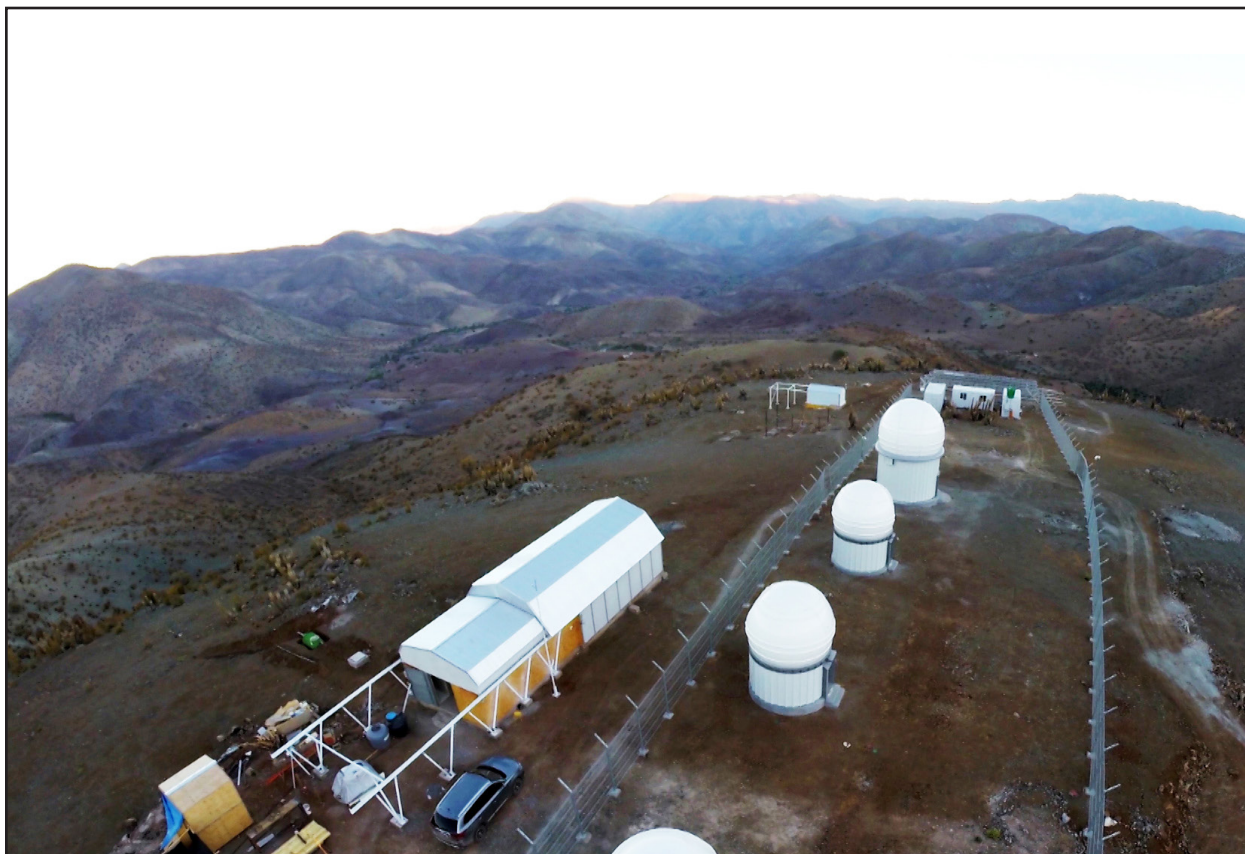




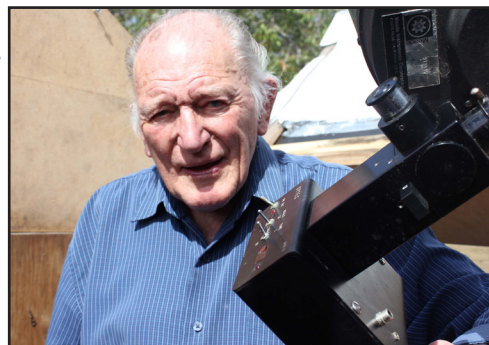
El Sauce observatory in Coquimbo province, Chile. For details see “A remote observatory in Chile” on p32.

Contents

From the director - <i>Stan Walker</i>	2
Clive Rowe & the Auckland Observatory – <i>Stan Walker</i>	3
Notes on S CMa and Z Pup – <i>Mati Morel</i>	5
Congarinni Observatory – Part 1 – <i>Mark Blackford</i>	7
Experimental modelling of bright southern EBs II – <i>Col Bembrick</i>	9
Colour measures of hump stars – <i>Stan Walker</i>	19
The stellar detective III – <i>Tom Richards</i>	24
Changes in L2 Puppis reflected in historic data – Part 2 – <i>Aline Homes, Pauline Loader, John Homes, Stan Walker, Andrew Pearce</i>	26
A remote observatory in Chile - <i>Phil Evans</i>	32
Publication watch	38
About	39

From the director – *Stan Walker*

astroman@paradise.net.nz



Best wishes to all for the New Year. I'm told that 2017 is a prime number so the year should be even better than 2016! And since our latest sunset was on 5 January the observing times are now coming earlier - but that's still not far short of 10pm with this daylight saving. Even worse in the deep south.

This time last year we were preparing for NACAA and VSSS4 although most of the on-the-scene work was done by Mark Blackford and David O'Driscoll with assistance from several others. A very enjoyable conference and meeting. Later this year we should look at the idea of VSSS5 - I cannot imagine too many of our Australian members making the trip to the RASNZ conference in Dunedin in May - so another get together would be rather useful.

One aspect of the AAVSO activities interested me - I had a note from Peter Williams mentioning the 'Weekly Data Usage Report' which indicates to observers when their measures have been accessed. Included in this was a downloading of his 2491 visual measures of U Carinae so perhaps others are interested in Cepheid stars. This leads into the observing area and several ideas arising from this.

Back in 1979 the CV star EX Hydrae was something of a puzzle with two discrete but confusing periods - 98.25 minutes and 67.03 minutes. The problem was resolved with a world wide collaboration in which amateur photometrists featured strongly. EX Hydrae is now probably the most studied intermediate polar - a magnetic subtype of CVs with direct accretion onto the poles of the white dwarf component - no disc! In time the rotation of the WD star will become synchronous with the binary orbit.

In 2017 we're setting up a similar widely spaced in longitude collaboration to detect and measure in one season the four eclipse contact points of QZ Carinae. So we need photoelectric observers in South Africa and South America to extend the strong Australia/New Zealand support to make observations to include these points. With central eclipse in the Tasman Sea area the Argentine/Chile area can observe first contact, South Africa the last. The system is bright, even at 7500 light years it's $V = 6.2$ out of eclipse, so small telescopes or stopped down larger ones will be needed along with BV filters. This is a unique opportunity and all participants will be co-authors of a special paper. The data will also provide an observational check of contemporary models of this massive and complex eclipsing system. Can you help us?

I'm intrigued about the way that manufacturing and advertising affect observing performance. When we began planning PEP in 1968 all the publicity was about the 1P21 photomultiplier tube. We were fortunate that Clive Rowe persuaded us to go the EMI way with more sensitive and dramatically less noisy pm tubes. I'm interested - as are many of the observers of massive stars - in seeing greater emphasis on the use of B and U filters - after all, these stars are mostly hot and bright with most of their radiation in these parts of the spectrum. I haven't really followed the CCD developments except to note that CCDs are becoming more sensitive and able to cover greater areas of sky. This last may be useful for deep sky imaging but seems to be rather a hindrance in VS observing where it merely slows the download rate. Even the sensitivity issue is presented in a biased manner by the manufacturers.

Aspects of the QZ Carinae project encouraged me to look for detectors with better short wavelength response. Kodak have always tended to highlight the yellow-orange response of camera film, with Agfa more blue sensitive and more realistic. But it seems that Sony have now taken over the latter role in CCD detectors with a much more balanced response and a near UV and blue performance that is similar to back illuminated chips, even if somewhat less sensitive. Here I began to get lost in all the deep sky oriented advertising and comments but I note that Atik cameras generally use Sony detectors and appear rather less expensive than some other brands.

Is there someone in Variable Stars South who can evaluate - or who already has done so - what is on the market and write an article, or series of articles, for this Newsletter so that we can get the best value on our investment as well as a camera which does what we really need - measures of the target star, a few others as comparisons and checks, and the sky background?

This leads to another topic, one which saddens me more than a little, in the recent demise of Clive Rowe,

one of the amateurs who made New Zealand and Eastern Australian amateur photoelectric photometry what it was in the 1970s and 1980s. Not so active in later years but still interested in VSS news and research. A review of his work in this area appears below.

This year of 2017 marks the fiftieth anniversary of the formal opening of the Auckland Observatory on 21 March, 1967, by Sir Bernard Fergusson, then Governor General of New Zealand. I had hoped that this would be marked by some type of research conference - the RASNZ Annual Conference would have been ideal - but this is not to be - research has played a very minor role at the Observatory since the early nineties with the planetarium and education dominating their activities. What observations are made in Auckland now are almost all at private observatories - most of which are well set up but rely heavily on being part of overseas collaborations with limited goals and little feedback into this area.

We must also file an Annual Report as a Section of RASNZ and this is requested by early March to allow publication in their journal, *Southern Stars*. So could all project leaders send me a summary of their group's activities by mid-February? This request also applies to individual members - what are you doing, why and with what results - our own Editor, Phil, is interested in these as well.

Clive Rowe & the Auckland Observatory – Stan Walker

astroman@paradise.net.nz

I'm saddened to hear that another one of the people who helped set up the Auckland Observatory's photoelectric equipment has passed on during November. Clive Rowe was instrumental in persuading Brian Marino and I that we should adopt what was then an innovative and ground-breaking method of photo-electric photometry.

It had begun earlier with the opening of the Auckland Observatory in March, 1967. Our first international programme was in conjunction with Bruce Slee of the CSIRO in the monitoring of flare stars. He used radio detectors with the Parkes 210 foot telescope - we used eyeball techniques on the 50cm Edith Winstone Blackwell Telescope by Zeiss of Jena - a beautiful instrument to use but demanding more than the unaided eye if we were to make the most of it.

At that time F Bradshaw Wood of the University of Pennsylvania was a leading figure at the recently opened Mt John Observatory (it predated Auckland by two years) but most of their equipment was conservative - it used the conventional 1P21 photomultiplier tube with its need for cooling before feeding the signal into an unstable DC amplifier with a chart recorder output. This needed manual measuring to derive intensities. But he did one thing which set Auckland going - he wrote and edited a book *'Photo-electric Photometry for Amateurs'* and some prescient librarian in the Auckland Public Library ordered a copy which I discovered and read with interest. This was what we needed!

Imagine the puzzlement at the next AAS council meeting when I set out to sell the idea. What is photo-electric photometry? Our recently formed Observing Committee persuaded the council of its suitability and a grant from the RASNZ Kingdon Tomlinson Memorial fund helped to get it moving. The conservative members of the AAS council insisted that we adopt conventional equipment and techniques. But other groups were interested, particularly George Eiby and Clive Rowe. In early January, 1969, Bob Evans and Stefan Mochnacki turned up from Christchurch with an operating photometer. Perhaps the construction was not ideal but the electronics were 'state of the art' or perhaps even more advanced. This was the catalyst!

Clive advocated using the much more sensitive and quieter EMI 9502 photomultiplier tube with an A/D (analogue/digital) converter designed by him, the output being displayed on a standard digital frequency meter (DFM). This pm tube avoided the cumbersome cooling necessary with the 1P21 - in fact one of the pair of tubes we bought in 1969 had a dark current of only 0.1 nanoampere at 5C - well under 1% of the sky background. The A/D converter which was known as the 'integrator' used current to frequency conversion and after warming up for 20 minutes or so beforehand was very reliable and had a great dynamic range which could be extended even more by changing the pm tube operating voltage.

In simple terms this increased our operating limit by several magnitudes, provided a numerical intensity output which could then be transformed into magnitudes with a small HP calculator, also new on the scene. Rather like the difference between a crystal set and a modern radio. But there was opposition.

Why change from the tried and true? Luckily the University of Auckland came to the rescue with Bob White (Physics Professor) offering to lend the group a power supply and the DFM. Such an offer, along with Clive's innovative electronics, set the whole of the Auckland Observatory/Society photoelectric research into action.

We moved into the 1970s with front line equipment and a group of people whose desire was to use this to its fullest. It was an exciting time, particularly in the CV field where these new techniques, combined with the realisation that these stars were interacting binaries, led to a wide range of discoveries. Comparison sequences, much better flare star results, UBV photometry of Mira stars, all were part of the research. Particular stars such as BH Crucis, Welch's 1969 bright nova in Sagittarius, VW Hydri and QZ Carinae, probably the most complex multiple system in the Milky Way galaxy, all date from these first few years.



Clive Rowe seated at the right with a few of the eighty or so participants at the PEP3 Conference held at Blenheim in 1987. Also Michael Snowden from Tahiti, Denis Sullivan, Wellington, seated, and David Crawford of the USA in blue, standing.

When the RASNZ Photometry Section was set up in the early 1980s Clive was one of the founding members. This section was involved in many pro-am collaborations and took over the Photoelectric Conference series, initiated by Murray Lewis of Carter Observatory about 1976, and holding the final of the series in Nelson in 2002. The section continued, heavily involved with cataclysmic variables and Joe Patterson's CBA before ceasing formally in 2009 and transferring its remaining funds to Variable Stars South in which several of us became members.

This link with Clive has always been maintained - Clive designed and supplied much of the electronics for Harry Williams' 53cm telescope in Milton Road and even repaired the AAS photometer which I had been using before it finally expired. These are the Auckland connections - but he was also involved in Mt John and the University of Canterbury's ring laser operation and many other projects including the Christchurch Astronomical Society's West Melton Observatory.

Clive was part of the group that changed New Zealand astronomy in the 1960s and 70s which, apart from the Aucklanders, included Norman Rumsey, Gary Nankivell, George Eiby, Bob Evans and Bill Allen - all with interests in the then new techniques of photoelectric photometry. I had hoped to meet with Clive again at next year's RASNZ Conference in Dunedin but this will not happen - his departure is a sad loss to NZ astronomy.

Abstract

Research into historical records reveals how CPD-32 1376 came to be designated S CMa (considered constant). Some anomalous observations have yet to be explained.

Z Pup has an interesting history, with one predisccovery observation dating from 1798. Both BD and CPD catalogues cover the region, but Z Pup has a nearby companion, and the quoted DM numbers are incorrectly assigned in the literature.

S CMa

Position (1875): 07h04m46.4s -32°43.6' CPD-32 1376 (8.9). Not in CoD.

Spectral type: A5. Originally A 5 F, the notation of the early 1900s. Quality unknown.

Modern photometry yields $V = 9.636 \pm 0.028$, $B-V = 0.285 \pm 0.026$, $B = 9.921$ Tycho-2.

It is missing in the *Cordoba Durchmusterung*, a surprising fact for such a relatively bright star. This was noticed by Kapteyn (1903) when comparing other catalogues with the CPD. It was immediately suspected to be variable, and published in a short list by Gill (1897). Sixteen visual estimates by Innes in 1897 ranged from 9.0 to 9.7, with no discernable regularity. Innes did not specify which comparison stars he used. The star came to the attention of Cordoba Observatory, compilers of the CoD. They checked their records and reported back as follows (Thome 1897):

“[The CPD star] was seen once as 10mag (~11mag on modern scale); on two other occasions it was below our limit (12mag). As this gave really three estimates of a very faint star, presumably below our lowest limit, it was not looked for again.”

The dates of Thome's observations were not given, but from Part II of the CoD I find that the region of S CMa was observed on the following dates:

1888 Nov. 6; 1889 Jan. 1; 1889 April 19; 1890 Feb. 24; 1890 Mar 24; 1890 May 12.

It is not certain when S CMa was observed faintly (~11 mag), but after 1889 Mar. 18, to accord with CPD records. On all subsequent dates it was too faint to be seen, according to Thome. This is in sharp contrast with the CPD record, on three plates obtained in 1888 and 1889, showing S CMa bright. Why was it missed by Thome? The field is not crowded, or challenging in any way.

CPD Plates

The introduction to the CPD, Part II (Cape Ann 3) lists all plates used, including rejected ones. However, individual CPD stars are not matched with plates used. This would be impractical. I have identified with reasonable certainty the plates taken for the region of S CMa. These are :-

Plate	1152	1888 Feb. 4	Rejected plate.
"	1311	1888 May 8	Centre (1875) 7h12.0m -31.5°
"	1327	1888 May 30	" " " "
"	2185	1889 Mar. 18	" " " "

Kapteyn (1903) states that S CMa is contained on all three plates. As two plates were always used in conjunction, one must surmise that all three plates from 1888/1889 were used in their measurements. From this, clearly, the position and magnitude for CPD-32 1376 is a record for this star at that time. The magnitude, 8.9 on the CPD scale, converts to 9.8 or 9.9 on the modern B scale, in good agreement with modern photometry.

Discussion

The Cordoba observers were very diligent in their work, and wished to make their survey as complete as possible down to 10.0v, and would hardly countenance the omission of such a bright star. Yet, they could only include stars in the CoD with three concordant observations. For whatever reason, in 1889 S CMa

just did not cut it, and was omitted. Did S CMa really undergo a fading episode, lasting several months? Such an event has never been observed again, to my knowledge. Other possibilities:

- There has been a failure at the observational level. Not very plausible, as it extends over multiple nights, concerning one particular star.
- A failure in reduction of observations. Again, plausibility is stretched, as Thome is totally at odds with the CPD records.

The only available spectral type (A5), is very old, dating from the early 1900s. Apparently no recent type is available. It may be worth looking at the spectrum again, with modern equipment.

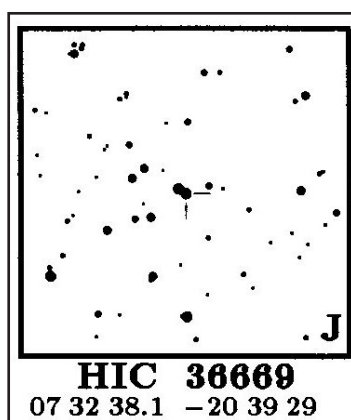
Z Puppis

HD 60218 = HIP 36669. Not in BD or CPD. Mira; 7.0 - 15.3V; 516d

Position (J2000): 07 32 38.06 -20 39 29.3

There is a companion star, 10.75V, about 24" NE. This star is BD-20 2007 = CPD-20 2569.

Position (J2000): 07 32 39.49 -20 39 15.3



Note the distinction between Z Pup and its companion; only the latter is in the DM catalogues. This fact has been noted as far back as Innes (1903). Modern databases (including SIMBAD) have messed up these alternative names, crossing over from companion to variable, or vice versa.

Z Pup was first observed, by chance, by Lalande from Paris on 1798 March 1. His observations were later reduced and published in 1847 in the B.A. Catalogue, star number Lal 14755. The position in the 1847 catalogue is for Jan. 1, 1800., but when precessed forward 75 years, we have

(1875) 07h 27m11.8s -20 23.4 BAC edition. No pm. Z Pup has small pm. My calculations are :

07 27 11.69 -20 23 26.3 Proper motion corrected.

07 27 11.74 -20 23 27.4 No correction for pm.

Fig 1. Finder chart for Z Pup.

The positional similarity between Z Pup and its companion was noted by Innes (1903). He gives both DM positions for the companion.

07 27 13.1 -20 23.9 BD-20 2007. Dec. slightly too far south.

07 27 12.6 -20 23.3 CPD-20 2569. Best position.

Z Pup was officially discovered in 1897 by Arthur Perry. A preliminary period of 524d was found. This allows the Cape observers to roll back the cycles to 1889 when the relevant CPD plates were taken. On plate 23, taken 1889 Mar. 23 = JD 2411085, Z Pup was invisible. Using $P=524d$, I calculate that maxima occurred on JD 2410816 and JD 2411340, and therefore the CPD plate mentioned was taken when Z Pup was midway between the two, i.e. near minimum. **This confirms that Z Pup was well below the limit of this CPD plate.**

References

- Gill, D. 1897. Astron. Nachrichten 144,143
 Innes, R. 1903. Ann Cape Obs 9,49B [Z Puppis]
 Kapteyn, J. 1903. Ann Cape Obs 9,8B
 Perry, A. 1897. Astron. J. 17,107
 Thome, J. 1897. Astron. Nachrichten 144,333

Congarinni Observatory – Part 1 – *Mark Blackford*

markblackford@outlook.com

In November 2016 my wife and I retired to a rural property in Congarinni, 7km west of Macksville on the NSW Mid North Coast. A primary factor in choosing this particular property was its suitability for astronomy. While only about 12km from the ocean, the skies are a huge improvement on those of our former residence in Sydney and there are two potential observatory sites available. In this (hopefully short) series of articles I'll document the construction of my roll-off roof observatory.

One potential observatory site, on the highest part of the property, would require local council approval as it's within 10m of a boundary fence. However, the other site does not require approval according to the council staffer I spoke to. So that's where the new observatory will be constructed. I'll leave the first site for another time, if I can convince Nerida that a second observatory is absolutely essential.

Before embarking on the permanent observatory I needed to get a temporary one in place so I could continue monitoring a couple of important eclipsing binary targets over the summer months. My Sydney observatory (briefly described in the February 2011 Variable Stars South Newsletter) was dismantled and transported to the new property, then reconstructed as a roll-off shed arrangement as shown in Figure 1.



Figure 1. Left: Original Sydney observatory was transformed into a roll-off shed design as a temporary shelter whilst the permanent roll-off roof observatory is constructed. **Right:** A tarpaulin fixed in place with Occy straps provides adequate weatherproofing.

Treated pine sleepers were used as running boards for the cheap plastic and rubber wheels. These provide smooth and easy movement of the shed at the beginning and end of each observing session. The shed contains a small but functional work area for the computer used to control the telescope mount and DSLR cameras. Despite less than ideal weather in December and January, I've managed several time series of QZ Car and KX Vel and the temporary observatory has performed flawlessly.

The site for the permanent observatory is behind an existing garage and granny flat. It is essentially level where the concrete slab will be poured, so construction and running power to the observatory will be straightforward. The gantry onto which the roof will roll will be on a significant slope but that shouldn't pose too many problems (he says hopefully).

The observatory will house two computer controlled telescopes on separate piers for photometry and have enough free space for a reasonable sized Dobsonian so I can enjoy visual observing while the other scopes acquire images.

A mechanical post-hole digger (Figure 2) was hired to prepare the two pier holes as well as post holes for an adjacent retaining wall where our vegie garden will be established. For the smaller pier a single ~35cm diameter hole was drilled to a depth of 1m. For the larger pier I drilled three overlapping holes to about 0.8m.

Over a 4 day period more than 60 wheelbarrow loads of concrete were mixed by hand for the retaining wall posts and pier bases. If I was to do this again I'd hire an electric concrete mixer.



Figure 2. Left: a post-hole digger made light work of the two pier holes. **Right:** frames made from welded lengths of galvanized threaded rod were cemented into each of the pier bases.

The two metal piers were fabricated by Joe Cauchi from the Astronomical Society of NSW. Joe also welded lengths of galvanized threaded rod into a frame to embed in the concrete bases (Figure 2 right). Rods protruding from the concrete fit neatly through holes in the bottom plates of the metal piers and allow precise leveling by adjusting nuts threaded onto the rods above and below the bottom plate.

Figure 3 shows the two piers in place with mounts and telescopes, there is adequate room between the piers to avoid collisions and allow visual observing through the scopes when desired.



Figure 3. Left: View looking south-west shows the two piers with mounts and telescopes in place. **Right:** View looking north-west, the temporary roll-off shed observatory is located on the far side of the water tank.

The next steps are to form up and pour the concrete slab then construct the observatory wall frames, roof gantry and light weight roof frame. I considered doing this myself with the help of neighbours, friends and family. But in the interests of speed and quality I've opted to engage a professional builder. Now all I need is to find one that can do it for a reasonable price. Stay tuned for the second installment.

Experimental modelling of bright southern EBs II – Col Bembrick

mountovensview@gmail.com

Abstract

Five bright, southern, eclipsing binary systems have been examined (Bembrick & Blackford, 2016) using DSLR photometry. The V band light curves have been used to interpret preliminary (in the absence of readily available radial velocity data) astrophysical models of these systems with the aid of Binary Maker 3. As these are bright binaries (typically V magnitudes 6.5 to 7.2) their spectral classifications are published – in some cases for both components. This aids significantly in the modelling as it serves to initially constrain the possible photosphere temperatures.

Three of these systems have previously been discussed – CN Hydri, RR Centauri and V535 Arae – with particular reference to determining the mass ratios (Bembrick, Col, 2016). The remaining two will be discussed here - namely GG Lup and μ^1 Sco.

Introduction

Preliminary models of five eclipsing systems were presented in the poster paper by Bembrick and Blackford (2016), and three have been discussed previously. The remaining two – GG Lup and μ^1 Sco will now be the subject of this paper.

The bright stars chosen for this exercise rely on the excellent DSLR photometry (transformed B,V,R) provided by Mark Blackford – as shown in our poster paper (Bembrick & Blackford, 2016). For this project, these have the advantage that they are bright, have spectroscopic classifications and are well studied in the literature. The opportunity has now been taken to attempt some comparisons between Binary Maker 3 (BM3) modelling of bright eclipsing systems (using no radial velocity data) and the professional models (which include RV data) published in the literature.

The results of these comparisons are presented in the following sections.

The modelling approach - a quick re-cap

In the initial modelling approach it is useful to follow the scheme outlined by Richards (2016a & b) and just sit down and eyeball the light curve while thinking about the basic geometry of the system. In this we can be aided by diagrams such as the ones to be found in Hoffmeister et al (1985).

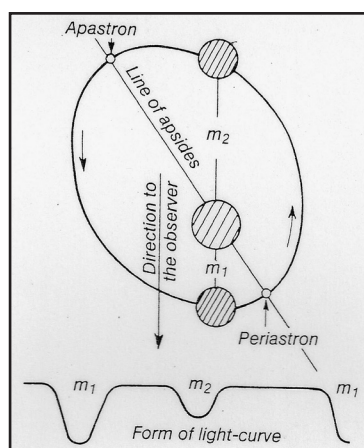


Figure 1. Looking down on the (eccentric) orbit and with the typical light curve below, showing the deep primary eclipse and the shallow secondary eclipse – in this case of eccentric orbit, not at phase 0.5. As this example is not a contact system, the light curve does not vary out of eclipse. Adapted from Figure 129 of Hoffmeister et al.

Another way of visualising the system geometry – particularly for W UMa binaries is shown in Figure 2 – adapted from Figure 125 of Hoffmeister et al.

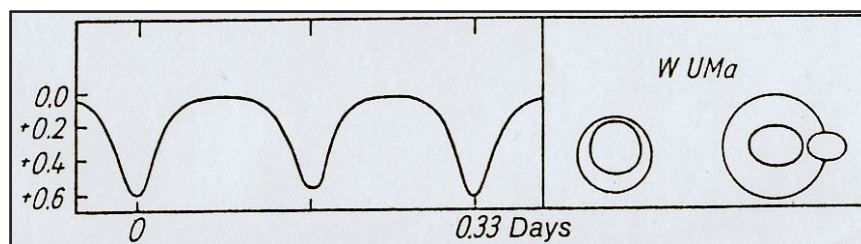


Figure 2. The light curve of a short period *W UMa* system with virtually continuous change of flux exhibited in the light curve. Note the eclipses are of very nearly equal depth and both stars are non-spherical in this instance – although they are not ‘overcontact’.

In the study of eclipsing systems the professional and the non-professional observers often adopt a different approach. The professional commonly (but not always) has spectroscopic and RV data to work with, the system being well studied usually by large aperture telescopes. In the amateur situation, the data available are usually more restricted. The star may be poorly studied, with little or no spectral classification published and no RV data available. A phased light curve (possibly only in one bandpass) is often the best the amateur can acquire, with some B-V or other colour indices perhaps. As the stars are often relatively faint, spectroscopic information is almost invariably lacking.

As there are very many unstudied or poorly studied eclipsing system – particularly in the southern hemisphere – the question arises as to what is the best and most efficient way for amateurs to attempt to model these systems with the data available to them. Binary Maker 3 provides one approach to enable the amateur to model these stars, but there are various other software packages around which are championed by different groups – eg Winfitter, Phoebe, Wilson-Devinney, etc. The author’s experience to date is solely with BM3 and that will be the tool for modelling the systems described here.

The method

Professionals attempting to model eclipsing systems without RV data often advocate the q-search or q-grid method. This is a method by which some sort of best estimate may be made of the crucial parameter q , the mass ratio (see Wadhwa & Zealey, 2005). The exact method is somewhat involved and time-consuming, particularly if implemented on BM3 where every iteration must be manually initiated. Consequently, a quick ‘nifty abbreviated version of this q-search method was used for this exercise to see if useful results could be obtained.

In BM3 this involved varying q (and only q) in discrete steps while noting the residuals of the model fit to the observed data – the flux curve. This residual number is output by BM3 after the model has been rendered each time. Choosing to use residuals in BM3 is time consuming as it slows the program down considerably – and even more so if eccentric orbits are involved. The starting values for q are decided by an initial good eyeball fit in the modelling exercise. This fit is derived by some trial and error with BM3, taking into account the spectral type (if available) and B-V index to derive an initial temperature (T_1) for star1. Various sources may be used to relate B-V to stellar temperature (see Flower, 1996).

The technique is to then plot q on the abscissa and the residuals (scaled) on the ordinate. If all goes to plan, then the minimum of the curve obtained should give a best estimate of the correct mass ratio, q . This then can be fixed in the model, together with T_1 and modelling can proceed to adjust the inclination, i , the other star temperature, T_2 and other factors.

In this way there should be a good chance that the best model that can be expected in the absence of RV data will be achieved. Without RV data of course, the model cannot be definitive.

GG Lupi

So, let us start by looking at the flux curve of GG Lup, which is produced from our phase-magnitude photometry data by BM3. As it is a linear scale, flux is easier to work with than magnitudes (Figure3). Following the Tom Richards methodology, we will put our thinking caps on and keep our eyeballs skinned to observe some simple but significant features from the flux plot.

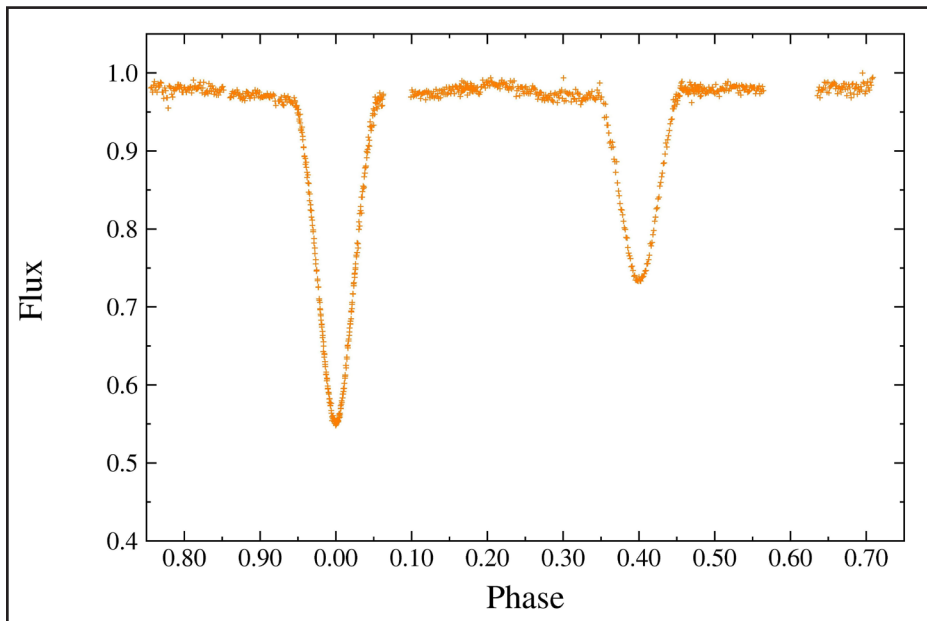


Figure 3. Flux plot for GG Lup - max brightness normalised to 1.0

1. a deep primary minimum (45% flux loss) and the secondary min shows 25% flux loss.
2. eclipses are not total - no flat bottoms.
3. curve is *almost* flat out of eclipse - not a contact binary.
4. secondary min not at 0.5 phase - orbital eccentricity present.
5. slight hump at about 0.2 phase - could this be related to periastron/eccentric orbit?
6. there is a *slight* suggestion that the eclipse widths are not *quite* equal - confirm by modelling perhaps?

So, we immediately see we have a more complex modelling exercise here - with eccentricity present, the position of the secondary minimum will depend on both the eccentricity, e , and the longitude of periastron, ω . We do not have the luxury of total eclipses and the eclipse widths *may* not be equal. A quick dip into the BM3 manual (Bradstreet & Steelman, 2004) tells us that the small hump may indeed be related to the tidal distortion of the stars when they are briefly close at periastron.

One other thing which results from eccentric orbits is apsidal motion (the orientation of the orbit changes in space), which means that the photometric light curves from different epochs may not be identical - the position of the secondary eclipse may have changed and the eclipse widths may change at different epochs (cf Clausen et al, 1993).

For the purpose of this modelling exercise, let's assume that this binary has no RV data and we utilise quoted spectral classification data (eg AAVSO database) to derive an input temperature (12775 K) for star 1. Using some preliminary, intelligent guesses, we derive an initial model using BM3. A number of iterations will be necessary to achieve a model which you deem to be acceptable as a first pass. Then, as outlined in the earlier section, the (guesstimated) mass ratio, q , is varied in discrete steps and a q -plot obtained.

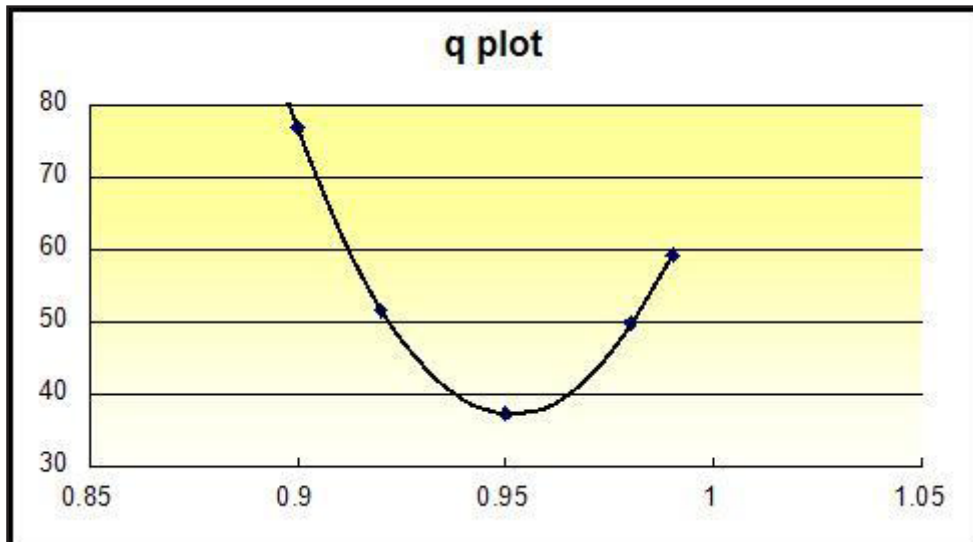


Figure 4. *q-search plot for GG Lup*

This appears to be a very nicely behaved q-plot showing a well-defined minimum at mass ratio, $q = 0.95$. Wonderful, you say, and we'll slip that q value into our BM3 model as our definitive value.

This produces a very nice fit to the observed flux curve, with a residual value of 0.03739.

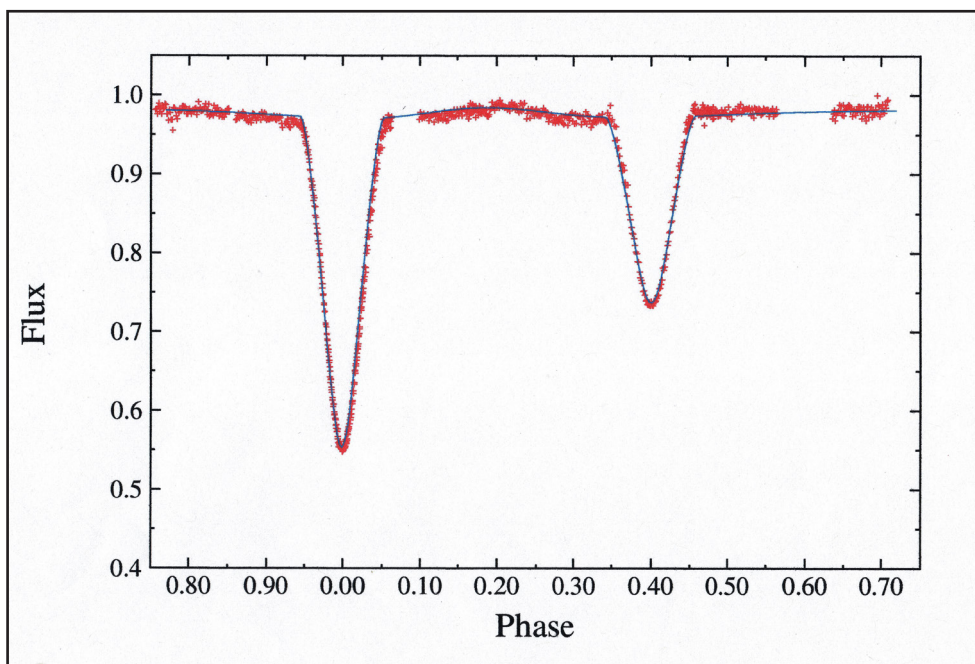


Figure 5. *Author's BM3 model fit to observations for GG Lup, using $q = 0.95$.*

Not a perfect fit, particularly around the hump, but fairly reasonable you would probably say. So, we are now in a position to compare this with the results from our professional guys who have the luxury of access to highly accurate radial velocity data (Andersen et al, 1993; Budding et al, 2015).

Before we do that, let's just have a quick look at the scatter in our residuals for this model version - see Figure 6.

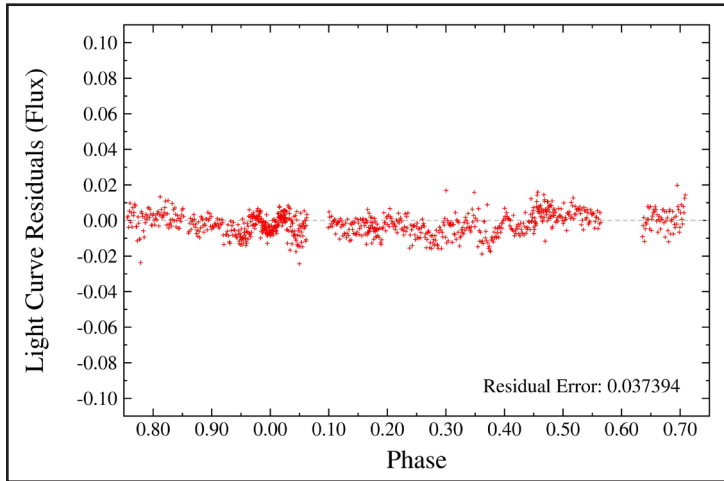


Figure 6. *Residuals from fit of BM3 model to observations - note small scatter.*

The residuals appear well behaved - no significant periodicity and small scatter. On this basis we would expect to have some confidence that this was a reliable estimate of the mass ratio, q . So, now we examine the comparisons with the parameters published in the literature - in the table below, **B³** is shorthand for the Budding, Butland and Blackford paper, 2015.

Table 1. GG Lup Model Comparisons

Parameters	Author, 2017 ver5	B³ , 2015	Andersen et al, 1993
Mass ratio, q	0.95	0.634 (rv)	0.610 (rv)
T1	12775 K	13000 K	14750 K
T2	10150 k	10600 K	11000 K
Inclination, i	84.2°	87.5°	86.75°
Omegas	7.4, 6.3		
Eccentricity, e	0.156	0.154	0.15
Longitude of perihelion	184°	178.7°	86.4° (1985)
Notes:	(B-V) = -0.099	Sp: B7 V, B9 V	Sp: B7 V, B9 V
	(from Hipp)	high eccentricity & short period	eccentric orbit

Looking at the first line across the table we see we are in trouble here - it seems our ‘quick-n-nifty’ q -search method has led us seriously astray on the mass ratio, q . The temperatures are not too different, the inclinations are very close, as are the eccentricities. The longitude of perihelion is slightly astray between our model and the **B³** parameters - it is different from Andersen et al (1993) because theirs is a much earlier epoch.

The two models utilising radial velocity data (**B³** and Andersen) agree closely on the mass ratio, q . The temperatures are close but not identical, the inclinations virtually identical, as are the eccentricities. All well and good and to be expected, but why is our BM3 model so different in mass ratio? Particularly given the nice q -plot and the well-behaved residuals

As our model and the **B³** paper rely on the same (Blackford) photometry, we can plug their parameters into our flux curve in BM3 and see if we get a good fit. We cannot do this for the Andersen model as theirs is from a different epoch and the light curve is markedly different (see Clausen et al, 1993). This is where the apsidal motion comes into play as the eclipse widths are very different between primary and secondary.

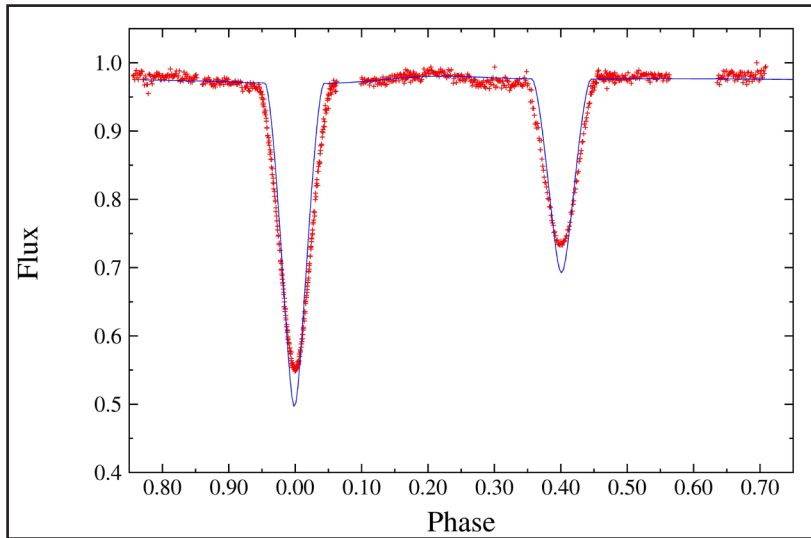


Figure 7. The $\mathbf{B}^3$ parameters entered into BM3 to fit the photometry common to this author and the $\mathbf{B}^3$ paper:

We can see the fit is not great here - even by eyeball. However, we can see it is on the right track. A slight bit of tweaking of the inclination, the temperatures and the stars' diameters (but not q) will improve the fit no end. But of course that is moving away from the $\mathbf{B}^3$ model - derived from the radial velocity data. So, what is going on here? At this stage I'm ready to subscribe to the RNK theory - (*Reckon Nobody Knows*)

Perhaps we could go with the opposite approach - change q in our model (to match the $\mathbf{B}^3$ model) and see how the fit looks.

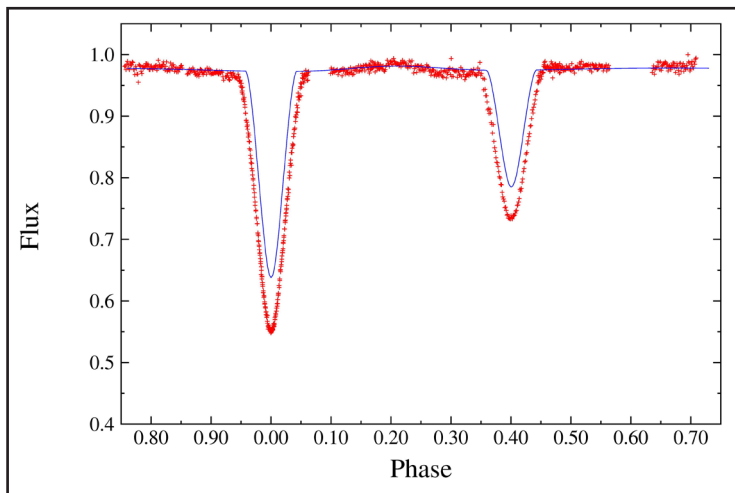


Figure 8. The author's model (cf Figure 5) with q changed to the value in the $\mathbf{B}^3$ model - no other parameters changed.

Again, we can see that the fit is not great, but with some little tweaking - inclination, temperatures and star size (but not q) - it is on the right track. So, what is all this fiddling around telling us?

The most likely hypothesis seems to be that the models are very insensitive - at least in this case - to the value of mass ratio, q . How does this relate to the nice q -plot we saw in Figure 4? How can we evaluate this? Let's extend our quick-n-nifty q -plot to a wider range of values and see what results.

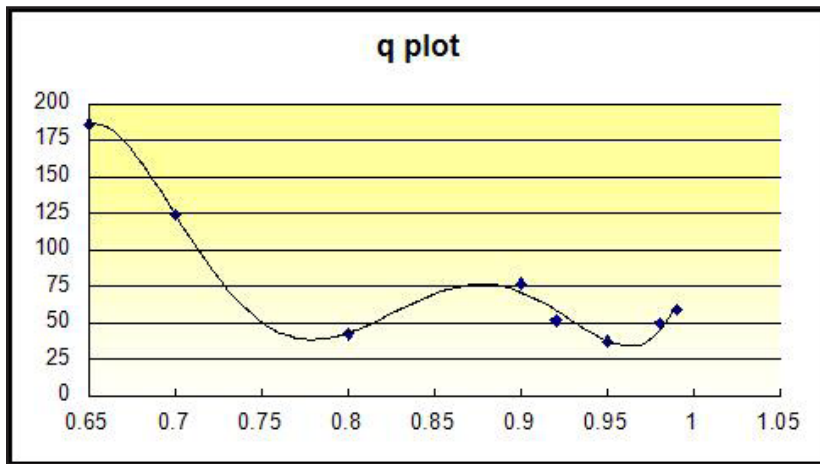


Figure 9. The q -plot for the author's BM3 model, with extra values of q inserted.

Here we see that in q -space there are several minima, with one close to 0.95 and one near 0.78. Curiously, there appears not to be one near 0.64 (as required by the B^3 model). Thus the initial minima we picked for this model exercise appears to be just one of a number of possibilities. In this sense, the models are insensitive to the mass ratio, q .

We can demonstrate this by plugging $q = 0.78$ into our initial model (where q was 0.95) and comparing the fit to the flux curve. The figure below shows the result - with residuals of 0.0343 - only fractionally different than our best model.

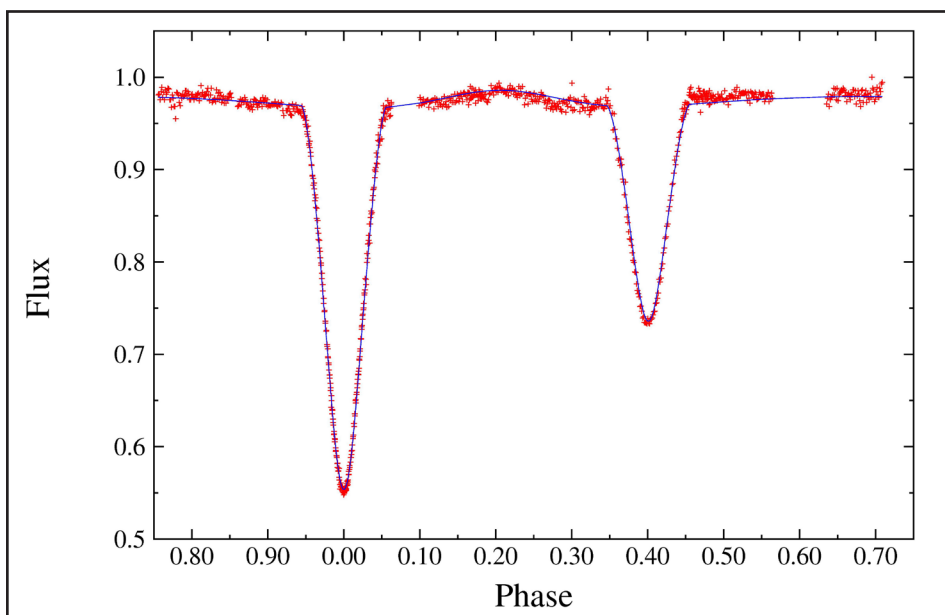


Figure 10. The author's model of Table 1 but now using $q = 0.78$. Residual 0.0343

As we have seen in the previous paper (Bembrick, 2016) the quick-n-nifty q -search method gives useful results in many cases. How then are we to distinguish cases such as the above, where it clearly is misleading and insensitive to the modelling process?

Over to the multiple brains trusts out there.

μ^1 Scorpii

Now let us turn our attention to the μ^1 Scorpii system, a well-studied binary (van Gent, 1939; Schneider et al, 1979; van Antwerpen & Moon, 2010; Budding et al, 2015).

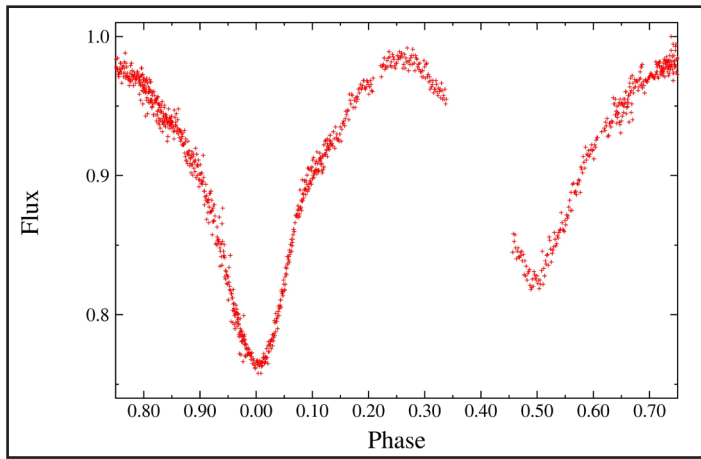


Figure 11. Flux plot for μ^1 Sco with max brightness normalised to 1.0

Once again - thinking and eyeballing - we observe the following features of the flux plot...

1. deep primary and secondary minima.
2. the secondary is at 0.5 phase - circular orbit.
3. flux varies out of eclipse in a continuous fashion - ?maybe a contact binary.
4. the eclipses are not total- no flat bottoms.
5. parts of the flux curve have small inflexion points.

Based on the quoted spectral type (B1 & B6) we derive a temperature for star 1 (21500 K), which leads to a preliminary model with BM3. This gives us a starting value for our q-search. The resulting q plot is displayed in Figure 12.

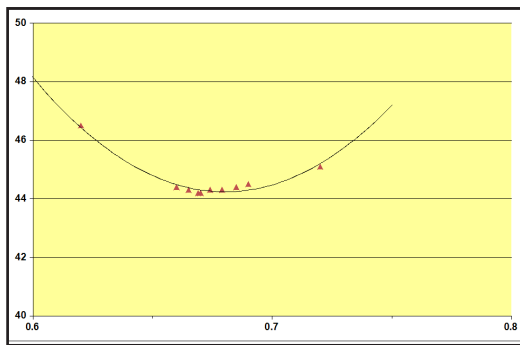


Figure 12. q-search plot for μ^1 Sco. Min at $q = 0.674$

The plot appears well-behaved, although the minimum is shallow - note scale. Inserting this into our BM3 model we produce a fit with the observed flux curve.

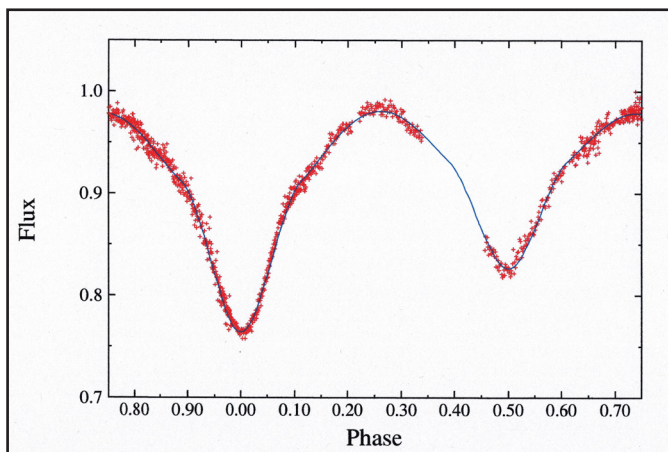


Figure 13. Author's BM3 model fit to observations, using $q = 0.674$. Residuals = 0.0443

The fit is not wonderful (as the residuals show), but considering we have arrived here without using RV data, it could be considered fairly reasonable. The inflexion points on the primary minimum part of the curve appear well matched.

So how does our residual plot look in this instance?

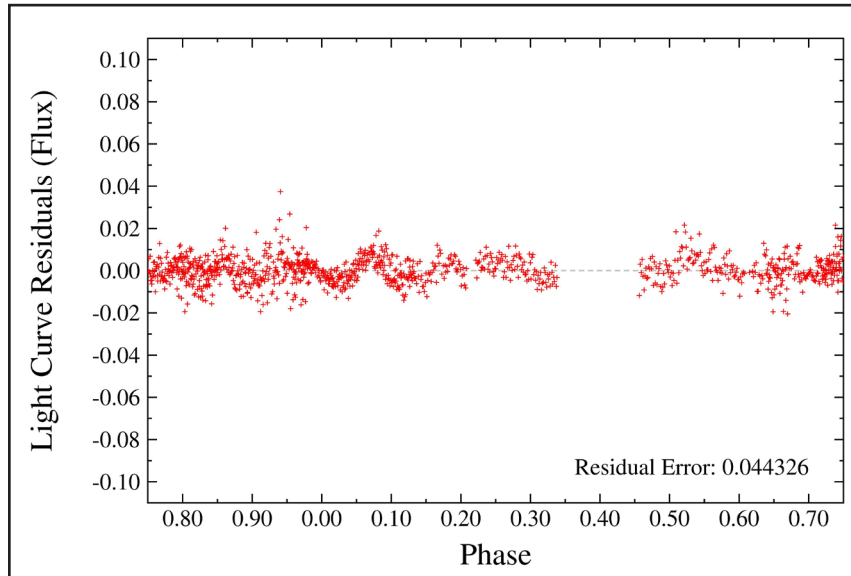


Figure 14. *Residuals from fit of BM3 model to observations - fairly small scatter.*

All looks in order to make our comparisons with the models published in the extensive literature. In the table below **B³** is again shorthand for the Budding et al, 2015 paper.

Table 2. μ^1 Sco Model Comparisons

Parameters	Author, 2017 ver 2	B³ , 2015	van A & Moon, 2010	van Gent, 1939	Schneider et al, 1979
Mass ratio, q	0.674	0.55 (rv)	0.627 (rv)	-	0.674
T1	21500 K	24000 K	23725 K	20000 K	21500 K
T2	16350 K	17000 K	16850 K	12500 K	16200 K
Inclination, i	63°	64.3°	65.4°	61.1°	-
Omegas	3.5, 3.2				
Eccentricity, e	0	-	0	-	-
Notes:	(B-V) = -0.20	(B-V) = -0.16	(B-V) = -0.212	-	(B-V) = -0.16
	Hipp.	secondary larger than primary	Star 1, B1.5-B2.0 Star 2, B3-B8 secondary fills Roche lobe		

The author's model here is in good agreement with three of the published models - those of van Gent, Van Antwerpen & Moon and Schneider et al. In particular, the mass ratio is in very close agreement, while the inclinations are close, as are the temperatures. The same could be said for the **B³** Model, but with the notable exception of the mass ratio - why is it so?

Is this a spectacular success for the q-search method or not?

Since the author and the **B³** Model utilise the same photometry, a quick comparison can be made. Using BM3 and inserting a mass ratio of 0.55, and with **B³** temps, we get a plot as shown below.

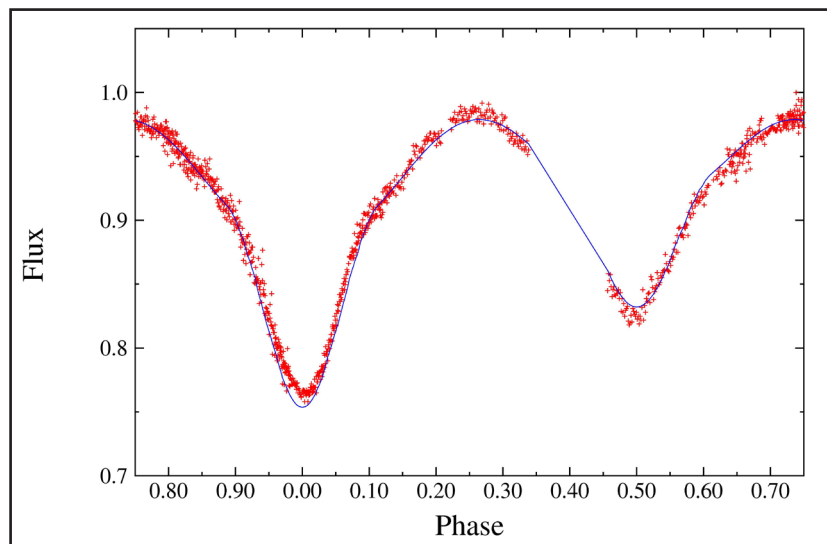


Figure 15. The B^3 Model parameters fitted to observed photometry

Here we can see the fit is not the best, and the residuals are 0.0779, significantly worse than the 0.0443 of the author's fit. Again, why is it so? Is this another case of the models being fairly 'insensitive' to the mass ratio used? Further discussion and investigation is needed here I feel.

Summary

The above two examples, when combined with the three examples discussed in the previous paper, lead one to the conclusion that the quick 'nifty method' may give excellent results.

It appears that if one has a well behaved q-plot then the results for q can be in excellent agreement with those derived from interpretation using RV data. However, beware of q-plots with more than one minimum.

However, there are other cases - as outlined above - where it may give a value close to the correct mass ratio q, or it may be significantly adrift. How to distinguish between these cases is the problem. It appears we should heed Ed Budding's (and others') reservations re the use of the q-search methodology.

References

- Andersen, J., Clausen, J.V. and Giménez, A., 1993. *Absolute dimensions of eclipsing binaries - XX. GG Lupi: young metal-deficient B stars*. *Astron. Astrophys.* 277, pp439-451.
- Bembrick, Col, 2016. *Experimental modelling of bright southern EBs*. VSS Newsletter, 2016-2, pp48-53.
- Bembrick, Col and Blackford, Mark, 2016. *Bright Southern Eclipsing Binaries - Preliminary Modelling*. Poster paper, 27th National Australian Convention of Amateur Astronomers, Sydney University.
- Bradstreet, David and Steelman, David, 2004. *Binary Maker 3*. Contact Software, Norristown, PA, USA.
- Budding, E., Butland, R. and Blackford, M., 2015. *Absolute Parameters of Young Stars: GG Lup and μ^1 Sco*. *Mon. Not. R. Astron. Soc.* 448(4), pp3784-3796.
- Clausen, J.V., et al., 1993. *Four-colour photometry of eclipsing binaries. XXXV. Light curves of GG Lupi: Young metal-deficient B stars*. *Astron. Astrophys. Suppl. Ser.*, 101, pp563-572.
- Flower, Phillip J, 1996. *Transformations from Theoretical Hertzsprung-Russell Diagrams to Color-Magnitude Diagrams: Effective Temperatures, B-V Colors, and Bolometric Corrections*. *Ap. J.*, 469, pp355-365.
- Hoffmeister, C, Richter, G and Wenzel, W, 1985. Translated by S. Dunlop. *Variable Stars*. Springer-Verlag, Berlin. pp328.
- Richards, Tom, 2016a. *The stellar detective – Reading the clues in light curves of eclipsing binaries Part I - finding star sizes*. VSS Newsletter, 2016-3, pp24-27.
- Richards, Tom, 2016b. *The stellar detective II – Reading the clues in light curves of eclipsing binaries Part II - Interpreting eclipse depths*. VSS Newsletter, 2016-4, pp21-27.
- Schneider, Donald P., Darland, Jeffrey J. and Leung, Kam-Ching, 1979. *Semidetached systems of spectral type B: BF Aurigae, μ^1 Scorpii and V Puppis*. *Astron. J.*, 84(2), pp236-243.
- van Gent, H., 1939. *Communications from the Observatory at Leiden. Photovisual photometry of the eclipsing variable μ^1 Scorpii*. *Bull. Astron. Inst. Netherlands*, 9, pp15-23.
- van Antwerpen, C. Moon, T., 2010. *New observations and analysis of the bright semidetached eclipsing binary μ^1 Sco*. *Mon. Not. R. Astron. Soc.* 401, pp2059-2066.
- Wadhwa, S and Zealey, W, 2005. *UX Ret and CN Hyi: Hipparcos Photometry Analysis*. *Astrophys. Space Sci.*, 295, pp463-472.

Introduction

The historical database of Miras, semi-regular stars and other LPVs is based upon time series photometry - TSP - and the classification of these stars into types is based largely on shapes, periods and amplitudes derived from this, with some influence from spectral measures of the brighter objects.

Since the 1950s the introduction of filters and colour photometry has allowed these measures to be extended to determine temperatures more quickly and to much fainter magnitudes, as well as providing information on the emission by way of the U filter and cooler dust cloud radiation by way of the I filter.

It has always intrigued me that amateur observers seem reluctant to get involved in colour photometry - and that many professionals do not include this extra information in their papers.

Can colour photometry help with humps?

One answer is simple - we won't know until we try! And too few people are trying. Also, the AAVSO method of publishing filtered measures as U, B, V, R, I instead of the conventional V, B-V, U-B, V-R, R-I and V-I is not particularly helpful in understanding what is happening. V, B-V provide the most important information - the star's brightness and its temperature, but V-I will be significant if there is any radiation from dust clouds. U-B has value also but many CCD cameras are insensitive in the U region and the faintness of this in red stars requires a large telescope and patience. But measures of L² Puppis in U-B are very informative and it was something similar to a hump on the light curve which encouraged the Auckland Observatory's project on this star - see the abstract elsewhere in this newsletter (p38). I note that ATIK CCDs tend to use Sony detectors which are far more sensitive in the blue and near ultra-violet regions than Kodak ones so if you have one of these try out a U filter.

Two illustrations from a paper about BH Crucis published in JAAVSO in 2009 illustrate this concept. For what it's worth BH Crucis is now a single maxima Mira with a pronounced hump where the first maximum used to be. So are double maxima an extreme version of humps?

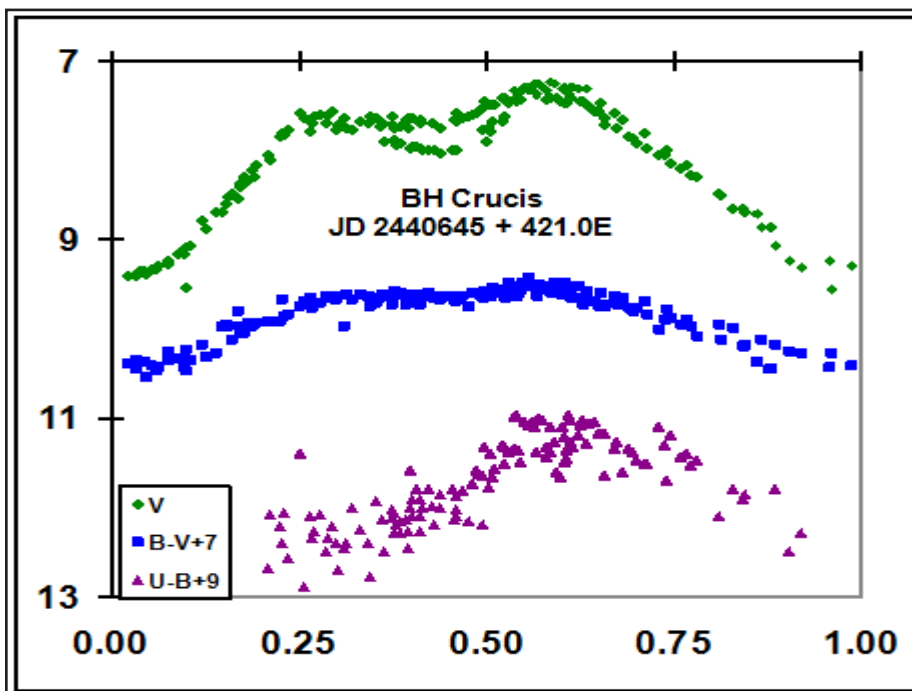


Figure 1. This shows *V* measures as well as *B-V* and *U-B* colours during the interval JD 2440862 - 2544 phased to the light elements of the deep minimum - JD 2440645 + 421E. The *B-V* has been offset by adding 7, *U-B* by adding 9. The scales are identical otherwise. *U-B* colours up to phase 0.20 were very poor due to the faintness of BH Crucis in *U*—magnitude 15-16 at those phases. But these still show the remarkable difference between the *U-B* colour of the two maxima.

Quite clearly something caused the U emission to become much stronger during the second maximum. No one has as yet been able to explain what this was. So let's examine another aspect of BH Crucis - the change in colours as a result of the period change from 421 days to 525 days. In 2008 this longer period seemed to be about 530 days, by 2016 it seems to have stabilised at ~505 days. Even this period change can be explained by the alternation of two periods displaced from a common mean - a feature of most LPVs.

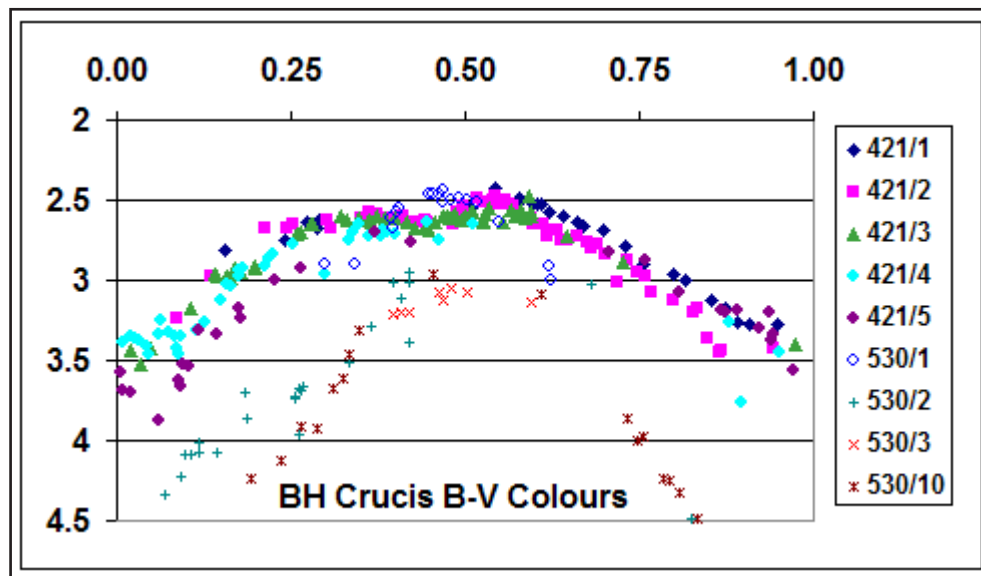


Figure 2. This shows B-V colours during the two stable periods - firstly 1970-76 then 1991-2006. The period key is at the right. The earlier cycles are denoted by solid colours, more recent ones by unfilled circles or crosses of various kinds. There is a noticeable change in the B-V amplitude, from 1.0 magnitude in the 1970s, to 1.5 magnitudes in the 1990s and 2000s.

So, assuming the star follows the normal relationship $L = T^4 \cdot R^2$ and that B-V is indeed measuring temperature in this case, we are looking at a much larger star. This is also supported by the period/radius relationship but what caused the change?

In the context of the discussions which have been taking place in the AAVSO LPV Section how does R Centauri fit the idea that the humps are a rising branch feature? It is the second maximum of that star which appears the less stable from visual measures over the past two decades. An interesting aspect is that the first maximum of R Centauri is the bluer and hotter, but it was the second in BH Crucis. We do not have this information for other DM Miras such as V415 Velorum, R Normae and others - so these would be rewarding targets.

What observations are needed?

What needs observing is whether there are any significant colour differences between a cycle with a hump and one without. It's useful to measure these in BVI at least to derive V, B-V and V-I. U-B would be possible in brighter Miras. So let's look at two different rather different Mira stars - the filters were UBV, the normal ones from 1950 to 2000 before CCDs became widely used in these fields. S Carinae is a normal Mira with temperatures reaching a peak at maximum as shown by the two lower colour curves. R Carinae, on the other hand, has a semi-inverted B-V curve and a strongly inverted U-B curve - in summary, indicative of either a blue companion, physical or line of sight, or a strong emission component in the star.

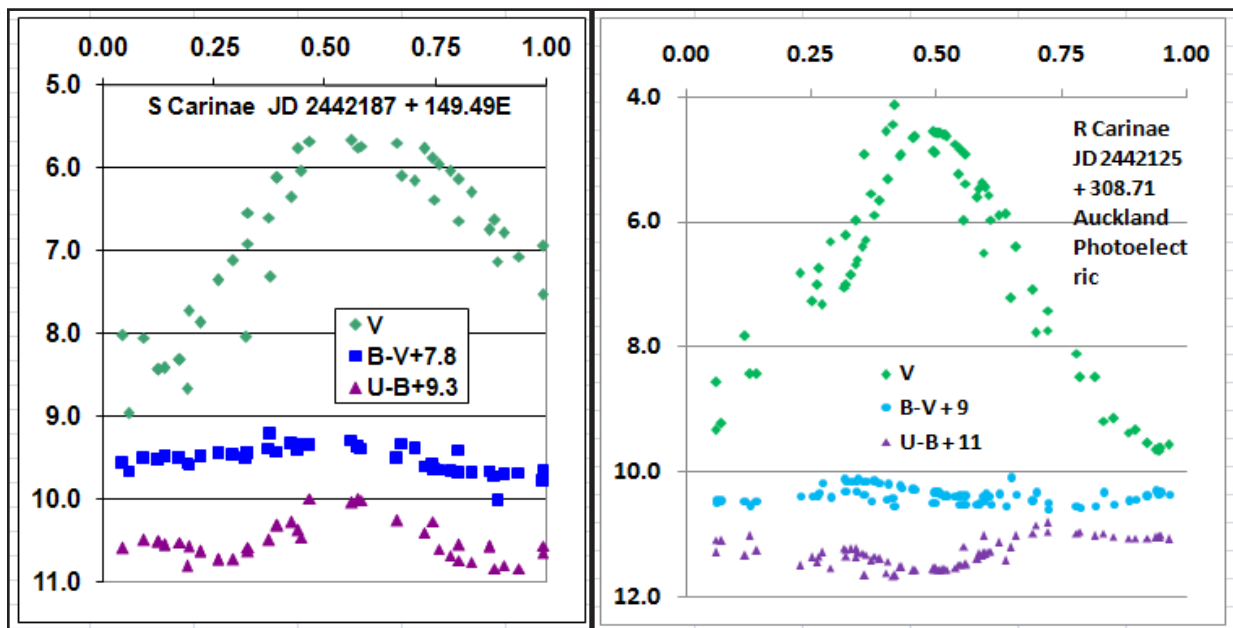


Figure 3. Two stars with contrasting colour changes during a cycle. *S Carinae* is quite blue for a Mira being K5e at maximum. Whilst *R Carinae*'s spectrum is normal at M4e the *B-V* colour of ~ 1.1 at maximum is far too blue. More about this below.

To obtain curves of this nature a measure every 10 days during one or two cycles each decade is adequate. The non-repetitive nature of the light curves is clear from these graphs. There is little advantage in using anything other than visual measures to establish epochs of maxima and the general shape of the curves. Untransformed *V* measures contribute little extra. But let's take another star where colour measures might tell us a little more.

KK Carinae - an interesting Mira star?

Andrew Pearce of Perth, with assistance from Frank Schorr in the US, is gradually transforming the AAVSO LPV Section into an interesting area with a strong emphasis on Mira stars with humps and bumps on the light curves. This month I was intrigued by the choice of KK Carinae, a star I'd never seen mentioned before. It's clear from the International Database that few people are observing this as the total visual measures recorded are less than 300 - 82 by PEX and 130 by JA. A light curve appears below.

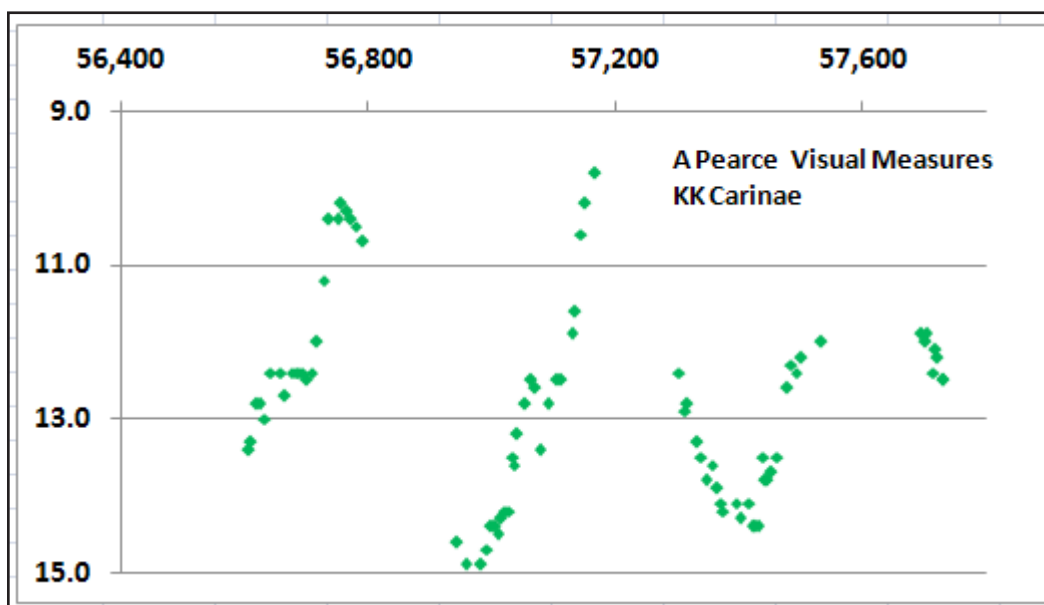


Figure 4. Visual observations of KK Carinae since late 2013 by Andrew Pearce. There are suggestions of a hump on the rising branch which is presumably why it's featured as a useful target.

I then looked at a few other references for more information. The GCVS gives a photographic range of 11.8 to 15.2, with no period but a spectral class of M5ep. ASAS3 offers a range of 9.2 to 14.2 but the International Database gives 9.7 to 15.0. The period from ASAS3 of 415 days is probably within a few days of the correct value. Guide 9 offered values from Tycho - VT of 10.999 and BT of 12.562 but an interesting B-V of 1.310 ± 0.17 .

The photographic values are probably ~ 1.5 magnitudes too faint as they would have been based on the old blue sensitive film and were measuring in what is close to the B filter of the UBVRI system. So all of the maximum and minimum values after adjustment for this are within one magnitude which seems normal for Mira stars. But the B-V value of 1.31 is too blue - even if we took the extreme value of 1.48. The 'p' term (peculiar) in the spectral class also suggests something unusual. Perhaps there is a blue companion - fairly common in Miras - affecting the measures.

This confirms the need for something more than just visual measure of these stars. I notice a few V filter measures but alone these have little value. In this case they are also ~ 0.7 brighter than the visual measures which indicates that one or the other is based on incorrect comparison values. We await Gaia's measures so we can finally be certain of magnitudes in the mag 10-20 range!

It would be good to see a few CCD operators providing BVI measures of these stars. Even better - some U-B as well. The reasons for this are discussed below.

Let's look at another of these stars which may be similar. We go back to R Carinae with GCVS light elements of MJD 42000 + 308.71 and an M6e to M8e spectrum.. This was measured from 1981 to 1986 in Auckland and a more accurately phased light curve appears in Figure 5. Whilst the epoch is correct the period at that stage was the shorter of the alternates, ~ 304 days.

Let's examine the colours first. B-V varies from 1.094 to 1.586, U-B from -0.195 to 0.660. Both these colours are far too blue for the spectral class quoted. The B-V curve is relatively flat but is brightest just before maximum in V, fairly normal for pulsating stars. U-B is completely inverted, being reddest at maximum. It is brightest at phase ~ 0.30 , not unusual for a Mira star as this is when the emission from ejected material is strongest. It seems clear that along with the Mira star we are measuring a much bluer object than a Mira. Two other aspects of the light curve support this - the amplitude is not large for a Mira and the minimum is perhaps a little wider and more rounded than in other Miras, indicating that the fainter but hotter star is beginning to affect even the V light curve.

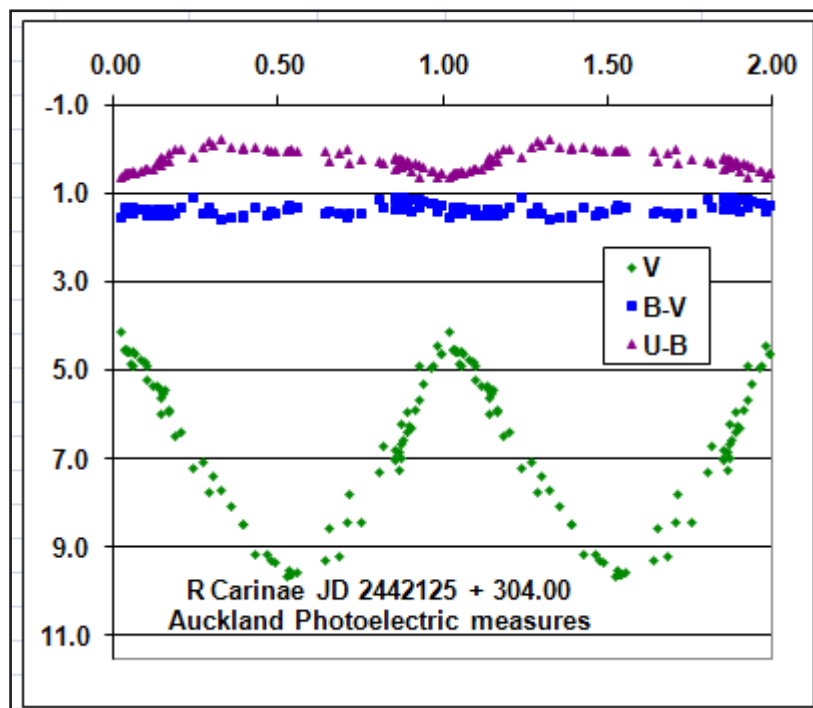


Figure 5. *V*, *B-V* and *U-B* measures of *R Carinae* from Auckland Observatory over a six year period. This is a popular object as it is visible with the unaided eye at maximum and easy to locate.

Does KK Carinae share any of the peculiarities of R Carinae? Unfortunately no one seems to have made colour measures of this star. So only the visual measures are available. Do the Jones measures help at all? They are shown in Figures 6a and 6b.. Details of the intervals covered are shown in the actual figures along with the light elements adopted.

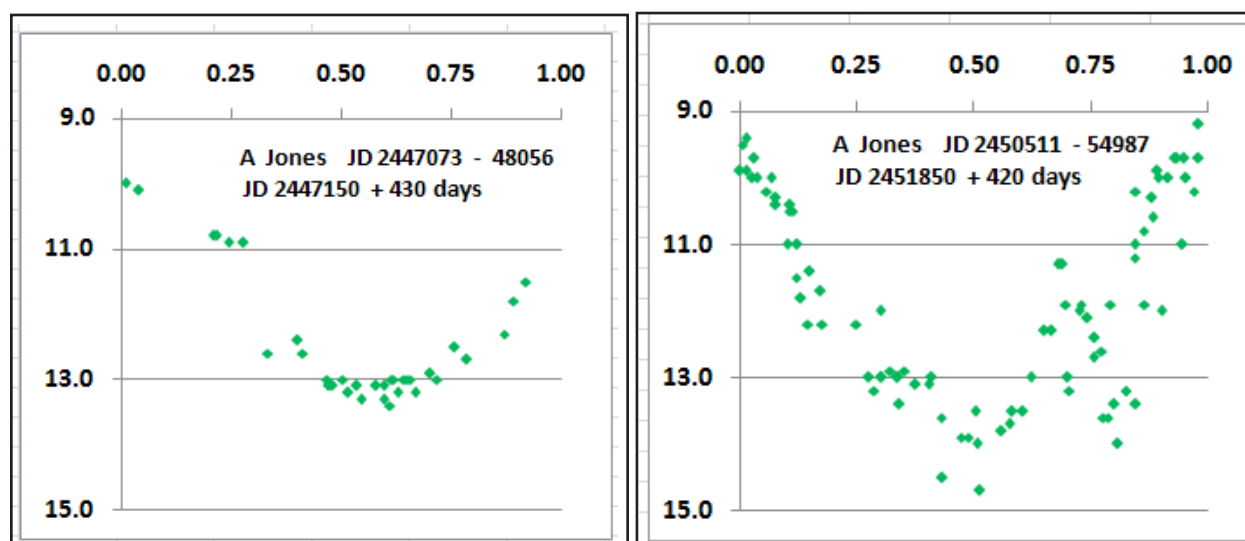


Figure 6a, 6b. These show rather contrasting behaviour. During the first interval of ~3 years the minimum was just below magnitude 13, rather brighter than the 14.0 to 14.5 of the following 16 years. As well, the latter interval seems to show a marked feature on the rise.

In the early interval the minimum seems unusually wide and flatter than normal. This is not as pronounced in the later measures although there is a clear hump. Unfortunately the data are quite sparse and with the probable period alternations it's difficult to present a well defined phase plot in the later Figure 6b. About half of Jones' later measures are covered also by ASAS3 which confirms the existence of the rising branch hump during some cycles.

As mentioned in other areas colour measures through a single cycle will reveal much about the star. Even one measure at maximum and minimum is useful. It would indicate whether the Tycho B-V colour is real. If anyone has a U filter - whilst it takes time - KK should have a measurable signal. B and V are essential to give a good indication of temperature changes. R and/or I filters have some value normally but little when the idea is to detect a hotter star.

What role do these ideas play in hump stars?

TSP is based largely on the shape and periodicity of light curves in monochrome. In these stars it is trying to explain humps as interactions of periods without considering some other physical aspects of Miras and other LPVs. A Cepheid star with a period of less than 20-30 days is a very regular pulsator. Its larger mass and smaller radius is quite different from a Mira star which has a mass, at most two or three times the Sun, but an extremely large radius with surface gravity not much greater than the internal radiation pressure. As well, the radius changes from smallest near maximum brightness to much larger near minimum. Thus we have opportunities for mass ejection which we see as emission lines in the U and R filters and cooler but strong radiation from dust clouds in the I filter. The outer convective layers also affect the shock waves which cause the pulsations.

Little attempt has been made to link these ideas together by researchers obtaining filtered measures of these stars. There seem to be several questions arising from the visual measures: what causes the humps; why are they largely confined to the rising branch when the surface layers are contracting; why do they not occur in every cycle?

Amateurs are now using filters much more frequently but to date there is little colour photometry from those in the northern hemisphere. It is much stronger in this field in the south. To a large extent it's a long term project but most variable star astronomy is of this nature. Even one night a month would provide useful data. So if any of our readers would like some variety why not try this - beginning with KK Carinae and perhaps the DM Miras.

Reading the clues in light curves of eclipsing binaries

Part III – The strange case of V477 Lyr

In Parts I and II of this series (this Newsletter 2016-3 & 4) I discussed the variety of information you could derive from just looking at the light curve of an eclipsing binary. Some information you can derive in this way is recognising if an eclipse is total, obtaining the relative sizes of the stars from total eclipses, recognising if the stars are relatively close to each other, the tidal distortion of very close pairs, stellar limb darkening; and, if total, using depths of the two eclipses to derive relative brightnesses and luminosities of the two stars, and hence their relative radii.

For this instalment I said I'd discuss colours and temperatures, but I decided first to apply what we've learned to the curious case of V477 Lyr, and apply our non-mathematical, non-computational clear-thinking approach to try to unravel it.

The volcano curve

We have already discussed the light curve of AZ Cam (Figure 1), and seen that the hump in the middle of the uneclipsed portions of the light curve indicates tidal distortion in a very close pair. (This and Figure 2 are from CALEB, *the Catalog and Atlas of Eclipsing Binaries* (Bradstreet 2004).)

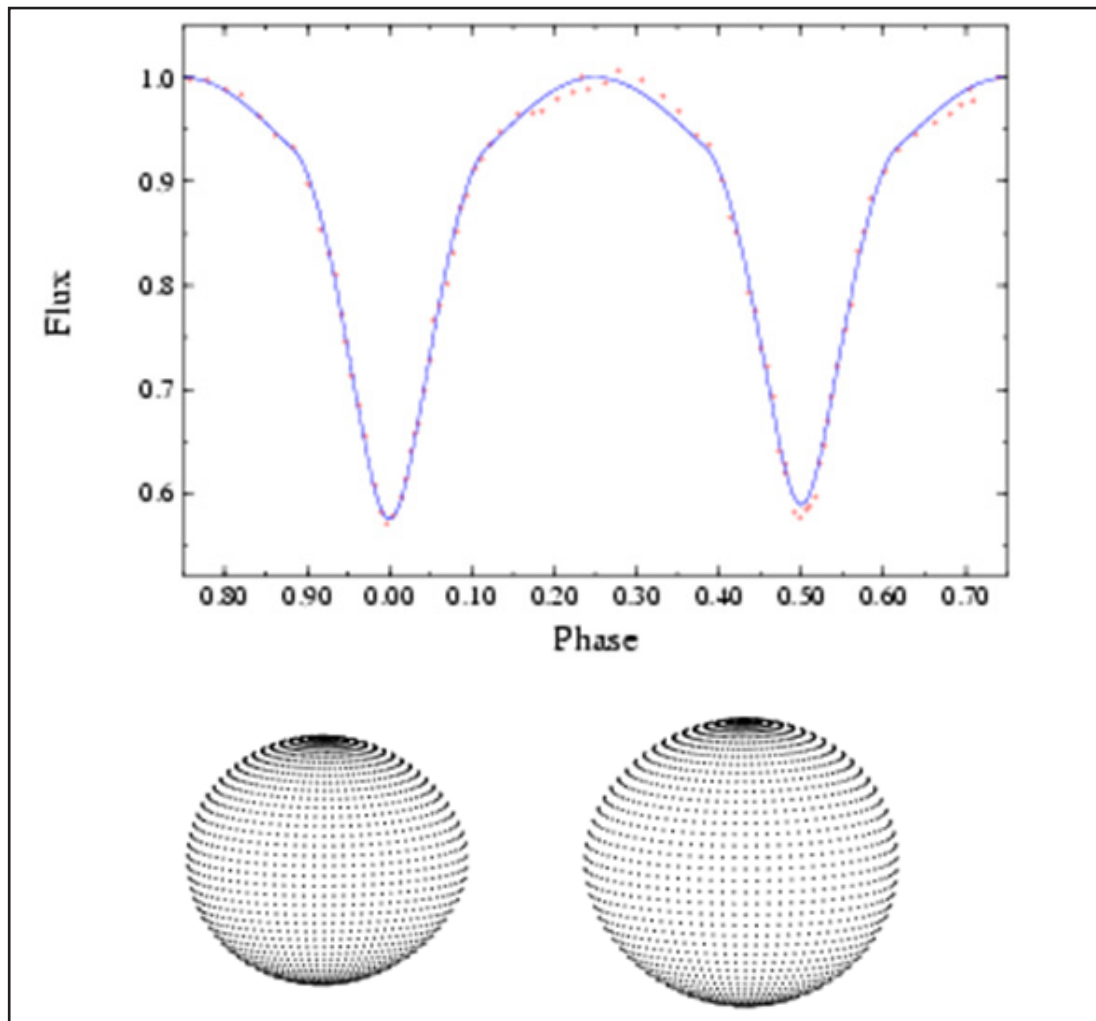


Figure 1. *AZ Cam, a close binary exhibiting tidal distortion. (From CALEB)*

But what are we to make of the out-of-eclipse shape of V477 Lyr (Figure 2)? The steep increase in bright-

ness between the primary and secondary eclipse increases the flux (luminosity, total light) of the system by about 40%.

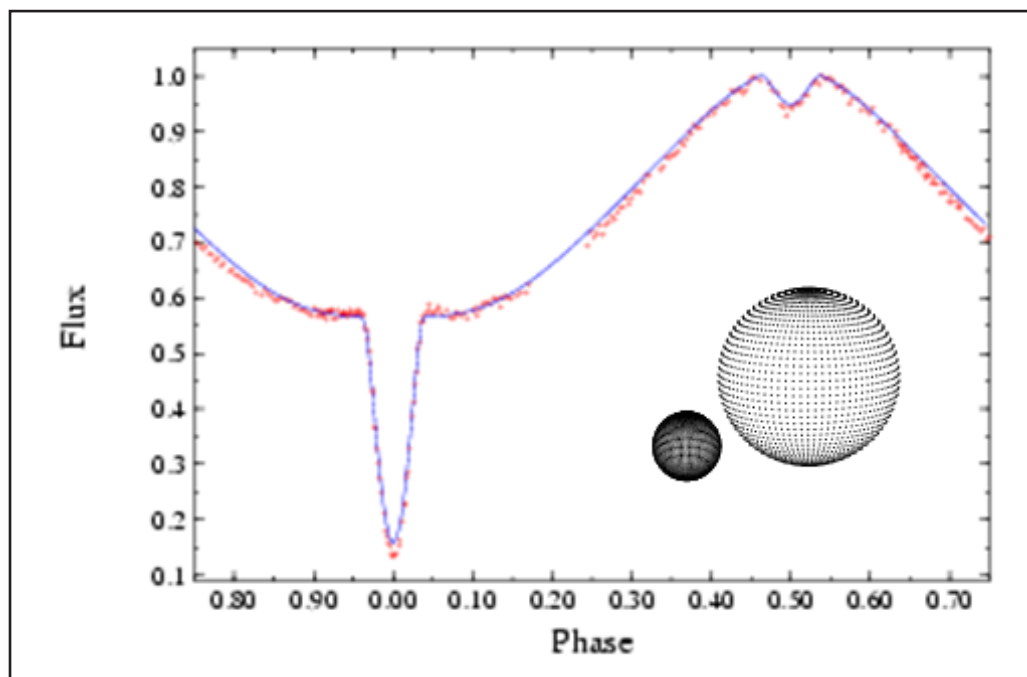


Figure 2. *V477 Lyr, V-band light curve.*

So, as we approach secondary eclipse, why does the flux of the system increase so much? Logically, either the backside of the primary is much darker than the rest of it (for which there is no plausible explanation), or the side of the secondary facing the primary is much brighter. That must be the answer, but why? The obvious, and correct, answer is it is being heated by a much hotter primary. Hotter so brighter than the rest of the star. This is misleadingly known as the *reflection effect*.

The reflection effect

How much hotter is the primary though? That is going to be impossible to measure by our deductive techniques. Where eclipses are total, the depth of the primary eclipse can be used to derive the relative luminosity (total flux) of each star by very simple arithmetic — as we saw in the previous instalment.

But here, we do not have total eclipses (why not?), and worse, the secondary is far from uniformly bright. All we can say is that the primary must be *very much* hotter than the secondary to heat its facing side. At the shoulders of the primary eclipse, we see the backside of the secondary. But from there to the shoulders of the secondary eclipse the flux nearly doubles, which must be entirely due to the very much brighter facing side of the secondary. That also invalidates our technique of estimating relative brightnesses (flux per unit projected area) of the two stars by measuring relative eclipse depths, since at one eclipse the secondary appears much darker than at the other.

At the shoulders of the primary eclipse, flux measures about 0.55, dropping to 0.15 at minimum. If that were a total eclipse at the bottom we would see only the secondary, providing a flux of 0.15. The lost flux from the primary is $0.55 - 0.15 = 0.40$, 2.7 times as luminous as the secondary.

But then after the climb to the shoulder of the secondary eclipse, flux increases by 0.45, all due to seeing the reflection effect swing fully into view. So how luminous is the secondary now? On the shoulder of the secondary eclipse flux = 1.0. Subtract the known flux of the primary (0.40) since on the shoulders we see it fully, and we are left with a flux of 0.6! So now, the secondary star appears to have $0.6/0.4 = 1.5$ times the luminosity of the primary, and has brightened four times! (Assuming totality, which it's not.)

But this does suggest that the secondary is much bigger.

And another clue. The light curve is symmetrical about the secondary eclipse, there is no lag in peak flux. So surely the secondary is tidally locked — its rotation period equals its orbital period, like our moon.

If it were faster or slower, since the heating and cooling of the bright spot is not instantaneous it would precede or lag behind the secondary eclipse.

And you'd be right in all these deductions. The diagrams in Figure 2 are derived from a study by Polliaco & Bello (1994), including radial velocity spectroscopic data. They found the inclination of the system was $i = 80.5^\circ$, not close to totality. The smaller star is far hotter and more massive (mass ratio $q = 0.29$), as we deduced, and the system is tidally locked, as we also deduced. The stars are spherical in a circular orbit. The relevant details are in Table 1.

Star	Mass (Sun = 1)	Radius (Sun = 1)	Effective Temperature	Log luminosity (Sun = 1)
Primary	0.51	0.17	60000 ± 10000 K	2.52 ± 0.30
Secondary	0.15	0.46 (ratio 2.7:1)	6500 ± 500 K	-0.46 ± 0.14

Table 1. Some data of the two stars in V477 Lyr (from Polliaco & Bell, 1994)

On the reflection effect, the authors write “These revised solutions indicated that the substellar point on the secondary component is being heated to between 12 000K and 30 000 K for primary component temperatures of 30 000 K to 130 000 K.”

They also found the reflection effect was so strong that there may be limb *brightening* of the secondary. Note however they get a far higher luminosity ratio than our back-of-the-envelope figuring, namely ~1000 times! I find that very hard to accept, just because it is so far away from our commonsense reasoning, even after rejecting our totality assumption.

V477 Lyr is the central star of the Ring Nebula (Abell 63), so it has shed mass to form the planetary nebula, and also transferred mass from secondary to primary, and may well have had a common-envelope phase. These two stars are anything but ordinary main-sequence inhabitants, which serves to remind that if you want to deduce the luminosity of a star in a close binary pair from its colour, you can't just assume it's on the main sequence and read it off from the H-R diagram. But more of that next time, when I will look into colour and temperature.

References

- Bradstreet, D., 2004. *Catalog and Atlas of Eclipsing Binaries*. <http://caleb.eastern.edu>. Accessed 14 January 2017. (Note change in URL!)
- Polliaco, .D.L and Bell, S.A., 1994. *MNRAS* 267, 452-464.

Changes in L2 Puppis reflected in historic data – Part 2

– Aline Homes, Pauline Loader, John Homes, Stan Walker, Andrew Pearce

Abstract

205 photometric observations of L2 Puppis in V, B-V and U-B obtained at Auckland Observatory (AO) over the period JD2446051 to JD2451320 (December 1984 to May 1999) have been analysed. The light curves and the analytical results for the 1984-1984 season were discussed in part 1 of this article and indicate that the primary period remained essentially unchanged over the period of the observations, while visual and V magnitudes declined dramatically from 1995 on, but magnitudes in both B-V and U-B remained essentially the same. Analysis of the AO data is now complete as is analysis of more recent visual observations by Andrew Pearce. All analyses indicate a period that varies within a relatively narrow envelope of 130 to 150 days. Other periods may exist these are weak and some may be due to discontinuities in the data. The dimming that began in the mid 1990s has continued beyond the period of the Auckland Observatory observations and the star is no longer visible to the naked eye at any stage of its cycle. We conclude that this dimming is consistent with the formation of the dust disc detected in recent images. It is probable that L2 Puppis is a low amplitude Mira entering the planetary nebula phase.

In part 1 of this article (Homes et al., 2016) we discussed the light curves plotted from observations

made at Auckland Observatory over the seasons 1984-85 and 1993 to 1999 and presented an analysis of variation in V, B-V and U-B for the 1984-85 season. In Part 2 we look at analyses in V and B-V for the period 1993 to 1999. Because of problems experienced with the U filter (S. Walker, pers. comm.), U-B was omitted from this analysis. We also present an analysis of 52 visual observations made by Andrew Pearce between 25-11-2012 and 20-01-2015 and compare all our results with published data.

Analytical methods

Analysis was carried out using a spreadsheet (LibreOffice Calc), the V-Star program from AAVSO and the self-correlation program from John Percy's website (Percy et al., 2006). Self correlation was used to cross-check periods from Fourier analysis (V-Star) because it is usually less prone to aliasing when dealing with discontinuous data. For analytical purposes the AO data was divided into two blocks: 1993-1996 and 1997-1999.

Light curves

Light curves for 1993-9, 2012 – 2015 and recent data reported to AAVSO are given in Figure 1 a-c.

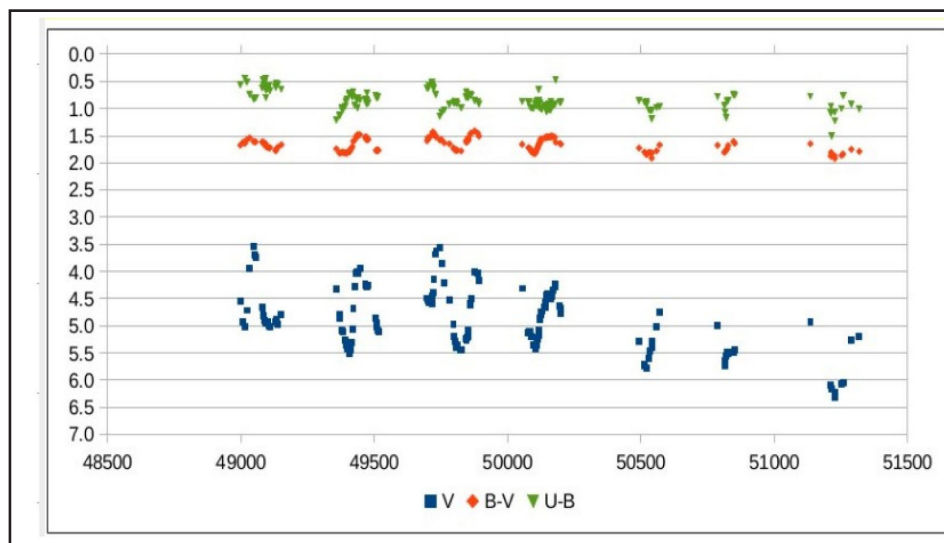


Figure 1 a. Light curves 1993-99. Note the decline in V affecting both maxima and minima over the observation period compared with little change in B-V or U-B.

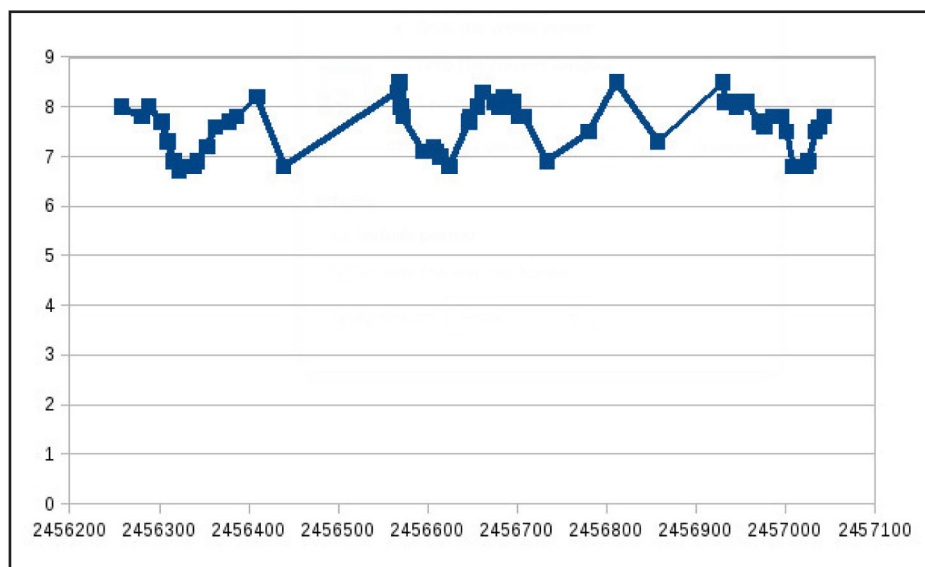


Figure 1 b. Light curve (visual) plotted from data supplied by Andrew Pearce. Currently the star is varying between approximately 6.5 and 8.5 with some maxima fainter than others.

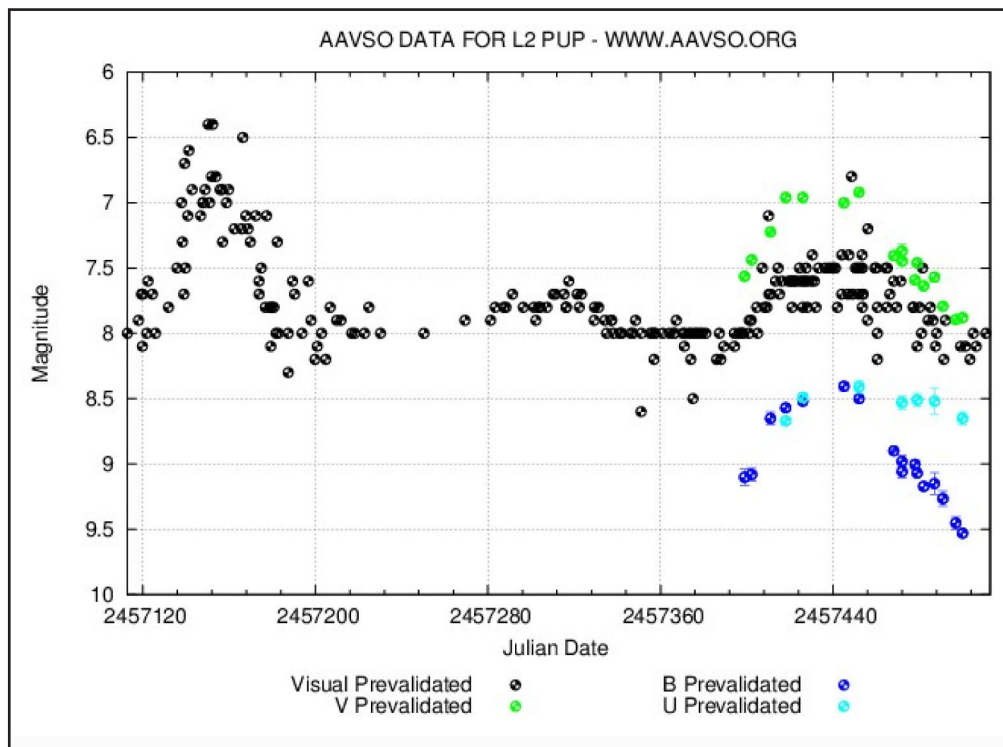


Figure 1 c. Light curve plotted from recent data submitted to AAVSO. The B and U values for the reported for the last cycle cannot be directly compared to the AO data due to different methodology. There is an exceptionally weak double-peaked maximum at about JD 57300 resulting in an extended minimum.

Over the seven observing seasons between 1993 and 1999 only a single cycle per season was observed and sometimes less, probably reflecting a fairly close match between the pulsation period of the star and the window of observability (Figure 1a). There are fewer observations per season than in 1985-86 and this may affect the accuracy of the analyses. Between 1993 and 1995 visual brightness varied from 3.94 to 5.50, but from 1996 on there was a steady decline in both maxima and minima, although sparsity of data has meant that no completely reliable figure could be obtained for maximum brightness. Throughout this period, there was little change in brightness in B-V or in U-B, although the U-B curve is markedly noisy.

The observations submitted by Andrew Pearce comprise 58 observations from 25-11-2012 to 20-01-2015, plus three more from a cycle or more earlier which we have excluded. These are visual observations only. As can be expected with visual observation, there appears to be a fair amount of noise. Visual inspection of the curve (Figure 1b) suggests the cycles are still more or less regular, both in length and amplitude. A light curve plotted from recent data reported to AAVSO also indicates little change apart from an extended minimum in the later part of 2015 when one cycle had an exceptionally weak maximum. This could represent a further ejection of dust.

Analysis

Auckland Observatory data 1993/95

There are 93 observations from 09-01-1993 to 26-06-1995. The U-B values are known to be untrustworthy, due to a faulty filter, and will not be analysed. SCS analysis has been limited to a maximum of 200 days, to keep bins narrow. A trial analysis with a larger limit suggests that this does not lose anything significant.

Visual brightness during this period varied from maxima of 3.54, 3.94 and 3.56 to minima of 5.01, 5.50 and 5.44, little altered from 1984-5. The self correlation plot of the V data for 1993 to 1995 is shown in Figure 2.

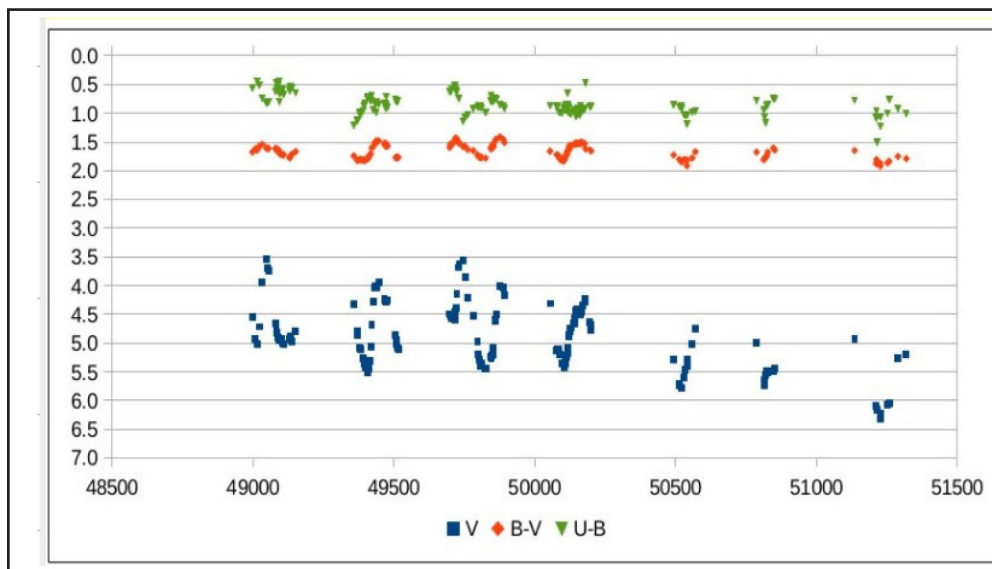


Figure 2. SC plot of AO V data for 1993-1995.

This plot gives a value for K (index of regularity) of 0.676 suggesting a moderate to high degree of regularity. The first major minimum occurs at about 140 days which is good agreement with the accepted period from the VSX database. There are also points of inflection at approximately 32 days and 96 days and another minimum at 164 days suggesting there may be multiple cycles. A self correlation plot for B-V for the same period (Figure 3) reports a cycle of about 150 days, somewhat longer than V but still within envelope. This may be an artifact due to the cycles in V and B-V being out of phase.



Figure 3. SC plot of AO B-V data for 1993-1995.

Analysis of the same data set using V-Star DC-DFT (V data) is summarised in Table 1.

Frequency	Period	Power	Harmonics
0.00713	140.344	32.706	5
0.00433	231.155	17.839	3
0.00967	103.412	11.928	2

Table 1: DFT analysis (*V*) of AO observations for 1993-1995

The most marked frequency found by the V-Star DFT analysis was at 0.00713 with a power of 32.706. This frequency equates to a period of 140.344 days. The DFT analysis also identified a number of other significant frequencies. A model using these top frequencies was created using V-Star and a phase plot of the data with the model is shown in Figure 4.

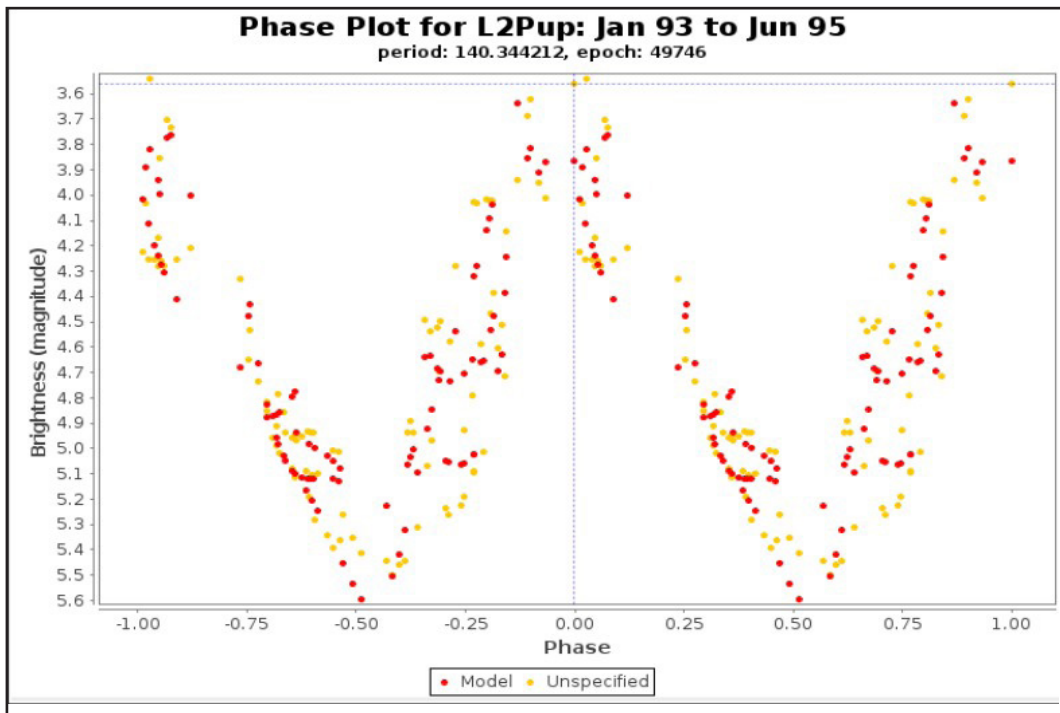


Figure 4. Phase diagram for AO *V* data for 1993-1995.

Auckland Observatory data 1995/99.

There are 69 observations from 02-12-1995 to 21-05-1999, with some substantial gaps, of a cycle or longer duration. An inspection of the light curves suggests that the observations from 02-12-1995 to 1996 should be analysed along with the 1993/95 observations rather than here. This is to be followed up. The relative sparseness of the data has made analysis difficult.

During the observing period December 1995 to April 1996 the *V* brightness varied between 4.230 and 5.429. In the subsequent seasons the minimum brightness was noticeably dimmer at 5.8 (1997), 5.7 (1998) and 6.3 (1999). The observations for these years are insufficient to identify any maxima for the brightness. Self correlation analysis of the *V* data for December 1995 to May 1999 returns a value of 0.621 for *K* indicating a moderate degree of regularity, and a primary period of about 140 days. Points of inflection at approximately 92 days and 116 days indicate possible secondary periods similar to those returned for 1993-1995. However, there are few points for any of these periods so the results should be treated with caution. In B-V, SCS can find only one point to support a cycle of 144 days, which is not adequate. Shorter cycles are not well supported.

Analysis using V-Star DC-DFT reports multiple cycles. A period of 144.60 days is strong, and so is three times that at 433.80 days. There are also strong periods of 234.97 days, 296.81 days, 1879.80 days, and 704.92 days. In B-V, Vstar reports multiple cycles. Periods of 144.60 and 433.80 are strong. The observations taken from 1996 to 1999 are noticeably fewer than for the previous seasons and no season covers a full cycle. The numerous periods obtained could be artifacts of incomplete data. To obtain more reliable results for this period it will be necessary to obtain a fuller data set.

Andrew Pearce data.

There are 58 observations from 25-11-2012 to 20-01-2015, plus three more from a cycle or more earlier which we have excluded. These are visual observations only. As can be expected with visual observations there is a certain amount of noise. Vstar DFT reports a cycle of 136.55 days. There is another weaker cycle of 98.62 days. Other periods found by DFT are weak, and likely to be artifacts.

On the other hand, SCS reports a cycle of about 119 days, and a second weaker one of about 140 days. Looking at the graphed output, it appears that SCS is much more strongly affected by the noise than Vstar.

Discussion

Putting all the results together, analysis suggests a primary period of around 140 days but varying from cycle to cycle within an envelope of 130 to 150 days. This has remained unchanged from the 1980s until the present and also accords with the analysis of several decades of data by Bedding et al. (2005) who also found a stable and remarkably regular pattern of variation somewhat at odds with the published classification of SRb. Variation in V amplitude, particularly in the brightness of maxima are much more marked, but this is not particularly unusual for red giants since the bulk of the energy is emitted in near IR. As the star cools it becomes fainter at visual wavelengths. The situation is compounded by the formation of TiO which absorbs preferentially in visible spectrum, especially the V bands (Percy 2007).

A major dimming of L2 Puppis began around 1995 to 1996 according to the AO data although other sources place this earlier (eg. Bedding et al. 2002). There has been no recovery in the intervening years. Light curves plotted from the AO observations show the dimming to have been more or less entirely in V and has affected both maxima and minima to an equal extent consistent with dust ejection. This accords with professional observations (Bedding et al. 2002; 2005). The emission must however have been on a far larger scale than previous ejection events and other factors might also be involved.

Recent images obtained using the SPHERE/ZIMPOL instrument of ESO's Very Large Telescope in Chile have revealed the presence of a dense dust disc around L2 Pup partially obscuring the star (Kervella et al. 2015). This disc is nearly edge-on from our viewpoint. The image also shows a possible close companion, originally thought to be another, slightly less evolved red giant. The dust disc and companion appear to be collimating mass loss into a bipolar flow that could be the precursor of a "butterfly"-type planetary nebula.

Follow-up work using the Atacama Large Millimeter/submillimeter array (ALMA) has clarified some features of the system (Kervella et al. 2016). The mass of the primary is now reasonably well established as 0.66 solar which has allowed an estimate of the mass of the companion. This is smaller than originally estimated from the SPHERE images (Kervella et al., 2015) and L2 Pup B is now thought to be a large planet or small brown dwarf about 12 Jupiter masses, orbiting at a distance of 2 AU and with an orbital period of 5 years (Kervella et al. 2016). The geometry of the system suggests that this could be an eclipsing binary albeit with a very small secondary. None of the data sets we have analysed to date covers a long enough period to pick up a cycle of nearly 2000 days.

L2 Pup A is estimated to be about 10 Ga old and to have had an original mass of approximately the same as the Sun. It is clear both from the present estimated mass of the star and the quantity of dust surrounding it, that a considerable amount of mass loss has already taken place. This would argue against its classification as a semi-regular, and it may well be best regarded as a low-amplitude Mira possibly in the initial stages of planetary nebula formation. Further observations are called for including instrumental observations aimed at picking up transits.

References

- Bedding, T.R. et al., 2002. MNRAS 337: 79-86
- Bedding, T.R. et al., 2005. MNRAS 361: 1375-1381
- Homes, A.M., et al. 2016. VSS Newsletter
- Kervella, P., et al., 2015. arXiv:1151.0444v1 [astroph.SR]
- Kervella, P., et al., 2016. A & A 596: arXiv:1611.0631v1 [astroph-SR]
- Percy, J.R., 2007. Understanding Variable Stars. First paperback edition 2011. C.U.P.
- Percy, J.R. et al., 2006. Pub. Ast. Soc. Pac. 118:1390-1395

A remote observatory in Chile - *Phil Evans*

phil@astrofizz.com

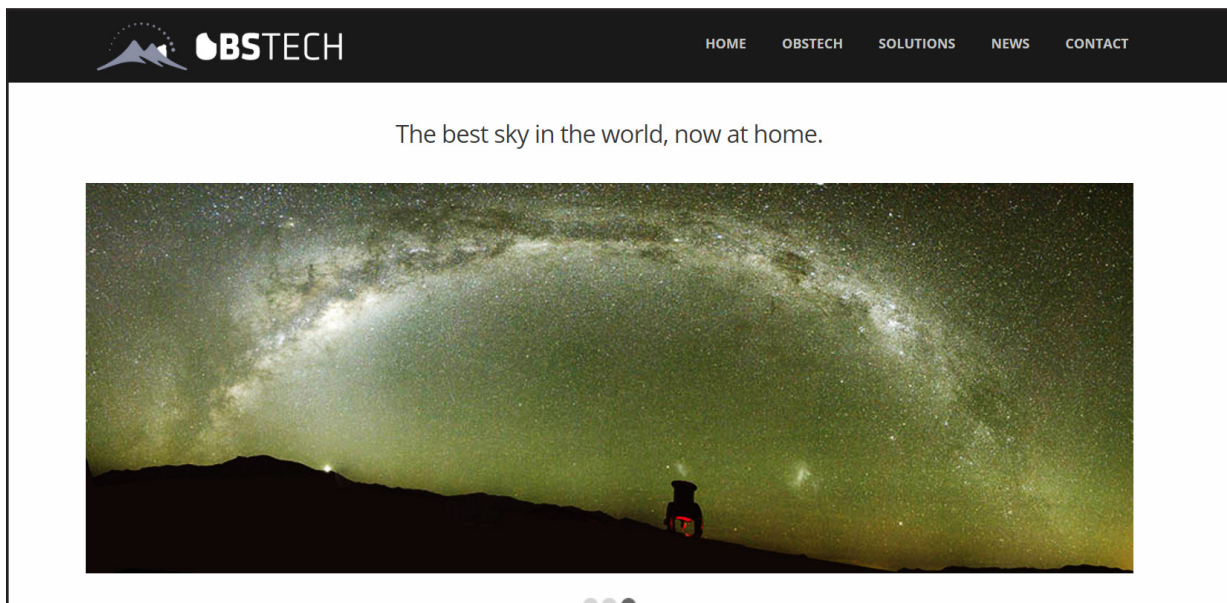
Rarotonga is a lovely place and great for tourists. We often have clear hot weather during the day with warm nights. But for an astronomer those warm nights come at a cost as it means there's cloud about. Over the last 15 years I have seen the number of fully clear nights drop from around 40-50 a year to now less than 20 as a result of changing weather patterns. So when I retired from running the daily newspaper in 2008 I had big plans to have an observatory in Chile. Within two weeks of leaving my job I was in northern Chile scouting out a place to build.

I'd read about Alain Maury, a former photographer for the ESA, who had some land outside of San Pedro de Atacama and wanted to start a telescope farm. We met and discussed the idea. The location seemed almost perfect – 2400m above sea level, 300+ clear nights a year with a competent technician (Alain) living on site – but then came the financial crash of 2008 and reluctantly I had to put my plans on hold.

Then in 2012, when my finances were back in order and the Kiwi dollar once again topped 80c to the mighty USD I began to plan again. Google Earth now showed that Alain had almost a dozen individual domes on his land so I contacted him again. But now he said he did not want any more individual domes, instead he was planning to build a large roll-off to house six telescopes. There was one space left in his proposed shed which I could have.

Not having to pay for a dome was a bonus so I began to look seriously at equipment. In the meantime I kept up my correspondence with Alain hoping to hear that he had begun to build, but all I ever got was "soon". Eighteen months later my patience had run out and Alain was still saying he'll start to build soon so I began to look for another option.

I quickly found ObsTech on the web, a company owned by several professional astronomers at the Pontifical Catholic University of Chile. I contacted them and asked if they could offer me anything.



ObsTech web site www.obstech.net

Yes, they replied, we are going to build a large roll-off shed to house six telescopes on mountain top site called El Sauce and there's room for yours. We will be starting soon. I didn't know whether to laugh or cry but decided to stick with them as they seemed to be more likely to get started than Alain.

By this time I had already settled on the equipment. Following the conventional wisdom I decided that the mount would be the biggest item in my budget and, having learnt to hate meridian flips, it had to be a fork mount. That cut the choice down severely but the Mathis Instruments MI500F stood out. I already owned an MI250 GEM (made by Mountain Instruments) so I knew the quality would be good. Long ago I'd had swing-through problems with a Meade LX200 with a fork mount so I opted to have the longer 750

arms fitted to the MI500 – this now became MI500/750F. As the system was to be operated remotely I chose to have high resolution Renishaw encoders fitted along with a homing sensor.

Most RC scopes were beyond my budget (except the new Chinese ones then coming on the market) so I opted for a Planewave CDK14, SiTech controller, their IRF90 rotating focuser and electronic focusing kit.

For the CCD, I have a soft spot for SBIG products simply because they have a wonderful accessory they call an adaptive optics unit, their AO-8. It's not what the big boys call an AO and it should probably be called active optics rather than adaptive but it works really well. With my existing 25cm LX200 on the MI250 it would hold a star on the same pixel all night long (well, until the meridian flip). It requires a dual CCD camera or SBIG's integrated filter wheel and guider.

I wanted a camera with a high QE in the red end as I had been mostly doing exoplanet observing and it had to be one that either had big pixels (deep wells) or could be binned to produce big pixels. It also had to be non anti-blooming, have Ethernet capability, fast download time and a hefty cooling delta. The best ones in the SBIG range were the STT3200 and the STT1603. By now the budget was looking a lot thinner so I opted for the STT-1603 camera and FW8G-STT filter wheel with integrated guider. I planned on using my existing AO-8 with these. The STT-1603 had a KAF-1603 chip with 9 micron pixels which could be binned 2x2 to produce an image of 768 x 512 pixels. Unbinned the well depth was 100,000 electrons. Binning 2 x 2 quadrupled that.

SBIG's newest FW8G-STT filter wheel has eight slots and boasts a repositioning accuracy of a few microns. For filters I bought a set of 36mm unmounted UBVRI from High Point Scientific. They are made by Optolong, a Chinese company and seemed a reasonable price. No mention of them being parfocal but that is not a problem for me. The filter wheel assembly also housed a 648 x 486 guide CCD (KAI-0340) which hooks up to the AO-8. The computer was a Shuttle DS61 V1.1. Remarkably it had two native RS232 COM ports, 2 USB 3 ports and 2 Gigabit LAN ports. I added a 500GB SSD, 8 GB of RAM with a low-power Intel i5 CPU.

Planewave offered to completely assemble the system, provide all cables and spacers, set up the software on the tiny computer I sent them and test it (for a price), so I let them order the mount and camera. All I had to do was wait six months for the mount to be made. The CCD was ordered late but by then Maxim (new owners of SBIG) had made the STT-1603 a special order so we had to wait a couple more months for that.

By July 2015 Planewave announced that all was ready and tested so I had it shipped to Santiago where ObsTech stored it in the university astronomy department free of charge. The freight cost and Chile's 19% VAT ate up rather more of my budget than I'd planned.



Getting to El Sauce - from La Serena to Vicuña is highway but from then on the road is unsealed mountain road.

In the meantime Obstech were planning their roll-off. The ground was prepared and building had begun. with a finishing date of October and scope installation in November. That soon slid to finishing in November with installation in December, to be followed by finish in December with installation in January.

I booked to go to Chile in March, thinking I'd give them a few months leeway. My plan was to have the gear taken to the site and for me to install it.

Getting there is not easy. I flew to Santiago from Auckland and then on to La Serena. I hired an SUV at La Serena airport and drove the rest of the way. La Serena to Vicuña was excellent highway but from then it was unsealed mountain road, single lane, all twists and turns, rising to almost 2000m and very dusty. Fortunately there was hardly any traffic.



It is about 50km from Vicuña to the Hacienda Los Andes where I stayed (owned by well-known astrophotographer Daniel Verschatse). From the Hacienda it is 18km on unsealed but reasonable road to the El Sauce turn off and then another 18km on the most difficult road I've ever driven on.

The courtyard at the Hacienda Los Andes

The Hacienda is a very pleasant place to stay with good food (and wine). There weren't many other guests during my stay but one of

them was a professional astronomer from Germany who just wanted to use Daniel's telescopes to build up a library of galaxy photos. Other guests were there for horse riding or just passing through.

One Englishman arrived on a very powerful BMW motor bike and I became quite concerned when I heard it roaring around the yard at 1am one night, but it wasn't him, it was an earthquake. It was noisy, the walls rattled a bit and then everything calmed down. It was repeated again the next night and in the days that followed we had minor quakes most days. The largest one I experienced was 5.2 but most were under 4.

The Obstech team arrived at the Hacienda after a couple of days and they took me to the site. What a disappointment, and how naïve I had been. When I got there just the skeleton of the shed was ready and there was no chance of it being finished during the two weeks I was to spend there.

But at least I got to see how good a site it was and I got to meet the team. The site's name – El Sauce – means the Willow.



March 2016 and there was just the skeleton the roll-off finished.



The solar panel installation at El Sauce. The dome is in the Russian sector of the site.



The base of the MI500/750F mounted on its column March 2016.

At this stage most of the solar panels were in place but the battery storage was not. When the team brought my equipment from Santiago they also brought several tons of lead-acid batteries for storage of the PV power to be used at night



A 360° panorama taken at El Sauce in March 2016

While I was there the workers built my column and we set the base of the mount into it. That was as far as I got with the installation. I was deeply disappointed but could see the potential of the site and it was comforting to know that we were in good company as we could see the Gemini South observatory to the north.



El Sauce is at 70.765 W and 30.4711 S at an altitude of just under 1600m. It is 26 km due south of Gemini South which can be seen from El Sauce, though it is a bit higher at 2700m altitude.

My little Nikon Coolpix P610 camera has a massive 60x zoom with very good image stabilisation.

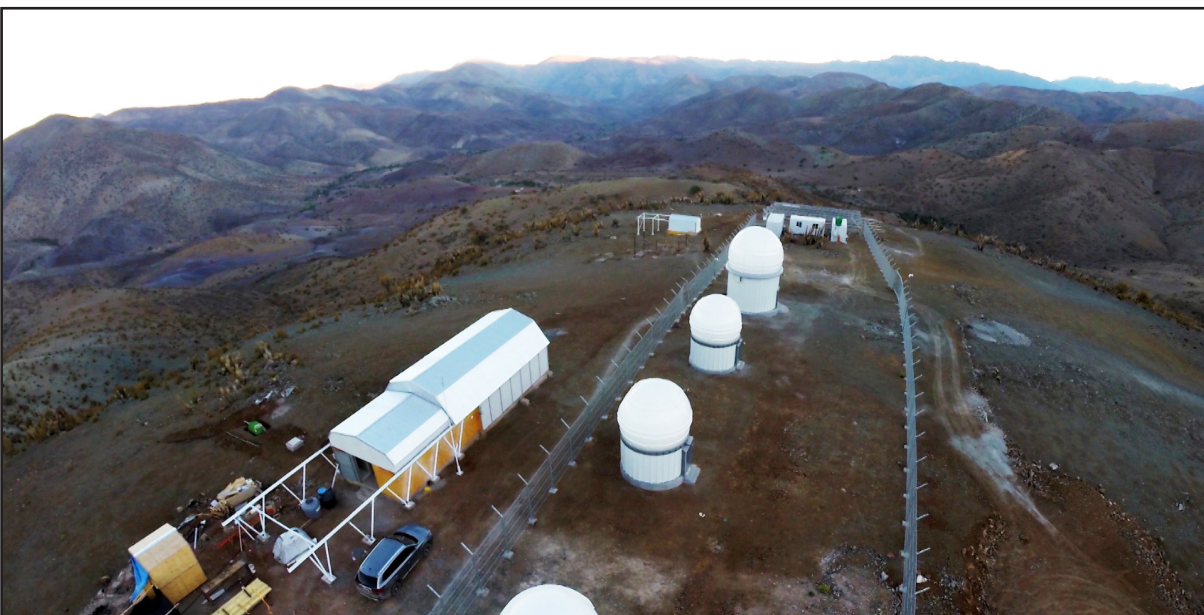
I flew back home to Rarotonga to wait.

Four months later, in July, a staff member from the Hacienda went to the site and took a photo that showed no progress.

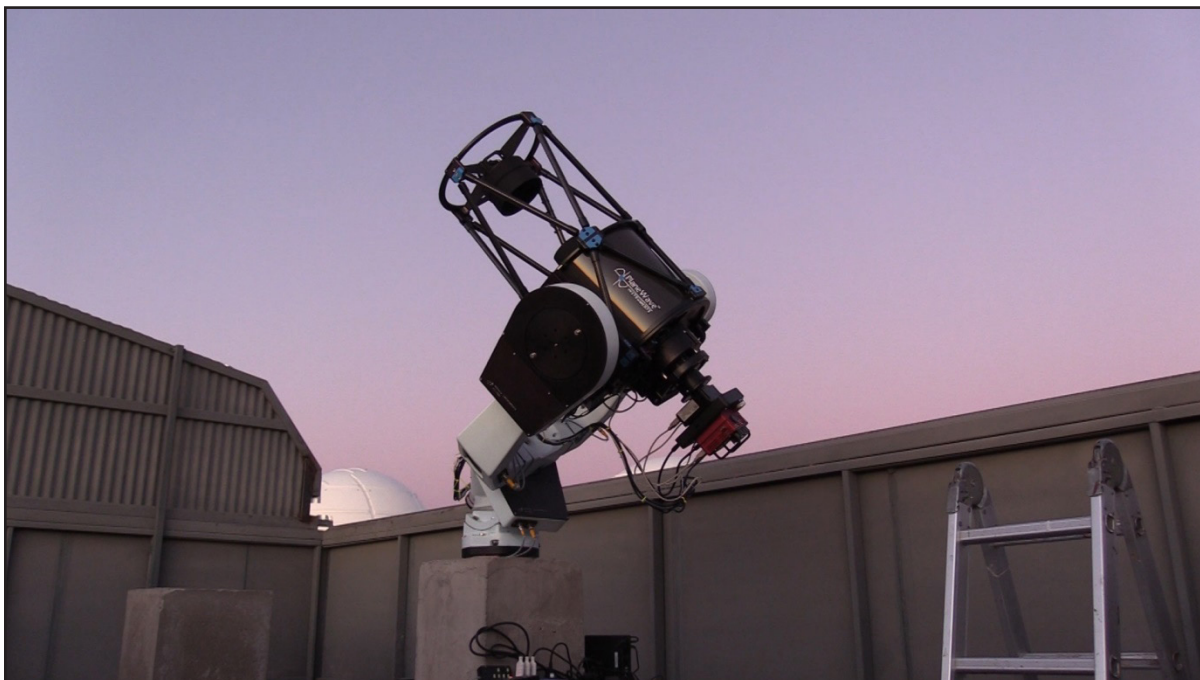
But then in September Obstech announced that all was ready and they were installing the scope for me. First light was on October 7 last year.

Wendy and I booked immediately to go back to El Sauce in November taking my AO-8 to install in the imaging train. This time we took a dashcam and a drone for aerial photography and Wendy made a video of the drive and of the observatory. You can find it here:

<https://www.youtube.com/watch?v=S4rFdr2Qmjk>



An aerial view of the El Sauce Observatory site. The fenced off section at right houses a 1m ASA scope in the far dome (cost USD 1 million) and 0.75cm Newtonians in the other three. The section is leased by a group of Russian amateurs. ObsTech is contracted to maintain the systems



The completed system – Planewave CDK14, STT-1603, FW8G-STT filter wheel and guider and AO-8.

Not only was the roll-off finished but ObsTech had added some basic sleeping quarters, a flush toilet and shower and office space.

To use the system I log in to the scope computer using Team Viewer. I have ACP but am not yet using it (I will, real soon now). I use Maxim for CCD and scope control with Planewave's ASCOM client for the SiTech controller.

With the AO-8 installed there followed an anxious month as I played with the settings in Maxim trying to get it to interface with the mount. Eventually Doug at Maxim helped me out with that. A series of power problems stemming from loose cables plagued the next month, but from the beginning of January this year I have been imaging every day bar one cloudy day and I'm thrilled with the performance of the system.

There isn't a seeing monitor yet at the observatory but the air is so clear and there are no light domes that I can regularly achieve <2 mmag precision and, on a photometric night, with a brighter star and a good comp ensemble, I have got to ± 1 mmag.

At present I have to send a command each day that programmes the roof to be opened at sunset and closed at sunrise, but eventually this will be integrated into a fully automatic weather-controlled system.

With the time difference of 7 hours between my home in Rarotonga and Chile it means I plan my night's observing during the Rarotonga morning then send the roof command after checking the weather and the skycam. At the time of writing sunset at El Sauce is just before 2pm Raro time so I do dusk flats as soon as the sky is sufficiently dark then wait until my target comes into view. I am imaging throughout the afternoon and evening in Rarotonga which means I can have a social life and get a night's sleep.

For now most of my observations have been for the KELT team, checking their candidate exoplanets. Many turn out to be spurious but it is quite thrill to see the occasional transit dip and know that you are among the first, professional or amateur, to spot that particular exoplanet. I am also continuing to observe already published exoplanet transits for a European astronomer in Slovakia and a Russian astronomer at the Pulkova Institute.

At present mine is the only scope installed in the roll-off but Obstech tell me that they have two other clients ready to install and that leaves three berths still to be filled. So if you want a remote telescope in Chile give Obstech and Planewave a call.

Publication watch

Walker, S. et al *The multiple periods of L2 Puppis*. Southern Stars, December 2016

Stan Walker, Neil Butterworth, Terry Bohlsen, Giorgio di Scala, Peter Williams

Abstract: We analyse 125 years of visual measures of the semi-regular variable star L2 Puppis together with 274 UBVR BVRI measures. The period change in 1967 is confirmed. This star has intervals of quite regular pulsations but at other times it is very irregular. The colour measures do not support the presence of a hot companion star as earlier believed, the strong ultra-violet emission appears to be associated with the presence of material in the nebulosity surrounding the star. This has almost certainly been present for most or all of the period observed. The present decline in luminosity is not unique, there have been three previous instances recorded but this is the deepest and is still in progress.

Axelsen, R.A. & Napier-Munn T. *The High Amplitude delta Scuti Star AD Canis Minoris*. JAAVSO Vol 44 No 2, 2016

Abstract: The high amplitude delta Scuti star AD Canis Minoris was studied by photoelectric photometry (PEP) during one night in February 2011 and by digital single lens reflex (DSLR) photometry during seven nights in January and February 2016. Nine light curve peaks were captured, eight of them by DSLR photometry. A review of the literature enabled us to tabulate 109 times of maximum since 1959, to which we added 9 times of maximum from our data, thus creating the largest dataset to date for this star. Assuming a linear ephemeris, the period of AD CMi was calculated to be 0.122974511 (+/- 0.000000004) d, almost identical to that quoted in earlier literature. We constructed an observed minus computed (O-C) diagram which exhibited a quasi-sinusoidal shape, and fitted a weighted model characterised by combined quadratic and trigonometric functions. The fit indicates that the shape of the O-C diagram is attributable to the effects of a slow increase in the pulsation period of AD CMi at a constant rate, and the light time effect of a binary pair, confirming the results from previous authors, and updating most of the coefficients of the equation for the fitted model. The values of all of the coefficients in the function are statistically significant. The rate of increase in the pulsation period of AD CMi was calculated from the entire dataset to be $dP/dt = 6.17 (+/- 0.75) \times 10^{-9} \text{ d yr}^{-1}$ or $dP/Pdt = 5.01 (+/- 0.61) \times 10^{-8} \text{ yr}^{-1}$.

Stubbings, R. & Simonsen, M. *UY Puppis—A New Anomalous Z Cam Type Dwarf Nova*. JAAVSO Vol 44 No 2 2016

Abstract: The defining characteristic of Z Cam stars are “standstills” in their light curves. Some Z Cams exhibit atypical behavior by going into outburst from a standstill. It has previously been suggested that UY Pup had been a Z Cam star, but it was ruled out due to its long-term light curve. However, in December 2015 UY Pup went into outburst and unexpectedly entered into a short standstill instead of returning to quiescence. Furthermore, UY Pup exhibited additional unusual behavior with two outbursts detected during its standstill. After this standstill UY Pup made a brief excursion to a quiescent state and slowly rose to a longer and well-defined standstill, where it again went into another outburst. Through comparative analysis, research, and observational data of UY Pup, it is evident and thus concluded that it is indeed a Z Cam star, which renders it one of only four known “anomalous Z Cam stars.”

About

Variable Stars South is an international association of astronomers, mainly amateur, interested in re-searching the rich and under-explored myriad of southern variable stars.

Renamed from the Variable Star Section of the Royal Astronomical Society of New Zealand, it was founded in 1927 by the late Dr Frank Bateson, OBE, and became the recognised centre for Southern Hemisphere variable star research.

VSS covers many areas and techniques of variable star research, organised into “Projects” such as Beginners’ Visual Observations and Dual-Maxima Miras. The goal of each project is to obtain scientifically useful data and results. These may be published in recognised journals, or supplied to international specialist data collection organisations.

VSS is entirely an internet based organisation, working through our website <http://www.VariableStars-South.org> and its e-group <http://groups.google.com/group/vss-members>. It also encourages members to work in with major international organisations such as the British Astronomical Association, the Center for Backyard Astrophysics and the American Association for Variable Star Observers.

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

Who’s who

Director Stan Walker, 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. There is no annual subscription but donations would be gratefully received. 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 and wish to make a donation 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 (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.

Reproduction rights

To obtain permission to reproduce any content for legitimate scientific or educational purposes please contact the director, Stan Walker, at director@variablestarssouth.org.

Citations of material in this newsletter should refer to “Newsletter of Variable Stars South, RASNZ” with year and number, and include the download URL.