



Clear Skies! We in the south might be having La Nina clouded skies but at 4200m above sea level the twin Keck telescopes have it easy. Photo by PE. If you have any interesting photos of any astronomical topic that could grace a future newsletter please email them to the editor.

Contents

From the director - <i>Tom Richards</i>	1
From the editor - <i>Phil Evans</i>	2
The Primary Eclipse of BL Telescopii in 2000 - <i>Col Bembrick & Tony Ainsworth</i>	3
BL Tel – 2011 Eclipse Visual Observing Program - <i>Peter Williams</i>	7
DSLR Photometry II - <i>Mark Blackford & Glen Schrader</i>	8
The CCD Column - <i>Tom Richards</i>	14
Bright Star Astronomy - <i>Stan Walker</i>	16
SPADES Project - <i>Tom Richards</i>	20
Equatorial Eclipsing Binaries Project - <i>Tom Richards</i>	23
VSS Research Grants Scheme	27
About	28

From the Director – *Tom Richards*

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Our New Editor

With this edition, I'd like to welcome Phil Evans of Rarotonga, Cook Islands, to the controls of the Newsletter. No stranger to editing and publishing, Phil will, I am sure, add his stamp to the excellent quality publication that Stan Walker has left us. To Stan, our gratitude for the painstaking work he has put in to the nine Newsletters he has edited.

What's in a Project? The example of BL Tel

Back in mid-April, Alan Plummer wondered aloud to the VSS-members egroupp if anyone though BL Telescopii might be worth observing, adding "Does anyone know off hand when the next eclipse is due?" That started out a storm of interest from many, evidenced by another 58 emails to VSS-members over the next month.

Peter Williams replied immediately "The eclipse period is about 778.0 days with eclipses therefore occurring every 2 years and 2 months. The next eclipse is expected to be centred around 2011 May 23 and as the eclipse duration is around 2 months, if we are going to concentrate on this event we should start observing NOW to ensure we catch the onset of decline!! Coincidentally, I have already made a couple of recent observations :))" I then asked Peter if he'd be willing to run a VSS project on this, and the rest, as historians say, is history. We have a VSS project, we have an area for the BL Tel project on our website, and we have a BL Tel forum for observers. Read all about it in Peter's article on page 7.

This is what Variable Stars South is set up to do. We are not trying to compete with the AAVSO by archiving any and all southern observations. The AAVSO should be, because of its enormous database and excellent submission, retrieval and visualization tools, the one place where everybody should send all their observations. Trying to compete with that is divisive, parochial, and unhelpful to science.

Our mission instead is to develop and support specific research projects on particular variables that we southerners can see in our skies. The BL Tel Campaign has joined a half-dozen active VSS projects, all aiming to produce not just time/magnitude data for the AAVSO, but coherent research results and analysis from the data of our observers. Observers in all our projects should be sending their data to the AAVSO, but also to their project leader in whatever form it is requested, for study, analysis and ultimately publication.

Variable Stars South supports these projects in two main ways. First, we provide a website, forums and an egroupp so an enthusiast can start up a project and get it known to our members, and the wider audience who follow our doings. This provides a way for the isolated observer who is interested in, say, RR Lyraes, to develop a campaign where others will help fill in the observational gaps, extend the coverage to more targets, and help in the resulting analysis and paper production. This is what Peter did and is doing.

Creating these campaign groups also provides a relatively cosy and un-threatening way of learning the ropes, with other members helping to guide you.

Secondly, and this is still somewhat under-developed, we provide facilities in our website for storage and presentation of observers' results, and their analysis, in a format appropriate to each project. As an example, in my Equatorial Eclipsing Binaries Project, I want to develop online storage of light curves, time-of-minima and O-C analyses of all the target stars, as well as access to normalised (not just raw) observer data in formats suitable for analysis software tools such as PERANSO. The SPADES Project will also be developing online facilities of a similar type; and indeed already has quite a comprehensive database of the information required by observers. These facilities will be tailored to each project, and developed by David O'Driscoll our webmaster, in response to what project leaders say they need. And the more who are willing to assist in this work the better!

It may also be appropriate for us to launch an online refereed journal for work that has permanent archival and research value. This, so far, is notional, but I would be most interested to see a discussion about this on VSS-members, especially about what form it should take and the software vehicles for its publication. Again, though, we should not try to compete with established publications such as the IBVS, OEJV, AAVSO Journal, and others. For that reason I have so far been unwilling to push for a journal until a clear role and differentiation is provided, let alone publication model.

Back to BL Tel. I hope that Peter and all BL Tel observers will make use of our website, and the BL Tel forum David has set up, to create a real resource on this star and the work we're doing. Websites and their forums and blogs have the advantage over paper, and email, of marrying fast flexible interactive acquisition, discussion, and presentation of information, with archival permanence that is accessible to all. I think that VSS as an organisation will stand or fall with how well it supports and enables targeted projects in these ways, and in others we haven't thought of yet.

So if you, like Peter, have an interest you want to turn into a team effort, email me. And, dear member, which projects of ours are you actively working in? Best way to learn!

From the editor - *Phil Evans*

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Welcome to my first edition as editor of the VSS newsletter. When I retired from publishing the Cook Islands daily newspaper three years ago I never thought that I would again be in the hot seat of a publication, but I am happy to be given the opportunity once more.

With a newspaper the most interesting articles are almost always those submitted by the readers (though I sometimes wished they could have been less interesting) and so it is with our newsletter. It cannot exist without reader contributions and I'm happy that my first edition has a good mix of both scholarly and educational articles.

Mark and Glen's article on DSLR photometry should give much hope to the many astronomers who own DSLRs but not a dedicated astro CCD camera. It is complemented by Stan's article on bright stars which advises on the sort of targets at which DSLRs excel.

Tom's thoughts on the meridian flip problem will be useful to those like myself who have a GEM and struggle with consistency of photometry before and after the flip.

The scholarly balance is provided in an excellent article by Col and Tony on the 2000 eclipse of BL Tel.

I see the newsletter primarily as a place to inform and educate but also as a medium for the occasional personal story. We live thousands of kilometres apart and in a few cases in isolated areas - my nearest VSS neighbour is probably Stan who is 3000km away - and there are few opportunities for personal contact. As Tom has pointed out in his director's message, website forums and email are excellent for rapid to-and-fro discussion on current topics but there is a place in the newsletter for longer stories about you and your work.

I would like to see in future editions a few more personal stories particularly from those who are not regular contributors to the newsletter. Tell us who you are and how you are involved with astronomy. A few hundred words and a photo or two will be ample.

If Tom's speculative proposal for a peer-reviewed journal sees fruit in the not-too-distant future it will probably impact the mix of articles you'll see in the newsletters, but everything evolves so it's no bad thing.

And now I must pay tribute to Stan for getting this newsletter started and nurturing it for over two years. I'm sure that we have all benefitted from his encyclopaedic knowledge of variable stars and his long memory of the southern amateur photometry scene. I wish him well in his editorial retirement and hope he enjoys good health and clear skies for many years to come.



The Primary Eclipse of BL Telescopii in 2000

by

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Abstract: CCD photometry of long period eclipsing binary BL Tel during its primary eclipse of 2000 yielded an epoch of primary minimum (HJD 2451813.47 ± 0.17) and an indication of the colour changes during total eclipse. The depth of the primary minimum was approx 1.8 magnitudes and the duration of the total phase was approx 5.2 days

Introduction: This variable was first identified by Luyten (1935), who lists it as “950.1935 Telescopii” with a magnitude range of 7 – 9. He notes it is equivalent to CoD -51° 11917. Subsequently it appeared in the Catalogue of Variable Stars (Kukarkin & Parenago, 1948), where it was listed prior to 1948 as a possible RCB star. It is also known as SAO 245923, located at RA 19 06 38, Dec -51 25 03 (2000). Other designations include GSC 8386 1623, PPM 347434, HD 177300, HIP 93844. The star has a listed catalogue magnitude range of 7.09 to 9.41 (GCVS), 7.72 to 9.82 (B in MHD cat), 7.21 to 8.90 (HIP). Spectral type designations include gF8 and M and also F5 IAB/B (MHD). The Johnson B-V index is 0.523 and the Cousins V-I index is 0.60.

This interesting long period system (Akyuz, 1972) was first brought to the attention of Peter Williams, leader of the current VSS campaign on this star, by Ferrin (1983) via an IAU Circular. Subsequently, a finder chart with a comparison sequence to facilitate visual observations was compiled by Williams (pers comm.). Williams commenced visual monitoring in July 1983 and subsequently summarised the visual results (Williams, 1983 & 1985). This variable was brought to the attention of the first author (CSB) by Williams in early 1985.

Additional observers contributed visual observations in 1985, (see Williams, 1988 and Bembrick, 1986), 1987 (Williams, 1993), 1994 (Williams, 1997), 1996 (Williams, 1998), 1998 (Williams, 2000) and in 2000. As a result of these combined efforts, Williams (2002) presented a summary and analysis of all the local visual observations to date.

The resulting ephemeris presented by Williams was:

$$\text{Primary Min (JDgeo)} = 2434692 + 778.1 \times E$$

Observations: CCD observations in 2000 were planned on the basis of the ephemeris presented above. In Sydney observations were conducted at Gungah Bay Observatory using a 23 cm Schmidt-Cassegrain telescope mounted on a GM8 German equatorial mount. The detector was an ST7E camera using the KAF400E chip. In Bathurst, NSW observations were conducted from Mt Tarana Observatory, using a 40 cm Schmidt-Cassegrain and an ST8 camera, with the KAF1600 chip. The response curves (QE) of these two chips are somewhat different, the E chips being considerably more sensitive than the standard chip at shorter wavelengths – ie towards the blue. The differences can be seen in the figure reproduced in Fig 1. The KAF400E is just a smaller version of the KAF1600E.

As no V filters were available to us at the time, all observations were made without filters in the instrumental bandpass of the CCDs. The integration times were chosen to yield a signal to noise ratio of better than 100, thus ensuring 1% photometry was achieved. Measurements of the variable and comp star were made on average twice per night.

Photometric reductions were made using the “Mira” software package by means of synthetic aperture

*Deceased: My good friend and observing colleague passed away in March 2009.

photometry. A master flat was applied to each image prior to reduction. The master flat was made using multiple night sky images and the median combine method. A comparison and a check star were used in the reductions and the difference between them was used to gauge the sky stability on the night.

The Check star was TYC 8386-1191-1, B= 10.934, V= 10.66, B-V= 0.253.

The Comp star was TYC 8386-1988-1, B= 10.797, V= 10.318, B-V= 0.451.

Results: All data were reduced as described above and the results plotted using an Excel spreadsheet. The data from each site for the primary eclipse was combined (see Fig 2), with the out of eclipse portion of the light curves aligned. As can be seen from the light curve, the primary minimum is approx 1.8 magnitudes deep (KAF1600) and the out of eclipse portion of the light curve is essentially flat. The rise from primary minimum to maximum light takes approx 31.5 days. Thus the total duration of the primary minimum could be expected to be 63 days, but due to the slight curve asymmetry, this is actually closer to 65 days. This compares to a duration of 68 days observed visually (Williams, 2002).

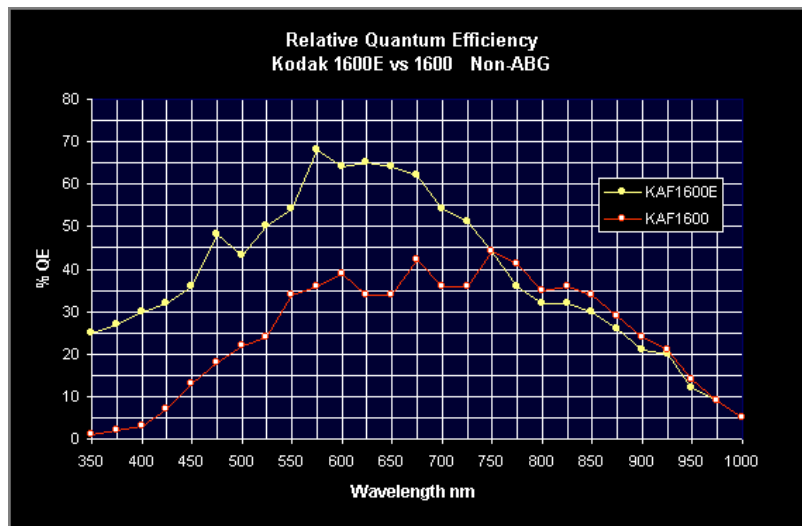


Figure 1. The response curves of the detectors

The light curve is flat bottomed at primary minimum, with this phase lasting approx 5.2 days. The E chip, which is more blue sensitive, shows a fainter magnitude at primary minimum, thus indicating that the system is redder during primary eclipse.

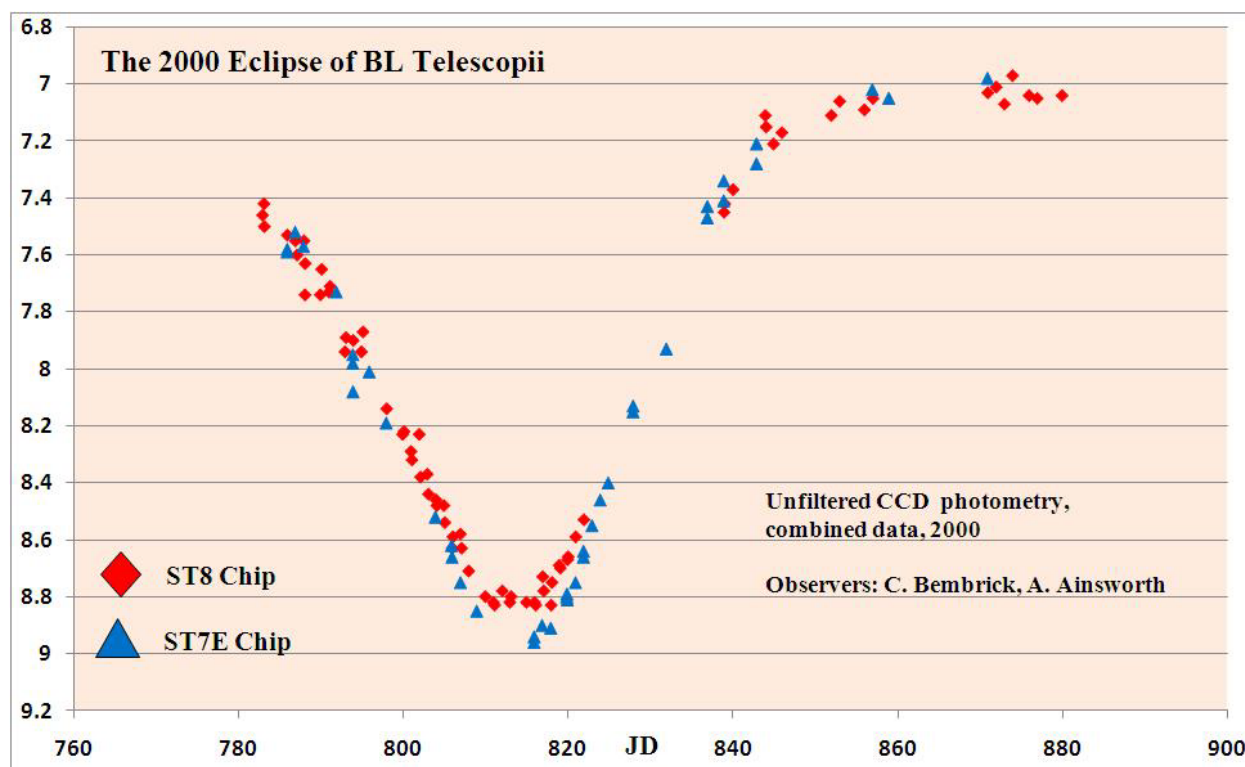


Figure 2. The primary eclipse in 2000 as measured by two different detectors.

The epoch of primary minimum determined from these CCD results is HJD 2451813.47 $\pm$ 0.17

Analysis of the previous primary minima timings derived from visual results is presented in Table 1. This utilises our newly determined epoch and the mean interval between observed primary eclipses. The mean interval we derived is 777.53 ± 0.74 days.

Discussion: The following brief comments will serve to highlight the features of the system that are known and also the queries that remain to be answered by further observation and analysis, together with modelling of the binary system. The system is interesting not only for its very long period between eclipses, but because the period appears (from visual observations) to vary slightly from cycle to cycle and the eclipse depths also vary.

- Primary eclipse is flat bottomed (see Fig 2) and thus the eclipse is total or annular.
- Distinct colour changes are observed as the eclipse progresses, with the system being redder during eclipse. Note that the ST8 chip, which has a redder response, shows a shallower eclipse – Fig 2.
- The primary eclipse light curve is slightly asymmetric – it has a sharper rise than fall – this is also apparent in some of the visual light curves. This needs to be accounted for in the modelling.
- There is (as far as it has been sampled) a flat light curve out of eclipse – therefore no reflection effect.

The system has previously been interpreted (Gaposhkin, 1970) as a blue supergiant (F8) primary with a red (M0) secondary. Masses have been interpreted as 32 solar and 9 solar for the primary and secondary respectively. These systems are fairly rare and have been shown to have alternating pulsation modes (Sasselov, 1983), leading to their inclusion in a class called "UU Her type" (Sasselov, 1984). This system has received considerable attention in the professional literature – see van Genderen, 1986 and Feast, 1967 – where multi-colour photometry, spectral and radial velocity data are discussed..

Conclusion: The results presented here are from the close collaboration of two observers at different sites and with different equipment. Time and weather constraints affecting individual observers make this type of collaboration particularly fruitful in a long observing program such as this.

The epoch of primary minimum determined from this CCD photometry in 2000 is HJD 2451813.47 $\pm$ 0.17. The primary minimum (see Fig 2) has a depth of 1.8 magnitudes in the KAF1600 bandpass and 1.9 magnitudes in the KAF400E bandpass (cf > 2 magnitudes in the visual). The light curve is flat bottomed, so this eclipse is total/annular.

Using the above epoch and the mean period derived from the previous data (Table 1), an ephemeris is presented for future eclipses of this interesting long period eclipsing binary.

The ephemeris is:

$$\text{HJD} \quad 2451813.47 \pm 0.17 \quad + \quad 777.53 \pm 0.74 \times E$$

References:

- Akyuz, Janet H. 1972. *BL Telescopii – A Rare Eclipsing Binary*. Jour. AAVSO, **vol 1**, no.2, pp50-51.
- Bembrick, Col, 1986. *The 1985 Eclipse of BL Telescopii – Preliminary Results*. The Bulletin, Jan., Brit. astr. Assn. (NSW Branch).
- Feast, M.W., 1967. *The Supergiant Eclipsing System BL Telescopii* Mon. Not. R. astr. Soc., **135**, pp287-304.
- Ferrin, I., 1983. IAU Circular 3827(3).
- Gaposhkin, Sirgay, 1970. *The Photographic Light Curve of the Supergiant Eclipsing Variable BL Telescopii*. Astr. J., **75**(5), pp641-642.
- van Genderen, A.M., *The 1983 eclipse of the high-latitude eclipsing system BL Tel*. Astron. Astrophys., **158**, pp361-366.
- Kukarkin, B.V. and Parenago, P.P., 1948. Catalogue of Variable Stars. Moscow.

Table 1		
Observed (HJD 24...)	Calculated (24...)	O-C (days)
45591.50	45593.222	-1.72
46369.49	46370.753	-1.26
47144.49	47148.284	-3.79
48702.99	48703.346	-0.35
48702.99	48703.346	-0.35
49481.02	49480.877	0.14
50256.00	50258.408	-2.41
51034.50	51035.939	-1.43
51813.47	Epoch (CCD)	0

Luyten, W.J., 1935. *Astr. Nachr.* **258**, p121.

Sasselov, Ditmar D., 1983. *On Some Remarkable Pulsation Properties of the high-latitude F-Type Supergiants*. IBVS 2387.

Sasselov, D.D., 1984. *The UU Her Type Stars: Possible Tracers of Recent Star Formation at High Galactic Latitudes*. *Astrophys. Space Sci.*, **102**, pp161-178.

Williams, Peter F., 1983. *The 1983 Eclipse of BL Telescopii*. in *Variable Stars*, Sthn Observer, **22**(6), pp111-113.

Williams, Peter F., 1985. *Visual Observations of the 1983 Eclipse of BL Telescopii*. *Publ. Var. Star Sect. Roy. astr. Soc. NZ*, **12**, pp8-10

Williams, Peter F., 1988. *Visual Observations of the 1985 Eclipse of BL Telescopii*. *Publ. Var. Star Sect. Roy. astr. Soc. NZ*, **14**, pp40-43

Williams, Peter F., 1993. *Visual Observations of BL Telescopii*. *Publ. Var. Star Sect. Roy. astr. Soc. NZ*, **18**, pp11-16

Williams, Peter F., 1997. *Visual Observations of the 1994 Eclipse of BL Telescopii*. *Publ. Var. Star Sect. Roy. astr. Soc. NZ*, **22**, pp46-48

Williams, Peter F., 1998. *Visual Observations of the 1996 Eclipse of BL Telescopii*. *Publ. Var. Star Sect. Roy. astr. Soc. NZ*, **23**, pp13-17

Williams, Peter F., 2000. *Visual Observations of the 1998 Eclipse of BL Telescopii*. *Publ. Var. Star Sect. Roy. astr. Soc. NZ*, **24**, pp6-10

Williams, Peter F., 2002. *BL Telescopii - Visual Observations of the Year 2000 Eclipse*. *Publ. Var. Star Sect. Roy. astr. Soc. NZ.*, **25**, pp 11-15.

BL Tel – 2011 Eclipse Visual Observing Program - Peter Williams

INTRODUCTION

Visual observers are invited to participate in monitoring the 2011 eclipse of BL Tel for which observations are required between mid April through to the end of June 2011.

BL Tel was the subject of a long-term visual study between 1983 and 2000 with the recording of 8 eclipses during that time. Results of those eclipses are summarised in Publications 25 (C99) of the VSS RASNZ (2000). BL Tel is an Algol type system of period near 778 days and visual range between magnitudes 7 and 10. Eclipses are of duration up to 2 months.

OBJECTIVE

The objective is to produce a complete visual light curve based on daily mean magnitudes and from this to determine the basic parameters of the eclipse – the date of mid eclipse, daily rate of brightness change, overall duration and amplitude. These results can then be compared with results from the earlier eclipses.

OBSERVATIONS

Visual observers should obtain magnitude estimates on a daily basis commencing immediately and continue through to the end of June 2011. BL Tel is suitable for observation with bi-noculars when at maximum and during the early and late stages of eclipse. Large binoculars or small tele-scopes will follow through it through minimum. A chart showing suitable comparison stars is shown in Fig 1.

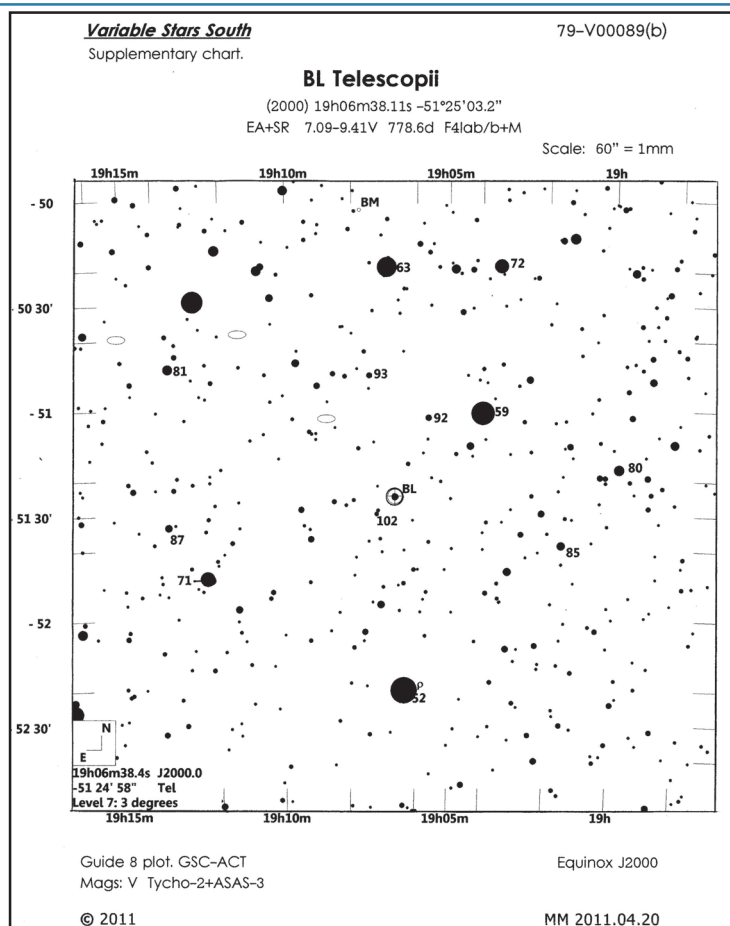


Figure 1. Finder chart with suitable comparison stars for the eclipsing binary BL Tel. The chart was produced by Matti Morel.

All observations should be included in usual reporting to the AAVSO. Observers should also send a complete list of their observations in JD format (no heliocentric corrections required) to the undersigned at completion of the program. Multi colour photometry is also most welcome. Arne Henden, Director of the AAVSO, is also investigating use of the BSM-South telescope during this time. - *Peter Williams*.
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DSLR Photometry II - *Mark Blackford & Glen Schrader*

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Our February 2011 Newsletter article described the use of a consumer level DSLR camera with a standard telephoto lens for photometry and presented some very early results for RS Puppis. We touched on a few techniques necessary to record good images and pointed out the requirement to transform measured magnitudes into standard BVR magnitudes in order to compare data with other observers.

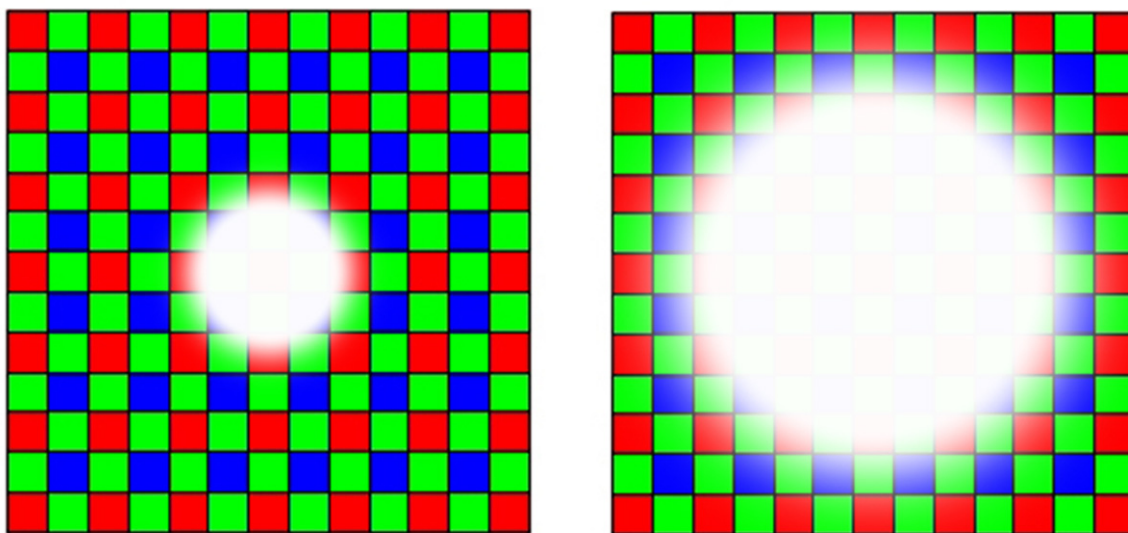
In the following pages we'll show how we determined transformation coefficients and present further results. We will also discuss linearity and other issues relevant to image acquisition and analysis. But first a quick recap.

A Canon 450D DSLR and Nikkor 180mm f2.8 lens piggybacked on an 8" Celestron telescope on a CGEM mount constitutes the imaging system. Images are recorded in 14 bit RAW format. The field of view is $\sim 7.0 \times 4.7$ degrees; ensuring suitable comparison stars are always available.

Bayer matrix colour filter issues

An advantage of DSLR photometry over PEP or CCD photometry is that R, G and B images are recorded simultaneously thereby reducing acquisition time. However there are a few issues with one shot colour imaging that have significant implications for photometry.

In the Bayer filter array used in DSLR cameras half the pixels record green light and one quarter of the pixels record red or blue light (see figures 1a and 1b).



Figures 1a (left) & b. The figures show schematics of a focused star image (left) on a Bayer filter matrix and a defocused one on the right. In the focused image only a small number of individual pixels of each colour are illuminated leading to poor photometry in each colour. Also, each pixel reaches saturation relatively quickly despite total photon flux (and therefore starADU) being relatively low. In the defocused image more individual pixels of each colour are illuminated allowing better photometry. Furthermore, longer exposures are possible before saturation occurs so total flux (starADU) is increased.

Software that interprets and displays these images has to estimate how much red, green and blue light would have fallen on each pixel in the image. It does this by looking at, for instance, the surrounding green

pixels and interpolating how much green light should have fallen on the red and blue pixels.

For normal terrestrial or astrophotography the accuracy of interpolation is not critical but for photometry it definitely is. Therefore it is essential that the software used for extracting red, green and blue channel images for photometry uses robust interpolation algorithms so that accurate raw instrumental magnitudes can be determined. Any of the specialist astronomy programs that handle DSLR raw images, such as AIP4WIN, MaxIM DL or IRIS, will carry out this process adequately.

As shown schematically in Figure 1a, a tightly focused star image extends over only a few pixels of each colour. This leads to imprecise interpolation. Furthermore, pixels reach full well capacity in relatively short exposures.

Defocusing slightly extends the star image over many more pixels which leads to better colour interpolation. It also allows longer exposures before pixel saturation, hence better counting statistics.

Linearity and ISO

Use the lowest ISO compatible with reasonable exposure times. Higher ISO only scales the gain so ADU per incident photon is increased. If a 1 second exposure at ISO 100 gives 5,000 ADU then the same exposure will give 10,000 ADU at ISO 200. There is no more information because the noise is also scaled by the same factor.

Camera response will deviate from linear as the well capacity of pixels is approached. The Canon 450D showed linear response up to at least 14,600 ADU at ISO 100. Higher ISO settings cause ADU values to exceed the analogue to digital converter maximum (14 bit = 16,384 ADU) before well capacity is reached. Hence higher ISO settings should have linear response throughout the ADU range, but at the cost of reduced dynamic range.

Richard Berry (Berry 2011) made the following comments which neatly summarise the issues:

The CCD/CMOS sensor captures essentially the same data regardless of the ISO setting. What the ISO setting does is to increase the analog gain, that is, to multiply the pixel values by a constant. Bigger pixel values make for a brighter JPEG, but since you're working with raw images, you only care about the numbers. With the camera on a tripod and exposures on the order of 6 to 10 seconds, your limiting magnitude is set by a combination of photon statistics and intrinsic detector noise. It doesn't help to multiply the ISO 100 pixel values by some factor (increasing from ISO 100 to ISO 800 is a factor of 8) — it just reduces the dynamic range. Longer exposures (i.e., tracking) at a lower ISO setting is a great way to go. Stacking at a high ISO setting does work, but it is not the most efficient way to add to your total photon count, in part because stacking makes reducing your images considerably more time-consuming. Resort to stacking when you have maxed out your ability to capture the stars you want to measure at a low ISO setting.

As I mentioned, the DSLR parameter space is large, and people have shown that they can get acceptable results from many locations inside that parameter space. What you'd like to find is the spot that gives you the best data for your investment of time and energy. The optimum spot means that you can either work fainter stars, work more stars, or work at a higher cadence.

Choice of f-ratio

Fast camera lenses allow shorter exposure times; however, it may be necessary to stop down the lens aperture one or two stops. Coma, spherical and chromatic aberrations can cause unacceptable distortions at the edge of images, especially since we intentionally defocus to spread star images over more pixels.

FWHM of R, G and B channels

Chromatic aberration causes the FWHM to be different for each colour, especially when the lens is out of focus. We found with the Nikkor 180mm f2.8 lens Mark uses, the red and blue channel star images have larger FWHM than the G channel, so appropriate aperture radii for aperture photometry analysis must be determined for each channel.

Transformation to standard BVR system

We showed in our previous article that the blue, green and red filters in the DSLR camera Bayer matrix array are not well matched to the standard B, V and R photometric filters. We should not be surprised by this since these cameras were not designed for photometry.

With a little effort, however, it is possible to correct the spectral response of Bayer matrix filters to better represent BVR filter responses. This transformation process can be achieved in many different ways. We adopted the method introduced by R. H. Hardie (Hardie, 1962).

Derivation of formulae will not be addressed here. Instead we will simply present the relevant Hardie formulae, describe how to calculate the coefficients and illustrate how they are applied to derive transformed magnitudes.

Nor will we cover the issues of primary extinction (dimming due to longer atmospheric path length at lower altitudes) and secondary extinction (the inescapable effect of the atmosphere upon a star's colour). Stan Walker described these in his article "High Precision Photometric Transformation to the Standard UBVRI Colour System" in the November 2010 Newsletter, page 26. Extinction corrections are necessary for higher air mass values and large colour differences between target and comparison stars, and can be incorporated into the Hardie equations. Stan suggests that most extinction can be ignored with DSLR cameras if simple techniques, used in the early days of photometry, are adopted:

In most city sites which our members operate from, the secondary extinction (SE) in B-V will be close to 12-15%, or 0.12 to 0.15 per air mass per magnitude of colour difference. In V-R it's only about half this. Primary extinction is much higher, but since the target stars lie within 1-4 degrees of each other its effects will be less than 0.010 magnitudes except at air masses greater than 2, which is about an altitude of 20 degrees. Secondary extinction is always present but consider the following:

$$SE(B-V) = EF_{bv} * dX * d(B-V)$$

SE(B-V) is the secondary extinction in B-V;

EF_{bv} is the B-V secondary extinction correction factor, say 0.15 as stated above;

dX is the difference in air mass between target and comparison, say 0.25;

d(B-V) is the difference in B-V between target and comparison, say 0.25.

Therefore:

$$SE(B-V) = 0.15 * 0.25 * 0.25 = 0.009$$

The effect of secondary extinction is much smaller than the precision of the measures.

Since the DSLR introduces a whole new approach to measuring standards in the E Regions - 10 images can be obtained in a few minutes - it might be sensible to obtain calibration images at 1.25 air masses which would then make for high class photometry down to 1.5 air masses, or an altitude of around 40 degrees, without need for correction, provided the comparison stars are well selected.

Hardie equations

For clarity, the terminology we use below is slightly different to that used by Stan in his article. The transformations equations are:

$$1) \quad (B-V)_t = d(b-v) * T_{bv} + (B-V)_c$$

$$2) \quad (V-R)_t = d(v-r) * T_{vr} + (V-R)_c$$

$$3) \quad V_t = dv - T_v * (B-V)_t + V_c$$

Lower case terms are raw instrumental magnitudes measured from images.

(B-V)_t, (V-R)_t and V_t = transformed magnitudes;

T_{bv}, T_{vr}, T_v = transformation coefficient for B-V, V-R and V, respectively;

(B-V)_c, (V-R)_c and V_c = catalogue magnitudes of the comparison star;

d(b-v) = measured (b-v) of the variable - measured (b-v) of the comparison;

d(v-r) = measured (v-r) of the variable - measured (v-r) of the comparison;

dv = measured v of the variable - measured v of the comparison.

(B-V)_t must be determined before V_t can be calculated. From these we can determine B and R transformed magnitudes:

$$4) \quad B_t = V_t + (B-V)_t$$

$$5) \quad R_t = V_t - (V-R)_t$$

Determining transformation coefficients

In order to determine the three transformation coefficients we image a region of sky containing a number of standard stars with a range of colours and accurately known B, V and R magnitudes. The more stars the better but 15 to 20 should be sufficient. We then measure b, v and r raw instrumental magnitudes of these standard stars from the images. This is all the information we need.

We used a set of images of the Cousins E3 region. The images incorporated several dozen standard stars however some were either too bright or faint so a subset of about 30 stars was measured. At least 10 images should be recorded and separately measured, and the average values for each star used for determining transformation coefficients.

A graph of measured (b-v) against true (B-V) is shown in Figure 2. The T_{bv} transformation coefficient is the inverse of the slope of the line of best fit through this data. T_{vr} and T_v can similarly be determined as shown in Figures 3 and 4 overleaf, respectively.

We found that several standard stars had to be rejected from our analysis because their data points did not fall near the line. In a couple of cases brighter stars had saturated pixels so the measured magnitudes were fainter than they should have been. In other cases a nearby star contributed to the measured

ADU and so the measured magnitude was brighter than it should have been. In a couple of cases we have not yet identified a clear reason for why the data point was significantly displaced.

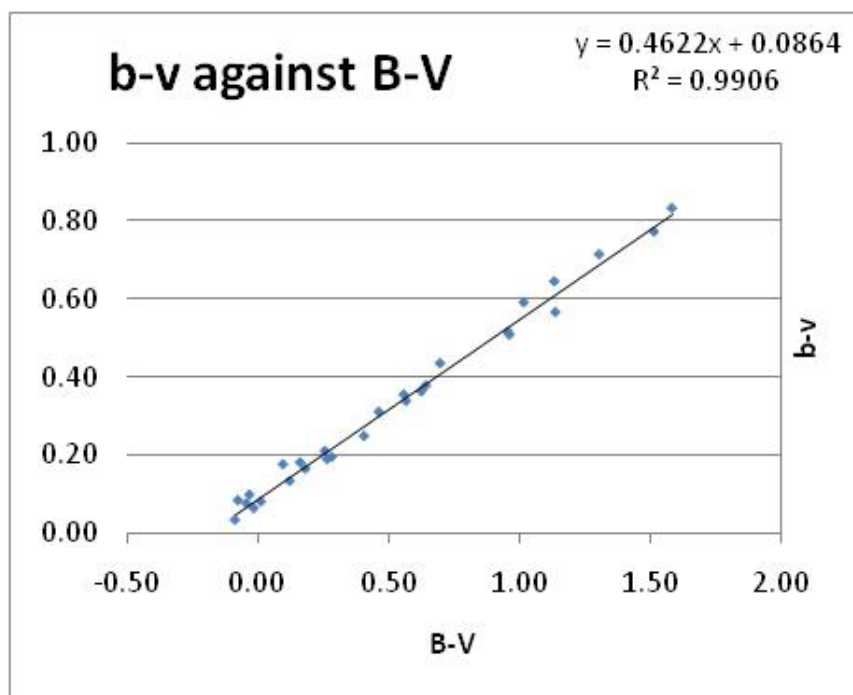


Figure 2. Plot of raw instrumental (b-v) against true (B-V) for a set of standard stars in the Cousins E3 region. The T_{bv} transformation coefficient is simply the inverse of the slope of the line of best fit (T_{bv} = 1/0.4622 = 2.1634).

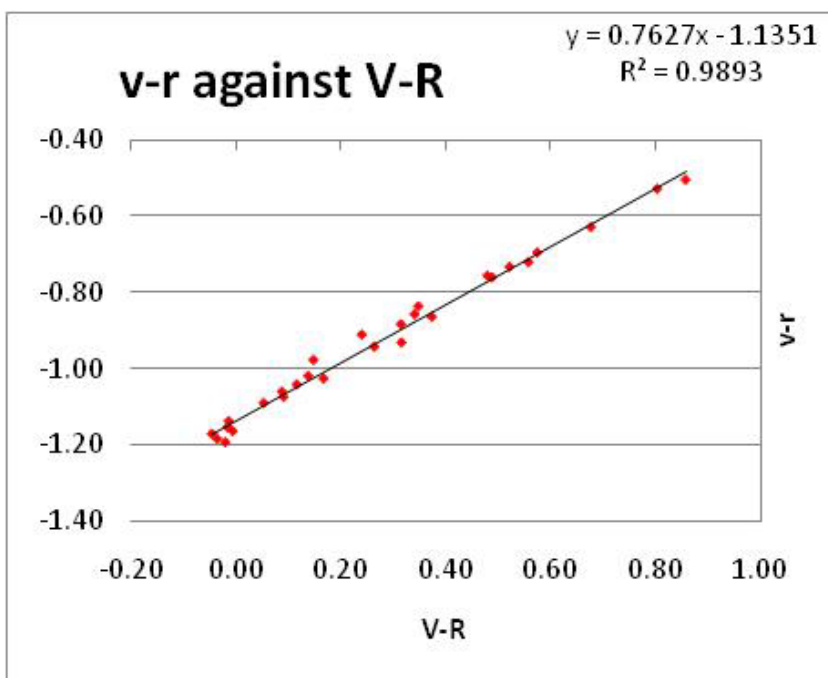


Figure 3. Plot of raw instrumental (v-r) against true (V-R) for a set of standard stars in the Cousins E3 region. The T_{vr} transformation coefficient is simply the inverse of the slope of the line of best fit (T_{vr} = 1/0.7627 = 1.3112).

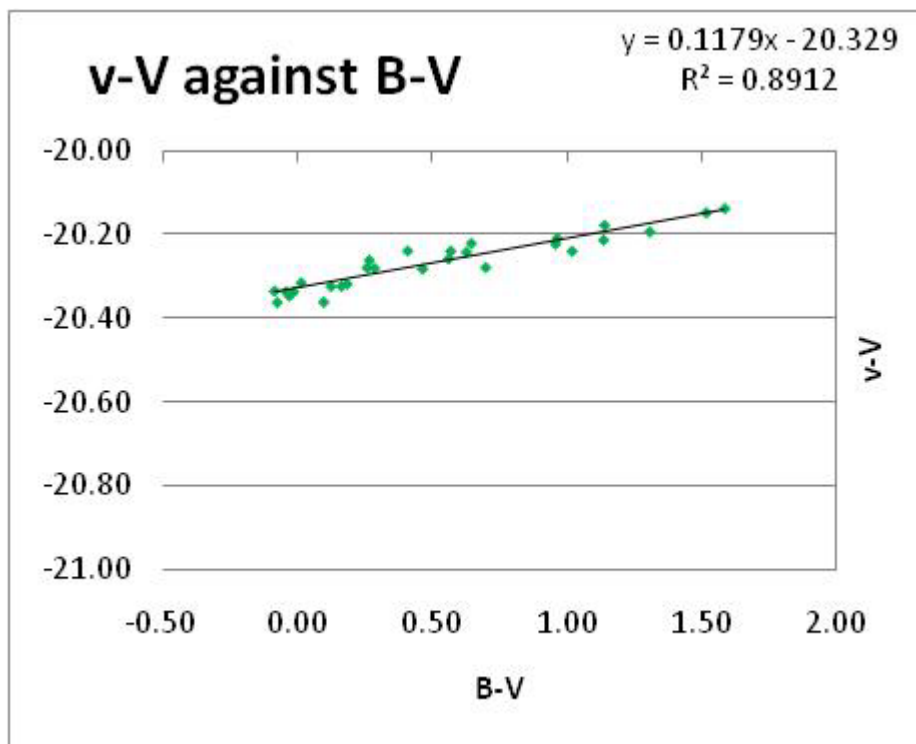


Figure 4. Plot of raw v instrumental minus true V magnitude ($v-V$) against true ($V-R$) for a set of standard stars in the Cousins E3 region. The T_v transformation coefficient is simply the slope of the line of best fit ($T_v = 0.1179$).

Applying transformations

Having determined transformation coefficients for our imaging system we can apply them to measured raw instrumental magnitudes to transform them to standard BVR magnitudes. These calculations are easily implemented in Excel.

We'll illustrate this process using RS Puppis measurements where we determined:

RS Puppis $b = -11.979$, $v = -12.843$ and $r = -12.330$

Comp star $b = -12.078$, $v = -12.791$ and $r = -12.159$

Tycho 2 catalogue (from Cartes du Ciel Sky Charts) V magnitude of the comp star is $V_c = 7.200$

Tycho 2 catalogue $B-V$ value of the comp star is $(B-V)_c = 1.360$

Tycho 2 catalogue does not list $V-R$ values. Therefore we used the relationship $V-R = 0.52 \cdot (B-V)$, where the scale factor 0.52 is the average of $(V-R)/(B-V)$ for fifty standard stars in the Cousins E3 region. For our comp star:

$$(V-R)_c = 0.52 \cdot 1.360 = 0.707$$

From Figures 2, 3 and 4 we have transformation coefficients:

$$T_{bv} = 2.1634, T_{vr} = 1.3112 \text{ and } T_v = 0.1179$$

First we calculate the transformed $(B-V)_t$ value using equation 1:

$$(B-V)_t = [(-11.979 + 12.078) - (-12.843 + 12.791)] \cdot 2.1634 + 1.360 = 1.687$$

Next we calculate the transformed $(V-R)_t$ value using equation 2:

$$(V-R)_t = [(-12.843 + 12.330) - (-12.791 + 12.159)] \cdot 1.3112 + 0.707 = 0.863$$

Next we calculate the transformed V_t value for RS Puppis using equation 3:

$$V_t = (-12.843 + 12.791) - 0.1179 \cdot (1.687 - 1.360) + 7.200 = 7.109$$

Finally we calculate B_t and R_t for RS Puppis:

$$B_t = 7.109 + 1.687 = 8.796 \quad R_t = 7.109 - 0.863 = 6.246$$

E4 Region measurements

A different standard star field, the Cousins E4 region, was imaged to test how well our transformation coefficients and the Hardie equations work. Results are summarised Table 1.

E4	Transformed Values			Catalogue Values			Delta Mag		
Region	Vt	Bt	Rt	Vc	Bc	Rc	Vt-Vc	Bt-B	Rt-R
405	8.189	8.182	8.143	8.191	8.195	8.185	-0.002	-0.013	-0.042
410	7.462	7.595	7.393	7.462	7.595	7.393	0.000	0.000	0.000
412	8.046	8.101	7.962	8.020	8.113	7.976	0.026	-0.012	-0.014
413	7.996	8.327	7.900	7.995	8.175	7.901	0.001	0.152	-0.001
425	7.587	8.184	7.293	7.570	8.058	7.292	0.017	0.126	0.001
428	6.628	7.872	5.975	6.627	7.829	6.008	0.001	0.043	-0.033
429	6.704	7.945	6.011	6.703	7.938	6.066	0.001	0.007	-0.055
439	6.672	7.139	6.347	6.661	7.091	6.398	0.011	0.048	-0.051
443	7.267	7.202	7.279	7.275	7.177	7.312	-0.008	0.025	-0.033
445	6.607	7.185	6.282	6.601	7.077	6.323	0.006	0.108	-0.041
475	7.288	8.000	6.876	7.306	7.978	6.937	-0.018	0.022	-0.061
496	6.742	6.712	6.731	6.740	6.734	6.750	0.002	-0.022	-0.019
stdev							0.011	0.058	0.022

Table 1. Transformation results for Cousins E4 region

Star 410 was used as the comparison; hence its Delta Mag values are zero by definition. Transformed values are averages from ten images recorded on a single night. The difference between catalogue values and our transformed measurements for these stars is generally quite small except for stars 413, 425 and 445 in the B band. These three stars have Bt magnitudes >0.1 Mag dimmer than their catalogue B values. We are still investigating the reason for this discrepancy. Transformed magnitudes in V and R bands are more consistent, with standard deviations of 0.01 and 0.02 Mag, respectively.

RS Puppis measurements

In the February 2011 article we presented Giorgio de Scala's V light curve of RS Puppis with four transformed measurements by Mark superimposed. Here we present in Figure 5 the same data with an additional 12 transformed DSLR measurements. B and R light curves are also shown.

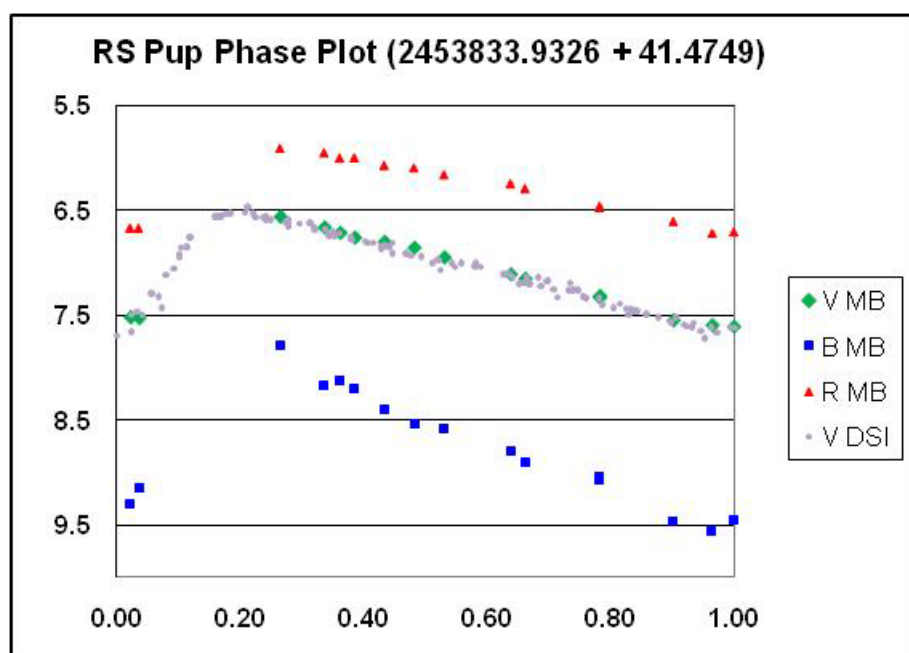


Figure 5. V light curve of RS Puppis by Giorgio de Scala (V DSI). Superimposed are 16 transformed observations by Mark using the Canon 450d. Mark's V measurements (V MB) are in excellent agreement with Giorgio's. Amplitude in R is shallower than V, whereas B amplitude is larger and has more scatter.

Four check stars were measured in addition to RS Puppis and the comparison star. Table 2 shows standard deviations of transformed V, B-V and V-R of the check stars from 16 measurements between January 30th and April 21st, 2011. The catalogue values used are also listed.

		Transformed Values			Catalogue Values		
		Vt	(B-V)t	(V-R)t	Vc	(B-V)c	(V-R)c
Check 1	average	6.687	0.661	0.343	6.720	0.560	0.291
	stdev	0.016	0.069	0.026			
Check 2	average	7.620	0.982	0.515	7.630	0.940	0.489
	stdev	0.017	0.066	0.027			
Check 3	average	6.912	0.844	0.421	6.920	0.740	0.385
	stdev	0.011	0.046	0.016			
Check 4	average	6.790	1.278	0.641	6.800	1.300	0.676
	stdev	0.015	0.055	0.020			

Table 2 shows catalogue values and standard deviations of transformed V, B-V and V-R of 4 check stars from 16 measurements between January 30th and April 21st, 2011.

It is obvious from the standard deviations that B-V measurements have greater scatter than V and V-R. This is in part due to the comparison and check stars being significantly fainter in B than V and R. Also, the DSLR sensitivity to B and R wavelengths is lower than V. Furthermore, it is possible that Hardie transformations may not be the best option for DSLR cameras. We will investigate this further in a future article.

Transformed B-V measurements also differ significantly from the catalogue values used. This may in part be due to errors in catalogue values. Tycho measurements were made through non-standard filters. Transformation to the standard system has been done by several people with different results. For instance, the AAVSO SeqPlot program gives the following B-V values:

Comp = 1.345, Check 1 = 0.604, Check 2 = 0.967, Check 3 = 0.775 and Check 4 = 1.290

There is obviously a need for more accurate B and V, as well as R sequences.

These results show that DSLR photometry is capable of 0.015 Mag accuracy in V, 0.02 in R and 0.06 in B if care is taken when recording images and analysing the data. Using more images per measurement should improve these figures even further.

References

- Berry, Richard**, 2011. AIP4WIN-Photometry forum, March 15th, 2011
Hardie, R. H. 1962, in Stars and Stellar Systems, vol. II: Astronomical Techniques, ed. G. P. Kuiper, & B. M. Middlehurst, Univ. of Chicago Press, Chicago, USA, 178)

The CCD Column – *Tom Richards*

The Meridian Flip Problem

What's the problem?

If you have a fork mount, read no further. If like me you have a German equatorial mount and need to flip the telescope when crossing the meridian, read on. The problem is succinct: if you flip your telescope you invert the star field image but not the camera-induced field sensitivity irregularities, so your photometry is compromised. Let's look at some examples.

In Figure 1 you see the field of T Pyx, taken before and after meridian flip. If you were measuring the

arrowed star in the pre-flip image against a nearby comparison star, it would measure up fainter than it should because it's sitting on a dust ring. But in the post-flip image it's not, so would measure brighter. (The dust ring is rather lost in the glare of the bright star.)

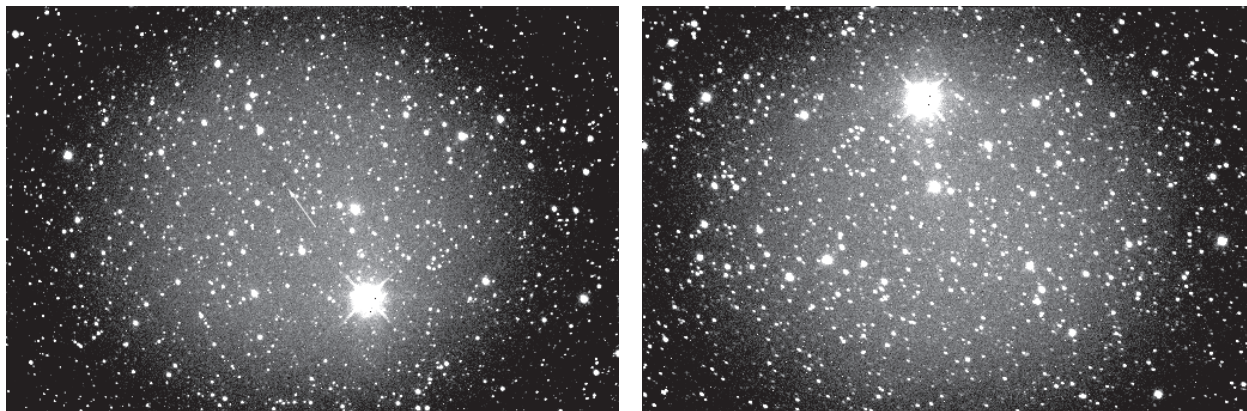


Figure 1. The field of T Pyx before (left) and after (right) meridian flip.

Is the difference big enough to matter to the photometry? Often not. When you do your photometry, include the check star in the plot and see if it jumps after meridian flip. Better, take the mean and standard deviation pre- and post-flip. In one case, I found a mean of 11.745 and 11.756 mag on either side of flip, with standard deviation of 0.007 each side. The error bars overlap, but not comfortably. In another case I was trying to observe a possible exoplanet transit. Ingress appeared to happen during meridian flip – it was fainter when I resumed imaging — and I didn't see the egress. But the observation run had to be discounted, because I couldn't show the decrease was not instrumental due to meridian flip.

Anyway, even if your check star shows no magnitude change before and after flip, your target variable may not be so lucky with the pixels it sits on, and may have a large change. The trouble is, that if the variable is changing, as in an eclipse, that change may be masked by the larger changes in its magnitude, and so go unnoticed.

So rotate the camera?

So why not flip the camera too – rotate it through 180° at meridian flip? Then both the star field and the camera field sensitivity features are flipped together and line up as before the flip. The stars sit on the same pixels as before. Yes that helps, but some instrumental sensitivity irregularities can be due to the telescope itself, or the telescope/camera alignment. These would change if you rotated the camera. In Figure 2, the camera was rotated 180° at meridian flip, so (hopefully) star images impinge on the same pixels as before. But note the vignetting. It's in quite different places in the two.

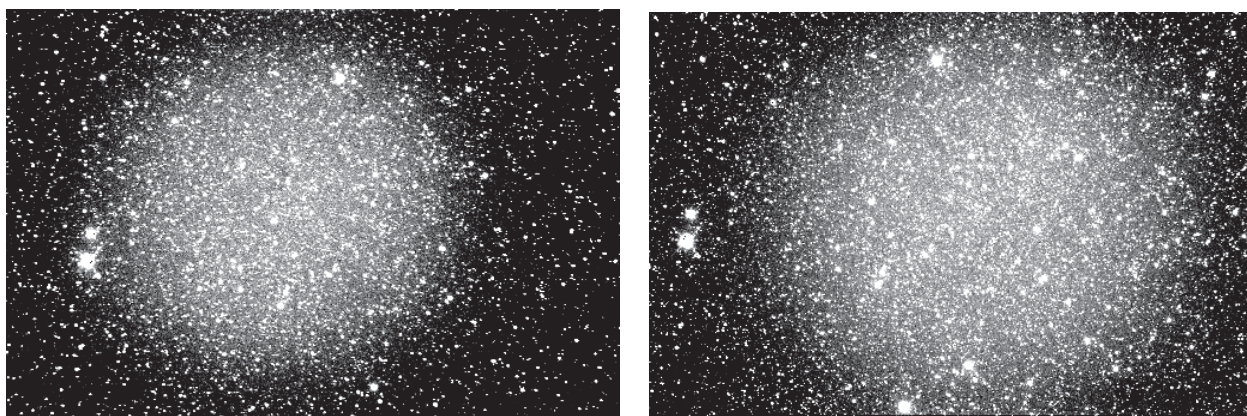


Figure 2. The field of V687 Ara before meridian flip (left) and right. This time the camera was rotated 180°.

So camera rotation helps a lot, but doesn't eliminate effects due to the un-rotated telescope.

Ideally, you'd rotate the entire telescope/camera assembly 180°, but most of us can't do that.

Doesn't flat-fielding fix it?

The above images are raw, just to make the problem obvious. And yes of course, flat-fielding can improve things. But flat-field masters aren't perfect. No matter how carefully constructed, experience shows they rarely flatten a field to much better than 0.01 mag. Try a test for yourself: take a whole lot of images of a pair of stars, shifting the field a little between images. Secondly, take the same number of images without shifting the field, so the stars sit on *exactly* the same pixels in each image. Calibrate your images, including flat-fielding of course. Now measure and plot the magnitude differences between the two stars. You can bet you'll find the standard deviation of the differential mags is considerably higher in the shifted-around series than the staying-still series.

That's why you're always advised, when taking a time-series, to ensure the stars stay on exactly the same pixels in every image. To ensure that through meridian flip, you *have to* rotate the camera. But as we have seen, doing so may change the camera's sensitivity map due to telescope-induced contributions, as in Figure 2.

The only answer to that now is to take a set of flat-field raws with the camera un-rotated, and another with the camera rotated – and construct a master flat from each set. That's the best possible solution; but again, flat-fields aren't perfect so you may still have an unwanted post-flip magnitude change. But it's the best you can do short of rotating the telescope.

Of course, you avoid all this if you don't have a meridian flip in your time series. Ensure the target won't pass through your meridian during the time series – though that may mean you're working at higher and faster-changing airmasses than otherwise. Or find out at what declination your telescope will pass under the mount without hitting the pier – and observe stars of that and lower declinations.

Or go back to nice simple visual observations.

Bright Star Astronomy – *Stan Walker*

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Introduction:

We're now into the second decade of the twenty-first century and it's interesting to see some of the changes that have taken place since I first looked at Saturn a half century ago. The sky is certainly a different place and the techniques have changed quite dramatically.

Photography is one area which has changed. In the 1960s it was slowly yielding a place in the lead to the relatively new techniques of photo-electric photometry which saw a new concept - that of filtered measures which provided an international standard of consistency and also provided much more physical information about the stars than simple photographs. Our present UBVR system dates from that time, largely set in motion by the work at Tonantzintla, but with minor changes to the R and I filters resulting from the work at Cape Observatory.

Photography was difficult in that the analogue information need to be measured with densitometers and other cumbersome devices - now it is done automatically with digital pixels in CCD cameras and even the humble domestic camera. The detection limit hasn't increased greatly - we were measuring down to V = 16.3 from Auckland in 1970 using offset photometry - but the difficulties of centring faint stars in a focal plane aperture disappears with the massive arrays of these modern digital devices.

DSLRs on the Scene:

Mark Blackford and Glen Schrader write elsewhere about their ongoing development of digital camera techniques. This is taking these devices to a level beyond what has been considered their limits and the accuracies obtained, in an area more demanding than simple time series photometry monitoring, are very impressive. The rather noisy B-V results are expected to be corrected by the addition of a simple IR blocking filter, but the V-R colour can also be used to transform V measures if B-V proves unsatisfactory, thus

providing a high degree of accuracy as compared to the crudely transformed data obtained by some other groups.

The DSLR has one great advantage - its wide field allows a good range of comparisons to be measured simultaneously with the variable star. The 4.5 x 7.0 degree field is about 10 times larger than the systems such as BSM South operated by Peter Nelson and thus is more effective in sparse star fields. With all of this type of photometry the dynamic range is limited so problems arise if the magnitude difference exceeds 3, without even considering colour differences. Mark manages to image the 27 comparisons of RS Puppis at one time and with judicious use of exposure times avoids saturation. That is a crowded field compared to beta Doradus, where the nearest good comparison star is 3 degrees away. Glen is experimenting with even simpler cameras with wider fields but laments that the limiting magnitude is 7.1. But look at all those unmeasured naked eye variables!

As mentioned in February, these cameras fit nicely into the range of stars too bright for CCD cameras without stopping down the telescopes - and they're a lot faster in getting the necessary images. So can they do the job - and what tasks are out there?

Just in this last week Glen Schrader and I, along with Mark Blackford, have been looking at the discordant results of the bright Cepheid, BG Crucis, only discovered in the late 1960s. It's suggested by Kovtyukh et al, 2003, that the inconsistencies in the descending branch of the light curve are caused by spectral changes, possibly resulting from the presence of non-radial oscillations, perhaps caused by resonances between the normal radial modes. Against this, the late discovery of its variability raises the possibility that BG Crucis is a relatively new Cepheid with, as yet, unstable pulsation properties.

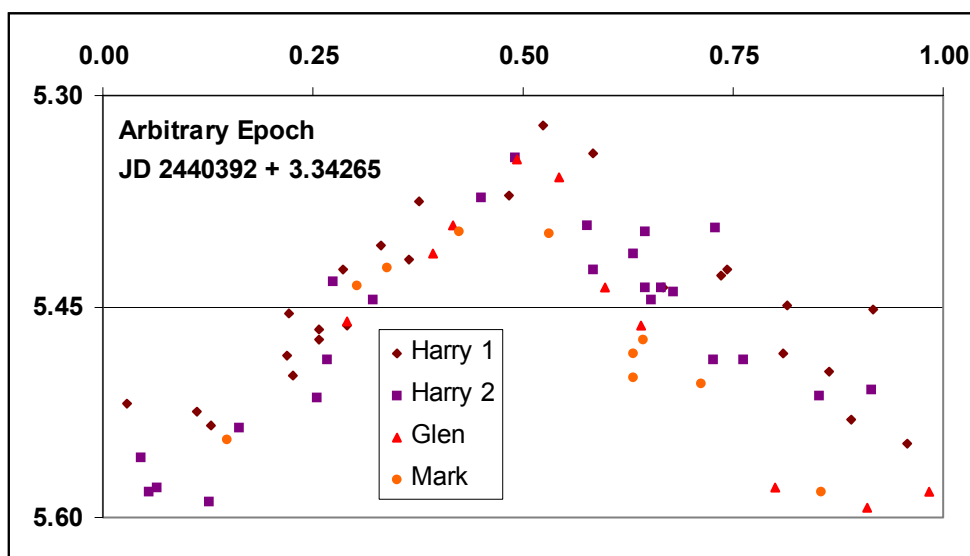


Figure 1: The UB light curves of BG Crucis obtained in the 1990s and early 2000s by Harry Williams compared with DSLR measures to date by Glen Schrader and Mark Blackford. The scatter of the PEP measures is about 5-10 times larger than normal and may show the effects of the non-radial pulsations mentioned. The recent DSLR measures are more consistent.

So what other stars can be measured usefully? Let's look quickly at what these cameras can do and how it fits into stellar photometry.

Colour Performance:

The generally accepted colour system is UBVRcIc. It's immediately clear that a camera designed to emulate the eye is not going to respond in any useful way at near UV or IR wavelengths. This is not a serious limitation, although it removes some of the easiest ways of deciding if a star will be variable or not. But most of the bright variables have already been found so this is not a real handicap. But the RGB data is easily transformed into BVR.

BVR provides two colours, B-V and V-R. Both can be used to determine temperature, although B-V with

its longer baseline is better. But B is shifted to longer wavelengths in these cameras so this baseline is constricted and may be less useful. Both can be used to calibrate the V response effectively, so that V measures of any star are very good. Thus it becomes a matter of how these colour choices fit the target stars.

What Targets are There?

The performance of the camera will decide this. From Mark & Glen's measures it seems that two to three minutes of imaging time will give an accuracy of ~ 0.015 magnitudes which is approaching good PEP at this brightness and equal to or better than most amateur CCD work. So this indicates that anything with variations of above 0.2 magnitudes can be attempted provided that the other attributes, such as relatively short periods and regular light curves, are suited to the equipment.

To date most of the observations are of stars in the Bright Cepheid project, although Glen and Mark are now measuring stars on the unpublished list of low amplitude targets. Digital cameras are ideally suited to these stars which tend to be white and yellow in colour. And if we are to be without ASAS there will be value in extending these measures to fainter Cepheids.

Mark has extended his ideas to monitoring such bright objects as T Pyxidis near maximum in the present outburst of the recurrent nova. He provides the following illustration of four hours' observing in V on 2011 May 12.

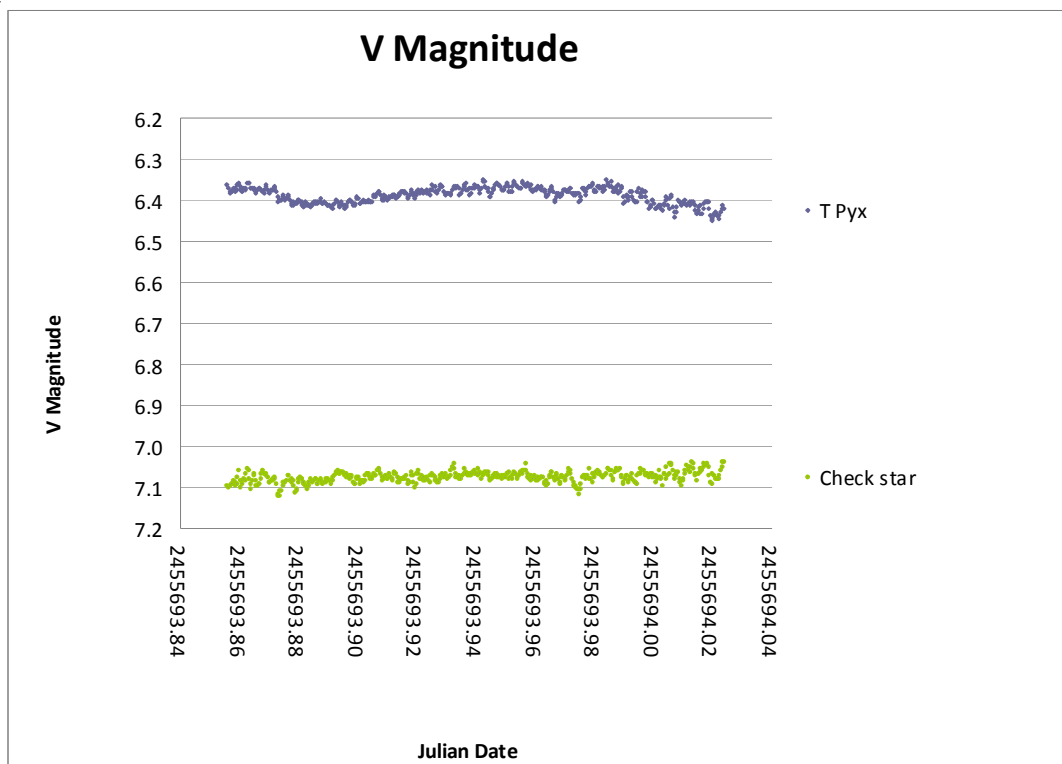


Figure 2: Measures of T Pyxidis on 2011 May 12 by Mark Blackford. There are 480 images covering a period of over 4 hours with air mass changing from 1.017 to 2.00. A 3 point rolling average has been applied. These show some fluctuations in the light from the nova over this period. Note that these are measures to provide high time resolution - if binned into sets of 10 in his normal manner the scatter would be in the 0.015 region. Good work, Mark!

As mentioned in February many of the naked eye stars are variable. But most are low amplitude, or long period, objects. A quick look through the GCVS amongst stars with Bayer/Flamsteed designations (Greek letter designations on maybe 300 rather bright stars) shows there are 20 or 30 quite interesting objects. There are many others like Spica or beta Centauri, but the amplitudes are often quite low.

There are a few bright EBs - delta Librae was on the EEB project last year and close by is μ 1 Scorpii which is brighter but with a lower amplitude. Or perhaps a real challenge - ν Sagittarii which, at 4.53p, has eclipses of 0.08 every 137.939 days.

People like Sebastian Otero have made some very informative measures of bright blue variables of gamma Cassiopeia type, although these tend to be irregular and low amplitude, but a measure or two a month may detect an outburst worth following. In this group is the hypergiant V382 Carinae, mentioned last year as a star measured in Auckland for a time in the belief that it was a Cepheid, but Otero showed that the archived measures showed an interesting outburst.

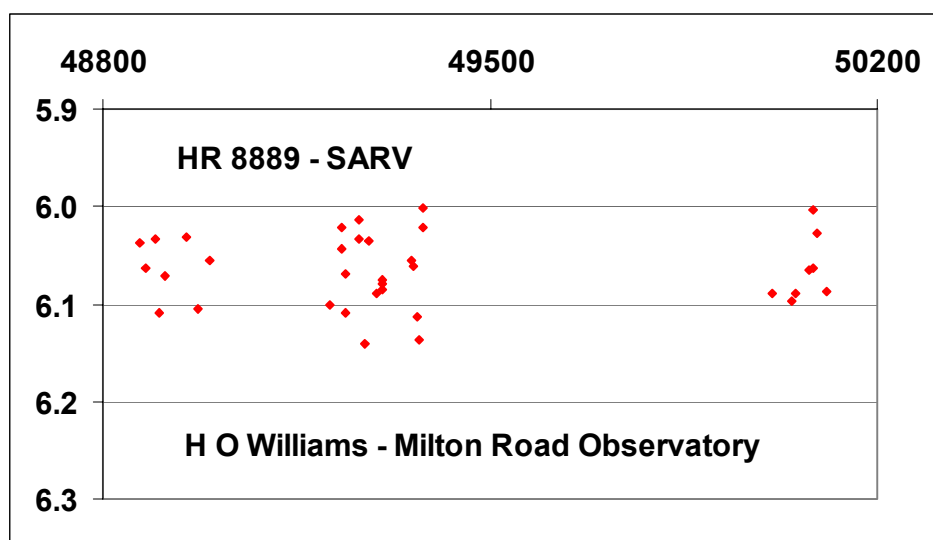


Figure 3: PEP measures of a small amplitude red variable, HR 8889 - are the variations real or just at the accuracy limit - and are the variations periodic?

One area which has interested me is the bright SR stars with short periods. Harry Williams and I measured some of these in John Percy's SARV project (Olin Eggen's term for small amplitude red variables) some years ago but with PEP the measures were difficult and we never got enough data.

A project devoted to getting an image of a bright SR star every clear night would yield interesting results in a season or two. Sigma Librae is another SARV, with a period of, perhaps, 20 days. John Percy and his students have been measuring a few of these objects intensively and finding very interesting sets of multiple periodicities.

Then there's always the 'astronomy for enjoyment' area. Not everything needs to be too purposeful. It might be interesting to spend a night on delta Scuti which shows light variations of 0.19 magnitudes - they are modulated so you hope for a time when the amplitude is large - over a period of about 4.5 hours.

The Mira field offers some opportunities at maxima of these stars. Determination of the epochs of maximum from visual measures is not all that reliable but, given the irregularity of the pulsations, has been good enough to show when periods have changed. But following through the maxima of some of the really bright objects such as omicron Ceti and R Hydrae with a measure each week would provide, in time, some really precise epochs. Danie Overbeek often deplored the lack of something with which to do 5% photometry - in the DSLR camera we now have a device which can do 2% photometry and quite quickly.

Since the main comparison star for o Ceti at maximum is itself a 9% variable, this would establish the values of that star at the time it's in use as well. More accurate epochs of maximum. At maximum most Miras are early M class which places little strain upon the filter system of a digital camera.

Conclusion:

Observers with digital cameras should endeavour to take advantage of the strengths of photometry using these devices: the wide fields; the simultaneous measures in three passbands; and the simplicity of use on bright targets. Areas where effective observing is already being done using other methods should be avoided - the whole idea should be to complement other observers, not compete with them.

Bright targets have one very great advantage - their early discovery has now built up a much longer baseline - often well over a century. Some of the brightest Miras have shown period changes over that interval. Had we colour photometry to determine temperature a century ago then detection of things like changes in average temperature and radius would have been found. So let's start now. One star where these changes have been measured is BH Crucis, Walker, 2009, and these are mentioned in the AAVSO's current 'Stars of the Season' article.

There is a clear need for cooperation to avoid wasted effort. There are a few CCD observers measuring in BVRI but their efforts are better suited to stars between $V = 8$ and 15. DSLR cameras appear to work best between $V = 3$ and 8 but their colours are restricted to BVR. Is the loss of I, which can be uncertain at times, a great problem? Probably not. The AAVSO's Bright Star cameras have reported ranges from $V = 2 - 11$ in BVRI, but probably lose B at the faint end and saturate in I and R at brighter levels. Scarcity of suitable comparisons may be a problem for them at the brighter end.

So colour DSLR photometry is in its early stages at present. But the prospects are looking very good.

References:

Kovtyukh, V V, Andrievsky, S M, Luck, R E, Gorlova, N I 2003 A&A 401, 661
Walker, W.S.G., 2010, Period, Magnitude, and Color Changes ,JAAVSO 37, 87

SPADES Project - *Tom Richards*

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New Stars in the Milky Way

The Search for Planets around Detached Eclipsing Stars now has 136 target stars in its database, from 22.0 h to 18.0 h RA. The latest tranche of additions covers the 17 hour band of RA, right through the star clouds of Ara, Scorpius, Sagittarius and Ophiuchus. There's 26 in this band, compared to none in the very empty 23 h band of sky.

The new additions are all suitable for observing now; but some of them will test your CCD observing skill, with dense star fields and some very close companions to the targets or comps. But by way of reward, some fields have numerous other variables in them, nearly all badly under-observed; so here's a chance to do some very useful work on the side! The CCD field of V0789 Sgr, in Figure 1, shows five other GCVS variables.

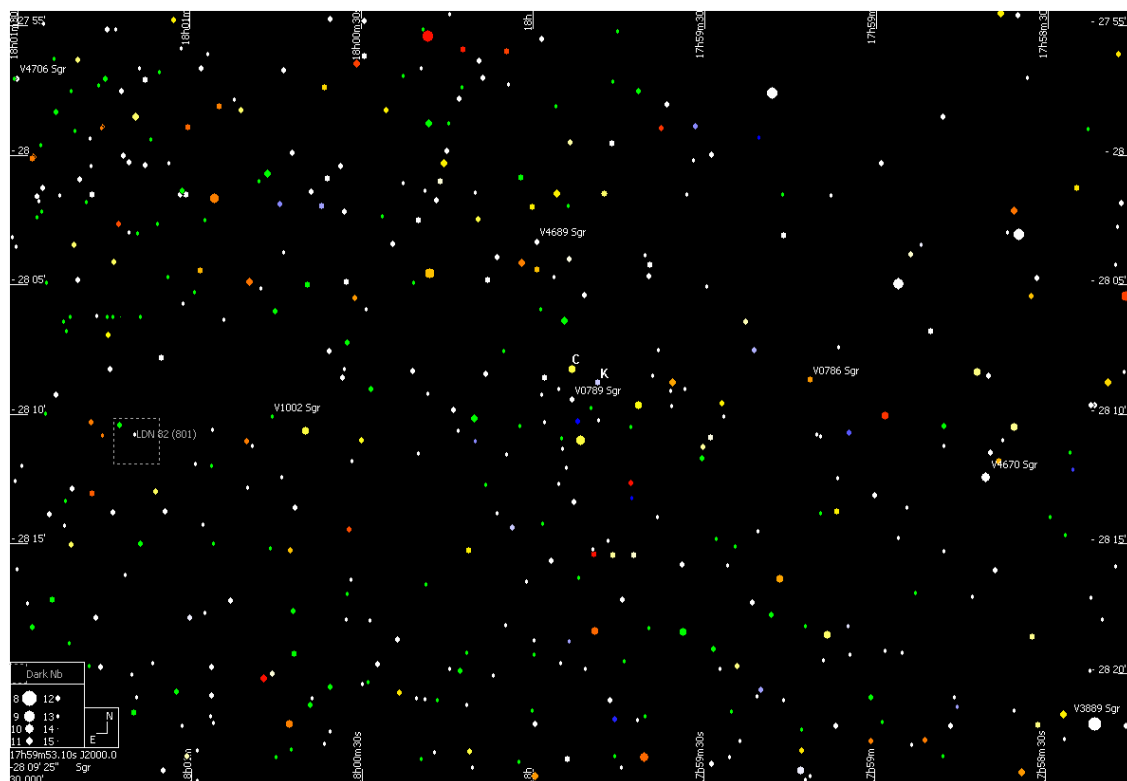


Figure 1. The CCD field of V0789 Sgr, showing the comparison (C) and check (K) stars to use. Every SPADES target has a field chart like this in the SPADES area of the VSS website.

Choosing the Target for Tonight – software aids

With so many stars to observe in the project, it becomes important to choose the best target on a given night from your location.

Times of Minima spreadsheet

You can find times of eclipses for a given star by downloading the “Times of Minima” Excel spreadsheet from the website at *Information and Resources > Useful Calculators*. Enter the star’s period and epoch in the header fields as indicated, and the start date for the output, and you’ll get all the times of eclipse from that date to the end of the table. Do bear in mind however that the period and epoch given in the SPADES web pages for that star may be quite wrong. They are derived from the GCVS, and so many of these stars are near-forgotten with poor out-of-date data. Part of the fun of SPADES will be improving the light elements of these stars!

Bob Nelson’s EB_Min program

But more useful than the spreadsheet, Bob Nelson’s **EB_Min** program will find all the eclipses of the SPADES stars visible from your location on a given night. Download the EB_min program from <http://members.shaw.ca/bob.nelson/software1.htm>. Download its data file for SPADES from the SPADES page on the website, at the end.

The control panel for EB_min is shown in Figure 2. I have it set to show me the primary and secondary minima and the hour angle and airmass of the stars at mid-eclipse.

EB Minimum Win v1.8

File Help

Observatory Location: Pretty Hill Observatory

Longitude (+ to west): -145.1213 DD.MMSSs

Latitude (+ to N): -37.4054 DD.MMSSs

Time Zone (+ to west): -10 PST=8, PDT=MST=7, MDT=CST=6, CDT=EST=5, etc.

Year (4 digits): 2011

Month (1-12): 04

Day (1-31): 24 evening date (local time)

Number of days to calculate: 6

Maximum Sun altitude (deg): -18 minus for below the horizon (usual case)

Minimum star altitude (deg): 40 plus for above the horizon (usual case)

Locations file: Location.dat

Site limits file: Limits.dat

Star data file: SPADES_EB_Min 2200-1800 cop ☐ Ignore EA secondary minima

Events: ☒ Prim. Min. ☐ Ph. 0.25 max ☒ Sec. Min. ☐ Ph. 0.75 max

Output: ☒ Alt. + Azim. ☐ HA + airmass ☐ HA + Decl.

☐ Skip eclipses close to local horizon ☐ Skip eclipses close to meridian

Calculate

Figure 2. The control panel for EB_Min. The file **Location.dat** lists many observatories. Edit it beforehand with your observatory’s name and data, select it in the pull down field and many other fields will fill in. Enter the dates and other choices, and press **Calculate**.

The output for April 24th and following nights is shown in Figure 3 overleaf

Which will be the target for tonight? Choose one that eclipses around midnight near your meridian so you can get a long set of images on both sides of the eclipse. Looking at the table, the two eclipses at 23:30, 47 and 57 are way off the meridian, as their hour angle shows – forget them. The eclipse at 23:10 is good: near the meridian and high in the sky (low airmass).

After midnight, forget the eclipses at 0:2 and 1:11, 14, and 17. However the two at 1:20 and 1:25 are

Output

E B M i n -- by Bob Nelson

Location = Pretty Hill Observatory
 Longitude = -145.1213 (ddd.aaaa)
 Latitude = -37.4054 (ddd.aaaa)
 Time zone = -10 (8-PST, 7-PDT-MST, 6-MDT-CST, 5-CDT-EST, etc.)
 Maximum Sun elevation = -18 degrees
 Minimum star elevation = 40 degrees
 Star limits file = LimitsPHO.csv
 Star data file = SPADES_EB_Min_2200-1800 copy.csv

JD	Star	Typ	Bt	Mag	Mag	Date	LOCAL time	HA	Z	Event	Comment
Saturday night											
55675.8947	V0521 Mon	EA	10.0	10.5	2011	Apr 24	19:28	2.35	1.54	II	
55675.9143	AS Car	EA	11.0	12.2	2011	Apr 24	19:56	-0.65	1.09	II	
55675.9184	BU Hya	EA	9.4	9.9	2011	Apr 24	20:02	1.67	1.22	II	
55675.9187	KT Cen	EA	12.1	12.7	2011	Apr 24	20:02	-1.94	1.16	II	
55675.9332	TZ Cha	EA	9.8	10.5	2011	Apr 24	20:23	3.51	1.52	I	
55675.9558	DQ Car	EA	11.1	11.5	2011	Apr 24	20:56	0.39	1.06	II	
55675.9571	BC Vel	EA	11.8	12.3	2011	Apr 24	20:58	2.06	1.09	II	
55675.9754	V0579 Pup	EA	12.4	13.6	2011	Apr 24	21:24	3.93	1.40	II	
55675.9917	EY Pup	EA	9.6	10.3	2011	Apr 24	21:48	3.83	1.35	II	
55676.0176	ZZ Vel	EA	9.9	10.4	2011	Apr 24	22:25	1.61	1.09	II	
55676.0241	CM Vir	EA	12.9	13.4	2011	Apr 24	22:34	-2.14	1.46	II	
55676.0487	AF Cru	EA	9.8	10.5	2011	Apr 24	23:10	0.67	1.11	I	
55676.0631	V0632 Sco	EA	11.5	11.9	2011	Apr 24	23:30	-4.01	1.41	II	
55676.0744	V0537 Oph	EA	12.5	12.8	2011	Apr 24	23:47	-3.96	1.54	I	
55676.0816	DU Vel	EA	10.8	11.5	2011	Apr 24	23:57	4.02	1.39	I	
55676.0851	V0569 Sco	EA	10.7	11.5	2011	Apr 25	0:02	-2.97	1.20	II	
55676.1326	V0626 Sco	EA	11.4	11.8	2011	Apr 25	1:11	-2.28	1.11	II	
55676.1349	AA Cru	EA	10.8	11.4	2011	Apr 25	1:14	2.78	1.22	I	
55676.1372	TZ Cru	EA	11.8	99.0	2011	Apr 25	1:17	2.95	1.23	I	
55676.1394	GK Lib	EA	12.8	13.8	2011	Apr 25	1:20	-0.07	1.08	II	
55676.1430	EZ Lib	EA	11.1	13.1	2011	Apr 25	1:25	-0.68	1.08	I	
55676.1590	YZ Cha	EA	11.2	0.4	2011	Apr 25	1:48	4.07	1.47	I	
55676.1875	V0775 Cen	EA	9.9	10.6	2011	Apr 25	2:30	2.35	1.13	I	
55676.2626	V0454 Ara	EA	10.1	10.9	2011	Apr 25	4:18	0.15	1.00	II	
55676.2628	V1721 Sgr	EA	10.4	10.6	2011	Apr 25	4:18	0.16	1.00	II	
55676.2977	V0634 Sco	EA	11.7	12.3	2011	Apr 25	5:08	1.62	1.05	II	
55676.2978	V0778 Sgr	EA	11.7	12.2	2011	Apr 25	5:08	1.06	0.95	I	
Sunday night											
55676.8089	TZ Cha	EA	9.8	10.5	2011	Apr 25	19:20	2.51	1.25	II	
55676.8910	CU Pup	EA	11.4	12.3	2011	Apr 25	19:23	1.68	1.10	I	
55676.8932	RZ Cha	EA	8.2	9.1	2011	Apr 25	19:26	-1.39	1.41	II	
55676.9008	BC Cru	EA	9.9	0	2011	Apr 25	19:37	-2.96	2.22	I	
55676.9653	XY Ant	EA	9.5	10.2	2011	Apr 25	21:10	0.75	1.01	II	
55676.9885	EL Vel	EA	11.0	11.6	2011	Apr 25	21:43	3.09	1.23	II	
55676.9894	EY Vel	EA	11.1	11.1	2011	Apr 25	21:44	1.09	1.07	I	
55676.9966	AF Cru	EA	9.8	10.5	2011	Apr 25	21:55	-0.52	1.11	II	

Figure 3. The EB_min output file

close to the meridian. Of the two, the one with the primary eclipse ("I" in the Event column) is preferable just because it's a primary. Secondaries can be quite shallow and so give poorer measurements. Of course, if you can find out that the star has a deep secondary, go for it. Anyway, the best candidate after midnight seems to be the eclipse at 1:25.

So we're down to the 23:10 and 1:25 eclipses. Go for the 23:10 – it's closer to midnight and about the same airmass as the other. So AF Cru it is.

David Motl's Ephemerides 1.11

Another program to use to help you find suitable eclipses is **Ephemerides 1.11** by David Motl of MuniPack fame. This is more up-to-date in style, more intuitive, and more robust, than EB_min, but we do not yet have a SPADES database for it. Phil Evans tells me he's working on one. Use it two ways: to get eclipse ephemerides of a given star (as Times of Minima does), or to see eclipses of any star visible at your location on a given night (as EB_min does). I love the Chart facility, and the Sun, Moon and Details popups are most useful. I do think that when we have a SPADES database for it, it's the tool of preference out of the three. Figure 4 shows its *Daily Ephemerides* interface.

Ephemerides of eclipsing binary stars

Daily ephemerides | Star ephemerides

Date (before midnight): 25/04/2011

Update | Sort | Delete | Details | Find | Print | Save | Copy | Sun | Moon | Chart | Setup | Help

Variable star	Time [UT]	Az	Alt	R.A.	DEC	Type	Mag	Catalogue	Pts	Rem
IT Nor	12.0	ESE	41	16:17	-45.0		9.4-10.0	BRNO	8	
AE Hya	12.0	WNW	59	9:45	-23.0		13.9-14.8	BRNO	9	
V 410 Pup	12.0	WSW	47	8:00	-47.3		6.7-6.7	BRNO	10	
AZ Vir	12.0	NE	41	13:43	4.6	EW P=0.3 d	10.7-11.4	BRNO	1	
FO Hya	12.0	WNW	59	10:00	-19.1		9.5-10.0	BRNO	6	
NY Vir	12.0	ENE	64	13:35	-22.4		13.3-13.3	BRNO	1	
Z Cha	12.0	SSW	44	8:07	-76.5		11.5-16.0	BRNO	8	
V 646 Cen	12.0	SSW	74	11:37	-53.2		9.0-11.7	BRNO	10	
G9269.1993 Aps	12.5	SSE	50	14:33	-73.8		10.9-11.2	BRNO	8	
SX Crv	12.5	NNE	70	12:40	-18.8		9.0-9.3	BRNO	1	
V1055 Sco	12.5	ESE	41	16:27	-37.5		8.7-8.9	BRNO	4	
V 635 Car	12.5	SSW	53	10:00	-70.0		12.6-12.8	BRNO	9	
V 811 Cen	12.5	S	64	11:51	-63.2		11.0-11.6	BRNO	9	
BE Cha	12.5	S	50	13:05	-76.9		13.8-14.7	BRNO	10	
RR Cen	12.5	SE	62	14:17	-57.9		7.3-7.7	BRNO	8	
PT Vir	12.5	N	42	12:24	10.6		13.4-13.6	BRNO	6	
MN Cen	12.5	SSW	65	11:28	-61.4		8.6-9.0	BRNO	5	
CX Vir	12.5	NE	57	14:09	-15.6		9.8-0.0	BRNO	4	
RZ Cru	12.5	S	64	12:57	-63.5		14.0-15.3	BRNO	9	
V 747 Cen	12.5	ESE	73	13:39	-45.1		9.9-10.5	BRNO	8	
AH Vir	12.5	N	40	12:14	11.8		8.9-0.0	BRNO	1	
FQ Vir	12.5	NE	58	14:06	-15.5		10.1-10.9	BRNO	6	
V 380 Cen	12.5	SSE	64	13:27	-61.9		9.7-10.2	BRNO	8	
YZ Vel	12.5	SW	64	10:37	-56.0		12.2-12.8	BRNO	9	
ZZ Hya	12.5	W	48	9:29	-20.9		14.3-14.9	BRNO	10	
GU Aps	12.5	S	44	15:47	-80.3		14.0-14.7	BRNO	9	
EH Hya	12.5	NW	83	12:05	-33.2		14.2-15.0	BRNO	9	
V Pup	12.5	SW	41	7:58	-49.2		4.3-4.9	BRNO	10	
EX Hya	12.5	NNE	81	12:52	-29.2		9.6-14.0	BRNO	10	
V 722 Ara	12.0	SE	42	17:00	-57.1		9.5-9.5	BRNO	8	

Figure 4. The Ephemerides 1.1 main window, showing the Daily ephemerides display.

The Meridian Flip Problem

Beware though – the requirement to get an eclipse close to the meridian can mean, if you have a German equatorial, that you have to flip the telescope close to mid-eclipse. Two problems here: a gap in the data where it really matters, and very probably a step in your photometric measurements. Of the two, the latter is the more serious as it can badly bias the eclipse timing measurements. Moreover the step in brightness, occurring on the slope of the light curve, may go unnoticed. I discuss this problem further, and its solutions (and sidesteps) in my CCD Column in this issue.

Equatorial Eclipsing Binaries Project - *Tom Richards*

tom@prettyhill.org

Over the last months, observers have provided much high quality CCD fast time series data on **CU Hya**, which I'm now analysing for publication. The campaign on this star is now finished, and we move on to **V1692 Aql**, currently an early morning object.

V1692 Aql – running fast?

We have been observing this EW contact binary for two seasons now. The 2009 data and report are available in the EEB area of our website. Briefly, its times of minima seem to be running about 44 minutes early since its discovery in 2002 (Lloyd *et al*, 2002) – indicating a strong period decrease – which is reason alone to put in some good work on this system! We received very little data in 2010, and it would be very good to have an intensive campaign on this star this season, which will last until November.

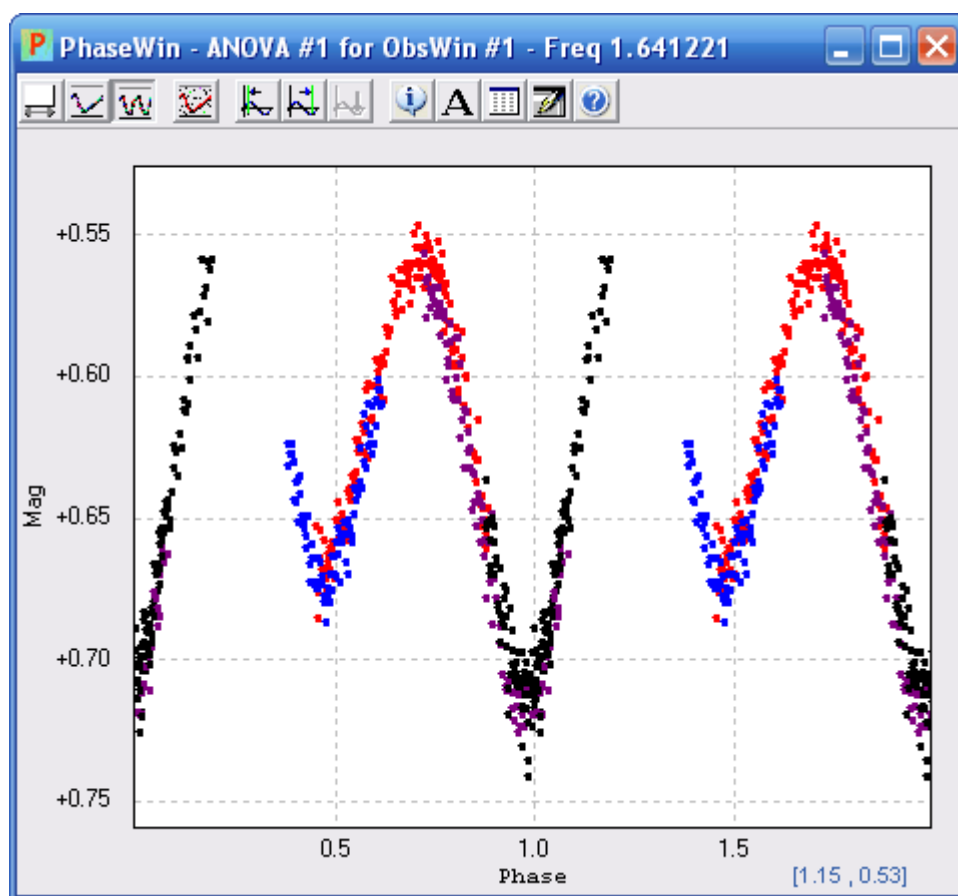


Figure 1. PERANSO phase plot of VSS data on V1692 Aql for 2009.

Our 2009 data folds onto a nearly-complete phase diagram with epoch HJD 2455072.0790(6) and period 0.6093(9) d. (See Figure 1 – using PERANSO, www.peranso.com). Plainly these light elements need

improvement, which we can do this season if we get enough data. Lloyd's light elements are $HJD\ 2452140.960(2) + 0.60926(6)$, which predicts a time of minimum for our epoch of $HJD\ 2455072.10986$, a difference of $0.00308\ d = 44.352\ m$!

Please observe in V (not Rc as previously) or unfiltered. Take as long a CCD time series as you can. If you have your system's transformation coefficients, data in B and V would be very welcome. Use the comparison and check stars shown on the web page for V1692, and provide differential data in either the AAVSO format or VSS Excel format (download from our website). Use our time-of-minimum predictor (also on our website) with our 2009 light elements (above) to obtain expected times of minima for this season.

CU Hya – Campaign complete

We have had very good data over the last few months, from Phil Evans, David Boyd, Terry Bohlsen, Margaret Streamer, and Roger Pickard. 29 observation sets in all, covering three months. This is a very creditable effort. This is on top of the 2010 campaign, to which Yenal Ogmen and I also contributed.

With all this data I can wind up the CU Hya campaign; currently I'm preparing a paper on the system.

First, we were able to combine all these data to get a good accurate period. Eighteen primary minima were measured over the two years of this campaign, and a best-fit regression (linear estimate) against epoch numbers was carried out. It yielded the following light elements (with uncertainties in the rightmost decimals as shown):

$$HJD\ 2455229.41005(9) + 0.71907525(23)$$

These elements are consistent with the ones we derived from the 2010 observations alone (Richards, 2010), but far more precise.

How accurately can a minimum be measured?

It's worth noting that this period error (second number) amounts to 0.02 seconds, but the zero-epoch (E_0) error is 7.6 s. Why is it so much bigger? (Epoch errors usually are.) The answer is, that by taking a linear

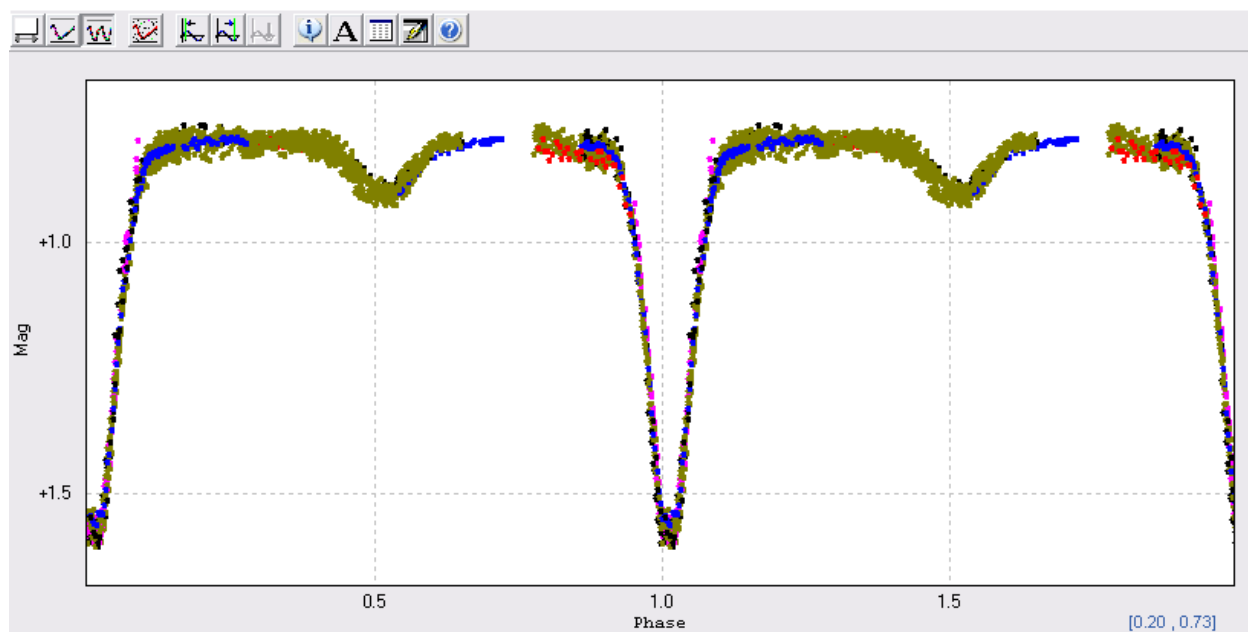


Figure 2. PERANSO phase plot for CU Hya folded on $E_0 = HJD\ 2455229$ and $P = 0.71907525\ d$.

best fit through many ToMs, you are going to get a more reliable value for any individual ToM than by measuring it individually. That's assuming, of course, that the period is completely constant. In fact the standard deviation on the (O-C)s for all our minima comes to 11.6 s, so our E_0 measurement was better than most. (That eclipse was observed by DB on 2010-02-01.) These uncertainty levels need to be taken in

to account in the SPADES Project, which relies on accurate ToM measurements. I think we can say that a 5-10 s uncertainty on any individual ToM measurement is the best we're going to get.

Phased light curve

Figure 2 shows a light curve for all our 2011 V-band data, folded on the above period and epoch. It is also normalised for different instrumental sensitivities in the V-band between observers (which is what happens if you don't transform your data to the standard magnitude/colour system). All observers used the same comparison star, GSC 217:456, $V=13.32$. Different colours in the plot show the data from different observers. Note the light curve is shown repeating itself through two complete phase cycles, for clarity. The curve exhibits the typical appearance of a detached eclipser with the hotter star smaller than the other, so more light loss when eclipsed. The curve between eclipses is not quite flat but climbs a little towards the secondary eclipse – evidence for the wrongly so-called “reflection effect”. The hotter star is heating up the part of the photosphere of the cooler star that's nearest to it. This brighter patch is best seen on either side of the secondary eclipse.

Can we model this system?

The royal road to getting an astrophysical model involves spectroscopy as well as photometry. From spectroscopy you can get the radial velocities and hence mass ratio q , a good place to start tweaking parameters. We don't have spectroscopic data, so we have to guess at q . The next important data to obtain

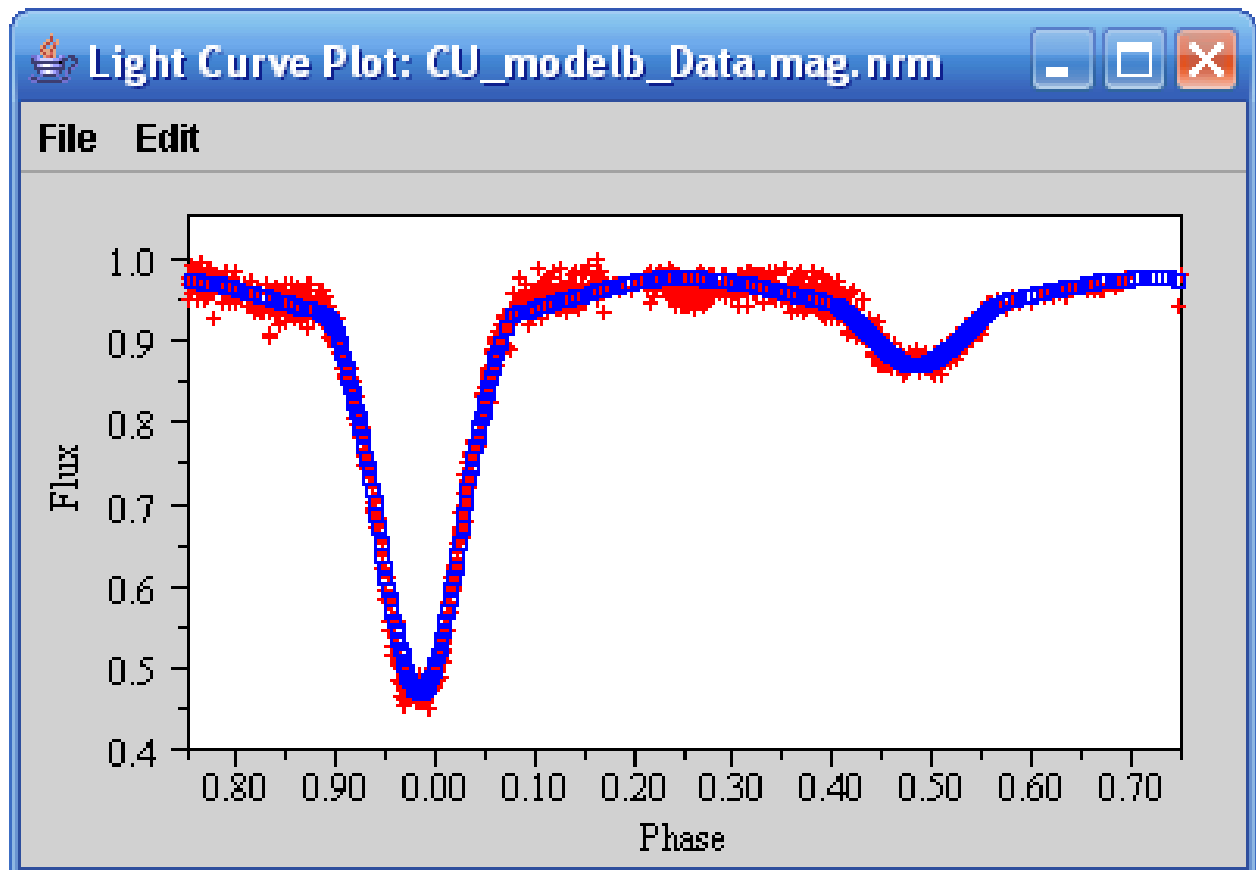


Figure 3. Plot of the synthetic light curve (blue) against the phased VSS data (red).

are colours, from which temperatures can be derived. TB on two occasions derived an out-of-eclipse colour index of $V-R_c = 0.326$, indicating a blended spectral type of F2 and temperature 7200 K. That is not out of line with an estimate by Svechnikov and Kutnetsova (1990) of F0 + G7 IV. Their estimate though is not direct but based on statistical dependencies of binaries of this type.

Col Bembrick has used BinaryMaker 3.0 (www.binarymaker.com) to find a stellar model to fit this light

curve. In the absence of spectroscopic radial velocities or good temperature data we cannot claim that the model is correct, but it is the best fit that Col could obtain. Figure 3 shows his fit to the light curve. There are discrepancies, notably out of eclipse. Other models may fit equally well or better. Note the ordinate is in flux units (relative to flux ~ 1.0 at quadratures), which are more relevant to modelling than the logarithmic magnitude scale.

Col's model has the stars' mass ratio $q = M_2/M_1 = 0.5$, and inclination 77° . Star 1 is the more massive, brighter, and slightly smaller star. Temperatures in CB's model are $T_1 = 7450\text{K}$ and $T_2 = 4650\text{K}$. From that we can assign spectral types F0 and K2, reasonably consistent with Svechnikov and Kutnetsova, and also with TB's blended colour index. Knowing the main-sequence masses of stars of those spectral types (1.6 and $0.7 M_{\text{sun}}$), and the period, we can infer from Newton's modification of Kepler's Law that the orbital separation is $\sim 4.4 R_{\text{sun}}$. The width of the eclipses gives us the sizes of the stars relative to the orbit, and we derive $R_1 = 1.26 R_{\text{sun}}$ and $R_2 = 1.35 R_{\text{sun}}$. That figure for R_1 is a little low for an F0 V star (main sequence), but it's at the end of a chain of error-prone inferences. What is completely out of line is R_2 , which for a K2 V star should be $\sim 0.8 R_{\text{sun}}$. The *ad hoc* solution is to say it's a sub-giant (luminosity class IV) having left the main sequence and swelling up as it ascends towards gianthood. It has just about filled its inner critical Roche surface however (fill factor = -0.017 , full is 0, nowhere near is -1) – the envelope at which it starts spilling mass onto the other star. In other words, it's at or very near being semi-detached.

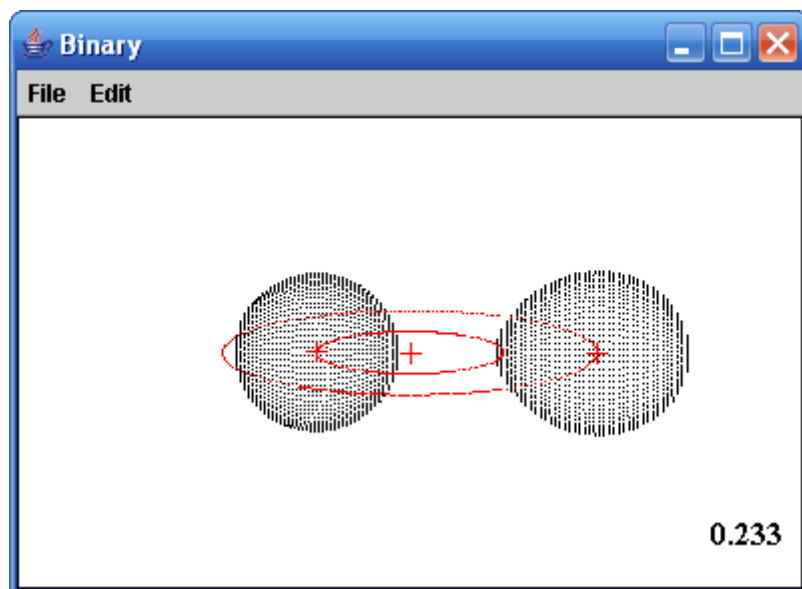


Figure 4. Rendering of Col Bembrick's CU Hya model in BinaryMaker 3. Star 1 (hotter, smaller, more massive) is on the left. Red crosses show centres of gravity and system barycentre. Red ellipses show the orbits of the centres of gravity around the barycentre. Note the tidal distortion of star 2.

Can we be confident that Col's model is about right? Not really. It is relying on the light curve alone without spectral data or good colour data. But, with a bit of ad-hocery about Star 2's size it makes astrophysical sense.

There will be many ways of matching our light curve with a synthetic one. Col's mass ratio of 0.5 sound suspiciously like a simple first guess. I tried 0.9 and with a bit of tweaking other parameters I got a reasonable fit. But the model didn't make astrophysical sense.

I'll put our phase/flux data for CU Hya onto our Equatorial Eclipsing Binaries > CU Hya web pages, so you can try fitting a model for yourself, using BinaryMaker or any other code. If you get interesting results, I'll discuss them in the next Newsletter.

References

- Lloyd, C., Frank, P., Bernhard, K., & Moscher, W. 2002, *IBVS*, No. 5260.
 Svechnikov, M. A., & Kuznetsova, Eh. F. 1990, *Catalogue of approximate photometric and absolute elements of eclipsing variable stars*, Vols. 1-2, Sverdlovsk, Ural University.

VSS Research Grants Scheme

Call for Research Grant Applications, mid-2011 Round

Financial members of Variable Stars South are invited and encouraged to submit applications for the mid-2011 round of research grants. It is very much hoped that more novice members of VSS, and school and club teams with a VSS member, will make submissions.

The purpose of the grants scheme is to assist a VSS member or research team that has a VSS member, in their participation in a recognised VSS research project. Applications will be considered for expenditure on items such as, but not limited to, the following:

- Items of instrumentation directly relevant to variable star research such as eyepieces and photometric filters
- Software related to image acquisition, processing, measurement, and data analysis
- Charges for access to research telescopes
- Obtaining research papers for which a charge is made
- Travel necessary for research purposes, e.g. to libraries or public/professional observatories where observing time has been booked.

Applications for the following will not be considered:

- Observatory equipment, as distinct from science instrumentation
- Equipment or software maintenance
- Subscriptions or books
- Conference travel or travel to a dark sky site.

Conditions of Grant

Only one application may be submitted by a VSS member for this round. The maximum amount of the application should not normally exceed NZ\$250.00, and smaller requests are more likely to succeed. Grant-in-aid applications, where the proposer wishes to make expenditure in excess of the amount requested and will meet the excess in other ways, are certainly acceptable.

Applications will be judged on their relevance to the purposes of VSS and its projects, and to the extent to which they will enable the grantee to be involved in those projects.

The amount granted must be spent within one year of the date of grant. The grantee should arrange for and pay for all purchases and other expenditure under the grant and submit receipts to VSS for reimbursement up to the maximum granted. If the grantee submits receipts in excess of the amount granted, only the amount granted will be reimbursed. If the grantee submits receipts during the grant period for less in total than the amount granted, then VSS retains the unspent balance.

The grantee is required, at the end of the grant period, to submit a full report to the Director of VSS of the research carried out using the grant monies. This report will be taken into account in the evaluation of future grant applications, and may at the discretion of the Director be published in the VSS Newsletter.

The grantee is required to ensure that in any research publications of which the grantee or any member of the grantee's team is an author, whether refereed or not, and arising from research of the grantee or team that was materially assisted by the grant, whether in the grant period or afterwards; appropriate acknowledgement of the grant shall be made.

Equipment and material purchased with the grant will remain the property of the grantee, not VSS.

Submission

Applications should be in DOC or DOCX format, no longer than one A4 page of 10-point type, including any illustrations or tables.

Applications must contain:

- Full name, postal and email addresses, and phone number of the proposer
- An itemised list of the proposed expenditure items. Where costing is difficult, please supply estimates.
- A justification of the expenditure.

Applications should be submitted as email attachments to the Director, Dr Tom Richards, (tom@prettyhill.org), by 30th May 2011. Proposers will be notified of the outcome of their application by email by 15th June 2011.

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.VariableStarsSouth.org> and its e-group <http://groups.google.com/group/vss-members>. It also encourages members to work in with major international organisations such as the British Astronomical Association, the Center for Backyard Astrophysics and the American Association for Variable Star Observers.

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

WHO’S WHO

Director Dr Tom Richards, FRAS.

Treasurer/Membership Bob Evans

Newsletter Editor Phil Evans

Webmaster David O’Driscoll

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

MEMBERSHIP

New members are welcome. The annual subscription is NZ\$20, and the membership year expires on April 30th. Find out how to join by visiting the VSS website. There you will find out how to join by post, email, or directly online. If you join by email or online you will get a link to pay by PayPal’s secure online payment system, from your credit card or bank account.

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

NEWSLETTER ITEMS

These are welcomed and should be sent to the Editor. 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 February, May, August and November, nominally on the twentieth day of these months and the copy deadline is the thirteenth of the month though earlier would always be appreciated.