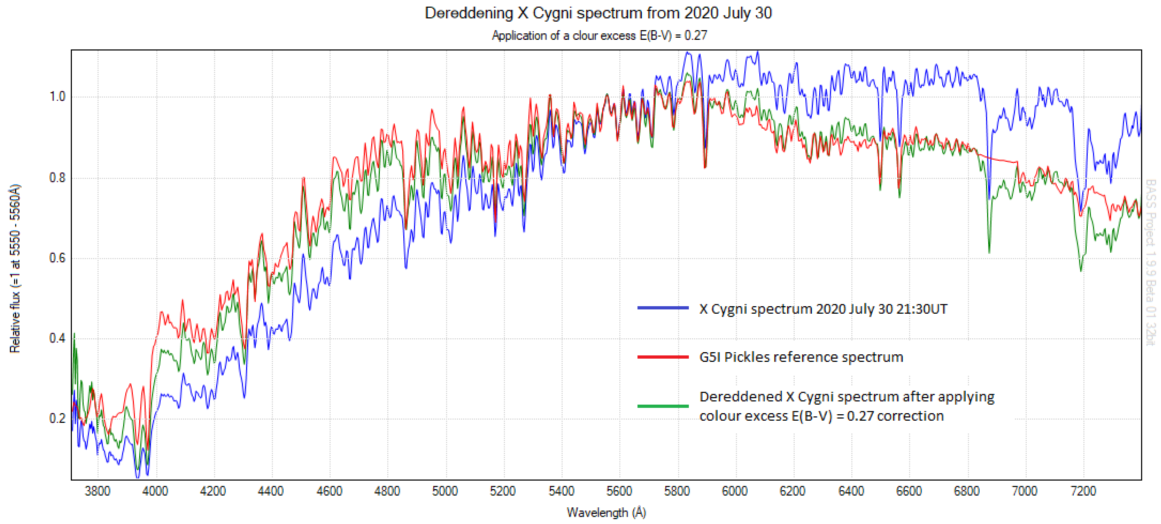


Figure 7: Estimation of X Cygni colour excess E(B-V). Dereddened spectrum created in ISIS software

References

1. Leavitt H. 'Periods of 25 Variable Stars in the Small Magellanic Cloud' Harvard College Observatory Circular Vol 173 (March 1912) pp 1 – 3 http://adsabs.harvard.edu/full/1912HarCi.173....1L
2. Engle S. 'The Secret Lives of Cepheids' March 2014 arXiv:1702.06560
3. Pickles A. 'A Stellar Spectral Flux Library: 1150 - 25000 Å' Publications of the Astronomical Society of the Pacific, Vol 110, No. 749 (July 1998), pp 863 – 878 https://iopscience.iop.org/article/10.1086/316197/pdf
4. Turner D. 'The Scale of Reddening for Classical Cepheid Variables' March 2016 arXiv:1603.02276

Acknowledgement

I acknowledge with thanks the variable star observations from the *AAVSO International Database* contributed by observers worldwide and used in this research.

Appendix: Measurement of Equivalent Width in BASS software

The continuum at the selected absorption feature is approximated by drawing a straight line between the wavelengths at which the absorption line starts to turn downwards relative to the continuum slope. This is illustrated in Figure 8 with the estimate in BASS software of the Equivalent Width of the Hγ absorption line in the Pickles spectrum for a F5I star. By zooming into the spectrum to within a range of 200Å the measurement error is limited to around 1%.

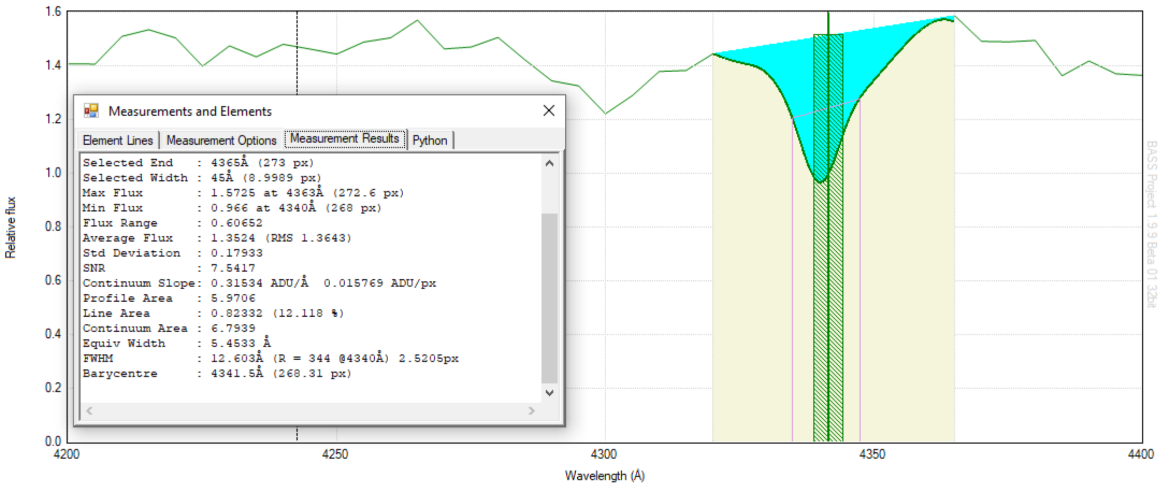


Figure 8: Estimation in BASS software of the Equivalent Width EW of the Hγ absorption line.
EW is the width in Å of the hashed rectangle having the same area as the absorption line under the continuum (blue area)

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Serendipitous observations of UCAC4 686-012519: a short period δ Scuti pulsating star in Andromeda

Martin J. F Fowler

Serendipitous observations are reported of UCAC4 686-012519 (= ZTF J020549.65+470041.0 = ASASSN-V J020549.64+470040.9) that were made whilst observing transits of the exoplanet HAT-P-32 b using the MicroObservatory. The observations demonstrate the value of MicroObservatory for observing a known transiting exoplanet for ephemeris maintenance whilst simultaneously characterising the stellar variability of another star, and support the findings by the Zwicky Transient Facility and the All-Sky Automated Survey for Supernovae that UCAC4 686-012519 is a δ Scuti variable with a period of ~103 min and an amplitude of ~0.1 mag.

Introduction

Delta Scuti (δ Scuti) stars are variable stars that pulsate at high frequency (0.02 d < P < 0.25 d) with typical V-band amplitudes in the range 3 mm < A < 0.9 mag [1]. They are of intermediate mass (1.5-2.5 $M_{\odot}$), with spectral types between A2 and F2, and are located near where the classical Cepheid instability strip intersects the zero-age-main-sequence [2]. Their light curves can show very complex variations with some pulsating in one radial mode only and others pulsating simultaneously in several radial and non-radial modes [3]. The discovery of δ Scuti variables has been revolutionised with advent of recent all-sky variability surveys, such as the Zwicky Transient Facility (ZTF) [4] and the All-Sky Automated Survey for Supernovae (ASAS-SN) [5], with ZTF and ASAS-SN collectively discovering ~23,000 examples.

Observations of transiting 'hot Jupiter' exoplanets by the 6-inch [152 mm] MicroObservatory robotic telescopes operated by the Harvard-Smithsonian Center for Astrophysics typically cover the same small patch of sky for 3-4 hours with a nominal cadence of 3 min [6,7]. With a field of view (FOV) of approximately 1º by 0.75°, MicroObservatory offers the potential to both observe a known transiting exoplanet for ephemeris maintenance, through initiatives such as Exoplanet Watch and ExoClock, whilst simultaneously observing other stars for potential transits and to characterise stellar variability [8]. In this article I describe serendipitous observations of the δ Scuti variable UCAC4 686-012519, whilst simultaneously observing transits of the exoplanet HAT-P-32 b.

Observations

Observations were made by the MicroObservatory telescope *Cecilia* located at the Smithsonian's Fred Lawrence Whipple Observatory in Arizona, USA, whilst observing 43 transits of HAT-P-32 b [9]. The unfiltered 60 second exposure images were acquired at a 3-min cadence over a period of ~4 hours when a transit was being observed.

Using the 'Find Variables' functionality of the Muniwin photometry package, a star in the image field acquired on 2019 Jan 11 was noticed to exhibit short period variability with an amplitude of ~0.1 mag and a period of ~ 0.07 d (~100 min). The star was subsequently found to have been observed during 15 further transits of HAT-P-32 b. Located towards the Northern edge of the FOV (Figure 1), plate solving using *AstroArt 7.0* gave a position of RA 02 05 49.7 Dec +47 00 40.9 and which corresponds to the 13.9 V-mag star UCAC4 686-012519. A search of the International Variable Star Index showed it to be a δ Scuti variable discovered by ZTF (= ZTF J020549.65+470041.0); the variable was also reported by ASAS-SN (= ASASSN-V J020549.64+470040.9).

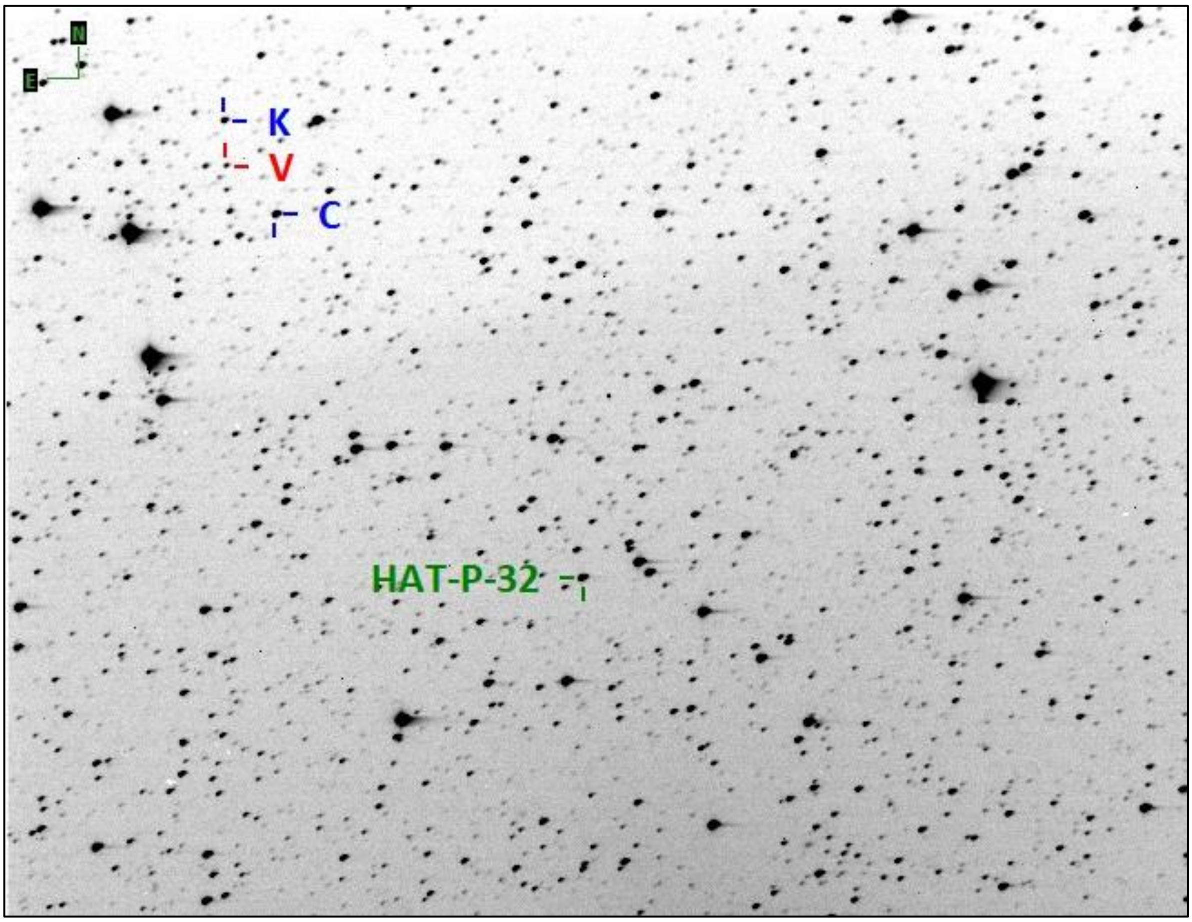

Figure 1. Representative unfiltered full frame MicroObservatory image of the HAT-P-32 field acquired on 2020 Feb 02. The location of UCAC4 686-012519 (V) and the comparison (C) and check stars (K) are shown towards the top of the image.

Differential aperture photometry of 1,210 dark field corrected images covering the 16 HAT-P-32 b transits observed between 2012 Sep 26 and 2020 Feb 02 was performed with Muniwin using the 11.9 V-mag star UCAC4 685-012265 as the comparison and the 12.96 V mag star UCAC4 686-012522 as the check star. A heliocentric correction was applied to the time values and the data were linearly detrended using Peranso version 2.6 [10]. The resulting light curves, comprising a total of 1,210 data points, are shown in Figure 2. Because of variations in the pointing accuracy and the tracking of MicroObservatory, on those epochs when HAT-P-32 was located towards the upper part of the image, UCAC4 685-012265 was outside the FOV and consequently no observations were obtained in 2015 and 2016.

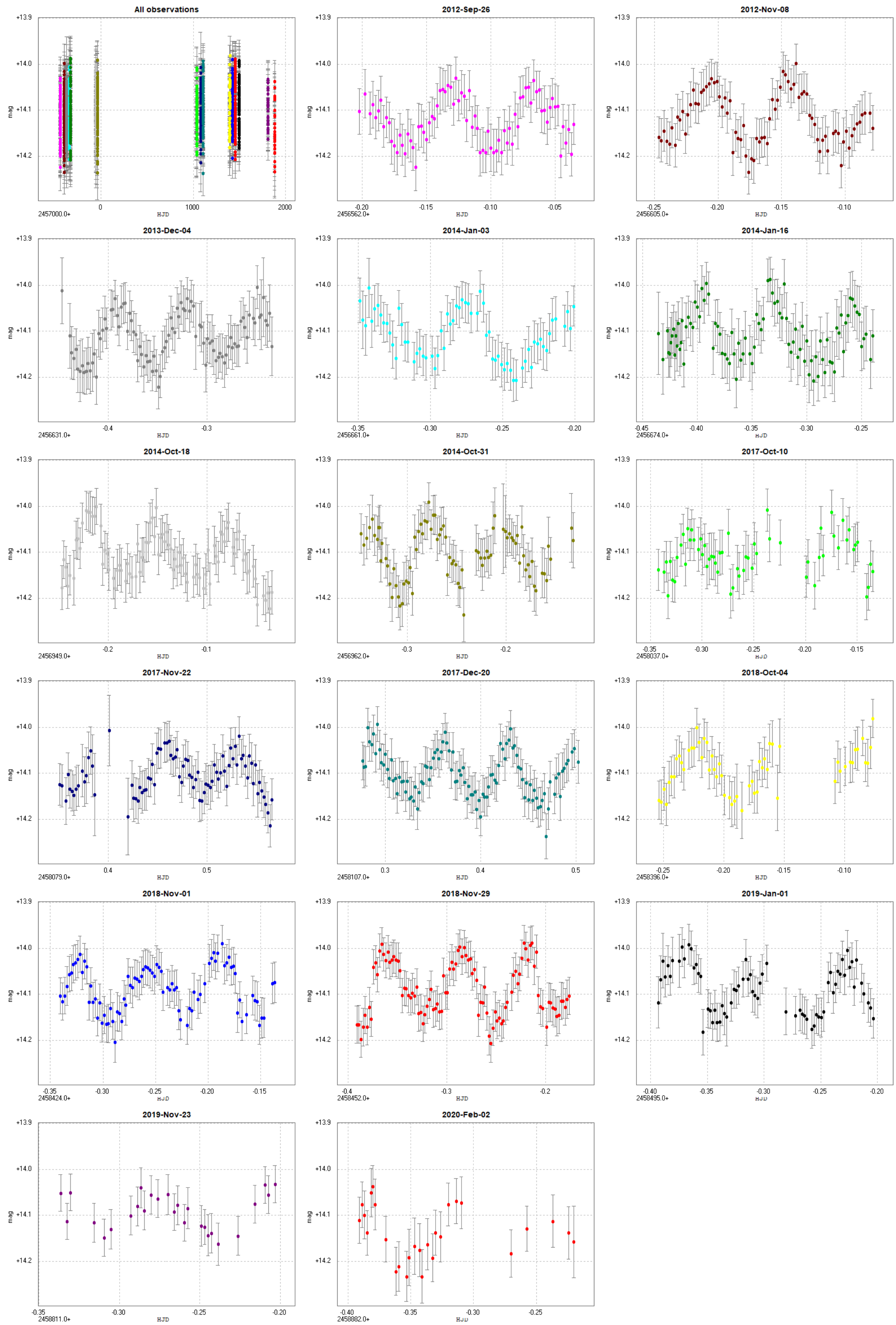

Figure 2. Light curves of UCAC4 686-012519 as observed by MicroObservatory.

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Characterisation

Dominant period determination was made using the analysis of variance (ANOVA) method of Schwarzenberg-Czerny [11] as implemented in Peranso version 2.6. This method employs periodic orthogonal polynomials to fit observations, and the ANOVA statistic to evaluate the quality of the fit. ANOVA was chosen as it strongly improves peak detection sensitivity and damps alias periods. The resulting power spectrum is shown in Figure 3 and shows a dominant period of 0.07153 ±0.0020 d (103 ±3 min). Folding the light curves on the dominant period yields the phase curve shown in Figure 4 with a mean amplitude of ~0.1 mag based on a polynomial curve fitted to all the phase data.

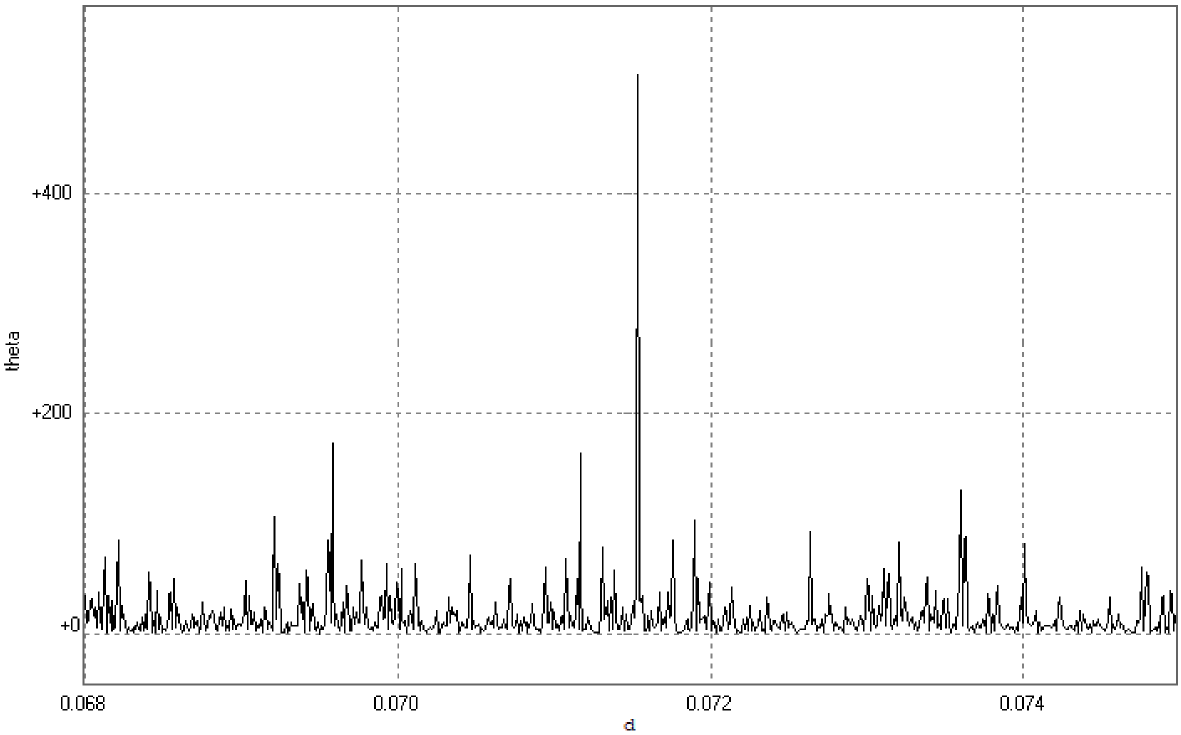

Figure 3. ANOVA power spectrum showing a dominant period of 0.071531 d.

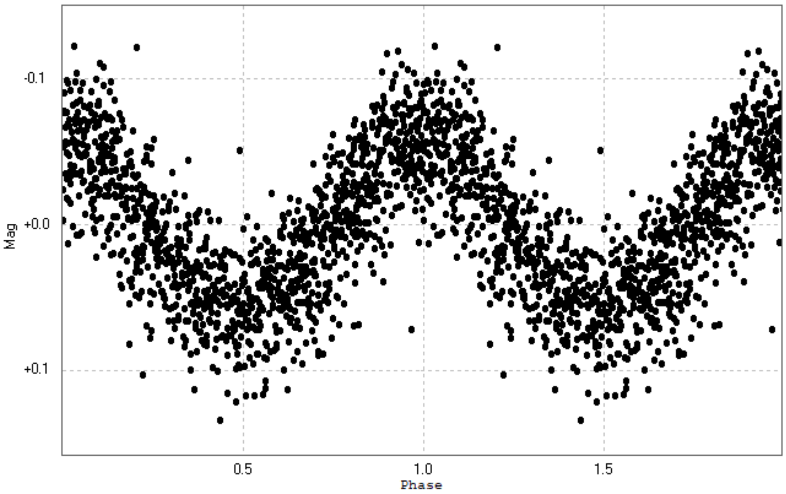

Figure 4. Phase diagram (double phase) based on the observed periodicity of 0.071531 d and an HJD epoch of 2456561.797812.

Comparison with ASASSN-V J020549.64+470040.9 / ZTF J020549.65+470041.0

ASAS-SN observed UCAC4 686-012519 (designated ASASSN-V J020549.64+470040.9) between 2013 Nov and 2018 Nov with a median cadence of 1.88 days for the 480 observations. The star was identified as a δ Scuti variable with a period of 0.0692277 d (99.688 min) and an amplitude of 0.14 mag. A similar period was found by ZTF. This period is some 0.0023 d (3.31 minutes) shorter than that observed in the present study but is within the 2σ uncertainty of the MicroObservatory estimate. The unfiltered mean magnitude and amplitude derived from the MicroObservatory observations are 14.1 and 0.1 mag respectively, compared with 13.86 and 0.14 mag determined by ASAS-SN, and may reflect differences in the photometry, comparison stars and filters used for the two sets of observations. Notwithstanding these differences, the observations support the findings by ZTF and ASAS-SN that UCAC4 686-012519 is a δ Scuti variable with a period of ~103 min and an amplitude of ~0.1 mag.

Discussion

The present study demonstrates the value of MicroObservatory for observing a known transiting exoplanet for ephemeris maintenance whilst simultaneously characterising the stellar variability of another star. Furthermore, the observations support the findings by the Zwicky Transient Facility and the All-Sky Automated Survey for Supernovae that UCAC4 686-012519 is a δ Scuti variable with a period of ~103 min and an amplitude of ~0.1 mag.

Whilst serendipity has clearly played a role in the positioning of the variable within the FOV of 16 out of the 43 HAT-P-32 observation runs that were used for ephemeris maintenance, a non-exhaustive search of other transiting exoplanet host stars that are routinely observed by MicroObservatory has shown that variable stars have also been observed in a number of their respective star fields. These include TrES-1, TrES-3, TrES-5 and WASP-77. With ~30 exoplanet targets being routinely observed by MicroObservatory throughout the year, it is considered that there be benefit from a systematic search of these datasets to identify variable stars worthy of further characterisation.

Acknowledgements

Frank Sienkiewicz of the CfA Science Education Department is thanked for supporting this study with the observation of HAT-P-32 from the MicroObservatory archive. The sponsors of MicroObservatory include the US National Science Foundation, NASA, the Arthur Vining Davis Foundation, Harvard University, and the Smithsonian Institution. MicroObservatory is a project of NASA's Universe of Learning, supported by NASA Award # NNX16AC65A. This research has made use of NASA's Astrophysical Data System (ADS

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Eclipsing Binary News

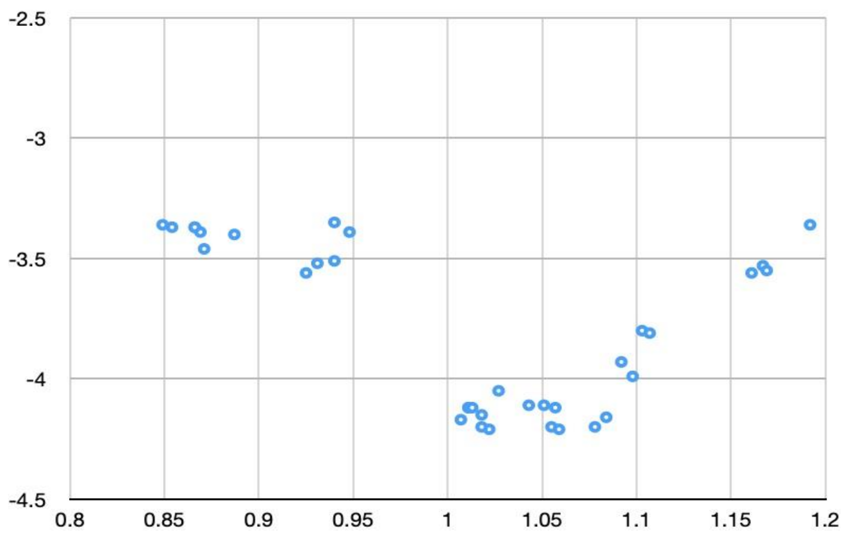
Des Loughney

Finding the new period of beta Lyrae

There seems to be some uncertainty about the current period of the famous eclipsing binary Beta Lyrae which has given its name to a whole class of eclipsing binaries. The uncertainty has meant that Krakow no longer publishes predictions for primary minimum on its website. I thought that it would be worthwhile to try and collect, in 2020, enough DSLR measurements of the observed primary minimum in order to compute the current period. Bill Parkes, who also uses the DSLR methodology, has also made measurements which are included in the diagram below. He has made measurements throughout 2020. I use a Canon 550D camera and a 100mm Canon lens. Bill uses a Canon 700D camera and a Canon 200mm lens. Although the equipment is different the measurements are similar.

The diagram below is a partial phase diagram which has been constructed to display our measurements around the predicted time of mid primary minimum. The phase diagram has been calculated assuming a period of 12.9408 days which was the last period quoted by Krakow. The vertical axis of the diagram is unfiltered magnitude. If the period was correct the primary minimum would be centered on 1.

From the diagram it can be seen that the primary eclipse lasts about two and a half days. It is therefore awkward collecting data across a primary eclipse because much of it takes place during daylight. We had hoped to collect a significant amount of new data during the eclipse that was predicted around the 7 November 2020 to the 9 November 2020. However, no measurements were possible at all, in our parts of Scotland, during those three days because of the weather.



The measurements that have been made so far in 2020 seem to suggest that the primary minimum is centred on 1.05 on the phase diagram. This means that the eclipse is occurring about 15.5 hours later than predicted assuming a period of 12.9408 days. It is our view that this suggests that there has been a significant change in the period. It has lengthened.

We think that a new period can be worked out but we need more measurements to do this reasonably accurately. We need more measurements to populate the phase diagram in the areas between 0.95 and 1 of the phase diagram and between 1.1 and 1.15 of the phase diagram. We hope that we will

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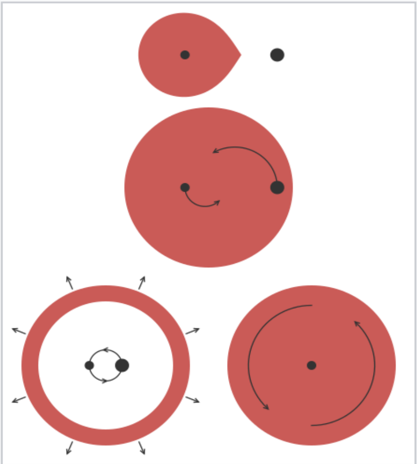
have enough measurements to write a formal article announcing the new period in the next edition of the VSSC. A reliable new period will allow good predictions to be restarted.

HW Virginis Systems



Key stages in a common envelope phase. Top: A star fills its Roche lobe. Middle: The companion is engulfed; the core and companion spiral towards one another inside a common envelope. Bottom: The envelope is ejected and forms a PCEB or the two stars merge.

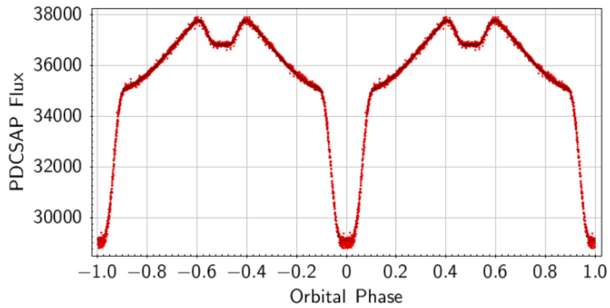
It has come to my attention that there is a sub class of eclipsing binaries named HW Virginis systems. The type system "comprises an eclipsing B-type subdwarf star and a red dwarf star that orbit each other every 0.116795 days" according to Wikipedia. The period is about 3 hours. The out of eclipse magnitude of this Algol system is 10.9. The primary eclipse has a depth of 0.8 magnitude.

According to Wikipedia the HW Virginis system is also a "post common-envelope eclipsing binary". *Left* is a diagram from Wikipedia illustrating how such a system might have evolved.

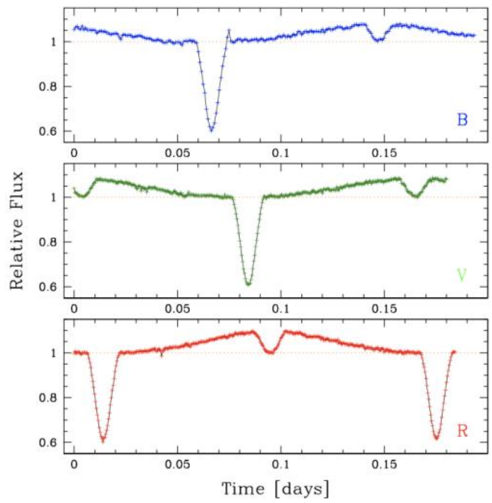
EPIC 216747137

A preprint of a MNRAS paper is now available. It refers to EPIC 216747137 which is a new HW Vir eclipsing binary (1). The system was observed over 81 days by the Kepler space telescope. It was then reobserved in 2017 from the South African Astronomical Observatory which obtained better data because of "the poor sampling rate of the K2 long-cadence data".

Below, taken from the paper, is the K2 light curve (*left*) and the SAAO light curves.



K2 Light Curve



SAAO BVR light curves. The flux is normalized to the level just before and just after primary eclipse.

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AAVSO Eclipsing Binary Data Mining Project

In a communication of 3/11/20 the AAVSO announced a data mining project: <https://www.aavso.org/new-data-mining-project-finding-offending-eclipsing-binary-0>. According to Sebastian Otero the AAVSO has a database of 148 objects that are eclipsing binaries which were originally suspected as being exoplanets. These objects now need to be checked ("perfectly suited for a novice to work with") so that they are properly identified.

Reference

1: "EPIC 216747137: a new HW Vir eclipsing binary with a massive sd0B primary and a low mass M-dwarf companion"

RV Aps: A very interesting but poorly studied Eclipsing Binary Syestem

ANDRE DEBACKERE[1], JOHN MURPHY[2], CONRAD STEVENS[3], LAURENT CORP[4], PAUL ROCHE[5], FRASER LEWIS[6], DAN REICHART[7], DAVID VALLS-GABAUD[8], OLEG MALKOV[9]

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[3]Towers School and Sixth Form Centre, Ashford, UK, Canterbury Academy, Canterbury, UK, Leight Academy, Dartford, UK

[4]Double Star Committee of the Société Astronomique de France

[5, 6]Faulkes Telescope Project, Cardif, UK

[7]Skynet Robotic Telescope Network, North Carolina, USA

[8]Paris Meudon Observatory, OBSPM, France, scientific advisor of the Double Star Committee of the Société Astronomique de France

[9]Institute of Astronomy of the Russian Academy of Sciences, Moscow, Russia

We present observations of the poorly studied eclipsing binary system, RV Aps. We report a photometric monitoring of RV Aps, consisting of ~ 1800 individual measurements in the B, V, and rp bands gathered over a three-year period as part of a collaborative programme with the Faulkes Telescope Project. We detected eclipses and we find that our observations are consistent with the elements (Min I = HJD 2453574.517(18) + 34^d.07502(06) x E, 12^m.1-14^m.0: V, D = 0^P.08) as described by Khaliullin et al. (2006). The V band light curve (Fig.1) confirms the significant variation outside eclipses. Furthermore, our analysis of the main minimum in 2019 shows an anomaly in the V mag, which is lower than expected. The observations of the main minimum in March and April 2020 are consistent with those of 2018, however a few measurements in May 2020 again show this unusual decrease in luminosity. Finally, we report significant variability during the main minima without highlighting a period. A search of past observations also shows these variations.

Keywords: astronomy, double stars, eclipsing binaries, photometry

Introduction

Eclipsing binaries are poorly studied by amateur astronomers. These are double stars which cannot be separated by optical telescopes. Photometry of these objects makes it possible to obtain light curves which highlights their binarity. Our target is RV Aps, located in the “Bird of Paradise” constellation ($14^h24^m17^s.0$, -73°17’27’’, J2000.0; GSC 9269.00545).

During a meeting of the Double Star Committee of the Société Astronomique de France on September 30, 2017 held at the OCA (Observatory of the French Riviera), Laurent Corp requested observations of RV Aps (also known as HV 5079), a “forgotten” eclipsing binary discovered in 1928 (Swope, 1931). RV Aps an eclipsing binary studied for the first time in 1931 by Henrietta Hill Swope then by Khaliullin et al. (2006). This object is located in Apus (genitive Apodis) a small constellation of the southern hemisphere situated between the Southern Triangulum constellation and the South Pole, and thus unobservable from the northern hemisphere. André Debackère suggested using the robotic telescope networks to which he has access: the Faulkes Telescope Project (using the LCO global network) and SKYNET. The LCO telescopes (0.4m and 1.0m) located in Siding Spring (Australia), Sutherland (Southern Africa) and Cerro Tololo (Chile) allow us an almost continuous observation of the target (Brown et al., 2013). The SKYNET telescope (0.6m, PROMPT3) is located in Cerro Tololo (Chile).

Observing Campaign – International collaboration

On the strength of the experience acquired during a previous European Comenius project, Debackère proposed involving the schools with whom he had worked from 2010 to 2012. The English and Irish colleagues responded positively to his call and we got organized to observe. It was the start of a long and fruitful collaboration. Our first observations of RV Aps began in January 2018.

The schools' team consists of Conrad Stevens (UK), John Murphy (Ireland) and André Debackère (France). LCO telescope time was shared between the three observers. Management and coordination of observations on LCO are provided by Debackère in collaboration with Paul Roche (Cardiff University, UK) from January 2018 to June 2020.

Observations on SKYNET are provided by Debackère in collaboration with Dan Reichart (North Carolina University, USA) in 2018.

Downloading, unzipping, conversion to FITS format, correct orientation (North up and East left), photometric measurements of all the images obtained are carried out by Debackère.

The analysis and exploitation of the data is carried out by Laurent Corp and Debackère under the scientific expertise of Oleg Malkov.

RV Aps system

Parameters of the components (Khaliullin et al., 2006).

The parallax of this object is 0.4350 ±0.0331 mas (Gaia-DR2, ESA), which corresponds to a distance of ~2300 pc. The two stars orbit around the centre of gravity of the system which is much closer to A than to B (star A being ~8.5 times more massive).

The distance separating the two stars is very small, about 41.5 x 10^9 m

Seen from Earth this system of two stars is not separated, and images reveal only a single bright point, but the particular light variations reveal the duplicity.

Parameter	**Primary**	**Secondary**
Spectrum	A2V	K4III
Mass	2.20 M⊙	0.26 M⊙
Radius	2.72 R⊙	13.1 R⊙
T_{eff}	8750 K	3900 K
BC bolometric correction	$-0^m.08$	$-0^m.90$
I **inclination**	83°.8	
A **radius of the relative orbit**	59.7 R⊙	

Science imagers

Corp provides the ephemeris of the minima whilst Debackère prepares the observations.

- from the LCO website based in the target's visibility from the three sites located in the southern hemisphere and the acquisition rates. Debackère distributes the requests for observations between the three observers in order to share the observation times.

- from the SKYNET website according to the target's visibility from Chile.

Site	Cerro Tololo	Cerro Tololo	Cerro Tololo	Siding Spring	Siding Spring	Sutherland	Sutherland	**Total**
Network Diameter	LCO T0.4m	SKYNET T0.6m	LCO T1.0m	LCO T 0.4m	LCO T 1.0m	LCO T 0.4m	LCO T 1.0m	
V band	427	172	17	298	10	249	10	1183
B band	118	68	14	54	10	23	10	297
rp band	108	88	14	50	10	21	10	301
Total	653	328	45	402	30	293	30	**1781**

Table 1. Statistics per instrument.

Data

Image preparation

All images are prepared for photometry by Debackère (download from the LCO and SKYNET websites, unzip, conversion to FITS format, photometric measurements).

Optical Photometry

Comparison stars

To undertake photometry of a variable star we must have comparison stars whose brightness remains stable during the observations. However, in the case of RV Aps, being poorly studied, there is no reference field for photometry. Debackère therefore looked for comparison stars following the recommendations given by the AAVSO and checked their stability over time. The initial choice of comparison stars included 3 stars: C1, C2 and C3. Finally, after checking stability, only stars C2 and C3 were retained (Table 2).

ref	UCAC4 catalogue GAIA-DR2			APASS catalogue			
	Id	RA	DE	B-V	V mag	B mag	r' mag
C1	083-039444	14:24:49.862	-73:24:19.85	0.465	13.437	13.902	13.320
C2	**083-039366** **5796625305941972736**	**14:24:02.426** **14:24:02.733**	**-73:28:59.06** **-73:28:59.07**	**0.428**	**12.377**	**12.805**	**12.288**
C3	**085-041556** **5796644787913767808**	**14:22:58.405** **14:22:58.407**	**-73:09:41.54** **-73:09:41.55**	**0.460**	**11.889**	**12.349**	**11.768**
RV Aps	084-040405 5796631967425008512	14:24:17.039 14:24:17.040	-73:17:27.14 -73:17:27.16	0.469	12.060	12.529	11.882

Table 2. Comparison stars and target identification.

Aperture photometry

Swope, 1931 gives the light elements Min = 242536.4+34^{d}.074xE (based on 310 observations). There is no known photometric measurement between this publication and January 2003.

About 600 measurements in V-band are available on the ASAS-3 photometric catalogue (between January 10th, 2003 to October 6th, 2009). Our observations are shown in Table 3 with ~1800 images in the B, V and rp band. Such a detailed study has never been performed on this star (Fig.2, Fig.3, Fig.4).

Year 2018	**Number of images per observer usable for photometry**		
Filters	A. Debackère	C.Stevens	J. Murphy
V	301	64	86
B	142	64	91
rp	157	60	84
Year 2019			
V	90	141	107
Year 2020			
V	184	71	139
Total per observer	874	400	507
Total in V band	1183		
Total in B band	297		
Total in rp band	301		
Total of images	**1781**		

Table 3. Statistics per observer

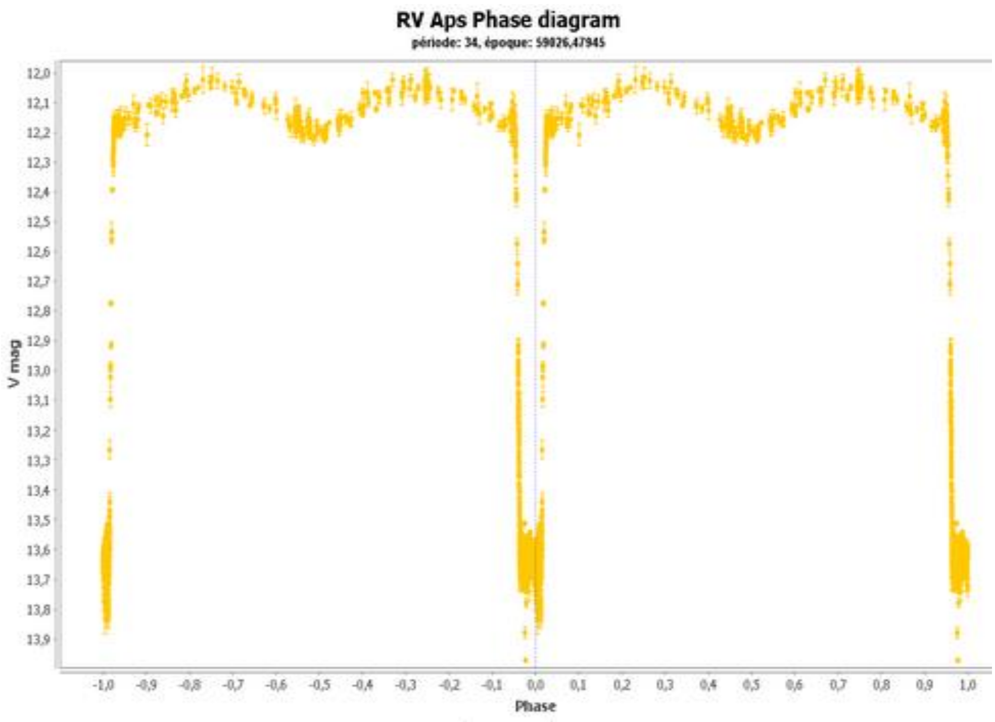

Figure 1. V-band light curve of RV Aps, phase folded.

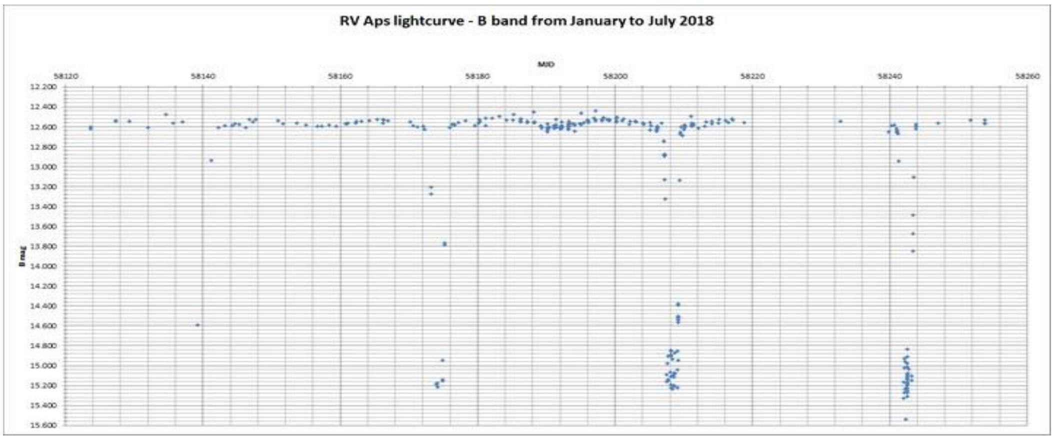

Figure 2. B-band light curve of RV Aps.

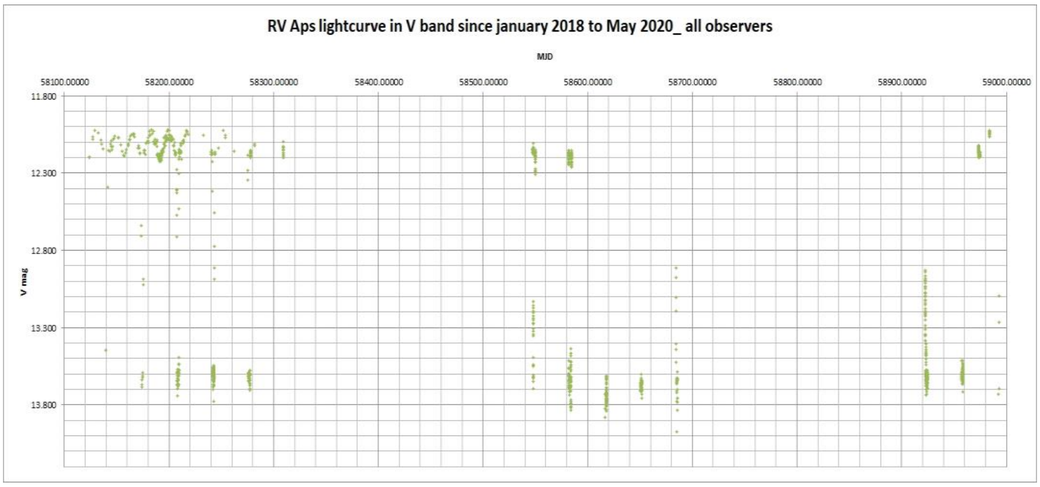

Figure 3. V-band light curve of RV Aps.

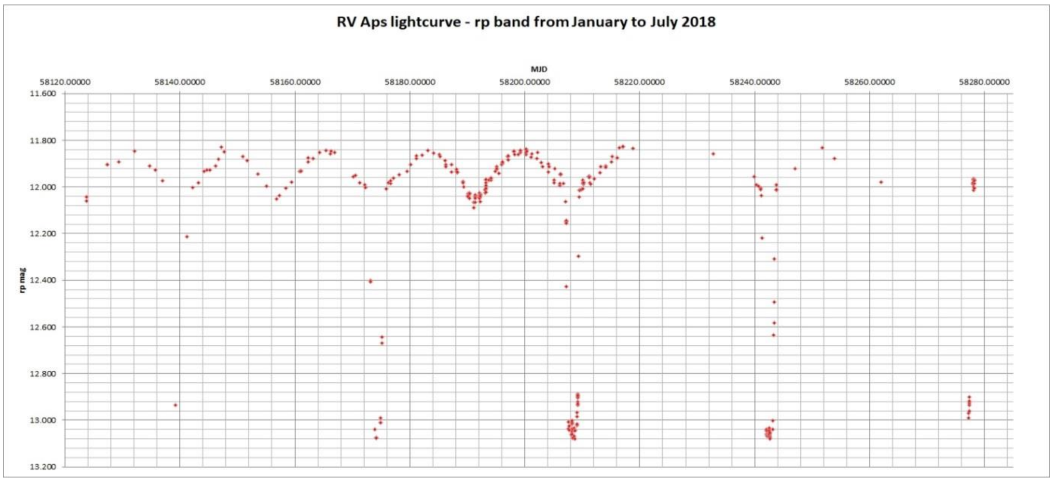

Figure 4. rp-band light curve of RV Aps.

Analysis

Older Observations

Swope (1931) indicated a variability range between $10^m.6$ and $15^m.2$ pg, whereas the ASAS-3 data in the V-band show a variability range between about $12^m.0$ to $14^m.0$ (Fig.5).

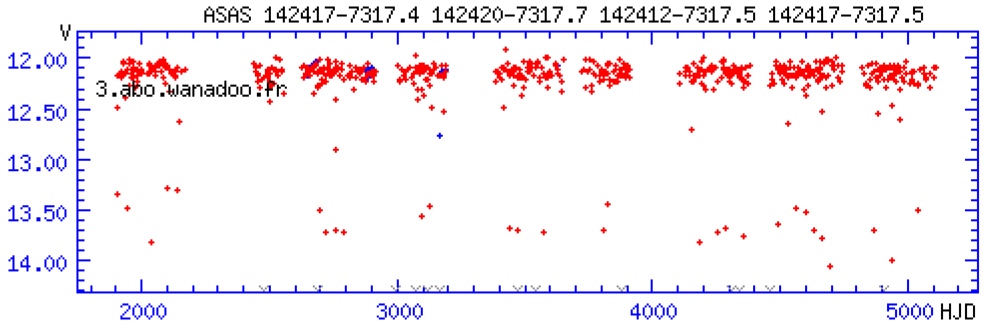

Figure 5. ASAS-3 light curve based on observations from January 10th, 2003 to October 6th, 2009.

Our observations

We do not find the large variability range (between $10^m.6$ and $15^m.2$ pg) indicated by Swope (1931) but our observations are consistent with the ASAS-3 data with the same variability range in the V-band between $12^m.0$ to $14^m.0$ as can be seen on Fig.1.

Variability detected

The statistics per year of our measurements during the main minimum are shown in Table 4.

We have compiled all our observations in V band of the main minimum in one period (Fig. 6). Considering all of our measurements during the primary eclipse ($1^d.7$), we get an amplitude of about $0^m.5$ (Table 5), much greater than the margin of error.

Year	2018	2019	2020
Number of Min I	7	5	3
N measurements	195	189	211
Duration (Days)	1.669	1.697	Incomplete
V mag average	13.614	13.697	13.620
Standard error	0.037	0.066	0.038
V mag min	13.492	13.523	13.512
V mag max	13.777	13.972	13.737
Amplitude	**0.285**	**0.449**	**0.225**

Table 4. ASAS-3 light curve based on observations from January 10th, 2003, to October 6th, 2009.

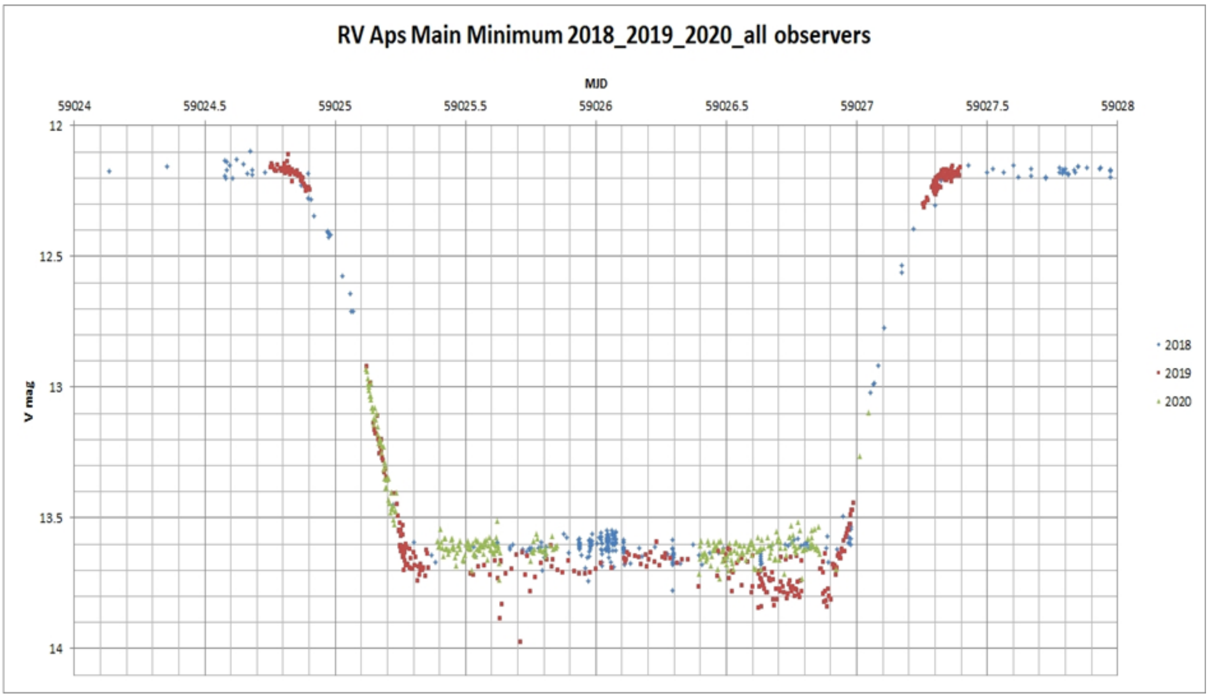

Figure 6. Compilation.

Years	2018/2019/2020
Number of Min I	15
Number of measurements	595
Duration (Days)	1.697
V mag average	13.642
Standard error	0.047
V mag min	13.492
V mag max	13.972
Amplitude	**0.460**

Table 5. Variability during the main minimum. All years.

Presentation of our work

Debackère and Corp presented the progress of our work during the fall meetings of the Double Star Committee of the Société Astronomique de France in Rodez, Aveyron, France in September 2018, Debackère and Corp et al. (2018), and in Lille, Hauts-de- France, France in September 2019, Debackère and Corp et al.(2019).

Discussion

We were surprised not to find the typical shape of the light curve of an EA-type eclipsing binary, especially during the main minimum where we notice a significant variability of about $0^m.6$. The 2019 anomaly (red dots) was not found during the 2020 campaign (green dots). The values obtained in 2020 are consistent with those obtained in 2018.

How to explain the 2019 anomaly?

One possibility is that the secondary component (K4III) observed alone during the totality of the eclipse during the main minimum is a semi-regular variable which presents irregular luminosity oscillations like those seen in RV Aps.

The typical period range of semi-regular variables is generally 30 to 1000 days, with an amplitude not exceeding 1 to 3 magnitudes.

Second possibility is that the significant variability during the main minimum is linked in some way to contamination by another star and/or star spot activity or even limb-darkening.

Photospheric spot activity is supported by the fact that the observed variations are very significant compared to the photometric errors. Future work will search for a cycle in the variations of brightness in the eclipses, including a second significant peak in the period diagram. In this case there should be phase opposition during the secondary eclipse.

Modelling

Using the software “BinaryView”, the following system parameters are determined:

Binary parameters
Mass ratio (M_B/M_A) = 0.118
Inclination = 83°.8

Primary star
Radius (R_A/a) = 0.046
Temperature (K) = 8750.0

Secondary star
Radius (R_B/a) = 0.219
Temperature (K) = 3900.0

We observe a strong deformation of the secondary component.

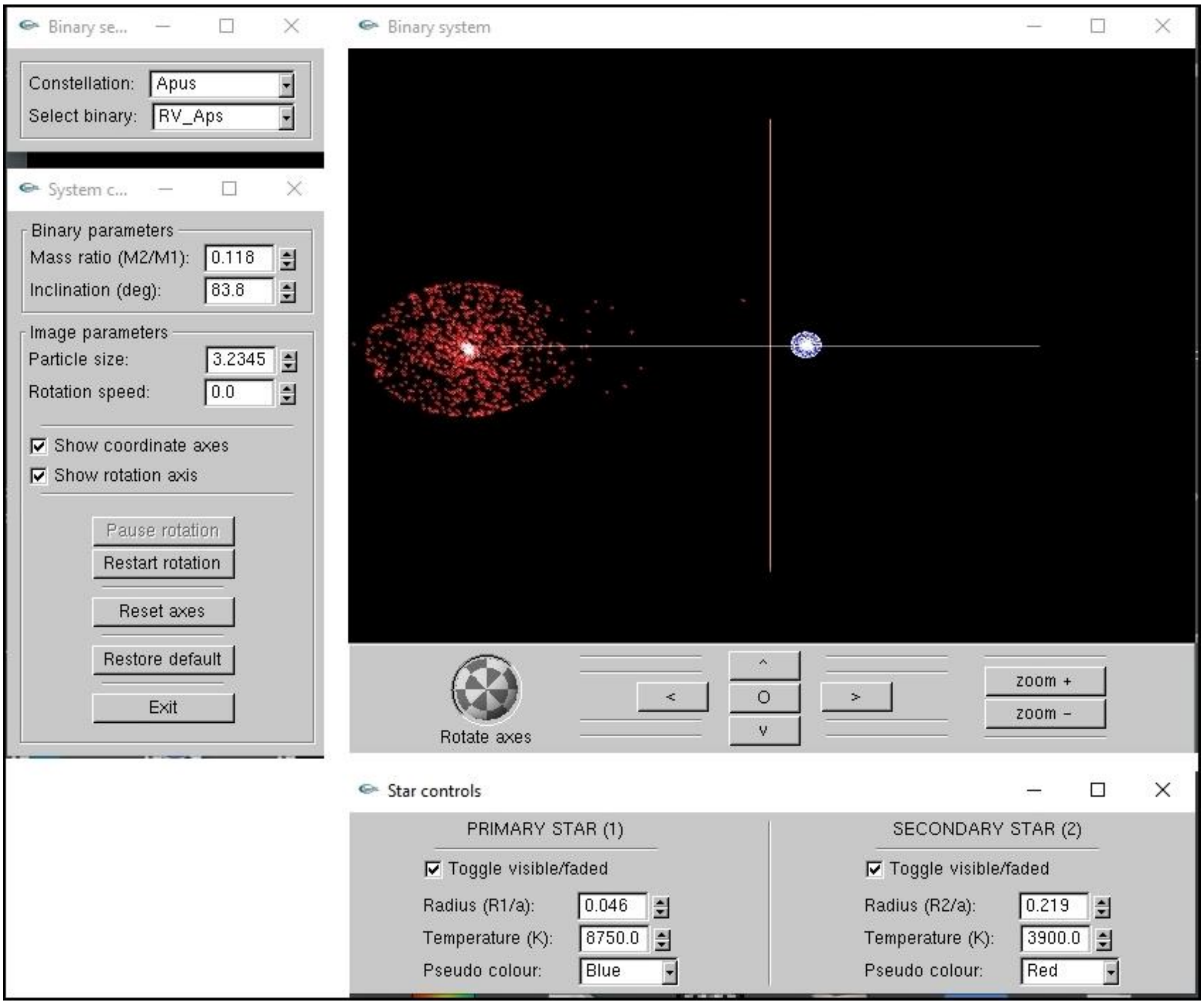

Figure 9. StarLightPro freeze frame

Conclusions

We carried out 7 series of observations in 2018, 5 in 2019 and 3 in 2020 and nearly 1800 photometric measurements which, to our knowledge, had never been done before.

This long collaborative work over a three-year period highlights a deep main minimum and a much less pronounced secondary minimum which indicates that the two components are differently sized, no plateau outside of eclipses which suggests limb-darkening and deformation of the components. Our measurements confirm the period of $34^{d}.07502(06)$ and show a variability range between $12^{m}.02$ and $13^{m}.97$ in V band that is consistent with Khaliullin et al. (2006). In addition to the variability recorded during each main minimum observed in 2018, we noticed an unexpected increase of the magnitude in V band in 2019, but not confirmed during the 2020 campaign, Debackère (2020). This star is really curious! we need to keep studying it by improving the modelling and measuring the radial speeds.

In order to improve modelling D. Valls-Gabaud suggests using some codes like PHOEBE2 which allows adding photospheric spots. He advises to use the book of Kallrath and Milone (2009) which is the reference in the subject where we can see the different effects that act on the light curve outside eclipses and which explains how to use the Wilson-Devinney code for modelling.

Concerning spectroscopy, Valls-Gabaud says “The ideal would be, of course, to have radial speeds. As much as there are amateurs who could take spectra in the Northern hemisphere, it’s not easy in the South. Maybe as at CFHT (Espadons), but the request should be substantiated even the target is quite bright and will allow for short observation times”.

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Acknowledgments

The author warmly thanks all the people involved in this study and more particularly Paul Roche who allowed us to obtain so much telescope time from the Faulkes Telescope Project. He would also like to thank Fraser Lewis for his technical advice and David Valls-Gabaud for his advice on the analysis of this very interesting object. Finally, the author greatly appreciated the involvement of his two colleagues John Murphy and Conrad Stevens and their students.

This research has made use of:

LCO global network.

VizieR catalogue access tool, CDS, Strasbourg, France (DOI: 10.26093/cds/vizier). The original description of the VizieR service was published in A&AS 143, 23 (2000).

SUBARU Image Processor: Makali’i

AstroImageJ software.

StarLightPro software.

VStar software.

Observations of the EW type Eclipsing Binary OO Aquilae

David Conner

The EW type eclipsing binary OO Aquilae is a 'young' binary system which is evolving by mass transfer between its components, and the system might also include a third object. It is part of my ongoing project to observe eclipsing binaries both from my own observatory and with an online telescope, and these are the observations to date.

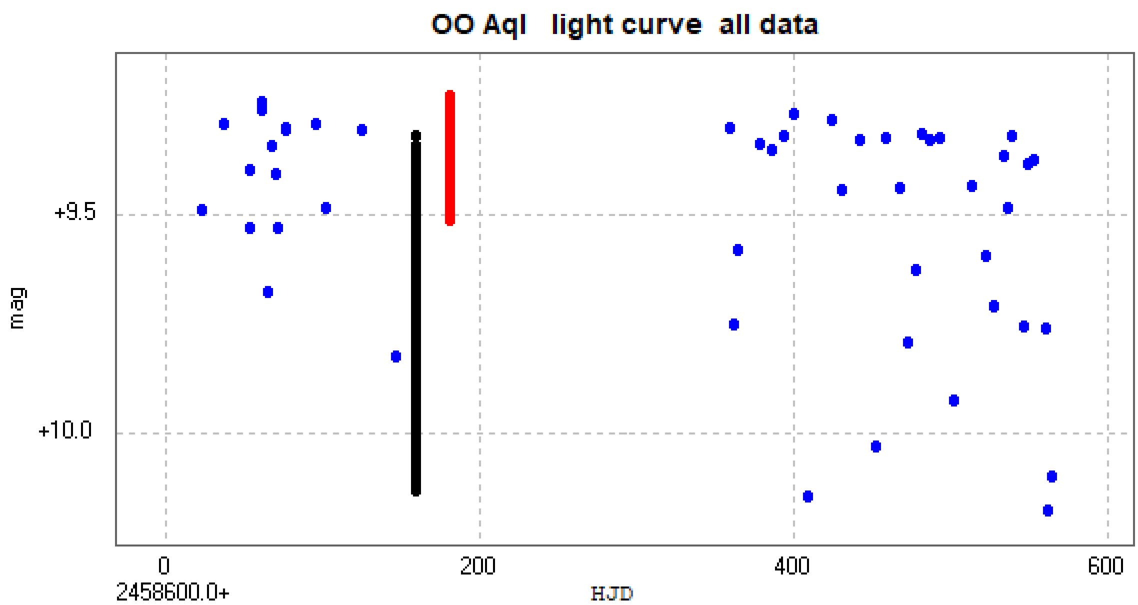
The eclipsing binary OO Aquilae was observed from Somerby, using the 2" Titan, and also with the Open University COAST telescope in Tenerife. The observations were then combined into a light curve and a phase diagram.

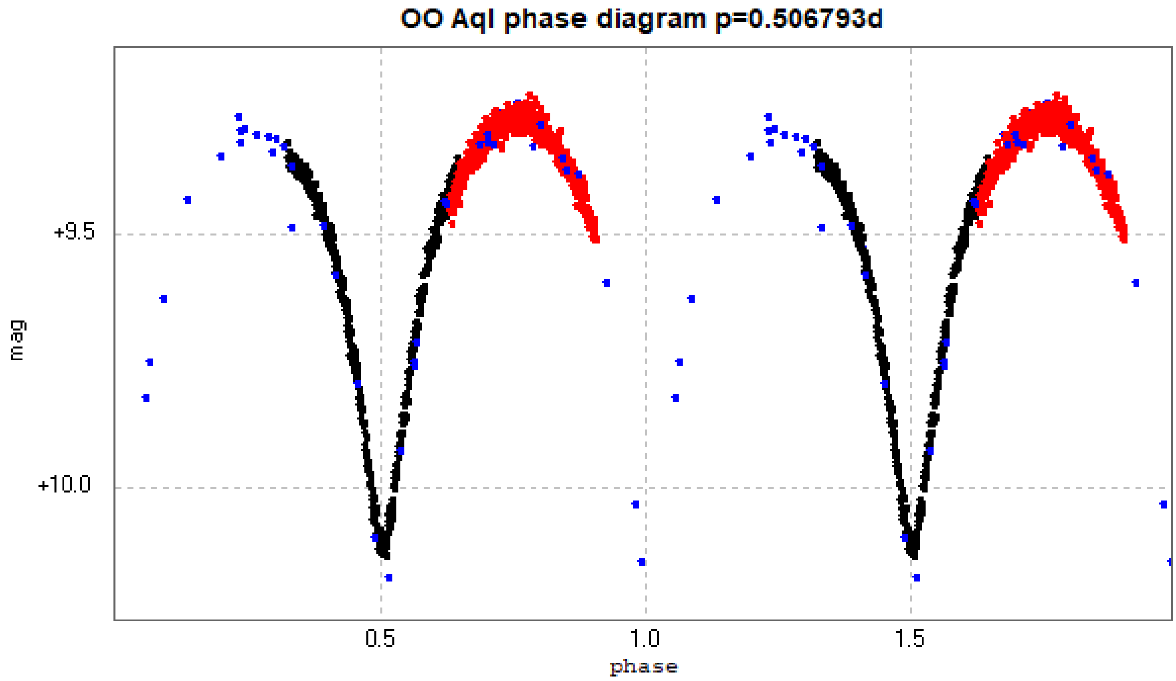
A *secondary* minimum of the star was observed with the Somerby 2" Titan on 2019 October 2. The 448 images were unfiltered. These are the black data points in the following diagrams.

A *maximum* was observed, also from Somerby, on 2019 October 24. This was coming out of a secondary minimum and going into a primary minimum. The 529 images were unfiltered. These are the red data points in the diagrams.

Between 2019 May 20 and 2020 November 10 a further 48 images were obtained with the Open University COAST telescope. These images were taken with a V filter. These are the blue data points in the diagrams.

No transformations have been made to compensate for the different filtering used.





The period used in the phase diagram was the best fit period suggested by Peranso, and is consistent with the current GCVS value of 0.5067928d, although there is considerable O-C activity with this system (Kreiner). [Accessed November 2020]

This is an evolving 'young' system, astronomically speaking, and the two components are currently of similar mass (eg Hrivnak *et al* 2001). The possibility of there being a third body in the system has also been discussed (Demircan and Gürol 1996)

The next task is to observe a *primary* minimum in more detail.

Further information about this and other eclipsing binaries can be found on my website

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