

From the Director

Tom Richards

V1243 Aql and more

Tom.Richards@VariableStarsSouth.org

Most of this year has been an observing desert for me. It began in March with a brief power cut, which re-started the RA drive (I had it suspended), driving the telescope into the pier and wrecking the RA drive motor. When I got that fixed, my camera's shutter gave out. Mind you, the weather was solid cloud for all those months, so I got a perverse satisfaction from that. Lyn and I are building a new home further out of Melbourne, at Pretty Hill, Kangaroo Ground; so I decided I may as well dismantle the observatory and shift



it to Pretty Hill. That I did, with the help of family and good astronomical friends including Bernard Heathcote. The dome is now sitting in bits on the grass in front of the new observatory, which is integral with the house. I aim to get it reassembled and craned into place by Christmas.

Dismantling the old observatory. Plenty of willing helpers with the supervisor in the foreground.

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And some important parts of the new observatory.

But it will be April or May before we can move into the new house. Here's a couple of pictures of removing a dome shell, and delivering the base ring to the new house.

Maybe all those problems saved my sanity, because I don't know when I would have found time to do any observing! I haven't even found time to keep up with my VSS duties, such as the demands of building a house and developing a 20-acre property.

Mean while, here's a brief on the VSS projects I'm involved in.

The SPADES Exoplanet search project

The Search for Planets Around Detached Eclipsing Stars is now up and running. This is a joint pro-am project between the VSS and AAO in the person of Dr Simon O'Toole, Deputy Gemini Project Scientist. Many observers, amateur and professional, have shown interest in joining this project, but so far no data has come in. Given the weather over the last couple of months in a lot of Australia and New Zealand, that may not be surprising. But a good proportion of the targets are equatorial, so we hope our northern hemisphere friends will join in. You do not have to be a member of VSS to join this project (or any VSS project), but it would be nice if you were!

Our new website, www.variablestarssouth.org, carries an extensive project description including the science case, and observing and data submission requirements. Information about the currently observable program stars is also there, which should enable a CCD observer with prior photometry experience to get started straight away. More program stars will be added shortly.

Equatorial Eclipsing Binaries Project

Some of the stars in this project now have two seasons of data. **V1243 Aq1** in particular has been reasonably well observed, and we are able to refine its previously announced light elements. Observers in 2010 were David O'Driscoll, Margaret Streamer, Phil Evans, Terry Bohlson, and Yenel Ogmen.

For an earlier report, see the Newsletter for May 2010. As noted there, the system has two very deep eclipses, totalling jointly ~100%, indicating that the two stars are the same size and totally eclipse each other. Col Bembrick is working on modelling the Rc data in BinaryMaker 3. His best fit so far is, to quote his email:

$q = 0.90$, $T_1 = 6560$, $T_2 = 6220$, $R_1=R_2 = 0.20$, $i = 89$. Plus the "standard" values for reflection ,etc etc.

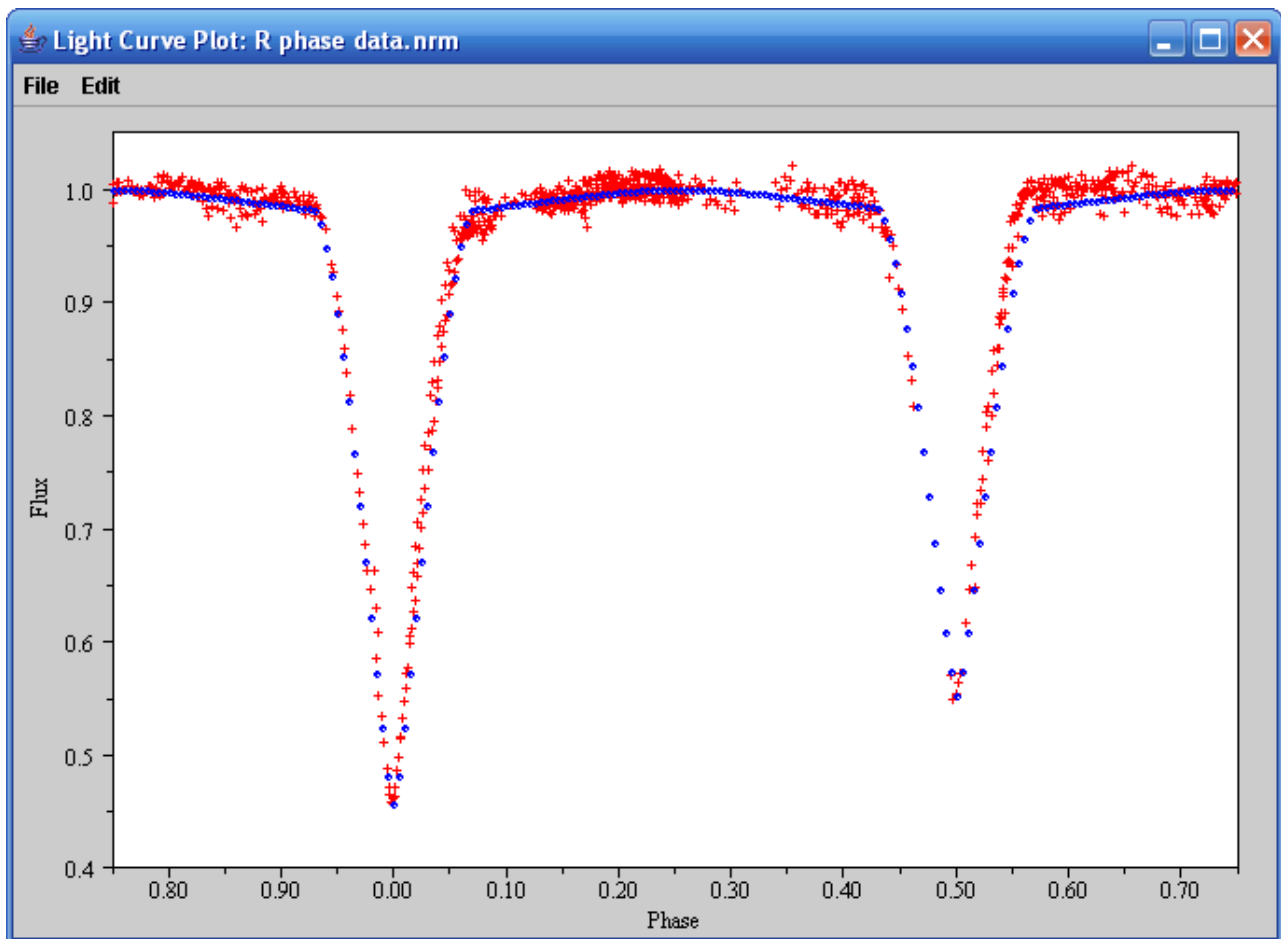
The phase diagram on the next page from BinaryMaker 3 shows all our data in the Rc bandpass in red (appropriately), and the output from Col's model in blue.

This is very exciting, and a paper is in preparation. Thanks to all the many observers, who will of course be co-authors and will receive a draft in due course. On to more colour photometry of it in 2011, so we can pin down temperatures better.

Other program stars for which we have received data this season are

V1692 Aq1 (Margaret Streamer, Neil Butterworth and Yenel Ogmen)

UV Psc (Roger Pickard and Neil Butterworth)



These are being combined with 2009 data. Initial goals for all targets are to determine light elements using data from multiple eclipses, which will be forwarded to relevant organisations such as the Krakow database. Then, where the data warrants, papers will be prepared for publication in refereed journals. We are also about to develop data access facilities for this project on our website.

More data are needed on all the stars in this project. At present UV Psc is the target of choice. For more information visit the EEB Project area of our website. More targets will be added soon.

EDITOR'S THOUGHTS

Whilst everyone is lamenting the poor weather we're beginning to suffer from drought conditions in New Zealand's Far North. I've had about 50% clear skies in November but after spending all day in the orchard irrigating and generally tidying things up it's hard to get up any enthusiasm for making PEP measures at night. Perhaps I just have to admit that the body is getting old.

But I still manage to get out and look at a few variables from time to time, even if I don't measure them. It's always good to see Mira—Cetus is one of my favourite constellations as it's easily recognisable, even if it doesn't much resemble a whale or other large sea creature.

This leads to thinking about the role of visual observers and where it will go. The historical concept of visual amateur observing is largely based upon time series photometry (TSP) which tries to follow stellar evolution by determining periodical light variations and searching primarily for changes in period. Amplitude variations are also important but harder to detect over long intervals. How successful has this been? Over the ~120 years that Mira stars have been observed there have been about 6-8 instances of period changes out of 600 or so stars—not a high return for something over 10 million separate measures, but the accompanying information has been very useful at times.

It does raise the question, however, has the visual measuring of Mira and other LPV stars run its course? About half the visual observers are now concentrating upon CVs of various types and acting as an 'early warning system' for those interested in studying outbursts electronically. But has even this reached a limit—there are few really exciting observational papers being published in this field—theoretical modelling using techniques beyond most of us seems to be the way the field is going?

However, Rod Stubbings also looks at his measures and on page 5 he writes an interesting article about WW Ceti—is it a Z Cam star or not? In pursuing some of the historical observations preparatory to putting together a paper on I Carinae based on the Bright Cepheid project I was puzzled by an epoch quoted by Parenago from 1836. However, Brian Skiff mentioned some early measures by Herschel—long before it was a recognised variable—which apparently were used by Parenago to determine an epoch.

These questions also caused Doug Welch to draw attention to the W Virginis and RV Tauri stars. There's more about these on page 6 and the O-C diagram of kappa Pavonis has been discussed in past Newsletters. Whilst the W Vir stars are more suited to CCD photometry—although some consistent visual measures of those fainter than ASAS3's limit of $V \sim 12$ might be valuable—the RV Tauri stars are an area which has not really been explored by amateur observers. The light curves are reminiscent of W UMa stars but arise in a different manner—RV Tauri stars are pulsating supergiants with two maxima per cycle.

The second half of this Newsletter comprises two articles examining software and reduction methods. I've been a bit puzzled why CCD photometry, with its inherent advantages, has not produced the level of accuracy that one expects. We were doing rather better back in the 1970s with tedious sequential photometry—the target star, the comparison, check and sky each needed to be measured separately. But Tom's comparison of various softwares on page 23 explains some of the differences and a useful discussion on the AAVSO photometry website initiated by Eric Rumbo has brought forward a variety of opinions. It seems as though the old problems of photographic observing—conversion of images to a digital format—are still not fully resolved.

Brian Warner, at one of the Photoelectric Photometry conferences, PEP 4 at Hanmer, made some important comments about errors: separating precision, which measures the internal quality of a dataset and accuracy, which concerns its quality in external terms, in this case how well any observation can be matched to a standard, in this case the UBVRcIc system.

So from page 27 onward we see a detailed discussion of the fundamentals of colour photometry and how to achieve a high standard of accuracy. We're indebted to Tom Krajci for an interesting discussion of why we need to do certain things to make it all work. The rest of the article then covers practical aspects of this type of photometry. CCD photometry rarely allows you to see what the sky is doing unless you select an area devoid of stars—does the current software allow this—I did it a few times with the old SBIG CCDOPS to find out what the sky here at Wharemaru was like? I imagine many of you observe from city sites which will be similar to Auckland in the 1970s.

I'm unsure whether this is astronomy or not but The New Zealand Herald carried an article reprinted from Telegraph Group Ltd regarding alien contacts.

"Dr Mazlan Othman was to be proposed at a Royal Society conference to fill a role as 'world leader' for dealing with alien visitors if such a contact should eventuate in the near future. Apparently this idea has been prompted by the large number of exoplanets being discovered—although our limited techniques make the discovery of earthlike planets pretty much a dream at this stage. The formal title is head of the United Nations Office for Outer Space Affairs".

Mazlan will be known to some of our members as she obtained her doctorate at Otago University and attended several RASNZ Annual Conferences and Regional IAU meetings—I remember talking to her about golf on a cruise before an IAU dinner at the Sydney Opera House—and is at present Director of the Kuala Lumpur Planetarium.

Let's hope the contact doesn't come too soon—it would likely take a lot of the fun out of VS observing!

STARS OF THE QUARTER

WW Ceti

Rod Stubbings

stubbo@sympac.com.au

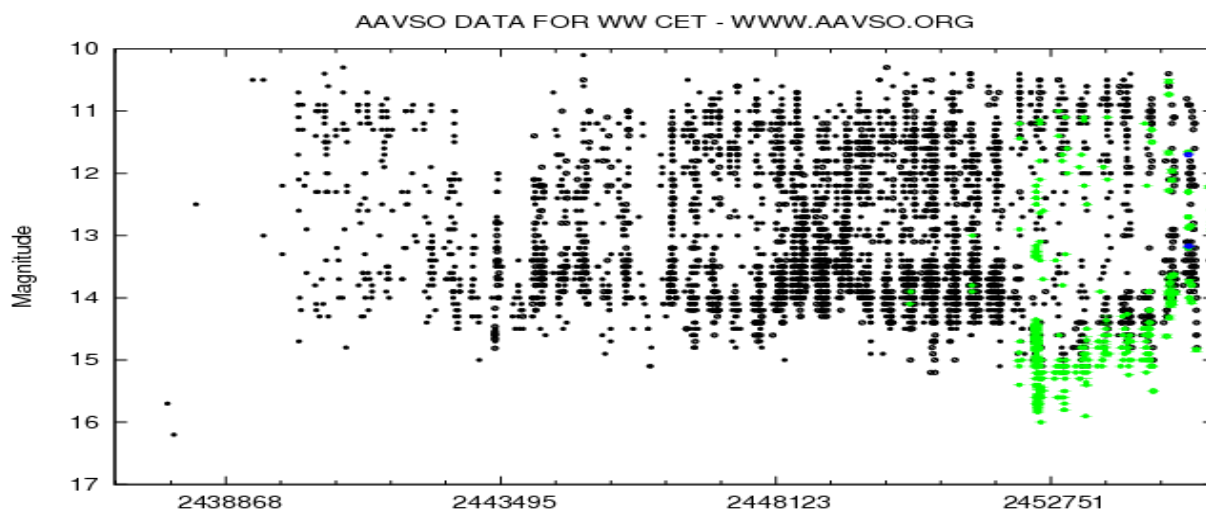
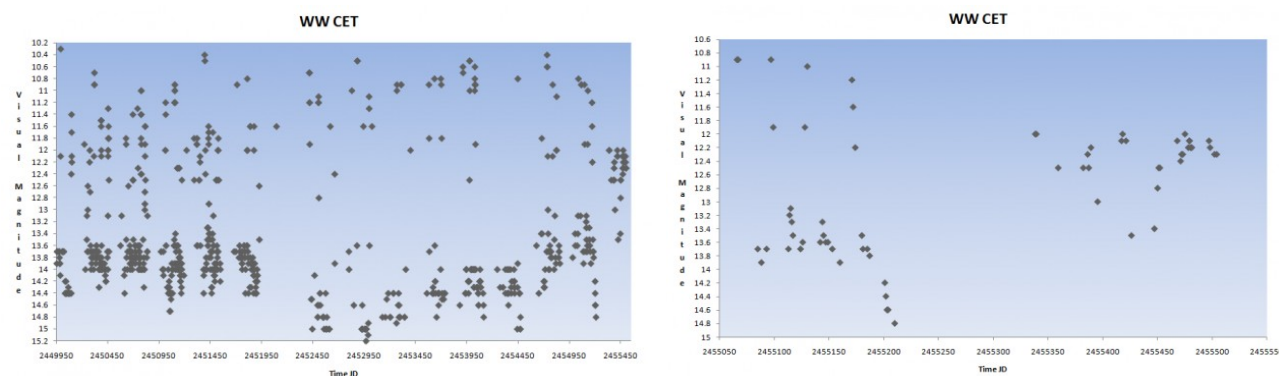
WW Ceti was first mentioned as a variable star by Luyten (1962), who already suspected its CV nature, which was later confirmed by Herbig (1962). Paczynski (1963) first published a light curve, but could not identify any periodic features. He was also the first to suggest the possibility that the system belongs to the subclass of the Z Cam stars. The system was included as a Z Cam star in the GCVS (Kukarkin et al, 1969)

Long term visual data from the Variable Star Section, Royal Astronomical Society of New Zealand can be found in Bateson & Jones (1979), Bateson & Dodson (1985), Bateson (1985) and Bateson & McIntosh (1984-1090). Conclusions gave a probable mean period of 30.70 days.

Warner (1987) and Ringwald et al. (1996) concluded the long term light curve behavior of WW Cet is not typical of the Z cam subclass.

WWCet is a system whose classification is still uncertain. Although classified as a U Gem type system, others suggest a Z Cam classification. Z Cam systems are characterized by prolonged states of intermediate brightness between quiescence and outburst called "standstills." Others propose that WW Cet forms a link between Z Cam and VY Sculptoris nova-like variables. The latter are systems that drop unpredictably into very low brightness states but spend most of their time in outburst. Without conclusive evidence of standstills, however, we tentatively classify WW Cet as a U Gem type dwarf nova.

The two light curves below show my visual observations of WW Cet from August 1995 to the current 2010 observing season. The extreme visual range of WW Cet is 10.2 to 15.0. There are both wide and narrow maxima. The faint peaks look to be oscillations which I believe to be a feature of WW Cet.



The lower illustration is of all the AAVSO measures of this star—including many from the RASNZ VSS. Not many are earlier than 1968 and there are several gaps. There is little evidence of its Z Cam classification but there are some similarities with RX And. In some cases the standstills of these stars are preceded by a period of low amplitude outbursts. Black dots are visual, green are V and blue are B of the UBVRI system.

DSLR Photometry, BSM South and DM Miras

Is anyone out there doing DSLR photometry? I receive a couple of requests each month about how to do this but there's little actual data being published. Is anyone doing this? BSM South seems close to producing valuable measures and I'm hoping that we can avail ourselves of this facility to get some solid colour photometry of the DM stars. Some will be a bit faint but in R and I they'll be easy targets. Looking at the AAVSO website I see that Arne has included U Mensae as one of the first targets—an interesting Mira with a rather unusual companion.

W Virginis Stars

In pursuing background on stars in the Bright Cepheid project I was getting some background material and had occasion to contact Doug Welch who said on AAVSO Discussion "Basically, it appears that a very significant fraction of W Vir and RV Tau stars - possibly all - are in binary systems. OGLE photometry has shown that LMC and SMC versions very frequently have eclipses or what appears to be orbital-ellipsoidal variations."

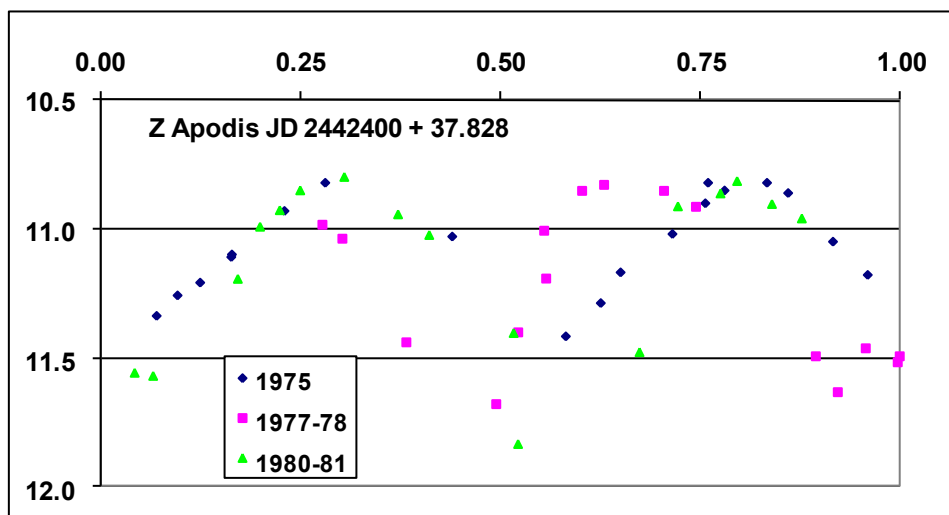
Our Bright Cepheid project targets kappa Pavonis—a very bright star of this group—which has a rather erratic period but there are many others.

RV Tauri Stars

Back in 1975 at the Auckland Observatory we noted an apparently bright dwarf nova in GCVS Edition IV—Z Apodis, a UGZ star—so we set about measuring it. However, with mean colours of B-V = 1.599, U-B = 0.864, it didn't look much like a CV. We went on to more productive tasks but tried again in 1977-78 and 1980-81.

RV Tauri stars are supergiants which show quite substantial colour changes over a cycle which itself is double wave, with rather unstable primary and secondary maxima. Spectral classes are F-G at maxima, K-M at minima. Some also show long term mean brightness changes although Z Apodis is claimed to not be in that group.

Whilst it has been well observed in the past there has been only one measure in the International Database



in the last 500 days. Now with a short period and these measures available it would be a useful small project for someone to update the data and produce an up to date review of what it's doing.

The Eclipsing Binary alpha Coma Berenices

An item on the AAVSO discussion site describes an interesting event—although it may be well in the future. "Alpha Com is a 4th magnitude visual binary discovered by F.G.W. Struve in 1827. It has a fairly short (for a visual binary) orbital period of 26 years. Its maximum separation is around 0.6" and the Earth lies almost exactly in the orbital plane. In 1948 Haffner already suspected that mutual eclipses were possible

(<http://adsabs.harvard.edu/abs/1948AN....276..145H>). His predicted times were however not very accurate, and I haven't found any attempts to observe the eclipses he predicted. Sky & Telescope (<http://adsabs.harvard.edu/abs/1989S&T....77..180M>) launched a call for observations for the 1989 eclipse, but again I don't know of any observations of the event (the predicted time was only accurate to about a month, with the eclipse predicted to last about a day).

The new orbit that has been calculated very recently by Muterspaugh et al. based on long-baseline interferometry (<http://adsabs.harvard.edu/abs/2010AJ....140.1623M>) is however much more precise and makes an eclipse on 24 January 2015 very likely. Considering the size of the orbit compared to the sizes of the stars, the chances of such an alignment are really very small, so this is a fairly unique opportunity. Due to the eccentricity, there will not be an eclipse half an orbit later. Pavel (<http://adsabs.harvard.edu/abs/1949AN....277..153P>) also notes that because of the high proper motion of alpha Com, eclipses can only take place for about 2000 years.

Although there is still plenty of time, perhaps you should already mark your calendars. The eclipse will last about two days, and may be 0.3 magnitude deep."

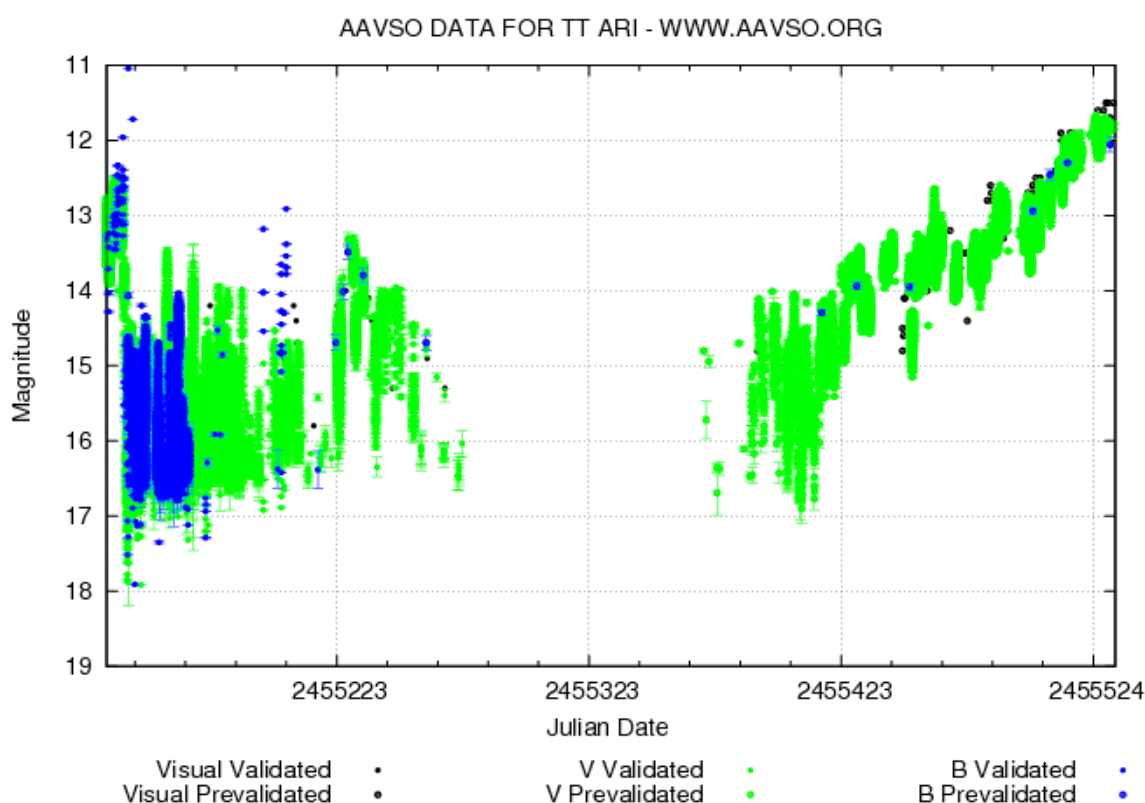
A Possible CV Star

Sebastian Otero raised an issue with a star known as GSC 04779-00669

"Is there any object at 05 38 54.44 -06 12 22.4 (J2000.0)? GSC 04779-00669 with mag. 11.75 P at Epoch 1986.132 and flagged as a non-stellar object is present in GSC. However, since Tycho-2 recorded it (TYC4779-669-1) I think it might be real: Vt mag 12.57 Bt mag 12.14 Anomalous blue colors but typical for Tycho-2 at these faint magnitudes. I couldn't find the object in any DSS image. It is also in USNO-B1.0 as USNO-B1.0 0837-0061881:B1 mag 11.94 R1 mag 12.76 R2 mag 12.78 I mag 12.99 When detected the "object" always seems to be blue...I am not experienced in the CV field so I leave this question up to you. Is there a chance for it to be a CV in outburst?"

TT Arietis Returning to Normal

After its puzzling behaviour earlier in the year Stephen Hovell reports that this CV is now slowly returning to relatively normal behaviour. A graph from the AAVSO website appears below. Aries is now prominent so take a look.



ASTRONOMY IN THE DESERT

Margaret Streamer

I recently spent nine weeks in Namibia as resident astronomer at Sossusvlei Desert Lodge, a fairly luxurious lodge in the far north of the NamibRand Private Nature Reserve. This reserve is adjacent to the Namib-Naukluft National Park and lies between a huge area of majestic, deep red sand dunes and the stark, barren mountains of the Namibian escarpment. The lodge's guests come to see this spectacular landscape rather than the wildlife and as an extra attraction the lodge includes the opportunity to see the glorious southern sky without the light pollution common to all urban areas.



View from the hill above the observatory. The Lodge buildings are at the base of the hill, looking onto a plain – currently covered in grass, now dry, from rain 2 years ago. Normally this is barren.

My work as resident astronomer was pretty minimal. The guests had early morning excursions (dawn starts) to beat the heat of the day and then late afternoon trips, often not returning until after the sun went down. Include lunch and there wasn't much of a break during the day for resting: - meaning that the guests were pretty much exhausted by the end of the day and just wanted dinner and their luxurious beds. So I usually only had to spend about an hour with people at the observatory around dinner time. With a maximum of 20 guests at any one time, my job really was a doddle. This just suited me fine and left me plenty of time to do my own work on variable stars.

The observatory was purpose built on the side of a hill behind the Lodge's main guest facilities. It's built out of the local stone and blends well with the surrounding terrain but the locality made the eastern horizon inaccessible. There is a round, uncovered observation deck where the 12" Meade LX200 GPS telescope sits on its tripod and a small storage area/office behind this. The Lodge management is conscious of light pollution and the buildings are designed to minimise light invading the observatory area. The walls around the observing deck effectively shield out any stray light from the guests' accommodation. The pathways connecting the guests' rooms with the main facilities and the observatory are all illuminated with dim red lights. There are no nearby town centres to offend with their night glow so the skies were black without the moon.



Observatory at Sossusvlei Desert Lodge. The telescope is left outside with a simple cover to protect it as rain is so rare that a roof is unnecessary. For a better perspective of the location, see the previous photo of the view from above the observatory.

For the first 5 weeks, would you believe the skies were cloudless all night, every night!! During the last four weeks, with the advent of spring and more unstable air patterns, the clear skies were punctuated by clouds, with one particularly bad spell of 5 out of 6 nights/days being total cloud. However, even the clear nights had a downside – a fairly persistent dust/smoke haze that varied in intensity depending on which way the wind was blowing. This reduced the transparency by varying degrees and made viewing deep-sky objects very frustrating. I also had difficulties convincing some guests that the reason the Milky Way was barely visible was because of the crap in the air. In their minds, no cloud equalled clear skies!

The atmosphere was dry and steady with the humidity being around 10-14% - no dew shield or heater needed and not once did the eyepieces or my own glasses fog up. My skin suffered badly and I used about 3 bottles of moisturising cream in an attempt to stop my hands and feet from cracking up completely. The night temperatures were as varied as the day time ones. The coldest I recorded at the telescope was 8°C with the highest, just a couple of days later, being 28°C. By the time I left on 10th October, day time temperatures were regularly reaching 38°C.

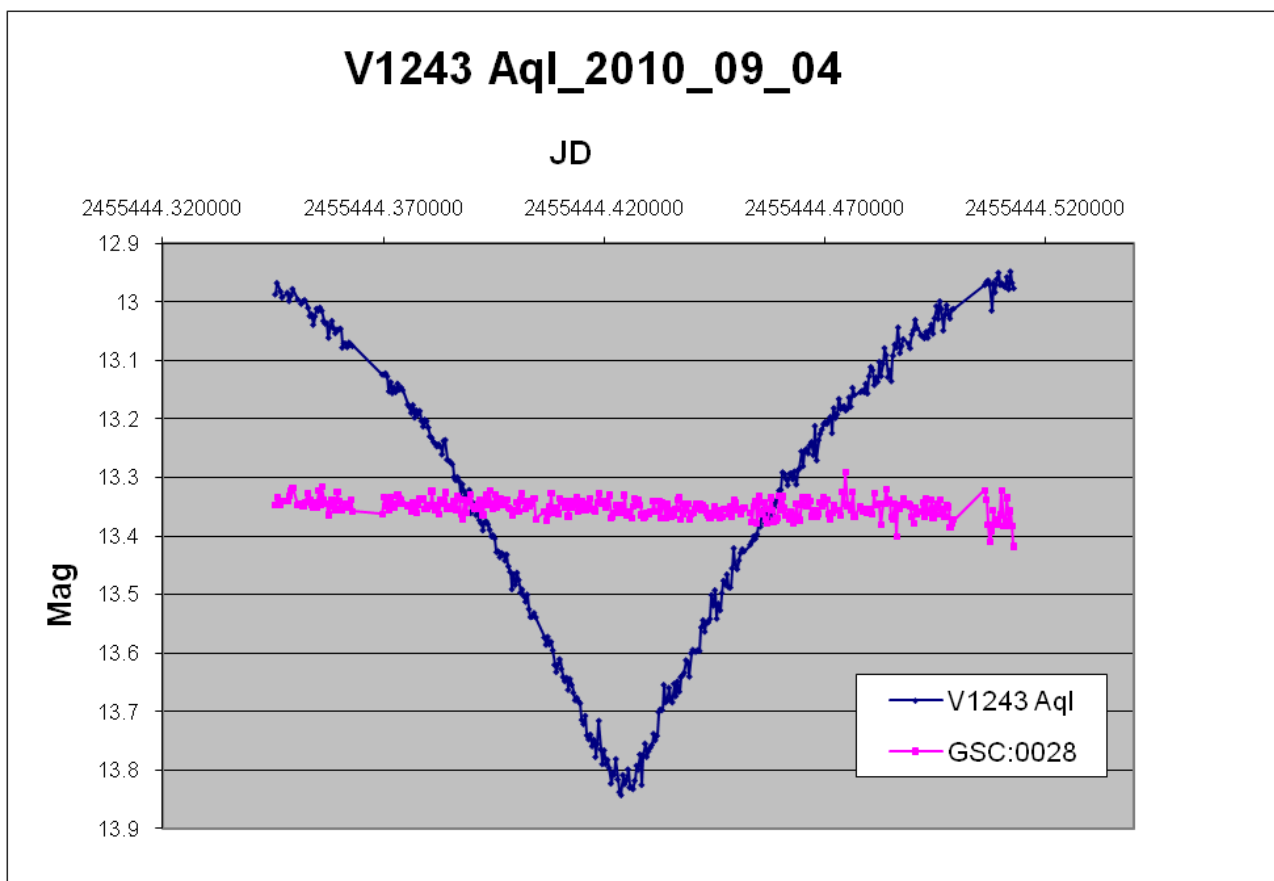
At least for my first 5 weeks, and despite the atmospheric crap, it was so nice to be able to plan an observing session and be able to do it!! The only time I had to abort a session was because the wind blew so strong that I couldn't maintain focus as the telescope was being buffeted too much.

This really was my idea of a little bit of heaven. Coupled with no household chores, shopping, washing, cooking etc what more could a girl want? Well, I was a little frustrated as a threaded fitting was missing from the LX200 and I was unable to fit my focal reducer to the telescope. I foolishly assumed the telescope would have Meade standard fittings and this was one question I never thought to ask before I went. I even resorted to trying Gaffa tape to attach my focal reducer but I soon gave up on this when it and camera came loose – thankfully, I'd had the foresight to tie them to the scope in case of this eventuality. Unable to use my focal reducer, I had a very small FOV with the camera and there was some work I had planned that couldn't be done because of this. However, I generated sufficient data with my camera to keep me occupied and the brain busy during the day.

So what did I do at the telescope after the guests retired for the night? I like to monitor variable stars both visually and with an SBIG ST-402 I have on loan from the AAVSO. The visual observations of long period variables were simply fitted in around the guests but I had to wait until the last guest retired before I could attach the camera to the telescope.

I used most of this time to monitor the eclipsing binary star system, V1243 Aquilae. This system has an orbital period of 1.4 days with a magnitude drop of about 0.8 for the primary eclipse and 0.6 for the secondary eclipse. With a starting magnitude of about 13, I was struggling to get really good results in Canberra with my 8" Meade LX90 which is not, as yet, on a wedge to give me polar alignment. Also the high humidity and passing cloud always seemed to be against me. But at Sossusvlei, I obtained several sets of beautiful data, showing very clear times of minima with one set giving an accuracy error of only 3.5 seconds. A typical observation night would last at least 4 hours with a consecutive series of 30-second images being obtained. My 8-year old lap top had no difficulty controlling the camera and the acquisition of 400 – 500 images, but the processing was painfully tedious. With only 256MB RAM (yes, I know, my laptop is a real dinosaur – I have a much more powerful desk-top computer at home) I could only process about 50 images at a time without the system having an apoplexy. But I had time on my hands during the day, so this was no real drama. All the data on this system was sent to Tom Richards at Variable Stars South.

I also did some work on long period variables using the CCD but this turned out to be very time-consuming and mega frustrating because of the small FOV. It would take me ages to be sure that I was on the target star even if I synchronised on a nearby bright star first. After my first initial attempts, I eliminated the majority of my planned targets from my list as I was unable to fit any comparison or check stars in the same image.



My best set of results for V1243 Aql showing a primary eclipse. Tom Richards commented “Your data is beautiful. Your data on Sept 4 yielded a very precise time of minimum HJD 5444.42775(4). That uncertainty comes to 3.5 seconds!”



I invited the staff to see the night sky on the rare occasion when there were no guests at the Lodge. The manager decided to turn it into a party with crazy hats as the theme. I’m the pale face in the photo.

This also shows the Meade telescope I used whilst there.

Now I’m back in Canberra and my 8” LX90 seems very small compared to the 12” at Sossusvlei and I’m now seriously contemplating buying a bigger scope. There have been only 3 or 4 clear nights in the last 3 weeks and even then the humidity has been a nuisance. But at least my current scope is very easy to focus compared to the one at Sossusvlei and of course the FOV is so much bigger, making the target so much easier to find.

My home observatory (Lexy's Palace) lacks the character of the Sossusvlei one, but the green galvanised walls blend just as well with its environment! It is only a few metres from my back door and I don't have to look out for scorpions and black spitting cobras as I walk between the two. I was always a wee bit nervous at Sossusvlei during the walk at night from the observatory to my accommodation. Luckily I only saw two scorpions and never a cobra but I did see a horned adder (also venomous) near the dining area a couple of times. Oryx and springbok would come near the rooms at night and would clatter away in the dark as I approached. The mournful cries of jackals constantly punctuated the silence after dark and I was so glad there were no big cats (lions or leopards) in the area. I always hoped the cats had read the same text book and weren't venturing out of their 'known' territory!!



'Lexy's Palace' in Canberra. The walls are galvanised sheeting with styrofoam insulation (one day I'll paint it a darker colour). The roof easily rolls back. The timber floor is suspended on concrete pavers and is discrete from the pier cemented into the ground.



Oryx, the national emblem of Namibia.

And one of the friendlier animals—I trust? Ed

A few pictures to illustrate the area.



“Big Daddy” – the climb along the ridge of this 300m sand dune is no easy task.

Moonrise over the mountains.



View from the sand dune close to the Lodge. The origin of the ‘Fairy circles’ on the plain remains a mystery.

ECIPSING BINARY MODELLING

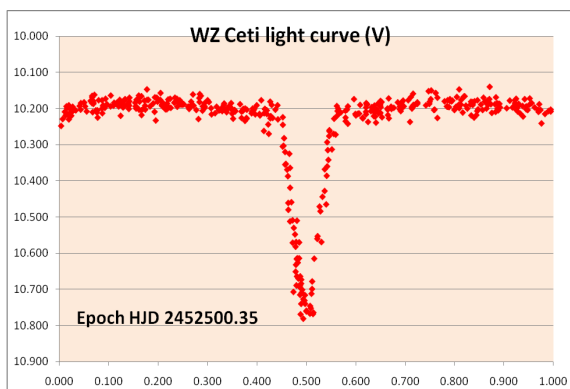
Col Bembrick

taranaob@activ8.net.au

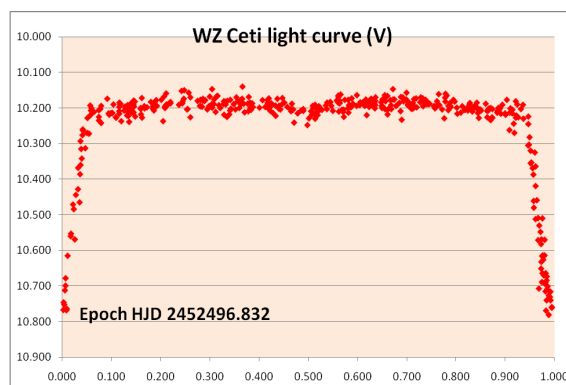
While I can't claim to be an expert on this matter, I'm trying to come to grips with the "black art" of binary modelling using David Bradstreet's software, **Binary Maker 3**. This package, while nowhere near as sophisticated (and complex) as the Wilson-Devinney industry standard, does allow one to tweak a variety of parameters and obtain a more or less realistic model for the system. The major problem is that, without radial velocity data – rarely available to amateurs – the model solution is not unique. Another problem is that for the fainter binary stars "discovered" by amateurs there is often a lack of good colour data or spectral types. It's the old story of "the more data the better" and it applies in full measure to the modelling of binary stars. That being said however, this software does allow one to get a reasonably good feel of the probable parameters of the binary system.



The starting point of the modelling process is to obtain a good estimate of the period of the binary and compile a phase/magnitude plot of the light curve. This is what amateurs with good photometry skills can now do as well as the professionals. Software such as **Peranso** manages this type of operation very elegantly. In the case of **WZ Ceti** this data comes from the **ASAS** database for 2009. The phase/magnitude plot is normally manipulated so that zero phase lies at the centre of the primary minimum of the light curve. This is the format that BM3 expects. The phase plots below were done with the old trusty Excel software, having used **Peranso** to zero in on the correct period.

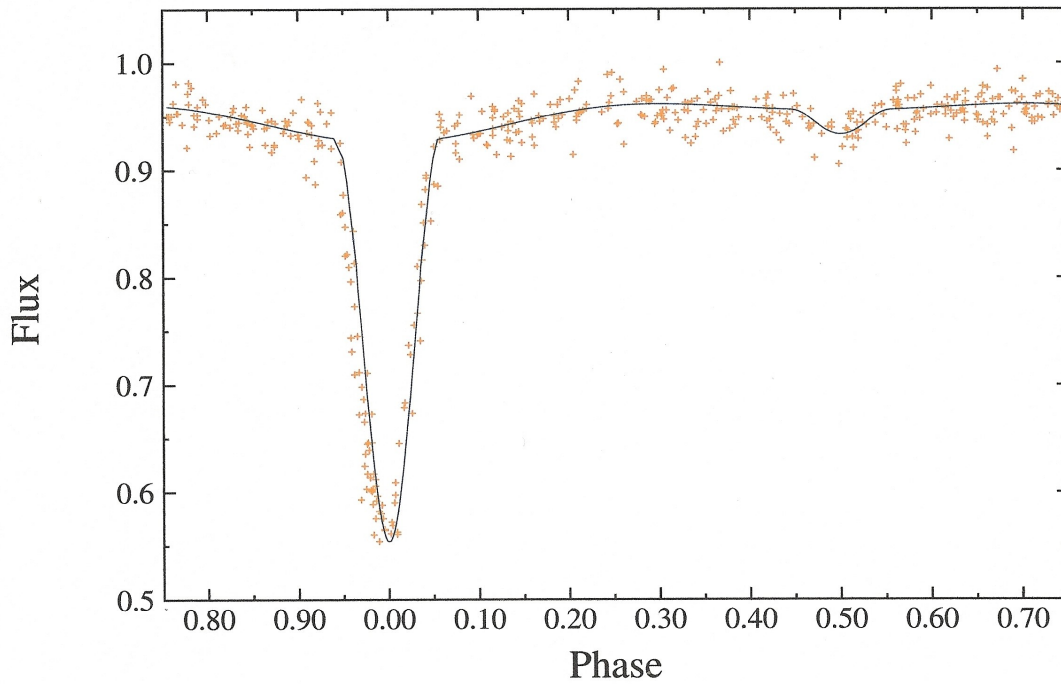


Phase/Mag plot to best display the Primary Minimum.



Phase/Mag plot with phase zero at Primary Minimum.

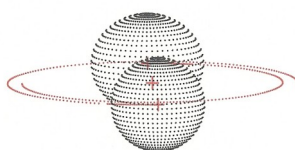
On plugging this data into BM3 it automatically transposes this light curve into a flux curve (i.e. linear scale) with the brightest magnitude normalised to a flux of 1.0. This then is the observational light curve which the model tries to match by adjusting the various parameters—see next page for output plot from BM3.



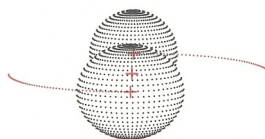
Without going into all the parameters which may be adjusted in BM3, I'll work through the main ones using **WZ Cet** as an example. This star is on the program of the VSS EEB project and is currently under observation in 2010. From the light curve we can see the primary eclipse is very deep but not total (no flat bottom) and the secondary eclipse is barely visible. This immediately tells us that the temperatures of the two stars are very different. From the published spectral type A0 we can (from published tables) infer a temperature of some 12000 K for the hotter star and to get the differences in depth of the eclipses we need a temp for the secondary of around 4000 K. Playing around with the mass ratio parameter, we get an initial model curve which fits the observed curve fairly well. This model curve can then be adjusted in terms of observing viewpoint (i.e. the inclination of the system to the observer) and further refined by adjusting other parameters such as gravity brightening, limb darkening and reflection coefficients.

The "thrill" of the modelling exercise comes when we press the "go" button in BM3. Three windows or panes come alive and the 3D representation of the system rotates in one pane as the model light curve is drawn on top of the observed light curve in the other pane. The third pane (if used) shows the theoretical radial velocity and the observed radial velocity data superimposed. The process can be halted at any time and re-started and the windows can be re-sized so as to examine the detail of the fit between the model and the observed light curve. The only "beef" I have about all this is the graphic output is in the form of post-script files only. There are several ways around this of course, but it is a bit of a pain. The other criticism of the program is that the modelling is not iterative, so one has to enter any change of parameters manually and run the model again—not really a big deal, but it does take some time and of course the program does not converge to a better solution automatically.

Phase 0.01
Primary (partial) Eclipse



Phase .49
Secondary Eclipse



Phase 0.75
Out of Eclipse



The (very preliminary) basic parameters for this model work out as:-

Mass ratio, $q = 0.9$, $T_1 = 12\,000\text{ K}$ (an A0 spectral type), $T_2 = 3900\text{ K}$, Inclination, $i = 81.5^\circ$

BSM SOUTH AT ELLINBANK

Peter Nelson

pnelson@dcsl.net.au

The AAVSO have a Bright Star Monitor set up in Arizona at Tom Krajci's telescope "farm". The aim of this observatory is to monitor the brighter stars (from about magnitude 2 - 10). The rationale behind setting up this observatory is that the brighter variable stars seem to be neglected. BSM can also do calibration work for comparison stars. To mid October, some 87,000 science frames and some 10,000 calibrations frames had been taken over 140 nights. This equates to about 620 science frames a night! Details of BSM North can be found at <http://www.aavso.org/bsm>

The AAVSO is developing quite an array of remotely controlled telescopes, and these can be viewed at <http://www.aavso.org/aavsonet>. Of particular interest is the 0.61 Optical Craftsman telescope at Mt John. Some time ago, Arne Henden (Director, AAVSO) was looking for a site for a BSM South. I expressed interest, but with the reservation that my site does not have a vast number of clear nights. Arne's principle concern, however, was to have a site where the observatory could be maintained. As I was setting up a new remote controlled observatory of my own, and having the expertise and support of Chris Stockdale and Rod Stubbings near by, it was decided that BSM South would reside at Ellinbank, Victoria, Australia.

Not Peter in the illustration to the right but Stewart who looks rather pleased with progress. When the project was first described it all sounded quite simple—see an article by Tom in the 2010 February Newsletter. But there's obviously a lot more involved than you might think. And below a close up of the BSM South itself.



It was decided to build a roll off roof observatory for BSM, and work commenced on 20th February, 2010. Construction of BSM occurred in parallel with my new observatory (a Planewave 12.5 on a AP1200 mount, housed in a Sirius 3.5m dome). The whole process was a big learning curve, but it has been most worthwhile. The telescope used for BSM is an



Another view, this time from the outside, showing the scale of the housing and the telescope

Astro-Tech 72mm f/6 refractor with field flattener. It is mounted on a Celestron CGEM mount and the camera is an SBIG ST8XME with BVRI & Clear filters. The computer is an older Athalone based machine with 1MB RAM. Software used includes The Sky V6, MaxIm DL, ACP and Scheduler. First light occurred on 10/10/10. Details of the observatory construction, and images, can be viewed at www.ellinbankobservatory.com

Construction of the observatory and setting up the telescope was one hurdle. For me, an equally large hurdle was firstly getting my local area network setup. Then, the task of allowing remote access to the observatory. ACP has a web server, and Arne was successful in connecting to this on 25th November. The final step was getting remote access control using VNC or MS Remote Desktop. This was achieved



The first image—taken on an auspicious date—10/10/10!

on 29th November. We now look forward to BSM commencing work (once the weather clears!!).

There is still work to be done. The roof has to be motorised so that it can automatically close should poor weather occur. In the meantime, I am looking at a notification system from my Boltwood cloud sensor on the main observatory. This system involves Skype, via

ACP, sending a message to my mobile phone. In this way I can go to bed!

I would like to thank the assistance of the BSM South team of Chris Stockdale and Rod Stubbings. Also, there has been a lot of hours put into the observatory construction by friend (and builder) Stewart Jones.



And here's Peter, the guy who took on the project. A slightly worried look but that was back in late July when he was probably wondering at the scale of building two observatories, not only his own but one for BSM South as well. Congratulations to Peter and his team for getting it up and running.

Arne welcomes observing requests for BSM, and some time has been made available for this. Arne's primary concern is that good science is done with the observatory. When thinking about targets, remember that the ideal range is from 2 - 8 magnitude. All images will be processed at AAVSO HQ, and be available either through public anonymous ftp access, or through the Photometrica website if the observer is an AAVSO member. The photometry from BSM is in the public domain, but Arne says he will support a proprietary period for access if the observer so requests. Observers should contact me in the first instance at pnelson@dcsi.net.au. I will liaise with Arne re adding the requests as additions to the observing program.

A NEW UG WZ CANDIDATE IN PISCES

Stephen Hovell

Stephen writes: "I am not sure if you get these. If you have a small gap you might be able to mention this star. Isn't it amazing that a star as bright as 12.1 at max has remained undetected for so long. I wonder how long they take to evolve?" Outbursts of WZ Sagittae are rare and quite lasting, although they usually do not show superhumps in the early stages. Many of our members can see this far north so try it. *Stan*

AAVSO Special Notice #225 A new UGWZ candidate in Pisces December 1, 2010. A bright transient in Pisces was discovered by K. Itagaki at an unfiltered magnitude of 12.3 on 2010 November 30.50663 UT (JD 2455531.00663; reported by H. Yamaoka in vsnet-outburst 11854). The object was confirmed at V=12.1 by A. Oksanen (Muurame, Finland) shortly afterward (vsnet-outburst 11855), and I. Miller (Swansea, Wales, UK) reported the presence of superhumps with period 0.0571 day (reported by T. Kato, vsnet-outburst 11859). As noted by Yamaoka and by R. Koff (via cba-chat), the position of the optical transient is coincident with a faint star (<19.0); Koff identifies this object as USNO B1.0 1229-0022624. As noted by T. Kato, this object shows many of the properties of the WZ Sge subclass of dwarf novae. Time-series observations of this object are encouraged to better understand its nature, and to follow any subsequent evolution of the outburst.

The superhump variations will show significant changes in morphology during the course of the outburst, and time-series observers should strike the best balance between signal-to-noise and short exposures; the period of the star was stated as 0.0571 day (82.2 minutes), and observers should try to obtain exposures much shorter than this if possible. Unfiltered observations are acceptable, but the use of a V-filter is encouraged if it does not significantly increase exposure times to reach comparable signal to noise.

The object is located at the following (J2000) coordinates: RA: 01 20 59.60 , Dec: +32 55 44.8. The field does not yet have comparison stars assigned, so observers should clearly indicate the comparison stars used for their measurements. Finder charts may be plotted for this field using VSP:

<http://www.aavso.org/vsp> Please submit all observations of this star to the AAVSO using the name "VSX J012059.6+325544". *This Special Notice was prepared by Matthew Templeton.*

THE SPM4 CATALOGUE AND ITS APPLICABILITY TO VSS WORK.

Mati Morel

mmorel7@bigpond.com

The *Yale/San Juan Southern Proper Motion SPM4 Catalog* is the culmination of a 47-year collaboration (1962-2009) between the National University of San Juan and the Yale Southern Observatory. It was finally completed in September 2009. SPM4 contains celestial coordinates, absolute proper motions, blue and visual passband photometry for 103,319,647 stars and galaxies between the south celestial pole and -20 degrees declination. The catalogue is complete to $\sim 17.5V$. For a brief summary, go to <http://www.astro.yale.edu/astrom/spm4cat/spm4.html>

SPM4 is available for ftp download from the above website as a set of bzip2 and plain ascii files plus explanatory readme file. Total file size is ~ 4.3 GBytes, compressed. Alternatively a DVD-R copy of the catalogue may be obtained upon request from terry.girard@yale.edu.

A rather more detailed description of SPM4 appeared as a poster paper, which can be read at adsabs.harvard.edu/abs/2009BAAA...52..291V

Construction of the Catalogue.

The astrometric reductions made use of an input "master" catalogue, to properly identify objects on plates and CCD images. It was built from the following external catalogues, in order :

- 1 = Hipparcos
- 2 = Tycho 2
- 3 = UCAC 2
- 4 = 2MASS psc (point sources)
- 5 = 2MASS xsc (extended sources, largely galaxies)
- 6 = LEDA (confirmed galaxies, Paturel et al 2005, A&A 430,751)
- 7 = QSO (Veron-Cetty & Veron 2006, A&A 455,773)

The use of a multi-source master catalogue such as this, for object recognition, should ensure that few, if any, stars will be overlooked. My use of the catalogue tends to confirm this.

Photometry.

SPM4 reports B and V magnitudes for each object. However, the quality of each magnitude is hard to assess, a fact acknowledged by the authors themselves. This is due to the heterogeneous nature of the compiled magnitudes. They come from:

- Measurements of photographic plates from 1962-2000.
- CCD imagery from 2000 onwards (2nd epoch survey). The necessary photographic plates were no longer being produced.

The final catalogue flags each magnitude as to its source, but it is not uncommon to find a CCD-V magnitude (2nd epoch) matched with a B mag. from 1st-epoch photo plates taken decades ago. From my experience I have found many of the B magnitudes to be rather poor - a calibration problem with the early plates? The 2nd-epoch survey is approximately 33% photographic (from 1988-1998) and 67% CCD-based (taken from 2004-2008). V mags from CCD imagery has proven to be of consistently acceptable quality. They may not be as good as the very best CCD data available today, but still good enough for visual observers. They can be used to extend VSS sequences from $\sim 13.5V$ to nearly $16.0V$ with reasonable confidence, by comparing with ASAS3 in the overlap regions. When rounded to 0.1 these mags should be no worse than mags from other sources, and likely a bit better. SPM4 is useable, and with care is being successfully employed to extend old sequences, and create new ones.

SPM4 on DVD-R.

I didn't fancy the prospect of downloading 4.3GB by ftp (would blow my monthly allowance), so I sent an

email to Terry Girard on August 25, 2010 for the DVD. This duly arrived a week later. The first thing one notices is that the compression format (bzip2) is one that is not recognized by WinZip. A bit of hunting around on the internet turns up another program, "Files Zipper" which unzips it with no drama. When unzipped one finishes up with 70 data files in plain text ASCII format. Those near the South Pole are relatively small, but those north of -60° are quite voluminous, often exceeding 300MB. The southern sky from -20° to -90° is divided into 1° strips, so the stars between -59° and -60° decl. are stored in the file called *rs59.asc*. Despite the unique filename extension it is still a text file which is easily read by a good text editor.

SPM4 is not yet online via the Vizier service of the CDS, but no doubt it's just a matter of time.

Applicability to Guide8.

Being plain text files, each SPM4 data file can be read and displayed by Guide8, providing you install an appropriate TDF (Text Definition File). Such a file has been written by John Greaves and reproduced below. Note that the TDF as written will happily read the contents of *rs59.asc*. All 300MB, covering all RAs from 0h to 24h. This is quite unnecessary, as when creating a new chart or sequence one will be working on a tiny patch of sky at any one time. I prefer to first determine the RA limits of the field, then convert the RA to degrees (eastern and western limits). Then by opening *rs59.asc* with a text editor I scroll down and select the portion of the file I require. This is then copied, pasted and a new file created, and saved under the Guide8 directory. It's usually necessary to give the file a new name, say *rs59A.asc*, and also edit the first line of the TDF ("file....."). The subset of data can now be displayed much faster.

TDF file for reading SPM4 data file.

```
file rs59.asc
title SPM4
RA H 2 10
units0 -2
de d 14 10
mag 76 5
text 110 9
photo B:70,5 V:76,5
~b 5 1 SPM4\n\n
~r 2 10 R.A.2000 %R +/- %[26,5] arcsecs\n
~r 14 10 Dec2000 %D +/- %[32,5] arcsecs\n\n
~r 2 10 RA %s deg Dec %[14,10] deg\n\n
~b 38 8 muRA %s
~r 56 6 +/- %s
~b 5 1 \n
~b 47 8 muDE %s
~r 63 6 +/- %s
~b 5 1 \n\n
~b 76 5 V %s
~b 83 0 3 CCD
~b 70 5 \nB %s
~b 82 0 3 CCD
~b124 6 \nJ %s\n
~b138 6 K %s\n

epoch 2000
type 6
sort 0
field 0.00 100.00
mag lim 174
shown 5
end
```

Postscript.

A set of 50 charts, mostly for poorly known, far southern CVs is in preparation. SPM4 data is used extensively. A PDF file of charts should be ready within weeks.

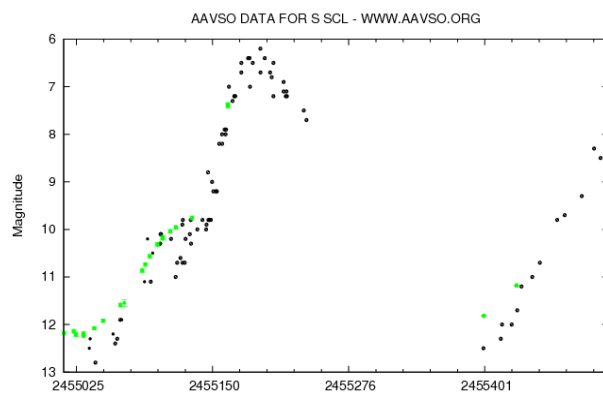
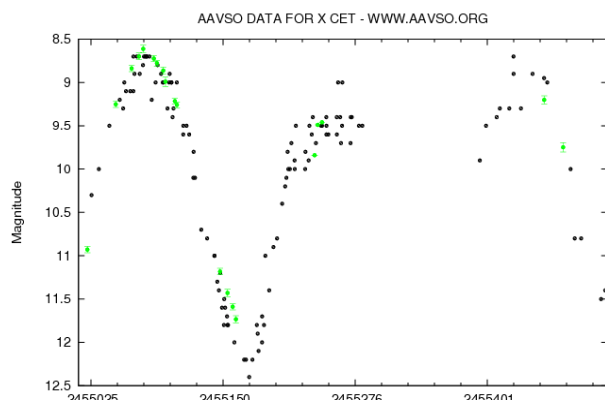
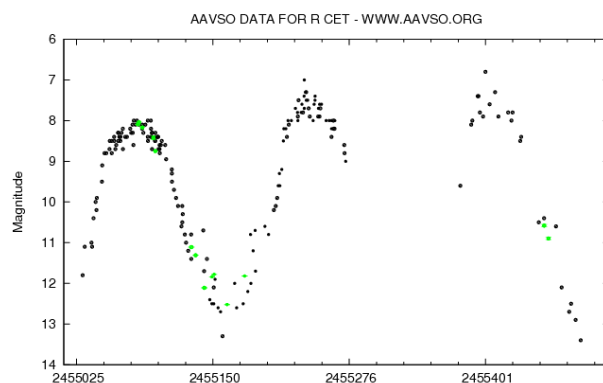
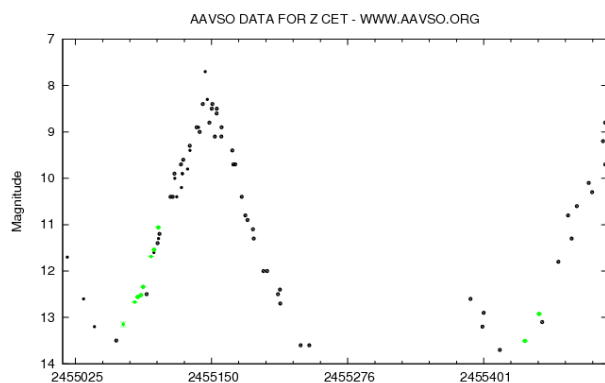
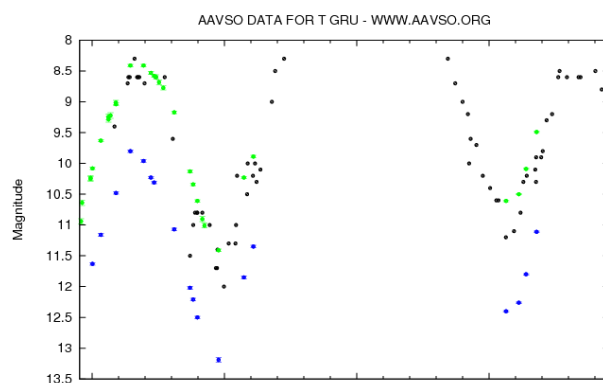
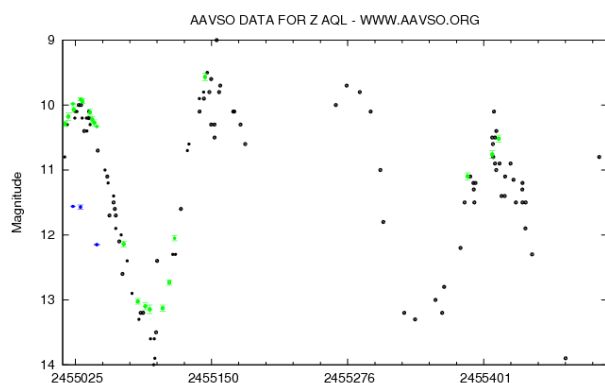
SOME SUMMER MIRA & SR TARGETS

Stan Walker

astroman@paradise.net.nz

Some of the more interesting Mira stars have periods between 100 and 200 days and these may well be different from their medium period cousins. They are not as regular and when subjected to a period analysis it often reveals two or more subsidiary, low amplitude periods. A number also belong to MK luminosity classes I and II indicating supergiant status.

From the observing viewpoint they have the advantage that brightness changes are quick—Z Aquilae can change by 0.5 magnitudes in a week and others by 0.3 in the same time! Light curves of five of these stars appear below along with one of their much slower cousins, S Scultoris with a period of 363 days.

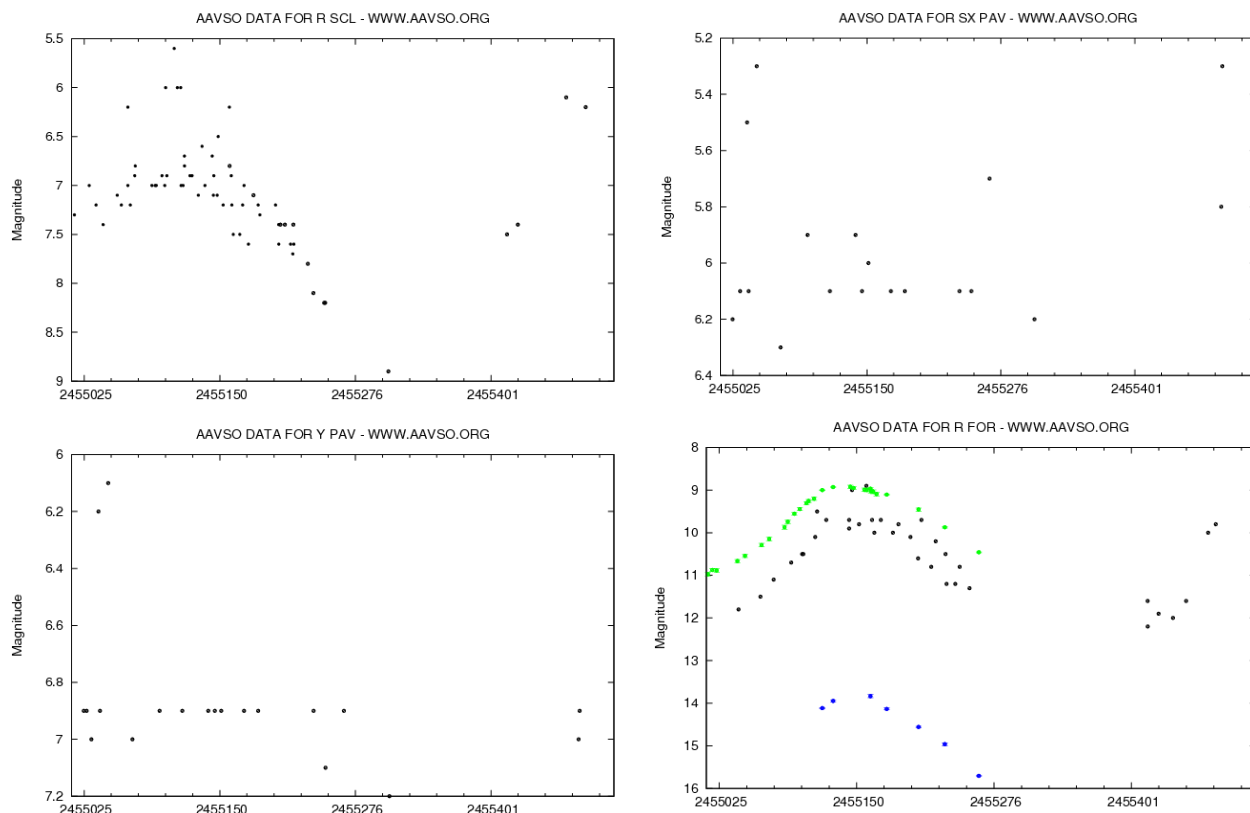


The black dots are visual measures, green are V and blue are B. There are some nice B-V colours for T Gruis indicating a substantial colour/temperature change during a cycle. S Scultoris often shows a pronounced hump on the rise and with its yearlike period will be at maximum near 1 December for a few years yet.

Mira has just passed maximum—it's always good to see it there in the sky and the brightest of the long period variables, Betelgeuse, is now visible low in the east. It's had a number of periods assigned to it but the strongest seems to be about 2071 days. With an amplitude of just over half a magnitude you need patience

to follow this. But during the flare star programmes of the 1970s it received a lot of attention. For comparisons Rigel at 01, Procyon at 04 and Aldebaran at 09 are useful, even if the first two are slightly variable.

Whilst we're looking at red stars some other targets for the summer include R Sculptoris, and SX and Y Pavonis. These are all low amplitude extremely red variables, lacking the TiO and other molecules which make the Mira light variations so large. The light curves show that R Sculptoris is reasonably well observed, although not this summer so far, but there are puzzling results in the other two. R Fornacis is a carbon Mira which also makes it quite red. The B-V colour at maximum is about 5, changing to 5.5 partway through the decline. Thanks to Neil Butterworth for these colour measures. It's near maximum at present so should be a target for the summer and autumn.



These graphs—and the ones on the previous page— are all from the AAVSO, using data from the International Database. A mix of southern and northern observers doing good work. When the amplitudes are large the visual measures easily define the shape and amplitude of the light curves but the combination of B and V measures adds an extra dimension. They're only needed for one cycle every decade or so.

The measures of the two Pavonis stars are confusing. SX Pav is an SR star with a period of about 50 days but it's probably got multiple periods making this up. An interesting project for someone who can make a couple of measures a week—and at 70S it's visible for most of the year. Y Pavonis has a longish period of 233 days but the measures in the graph don't show this. A good target for someone to see whether it has really ceased to vary. These stars would be ideal for someone with a DSLR camera—they wouldn't need long exposures, tracking would be unnecessary, and such a camera could avoid the saturation of the far more sensitive CCD camera. G and B would provide very good information.

I've always enjoyed looking at these two stars. Not only are they next to each other in the sky but close by is a sixth magnitude very blue star and the colour contrast is quite stimulating. These make up a nice crescent of interesting stars. And you can add in the orange red NSV 25504, a fifth magnitude M0 type star about a degree away, as a little bonus.

So how many other interesting groups of stars are out there? Let's know of any that interest you for the next Newsletter.

CCD COLUMN HOW DO PHOTOMETRY TOOLS COMPARE?

Conducted by Tom Richards

Tom.Richards@VariableStarsSouth.org

How do photometry packages compare in their photometry, and in their output formats? I receive a lot of CCD time series data from many people in the Equatorial Eclipsing Binaries (EEB) Project, and it usually comes in different formats, including the VSS CCD Excel spreadsheet, the native formats of various photometry packages, and the AAVSO "Extended Format". The first thing I have to do is to extract the basic data so that results can be compared. In the EEB Project, the data usually goes into the PERANSO period analysis program (Tonny Vanmunster, www.peranso.com) in a 3-column format: <(H)JD>,<mag>,<mag-error>. The last column is optional, and HJD is preferred but not always supplied. And sometimes it is truncated from the left by some number of digits or other. And often the data comes with different comparison stars, or different magnitudes assigned to the same comparison star (including 0.0 to get differential magnitudes.) This all has to be reconciled, made consistent and uniform. Ho hum, thank goodness for cloudy nights.

The AAVSO Extended Format

For the last couple of years there has been a cross-product standardised photometry output format for CCD or PEP data, called the AAVSO Extended Format (AEF). It would be very helpful if VSS could see clear to adopt it at its preferred CCD data submission format – at least as an option. Different VSS projects can have different data requirements, so we have never developed a standard, absolutely required, VSS format.

You can find the AEF specification, with examples, at <http://www.aavso.org/aavso-extended-file-format>. Six photometry packages now output to the AEF, including the three I will discuss:

- AIP 2.3.1 (<http://www.willbell.com/aip/index.htm>),
- MaxIm-DL 5.12 (<http://www.cyanogen.com/>), and
- Mira Pro 7.974 (<http://www.mirametrics.com/>).

These are the latest releases, but Richard Berry, who developed AIP, tells me (personal email) that there is a much improved public beta available now which users can test by joining the AIP4Win-Photometry Yahoo Group.

The AEF is quite a comprehensive format, intended for submission of observations on one or more stars by one observer/system, on one or several nights, using one or many filters. An AEF document is a plain text file intended for uploading to the AAVSO database. It begins with a header of parameters that apply to the all data entries in the file, e.g. observer code and date format. Here is an example:

```
#TYPE=Extended
```

```
#OBSCODE=RIX
```

```
#SOFTWARE=MaxIm DL Version 5.12
```

```
#DELIM=,
```

```
#DATE=JD
```

```
#OBSTYPE=CCD
```

Then each observation (data point) gets a line of its own. Here's one line with the column headers:

```
#NAME,DATE,MAG,MAGERR,FILTER,TRANS,MTYPE,CNAME,CMAG,KNAME,KMAG,AIRMASS,GROUP,CHART,NOTES
```

```
CU Hya,2455268.9180787038,14.6018,0.0148,V,NO,STD,C,13.2278,K,12.4710,1.503,NA,NA,na.
```

The AAVSO database needs to contain the information any researcher is likely to want, at some time in the future. This is unlike the VSS, whose data requirements are all project-oriented and so a submission format can be designed to suit the needs of an individual project. Is then the AEF a satisfactory superset of all likely VSS CCD project requirements? I will look at that shortly; but first, how does the photometry in the three packages compare?

Comparing Photometry in AIP, MaxIm and Mira

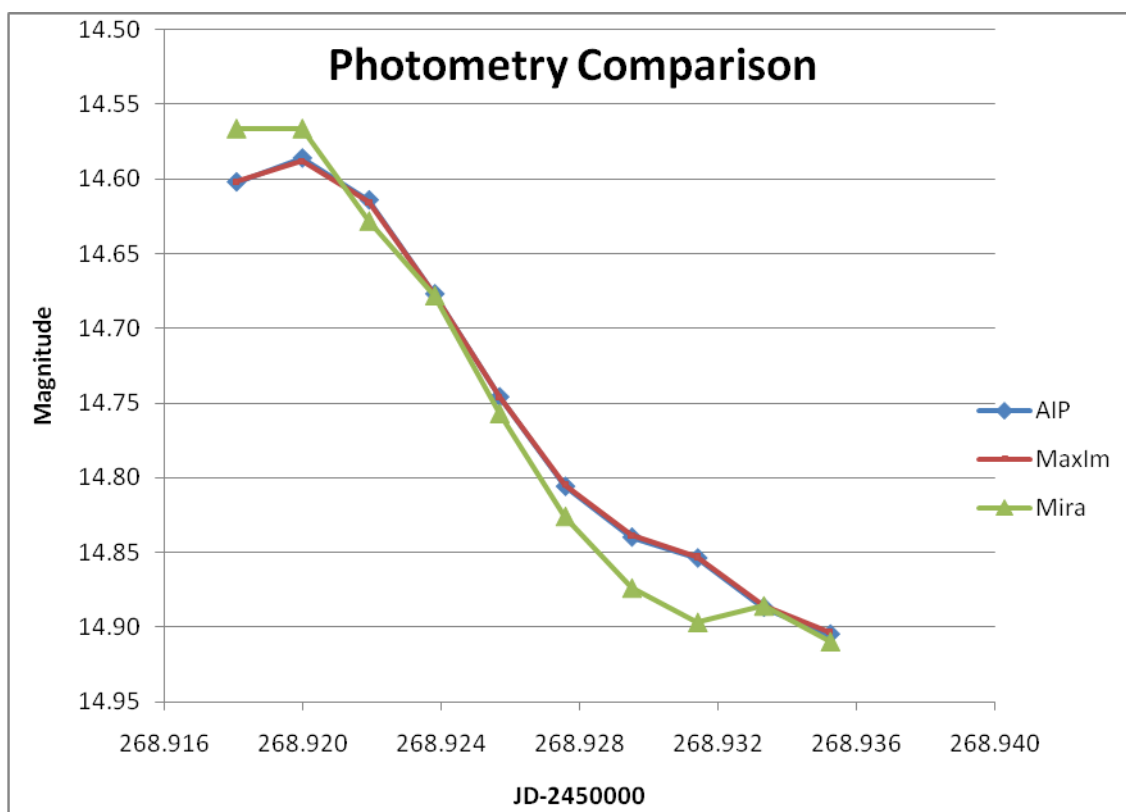
First of all, the three packages do not give the same magnitude results on a target variable, within limits of error. This reflects differences in the algorithms used by the packages. But it is a warning not to expect uniformity of results from different packages.

Here are the results of measuring the same image with the same apertures in the three packages. In each, the magnitude of the comparison star C was set to 13.32. VMAG refers to the magnitude of the variable, and MERR to the error they packages report in VMAG. Columns from #NAME onwards are from AEF reports; the first two in blue I added to assist you, dear reader. CMAG(assigned) means the magnitude assigned by the observer (me) to the comparison star C.

Software	CMAG(assigned)	#NAME	DATE	VMAG	MERR
AIP	13.32	CU HYA	2455268.91808	14.602	0.024
MaxIm	13.32	CU Hya	2455268.91808	14.602	0.015
Mira	13.32	Mira-1	2455268.91808	14.566	0.016

Note the close magnitude agreement of AIP and MaxIm, and AIP's more conservative error estimate. I won't look into the error calculation methods of the packages, however. My own estimate of the mag error on the night, based on the standard deviation of the check star mags through the time series, is 0.01 mag.

Interestingly, AIP and MaxIm always have the same photometry results, as shown by this plot of measurements of 10 images by them and Mira. The differences between them and Mira sometimes lie outside the error estimates, so are possibly significant. Of course, we cannot say AIP and MaxIm are right because they agree – photometry is not a democracy. Testing for which is "right" is best done against a standard star field such as one of the Landolt Southern Standards.



Handling Comparison and Check Stars –the AAVSO Extended Format approach

So far, so good. Now for the photometry of the comparison and check stars, C and K. Here are extracts from the same three lines of the same three AEF reports as above. I have added the two first columns as before, and also the two last columns, V-C and K-C.

Software	CMAG (assigned)	CNAME	CMAG	KNAME	KMAG	V-C	K-C
AIP	13.32	C	13.113	K	12.356	1.489	-0.757
MaxIm	13.32	C	13.228	K	12.471	1.374	-0.757
Mira	13.32	Mira-2	13.320	Mira-3	12.559	1.246	-0.761

Immediately we note big differences between the three CMAGs and also the KMAGS and the V-Cs, yet the K-Cs are effectively the same. At the least, AIP and MaxIm should agree on CMAGs. Also, why isn't the CMAG always 13.32, where the user set it? What's going on?

The answer is, first, that VMAG was measured by finding the difference in *instrumental* mags between V and C, then adding the user-assigned magnitude for C:

$$\text{VMAG} = \text{VMAG}(\text{inst}) - \text{CMAG}(\text{inst}) + \text{CMAG}(\text{assigned}) \quad (1)$$

That is how the AAVSO requires VMAG to be calculated. An instrumental magnitude is defined as the conversion of the star ADU count rate in the (inner) measurement circle to magnitudes using Pogson's formula:

$$\text{MAG}(\text{raw inst}) = -2.5 \log(\text{ADU}/\text{exposure time [sec]})$$

Note that's the *raw* instrumental magnitude, and typically gives a result 20 or so magnitudes too bright, so customarily a zero-point offset Z is added:

$$\text{MAG}(\text{inst}) = \text{MAG}(\text{raw inst}) + Z$$

Z can of course be calculated accurately if the actual magnitude of the comparison star C is known, but we won't pursue that.

However, the AAVSO requires that CMAG and KMAG are defined differently from VMAG. In fact, they are required to be *just* the instrumental magnitudes. This can be a real trap, since the addition of Z to a raw instrumental magnitude can produce a result that seems very realistic, tempting one to find the differential magnitude V-C (as in the table above) by the subtraction VMAG – CMAG. So totally wrong! (Yet, K-C is correctly given by KMAG – CMAG. If you can see why, you've followed the argument so far!)

The AAVSO has good reason for this definition. Changes in CMAG and/or KMAG thus defined, in a time series over a few hours, show changes in sky transparency, caused perhaps by faint clouds or sinking stars. And a trend in K-C likely shows the two stars are of different colours – undesirable – or that one is variable. Further, if an image has an anomalous K-C, it may have a defect – check out why. Nevertheless it can and does confuse observers. Developers of some of these three products tell me they often get worried emails about seemingly wrong differential magnitudes.

Still, how come the three products report incompatible CMAGs and KMAGs? The answer lies in the zero-points Z. For AIP, the user sets Z (defaulting to +20.0). Change that to 10.0, and the CMAGs and KMAGS are suddenly 10 mags brighter. For MaxIm, I don't know how it is set. A comparison with AIP shows that for these 10 images, it appears to be set at 19.886, thus delivering CMAGS 0.114 mags brighter than AIP.

Of course, the zero-point is irrelevant for the purposes just described, so long as it is constant through an observing run. So this difference between AIP and MaxIm doesn't matter. However, Mira departs from the AAVSO definitions for CMAG and KMAG. In Mira, they are calculated thus:

$$\text{CMAG} = \text{CMAG}(\text{assigned})$$

so CMAG always equals 13.32 for these images. And:

$$\text{KMAG} = \text{KMAG}(\text{inst}) - \text{CMAG}(\text{inst}) + \text{CMAG}(\text{assigned})$$

just like VMAG. So for Mira, V-C and K-C yield correct values, but should not – according to AAVSO definitions.

Pity the Poor Analyst

So from the point of view of a hypothetical analyst, such as me, receiving data on a hypothetical star such as V1243 Aql from users of the three packages, such as you, what are the pitfalls?

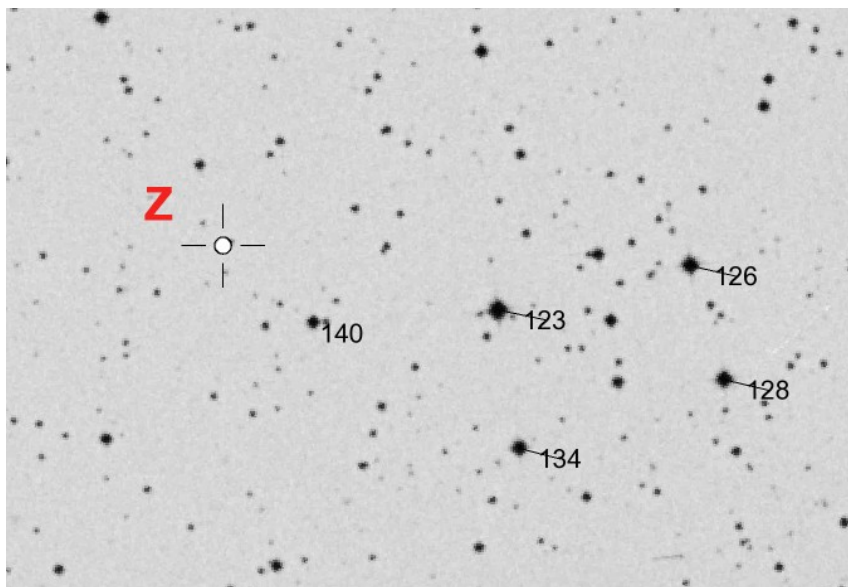
1. It is apparent that different packages will yield magnitude data that differ outside the error limits. If everyone used one package, such as AIP, that would be avoided. This anomaly may possibly be made worse if observers used different comparison and check stars; but at least in the EEB and SPADES Projects, they are told what stars to use for C and K and the magnitude to assign to C. (It's a real pain anyway when users don't use the same C star at the same magnitude.)
2. For a given observing run, the VMAGS on a star depend on the magnitude assigned by the user to the comparison star C. See equation (1) above. But here's a problem with the AEF. Nothing in an AEF report tells a reader what that is. For the AAVSO that's not a problem, since they require a user either to report a differential magnitude (which effectively sets CMAG (assigned) to 0.0), or to use a *standardized magnitude* for C, that is, the magnitude given on an AAVSO chart (and you have to supply the chart ID). This is wonderful, because their database software can find that magnitude, and moreover as charts go through magnitude revisions (which changes chart IDs) they can update all earlier observations accordingly. But for an analyst using an AEF report, they have to look up the chart, if it is still available online. Or else ask the observer what their CMAG(assigned) was.
3. In a Mira AEF report, data for CMAG and KMAG does not conform to the AAVSO specification. This does not matter unless the analyst is pursuing certain issues of image-by-image precision and quality, and some can effectively be handled anyway from the data provided.

So, are AEF reports a boon or a burden to an analyst? I now think that, contrary to previous policy, VSS should accept AEF data, provided the observer submits also CMAG(assigned). For this reason, and because we lack the software facilities of the AAVSO, one report should be about one star for one night, using one filter and one comparison star. However, various VSS projects may well prefer other, simpler formats easily derivable by the observer from the software's native mode report format.

Acknowledgements

I have been very greatly assisted in the preparation of this article by developers Richard Berry of AIP, Hil-deric Browne of MaxIm, and Michael Newberry of Mira. Arne Henden of AAVSO has helped me much with aspects of the AEF and AAVSO's thinking. My thanks to all of them for clarifying important issues and saving me from mistakes. Remaining mistakes are my own.

Z Chamaeleontis—an Identification Problem



Over the years there have been confusing measures with this star. At minimum it's usually about 15.5 with eclipses taking it down to 17. But it has been reported at around 14.5 to 14.8 on many occasions leading to the speculation that it has low amplitude outbursts that may be precursors to the rather infrequent outbursts. It's found by taking a line through the 128-123 stars and extending the same distance. It's easy, however, to confuse it with the star to the upper left of the Z on this chart which may be variable at a low level. Z Cha itself may be slightly out of position here—is it the faint star shown?

HIGH PRECISION PHOTOMETRIC TRANSFORMATION TO THE STANDARD UBVRI COLOUR SYSTEM

Stan Walker

astroman@paradise.net.nz

1.0 Introduction:

Amateurs have been involved in photometric photometry since the late 1950s. For the first 40 years of this, setting up and operating a system was a quite difficult task. As a result the exponents spent considerable time 'learning the trade' and consequently became very competent.

From about 1995 onward inexpensive CCDs have become available, along with a proliferation of 'how to' books with a variety of reduction packages. This has made photometry much simpler, but this ease of getting started has seen a substantial decline in the accuracy of the data. An examination of BVRI data in the International Database maintained by the AAVSO shows numerous instances of essentially simultaneous measures differing by as much as 0.05 magnitudes, with a few even worse. This compares poorly with conventional PEP, which usually targets an accuracy of 0.005 at brighter levels. And CCDs have the advantage that in most cases the measures are not sequential but simultaneous, with the target star, comparison and check and sky all being on the same frame. This raises the question—why is CCD not performing as well as it should?

What is required in the way of accuracy? Measures should be tailored to fit the needs of the research—both now and in the future. An accuracy of ± 0.05 is good enough for many large amplitude pulsating variables, but is almost useless in the determination of EB system parameters or with short period pulsators such as the various types of Cepheids, or the low amplitude, short period semi-regular stars and similar objects.

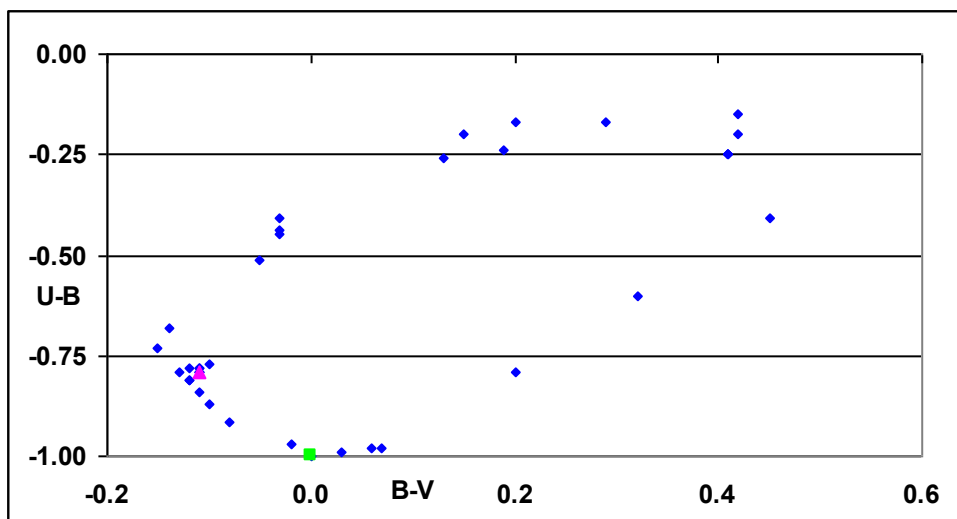
This problem does not occur where CCDs are being used unfiltered as the targets—CVs, Minor Planets, EB minima—these either show little colour change, or the colour changes affect only the recorded depth, not the time unless there is a marked colour difference between the two stars and the air mass is changing fast. These observations are all time series photometry (TSP) and are easily carried out effectively. Simple scaling and zero point corrections resolve the differences between various datasets. We used this method in Auckland when combining UBV and visual measures and it is quite effective.

Unfortunately these measures tell us little about the physical nature of the target. So let's look further into methods of getting high quality colour measures to understand the physical nature of some systems.

- Either B-V or V-R will provide a good indication of temperature unless the object is highly reddened by interstellar absorption.
- This absorption can be measured by plotting U-B against B-V in a colour-colour diagram and comparing this with theoretical values. Similarly B-V against V-R but this is not as effective. (Note that this is a slightly different colour-colour diagram to the one on the next page.)
- Comparison of the corrected, unreddened colours with theoretical models will separate out the MK luminosity classes I, II -V, etc.
- Ultraviolet excesses—seen by comparing U-B to B-V—provide evidence of gas shells.
- Infra-red excesses—compare V-R to R-I—allow the detection of dust shells.

Whilst the derived information is by no means as reliable as spectra it is easily and quickly obtained down to much fainter magnitudes. It is very valuable in determining the nature of new variables, or even of identifying likely variables on VRI image frames. Illustrative of this last point—Arne Henden some years ago published in the AAVSO discussion area some BVRI colour measures of a few fields and it was simple to identify a few possible red variables from V-R/R-I colours—at least two of which showed variations when one or two of us made measures over a month or two.

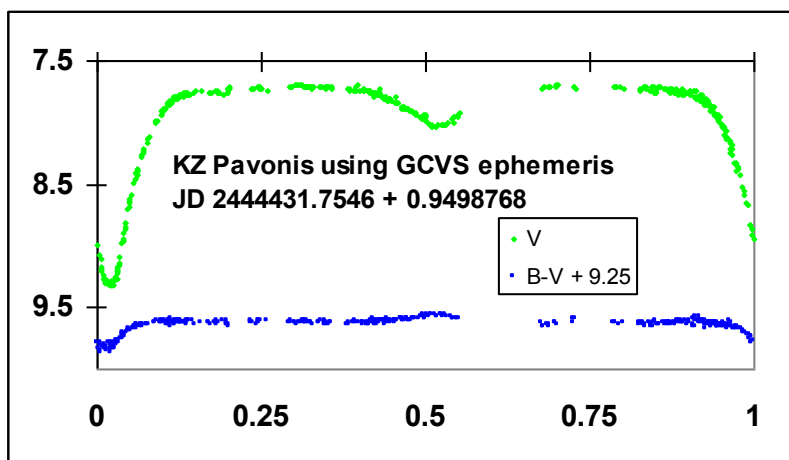
Another area of interest was in the CV field when observers were trying to determine where the outbursts were occurring. Was it an event on the cool, mass losing star, or was something happening on the white



This colour-colour diagram is a plot of U-B against B-V. At the start of the outburst the colours are represented by the green square. As the outburst proceeds the colour changes move in an anti-clockwise direction. Maximum at $V = 9$ is shown by the magenta triangle. The time scale is variable—it takes about 20-25 hours to reach maximum and three days to return to normal.

What is this telling us? At the start of the outburst a considerable portion of the light is emission from a gas cloud as evidenced by the strong ultraviolet excess. In the initial stages of the outburst the system reddens quite substantially with B-V equivalent to an ~F6 spectrum, but still with a substantial Uv excess. It's about 1.5 magnitudes above minimum at this stage. The outburst continues with the overall colours changing to a more normal early B spectrum— B-V of -0.15 and U-B of -0.70 at maximum—a black body type radiation indicating that most of the light is coming from a fairly dense object—not a cloud of gas. The system then slowly fades, the temperature cools, and once again an emission spectrum is prominent. So theorists can begin to explain what is happening—they're still arguing over the interpretation but these U-B/B-V loops are present in most CVs.

dwarf, or did the event involve the disc—or perhaps several of the system's components. The illustration above shows some aspects of the normal outbursts. Below is shown a different application—determination of temperatures and spectral classes of stars from total eclipses.



What does this graph of KZ Pavonis tell us? At primary minimum we see only the light from the cooler star with a B-V of 0.584, equivalent to ~G0 and a temperature of ~6000K. The mean system B-V colour is 0.363 and during secondary eclipse it falls to 0.309 indicating a B-V of ~0.25 for the primary star, ~A9 at 7600K. The period indicates that both stars are still on, or close to, the main sequence. This is standard PEP with an aperture of 30" and the light from a companion star at ~7" distance has been removed.

So now let's look at an overall concept of what is needed to do good colour photometry. We'll begin with an interesting summary of what happens to starlight as it comes through the Earth's atmosphere.

2.0 Photometric Transformation Coefficients - General Concepts

(This section comes from AAVSO Discussion with thanks to Thomas Krajci of the AAVSO)

We're gonna conduct some simple thought experiments to help explain concepts that are important to photometry.

Thought experiment 1

Step outside on a clear day near noon, and let sunlight fall on a piece of white paper. You'd say that bright white light is falling on the paper. Do this again, but just before sunset. You'd say that fainter red light is falling on the paper. What happened here? Did the sun change? No. But the sunlight travelled through much more atmosphere in the case just before sunset. OK, then it should have been fainter *white* light, yes? Obviously it isn't, so something else is going on here.

Concept #1: Our atmosphere cuts down the amount of light that reaches us from space. This light travels through more atmosphere when the source appears closer to the horizon, so objects appear fainter when low, and brighter when high.

Concept #2: Our atmosphere does not cut down all colors of light equally. Red light is affected least (that's what you see in the sunset colors...it reaches your eyes), and blue is affected the most (little blue light reaches our eyes from light sources low on the horizon).

Thought experiment 2

Today it's clear, but the air is different. It may be a windy day dust storm, or smoke from a distant forest fire has drifted over you. Anyway, there's more stuff in the air today. Look at sunlight on white paper at noon, and just before sunset. What do you see? The noon light is not as bright as the 'transparent' day, and it may even have a yellow or orange tint. And sunset? If it's really heavy smoke/dust...the sun may be barely visible, and very deep red.

Concept #3: The amount of light that our atmosphere removes can change, depending on atmospheric conditions. (Not all clear days, or nights, are equal.)

Ouch! That darned atmosphere makes something simple, like observing our constant sun...change brightness and color...from hour to hour, and day to day! How can you measure brightness of stars when the atmosphere changes things so much? (There are 'work arounds' to this problem...and we'll get to them in a bit.)

Thought experiment 3

One clear night you're observing two stars that are close to each other — binoculars, telescope, it's not important. What's important is that these two stars are fairly close to each other...a couple degrees separation or closer. These stars are also the same color...both are orange, or both are bluish....doesn't matter. But to your eye they're the same brightness. You are observing them when they are high in the sky. Wait a few hours and observe them when they are much closer to the horizon...just before setting. Sure they look fainter, but how do they compare to each other? Are they still equal brightness? (We'll assume these are constant stars, not variable stars.) Yes, they are fainter, but they are still equal to each other in brightness.

Solution #1: Compare the brightness of stars that are not widely separated. That will eliminate the negative effects of the atmosphere. (This is not a perfect solution...let's call it a 75% solution.) ('Close together' is less than one degree...which is fine for most telescopes. But camera lenses?...that's a problem because they cover wide fields. We'll stick with narrow angle telescopes for now and avoid the problem of wide angle camera lenses.)

NOTE: We are measuring brightness by making comparisons to other stars. This is known as differential photometry. (What's the absolute brightness of a star? We don't know. We just know how it compares to a nearby star. But that's a pretty good start in the world of measurement.)

Thought experiment 4

One clear night you're observing two stars that are close to each other - binoculars, telescope, it's not important. What's important is that these two stars are fairly close to each other...a couple degrees separation or closer. Also, these stars are *different* colors...one is orange, one is bluish. But to your eye they are the same brightness. You are observing them when they are high in the sky. Wait a few hours and observe them when they are much closer to the horizon...just before setting. Sure they are fainter, but how do they compare to each other? Are they still equal brightness? (We'll assume these are constant stars, not variable stars.) No. The orange star now appears brighter than the bluish star.

Concept #4: As stars set, redder stars get fainter slowly, and bluer stars get fainter faster. (Conversely, as stars rise, redder stars get brighter slowly, and bluer stars get brighter faster.)

Double ouch! Thanks to our atmosphere, we're getting farther from our goal of measuring star brightness with any sort of confidence and accuracy.

What if the stars were the same color? In that case, they would get equally fainter as they set (and equally brighter as they rose). But stars come in various colors...and you can't change that.

Well, here's one work around:

Solution #2: If possible, compare brightness between stars that are reasonably well matched in color. (Sometimes that's not easy. In the star-poor spring sky, such as Leo,...you may not find a nearby star of a similar color. You may have to use mis-matched stars, which is not a good solution. But it may be the only solution in some cases.)

NOTE: We are doing unfiltered photometry..and we need to be careful and try and match the color of the stars we study. If not, our accuracy suffers. Perhaps you *can* can change the color of stars?

Thought experiment 5

You found some old glass filters from your (or your father's) film-photography days...red, green, blue. Look at a white star through the red filter - what does it look like? Red. Through the blue filter? Blue. And it looks green in the green filter.

That's not too surprising, because white light is all colors combined. What about a reddish star? Through the red filter it looks red, in green it looks green (but a bit less bright), and in the blue filter it's blue...but even fainter.

And a blue star? Through the red filter it looks red (but somewhat faint), in green it looks green (but a bit brighter), and in the blue filter it's blue...but even brighter.

Concept #5: Stars (except exotic ones, which we'll ignore for now) of various colors still have some amount of light from all colors of the rainbow. (Neon signs, mercury vapor street lights...they only have one, or a few discrete colors. But stars, at a simple level, show all colors to some extent.)

Hmmmm, we may have found a way to 'force' stars to have the same color...use a filter. Now we can get them to behave the same way in terms of color/brightness, and how the atmosphere affects color/brightness as they rise and set.

Solution #3: Use a filter to 'force' all stars to have the same color. (This is not a perfect solution...let's call it a 90% solution.)

Thought experiment 6

You learn that there are standard photometric filters for science purposes, and you find some in the high school physics classroom, forgotten in a drawer. You learn that they have a V filter (passes green light), and B (blue) and R (red). You compare them to your film-photography red/green/blue filters. Looking through them, these two sets of filters are similar, but not identical. In your case, you find your film/green filter, compared to the photometry/V filter, passes a bit more red light, and a bit less blue light. In other words, your film/green filter is 'redder' than the photometric/V filter...its bandpass is shifted toward the red end of the spectrum.

OK, make some careful measurements of stars with these two filters. What do you find? If the star is white, you'll find its brightness is pretty much equal in these two filters. If the star is red...you'll find your film/green filter shows that star a bit brighter than through the photometry/V filter. And if the star is blue, your film/green filter shows it as a bit fainter than through the photometry/V filter.

Why? For the example of red stars, they have a larger output of red light than other colors. And your film/green filter has a bandpass that's shifted toward the red. Compared to the photometry/V filter, your film/green filter passes more light from a red star. (And for blue stars it's the opposite. Those stars have more blue, and less red light. Your film/green filter passes less light compared to the photometry/V filter.)

Concept #6: Not all photometry filters are created identical/equal. Small differences exist...small deviations from the ideal definition. This will create small offsets in your measurements. (And the same can be said of

your telescope optics, and CCD chip, and your atmosphere...they also introduce shifts/errors/deviations from the ideal.)

Where is this ideal place to do photometry? Above our atmosphere. And, using equipment that has the 'ideal' bandpass/response.

Fortunately, the deviation of your ground-based equipment from the standard is pretty much repeatable...at least if you're careful in using it.

Solution #4: Measure brightness of stars with your 'imperfect' filters/CCD/scope/atmosphere, and compare your results to 'catalog' values. Analyze the differences, and you'll probably find that they are repeatable and consistent. Then, apply a difference correction to your measurements and they should (pretty closely) match the 'catalog values.'

NOTE: This is the essence of transformed differential photometry. You've used good practices, and determined your small offsets from catalog values. You can produce well calibrated measurements...as if you were making measurements from above the atmosphere, with a perfect/ideal system. And, if other folks around the globe do similar calibration of their equipment...your measurements should be in very good agreement. That makes collaboration much easier.

This is not a perfect solution...let's call it a 98% to 99% solution. Remember, different photometry projects require different amounts of calibration. In the beginning you work with the 75% solution...choose stars close to each other, and that have similar colors. Later, you can add filters, and that can improve your solution to 90%. Then you measure your filter deviations from the gold standard...and you can work at the 98-99% level.

The history of measurement has examples for us. Centuries ago one inch was defined as three barleycorn. Later, the meter was defined as the distance between two thin scratches in a bar of low-expansion metal. These days length is defined in terms of light wavelengths (of a precise color) in a vacuum. Photometry is the same way...with time and experience you learn to make more precise measurements.

3.0 *And now to Stan Walker describing the system used at Auckland to produce rather good photometry.*

Robert Hardie, 1962, wrote a treatise explaining how to quantify all of these things and how to remove them from your measures. Basically he separated out three things:

- The telescope, detector & filter system which changes the wavelength of light from the standard system—the scale factors. See Krajci No 6. But CCD filters are much better matched to the standard UB VRI system so these corrections are usually small.
- The amount by which light seen through any filter, or pair of filters, is attenuated by the atmosphere—primary extinction. See Krajci Nos 1 & 2.
- The effect of extinction on the colour of the star—secondary extinction. See Krajci No 4.

Things have changed a lot from Hardie's days but the concepts are still the same. So how do we implement what Krajci and Hardie are describing?

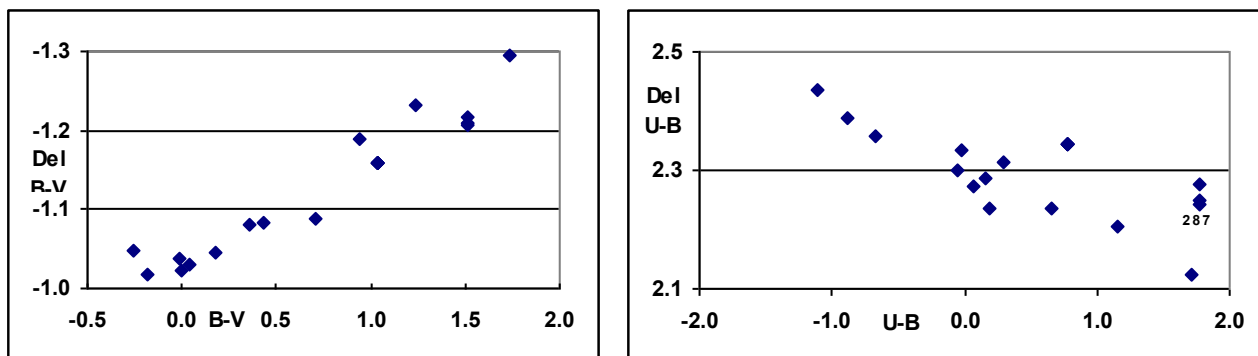
4.0 *Determining the Coefficients.*

At this stage we are faced with a need for very accurately measured stars to use in determining the various transformation coefficients. There are many published listings of stars and colours beginning with the Royal Observatory Bulletin 64, then the Yale Bright Star Catalogue and later a variety of other compilations. These are usually $\pm 2-3\%$ (0.02–0.03) but the genealogy of some of the lists is hard to find and errors of 10% are not unknown. So we need a very reliable source.

In the south we are fortunate in having UBVRi measures of nine E Regions at 45S, every 40 degrees of right ascension, three F Regions at 75S with 120 degree separation, and selected stars in the LMC and SMC. Measures of these regions were begun at the Cape Observatory about 1960 by Alan Cousins and Richard Stoy and since updated by their colleagues and extended to fainter limits by John Graham at Cerro Tololo.

To determine the scale factors choose a region which is about an hour before the meridian and measure it until an hour past. Pick a reference star about F or G spectral type and remeasure this each 30-45 minutes. For the other stars get a good colour selection.

Now here things change from what you might expect. The different telescope/filter/detector response changes the effective wavelength of the system. It's almost impossible to determine this using single filter response so the method is to work with colours and the V which is almost invariably used to give the basic magnitude. Most colour photometry has been done using UBV but in this CCD age we'll describe the methods with VRI photometry although the two illustrations are in UBV.



These two graphs are typical of what you will get. They are PEP rather than CCD and illustrate the difficulty with the old UBV filters which relied upon atmospheric cutoff to define the short wavelength side of U and pm tube sensitivity to define the longward side of V. The numbered star in the second graph is a known variable. There is also a loop in the U-B colour with stars of A0 and F5 spectral class both having U-B of ~0.0. Little wonder that many people prefer BVRI but U-B does have some very useful features.

Convert everything to magnitudes and colours. You end up with v , $v-r$, $v-i$. Then look at your reference star values. If these have changed much you should make percentage corrections up or down to all the readings to cancel out the effects of these changes. Now make three plots, v/V , $v-r/V-R$, $v-i/V-I$. In these plots lower case letters indicate the observed magnitudes, upper case ones are the true, outside of atmosphere, values. From these plots you can determine the 'scale factors' and use these to correct your observations. If your research is largely time series photometry and you want single filter values then V is V , R is $V - (V-R)$ and I is $V - (V-I)$.

At this stage the photometry is probably good enough for many purposes. We got rid of the primary extinction by correcting to the reference star but these corrections determined still include the secondary extinction. They will be altitude dependent in the colours, particularly if you use B-V or U-B. At Auckland we would experience extinction through the various filters over a difference on one air mass (X) of something like: $U = 0.25$; $B = 0.20$; $V = 0.15$; $R = 0.12$; and $I = 0.10$. On a night with a strong inversion layer these could be up to 40% higher. For colour photometry of LPV stars it's probably not essential to get rid of the secondary extinction except when the B-V is large, say 3.0+. But then how reliable are the other transformations with such a large difference between the comparison and variable star? In many cases, such as binary star modelling, it pays to be very accurate—see Bob Nelson's series of articles in previous Newsletters.

So let's determine these extinction corrections. It's better to use the instant method described by Hardie than rely on measures of a red/blue pair as they travel through a range of air masses. This latter assumes very steady skies and these are rare. Think of Krajci's description of all the things which can affect the air you're looking through.

We need red/blue pairs in several E Regions to give a range of air masses (X). One near the meridian and two at lower altitudes. They will normally be the meridian E Region, say E8 in November, then two at ± 2 regions, say E6 and E1. This will usually give a range of about $0.6X$. Once again, repeat your meridian region measures at start, middle and end of the sequence and adjust all observations if necessary.

The plots this time are of colour differences $(v-V)$, $(v-r) - (V-R)$, $(v-i) - (V-I)$, each against X . It will pay to identify the red and blue stars by separate colours/symbols. In selecting objects try to get all the blue stars

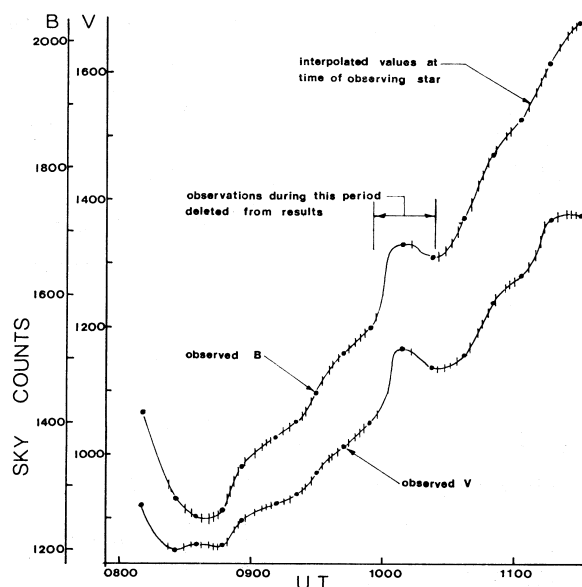


Figure 1.—B and V sky-brightness changes for RS Col, 1970 Feb. 19 U.T.

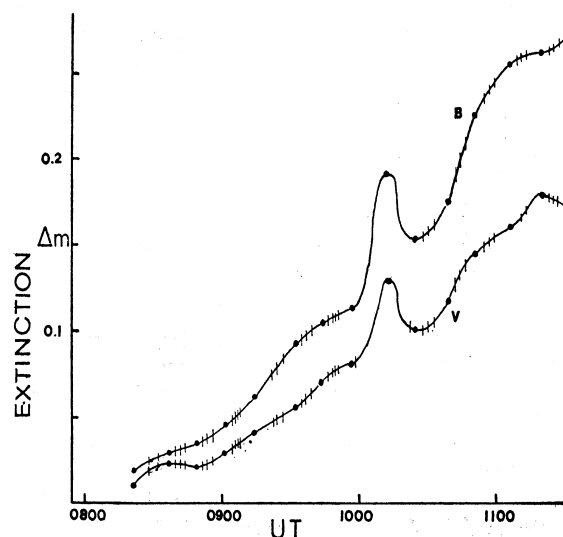


Figure 2.—B and V sky-transparency changes for RS Col, 1970 Feb. 19 U.T.

These two graphs are illustrative of what Krajci and I have been describing. In 1970 Auckland city skies were quite poor—later the clean air regulations improved them—and there were often smoke trails which produced the poor region about 1000 UT. The vertical lines indicate where measures of the variable star occurred. The right hand graph shows clearly the secondary extinction in the B-V colour. CCD observing is much easier when it removes the necessity for sequential measures and with the longer wavelength passbands the secondary extinction is smaller. But it's still there and many observers have skies which are similar to that shown here!

at $B-V < 0.05$ and the red stars in the range $B-V = 0.9$ to 1.2 . Intermediate coloured stars tend to make it harder to interpret.

The slope of the blue star gives you the primary coefficients, the difference in the slopes of the red and blue stars is the secondary co-efficient. Through the V filter the slopes should be the same, indicating a secondary co-efficient of zero - the others should be small with $B-V$ the largest. $V-R$ will be smaller than $V-I$ which has a larger wavelength spread. $R-I$ can be interpolated or plotted if you wish.

Now extract the secondary terms from the scale factors and it's all done. With more recent CCDs the filters and response of the detector are a much better fit to the standard system so all scale factors should be close to 1.0. Earlier CCDs may be weak at the B end and sometimes erratic in the I filter.

Don't stop with this, however. Keep a watch on the extinction at any time you measure the same or similar stars over a range of air mass. And you should probably check the scale factors each six months, or whenever you change anything in the optical path. The secondary extinction values don't change much.

5.0 Using the Transformations:

Your main colour will be either B-V or V-R. B-V has a better wavelength spread. Some observers recommend V-I but not all CCDs perform well in I, or B for that matter. U is very difficult with low cost CCDs, but simple with a photomultiplier type PEP system. The I filter may measure dust radiation in some cases, U will often detect gas shells - and since both are in the regions where the slope of the detector falls off steeply they are best to be treated as subsidiary colours.

The transformations are:

$$V = (dv * SF) - (dv * PEv) + Vc$$

$$B-V = (db-v * SFbv) - (dbv * dX * PEbv) - (dbv * X * SEbv) + B-Vc$$

$$V-R = (dv-r * SFvr) - (dvr * dX * PEvr) - (dvr * X * SEvr) + V-Rc$$

$$V-I = (dv-i * SFvi) - (dvi * dX * PEvi) - (dvi * X * SEvi) + V-Ic$$

All lower case terms are as observed, SF = scale factor as appropriate, PE = primary extinction, SE = secondary extinction, c refers to the comparison, dv etc., refers to the variable - comparison values in the appropriate colours. Do not change this sequence. Except for V, which has been calibrated against the main colour of B-V or V-R there are no single filter transformations.

And again $V = V$, $B = V + (B-V)$, $R = V - (V-R)$, $I = V - (V-I)$.

6.0 Making the Observations.

At this stage we are faced with the choice of two types of photometry - absolute photometry (all-sky photometry) or differential photometry.

Absolute photometry is based upon measuring target stars and variables over a wide part of the sky, then correcting for the various effects discussed previously. It demands very clear skies with no azimuthal effects like smoke, haze or other pollution. Most of us don't observe from situations like that—we're in cities with industry and the pollution caused by habitation. Even proximity to the sea has effects. So the ideal site for this is away from all cities and at an altitude which is above cloud and inversion layers.

Differential photometry accepts that the sky is not uniform. So it endeavours to measure stars as close together in the sky as possible to remove the effects of primary extinction—and to measure stars close to each

other in colour to reduce the effects of secondary extinction.

A number of amateurs are using all sky photometry, largely because computer software is available which seems to make it simple—and it must be admitted that determining the values of the corrections to be applied in differential photometry is a little complex. But amateur all sky photometry probably has an accuracy limit of 0.03-0.05, often worse, whereas differential photometry can, with care, achieve better than 0.005 accuracy.

The relative accuracies can be seen in these two graphs, reproduced from a paper presented by Brian Marino at the RASNZ Annual Conference in 1970. To the left is shown differential photometry of RS Columbae—a W Ursae Majoris star with an amplitude of ~0.4 in V. These measures were made through the atmosphere shown in earlier graphs and using sequential PEP. The observing was in both B and V but the B measures, although fractionally more accurate, were not used in Marino's presentation.

So when do you use which? For

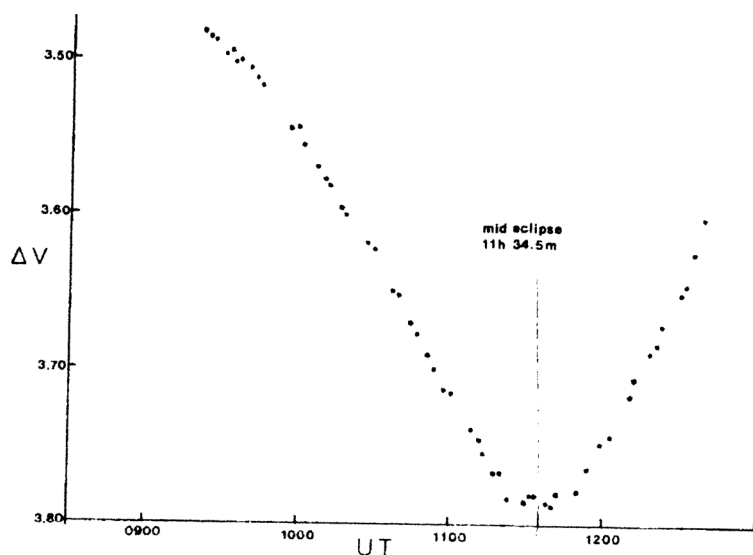


Figure 3.—Observations in V of RS Col, 1970 Jan. 25 U.T. showing a total eclipse.

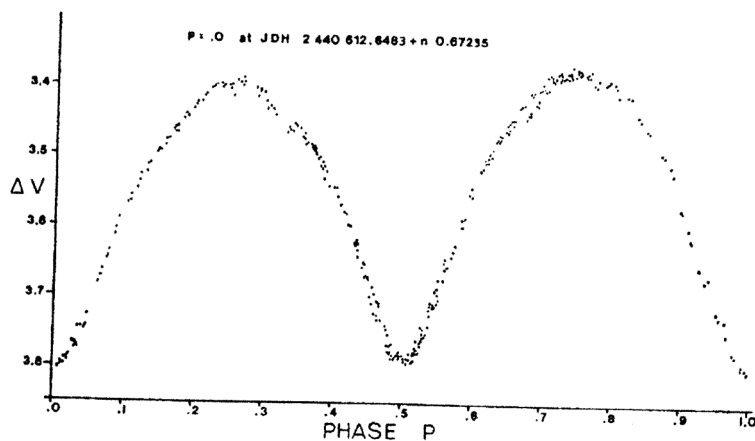


Figure 4.—V light-curve for RS Col, 1970 Jan.-Mar. From observations at Auckland Observatory.

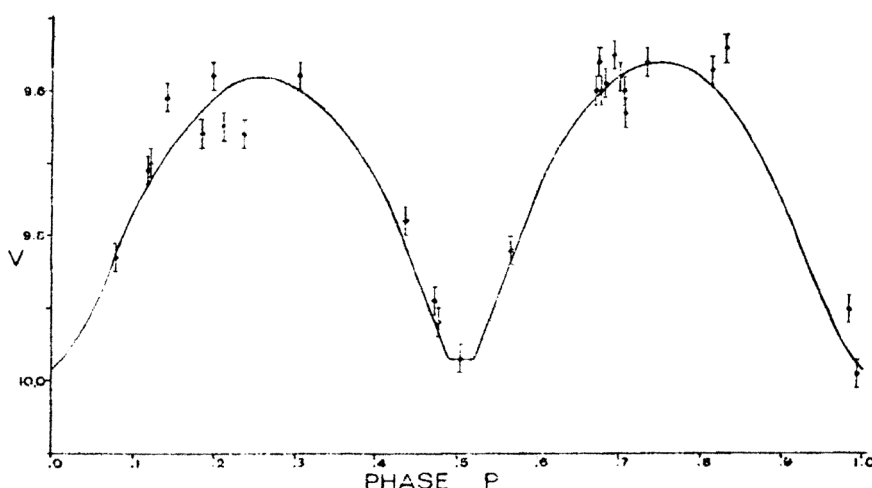


Figure 5.—Bond and Landolt's observations of RS Col superimposed upon the V light-curve obtained at Auckland Observatory.

In this figure the light curve from the previous page—in itself observations from a number of nights—is superimposed upon a graph from the original discovery paper by Bond and Landolt, 1969. It's clear that the all sky measures do not have the accuracy of the differential measures and that the errors are underestimated. Whilst W UMa stars do not have entirely smooth light curves—quite noticeably near maxima—the deviations are much too small to account for the deviations in this illustration.

most research involving long period variables 0.03 accuracy is adequate. The stars themselves are more erratic in their behaviour than this. The determination of minima of eclipsing binaries is adequately handled by this method. But if you are searching for small deviations, or wish to determine physical characteristics of an EB, then differential photometry is much better.

The advent of CCD photometry makes differential photometry much easier. The sky background is always measurable simultaneously and in many cases a suitable comparison star is on the same frame. Even if the latter is not true, it may still be much closer than in the all sky method. And, because the secondary extinctions are small, and they become well known over time, a substantial colour difference is not a real drawback.

In making the observations it always pays to interpolate rather than extrapolate, so if the comparison star is not on the same frame then measure it before and after the variable. And for fast changing stars which are being measured through more than one filter, make the measures symmetric - like BBB VVV RRR RRR VVV BBB. Three 10 second measures tell you more (how steady the system is) than one 30 second measure.

Bright objects may be difficult to measure as saturation becomes a factor. Don't try to make measures shorter than 10 seconds as on some of the older CCDs the slow shutter speed then becomes a factor. But it's easy enough to make an aperture stop when measuring bright stars. Make the smaller aperture circular and preferably not inclusive of the secondary.

In theory a star is an immeasurably small point of light from our distance. But various other factors which spread the image out need to be considered. And most amateurs are observing from less than ideal sites. With very faint stars 20" may be a realistic aperture size in order to reduce sky background but for all measures brighter than magnitude 10 the software aperture should be at least 30" in diameter. At magnitude 5 you can usefully use 45". Scintillation, which is wavelength dependent, is a problem at these levels. The 'sky' annulus should be similarly large. These values may increase the error levels as deduced by various software packages but these computer determined values are unreal in most cases.

7.0 *Determining Standards in the Field of the Variable:*

The great advantage of differential photometry— particularly when CCD frames get rid of the need to make sequential sky measures and may have a suitable comparison star nearby or on the same frame— is that it effectively removes primary extinction.

If this 'comparison' is not an E Region or similar star it might be as well to determine its value in the following manner—even if it has a published value. You do not know the quality of the values of most stars outside the Regions mentioned earlier. In selecting this star it's better to use the brightest star available, although the V magnitude difference between it and the variable should not exceed 3-4 magnitudes for a

CCD. A good PEP system has a much greater dynamic range. Obviously in some fields you might need a bright and a faint comparison star. Whilst we're talking about a comparison star you should always have a check star of known value which you treat as a variable in the reductions.

You need two E Regions with the particular variable star field to be as close to the meridian as possible. Always select the Regions each side of the field you wish to work in. Then measure in the sequence—setting Region, target field, rising Region, rising Region, target field, setting Region. Everything is symmetrical and balanced. This method keeps the primary extinction to a minimum. The Cape astronomers suggested that within 20 degrees of the zenith primary extinction effects could be ignored but if you're in a city it is better to do it this way.

The standardisation should be repeated at intervals until you're completely sure there are no problems. Say now, in a month, in 3-6 months, then next year.

8.0 Error Determinations:

Most image reduction software produces 'error estimates'. These are based upon a theoretical signal/noise ratio involving a number of factors. With early PEP we used the square root of the number of photons and these values are much the same. Accuracy, however, is based upon how closely you can match your results to the known catalogue values of stars.

The method we used was to take the results of the check stars during a season, usually a few dozen measures, and check the standard deviation. Since you will be measuring at a range of air masses this also checks the extinction coefficients at the same time. Alternatively, when you measure a region for a calibration check see how well you can get all the stars to fit as a block.

9.0 Other Considerations:

It helps with your photometry to examine the sky in daytime. How far can you see, how pale or whitish it looks at various altitudes - the sharper the blue - the better the transparency. Merle Walker used to estimate site quality by the number of days you could see objects at 50 miles from Kitt Peak.

Then a long spell of dry weather usually sees the sky getting slightly less clear—and you can usually judge this by the raw numbers or magnitudes your system produces.

Always test the transformations by measuring known stars from time to time. I select one or more E Regions and make a few measures, then choose one star as the reference/control and work everything against that. In any observing it's good to select one star as a reference to find if primary extinction is changing too quickly. Then correct all derived magnitudes by interpolation.

10.0 Future Possibilities:

The UBVR system was set up almost half a century ago and has its limitations. A number of other systems have been looked at, often with satellite measures where economy of equipment has been a consideration. These suffer in their transformation to the 'standard' system. More recently, the Sloan Digital Sky Survey has used a good selection of filters which are characterised by abrupt cut-offs at the edges of each band-pass, thus avoiding the overlaps of the old system.

11.0 References

Bond H E & Landolt A U	1969	Pub. Astr. Soc. Pacific, 81 , 696
Cousins A W J & Stoy R H	1962	R Obs Bull 49 , 3
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Hardie R H	1962	Astronomical Techniques, Univ Chicago Press, 178
Marino, B F	1970	RASNZ Southern Stars, 24 No 3 , 47

Call for Research Grant Applications

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

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

- Items of instrumentation directly relevant to variable star research such as eyepieces and photometric filters

- Software related to image acquisition, processing, measurement, and data analysis

- Obtaining research papers for which a charge is made.

Applications for the following will not be considered:

- Observatory equipment, as distinct from science instrumentation

- Equipment or software maintenance

- Subscriptions or books

- Travel.

Conditions of Grant

Only one application may be submitted by a VSS member for the 2011 round. The maximum amount of the application should not normally exceed NZ\$250.00, and smaller requests are more likely to succeed. Grant-in-aid applications, where the proposer wishes to make expenditure in excess of the amount requested and will meet the excess in other ways, are certainly acceptable.

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

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

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

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

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

Submission

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

Applications must contain:

- Full name, postal and email addresses, and phone number of the proposer

- An itemised list of the proposed expenditure items

- A justification of the expenditure.

Applications should be submitted as email attachments to the Director, Dr Tom Richards, (tom at prettyhill dot org), by 15 December 2010. Proposers will be notified of the outcome of their application by email on 20 December 2010. The grant expenditure period is from 1 February 2011 to 31 January 2012. All receipts for reimbursement must be received during that period.

Please note that the office of the Director will be closed from Christmas Eve 2010 until 1 February 2011.

ABOUT VARIABLE STARS SOUTH

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

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

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

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

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

WHO'S WHO

Director Dr Tom Richards, FRAS.

Treasurer/Membership Bob Evans

Newsletter Editor Stan Walker

Webmaster David O'Driscoll

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

MEMBERSHIP

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

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

NEWSLETTER ITEMS

These are welcomed and should be sent to the Editor. I'd appreciate them unformatted, with figures and tables separate, although if you wish a particular layout send a format-ted version *as well* and we'll ensure that this is followed as closely as possible. The main problem occurs when figures or tables run over into the next page but this is not usually too difficult to overcome. Publication dates are February, May, August and November—the twentieth day of these months—copy deadline is the first of each of these months.