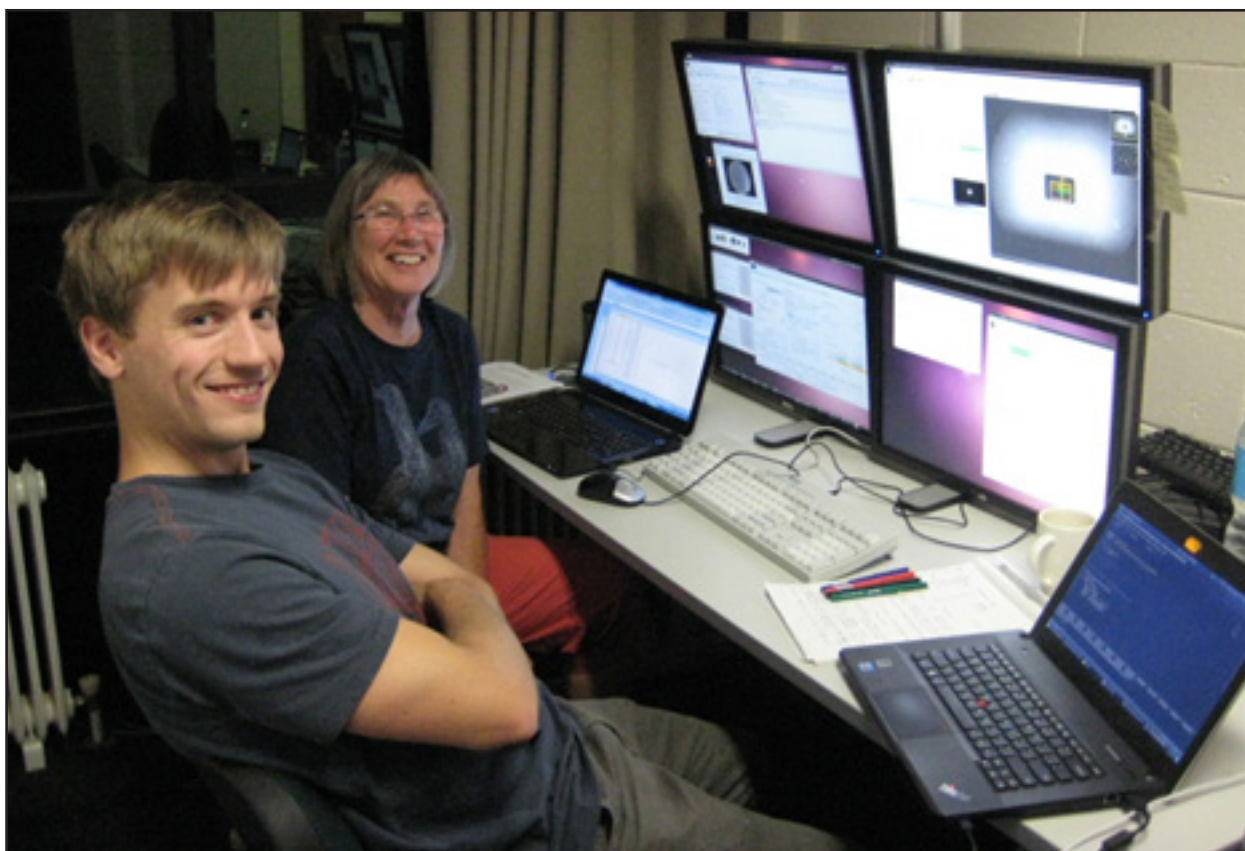




*Simon Murphy and Margaret Streamer at Mount Stromlo operating the 2.3m telescope at Siding Springs.
See Margaret's article on page 7*

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From the outgoing director – *Tom Richards*

And now for someone completely different...

It's been six years now since the RASNZ Council handed me the reins of the somewhat mothballed Variable Star Section of the RASNZ. Since the late Frank Bateson's retirement Pauline Loader had kept it in existence then gratefully passed it on. (Pauline is now doing analysis work for the Semi-Regulars Project.)

Unlike the old VSS, the new approach was to use the tools of modern information and communication technology to encourage and support the development of specific projects. This has worked very well indeed, though I think there are many ways it can be expanded, especially in the retention of and access to the derived results and analyses (not just the raw observations – that's the province of the AAVSO). Imagination needed here!

Now it's the turn of Stan Walker to make VSS grow. Stan has arguably been the most significant variable star amateur in the New Zealand scene for four decades. Back in the sixties he seized on the new technology of photoelectric photometry to develop new and significant areas of research, creating, it must be said, some tension between the old ways of the VSS and the "Auckland push" guided by Stan. I think Stan won. Now VSS is his; give him your support!

Before I disappear into the world of research unencumbered by administration, I'd like to thank the management team who have made VSS as an organization what it now is. David O'Driscoll in Brisbane managing the ICT and especially the website – a great ideas man and a joy to work with. Bob Evans in subantarctic Invercargill looking after money and membership, and providing much good advice and experience. Phil Evans in tropical Rarotonga seemingly effortlessly delivering an outstanding newsletter which just gets better and better.

But the *raison d'être* of VSS is its research projects, and for that I must thank the project leaders who have developed and run such important and exciting projects, and all those who have contributed observational data to them and done the vital analysis work. This rather decentralized approach to VSS has worked well, and my big hope and expectation is that Stan will develop it in new ways, and especially with the help of an expanded management team so he's not just the clerk of works. Also, my thanks to all who have offered ideas and advice to me; and in this category I must again single out Stan, who kept up a running and critical dialogue with me over these years and without whom I would have floundered around a lot more than I did. And finally, thanks to my wife Lyn who not only put up with all my distractions and problems, but actually encouraged me.

OK Stan, it's over to you.

From the director – *Stan Walker*

Some thoughts for the year ahead

Well, I don't think I'm all that different from Tom in my astronomy - but at this time he's managing far more observing than I am. We both like to make measurements of stars in an attempt to find the ones that are different and collect enough measures to produce something worthwhile for other people to see. Sometimes the results are spectacular - at others the star hides its secrets well.

Tom makes some nice compliments but in Auckland it was a team effort and we were lucky in that there were new fields to explore - flare stars, dwarf novae, even some interesting Mira stars and we received help from many people including many professional astronomers in what was, at that time, a small community of astronomers who all knew one another. This is an area I'd like to pursue and the first opportunity will come at Tekapo in May.

Tom has done extremely well in getting Variable Stars South up and running well and there have been interesting developments in eclipsing binaries and DSLR photometry by members. I think one measure of his successful guidance is the number of hits or downloads of items on the website maintained by

David O'Driscoll. Then there are the three Symposia and papers presented by members at either NACAA or the RASNZ annual conferences - I often think back to a long discussion Tom and I had in 2006 whilst strolling along the New Plymouth waterfront walkway and think how far we've all come since then. And a few months before each conference Tom is in there encouraging another presentation so it's my turn to suggest that you consider something for the RASNZ Conference in May.

There are no plans for dramatic changes but I'd like to encourage our members to take a little time away from observing - it does rain occasionally - and tell the rest of us what you're doing and why. One of my priorities will be to follow up on the various active projects so I know what is going on. When you live in NZ's Far North and 'broadband' is a startling 33KB/sec you realise that there are some disadvantages to clear skies and no street lights.

We explored some ideas for the future over a couple of months before Xmas. One change has been that we've set up a more structured management group to spread the load a little - largely based on Tom's management team. We have Tom on this as the outgoing director, I'm there until 31 December, 2017, at which stage we hope a younger person will take over the reins. To this we add Phil Evans, David O'Driscoll and Bob Evans with their particular responsibilities, with Mark Blackford and David Moriarty making up the number. And at least five of that group are committed to attending the Mt John Observatory Anniversary in early May which will provide opportunities for some useful discussion.

Another retirement is, of course, Arne Henden of the AAVSO. I've had some helpful and promising correspondence with the new director, Stella Kafka, but we both agreed to delay further discussion until she had moved to Boston later this month and we southerners had recovered from the holiday season.

Returning to the concept of establishing better relationships with professional astronomers who can help guide us in what we're doing and research possibilities - if any of our members have contacts in this area let's know. Harking back to the early days in Auckland we had Bruce Slee of the CSIRO working with us on flare star programmes, Brian Warner in South Africa and the European astronomers at La Serena in Chile swapping information in the CV field and Ed Budding who was instrumental in encouraging many overseas professionals to get behind the PEP conference series. It will take some time to develop but it's not impossible to recreate something along those lines. The Mt John event should help to develop this. So best wishes for 2015 - let's make it another good year for Variable Stars South.

Activities in 2014 — *David Moriarty*

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Observatory and equipment

An observatory has been established at Salileos Farm, Glen Aplin (south east Queensland, altitude 750 m), housing the Celestron EdgeHD 14 on a Mathis Instruments 500 equatorial fork mount in a Sirius Observatory with a motorised dome rotation system.

It took until October to get the Mathis mount and controller to work well, after being informed by Daniel Coley, a user in the USA, that the Sidereal Technology Servo 2 (SiTech) software shipped with the mount controller was an old beta version with outdated firmware, which caused the PEMPro programme to give wrong data for periodic error control and polar alignment. Furthermore, the SiTech Servo website had not been updated for a long time and users were not informed that the only way to receive the latest versions of software and firmware was via the Yahoo SiTech Servo users group.

Also, the operating manual did not describe the correct procedures for modelling the mount. Therefore, all imaging with exposures of more than about 25 seconds with astrometric resynchronisation prior to October was affected by tracking errors.

With advice from two principal members of the SiTech Servo users group, I have now determined an accurate mount model from image astrometry of 35 positions around the sky above 28° altitude. The SiTech Servo system corrects drift in both RA and Dec.

Clear images with at least 5 minute exposures (and probably more than 20 minutes) can now be ob-

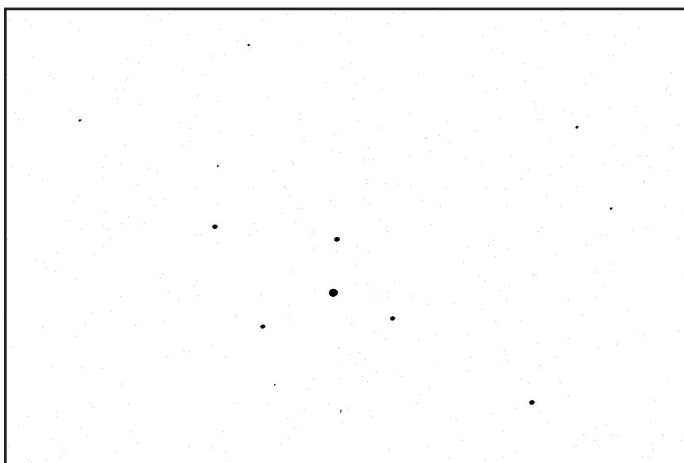


Figure 1. RX Gru 300 seconds, unguided.

tained without the need for guiding (Figure 1), The longest exposures needed thus far for faint targets (mag 15) are 3 minutes for time series with a fast cadence. The fork mount allows time series runs for the whole night on 1 target without the photometry errors due to image shifts on the CCD sensor that occur with German equatorial mounts.

An equipment issue with Schmidt Cassegrain telescopes is the effect of the focussing mechanism, which moves the main mirror and causes small shifts in the position of stars on the CCD sensor. Even with flat field corrections, these can cause variations of up to 0.05 magnitudes. With the large tempera-

ture changes that occur as the night progresses at Glen Aplin, especially in winter, refocusing is needed at intervals of 45 – 90 minutes. (Optec (USA) have manufactured a system based on locking the main mirror and focusing via the secondary, which would avoid that problem and greatly improve both the precision and accuracy of the photometric analyses. It will be installed in 2015.)

The computer equipment for both observatories and the software for imaging and analysis (MaximDL and ACP) for the Glen Aplin observatory were purchased with funds from an ECRF grant in 2014; the Celestron Edge 14 was purchased with an ECRF grant in 2012.

Some targets studied in 2014

V0775 Centauri

One primary and two secondary minima and a descent to a secondary minimum were recorded in B & V pass bands. Full light curves in B, V & I pass bands are required for transforming magnitudes and modelling this system. The light curve is asymmetric and the orbit is slightly eccentric as shown by the greater O-C values for the secondary minima, which occur a little after phase 0.5.

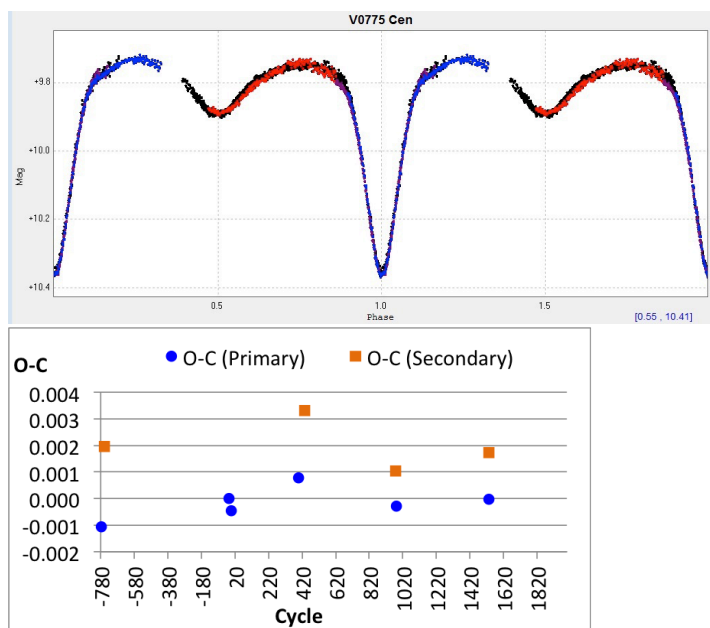


Figure 2. A phased light curve and O-C diagram for V0775 Cen.

TW Crucis

TW Cru is a contact binary with a period of 9.3 hours. The amplitude of the V magnitude varied by about 0.05 between eclipse cycles, probably due to star spots (Figure 3). The maximum after the primary minimum was usually 0.02 – 0.03 magnitudes brighter than that after the secondary minimum — the “O’Connell effect”, which is usually explained as being due to star spots. The B-V colour index is 0.9, indicating that the spectral type is K, and thus star spots are quite likely to occur, especially as strong magnetic fields would be present due to the rapid rotation of the system. In a preliminary model of the system, developed using Binary Maker 3, the best fit to an observed light curve was obtained when 3 spots were included (Figure 4). Now that the Mathis mount is working well at Glen Aplin, complete light curves in B, V & I pass bands will be obtained in 2015 to allow the magnitudes to be transformed, the model revised and a paper drafted.

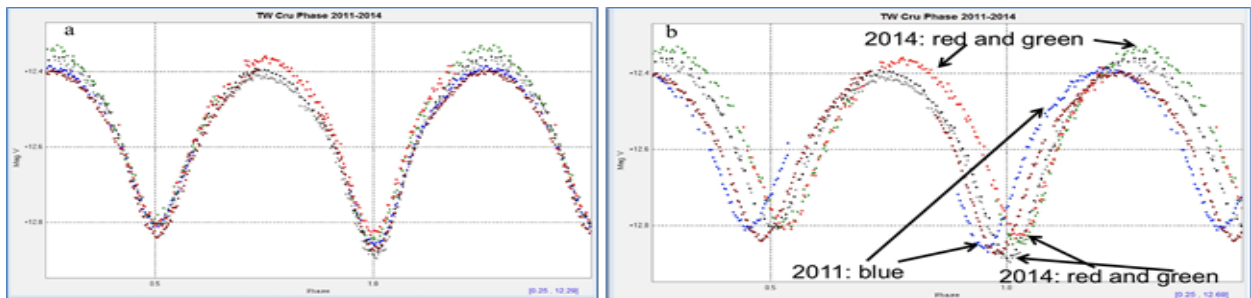


Figure 3. a: TW Cru phase-magnitude (V) plots for 2014-05-03 (green), 2014-05-04 (red) 2011-5-27 (blue); b: The phases of the eclipse cycles are offset and colours labelled for the benefit of spectrally challenged males.

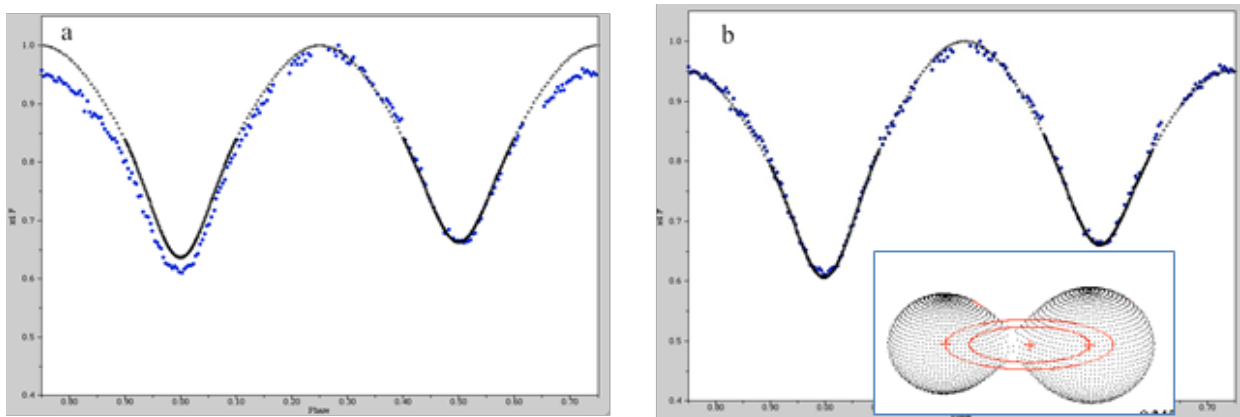


Figure 4. TW Cru binary model; observed light curve (blue dots) and modelled light curve (black crosses); a: no spots included; b: model with 3 spots. The binary shape is shown in 4b.

BC Gruis

BC Gru is a contact binary with a period of 7.3 hours. Over the past 28 years, there have been several studies of the light curve and period of this binary; each group reported a different period. One group stated that the original epoch for the primary minimum was actually based on a secondary eclipse. Given the historical data, it looked as though it would be an interesting target to study. I obtained 3 sets of the light curve in B, V & I pass bands on 2014-9-30, 2014-10-16 and 2014-11-14. There was a noticeable increase — reddening — in the B-V and V-I colour indices during both primary and secondary eclipses (Figure 5). The eclipse timings and light elements that I determined were not in agreement with those published by others; the O-C values over the past 28 years are variable, with no clear trend discernable. The secondary minima occur slightly out of phase with the primary, indicating orbital eccentricity. The difference in depths between the primary and secondary eclipse magnitudes is large — 0.1 (V band); therefore, it seems very unlikely that the original authors had mistakenly used the secondary minima to determine light

elements. In fact, this indicates that the period of BC Gru varies over the short time scale since its discovery by Hoffmeister in 1963.

In 2007 Dall et al reported that BC Gru is a triple system with all 3 stars having spectral types of K - K0. The most likely explanation for the varying period is the light travel time effect as the binary orbits the common centre of gravity with the third component of the system, which is probably close to the binary; it may also be causing

or contributing to orbital eccentricity and possibly apsidal motion. In fact, this indicates that the orbital period of BC Gru varies over the short time scale since its discovery by Hoffmeister in 1963

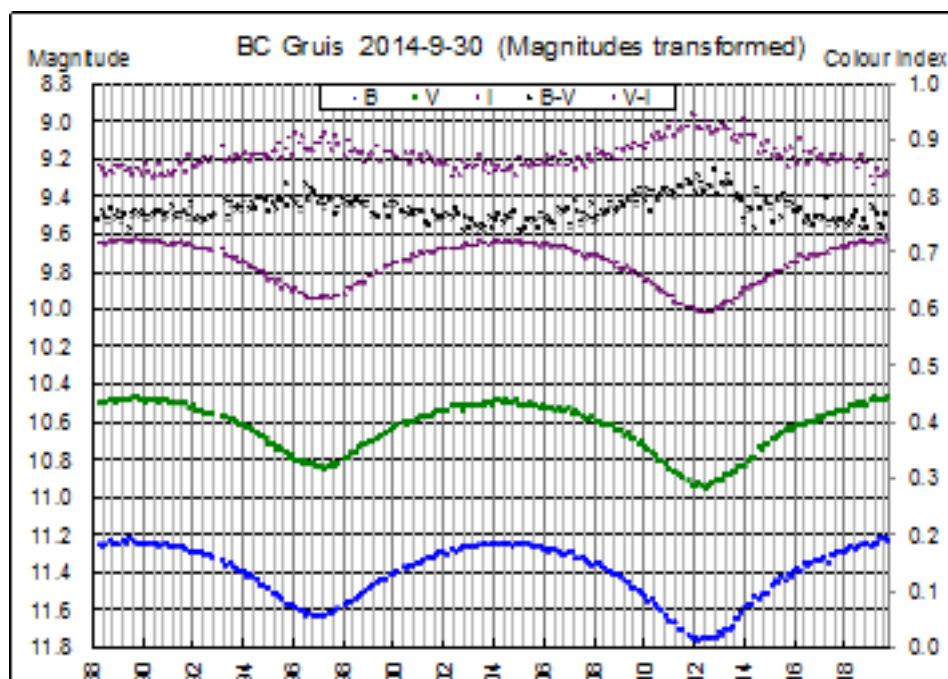


Figure 5. Light curves and colour indices of BC Gru.

RV Gruis

RV Gru is a contact binary with a period of 6.2 hours. Five eclipse cycles in B, V & I pass bands were observed in 2014. My data indicate that the period has increased by about 1.5 seconds since 1975; however, as data from a Czech group in 2013 show a decrease of 4 seconds since 1975, study of this system will be continued in 2015. The two stars are probably K spectral type and very similar in temperature. Margaret Streamer obtained a spectrum of RV Gru for me while observing TT Hor with the ANU 2.3m telescope (see Margaret's article on page 7). Similarly to BC Gru, the colour index is redder at mid eclipse than at maximum light (Figure 6).

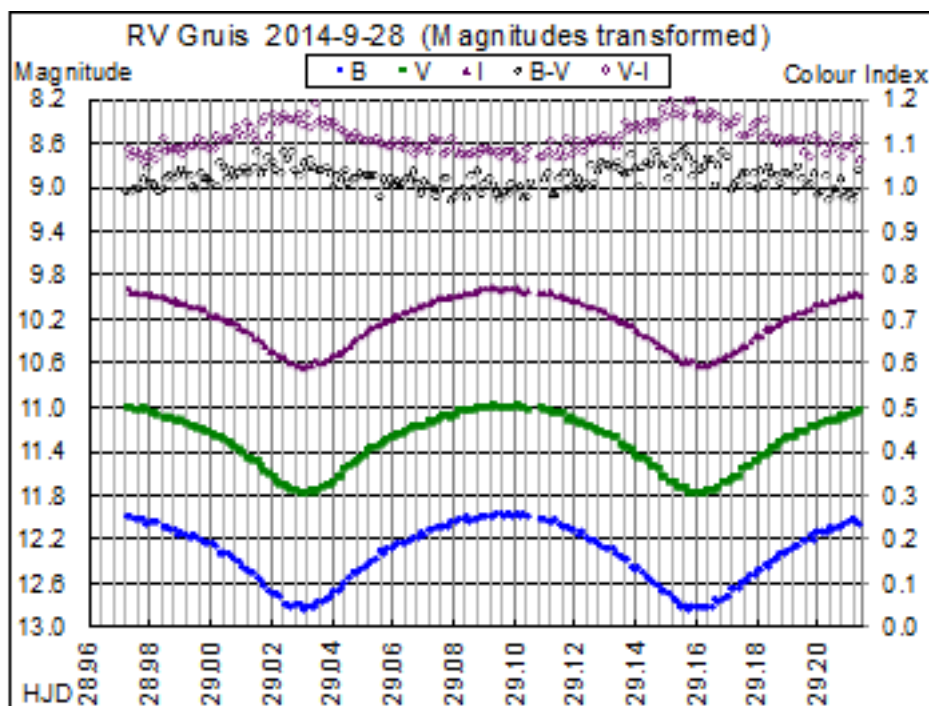


Figure 6. Light curves and colour indices of RV

Reference

Dall, T. et al. VSOP: the variable star one-shot project. A&A 470, 1201–1214 (2007)

2014 was dominated by two major endeavours for me.

The first was the decision to put together a paper reporting the results for the first 3 years of the SPADES project. I started just after Christmas 2013 and expected to have it submitted by Easter, 2014. How wrong could I have been! I finally submitted the paper in October 2014 to the Journal of the American Association of Variable Star Observers. It was accepted with only a minor addition. The full paper is available at <http://www.aavso.org/ejaavso> (eJAAVSO292).

The exercise was a real learning experience. I was constantly re-assessing which data to report for each target and how best to present the data. I was learning along the way and probably didn't communicate sufficiently well with other observers and the analysts about what I thought should be done. The final paper submitted was probably only 50% the same as the first draft.

For newcomers to VSS, I should explain that the "Southern Eclipsing Binaries - EA Project" had its roots in the "SPADES" project – the Search for Planets Around Detached Eclipsing Stars. When this project was initiated in 2011, we were only interested in obtaining precisely measured eclipse times of minima and we gathered a team of analysts to help out with the analysis of the data that was flooding in at the time.

While the goals for the SPADES project still exist the overall focus of the project has slowly changed. We concentrate on southern eclipsing binaries and many of these have not been observed since their initial discovery. This is good for us – little competition and the chance to make some exciting discoveries. We discovered many targets for which the eclipse predictions were hopelessly wrong. Tracking down the actual eclipses can be a frustrating and time-consuming exercise. Luckily, both Glen Schrader and Jeff Byron helped the observers by refining predictions using ASAS data.

The final paper summarises the results for 78 of our 150+ targets. We present revised epochs and periods for 25 targets (Table 1) based on our data alone and in combination with ASAS data. Some of these targets have almost identical primary and secondary eclipses, and we ascertained a new period half that previously reported. We have now studied these 25 targets reasonably well and we are now moving on to gathering sufficient data for astrophysical modelling of each system.

Ant XY	Cru AA	Hor TT	Pup HM	Sco V0632
Ara V0881	Cru BE	Lib KZ	Sgr V0849	Sco V0634
Cen DI	Cru SZ	Mic CY	Sgr V5552	Sco V0638
Cen V0775	Cru TZ	Mic RZ	Sco V0490	Tel LU
Cen V0777	Gru RU	Mon AS	Sco V0626	Vel AW

Table 1. Targets for which new light elements were determined.

For 3 additional targets, V0536 Ara, GM Nor and CT Phe we have obtained new light elements but they are a poor match to ASAS data and more work is needed to clarify what is happening.

For 32 targets (Table 2), we have insufficient data to report revised epochs and periods. However, the timings of the observed eclipses for these targets represent a vast improvement on previously available data. These targets still need more observations before progressing towards modelling.

Car DO	Gru W	Nor V0384	Sco V0606	Vel EL
Car GP	Her LT	Pic RV	Sco V1226	Vel ET
Car V0594	Lib GK	Pup AH	Sco V1270	Vel FV
Cen ST	Lup FV	Pup KX	Sct V0356	Vel RV
CMa TZ	Men RR	Pyx SV	TrA EQ	
CrA V0471	Mic CZ	Sgr V0789	Vel AR	
Cru AF	Nor VX	Sgr V2351	Vel EF	

Table 2. Targets for which new epochs were determined.

The remaining 18 targets (Table 3) have already been well-studied and the published light elements provided reliable predictions for times of minima. We just reported O-C values for these targets. We can probably drop these targets from our project but new observers might find them useful as a test of their procedures.

Ara V0339	CMa TU	Mon AN	Sgr V0526	Vel AO
Car DQ	Eri CW	Mon AQ	Sco V0457	Vel BV
Cen V0762	Hya VZ	Ori V0648	Sco V0569	
CMa AR	Lup FZ	Pup LT	Scl CE	

Table 3. Targets for which O-C values were determined.

My second endeavour was to finally connect with two professional astronomers who are interested in the work we are doing on pulsators in eclipsing binaries. David Moriarty and I have been constantly trying to garner interest from professionals but until recently to no avail. It is not easy. Though a pro might initially express some interest, the follow up has never happened.

Why do we need professional partnerships?

Simply discussing your ideas with a professional has obvious benefits and can refocus your observing programme and open up new projects. For a partnership to succeed though, the professional needs something in return. Amateurs have the benefit of having unlimited time on their telescopes and can dedicate numerous nights to the one target. Professionals don't have this luxury so they need to be tantalised by the target of interest.

For a number of our targets, we now have sufficient photometric data to attempt astrophysical modelling of the systems. To constrain the models, radial velocity (RV) measurements are needed. Amateur equipment doesn't have sufficient aperture to obtain such measurements on stars dimmer than about magnitude 6 in a short enough time frame. The 2.3m telescope, run by the Australian National University (ANU) at Siding Springs, is ideal for RV measurements but access is limited to members of contributing institutions. A professional partnership is essential.

In late July, 2014, Mike Ireland from the ANU was the guest speaker at a Canberra Astronomical Society meeting. I spoke to him after the meeting and he was instantly interested in our work on TT Hor. By the time he left the meeting he had my contact details, a copy of our paper in JAAVSO (Moriarty et al, 2013, *J. Amer. Assoc. Var. Star Obs*, **41**, 182) on the discovery of pulsating components in eclipsing binary systems and had made a promise to contact the δ Scuti expert (Simon Murphy) at the University of Sydney.

He also said he would be away for 2 weeks, one day after our discussion, so I had little expectation that any follow up would actually eventuate.

This time, though, my pessimism was ill-founded, as by 3 pm the next day, following a flurry of emails, I found myself in a partnership with Mike and Simon to apply for time on the ANU 2.3m telescope at Siding Springs to do spectroscopy measurements on TT Hor in November. The aim is to determine radial velocities over the orbital cycle to:

1) determine the spectral type of each star; 2) obtain RV measurements to measure the mass of each component so that the astrophysical model of the system can be more precisely constrained; and 3) determine the pulsation modes of the δ Sct component.

Applications closed 2 weeks after this decision was made. In the absence of Mike, Simon and I did the majority of the application. This was an excellent learning opportunity for me as I wrote the initial draft and then Simon and I discussed the content to decide upon a consensus draft. Simon did the justification for the instrumentation.

Simon also had a project for which he applied for time consecutively with the TT Hor project, the idea being that observations for both projects could be done each night according to prime visibility. We were granted 4 full nights for each project with a 3-night gap between sessions.

All observing was done remotely, firstly from Mt Stromlo, Canberra and then the University of Sydney. Unfortunately this meant I wasn't able to see the scope and instrumentation in action and experience the



Simon Murphy and Margaret Streamer at Mount Stromlo operating the 2.3m telescope at Siding Springs.

magic of being on site. For the professionals, however, remote observing is a huge advantage as they can drive the scope and instruments from home. Driving the big scope and the Wide Field Spectroscope (WiFeS) had a certain familiarity to what I usually do with my own photometry setup as neither has much automation. The only problem encountered was one of the cameras ceasing to function on two occasions. This meant a phone call to Siding Springs to wake up the duty technician. He was able to rectify the prob-



Simon Murphy and Jason Drury at Mount Stromlo

lem very quickly as it is not uncommon and we only lost about 20mins observing both times.

We were incredibly lucky with the weather and we managed observations on TT Hor every single night and sampled different phases of the entire orbital cycle. Only one night was almost completely clouded out but as TT Hor was high in the sky, some data collection was possible during the occasional clear patch. The all-sky camera at Siding Springs is a great help under cloudy conditions.

Simon had a PhD student, Jason Drury, helping out with the observations most nights, thank goodness, as the nights were exhausting for an old duck like me. For the Canberra observations I had an hour's travelling time each way, on top of the non-stop data collection from just before dusk to just after dawn. This made 12-13 hours away from home, with only 11-12 hours left to try to get some sleep and be organised for the following night. I don't sleep well during the day, so after the first night I progressively became more zombie-like. It was good to always have somebody else around to cross-check what was happening.

Observing has been the relatively easy bit of the exercise. Analysis of the data is a steep learning curve for me. I've jumped in at the deep end and lead weights seem to be added to my feet at every step. Simon and Mike are proving ever patient and helpful. The data reduction pipeline for the WiFeS data relies on the Python programming language which I have never used before. The pipeline is not very user-friendly and even less so for Windows users. Progress is slow, but I am notching up some successes.

A publication will eventuate and hopefully it will be this year – as I have other projects in mind while there are two helpful professionals around.

Visual observations of the 2013 eclipse of BL Tel – *Peter F Williams*

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Abstract

Visual observations of the 2013 eclipse of BL Telescopii are presented and summarised. These indicate the date of mid eclipse was GJD 2456484.0 (+/- 0.5 days), an interval of 782.0 days since the previous eclipse of 2011. The duration of this eclipse was 58 days and a minimum visual brightness of magnitude 9.5 attained. Based on these observations, a mean period of 778.04 days is determined from the 14 cycles since this program commenced in 1983. The next eclipse of BL Tel is expected to be centred near GJD 2457262 (2015 Aug 27).

Introduction

BL Tel has been the subject of a long term visual programme by members of the Variable Star Section of the RASNZ and more recently the new VSS, Variable Stars South. Eclipses of this long period Algol system have been monitored since 1983 with the aim of establishing the date of mid eclipse for each observable event and to establish the basic parameters of each event.

The eclipse of 2013 is the 10th event to be successfully observed.

Visual observations and results

A total of 108 visual observations were obtained between May and August of 2013. Numerous CCD and DSLR measurements were also obtained during this interval and these have already been discussed by Bembrick (1). This report will therefore deal only with the visual data as part of the long term visual programme on eclipses of BL Tel. The five observers who provided visual measurements were Jon Brandie, Robert Evans, Andrew Pearce, Rod Stubbings and Peter Williams.

These observations have been plotted as daily means in the light curve shown as Figure 1. A 6th order polynomial has been added and the date of mid eclipse measured directly from the light curve. As has occurred in previous eclipses, the rate of decline and recovery shows clear differences and the date of mid eclipse has been measured as the mid-point between decline and recovery curves at magnitude 9.0, around 0.5 magnitude above minimum brightness.

The date of mid eclipse has been measured as GJD 2456484.0 (+/- 0.3 days). No heliocentric correc-

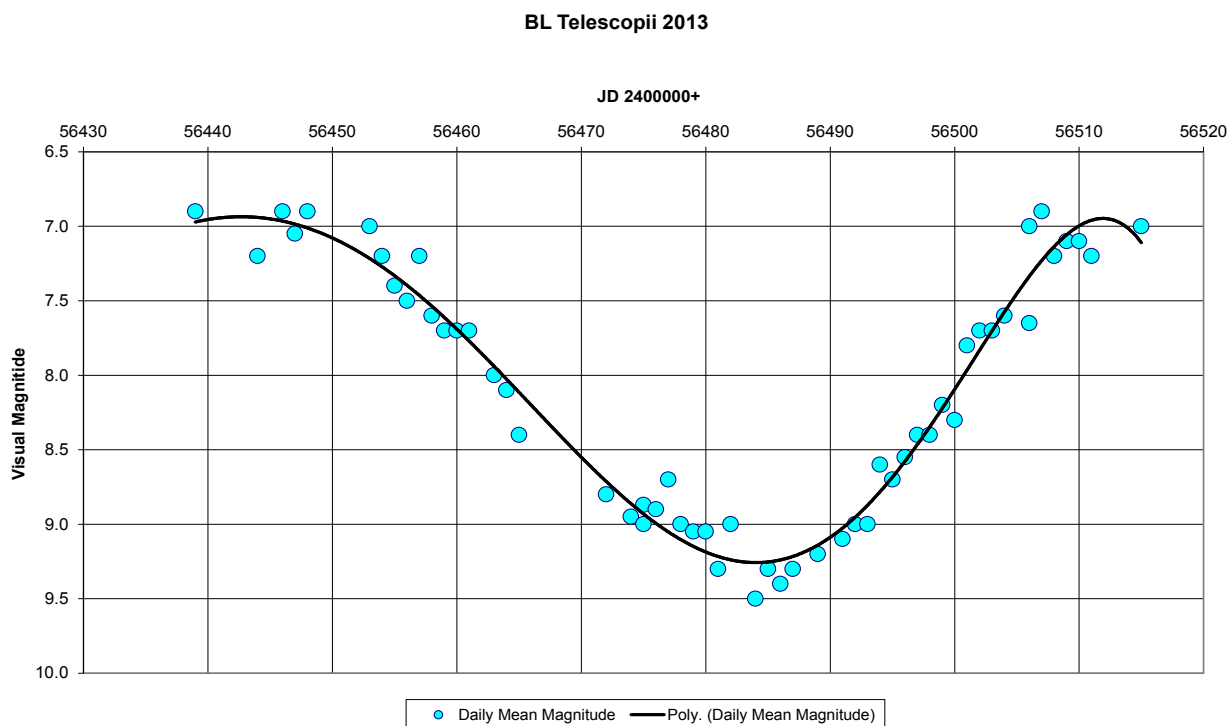


Figure 1. Daily mean visual magnitudes of BL Tel between May and August 2013.

tions have been applied as this is deemed unnecessary due to the nature of the visual data. The date of mid eclipse based on the visual data is in good agreement with the HJD 2456484.44768 (± 0.35) reported by Bembrick.

BL Tel faded to minimum over 34 days while the recovery took only 24 days, giving a total duration of 58 days from the 2013 eclipse and an interval of 782.0 days since the previously observed eclipse in 2011.

With completion of the 2014 event, 10 eclipses have now been successfully observed through the current visual programme. This available visual data now covers 14 cycles of BL Tel, yielding a mean period of 778.04 days over 10,892.5 days.

This mean cycle is, however, somewhat subjective as consecutive eclipses of BL Tel have been shown to vary by several days from the mean period. The goal of the visual programme therefore remains to monitor the eclipses and determine the basic parameters of each eclipse over the long term.

A summary of the 10 observed eclipses 1983 through 2013 is presented in Table 1.

Year	Observed	Calculated	O-C (Days)	Mag	Duration (Days)	Interval from previous (Days)
1983	2445591.5	2445585.4	+6.1	8.60	57.0	-
1985	2446369.5	2446363.5	+6.0	9.60	65.0	778.0
1987	2447144.5	2447141.6	+2.9	9.30	63.0	775.0
1992	2448703.0	2448697.8	+5.2	9.20	58.0	779.3 (1558.5/2)
1994	2449481.0	2449475.9	+5.1	10.10	62.0	778.0
1996	2450256.0	2450254.0	+2.0	8.90	65.0	775.0
1998	2451034.5	2451032.1	+2.4	8.96	56.0	778.5
2000	2451812.5	2451810.2	+2.3	9.60	68.0	778.0
2011	2455702.0	2455700.7	+1.3	9.50	57.0	777.9 (3889.5/5)
2013	2456484.0	2456478.8	+5.2	9.5	58.0	782.0

Mean period over 10,892.5 days (14 cycles) = 778.04 days.

Table 1. BL Tel eclipse summary calculated relative to catalogue elements JD 2434692 + 778.1 days.

Conclusion

Visual observations of the 2013 eclipse of BL Tel indicate mid eclipse occurred on GJD 2456484.0 (+/- 0.3 days), 782.0 days since the date of the previously observed eclipse. Total duration of this eclipse was 58.0 days and a minimum magnitude of 9.5 was attained. Based on these observations the next eclipse of BL Tel is expected to be centred near JD 2457262 (2015 August 27).

Acknowledgements

All observers are thanked for their observations and ongoing interest in the BL Tel eclipse programme.

References

1. Bembrick, C., BL Tel – Please Explain Yourself. VSSNL 2014-1 pp17-20, January 2014

Southern semi-regulars – a progress report – *Aline Homes*

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Progress to date

The latter part of 2014 has been spent on the analysis of data from Stan Walker (historic Auckland Observatory observations) and Neil Butterfield on T Centauri. According to the latest thinking, T Cen has been reclassified as an RV star rather than an SR, and therefore should not be part of this project at all, but given its previous classifications, our somewhat elastic boundaries and the high level of interest in this class of variables, I think we are justified in including it (and any other southern RVs that members have been observing).

The last analyses were only completed just before Christmas at a time when an avalanche of work threatened to bury me, so it is not possible at this stage to give more than a brief overview of our results so far. There is a lot more work to do, making comparisons between data sets, looking for longer periods and so on, and we look forward to receiving more observations next observing season.

Next up will be L2 Puppis. Thank you to Stan for supplying the Auckland Observatory observations. Thank you to Neil too, for all his contributions, and we'll be getting on to those shortly. Keep sending them in, folks. There's scope for visual, DSLR and CCD observations.

Preliminary analysis – T Centauri

Aline Homes, Pauline Loader, Stan Walker and Neil Butterworth

Introduction

T Cen (AAVSO no. 1336.33) is an interesting and much-observed long period variable. It has been variously classified in the past as a dual-maximum Mira or a Class a semi-regular (GCVS) but current thinking is that it is an RV Tauri type star (Percy and Tan 2013) and is now so listed by AAVSO. It varies between mag 5.5 and approximately mag 9 over a period of 90 – 91 days between successive minima, although there are alternating deep and shallow minima so the true primary period may be twice this.

Although T Cen varies in brightness by as much as 4 magnitudes, it fits rather better with the small-amplitude red giants (SAPRGs) than with the Miras. A detailed discussion of pulsating red giants may be found in Kiss and Percy (2012). SAPRGs are sun-type stars close to the end of their lives. They have exhausted their core hydrogen and ignited He fusion, and are found in the red giant branch of the HR diagram. As they exhaust He they undergo further expansion and cooling and move into the asymptotic red giant band. Many show long secondary periods which are often multiples of the primary period (Kiss and Percy 2012).

RV Tauri stars show an odd mix of regularity with underlying chaotic variation. They are known to be giants with masses close to that of the Sun and lower metallicity although some may be metal-rich population 1 stars similar to, but older than, the Sun. Spectral types at maximum range from F to late G or early K and they are often surrounded by dust clouds. They are thought to be post-asymptotic branch

giants close to the end of their lives, just prior to the ejection of the planetary nebula and ultimate collapse into a white dwarf (Templeton 2010). They are relatively uncommon, being a transient stage and there may be unrecognised RVs among the various classes of semi-regulars.

Exact period length seems to vary depending on the method of analysis used. Fourier analysis gives a value of 90.5 days, whereas self-correlation gives a period of 91 days (Percy and Tan 2013). Percy and Tan (2013) have also detected a 900 day LSP (long secondary period). There is also a substantial variation in the spectral class through the cycle, from K0 to M4 and the relationship between the visual cycle and that of temperature and class is not altogether clear.

Data

Two data sets have been received, a substantial set of 124 historic photometric observations made at Auckland Observatory and covering the period 26th February 1976 to 22nd May 1986 supplied by Stan Walker, and a smaller file of 24 recent photometric observations covering the period 15th March 2014 (JD 56732) to 17th August 2014 (JD 56887) supplied by Neil Butterfield. There is a large gap in the Auckland Observatory data, from 14th July 1978 to 31st March 1981, with smaller seasonal gaps where the star was too low in the sky for observation.

The Auckland observations were made with the 50 cm Edith Winstone Blackwell telescope using an EMI 9502 pm tube and V, B and U filters. Early data acquisition probably employed an A/D converter, but later observations were made using photon detection/counting with a prescaler. Data was transformed using the Cape photometry of E regions. The observations were made by a number of people at Auckland Observatory, so there could be some variations in accuracy, but errors are probably less than 0.008 except in U-B, where they could be up to twice as much.

Neil's observations were made at Townsville, N Queensland using a Canon 550D DSLR with a 135 mm f2.0 lens on a Skywatcher altaz mount. Data reduction was performed using an ensemble of comparison stars and RGB readings were transformed to standard colours.

Analysis

For the purpose of analysis, the data were divided into three blocks and processed separately. The first block covers the period JD 2442835 to 2443704, the second from JD 2444677 to 2446573, the third block being the recent data from Neil Butterworth. Analysis was carried out using a spreadsheet (LibreOffice Calc), V-Star from AAVSO and the self correlation program from John Percy's website (Percy *et al.* 2006).

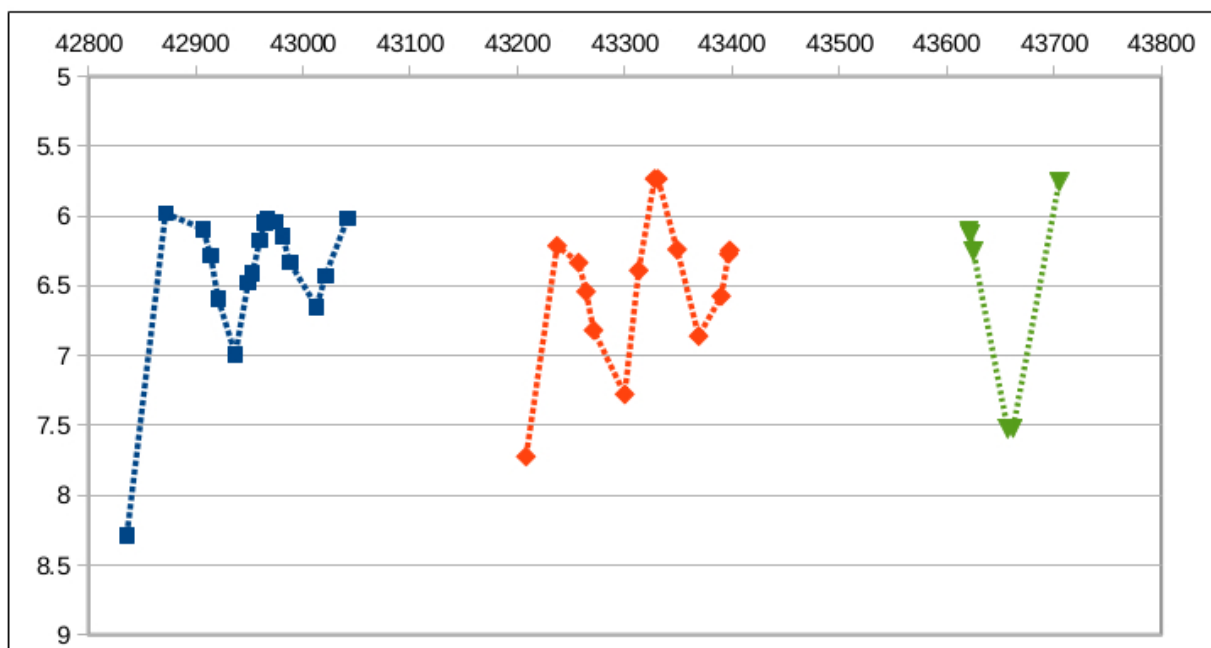


Figure 1. Light curves (V only), *T Cen* for the period 26 Feb 1976 to 14 July 1978. Each observing season is plotted in a different colour.

It is not possible to present more than a brief overview of our analyses at the present time. We hope to publish fuller details of all our work on T Cen in due course.

The maximum brightness over the three observing seasons was reasonably consistent at around magnitude 6 but the minimum brightness for each of the three seasons varied more, with recorded minima from 6.6 to 8.3. DC-DFT analysis for the 1976 V data gave a top period of about 88 days. The top period for 1977 was 82.2 days and for 1978 the top period was 104 days, however this result should be treated with caution as the data for this year may not have covered a full cycle. The DC-DFT analysis of frequencies also showed multiple harmonics which suggests that the star was pulsating in a number of different modes.

The self-correlation plot compares V, B-V and U-B measures for the same period.

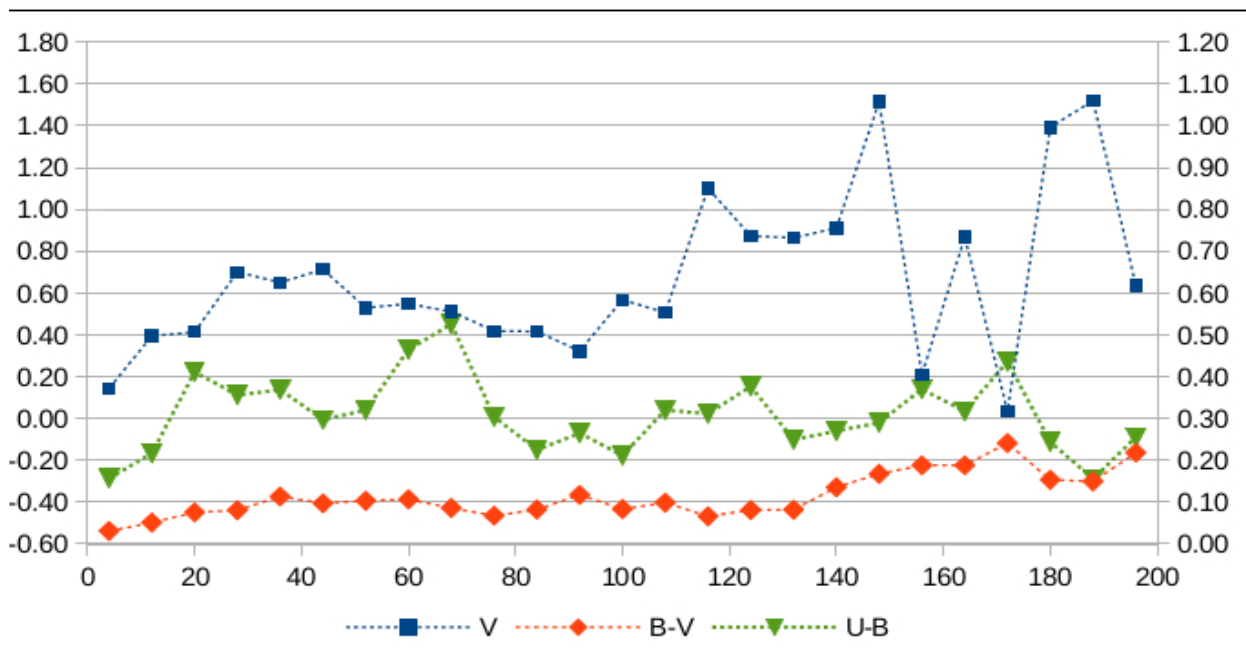


Figure 2. Comparison of self-correlation plots for V, B-V and U-B, 1976-1978. Two vertical scales are used so that the plots do not significantly overlap. Read the LH scale for V data (blue curve) and the RH scale for B-V (red curve) and U-B (green curve).

Self correlation diagrams allow the calculation of an index of periodicity (k) which takes values between 0 (no periodicity) and 1 (strong periodicity) (Percy and Tan 2013). The derived values for k for 1976 to 1978 are $k_V = 0.67$, $k_{B-V} = 0.45$ and $k_{U-B} = 0.37$, suggesting only a very low cyclical component in B-V, even less in U-B, but rather more periodicity in V.

The 1981-1986 data set covers five full seasons and part of a sixth. Light curves (V only) for each season are given in Figure 3.

Over the period maximum brightness varied between about 5.5 and 6, with minima between 7.5 and 8.5. The period generally varied between 95 and 100 days. There may be dual maximum cycles of between 190 and 200 days, however in 1983 periods within this range were not detected. There are a number of harmonics suggesting that the star may be pulsating in multiple modes. The basic frequency of the pulsations may also be varying over time.

For the 1981 to 1986 measures (Figure 4), the derived values of k are $k_V = 0.67$, $k_{B-V} = 0.59$ and $k_{U-B} = 0.59$ suggesting that there is at least some cyclical variation in both B-V and U-B over this period. In addition the B-V curve shows minima at 76 and 156 suggesting a possible period of 75-80 days. The corresponding U-B curve has minima suggesting possible periods of 84 and 148 days.

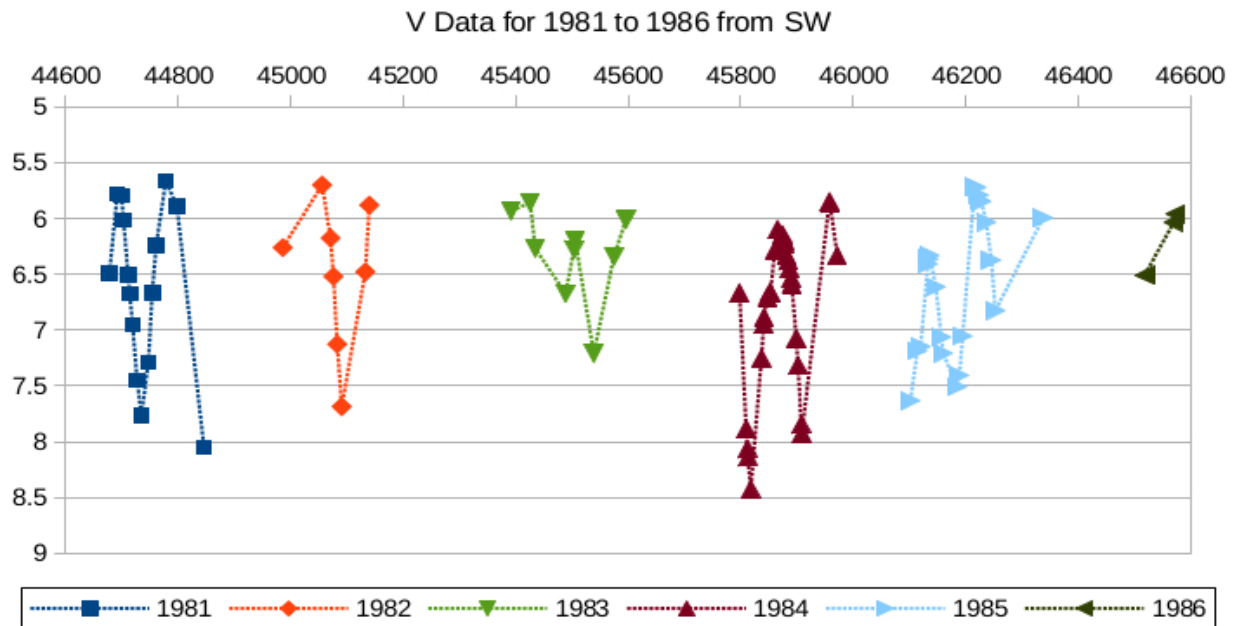


Figure 3. Light Curves, *T Cen* (*V* only), for the period March 1981 to May 1986. Each observing season is plotted in a different colour.

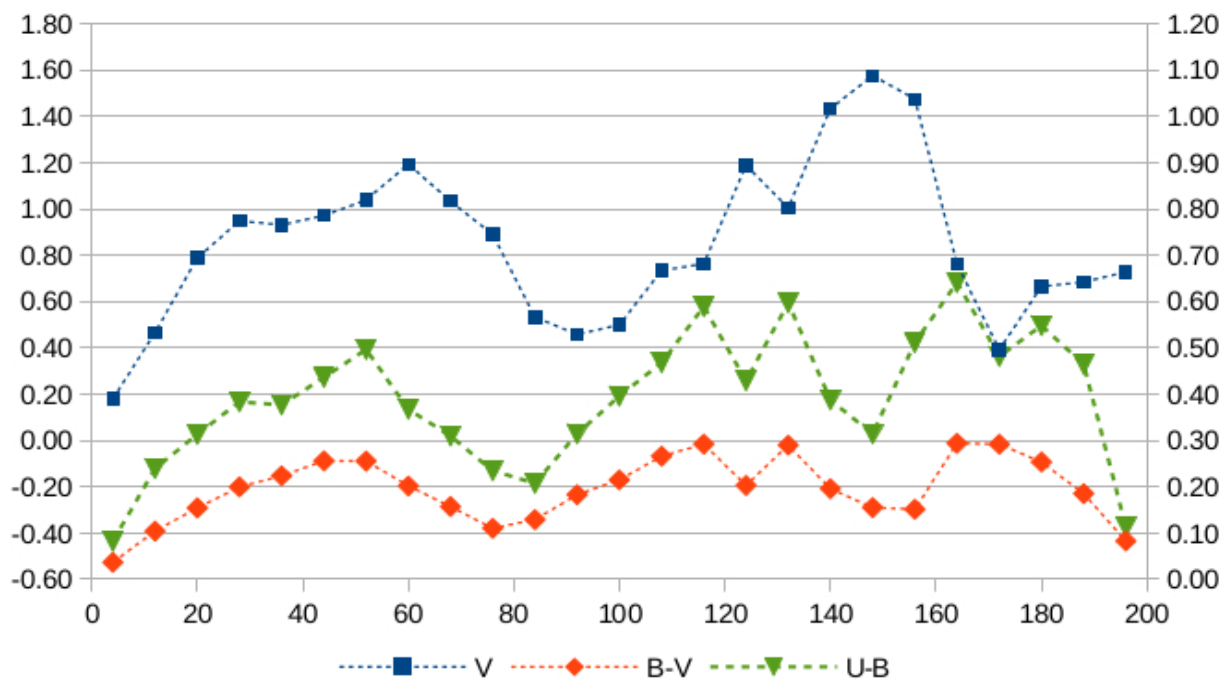


Figure 4. Comparison of self-correlation plots for *V*, *B-V* and *U-B*, 1981-1986. Two vertical scales are used so that the plots do not significantly overlap. Read the LH scale for *V* data (blue curve) and the RH scale for *B-V* (red curve) and *U-B* (green curve).

To summarise the Auckland Observatory results, little cyclic variation was apparent in measures using the B and U filters during the period 1976-1978, but there was some definite cyclicality during 1981 to 1986 with a probable period of about 89 days. In his original spreadsheet notes Stan Walker mentions a possible secondary period of 119.398 days, but this has not been found in the present analysis. However examination of *V* data season by season shows considerable variation in periods from year to year, so a period of this duration could be present at times.

The long secondary period of ca. 900 days detected by Percy and Tan (2013) has not been detected in

our work to date, but 900 days is approximately 10 times the 89.86 day period suggested by our results, so given the many resonances in the DFT analysis there is no evidence against it either. It is possible that our data is too limited. Percy and Tan's result is based on an analysis of the total AAVSO data set.

The third data set analysed, the recent DSLR photometric measures supplied by Neil Butterworth contains 24 photometric V, B-V and V-R observations for JD 56732 to JD 56887. The calendar date range being 15 March 2014 to 17 August 2014; a range of 155 days. Light curves for V, B-V and

V-R suggests (not shown) that the first maximum brightness for the B-V and V-R data may have occurred approximately 20 -25 days before the maximum brightness of the V data.

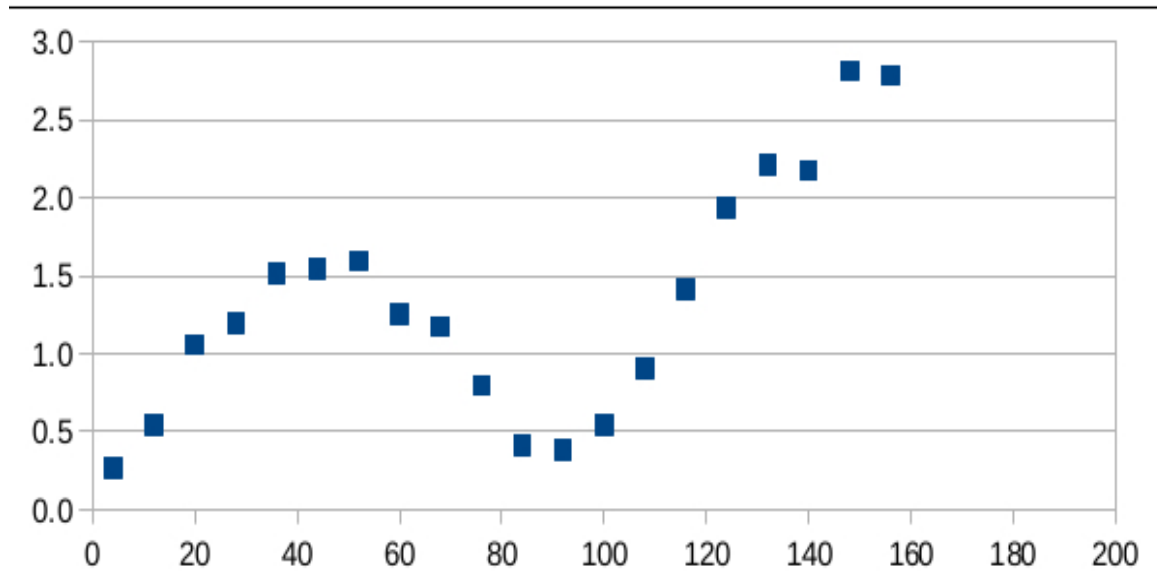


Figure 5. Self correlation plot for V measures, 2014.

The self-correlation plot for the V data gives a value for k_v of 0.88, indicating a high level of regular cyclic variation in the data. The first minimum occurs at about 90 days, suggesting a period in the range of 85 to 95 days.

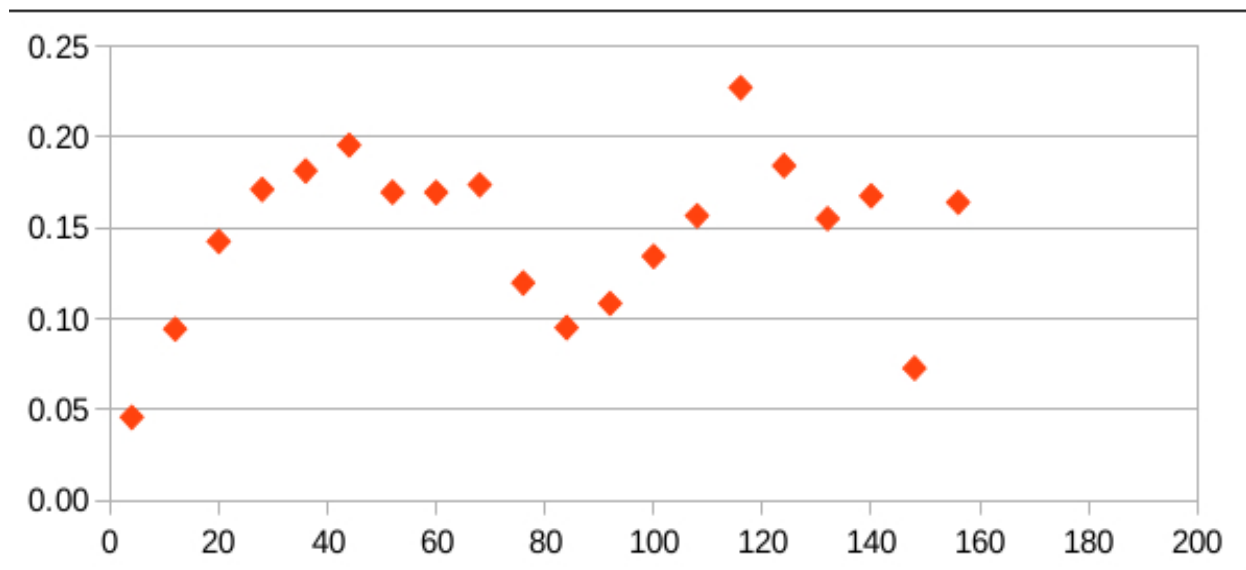


Figure 6. Self correlation plot for B-V measures, 2014.

Diagrams 6 and 7 show the self correlation plots for the B-V and V-R data respectively. These give

values of k_{B-V} of 0.65 with the first minimum occurring at about 85 days and k_{V-R} of about 0.4. This suggests that variations in B-V are not as strongly cyclic as in V, and that periodicity, while marked, may be slightly less than that of the V data. The k value for V-R data indicates only very weak cyclic variation. DC-DFT analysis of the V data indicates a period of 91.767 days, as did the B-V and V-R data but the cycles could be a few days out of phase. This work is still being evaluated.

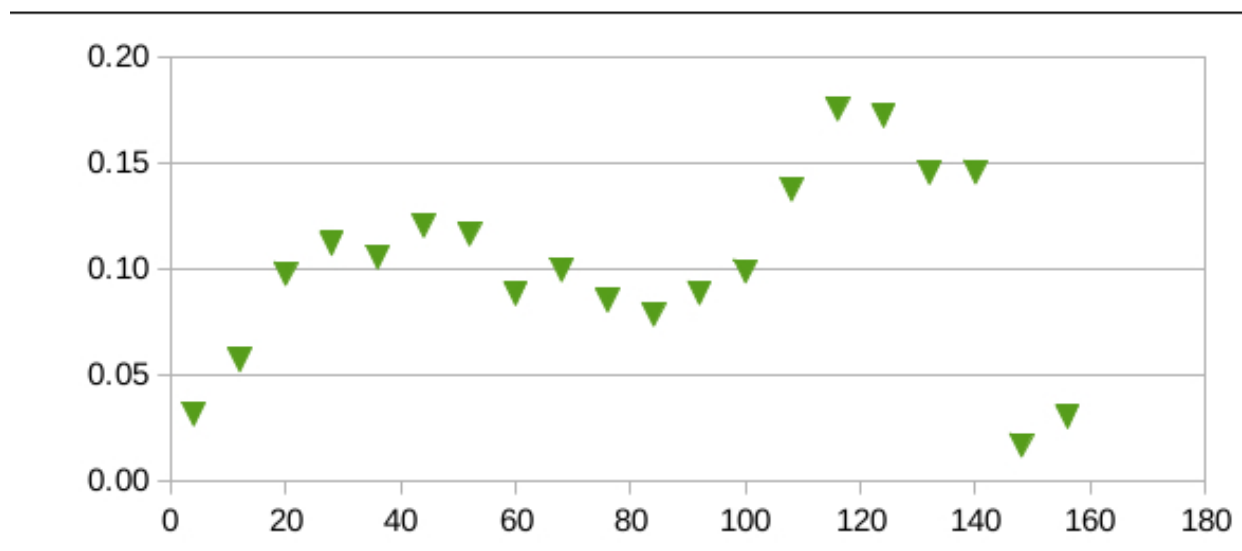


Figure 7. Self correlation plot for V-R measures, 2014.

In summary, during the 2014 observing season T Cen appears to have been little less unstable than during the 1970's and 80's. However the stability or otherwise would need to be confirmed over a longer time frame than just one observing season. The RV Tau stage is thought to last only a few thousand years (Templeton 2010) while they are crossing the high-luminosity extension of the Cepheid instability strip of the HR diagram, so it is likely they are undergoing rapid changes. Continuing monitoring of this star is therefore highly desirable.

References

- Kiss, L.L and Percy, J.R., 2012. JAAVSO 40: 528-538.
Percy, J.R., Gryc, W.K., Wong, J.C-Y., Herbst, W., 2006. Publ. Ast. Soc. Pac. 118: 1390-1395.
Percy, J.R. and Tan, P.J., 2013. JAAVSO 41: 1-14.

Defocus for DSLR photometry – Mark Blackford

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When recording DSLR images for photometry, it is accepted practice to defocus the lens or telescope to spread each star image across many pixels to ensure adequate sampling in all three colours. But what is the minimum allowable star image size and what are the consequences if focus is too sharp? Well in my case, one consequence was the price of a replacement DSLR because I thought the original had developed an electronic fault. This article will hopefully save others from similar expensive and embarrassing mistakes.

DSLR photometry is in principal very similar to CCD photometry, except that each DSLR image contains information in three different colours (red, green and blue), whereas in CCD photometry each colour is recorded in a separate image. A DSLR has an array of coloured filters, often called a Bayer array, in front of the CMOS sensor and each pixel in the sensor records only one colour. The basic 2 by 2 pixel block of a Canon Bayer array is shown in Figure 1, consisting of one red, two green and one blue pixel. The Bayer array is made up of repeated copies of the basic 2 by 2 block.



Figure 1. Basic 2 by 2 pixel Bayer filter block of a Canon DSLR. Other brands may use a different order of colours. The two green filters have the same spectral transmission characteristics.

If focus was sharp enough, all light from a star would fall on one pixel, perhaps red. Surrounding green and blue pixels would record no intensity from the star. Photometry from such an image would falsely indicate the star is bright in red wavelengths but very dim in blue and green. In practice, focused star images are not single points of light, instead they have a circularly symmetric (approximately) Gaussian distribution of intensity from a bright core, fading rapidly to background levels within a few pixels (Figure 2). Most of the star's light will fall on a single pixel but some intensity will be recorded in surrounding pixels. Photometry of the image would indicate excess brightness in the colour of the central pixel and decreased brightness in the colours of surrounding pixels.

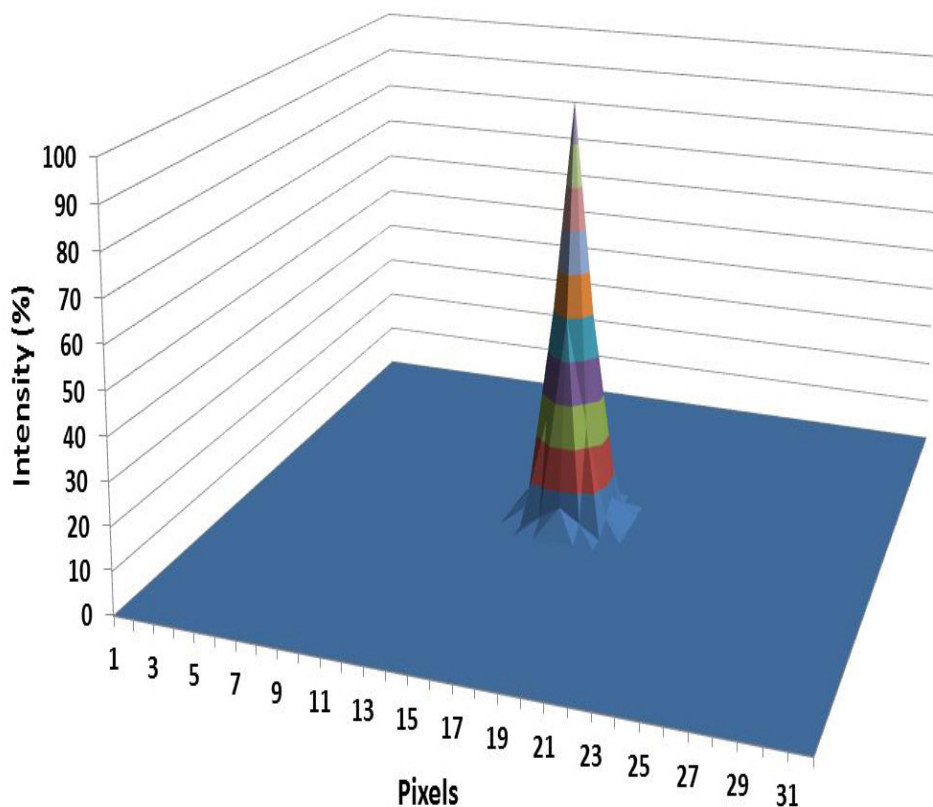


Figure 2. Gaussian intensity distribution of a sharply focused star image. Full width at half maximum intensity (FWHM) = 2 pixels, full width at tenth maximum (FWTM) = 3.65 pixels).

Most of my work involves time series imaging but my mount is not guided, so there is some drift of a star's image across the sensor over time. This means the central peak will move across many pixels and the relative brightness in each colour will change, depending on the colour of the pixel that the centroid falls on. Figure 3 shows the measured BVR magnitudes of nova Centauri 2013 (V1369 Cen) from a too-tightly focused time series recorded on 25/2/2014. The B and R light curves show oscillations due to

drift and periodic error in the mount's RA drive. The V light curve shows only a very low amplitude oscillation because the two green channels are averaged together, cancelling out their individual oscillations.

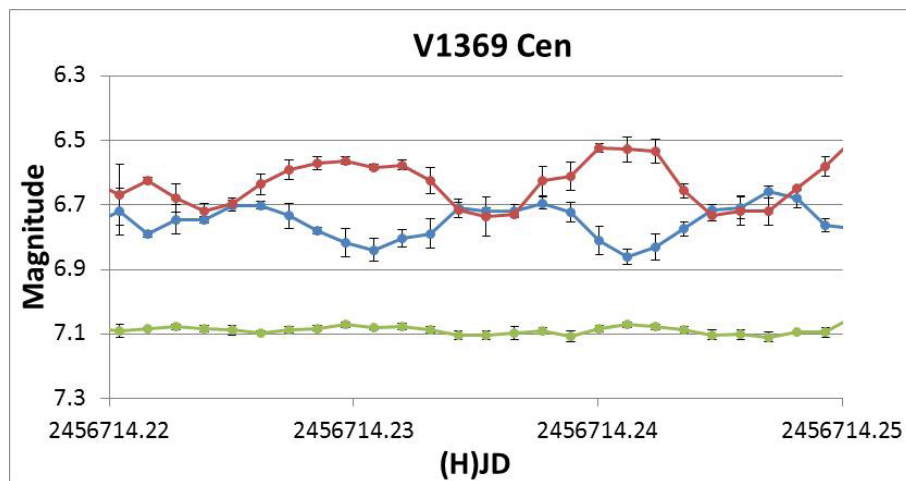


Figure 3. Nova Cen 2013 (V1369 Cen) light curves in B (blue line), V (green line) and R (red line) from images recorded with insufficient defocus. The oscillations are an artefact of the Bayer filter array, periodic error in the mount and drift due to imperfect polar alignment.

At the time I attributed the oscillations to an intermittent electronic instability in the camera. Not every data set was affected in this way, but I couldn't trust the photometry so I purchased a new DSLR. Nearly a year later the new camera also started producing oscillating light curves, so I started looking more deeply into the problem. Closer inspection revealed the slightly defocused star images, which resulted in oscillating light curves, still had a bright central core surrounded by a dimmer broad skirt (Figure 4 top), whereas star images which produced non-oscillating light curves did not show a tight, bright core (Figure 4 bottom). It is the sharp, bright core that causes the intensity oscillations observed in insufficiently defocused star images.

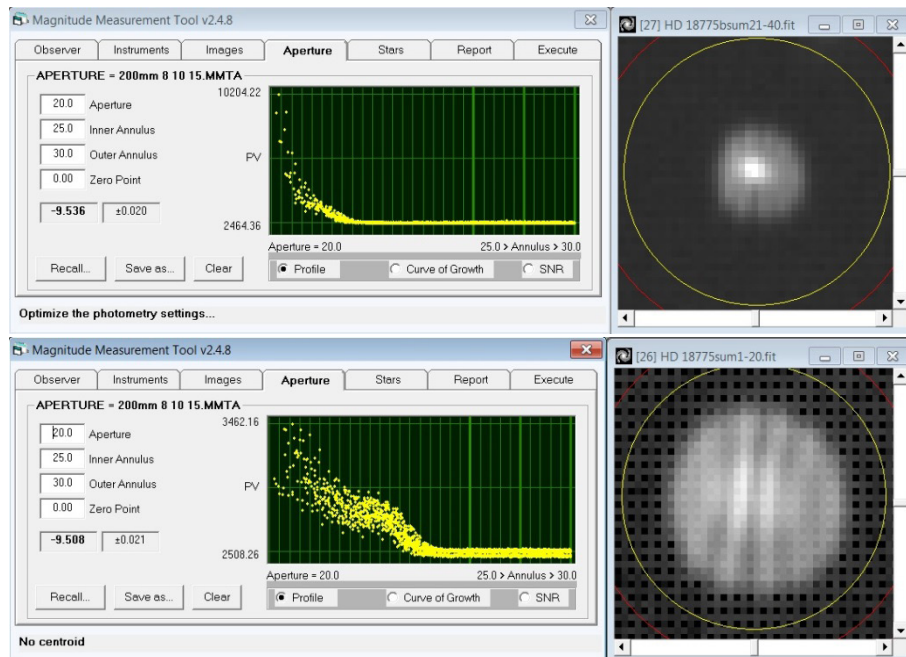


Figure 4. Profile plot (top left) showing the bright core and broad skirt of an insufficiently defocused star image (top right). With further defocus the profile and star image (lower left and lower right, respectively) are larger, with much reduced central peak. In each case 20 individual images were aligned and average stacked to improve SNR.

So, empirically, it was clear that more defocus produces better photometry; however the measurement aperture needs to be larger, which increases the chance of contamination from nearby stars. To determine the minimum defocus required for reliable photometry I used an Excel spreadsheet to model the response of a Bayer array equipped CMOS sensor (Figure 5). A 32 by 32 pixel model sensor is shown with a pattern of red, light green, dark green and blue squares representing the Bayer filter array. The wiggly red line represents the track traced by the centroid of a real star measured from a time series of images. Also shown is the intensity in each pixel of a synthetic Gaussian star image with FWHM of 3.06 pixels centred at the position of the red dot. The inner and outer circles show the positions of FWHM and FWTM intensity, respectively.

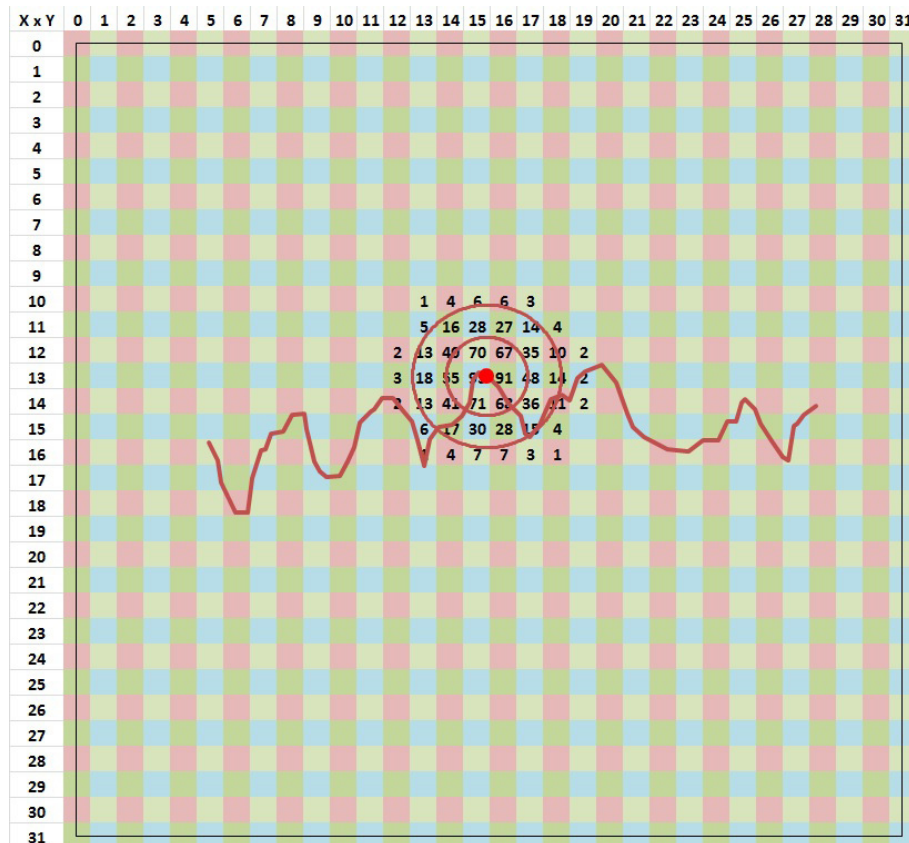


Figure 5. Model Bayer array showing measured star centroid position (wiggly red line) over a period of 45 minutes. Numbers represent intensity in each pixel of a model Gaussian star image centred on the red dot. FWHM and FWTM diameters are indicated by the inner and outer circles, respectively.

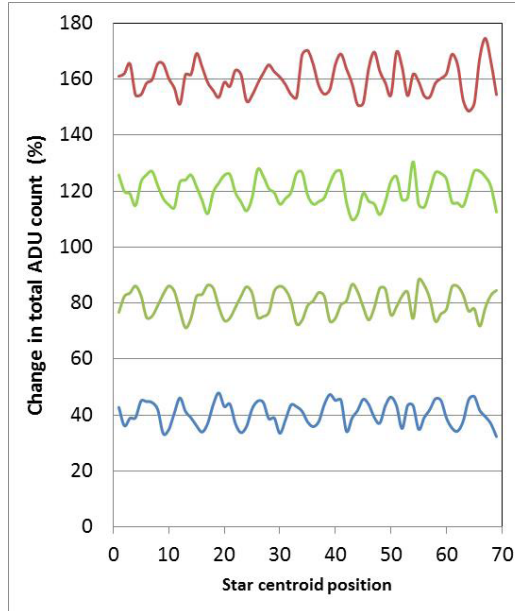
For a given star position the spreadsheet calculates intensity in every pixel, then sums all red pixel values to simulate the total ADU count in that colour, similarly for the G1, G2 and B pixels. This is repeated at each position along the red line. Figure 6 shows plots of variation in total ADU count as a function of star centroid position along the wiggly red line in Figure 5. The upper left panel shows actual measured star ADU count variations from the same time series of images from which the star centroid positions in Figure 5 were extracted. Standard deviation of the star ADU count is a convenient measure of the amount of variation. The other three panels show calculated variation for simulated Gaussian star images of different FWHM.

In terms of standard deviation, a simulated Gaussian star image of 2.05 pixels FWHM provided the best match to actual measured variation. Smaller FWHM resulted in greater amplitude variation, whereas increasing FWHM to 3 pixels results in essentially zero oscillation due to under-sampling.

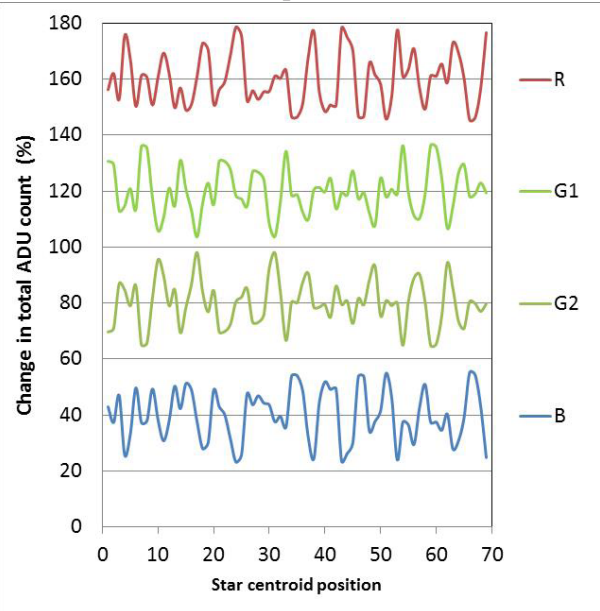
The real star image is not actually Gaussian; it has a bright core and fainter broad skirt (Figure 4 top right). However, for the purposes of this exercise Gaussian profiles are a useful approximation of the offending bright core. Photometry software will report larger FWHM values for the combined bright core

and fainter halo of real star images. For example, AIP4Win reported FWHM = 3.90 pixels for the upper right star image in Figure 4, not 2.05 pixels which produced the best fit to measured variation. To be safe, I'd suggest defocusing to get measured FWHM of at least 8 pixels, in case seeing improves or focus changes due to thermal contraction during the night. Check your star images; they should look more like the lower right image in Figure 4 than the upper right image.

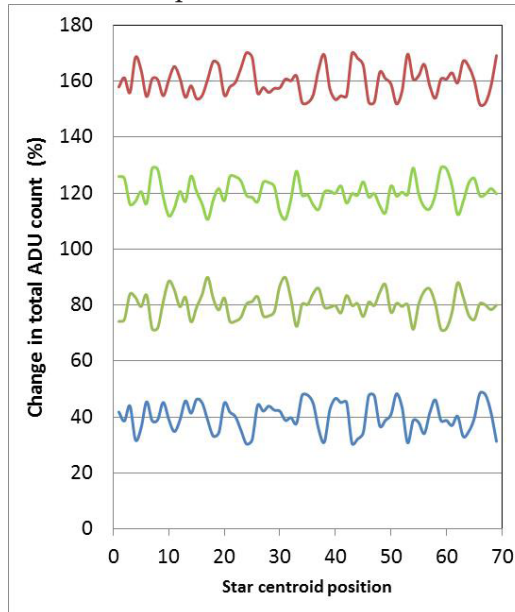
Measured oscillations, stdev = 4.9



FWHM = 1.88 pxl, stdev = 8.8



FWHM = 2.05 pxl, stdev = 4.9



FWHM = 3.00 pxl, stdev = 0.1

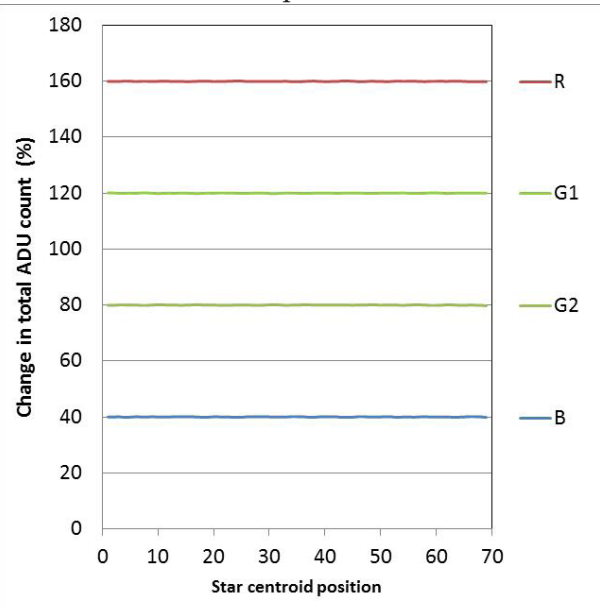


Figure 6. Variation of total ADU count as a function of star centroid position in each filter colour. Upper left panel shows actual measured variations from a time series of images. Other panels show calculated variations for simulated stars of different FWHM (as listed above each panel). An offset was applied to improve visibility.

The shape of an out of focus star image will depend on the degree of defocus and which side of focus is selected. The shape will usually be different in the red, green and blue channels and depend on the design of the lens, eg my Canon 200mm f2.8 lens shows donut shaped star images when over focused (Figure 7). You should experiment to find the most appropriate defocus setup for your lens and camera.

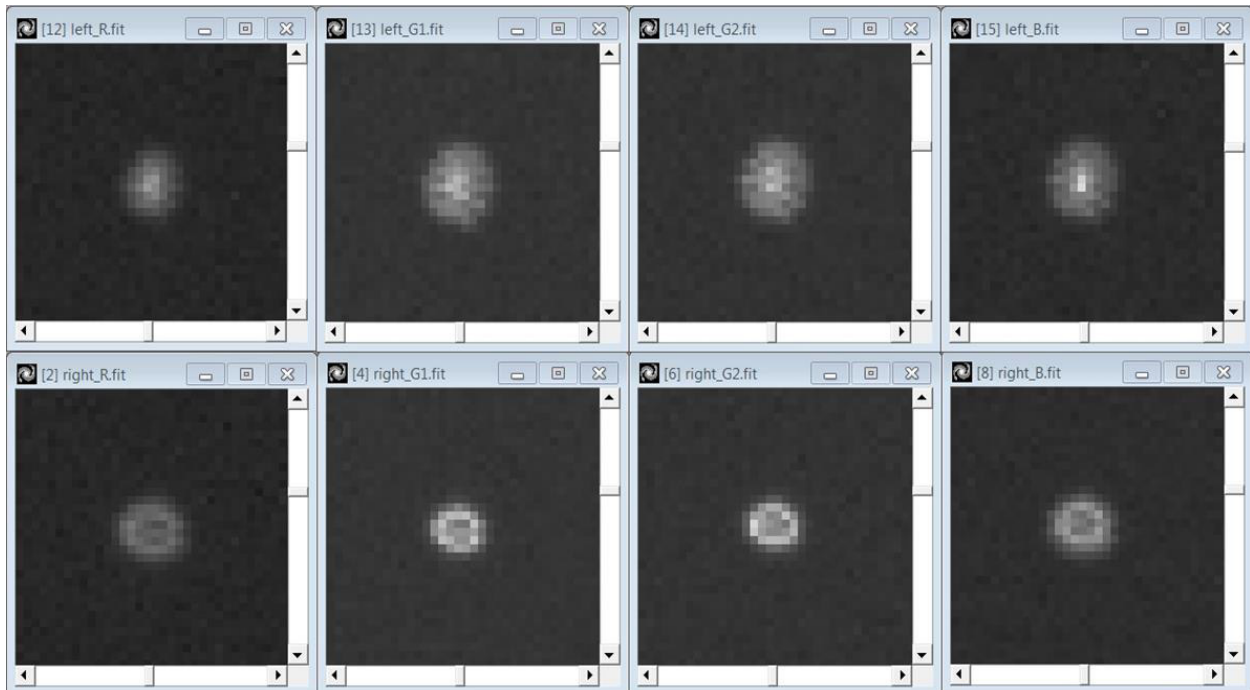


Figure 7. Shape of under focused (top row) and over focused (bottom row) star images in Red (first column), Green 1 (second column), Green 2 (third column) and Blue (fourth column) colour channels. The top images were extracted from a single RAW image recorded with a Canon 200mm f2.8 lens, the bottom images were extracted from a second RAW image from the same lens.

On all occasions when my light curves showed oscillations like those in Figure 3 I'd used sharper focus than normal because the target was either faint or had close neighbours which would have contaminated a properly defocused star image. I recommend DSLR photometrists leave these types of targets to observers with more suitable equipment, and concentrate instead on brighter, more isolated targets which can be adequately defocused.

The most annoying consequence of not defocusing sufficiently was that several perfectly good nights were wasted because photometry of the images was compromised. There is a silver lining though; I now have two perfectly good camera bodies so I can get a second DSLR photometry system set up using a new portable mount and 80mm apochromatic refractor. I'll let you know how they perform in a future article.

Why I hate German equatorials – *Tom Richards*

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What's the worst thing about German equatorial mounts, compared to just about any other? Even worse than hitting your head very hard on the counterweight in the dark of night, which can jiggle the image being taken or even shift the telescope's position (surely your cut head doesn't compare to those problems?) Answer – the meridian flip. It's not just the delay it causes, a big gap in data which always seems to occur at the crucial point in the light curve. It's what meridian flip does to your images before and after.

Look at Figure 1, a light curve taken one night, with meridian flip at the arrowed gap. Plainly the curves on either side don't match up. To get a good measurable eclipse curve we need to correct for the apparent jump in sensitivity after the flip. But by how much? The pre-flip data on the left needs to be raised maybe 0.03 mag to align with the post-flip side, but that's guesswork. Can we use the nice flat check star data, with its own hiatus, to get an accurate measure of the jump? No; in this case the K jump was three times greater – about 0.08 mag. Anyway you can't even in principle fix the variable's jump from the check's jump, as we'll see.

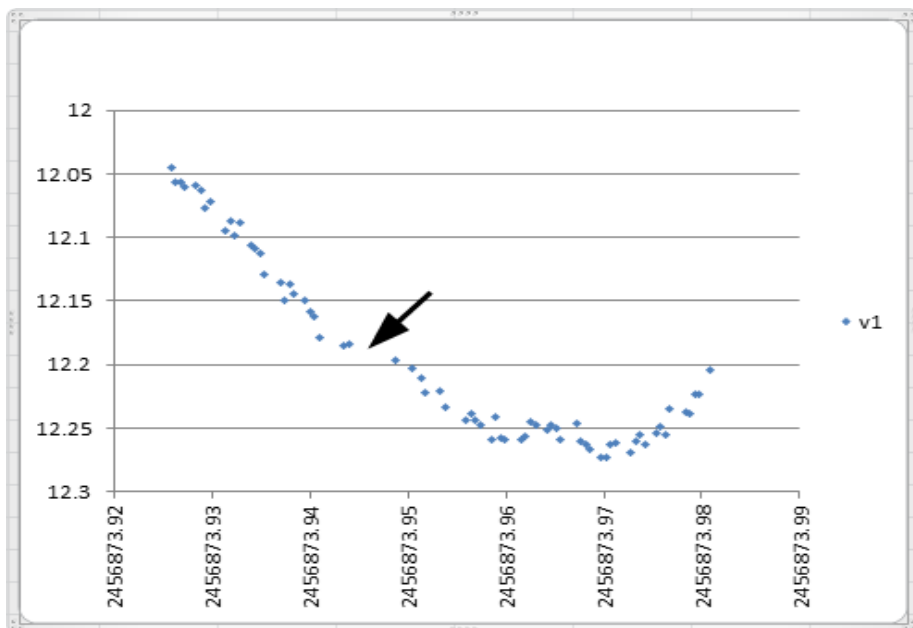


Figure 1. A night's light curve showing the meridian flip gap (arrowed).

In detail, what causes the jump? Have a look at Figure 2, which represents a German equatorial seen from the instrument end, very nearly on the meridian looking south, and about to flip. The black rectangle represents the camera image – if you like, a very big CCD chip! (To remind of camera orientation, it has a small black tab on the left of its top side.) Features on that image come from three sources.

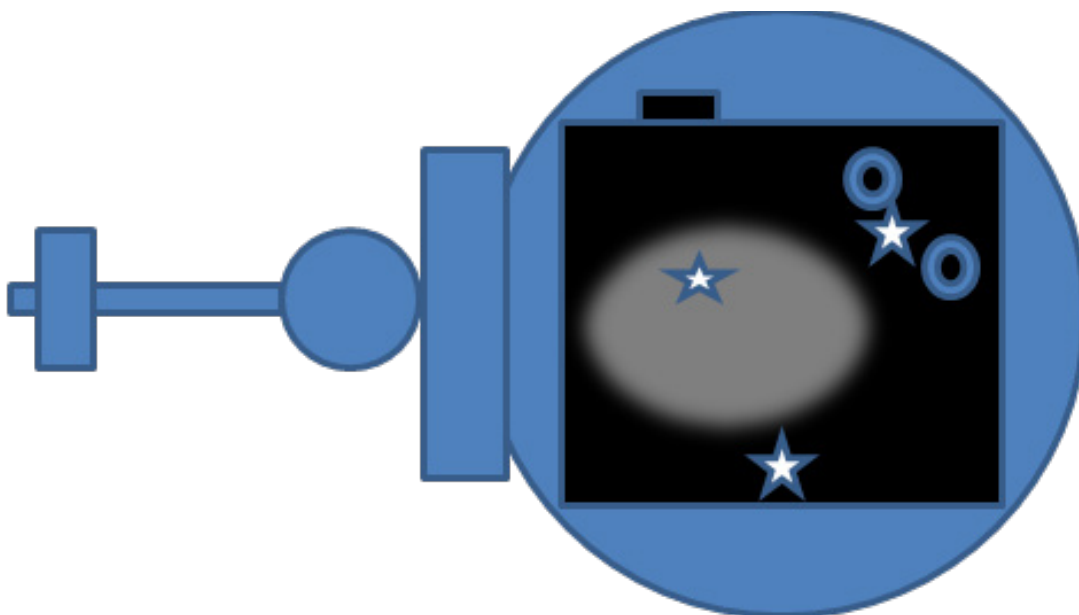


Figure 2. Telescope looking south, mount, and camera with image, just before meridian flip, seen from the instrumentation end.

- The oval in it represents the vignetting arising from the optical system – effectively from the telescope not the camera, whose added vignetting we can ignore in this discussion. The vignetting is shown off-centre towards the mount, to remind us that no collimation is perfect and the slightest offset shows up strongly on a tiny CCD chip.
- We also see artefacts introduced by the camera itself – a couple of dust rings on the chip cover or maybe the filter. They are to the right of the little black tab. Bear in mind too there are camera

artefacts that the bias and dark frames are designed to handle, though never perfectly.

- Finally there are three star images. One is inside the bright part of the vignetting, so it's getting more light than the others in the darker parts. If it's the variable and the bottom star is the comparison star, it will be recorded as brighter than it should be.

But shouldn't flat-fielding remove those anomalies? Well, that's the job of a flat-field, but unfortunately it's very hard to to flatten an image to better than 1% variation, so take Figure 1 as showing a flat-fielded image – much exaggerated.

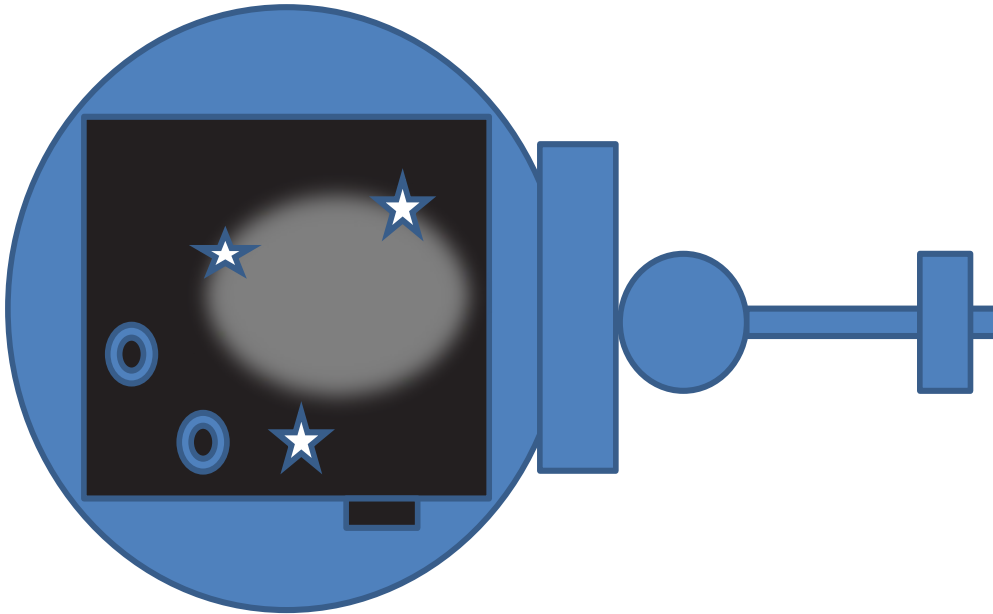


Figure 3. As for Figure 2, but just after meridian flip.

What happens to the image after meridian flip? See Figure 3. The telescope and its attached camera are rotated through 180° , but the star images stay where they are. In terms of what you see on your computer screen, which faithfully keeps the top of the chip (tabbed) at the top of the screen image, it's the stars that have rotated through 180° . Now the variable has moved to the edge of the bright vignetting spot so is getting less light. Its light curve will drop. On the other hand, the check star at top right will get brighter.

So that's how the hiatus happens and why the check star does not offer a solution. Now, aside from best possible flat-fielding, how can you avoid the problem?

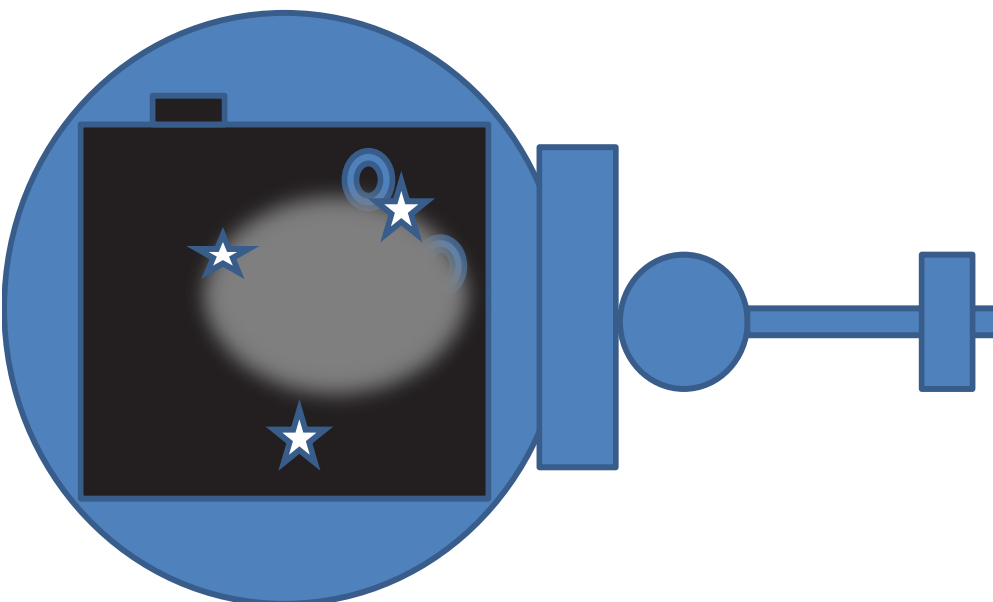


Figure 4. As for Figure 3, but with the camera rotated 180°

One solution might be to rotate the camera 180° to compensate for the rotation of the telescope. In that case we end up with Figure 4. Vignetting, caused by the telescope, stays offset to the mount-side of the telescope. The dust rings stay where they were on the camera, across from the tab position. One actually combines with the vignetting bright spot. The stars stay on the camera chip where they were before meridian flip. Better or worse?

So, to rotate or not to rotate the camera? A table shows what's the same or changed after flipping.

Meridian action	Stars wrt CCD chip	Stars wrt telescope artefacts	Stars wrt camera artefacts
Flip without rotating	rotated	rotated	rotated
Flip and rotate	same place	rotated	same place

When the stars stay in place with respect to the camera and its image artefacts, only the rotation of telescope artefacts causes problems, and that happens anyway whether or not you rotate. Also telescope artefacts, primarily vignetting, change slowly across the image so are well handled by flat-fielding. So rotating the camera at meridian flip is definitely the better option, two to none.

In my observatory I now invariably use a rotator, which minimises and usually eliminates the light curve problem in Figure 1. Rotating by hand is possible of course, but you may lose focus and you are unlikely to rotate exactly 180° . Also it may add precious minutes to the meridian flip delay.

It is also very important to return the stars to exactly the chip positions they had before meridian flip – and I mean exactly. And throughout the night's imaging they should stay exactly there. That also eliminates any change in their measured brightness due to the other camera artefacts that biases and darks help to compensate for. They, like flat fields, are never perfect and don't fully mask hidden additions to the Figure 1 problem caused by pixel sensitivities and unequal thermal responses.

And talking of flat fields, you need to take flats at both rotation angles – the before- and after-flip positions of the camera. In my case those settings are 0° and 180° . The need for this is obvious if you compare Figures 2 and 4. I use ACP to control the observatory, and it handles that automatically if connected to a rotator. For example if I tell it to get 24 B and V sunset flats, it will slew the telescope to the "flat spot" in the sky where the brightness gradient is a minimum, and when light levels are right it will take half of those at 0° rotation and half at 180° . Without that level of automation, you may need some planning and manual work to get both flat sets.

More pain comes in when calibrating your images. You need to divide your night's images into pre- and post-flip sets and calibrate the first using (in my case) the 0° flat masters, the rest with the 180° masters. It would be nice if there existed calibration software that acted on the ROT_PA FITS header keyword as a filter for automatically selecting the right calibration frames, but I know of none.

Cost comes into this – must you use a rotator? No, if you're willing to spend a lot of time sliding data up and down in your spreadsheet or other software until curves look right. But you can never be entirely confident your eyeballing of an eclipse curve got it right – straight lines are easier to judge. Positioning the variable dead centre in the CCD chip always helps too.

Or use a fork mount (sigh)!

RV and YY Gru

Grus has a high galactic latitude which gives observers two advantages – clean uncluttered images and minimal dust reddening. These two targets were observed at Pretty Hill Observatory (Kangaroo Ground, Victoria, Australia) in August and September 2014. In addition Phil Evans (Rarotonga, Cook Islands) contributed a night's data on YY Gru. Both systems are W UMa type eclipsing binaries (EW in GCVS parlance), i.e. two stars very close together, usually in contact with a common photosphere, giving rise to a dumbbell shape. Being so close they mostly orbit around each other in under a day, which makes for exciting photometry. These two have periods of around 7 hours, short enough to capture a whole orbit in a single night.

Untransformed photometric data have been uploaded the AAVSO variable star database (www.aavso.org).

RV Gru

GSC 8446 0744, ASAS J223924-4652.5

J2000 22 39 24.41 -46 52 32.1

EW/KW, 11.0-11.4V

According to (Duerbeck & Walter 1983) Cuno Hoffmeister (1956 – unfortunately not online) discovered the variability of this system and recognised it as a W UMa-type eclipsing binary with equal minima. Since that time it has been observed photometrically by Duerbeck & Walter in 1975-8 (Duerbeck & Walter 1983) and Covino and others in 1986 (Covino *et al* 1988). From the minima recorded in those two papers, Covino derived a linear ephemeris:

$$\text{HJD}_{\text{min}} = 2442655.7905(2) + 0.25951625(4) \times E$$

I obtained high quality B and V photometric data on the system on August 28th and two nights later. Figure 1 shows the CCD field with the comparison and check stars I used.

The latter data are plotted in Figure 2, showing (from the top) transformed V, B and B-V data. The maximum magnitude of V=11.0 and mean B-V of 0.88 agree well with the work of Eggen (1968) who found (B-V) = 0.93 and V=11.0 at maximum.

In Figure 2 it is obvious that the first and third maxima (both at the same orbital phase) are brighter than the second; and similarly the first and third minima are deeper. The difference in minima is so small (~0.02 mag) that it is no wonder Hoffmeister, working photographically, thought them the same. Inter-

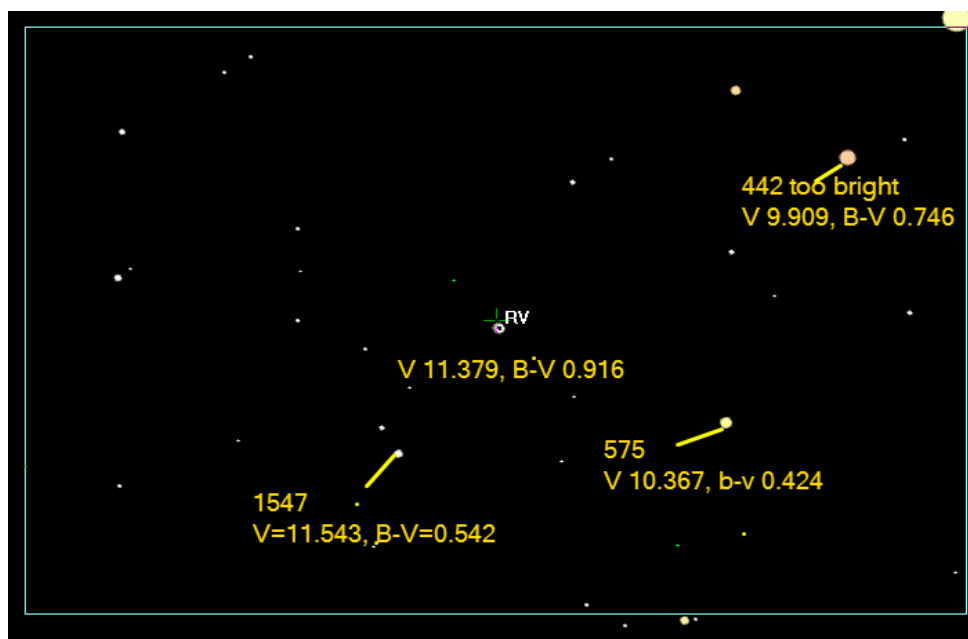


Figure 1. The CCD field for RV Gru. The comparison star is GSC 8446 0575, the check GSC 8446 1547; magnitudes are from the APASS catalogue (www.aavso.org).

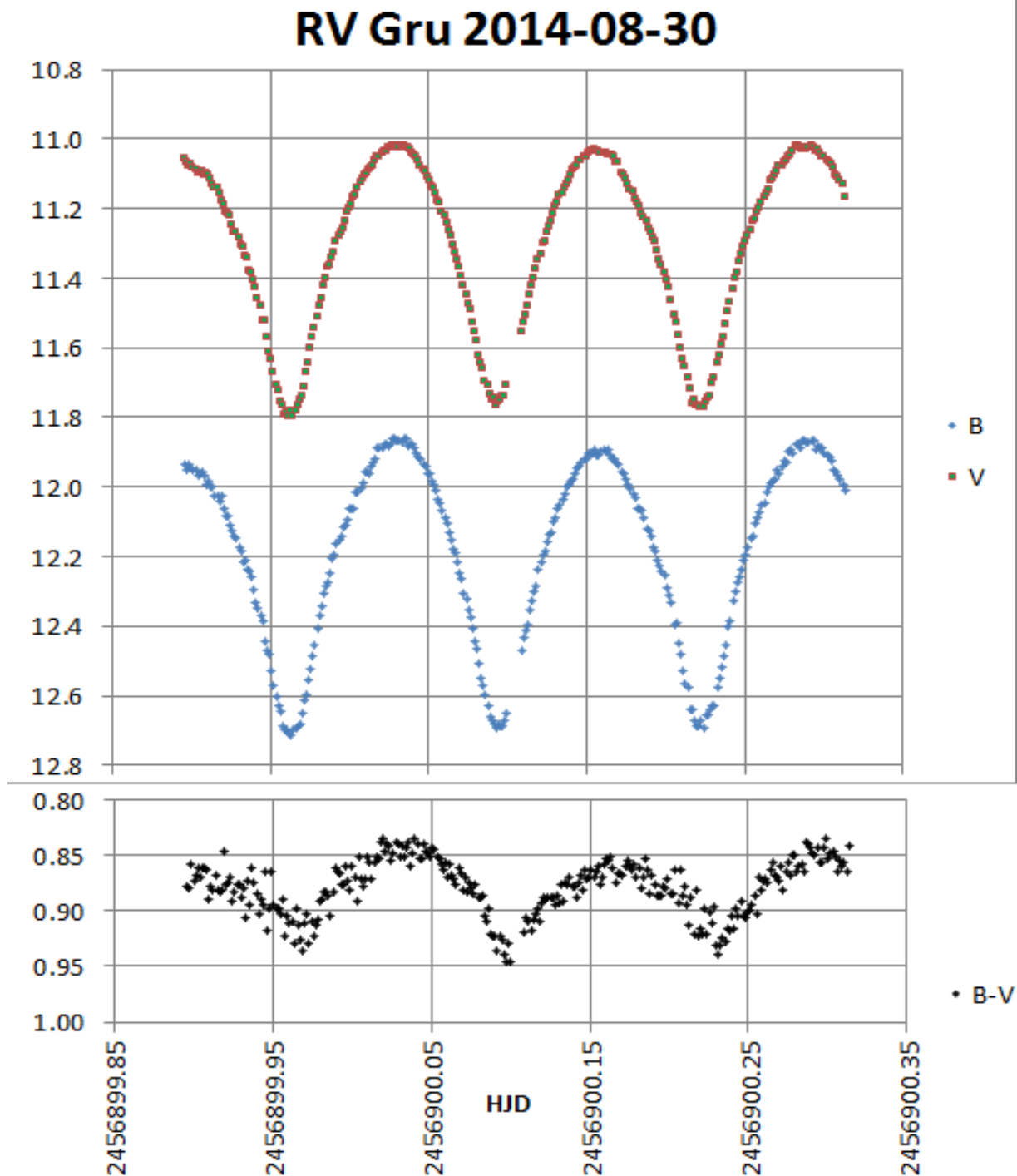


Figure 2. *Transformed light curves for RV Gru obtained on 2014-08-30. Top to bottom V, B, and B-V.*

estingly, on his light elements the deeper minima in Figure 2 turn out to be secondary, and the middle shallower one primary. Duerbeck & Walter noted the same thing working photoelectrically; and also that the secondary minimum (as defined here) varied by as much as 0.06 mag, the effect being detectable in timescales of months. Maxima exhibited similar changes. A somewhat similar situation can be found in my data comparing the two nights.

A comparison of the minima times given in the papers by Hoffmeister, Covino, Duerbeck and their co-workers, together with my data suggests a shortening period (see Figure 3 – a downwards parabola indicates a linear decrease). Unfortunately no observer has provided uncertainties for their minima timings, which are important in making these (O-C) comparisons (Observed – Calculated minima times, vital for investigating period change). More on this theme later. The minima times and (O-C) values calculated from Covino’s ephemeris (above) are set out in Table 1.

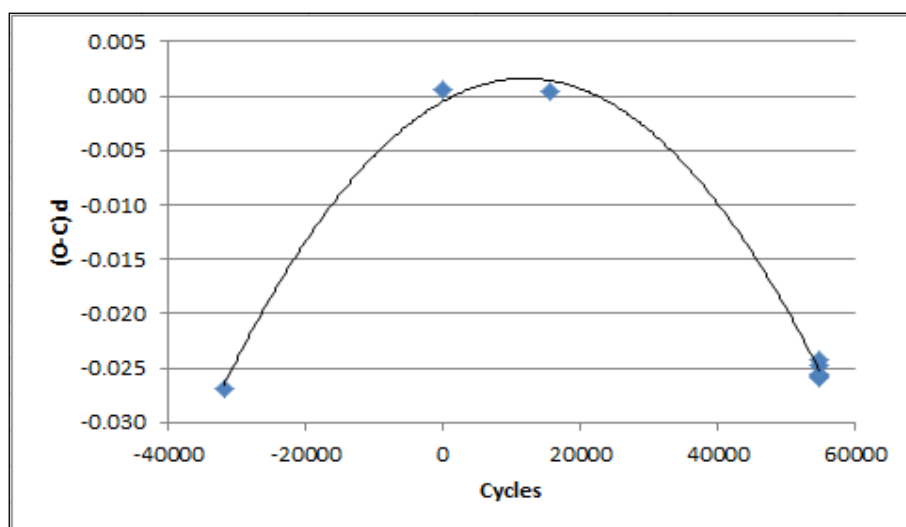


Figure 3. O-C diagram for RV Gru, based on Covino's ephemeris displayed in the text above. The four points from left to right are Hoffmeister's original minimum, those of Duerbeck & Walter (1983), then Covino et al (1988) at the top, and mine at the right-hand side. The downwards parabola joining them indicates a uniformly decreasing period.

	Cycle	HJD (O)	error	Min mag	C	C error	O-C	O-C error
Hoff	-31980	2434356.43400			2434356.46083	0.0013	-0.0268	0.0013
Duer&Wa	0	2442655.79110			2442655.79050	0.0002	0.0006	0.0002
Cov87	15483	2446673.88100			2446673.88060	0.0007	0.0004	0.0007
TR	54880	2456898.01759	0.00011	11.72	2456898.04230	0.0022	-0.0247	0.0022
TR	54880.5	2456898.14620	0.00010	11.75	2456898.17206	0.0022	-0.0259	0.0022
TR	54887.5	2456899.96291	0.00002	11.80	2456899.98867	0.0022	-0.0258	0.0022
TR	54888	2456900.09423	0.00029	11.77	2456900.11843	0.0022	-0.0242	0.0022
TR	54888.5	2456900.22259	0.00004	11.77	2456900.24819	0.0022	-0.0256	0.0022

Table 1. Minima and O-C data for RV Gru obtained on 28 and 30 August 2014 together with the minima from Hoffmeister, Duerbeck and Covino. O-C data are based on Covino's linear ephemeris (see text).

Using Covino's ephemeris, the (O-C) for both Hoffmeister's minimum and my minima are around -0.025 d. The Covino and Duerbeck data occur about halfway in time between the two, with (O-C) of ~0.0 d. Is the parabola in Figure 3 significant? The data of Duerbeck and Covino data are tight and reliable — though their uncertainties are unknown — as are mine. The only question mark is over Hoffmeister's photographic estimates. Certainly Hoffmeister's and my (O-C)s lie an order of magnitude outside the errors propagated from the Covino ephemeris. So I think period decrease is real.

Further work to be carried out on this system comprises (i) investigating a suggestion in Duerbeck's paper that small but systematic differences in primary and secondary minima (O-C)s are related to changes in the preceding maximum magnitudes; (ii) a quantitative estimate of period change, and (iii) shape modelling.

YY Gru

GSC 8453 0634, ASAS J224846-5059.6.

J2000: 22 48 46.62 -50 59 28.2

EW, 12.75-13.65V.

YY Gru is another discovery by Hoffmeister (1963 – also not online). His epoch is HJD 2436729.561 (1959 June 10) – without an uncertainty measure. The only other minimum I can find is in the VSX database (www.aavso.org), reported as derived by S. Otero from ASAS3 data. It is

$$\text{HJDmin} = 2451870.809 + 0.292649 \times E$$

No uncertainty is recorded. I obtained good data in B, V and I on two adjacent nights in August 2014, and Phil one night in November. Figure 4 shows the CCD field and comparison stars I used. The eight-week gap allowed us to derive a good ephemeris by linear regression:

$$\text{HJDmin} = 2456962.90703(36) + 0.2926472(27) \times E$$

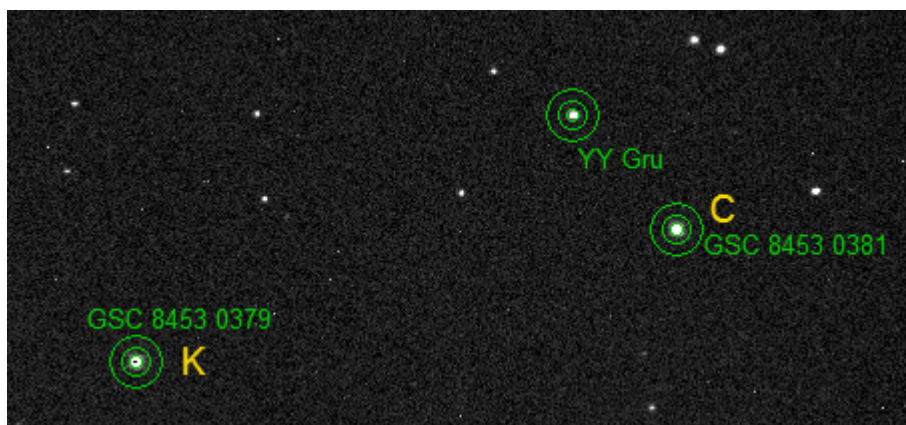


Figure 4. The CCD field for YY Gru. The comparison star, GSC 8453 0381 has magnitudes $V=11.535$, $B-V=0.684$ (APASS).

The phased V light curve I obtained is shown in Figure 5, folded on this period. A comparison of the B and V light curves gives a mean (B-V) value of 1.1, corresponding to a main-sequence K5 spectral type. Terry Bohlson (private communication) kindly obtained a spectrum of YY Gru, interpreting it as late G or early K. Bernard Heathcote, inspecting the same spectrum, estimates K0-K2 (private communication).

Table 2 shows the minima and (O-C) data, using this ephemeris, and including the Hoffmeister and

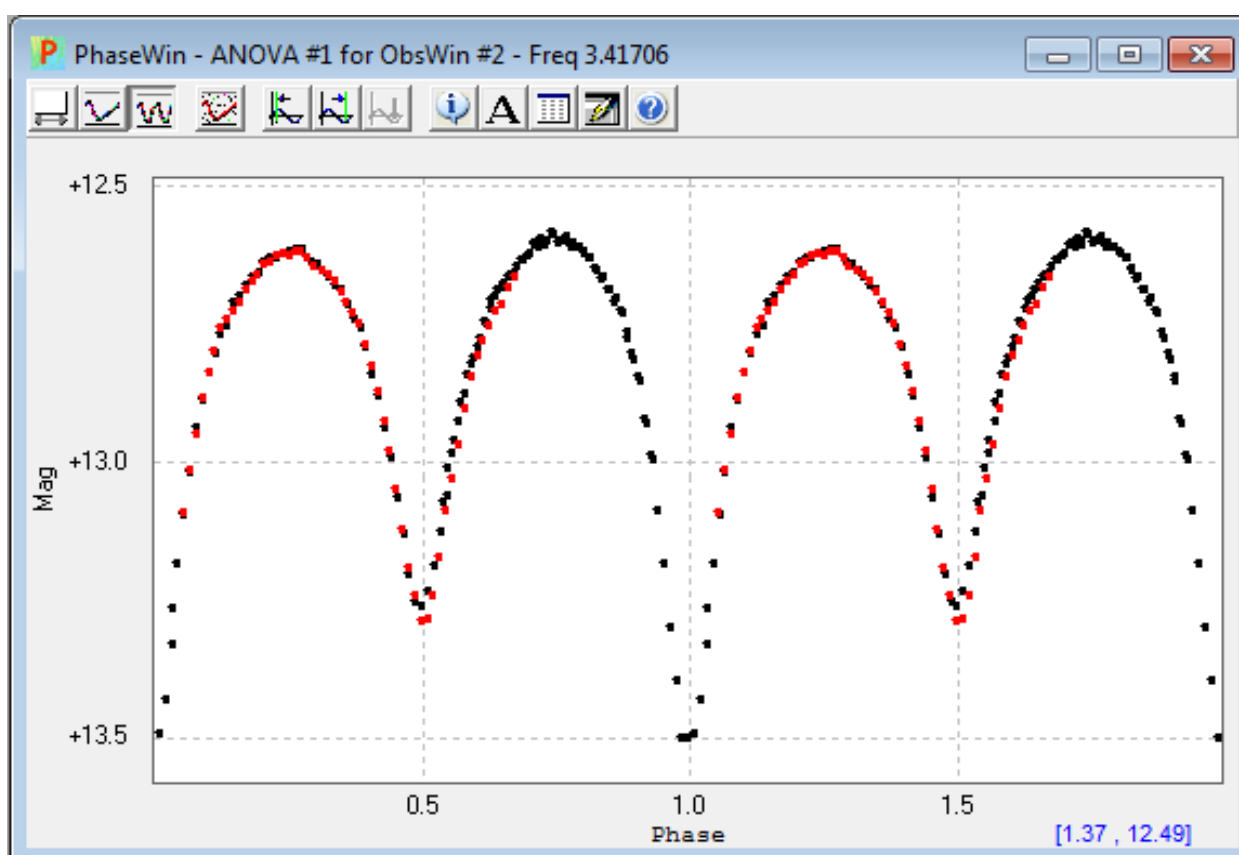


Figure 5. Phased light curve for YY Gru, using the ephemeris derived from our observations (see text).

VSX epochs. That table clearly shows it is not possible to make any speculation on period change. Derivation of minima from the temporally sparse ASAS3 sampling is unreliable; its (O-C) on our ephemeris is -0.037 d. Our 1-sigma period error accumulates to 0.047 d at its epoch, rather greater than the (O-C). Similarly, on our ephemeris the Hoffmeister epoch has (O-C) = -0.014 d, easily within the extrapolation of our period error back to that epoch (0.188 d). So, no indication for or against period change. When periods are very short as here, a very small error in period measurement (for us, 2.7×10^{-6} d), becomes quite large over a decade or more, swamping (O-C) differences. In such a case (O-C) measurements need to be very accurate, and the uncertainties in epoch and period measurements must be stated – but, as here, rarely are.

Cycle	HJD (O)	error	Min mag	C	C error	O-C	O-C error	
-190.5	2456907.157717	0.000075	13.26	2456907.15779	0.00063	-0.000071	0.00064	TR 2014-09-06
-187.5	2456908.035803	0.000059	13.28	2456908.03573	0.00063	0.000073	0.00063	TR 2014-09-07
-0.5	2456962.760239	0.000037		2456962.76075	0.00036	-0.000510	0.00037	PE 2014-11-01
0	2456962.907580	0.000073		2456962.90707	0.00036	0.000508	0.00037	PE 2014-11-01
-69139	2436729.561			2436729.57481	0.18822	-0.013806	0.19	GCVS
-17400	2451870.809			2451870.84642	0.04737	-0.037420	0.05	VSX

Table 2. Minima and O-C data for YY Gru by Phil Evans and myself obtained in 2014, plus the minima from Hoffmeister and VSX (see text).

In the absence of any useful investigation into period change, the remaining work to be done is to pursue shape modelling. More minima in a year's time may help the (O-C) problem by producing a very precise mean period over that time. Put it into your observing schedule!

References

- Covino, E. et al. 1988. *Astron. Astrophys. Suppl. Ser.* 73, 437-448.
Duerbeck, H.W. & K. Walter, 1983. *Astron. Astrophys. Suppl. Ser.* 54, 545-588.
Eggen, O.J. 1968. *Astrophysical Journal*, 153, 723-736.
Hoffmeister, C. 1956. *Veroeff. Sternwarte Sonneberg*, 3, 1-86.
Hoffmeister, C. 1963. *Veroeff. Sternwarte Sonneberg*, 6, 1-63.

Cepheid charts - can anyone help? – Stan Walker

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Introduction

Elsewhere in this newsletter (on page 33) is an article about the Type II Cepheid, ST Puppis, which shows Visual measures by Andrew Pearce in Western Australia. This star has a variable period, presently about 18.9 days and an amplitude of 1.3 magnitudes. In that it's similar to most of the Cepheids on our visual targets list - but its period changes are quite dramatic. Andrew's measures have been made using the AAVSO comparisons of the nearby Mira, CH Puppis. These Mira comparison magnitudes are only to 0.1 accuracy - which serves that purpose well - but our observers and others have shown that with care 0.05 or even better may be obtained with well selected sequences. The Mira sequences have been designed for stars with large amplitudes and have large steps.

Whilst most of our targets are binocular objects for all or part of the cycle the measures seem to be more accurate when made using a telescope, be it a C90 or a 254mm SCT. We are thus faced with the need for reversed charts as well as normal ones. One good thing, however, is that the comparison magnitudes are now very accurate and we won't be faced, as they were in the past, with periodic revisions of values.

A sample chart, that of the 12 day Cepheid, U Normae, is shown overleaf and it's sensible to look at this before continuing with this article.

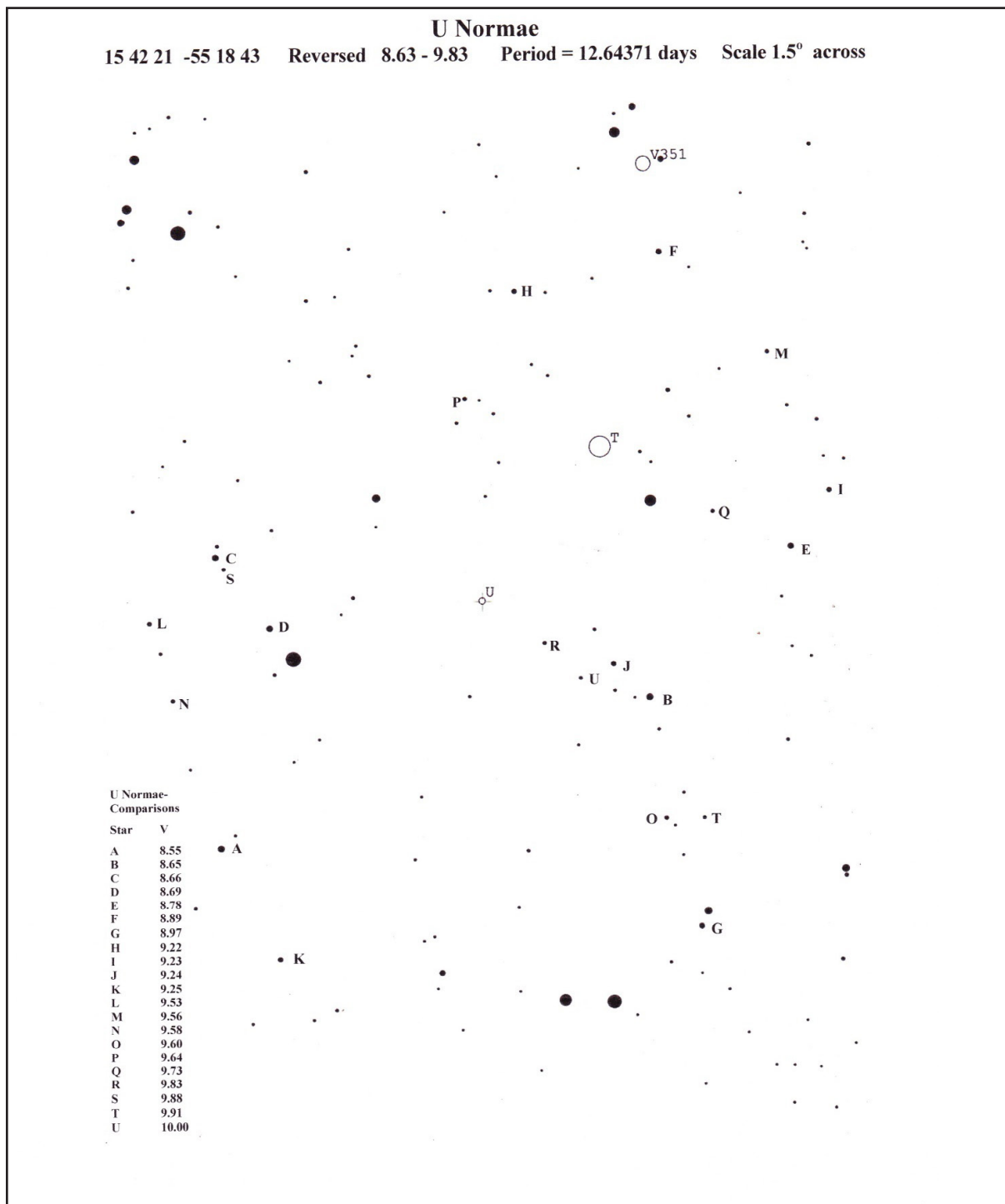
Information sources

To date Bill Gray's Project Pluto - Guide 8 - has been used. This provides reliable magnitudes, based on Michael Bessell's transformations of Hipparcos measures. As well, the limiting magnitudes of stars shown, and their size, can be varied as circumstances require to give a chart which is easy to work with.

Cepheids are amongst the most 'normal' of variable stars. They are much more compact than Miras, in most cases do not have strong emission in the spectra, and the spectral range is from F to K - or B-V colours of 0.3 to 1.3 normally. Guide also gives spectral classes or colours in the magnitude range we're interested in. It's best to exclude stars bluer than B5 or redder than K5. Even some early K stars seem to be variable by a few percent over decades.

Presentation & the chart

The goal is to have about the same number of comparisons as the range times 10. Thus we're looking



at 12-20 comparisons. So with values comprising 3-4 digits it would make for an extremely cluttered chart. This is overcome by using the old lettered sequences but ensuring - with certainty - that the brightness follows these exactly. The comparison star values are presented as a table at the lower left.

Guide allows printing of either direct or reversed charts - and will also save these in a rather large file. I found it best to merely print and copy them in jpg then work on these with Publisher. The more modern versions of Word emulate Publisher but not as well. There is also other software which does the same thing.

Can you help?

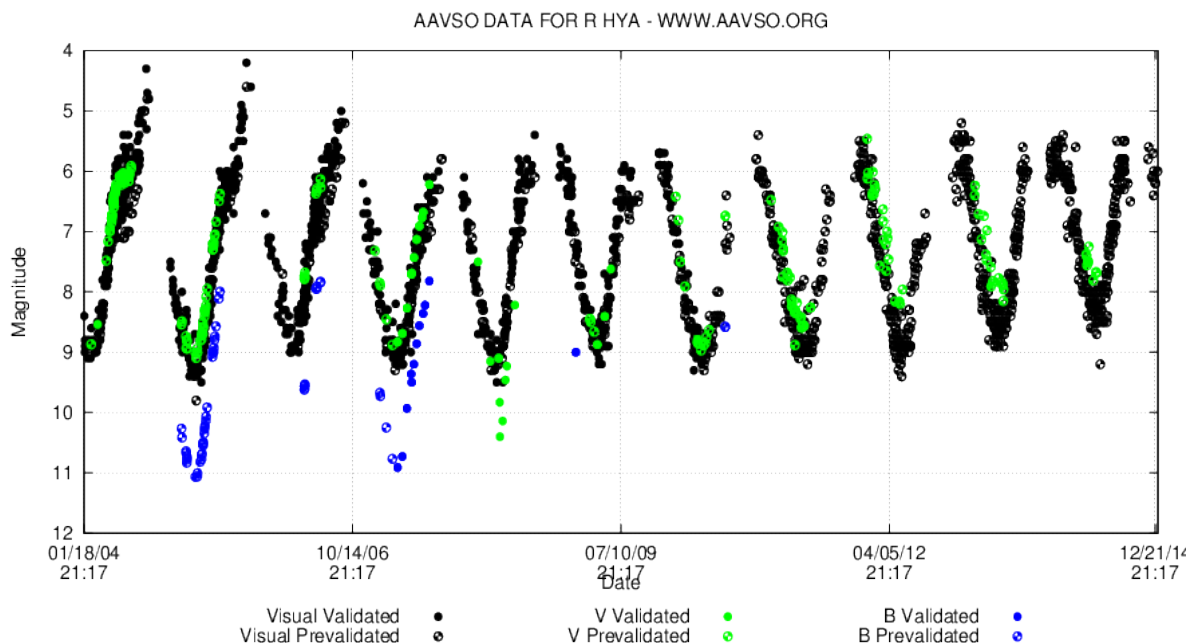
Firstly some observers might care to try out the chart and make comments. It's low in the sky but visible. But with taking over Tom's role I don't have as much time in this area as I would like. So one or more of our non-observing members might like to take this project on.

It seems to me that the star images might be too small and that the text in the table larger. But we need comments from the observers who might use this.

R Hydrae - soon to be a dual maxima Mira star? – *Stan Walker*

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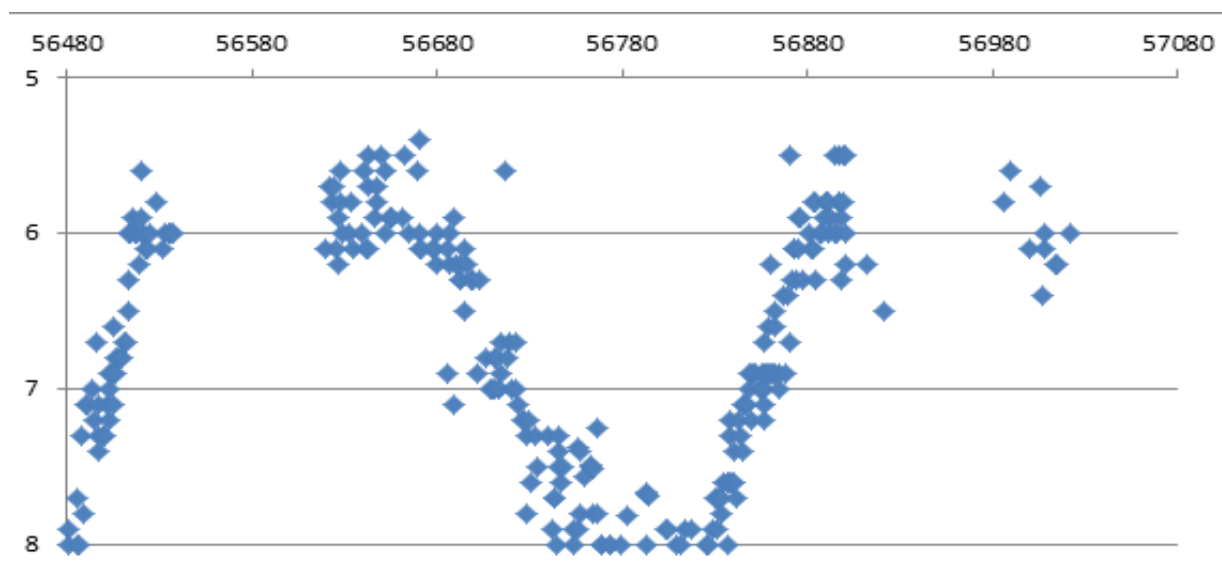
In the October newsletter I drew attention to possible changes in this star. Since its period stabilised at around 388 days about 60 years ago it has often had a pronounced hump on the rise. This is noticeable in the first three of the cycles observed during the last 4000 days as shown in the graph.



The coincidence of maxima with the Sun's passage is a problem but visual measures during the last four cycles - two shown here - hint at the possibility of it developing a double maximum. It seems a little wider at magnitude 6 than normally and there are some measures that are opposite to the normal rise or fall. Measures during the next few weeks will be extremely useful - some colour photometry from the DSLR people would also help.

It's also clear that the period has switched to 374 days, fairly normal for Mira stars - a difference of 3.6% which will probably persist for a decade or two yet making it hard to follow. A more detailed graph of the current and previous maxima appears below.

With the period of 374 days the possible secondary peak at JD 2456670 will take place at JD 2457044. Please watch carefully.



Visual observations of Cepheids - an update – Stan Walker

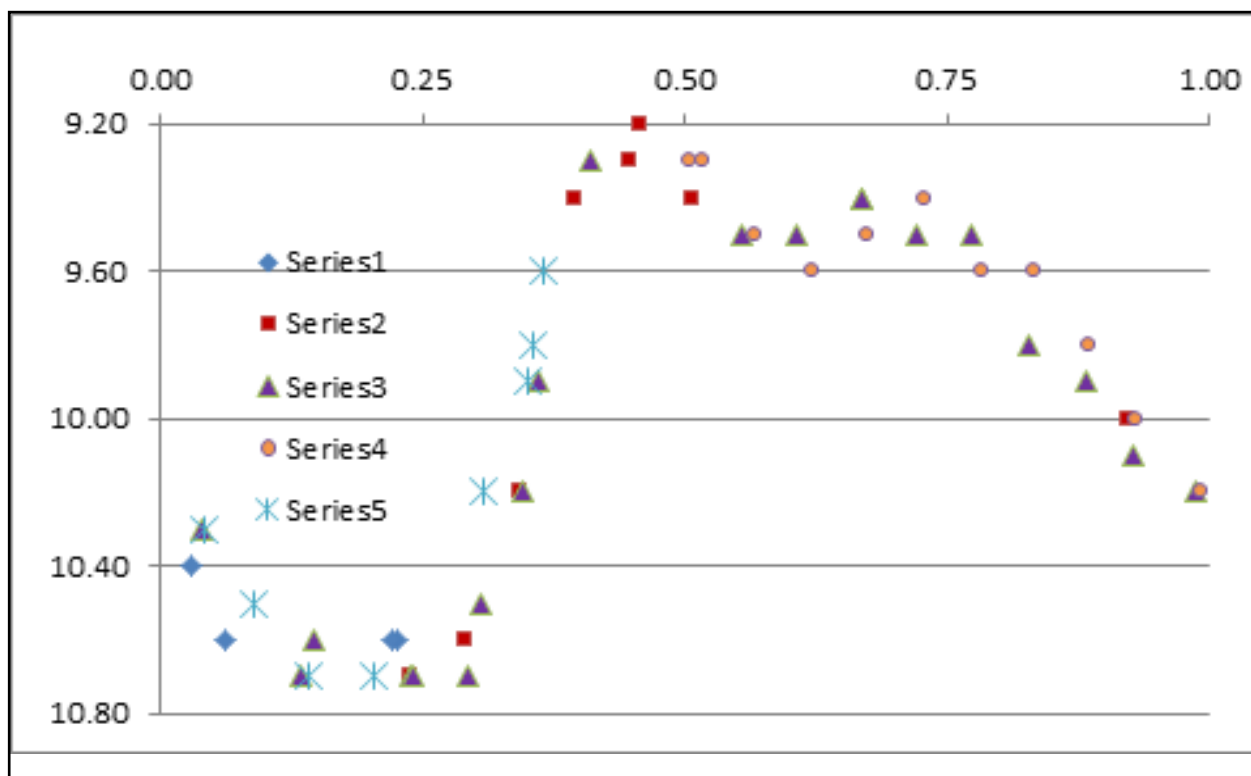
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Let's begin this article by repeating part of an item in the previous newsletter. With the co-operation of Andrew Pearce this idea has been tested and found to be quite practical provided a good comparison sequence is available.

This suggests a project rather like the Dual Maxima Miras where we're keeping a watch out for period changes by measuring epochs of maximum, but hope to produce a full colour light curve at intervals. This latter is a DSLR or CCD target in as much of BVR as possible, but the seasonal epochs may be a suitable visual target.

There were 21 stars in the list included in April. Of these 17 have amplitudes of one magnitude or more, up to 1.51. In intensities this is a range of 2.5 to 4.0, rather better than I Carinae's 1.95 or so. So once the basic colour curve is established for an epoch can we leave the coverage of some of these stars to the visual observers, preferably using Schrader's method of several comparison sets and an average?

At the time of writing Andrew has made 39 visual measures and Peter Williams 3. These are shown in the illustration. This uses an arbitrary epoch to allow the maximum to be seen more clearly. The series numbers merely refer to the cycles, beginning at minimum to avoid a changed number at maximum. Measures of this type would normally be fitted to a mean light curve to derive an epoch of maximum to be plotted on an O-C diagram but the pulsations of this star are so erratic that we need to plot a periodogram instead.



Determining a period is more complex requiring a number of measures over a number of cycles. The usual method is to determine two epochs of maximum and divide by the number of cycles, but with a star where the period is changing rapidly this doesn't work too well. There is also a variety of period search software available but these require hundreds of measures to be of any great use. I tried various methods in Peranso on a good dataset of 30 measures and derived periods with a spread of ~3%. Not much use in studying evolutionary period changes in Cepheids. So Andrew will take a break for a few cycles and measure it later in the season.

Whilst this is happening Neil Butterworth is supplying BVR colours with DSLR photometry, thus covering both aspects of the project. The star itself is interesting - clearly not a W Virginis object as shown in the GCVS - Olin Eggen's pseudo-Cepheid label seems appropriate - ST Puppis will be the subject of a paper at this May's annual conference of the RASNZ in Tekapo.

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.

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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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