

From the Director

The opening bars of the first movement



Sometimes I feel like the conductor of an orchestra – I wave a wand but everyone else produces the real music. And that's the way it is in these early days of VSS. A priority for me has been to recruit people far better qualified than I to develop the various specialist areas of VSS. In addition to Stan Walker in LPVs and Alan Plummer in Visual, we now have Dr Paddy McGee of Adelaide to handle CVs. With a PhD in CVs and a range of valuable collaborations, it would be hard to find better. I'm really looking forward to see what Paddy comes up with for us.

Bob Evans of Invercargill has kindly agreed to handle membership and finance for VSS. Thank God you're here, Bob! Membership already stands at 20, and I'd expect more to sign up at the RASNZ Conference. A membership form is in the back of this *Newsletter*. Remember, only VSS members can partake in VSS Projects.

After much arm-twisting, I've finally persuaded me to take on the role of Coordinator of the Eclipsing Binaries Programme. I've got a couple of projects in mind that I'll discuss later in this *Newsletter*, but I confess I've been too busy running this show to have anything concrete yet. Which is why a Director shouldn't be a Coordinator. Anyone want to take Eclipsers away from me, please? Pleeese?

Everyone is waiting on what Michael Chapman will produce for our website, www.varstars.org. The website will be absolutely central to our operations. It's a big undertaking, and when you have a very demanding day job and other astronomical obligations, let alone family, you can't power ahead as fast as a retiree like me. Mike will be at the Colloquium in Wellington on May 22nd, and I think you'll want to badger him with ideas and questions. I've provided him with fairly comprehensive specs, but the real work is turning specs into a workable reality.

Talking of the Colloquium, as of writing we have 30 registrants, which is good. The Programme is on page 31 of this *Newsletter*. We're finishing the Colloquium in the afternoon with an open session on ideas and proposals for VSS. Here are some headings you might like to think about. You can no doubt think up others.

- Research areas and projects.
- How should we organise and run Projects?
- Recruitment and membership.
- Training and advice.
- What do we want our website to do?
- Relations to other organisations.

If you're not going to be there, please email me at Tom.richards@varstars.org with a *brief* paragraph of your question or bright idea so I can put it to the meeting. Otherwise, see you there!

EDITOR'S COMMENTS

Stan Walker

I'm a bit rushed in completing this for a variety of reasons—none connected with astronomy other than the forthcoming Colloquium (and my undertaking to produce a couple of coherent and challenging papers). So please ignore any minor miscues—next one in August shouldn't have problems.

One thing that has not gone as well as expected are the targets for LPV projects—but these will be updated on the website. PEP in the south developed in a completely different manner than in the NH and it's taking a while to get to grips with some people's expectations that there will be selected comparison stars for each target star. At Auckland over the years we sort of learned DIY photometry as there were few people actively involved in this. The other is the conversion from the popular—and relatively simple—unfiltered time series photometry of CVs and similar objects. But there's a glut of observational data on these objects, the majority of which has not been analysed, nor published, so it's rewarding to tackle other projects. Multicolour CCD work is completely different to unfiltered TSP—so I have to be impressed to the work being done by Giorgio di Scala and others.

There are a number of people observing that we haven't managed to contact as yet—Alan Plummer is keen to work with any visual observers—and Tom, Paddy and I would like to hear from any 'electronic' observers. I'd like to be one myself but weather, the Newsletter and the Colloquium have rather precluded that. But let's hear from you.

We've also dropped the lists of Miras at maximum and minimum. Not because they're unimportant but because they're available on the AAVSO website and duplication is a waste. But I'm personally becoming more convinced than ever that we need these visual measures of Miras—in spite of ASAS3. So keep observing!

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STARS OF THE QUARTER

Stan Walker

BH Crucis

This star is an interesting Mira, but without a long history—which is a surprise as it reaches close to naked eye visibility at maximum of ~6.5. It was discovered by Auckland amateur Ron Welch in 1970 and its nature was determined by UBV photometry at the Auckland Observatory. It was one of the rare group of Mira stars showing double maxima—see *Newsletter*, 2009, February.

At that time it had a period of 421 days and a search of patrol photography in the 1930s and 1970s—though rather poor in quality—suggested similar periods then. However, after 5 maxima were measured the nature of the star began to change. The period lengthened dramatically and the first maximum became much less pronounced. Spectroscopy during the interval 1970-80 indicated an SC class, although this appeared to be changing.

It showed a gradually lengthening period during the next 12 cycles. These have been calculated using epochs of minima as the changing shape of the light curve made the detection of the date of maximum somewhat uncertain. The last 12 maxima show no period change and can be fitted by a period of 525 days.

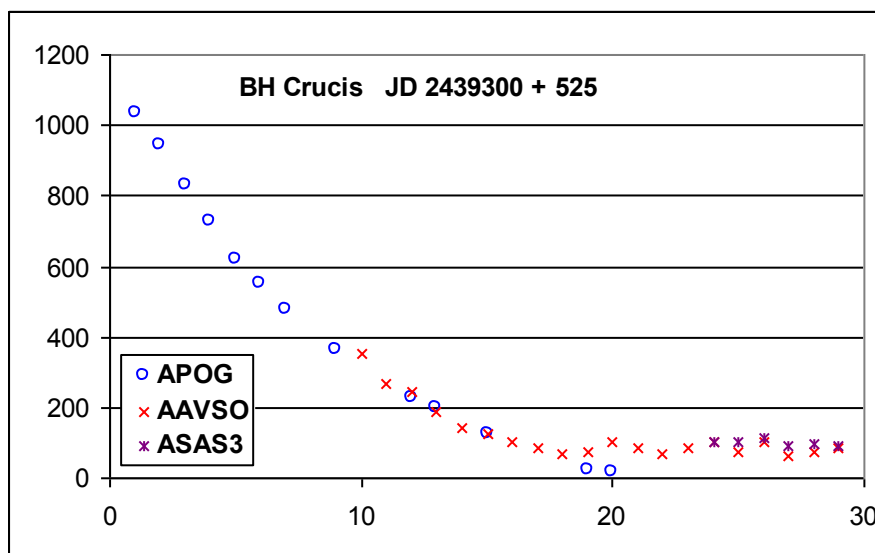


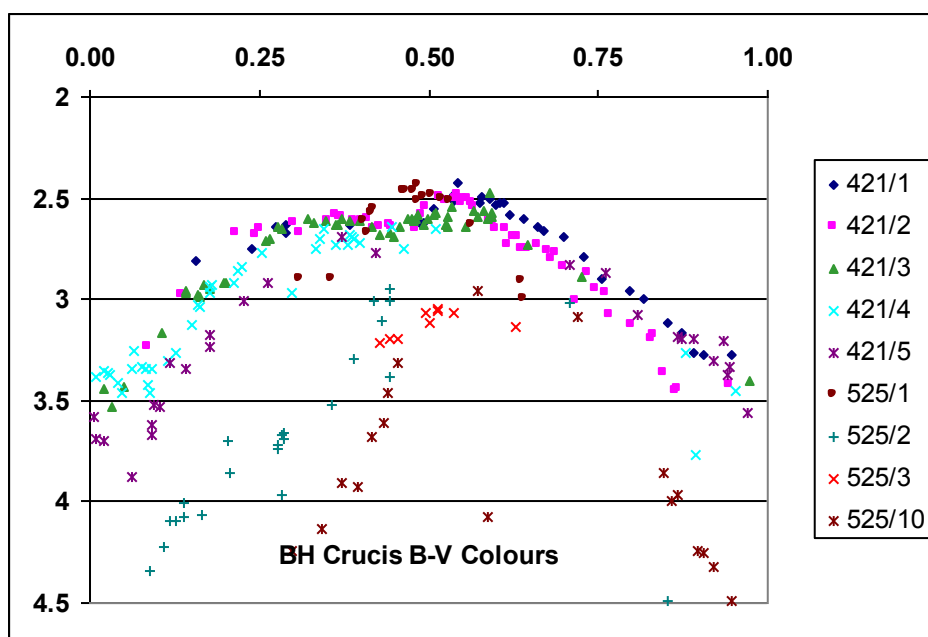
Figure 1 illustrates the changing period of BH Crucis over the past 28 years. The first five measures make a straight line, indicating constant period and the last 12 are similar.

This star is unlike the other classical period changing Miras—R Aquilae, R Hydrae and R Centauri in that the period change has been very quick—in 12 cycles as opposed to hundreds—and has lengthened, rather than shortened.

Initially consideration was given to the idea of a change of pulsation mode—after all, BH Crucis is unusual and almost anything seems possible. But the ratio between mode⁰ and mode¹ is rather larger than the 104 days observed. Higher overtones are possible, but these then require a much longer fundamental period.

If the period has changed by such a large percentage—and with very little brightness change—then the star itself may well have changed its diameter in conformity with theoretical models. This would result in a detectable change of temperature. Luckily there is a large number of UBV measures made by the Auckland Photoelectric Observers, as well as some more recent BVI measures made by Giorgio di Scala and available from the International Database. These are plotted in Figure 2.

These measures support the proposal that the star has cooled substantially, hence must have a much larger radius to emit a similar amount of light. The changing shape of the light curve is evident in this figure, as also is the position of maximum temperature. This is noticeable in the V light curves, where maximum is rather hard to determine accurately. The star seems also to be much redder at minimum.



The legend shows cycle numbers related to period. There are 12 cycles missed out between the two sets.

Cycles 421/1-5 were all measured at Auckland Observatory using an EMI 9502 photomultiplier tube. Cycles 525/1-3 are from Milton Road and Waiharara using an EMI 9924 pm tube—similar S11 cathode, fewer stages. The last measure was with an SBIG ST 9

Figure 2 shows B-V colours for 9 cycles—periods of which are noted in the legend. There is a noticeable reddening of the star, supporting a cooling and expanding star. With such a red object the transformations are probably not ideal as four different photometers have been involved. The B-V colour curve during the first five cycles—when BH Cru showed dual maxima—are reasonably similar. The remaining curves are quite different, due to the first maximum having turned into a rather erratic and quite small hump on the rising branch. Strangely, the first of the 525 day B-V curves shows little colour change. The last three, however, show a marked reddening of the star and follow the decrease in amplitude of the rising hump. Our project involving double maxima Miras fortuitously involves this star as one of the targets. Any observing contributions would be welcomed—see also the SC star article on page ##.

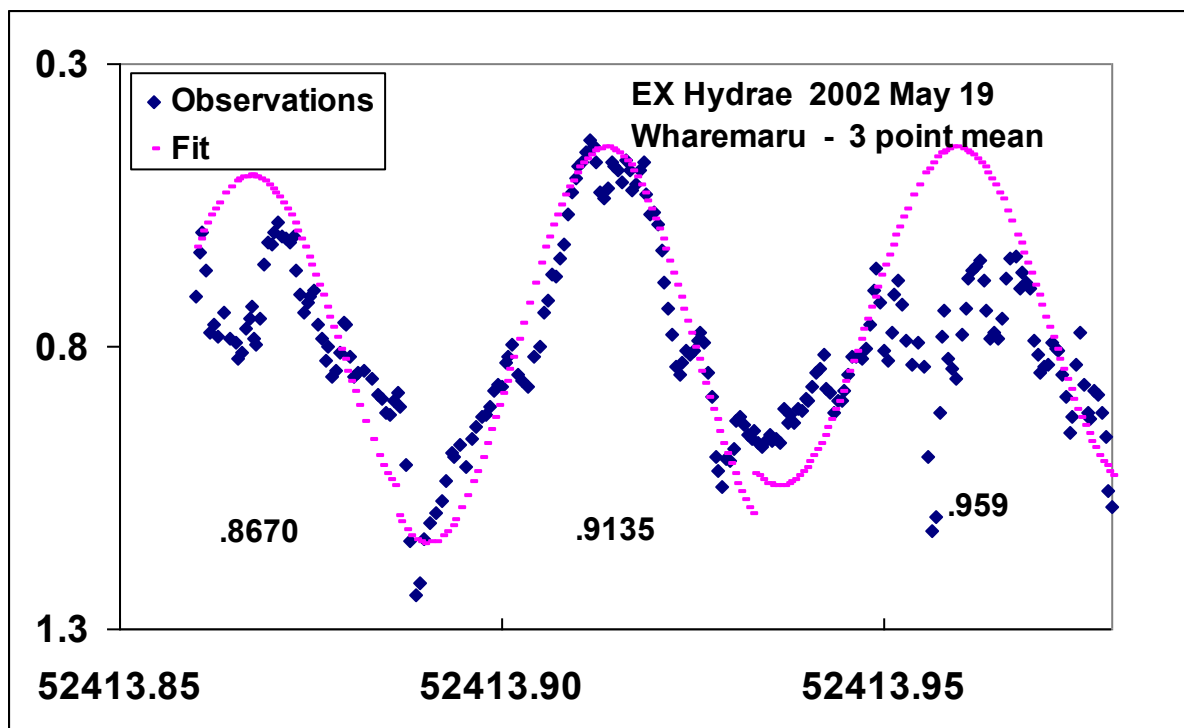
EX Hydrae

This CV is interesting as an intermediate polar, with periods of around 67 and 98 minutes. The AAVSO are promoting a campaign this winter and some of our readers may wish to participate—it is, after all, a southern object.

Its main properties were established in the 1970s, largely through a campaign involving amateur-professional cooperation on three continents. Observers included Nicholas Vogt in Chile, Chris Stercken in South Africa, Arthur Page and Harold Kennedy in Queensland and Brian Marino, the writer, and others at Auckland Observatory. This gave complete coverage apart from cloud and there were several stretches of more than a day. Amusingly enough, the most prolific site was Auckland with clear skies during over 80% of the dark hours in April, 1979.

What we're seeing is an eclipsing CV—which had been known since the 1950s—but with a very strong magnetic field which allows accretion onto the white dwarf only at the poles. George Mumford observed this star for a decade or two prior to this in the hope of seeing some evidence of gravitational slowing of the orbital period but even now it's not clear why the different periods are changing. After that Roger Freeth and Ian Bond made many hours of high speed measures from Auckland, Mt John and Black Birch observatories. Bill Allen and I observed it in the early 2000s, up to 2002 June, and published our findings in the last issue of the old style Southern Stars.

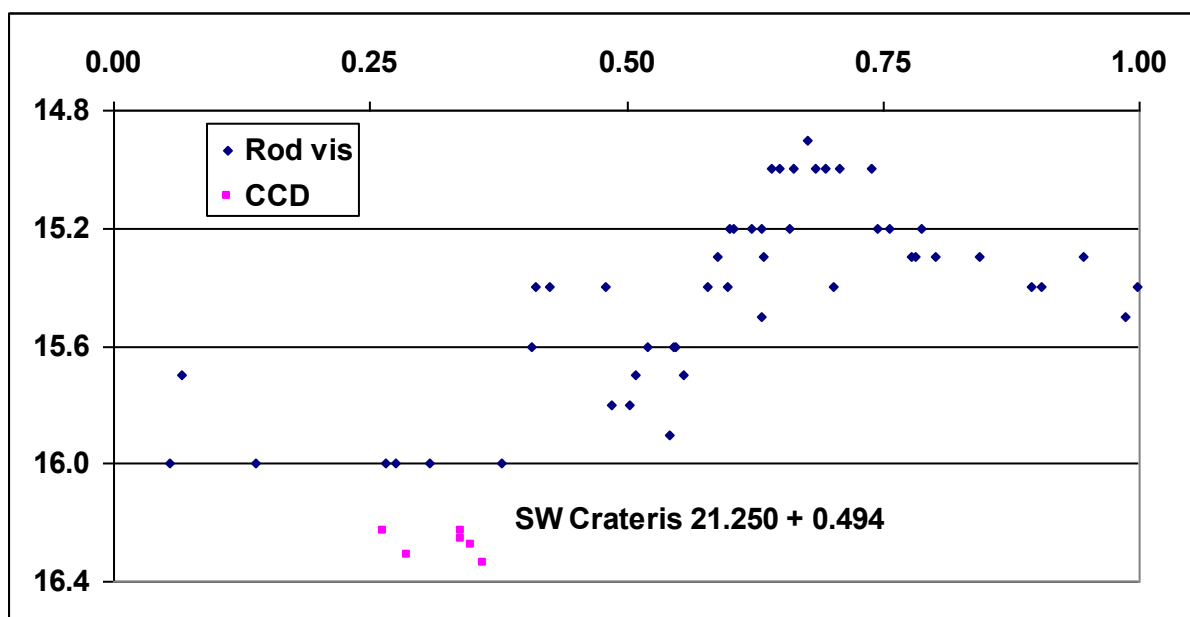
There's continuing interest in the period changes—whilst the conservatives opt for a gradual, parabolic change there is considerable evidence that the changes are abrupt—arguing for some event-based mechanism. The CBA were looking at this star a year or two ago but I have not seen the results published. But it's time that the star and the situation was reexamined.



Here we see three hours' measures of EX Hydrae with the purple line showing the expected white dwarf 67 minute period fitted to the data. Deduced fractions of a day are shown. Eclipses are easily seen—the first coinciding with the minimum of the WD rotation period, the second near its maximum, with dramatic distortion of the light curve. It's a challenging target! The running mean helps to cancel out the flickering.

SR Crateris

Rod Stubbings drew attention to this star. It has apparently been called both a CV and an RR Lyrae star. His light curve for March-April, 2009, appears below. Both this and the colours of B-V ~0.4 appear to support this, but it also has intervals when it behaves like a Z Cam star with no variation. What is it? Obviously the period of almost half a day is unattractive and presents problems but if any CCD observer feels like a different target here's a good one. Rod is at stubbo@sympac.com.au



Eclipsing Binaries for Fun and Profit

Bob Nelson, PhD

All right, there is no profit. But they *are* fun. A pair of stars, one being eclipsed by the other, yields a dip in the light intensity over time that is easily picked up by the eye or CCD camera. Accurate determinations of the times of minima yield information about any period changes that might be present which in turn yield information about physical changes in the stars, e.g., mass interchange, a possible third star, overall evolution, etc.



In a more thorough study, accurate measurements of the light intensity throughout a full period (called a *light curve*) using one or more colour filters can be analyzed by available software on any computer. The result is fundamental parameters about the stars, such as orbital inclination, stellar temperature and size, etc.). However, we should start at the beginning. Most astronomers know that there are three classes of variable stars:

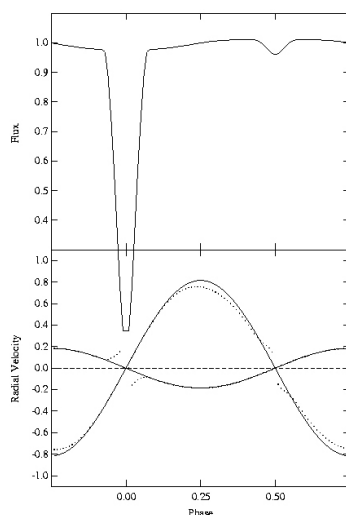
1. Eruptive -- protostars, Wolf-Rayet stars, supernovae, novae, U Geminorum
2. Pulsating -- Miras, Cepheids, W Virginis stars, Delta Scuti stars, RR Lyrae stars
3. Eclipsing -- EA, EB, and EW.

The first two classes are called *intrinsic* variables because the variation in the light intensity originates from physical processes within the star. The last class is called *extrinsic* because the variation in light intensity occurs to a process without the star (e.g., eclipses).

The simplest eclipse process results from two stars in orbit about their common centre of mass. Just by chance (we would not see eclipses otherwise) the inclination is close to 90° and one star passes in front of the other, resulting in a loss of total light that we see. It can get more complicated (with an accretion disks, mass transfer streams, star spots, etc.). Also, one or both of the stars can be a pulsator or even eruptive.

Eclipsing variables are classified by the General Catalogue of Variable Stars (GCVS) on the appearance of the light curve alone. There are three main classes: Algols (EA), Beta Lyrae (EB) and W Ursae Majoris (EW), together with numerous sub-classes, and the nomenclature in the GCVS can get quite complicated. Basically speaking:

The EA-type binaries exhibit light curves that are essentially flat between eclipses. The primary eclipse depth can be deep (by many magnitudes), and the secondary, very shallow or even undetectable. They generally have long periods, ranging as from a fraction of a day to as long as 10,000 days; however, at the 90th percentile, periods lie in the 0.7-18 day range.



RW Tau (Algol-type)



$$T_1 = 11,750 \text{ K}, T_2 = 4271 \text{ K}$$

$$q = M_2/M_1 = 0.2256$$

$$\Omega_1 = 5.599, \Omega_2 = 2.296,$$

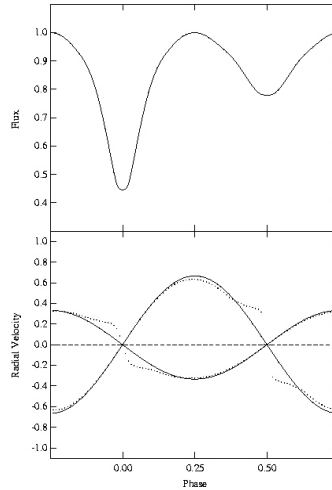
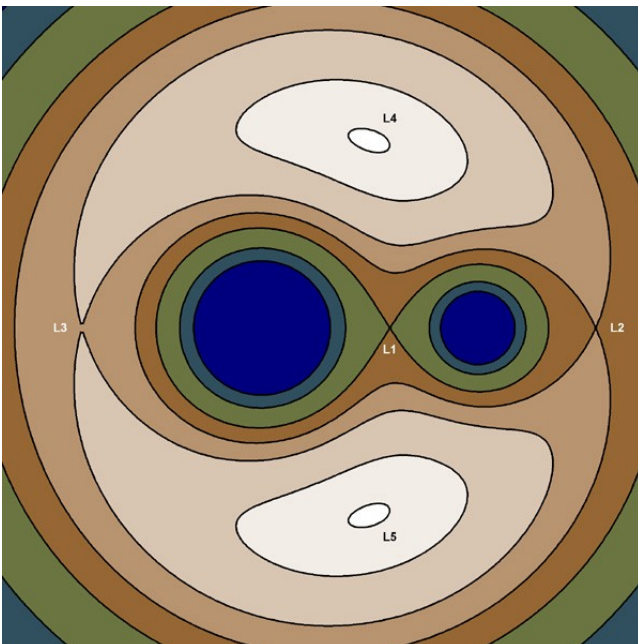
$$\Omega_{\text{inner}} = 2.296$$

phase = 0.2500

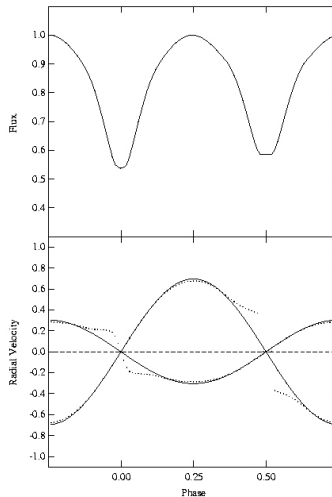
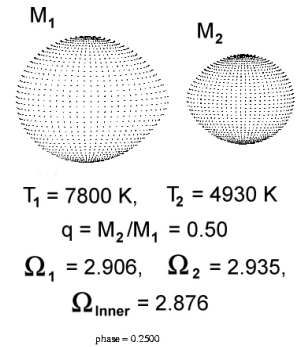
The EB-type binaries exhibit light curves that are continuously variable with eclipse depths that are, in general, unequal; the primary is typically a magnitude. Periods vary from 0.4 to 200 days; however, at the 90th percentile, periods lie between 0.46-8.8 days.

EW-type eclipsers also exhibit continuously variable light curves with equal eclipse depths 0.7 magnitude or less. Periods vary from 0.005 days (!) to 2.4 days; however, at the 90th percentile, periods vary from 0.26-1.1 days.

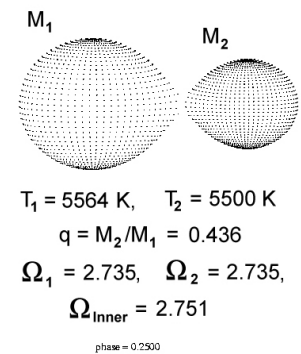
To understand the situation, one first needs to understand gravitational potentials and Roche lobes. As any student of physics knows, there are surfaces of equal potential energy surrounding two static masses (or like charges, in the electrostatic case). Close to each mass, the surfaces are spheres (or circles in 2-D). Further out, they get distorted due to the presence of the other mass. There will then be a potential energy value where surfaces of each star having that value just touch at one point (see L_1 below). In the rotating case, this potential surface is known as the *Roche lobe*, a dumbbell figure in 3-D, and a figure-eight in 2-D. (See Figure 1.) Further out, at lower values for the potential energy, the surfaces pass around *both* masses, becoming 'dumbbell'-shaped. And lastly, as the distances get larger and larger, the potential surfaces approach spherical shapes again.



EG Cep (EB-type)



RZ Com (EW-type)



When rotation is present, another term gets added to the mathematical expression for the overall potential energy. As a result, some of the outer lines cross and loop around. See Figure 4. Note that this diagram represents a slice through a 3-dimensional structure; the rotational axis is a vertical line.

The three crossing points (plus two others) are known as the *Lagrangian points*.

If we go to the analogue of a topographical map, the lines now become the contour lines. Close to each mass, we have the steep slopes of a 'volcano' and, in between, we have a pass -- the familiar saddle shape. This is represented by point L_1 . Further out, we have two

'sink holes' -- points L₄ and L₅. There are also two more saddle points -- L₂ and L₃.

Moving back to the case of the orbiting masses, we have many interesting examples. For example, take the case where the large, more massive object on the left is the Sun, and the smaller object is a planet. Remember that the whole structure is rotating about the centre of mass of the two objects. Point L₁ is the place where the two gravitational forces on a small object placed there just balance out. The Solar and Heliospheric Observatory (SOHO) was placed there by NASA in 1995-6 (originally as a 2-year mission; it is still operating). It has the advantage of being accessible from the Earth and getting an unobstructed view of the Sun.

The L₂ point (on the right in Fig 1) is where the two inward gravitational forces balance the outward centrifugal forces on a small object placed there. The Wilkinson Microwave Anisotropy Probe (WMAP) was placed there by NASA in 2001; future observatories to be placed there are the Planck satellite, the Herschel Space Observatory, the Gaia Probe, and the James Webb Space Satellite. They will also be accessible from the Earth and have an unobstructed view of the heavens away from the Sun.

The L₃ point is on the other side of the Sun, a little outside the Earth's orbit. There, the gravitational force from the Sun and the very weak gravitational force from the Earth (in the same direction) are balanced by the outward centrifugal force.

Points L₄ and L₅ are a curious case. They lie at the same orbital radius as the planet and, for each point, the lines to the two masses and between the two masses make equilateral triangles. It turns out that an object placed there is in an exceptionally stable orbit and can in fact make quite large loops around that point. Jupiter's L₄ and L₅ points contain several thousand *Trojan satellites*. Other planets may also have objects at their L₄ and L₅ points. (See Wikipedia for *much* more information -- key in 'Lagrangian point'.)

This discussion will resume next issue when we will use the knowledge of the potentials to look at the physical processes that produce the light curves.

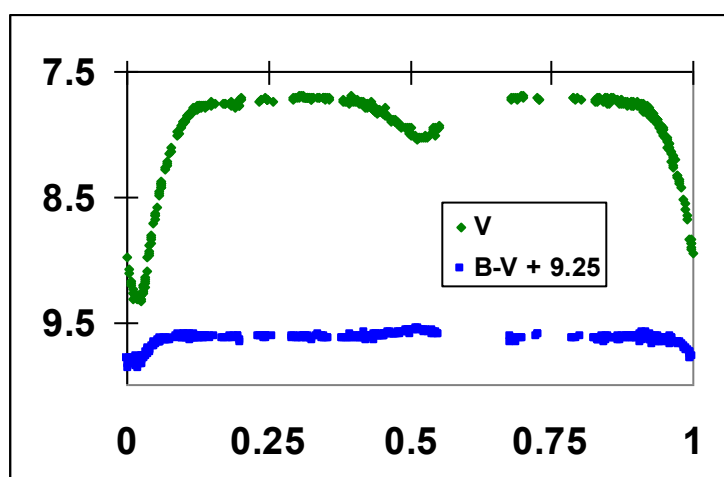
PROPOSED TARGETS

Bob has sent VSS a list of underobserved southern binaries—it's size is staggering—and Tom has been discussing joint observing programmes with him and with Roger Pickard of the BAA VSS. More about these in the next issue and also on the website.

Since we've got a space a light curve of KZ Pavonis, produced at Auckland Observatory Back in the 1980s, is shown here. The observations, phased to the elements:

JD 2444434.7546 + 0.9498768

show a couple of reasonably well-observed primary and secondary eclipses. Note the reddening during primary, and the slightly bluer light curve during the secondary. The B-V colour curve has been offset but the scale is identical.



Around the World with Eclipsing Binaries

Tom Richards

Coordinator, Eclipsing Binaries Programme

Tom.richards@varstars.org

I'm not going to tell you anything about EBs here, because either you know far more than me or you can read Bob Nelson's first instalment on these fascinating objects in this *Newsletter*. Instead, I'm announcing an international collaborative project on them, and asking readers to sign up for the ride. It's a project that can involve observers with many different instruments: from visual observing with small telescopes to CCD work on big reflectors – plus spectrography.

The idea arose from a visit to Roger Pickard, Director of the Variable Star Section of the British Astronomical Association. In our discussion he suggested a joint project on EBs near the celestial equator, which can be reached even by the far-north British Isles and the far-south Shaky Isles. A wide longitude coverage is very desirable for getting un-aliased period data quickly. When I proposed the project to Professor Bob Nelson of Canada, our EB Adviser, he was most enthusiastic about it and said he could probably help with obtaining RV spectra from the venerable 72-inch DAO reflector (pictured).

We will look at a small number of bright detached (EA) eclipsing binaries, within 10° of the celestial equator, and for which there's a good chance we can make significant contributions to what's known about them.

Ideally, we'd aim to obtain the following for all our candidate stars; but in practice we can start with good ephemerides.

- a) precise multicolour light curves and ephemerides,
- b) radial velocity curves,
- c) historical data from bibliographic searches,
- d) derivation of astrophysical quantities,
- e) analysis of secular changes,
- f) shape models where possible.

How will we go about it?

1. We will sign up observers from European longitudes through the BAA. We will go for observers in the Americas; and of course from Oz and NZ. Plus anyone else!
2. Observers will be assigned a small number of stars, maybe 2-3, suitable for their equipment. When one is due to have an eclipse in their skies they will be notified and asked to observe it. Full observing instructions and comparison star data will be supplied.
3. Observers will be asked to comb the available online data (Simbad, ASAS-3, etc.) to get as much information on their stars as possible.
4. Results will be collected and analysed centrally using our (upcoming) website.
5. Final results for each star will be published under the names of everyone who has contributed significantly to the work on it.

I'm working on the candidate star list right now. A full project spec, observing instructions, etc. will be available shortly. I'll have more to say about this project at the "Observing Southern Variables" colloquium in Wellington on Friday 22 May. Email me if you're intrigued.

VISUAL OBSERVING and VARIABLE STARS SOUTH

Alan Plummer Visual Coordinator

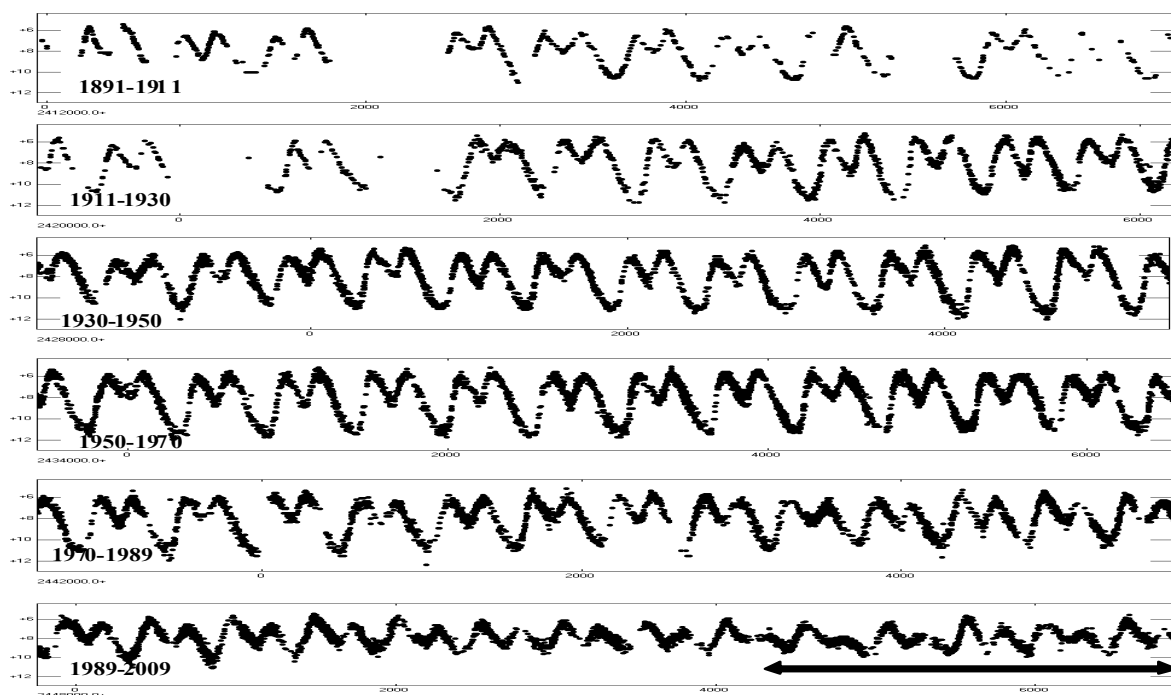
One of the finest observers of all recently expressed the concern to me that visual VSOing may not be valued by the VSS now-a-days, and to his pleasure, I could say otherwise. It is. Watching the public email discussion forums over some time I've only ever noticed one observer put down us eyeballers, and he just seems to pick fights anyway. To everyone that matters we are valuable observers working in partnership with the other technologies.

We visual observers may be our own harshest critics when it comes to the pros and cons of electronic and visual observing. My own issues include a continual struggle with the Purkinje effect, (I only have to find the *field* of a red star and it leaps out at me appearing brighter than it really is) and, why should I observe when the *All Sky Automatic Survey* (ASAS) does it better?

First and simplest, the Purkinje effect and other problems of technique; I can strive to improve. Anyone who doesn't know the potential problems here can read one of the visual observing manuals available from the RASNZ or AAVSO websites. And second, for an excellent discussion on working visually in the time of automatic surveys, we would all do well to listen to the AAVSO podcast 'Can Visual Observers Still Contribute to Science?' There is a transcript available too, on that website.

I observe for the sake of being under the stars, not to compete with anything or anyone. The ASAS is simply one very accurate and prolific (not perfect!) observer. Southern VSOers have had Albert Jones being prolific and accurate for decades, and, thankfully, have still worked. It must be similar also to being a professional golfer in the time of Tiger Woods.

Some *commitment* or other is important to get the most out of astronomy. For instance, look at Figure 1. Because the task I chose was VSOing, I've contributed to this data. This is the light curve of long period variable R Centauri, plotted from data downloaded from the AAVSO database. This includes contributions from the VSS RASNZ members, the AAVSO, and goes back to the work of one Alexander Roberts (1857-1938), an eccentric Scotsman living in South Africa who made over 70,000 observations. My own brief time observing, six years so far, is underlined. So you're looking at many people's entire observing careers here, finishing, and new ones beginning.



See how the light curve has changed. Sabin and Zijlstra (2006) state the following: R Cen has undergone a sudden change in the pulsation period evolution. From 1919 to 1935 the period decreased from 550 to 543 days and after a brief episode of increase to 553 days until 1949, we see a spectacular drop to 512 days by 2001. This fall may be due to the occurrence of a thermal pulse, a complicated interaction between the stellar core and a shell structure deep in the envelope. To witness this happening, to see it reflected in the light curve, is most exiting and unusual.

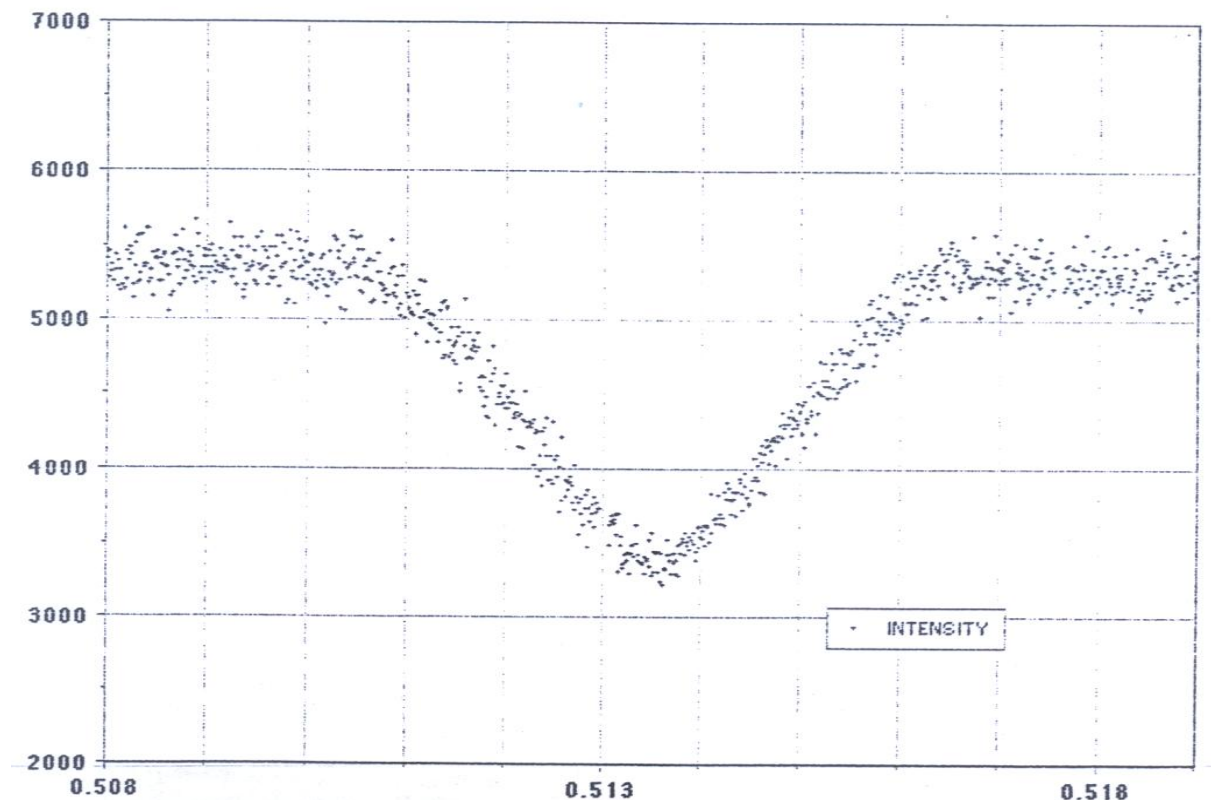
To get back to the VSS; it values its visual contributors as it does the electronic. The organization is 'project based' for visual observers as it is for others, to give a more focused, pardon the pun, approach to observing. At the time of writing there are two projects for the eyeballers: the dual maximum long period variable study which includes R Cen above (look at the curve!), and a beginner's project looking at eta Car and R Car in combination with John Tebutt's 19th century work.

For information about the dual max project contact Stan Walker—Stan.Walker@varstars.org, and for the beginner's project, including anyone that observes R and eta Car anyway, please contact me—Alan.Plummer@varstars.org. And of course, observe as many objects as you can, and come forward with project ideas yourself. You never know what you'll find.

Reference: L. Sabin and A.A. Zijlstra, 2006, Mem. S.A.It. Vol. 77, 933

MUTUAL OCCULTATIONS

Not strictly a variable star item, but it's the season for assorted planetary satellite eclipses and occultations. We're looking along the equatorial planes of Jupiter, Saturn and Uranus this year and their satellites go through a complex series of mutual events. I'm unsure if there's still any scientific value—but it's entertaining to watch and measure. Uranus is worth doing as the events will not recur for a long time! Armagh has a web site and there are various other sites, mainly in France. Below you can see Bill Allen's measures of Io occulting Europa in 1991.



SEMI-REGULAR VARIABLES

Terry Moon, Sebastian Otero and Stan Walker

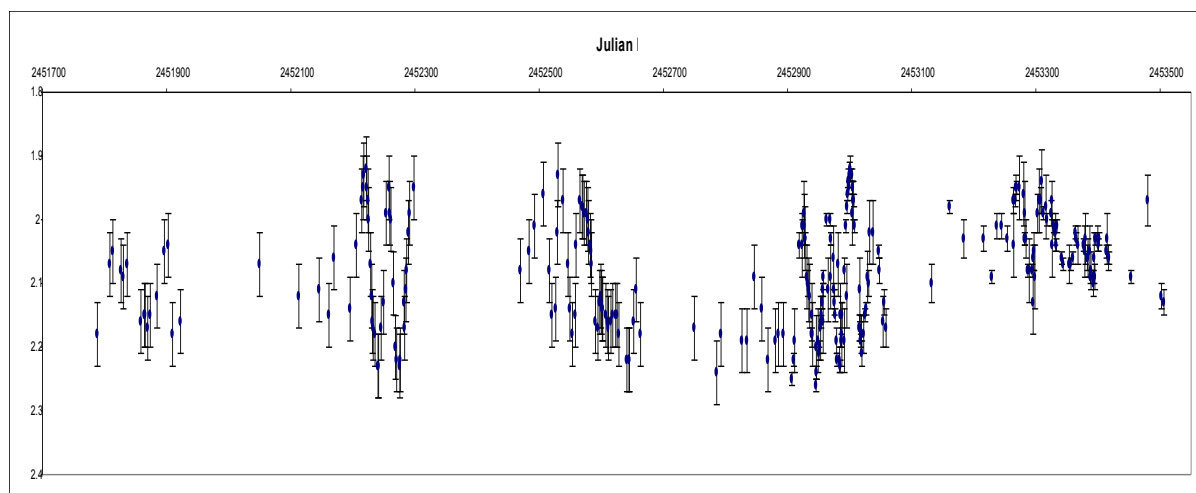
In the last two Newsletters we have mentioned a couple of semi-regular stars—L² Puppis and theta Apodis. In many ways these stars are more interesting than Miras—their periods tend to be less regular, hence the name, and often there is more than one periodicity present at the same time. But are they important? Well, from a personal viewpoint it shows what our own Sun will become a few billion years down the track from now. And the stars themselves are interesting and measures are scientifically valuable for many reasons.

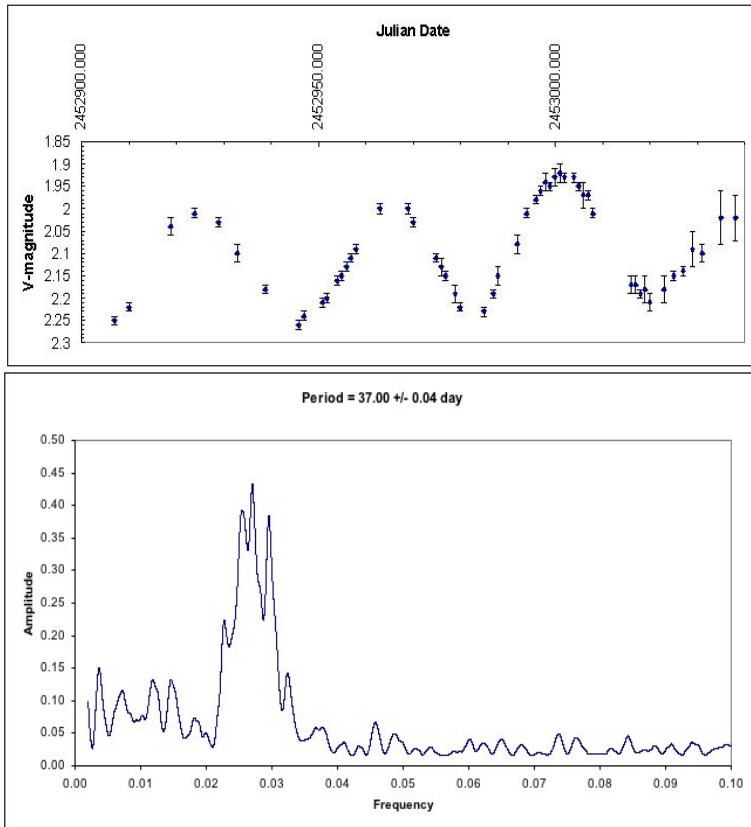
To gather data for better understanding of SR variables involves more consistency and more accuracy than observing Mira stars. Periods are generally shorter and of lower amplitude. Thus measures need to be more frequent and more accurate. The whole structure of visually observing Mira stars is based upon a large number of people randomly measuring brightnesses in the knowledge that these can be fitted together to provide a picture of what are essentially regular and almost predictable light variations. This doesn't work on short period, small amplitude stars.

Semi-regular stars on the other hand require that we move away from this essentially 'random data' approach and that each observer concentrates upon making far more measures of a more limited range of objects. Since each visual observer has different colour response and different equipment not more than two or three observers, who tend to get similar results, are needed for each star. We're not saying that one observer is better than another—just that each of us see these red stars in a slightly different manner.

In a way this is resurrecting the concept of a 'personal equation' which Frank Bateson was trying with the old RASNZ VSS. The concept was sensible, but it can only be applied when a small number of observers are producing large numbers of measures of one object. This was discussed in the February Newsletter, with Otero's visual and Moon's pe V measures being fitted together with small corrections, or Ives' measures and the AO V measures being matched in a similar manner.

So this is a different way of observing, with more organisation and targeting of stars. John Percy in Canada has been working with students to measure some of the very short period objects. Amplitudes of these are quite low. Let's look at a bright SR star, beta Gruis. Otero was the first to determine a period of 37 days and Moon then followed up with V photometry to refine the light curve. Five years of Moon's measures with error bars are shown below. These reveal an amplitude varying between 0.25 and 0.4 magnitudes—you wouldn't notice this at a casual glance. Overleaf a selected interval of 140 days—from JD 2452900-3040 shows a reasonably regular period





This expanded presentation covering 140 days shows clearly the beta Gruis light variations. They appear quite regular with no noticeable secondary period.

The periodogram below shows only a single period with some phase jitter—which is what you would expect in one of these stars.

To get this data, Moon has measured the star on average two to three times a week without any noticeable gaps. This is what is needed with these objects.

Quite obviously Otero made measures accurate enough to determine a period but even with his unique approach to measuring bright stars visually it required the accuracy of p_V to complete a picture of beta Gruis.

Many of these stars are close enough to have reliably measured parallaxes and even angular diameters, so there's more information available and a complete picture emerges. And simple colour photometry, and the spectral classes which are available for all these nearby stars gives good temperature values.

Continuing this theme we include a very recent email from one of the professional astronomers with whom Moon and Otero collaborate. This supports the ideas developed above.

Variable Stars South and Short Period Variables

Associate Professor Tim Bedding, University of Sydney

Terry, sorry for the delay in replying, both Laszlo and I are in Europe at the moment. As I said earlier, the best stars are those too bright for ASAS, which means $V=8$ or brighter. Given that, any star is potentially valuable, especially those that have been poorly studied. Anything classified as irregular would fall into that category.

And probably best to get good coverage on fewer stars, rather than sparse coverage of a bigger sample. The differences between observers/equipment suggests that individuals should concentrate on different samples, although certainly with some overlap, rather than getting everyone to observe everything.

Note that Vello has stopped observing in order to concentrate on writing his thesis, so there is no reason to avoid his stars. On the contrary, extending the time base could be a very good idea. It will be a long time before any new targets have a series as long as he has obtained. It would be worth going through his stars to see which would benefit the most from continued coverage.

Southern stars are certainly good, to reduce the gaps. And yes, shorter periods are good because more cycles can be covered in a given time, but note that longer period stars can also have shorter periods at the same time. So I guess I am advocating that each star should have long-duration coverage that is as complete as possible, from a relatively small number of observers. I hope this helps, and sorry again for the slow response.



Terry Moon at the controls of his 100mm refractor with attached SSP5 CCD camera. This illustrates one of his comments elsewhere that as long as the telescope supports the instrument without wobbling it's adequate. He states:

At the heart of my system is a SSP-5A photometer which has 3 sensitivity settings, 1, 10 and 100. With a 10 cm telescope I find that I can readily measure stars from 2nd magnitude down to almost 7th magnitude.

And Terry's just bought a 150mm Synta Maksutov which he's trying out as time permits.

A lot of these stars are quite bright and easy to locate. It has become clear over the past few decades that virtually every M type star is variable—and as a result thousands of new SR stars have been added to the roll of variable stars. But not all are likely to be rewarding so we need to take care in selecting candidates. SR stars are presently divided into four sub-types—SRa to SRd—but these categories are not the best from the observer's viewpoint. So let's do a little arranging.

Visually Observable.

Amplitude is the major factor here. Only very experienced and accurate observers can usefully make measures of stars with an amplitude less than a magnitude and bearing in mind the likelihood of an increase in the number 'of electronic observers' 1.5 magnitudes might be a better figure. Periods are important—it's difficult to get adequate measures with stars whose periods are less than 50 days. So most visual observers will be looking at classical objects—R Pictoris, T Centauri and similar—all of which have periods near to, or in excess of, 100 days.

How do you judge whether you're accurate enough to look at the harder targets? A useful exercise involves estimating I Carinae, a Cepheid which varies from 3.28 to 4.18 in V over a period of 35.54 days. The light curve is very repetitive and the amplitude of 0.9 magnitudes, combined with this shorter period, will provide you with something of a yardstick.

Sebastian Otero shown using something other than his usual binoculars or unaided eye. He states:

I live in Buenos Aires, the Capital city of Argentina, so I observe from a far from ideal sky. However, on the best nights I have reached a limiting magnitude of 5.7 naked eye. But most people don't even get to 5.0.



Suited to Single Colour PEP or Equivalent.

By equivalent we include CCD with V filters or SLR cameras with the ability to extract separate V measures, both of which can be transformed to the standard colour system. With these stars measures will produce good light curves with stars where the amplitude is 0.3 magnitudes or more. At least 10 measures per cycle are necessary—see the illustrations of beta Pictoris earlier. Transformation to the standard system is essential if measures from more than one observer of any star are to be useful.

Some observers may wish to observe one particular unstudied star and work on this. This may be useful with short/period low amplitude objects for exploratory purposes, although later more complex measures may be needed. Amplitude tends to follow the spectral class, increasing as the class moves from M0 to M5.

Colour Photometry.

Apart from standardising the V filters described above this is not a field for single observers. Amateur colour photometrists are usually working in three areas, UBV, BVRI or JH. So collaboration between a number of observers is needed if the measures are not to become just random data. Such a collaboration is envisaged in the Phase Lag project mentioned elsewhere and soon on the web site. To cover a range of spectral classes in these cool, red variable stars this includes a number of SR stars—but with longer and more regular periods so that the phases can be identified unambiguously.



THE POLAR TELESCOPE

Tom says I should include a photo of the Editor but apart from my passport and driver's licence I'm rather anonymous.

But back in 1997 Professor Joseph Patterson sent me an ST8 CCD camera—and I tried to get a few people to explain how it should be used. At the time we were building our residence at Wharemaru and the observatory was way down the list.

So I dumped a 3 metre stockyard post in the ground—with a lightweight but effective concrete support structure—the whole thing was more rigid than about 80% of the telescopes I've seen—and went about observing CVs for Joe.

The first project was on V803 Centauri and was very successful in observing the 23 hour outbursts of this object. More about this type of approach on page 28. And it took a long time to reduce the 3000 measures of V803! Progress has helped in one area—but don't take it too far!

This all illustrates a great truth—simplicity has its own rewards. I have a good friend who's building an observatory—has been, in fact, since 1985. But it's not finished yet and no observations have ever been made. I don't think they ever will be. So his heirs will be faced with getting rid of a strange and rather useless structure. And what's happened to the Polar Observatory? Joan now grows climbing roses on the post—after I removed the structure—and it's an unusual and attractive aerial garden! But the number of times I've had the bald patches on the head scratched!!

Choosing a Measurement Aperture

You can know all the theory of the “three-ring circus” of CCD photometry **measurement apertures**, (see lexicon on p.30) but still need experience and a lot of trial and error to do a good job – particularly if you are measuring a time series of a hundred or more images from one night. I find I can easily improve my results on early images from many years ago, by a more informed choice of measurement apertures. I also find that many others make poor choices of apertures.

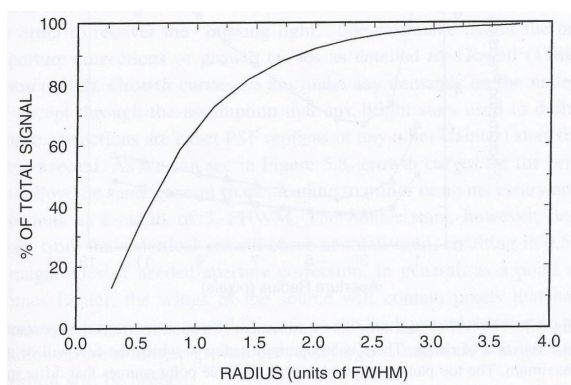
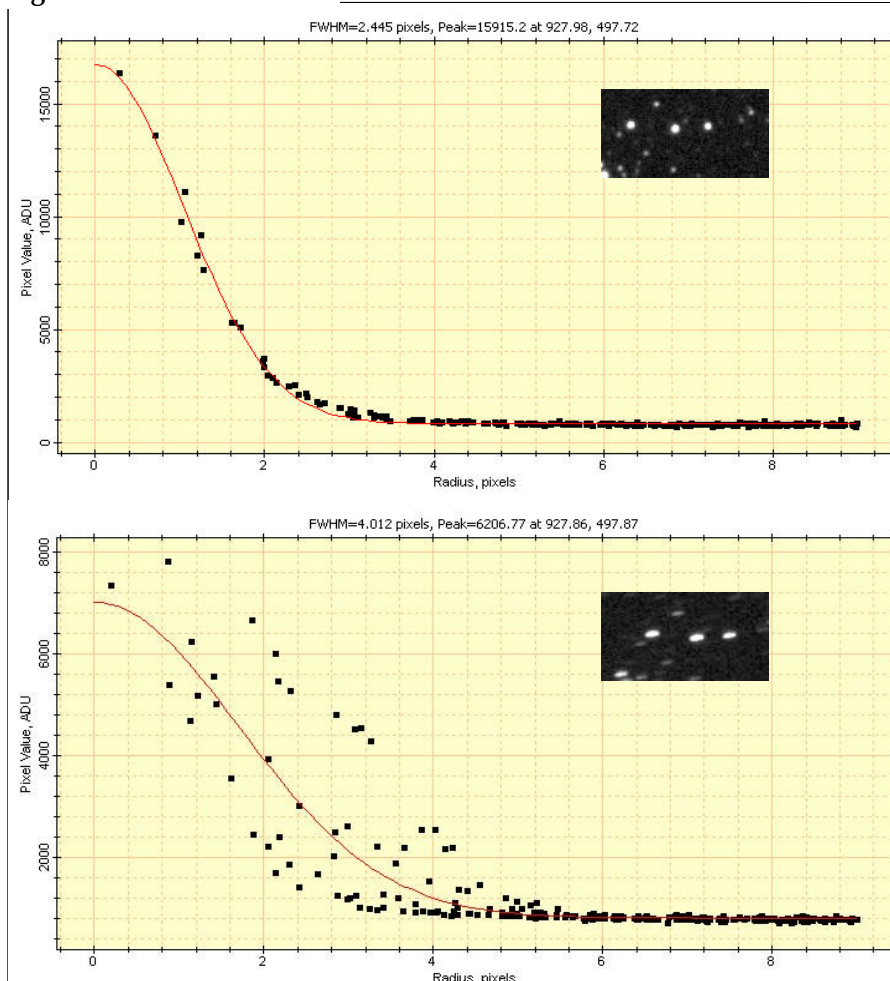


Figure 1. Theoretical curve of growth showing the fraction of a star's flux captured by a star circle of a given radius. From Howell (2006).

Most experts recommend that the radius of the inner “star” circle (r_1) equal 1 to 3 times the FWHM of the star's profile (or “**point spread function**”). See for example Howell (2006) pp.116-121. The minimum for r_1 maximises the signal to noise ratio (SNR) but excludes 1/3 of the star's total flux, as the “curve of growth” in Figure 1 shows, leading to measurement

Figure 2



On the other hand, $r_1=3$ FWHM includes effectively all of the star's flux, but also nine times as much flux from the sky, leading to much higher noise levels. So that doesn't help you much to make a decision. And bear in mind that a theoretical curve of growth is only a rough guide to actual situations. Remember too you're setting the circle's *radius* in terms of the image's *diameter*.

The difficulty is compounded in a time series. Some images will show nice sharp stars, others will be trailed or blurred. Get your software to measure the FWHM of your target star's PSF in all your

night's images, make a sorted table of the results, find the images with the median and the worst FWHM, and compare their radial profile plots. Figure 2 shows mine from a recent night. Note the FWHM of the good image is 2.4 px, increasing to 4.0 in the bad one. Note how the signal from the star fades slowly with radius from the centre, until you have only the sky background level (horizontal part).

Initially I chose r_1 as 3.5 px, a likely good value for the median image (1.5 times its FWHM). The result (Figure 3) is a very good light curve (red – note the very small calculated error bars) and a low-noise check star curve (blue) – except on the far right where there is some intolerable scatter. These deviant points have tiny error bars too, so don't trust low calculated error as a sign of accuracy! A better way to estimate the overall error of your light curve is to find the standard deviation of the check star measurements – here it is 0.019 mag. This is reliable where the check star is about as bright as the target – as here.

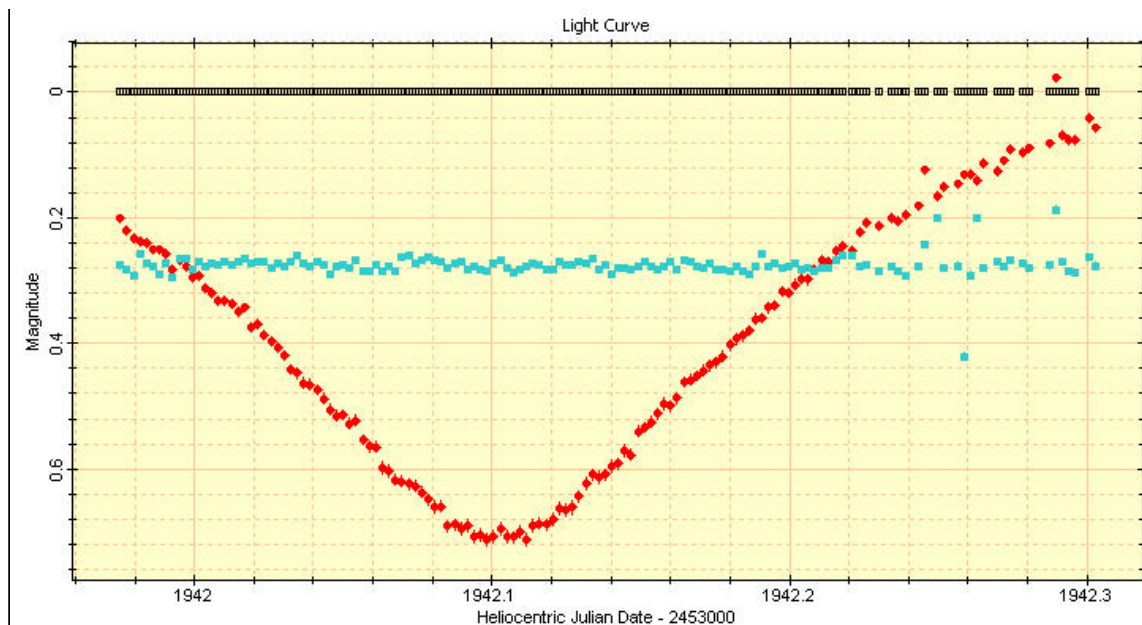


Figure 3: Photometry plot with $r_1 = 3.5$ px. Red is the target, blue the check, black the comparison. Note serious scatter near end.

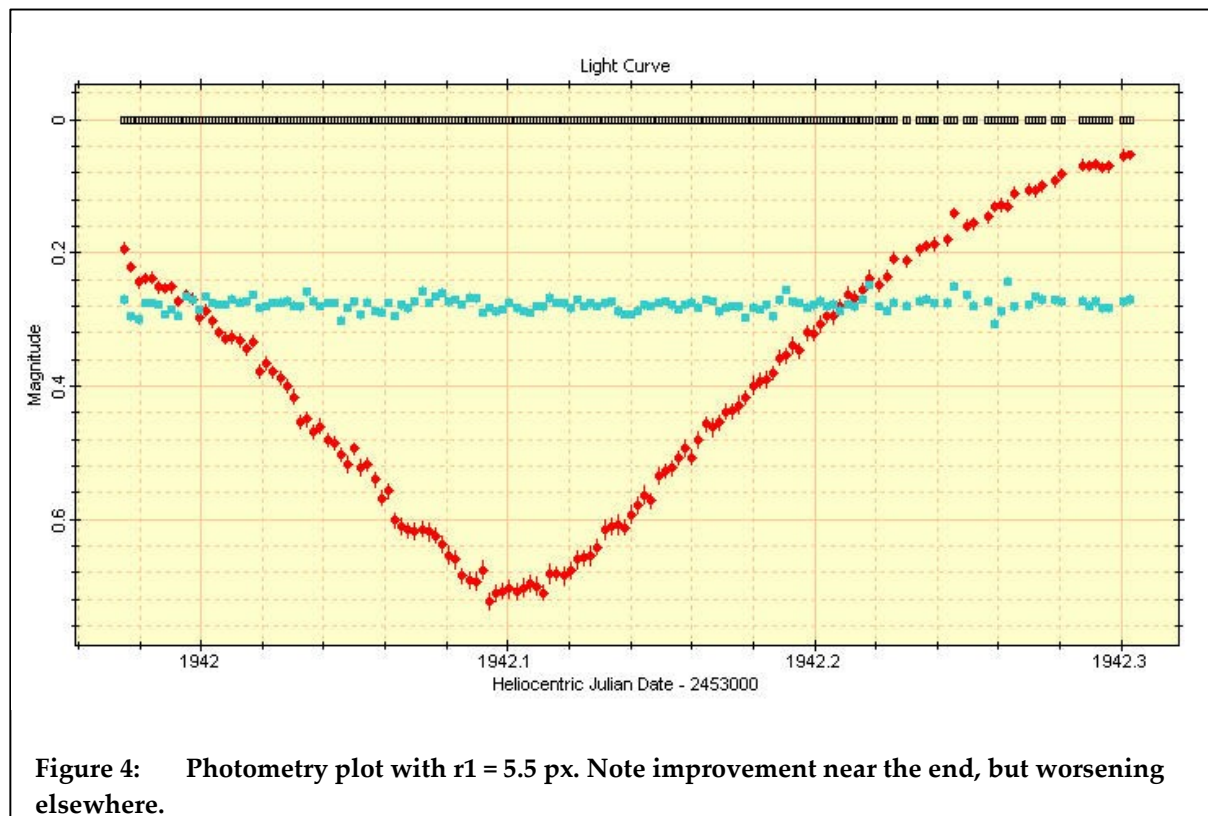
At this point I have two choices – remove the offending images from the measurement, or change r_1 . I tried increasing r_1 from 3.5 to 5.5 px, which the second radial plot in Figure 2 shows will capture nearly all the light from even the trailed image. This is still within the acceptable range for the median FWHM. The result is in Figure 4. The final part is much better, but the rest of the curve is predictably much less smooth, much noisier. Yet the standard deviation of the check star has dropped to 0.010 mag because most outliers have returned home. This suggested to me that the best procedure was to remove the deviant measures from the first measurement set. Doing that reduced the standard deviation on the check star to 0.007 mag, but the penalty was a lot of gaps towards the end of the data.

So to get good results,

- Try re-measuring with various star aperture radii, bearing in mind the FWHM of your median and worst images. As you do so:
- Be prepared to jettison images with outlying measurements,
- Watch the standard deviation of your check star,
- Look at the overall smoothness of your light curve.

Unfortunately that's not the end of the story. Changing the dead zone width (between rings 1 and 2) and the sky zone width (between rings 2 and 3) can affect the photometry and errors. But maybe that's a topic for another *CCD Column*.

Continued next page



All measurements and plots for this article were done in Mira Pro. The target is V705 Ara, allegedly a contact binary star, of maximum photographic magnitude 13.9. It was imaged with the 0.4 m telescope at Woodridge Observatory, Melbourne, at an image scale of 1.1 arcsec/pixel. All exposures were 3 minutes.

Reference

Howell, S.B. (2006). *Handbook of CCD Astronomy*. 2nd ed., Cambridge UK, Cambridge University Press.

Below—Bootes 3 as it now appears near Blenheim—and it's operating!



OBSERVING MIRAS & SIMILAR STARS

Stan Walker

The Historical Overview:

The variable star sections were largely built around the concept of observing Mira stars. So let's start by finding out what almost a century of this has told us. With reliable sequences we can ascertain:

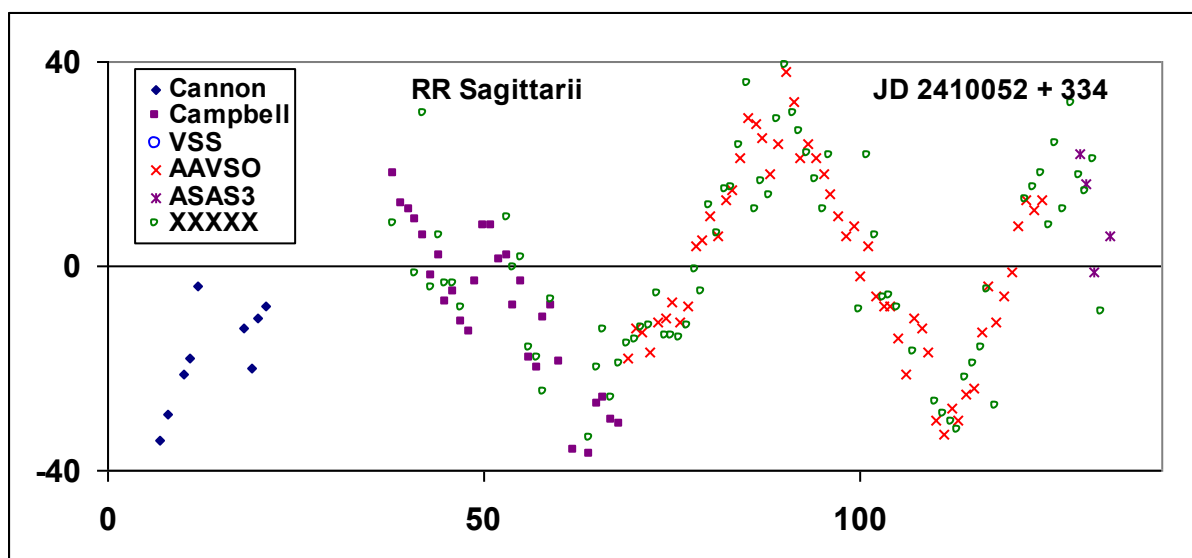
- The amplitude of light variations at a variety of wavelengths, but traditionally visual.
- The epochs of maximum or minimum—to determine an epoch marker for each cycle.
- Colour changes during each cycle—using UBV, BVRI, JHKLetc., filters.
- Spectral changes during each cycle—or over longer periods.

Models of Mira stars show that they are in what is called the Asymptotic Giant Branch (AGB) in the Hertzsprung-Russell diagram. They reside in this for perhaps 60,000 years before evolution changes them into some other type of star. Initial masses are thought to be less than 10 solar masses, but the present masses of individual Mira stars—after a complex evolution—in the AGB are uncertain.

Changing Periods:

Since there are about 12,000 known Miras it should be possible to see some evidence of a change in period over a timescale of 120 years, which is about the length of time most of the brighter objects have been observed. This has led to many searches for changing periods—and less than a dozen truly documented period changes.

The majority of the small number of true changes in period are attributed to helium flashes in a shell burning area. R Hydrae and R Aquilae are two well-known examples, although R Centauri and BH Crucis have recently shown have changing periods. The majority of Miras appear to alternate between two periods at intervals of 30-50 cycles. This is shown in the plot below of the epochs of maximum of RR Sagittarii. Two periods can be identified but actual values for individual cycles are hard to ascertain. Is the period changing? Who can tell from this? Mira cycles are not as repetitive as Cepheids so there is some scatter of maxima. Also, historically, a variety of detectors have been used—as well as different comparison sequences, so the data are noisy. At the end of the display seven cycles from ASAS3 are shown, but these do not exactly match the visual maxima—partly due to the difference in response between the eyeball and the photometric V filter., and in part because RR Sagittarii is too bright for ASAS3 at maximum.



Recently The University of Sydney group, led by Tim Bedding, have drawn attention to possible instabilities in the periods of pulsating variables attributable to chemical composition—for example, the SC stars, of which BH Crucis is one. See pages 4-5.

Observing—Visual or Electronic?

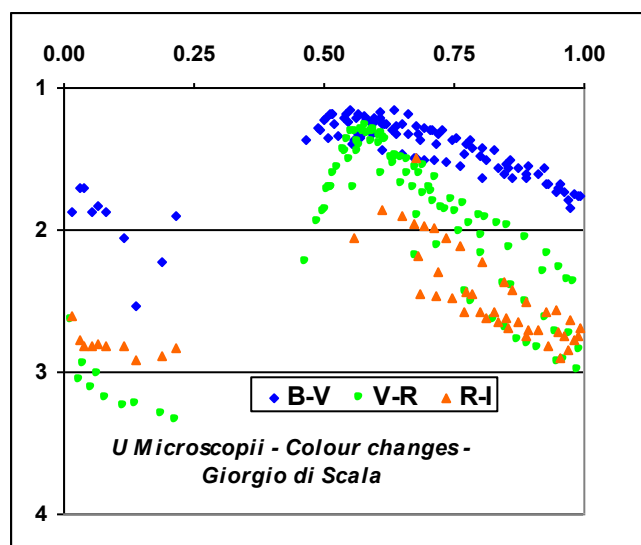
The question must be asked—what is the best way to observe these stars? With the better accuracy of PEP and CCD should these supplant the visual observers? Where does ASAS fit in? Is there any value in single V filter measures of Miras? Miras are very well suited to visual measures and even though ASAS is now contributing a substantial number of measures, these do have limitations. And Mira maxima appear always to be rather irregular, both in brightness and timing, so is great accuracy of any real value? There are frequent comments in the AAVSO pages about underobserved stars and more attention should be paid to these, particularly when maxima or minima fall outside the 7-12 magnitude range of ASAS3. ASAS3 also has longer gaps at solar conjunction, with maxima missed.

Mira light curves are not particularly repetitive and electronic observations can be used more usefully in ways other than determining V light curves. Those observers who wish to make simple V measures with CCD or other cameras would be much more effective if they concentrated upon the small amplitude objects which are largely unstudied. Since the visual observers like large amplitudes, most of the low amplitude stars do not even have charts. This is moving outside the Mira field, but it's where the need is—and the rewards are! The few V measures of Mira stars in the International Database cannot produce stand-alone information about Mira light variations and are really only random data.

Colour Measures of Mira Stars:

Colour measures using filters moves into a rather different area, the physics of stars rather than traditional measures of periods and amplitudes. The colour curves of BH Crucis on page 5 illustrate an immediate application. The suspected cooling of this star as a result of a dramatic expansion—for somewhat uncertain reasons—is quite apparent as a change in the B-V ratio. On page ## of this issue a particular project in this field is outlined—with the goal of confirming and measuring phase lags in selected Mira and semi-regular stars.

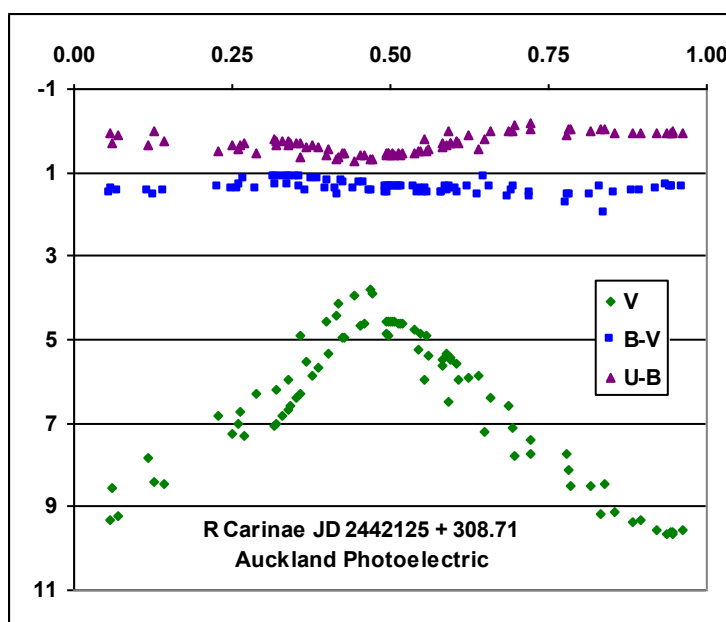
An example of this, compiled from data out of the International Database maintained by the AAVSO, depicts measures of U Microscopii made by Giorgio di Scala of Sydney. The phase has been changed to make maximum more easily seen (although the GCVS epoch and period is a little incorrect at the moment—see the type of variation illustrated on page 14). Also, the International Database treats each filter as a separate measure—but in this graph they have been combined to provide colours which are more informative.



U Microscopii colours in B-V, V-R and R-I from observations made by Giorgio di Scala of Sydney and published in the International Database of the AAVSO.

Each is effectively a temperature curve, but the V-R colour curve has twice the amplitude of the standard B-V colour curve. The R-I curve is flatter, but is probably affected by radiation from the dust shell common to Mira stars.

Also noticeable in this is a difference in the time of maximum in each colour. U Mic is quite bright in I, around I = 4, and would be even more so in J and H for those with SSP4 photometers. Our phase lag project—see web site—is designed to provide more information on this aspect of the colours.



Colour measures will also show the presence of another star. Here are shown UBV measures from Auckland Observatory and Milton Road Observatory. The V light curve is unexceptional, although it shows a variation of one magnitude at maximum—not unusual for Mira stars, where sometimes the maxima will vary by two or more magnitudes.

The B-V curve is rather flat indicating at first glance little temperature change during a cycle. But the U-B curve is inverted, being faintest when the star is bright and brightest when it's faint. This indicates the presence of another star—rather hotter than R Car—either a companion or a line of sight object. The bright U-B on the decline is typical of Mira stars—emission from the gas shell.

There seem to be a number of observers who are using CCDs with filters to make measures at these different wavelengths. What we need to see, however, is some coordination of measures to ensure that what is produced is not just random data—with a few points on scattered cycles of stars.

Another point which should be noted is that in spite of their irregularities, Miras are reasonably consistent stars, so that it's probably pointless to measure every cycle in a variety of colours. The best cover will come if visual observers provide the long-term continuous monitoring whilst colours are measured each decade or so—or when something dramatic happens! Perhaps colours during each alternate period as shown by the O-C diagram would also be sensible.

Other Types of Stars:

On pages 12-15 there's an article about semi-regular stars. Many of these are similar to Mira stars, differing only by their lower amplitudes. Others have erratic light curves caused by the presence of more than one pulsation period at any one time, others just have low-amplitude, short periods. The SR classification has recently tended to be something of a dumping ground for any red variable which isn't a Mira or a Long Period star so some SR stars may be something else.

This is an area which is largely unsuited to visual measures, unless you are prepared to be very careful and follow observing rules which differ substantially from those needed with Mira stars. Accuracy, frequency of measures, selection of comparisons become very important. But it's an ideal area for those observers with CCDs or photometers who wish to make simple V measures.

Rather than starting at the faint end, there is a great need for measures of the brighter short-period objects. We've featured the work of Sebastian Otero and Terry Moon quite prominently in Newsletters—as well as Frank Ives—but they have been making, and proving the possibilities, of this type of observation. Once again, cooperation is needed to ensure that the measures are adequate, but not more than necessary. The first cycle or two will give an idea of what exactly the star is doing, whether it's reasonably regular and whether an erratic light curve indicates multiple periods. The latter will take several cycles before enough data is available for these to be identified.

Some colour measures are valuable, but these need to be well-conceived. Once a pattern of colour changes is clear—then move on to the next object—the first star only needs to be remeasured in this way in a decade or so. Once again, this is such a mixed bag of objects that no-one is certain what you'll find there.

SUPERNOVAE AND LUMINOUS BLUE VARIABLE STARS

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Once upon a time we believed that all supernovae originated from red supergiant stars. Astronomy was simpler then. Then we learnt that the most massive stars had powerful winds that shed their outer envelopes into space exposing their hotter and bluer inner zones, thus skipping the red supergiant state. Wolf-Rayet stars were recognized then as another kind of supernova progenitor. And then SN 1987A went boom to teach us that also ordinary blue supergiants could explode. Now stellar evolution is shaken again by the fact that LBV (Luminous Blue Variables) stars may actually be supernova progenitors too.

LBV Evolution

Luminous Blue Variables are very massive stars (more than 25 solar masses, although some authors say 40) with strong mass loss caused by powerful stellar winds. These stars are so massive that they become unstable as soon as they leave the main sequence and get rid of some of their mass excess through eruptive events that may be spectacular like in the case of eta Carinae. Until recently experts thought that the LBV stage occurred before these stars started He fusion in their cores. The LBV stage would then be followed by the WR stage before the star's death.

A recent study by Avishay Gal-Yam (Astronomy Department, California Institute of Technology, Pasadena) and others, 2007, described the current state of the supernovae knowledge and focused on the IIn-type of supernovae which are thought to be caused by LBVs. Using HST images they identified a possible progenitor single star of $M_v -10.3$ for SN 2005gl, a typical example of the class. The fact that LBVs could explode as supernovae implies that what we see in the outside has nothing to do with what happens inside the star. The possible explanation is that very massive stars evolve so rapidly that can't get rid of all their envelopes before consuming all their nuclear fuel. Or the stellar wind speed wouldn't be so fast to accomplish that task "on time" for the star to become a WR. So stars with above 80 solar masses would skip the WR stage.

Extreme LBVs are surrounded by nebulae from their past eruptions. Those huge eruptions eject several solar masses each. No WR stars have been found surrounded by such a massive nebula, supporting the idea that the most massive stars explode while still in the LBV phase. Stars with masses below 80 SM would have time to lose their hydrogen envelopes. If they were born between 40 and 80 solar masses they would become LBVs and then WR stars, first of the WN-type (Nitrogen rich) and later, as more inner zones are exposed, of the WC and WO-type (carbon and oxygen rich) variety. Finally they would become SNe of the type Ic. If they had between 25 and 40 solar masses, they would explode as type Ib. Between 15 and 25 solar masses, we would have a SN IIL or IIB display with a Wolf-Rayet progenitor that previously was able to reach the supergiant stage, and finally for stars between 8 and 15 solar masses, we would have a red supergiant progenitor exploding as a modest SN IIP.

So, is the fraction of red supergiants causing SNe very small? Not necessarily. We must keep in mind that the number of stars decrease abruptly as masses go up. Stars with more than 80 solar masses are very rare so we know very few examples of these classes of supernovae and rely on the parameters of just a few stars to define the classes. As instruments are able to go deeper and deeper this is dramatically changing along with our knowledge of the supernovae zoo. To give an extreme example of this, there is the case of SN 2006 gy, the brightest supernova in history ($M_v -22$). Nathan Smith (Department of Astronomy, University of California, Berkeley) and his colleagues say this might be the result of a star with more than 100 solar masses and the first example of a pair-instability supernova. This kind of supernova would not leave a remnant, similar to those of the SN Ia-type. At this point, with so many subtypes mentioned, I think a short description of each of them is mandatory.

Supernova Classification

It is currently believed that supernovae can be divided in two groups: those that are caused by interactions in a binary system containing a white dwarf and those that come from single massive stars. That's certainly true, but be careful not to get confused and say that type I are binaries and type II are single stars! Actually, **SN I** are those with *no signs of hydrogen in their spectra*, while **SN II** are those where *hydrogen is present*.

There are type I SNe that come from single stars (Ib, Ic) and there are type II SNe that originate in binary systems (IIa). The "a" suffix thus includes all binary systems that cause supernovae while any other example comes from massive stars. Type IIb might come from massive stars in a binary system but the explosion is not due to a white dwarf gaining mass but to the core collapse of the massive star. Below, a description of each type.

Binary Systems

SN Ia = CO white dwarf accreting matter from (or merging with) a companion till it reaches the Chandrasekhar limit. No hydrogen. Silicon and iron lines. Mv -19.3. Detonation, no remnant.

SN IIa = CO white dwarf + a 6-7 SM main sequence companion. Mix of SN Ia and SN IIn. SN Ia surrounded by circumstellar matter (H) stripped from the companion. Mv -20/-21

Single Massive Stars

'Stripped core-collapse supernovae'

SN Ib = Intermediate mass WN progenitor. He lines.

SN Ic = WC or WO progenitors. No H and He. O, Mg and Ca lines. Mv -18/-20.

'Normal type II supernovae'

SN IIL = Intermediate mass late WN progenitor. Rapid and Linear decline in its light curve. Strong He lines. H envelope <2 SM. Mv -18

SN IID = SN IIL with Double P-Cygni profiles indicating the occurrence of strong wind episodes shortly before the explosion. Flattening in the light curve at later stages because of the interaction between the ejecta and the circumstellar material.

SN II-P = Low mass red supergiant progenitors. Extended Plateau optical light curves. H envelope 10 SM. Mv -16/-18.

SN 1987-like = Blue supergiant progenitor. Faint. Slow development. Late hump-like peak in optical light curves. Mv -15.5

SN IIb = Intermediate mass WN progenitor? Massive binary?. Rapidly declining light curve. Spectra evolve from strong H lines to strong He lines. (Mix of II and Ib subclasses). Outer layers stripped by companion?

SN IIN = LBV progenitors. Strong Narrow H-lines indicative of copious mass loss. Mv -17/-20.

SN II / pair-instability supernovae = SN 2006gy. Slow development. Interaction with its own ejected H envelope. LBV progenitors. SN IIn with masses above 100 SM. Star's core is obliterated. Mv -22.

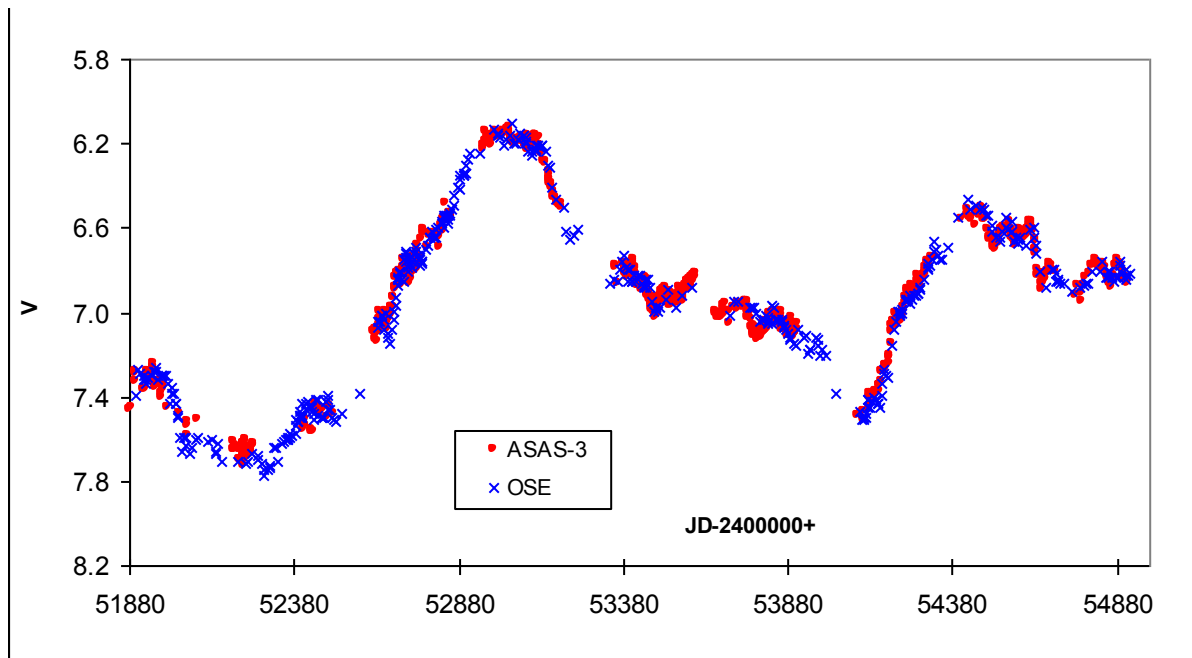
Supernova Candidates

Some SN IIN underwent huge eruptions called 'supernova impostors' years before the final event. When we read about that, it is impossible not to remember the eta Carinae explosion in the nineteenth century and think about a possible SN IIn event in the near future for it. So keep your eyes open.

The Southern sky contains several LBV stars. Some are dormant—some are active. There is no GCVS type for them but they are described as SDOR-type after the LMC prototype S Doradus. Actually the S Doradus phase is only one of the phenomena affecting LBV stars. These are pulsations on a time scale of months (and also shorter time scale variations superposed) that cause a change in the effec-

tive temperature of the star taking it to the right in the HR diagram (cooler and redder) when it reaches maximum light. The star's photosphere expands and the star becomes brighter at visual wavelengths but its bolometric luminosity remains constant. The other phenomenon is the unexpected eruptions that these stars undergo when mass loss abruptly increases. Some of the brightest LBVs can be observed with binoculars: They are: eta Car ($V=4.7-5.1$), AG Car ($V=5.7-8.1$), V766 Cen ($V=6.0-7.5$), V905 Sco ($V=6.2-7.0$) and HR Car ($V=6.8-8.8$). However, don't get too excited about them. Most are not as massive as eta Carinae, or even close to it, so their ultimate fate is very likely the WR stage before the SN explosion, which means we won't be able to see them go off. However, AG Carinae shows a WN9 spectrum at minimum and it is believed to have had 120 solar masses when it was born see Smith, 2006. It also has the highest amplitude S Doradus variability so observing this star won't bore you (at least in the long term, since it has been almost constant around $V=6.8$ for the last several months, see Fig.1 for its light curve). Also, there is a very interesting object in the Large Magellanic Cloud—HD 5980.

The light curve of AG Carinae for the past eight years is shown below. OSE, blue crosses, is the author, Sebastian Otero,



HD 5980

In 1994 this 11th mag. double star system (WN3+WN4) brightened by 3 magnitudes in an LBV-like eruption (first reported visually by Albert Jones) - unprecedented for an WR star, Barbá and others, 1995. During the outburst the spectrum of the WN3 star changed to a WN7 or even OB spectrum typical of the LBV stars. The outbursting component could have had more than 120 SM at birth so if we know that both WN and LBV stars are supernovae precursors, this system is number one in the list of targets to monitor (SN IIb maybe?). And it is eclipsing! The period is 19.2654 days and the orbit is eccentric (secondary minima falls at phase 0.36) with an amplitude of 0.25 mag. in V, see Sterken and Breysacher, 1997. ASAS-3 data, Pojmanski, 2005, show that the mean brightness of the system has been gradually fading from $V=11.2$ to 11.5 over the last 9 years.

So there are lots of targets to watch and now that we are aware that LBVs might offer more surprises than just irregular variations or some noteworthy eruption, these spectacular stars might deserve to be included in your program.

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PATROL SURVEYS and SOUTHERN HEMISPHERE ASTRONOMY

Stan Walker

I keep being surprised in discussions with reasonably well-informed amateurs suggesting that ASAS has completely negated the value of visual measures. So maybe a few comments are in order. As mentioned elsewhere ASAS has particular limitations—magnitude-wise and at solar conjunction. But there are others. Our database of Miras and other long period, large amplitude variables is based upon visual measures. And the eye sees a little bit differently to the V of the UBV system—see Alan Plummer's comments about the Purkinje effect. Then, at present, I'm told that the single colour ASAS measures are not rigorously transformed to the standard system. With rather red stars like SRs and a few Miras this probably results in slightly distorted values. So if we're looking to monitor amplitudes then visual observations are still the best and match the existing system.

Historically, only the amateur variable star observing groups have stood the test of time. The AAVSO will celebrate its centenary in 2011—the VSS rather later in 2027—but the BAA VSS goes back well over a century, as do isolated amateurs in various places, two of which are mentioned by Alan Plummer. They're not dependent upon funding—nor the whims of parent bodies.

From a personal viewpoint I think that the greatest contribution of organisations such as ASAS is to monitor the small amplitude variables—but then the problem is to analyse and interpret the data. Plenty of opportunity here! A criticism of ASAS is that it cannot accurately measure variables which are brighter than about seventh magnitude at maximum—but these are the very objects which have the longest base lines of observations. Even where it is effective, we need colour information to supplement the light curve measures. So we still require not only ASAS measures but visual and multi-colour measures—UBV, BVRI, JH. Let's keep all of them going and not decry the visual observers!

THE SC STARS—CANDIDATES FOR PERIOD CHANGES?

Stan Walker

The changes in BH Crucis encouraged me to read a paper by Zijlstra and others in MNRAS, 2004, 352,325. Here they speculate that all SC stars, and possibly CS stars, may be more unstable than most Miras insofar as periods are concerned. The reasoning is based on both BH Crucis and LX Cygni showing substantial period changes.—2 out of a few stars is a high percentage. Their lists, compiled from a variety of sources, include the following 14 southern stars—8 SC, 2 CS and 4 possibly SC.

LQ Ara SC: This is noted as a probable Mira with a period of 193 days. ASAS3 shows a range of up to 1.2 magnitudes at most, but more frequently from ~9.8-10.4 and a period of 188 days. Not a Mira!

AM Cen SC: The GCVS calls this star Lb, but Zijlstra et al determine a possible period of 276 days. There might be some confusion over identity—ASAS3 shows two stars—one variable between 13-14 and one around 7.5 which is what Zijlstra has analysed. Both stars exhibit rather short periods ~90d.

V372 Mon SC(N): Another low amplitude object, SR, from 9.3-10.3. The ASAS3 period is about 300 days with erratic maxima at times.

V3832 Sgr SC: GCVS calls this Lb but ASAS3 shows variations with time scales of 100-200 days and amplitude of 0.3 to 0.6. A typical SR star.

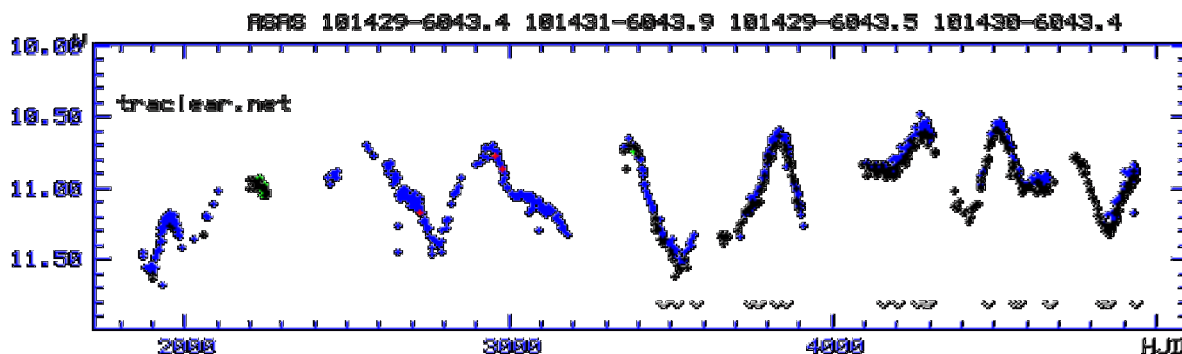
UY Cen SC: A much brighter SR star than the GCVS shows, ASAS3 has its period at 150-200 days and an amplitude of about 0.7, superimposed on long term brightness variations.

GP Ori SC: Also classed as C8.0J: ea. The GCVS period of 370 days is incorrect, - it's nearer half that, with erratic amplitudes—maximum at 8.8, minimum 10 at times. Zijlstra suggests an SR star with two simultaneous periods from the power spectra based on 440 visual estimates

BH Crucis SC4.5/8-SC7/8: More extensively studied than most.

The CS stars include TT Cen, which is part of our dual maximum Mira project and FU Mon. The first has a quite regular light curve and a period of 462 days. The amplitude of 4.5 magnitudes denotes a Mira. The second star is low amplitude and erratic, with a quoted period of 310 days.

The suspected stars, called SC initially by Catchpole and Feast in 1971, include VY Aps, AM Car, R Ori and VX Aql. VX Aql's light curve and amplitude are strikingly similar to that of TT Cen and with much the same maximum and minimum, but a very long 604 day period. R Ori is a typical Mira of 377 days. VY Aps at maximum of 8.7 and an amplitude of 0.8 is a typical SRa star, period 152 days. AM Car is the most erratic. The GCVS period is 314 days, but ASAS3 has these varying from 200-400 days. Maximum is 10.5, although some are fainter. It's light curve from ASAS3 appears below.



BEGINNER'S PROJECT UPDATE

Alan Plummer

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As most readers will know, a visual observing project suitable for beginners and experienced people alike studying R Car and eta Car has begun. We have sufficient numbers, but more observers will generate a better study. Anyone who has not thought about participating, please do. We want you. As well as our own observations, we will add historical data into the AAVSO database to extend the lightcurves of the two stars backwards in time as well as forwards, and then examine the data for any insights into the objects.

Our intent is to write up the work for publication somewhere, with all consistent contributors offered co-authorship. 'Consistent' here means anyone who's observed the stars reasonably well through the year-long duration of the study. We don't need to be perfect.

The AAVSO database, which today includes the historical VSS RASNZ data, contains observations of R Car going back to 1891. In passing, the same Scottish-South African, Alexander Roberts, was responsible for these early observations as well as those of R Cen elsewhere in this newsletter. A very fine observer! Entering 'new' historical data, we will extend the lightcurve backwards from 1891 for another 10 or 15 years. AAVSO and VSS observations of eta Car don't go back anywhere near that far, so our input there will be very significant.

Our historical observations are those of John Tebbutt (1834-1916). He observed R and eta Car for 15 or so years in the late 19th century. Variable star work was only a small part of his contribution to astronomy. He published hundreds of articles, appearing everywhere from the Monthly Notices of the Royal Society to regular columns and essays in local Australian newspapers about things astronomical. He discovered two comets, a probable nova in Scorpius, did much double star work, and kept what are now very valuable weather observations for the western Sydney area. I don't doubt he did much more. As for variables, he only observed R Car and eta Argus (as it then was) and made sporadic observations of T Cen.

As already stated elsewhere, 7 X 50 binoculars are a minimum requirement, and larger binoculars or a 90-100 mm telescope can be entirely sufficient. Correct VSS RASNZ charts will be provided, as well as any help necessary. For any comment or questions, please contact me.

COMPARISON STARS IN THE SOUTHERN HEMISPHERE

Stan Walker

In preparing some projects I have presumed that most participants would be familiar with methods of calibration and standardisation. I also overlooked the fact that CCD photometry is much different from conventional PEP. So, some modifications are needed.

The first relates to the dynamic range of common CCD cameras. For practical purposes we can assume that this is about 3-4 magnitudes - dramatically different from the PEP range of roughly double that, or more. Thus many of our large amplitude targets will need two or three sets of comparisons.

Another relates to determining values for these comparisons. It has been the normal practice in the south to select suitable nearby stars and determine values by interpolating between well measured standards in either the E or F Regions, with SMC and LMC sequences available as well. Whilst there are a large number of other published values for field stars, the accuracy of most of these is not always good. This is more so in the case of fainter stars where values have often been derived by transforming satellite measures in unconventional bandpasses to the UBVR system.

Thus some help is needed in getting suitable comparison stars for our targetted objects. Each field has now been studied carefully and appropriate comparison stars selected. But for most of these there are no values. This needs to be changed. Of course, we can make measures and sort out the values later, but most of us like to see real magnitudes immediately. So can we get some volunteers? Anyone interested in measuring these in UBV, BVRI should contact me immediately and I'll arrange a copy of the list.

To do this you will need properly calibrated equipment. Quite a simple task - it can be done in a couple of hours. All it requires is selecting an E Region approaching your zenith, selecting a suitable star as the 'control' then measuring a dozen or more stars in appropriate colours with the control interspersed each half hour to check extinction. Stars within 20-30 degrees of the zenith are little affected by normal extinction so the E Regions at 45S are adequate. Plot the derived colours b-v against B-V, v against B-V, etc., and slopes are readily obtainable. In this context small letters are in the system of your CCD or photometer, capitals the catalogued values. Two or three times a year - unless you change the system in some way - are adequate.

The original Cape standards as updated by Menzies et al can be found at <http://www.sao.ac.za/fileadmin/files/links/ereg50.txt>

There are a variety of others—John Graham's extension to faint stars was published in PASP 1982, 94, 244 and is easily accessed through the ADS service. Arlo Landolt has measured some southern areas but the combination of Menzies and Graham is probably adequate for most observers.

The photometry required for comparisons will involve measures on a very good night of a couple of stars in an E Region to the west, then the comparison stars in the field, then two more stars in an E Region to the east. In each filter, of course. Probably 3 x 10 seconds for each filter are adequate. This can then be repeated once or twice more over the next month. This gives us permanent values for the comparisons. If the stars saturate, then try using a cardboard off axis aperture to reduce the light grasp. This works, in spite of comments to the contrary in some publications. Just ensure that with the brighter stars the software aperture is large - say 50-60 arcseconds. Never go below 30 arcseconds.

Tom has written about aperture sizes—see page 16-18—and these are important in determining values for stars to be used as comparisons. But for most projects involving LPVs, other than very low amplitude objects, 2% photometry— ± 0.02 magnitudes—is quite adequate. Don't fall into the typical amateur's failing—trying to become more accurate than professionals using bigger telescopes and better equipment. Just get the measures to do the job!

THE POLAR TELESCOPE—CONTINUED

From page 15

I've always been an admirer of the Albert Jones approach—wheel out the telescope and begin observing—although the first thing I did in 1966 when I decided to observe variable stars was to build an observatory. When Joe sent me this CCD camera in 1997 I first tried to get a couple of people to use it in Auckland—but after several months of inactivity I faced up to the problem myself. We were—and still are—using a solar and wind powered electrical supply with batteries and an inverter to provide 230 volts. Notice the umbilical cord in the illustration. And the blue tarpaulin—with suitable lashings—to cover the equipment when not in use.

This arrangement survived the tail end rain and wind—120kph and 150mm/day—associated with two tropical storms in 1997 and 1998! Later I moved the whole arrangement to an observatory with a run-off roof above the office where I sometimes work—and where I'm presently putting together a newsletter. In this last context, I'd be grateful for some items. And like this one—your experiences!

CATAclysmic VARIABLES PROGRAMME

Paddy McGee

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Welcome to the first Newsletter article for the Cataclysmic Variables Programme. This will be something of an introductory affair, as we sort things out and get things going...



Please allow me to introduce myself briefly. I've had a long interest in astronomy, first ignited, perhaps, by a copy of Patrick Moore's "Legends of the Stars" (at least that's what I recall the book's title to be...), which I recall reading when aged around seven. This led to other reading, then casual observing with binoculars, then a trusty 4.5" Tasco reflector, experimenting with photography, and more recently to post-graduate studies at the University of Adelaide.

For my PhD I used a C14 telescope at the University's field station at Woomera, doing CCD-based optical photometry of newly-discovered high-energy sources; specifically, three cataclysmic variables (CV's) that were recently discovered by satellites. The observations at Woomera were the first substantial optical observations (apart from spectroscopy done as part of optical candidate checking) for these objects- an exciting thought at the time.

Other topics studied at the time included simultaneous optical/gamma-ray observations with the Japanese Cangaraoo telescopes at Woomera, and site testing via extinction photometry using both photo-multiplier tube and CCD methods.

More recent observations, post-PhD, have included some CV photometry for the Centre for Backyard Astrophysics, as well as exoplanet transit candidate photometry, revisiting the PhD targets for new data, and monitoring other CV's in collaboration with colleagues involved with the HESS gamma-ray observatory in Africa.

All this is rather unrelated to my day job, which involves support of what is termed "e-research", via use of web-based tools for data-sharing, web- and video-collaboration, and related applications. I do keep up some astronomy teaching with demonstrating at uni and some observational project supervision.

So where are things at with the CV Programme? Rather formative at the moment, it must be admitted. I have some ideas of my own for Projects (related to the topics mentioned above...), but I feel it prudent to determine our various capabilities in terms of interest and equipment.

One thing to be aware of here is that both visual and photometric/photographic/CCD observers are important in this area. What is important is that observations are made; that data are gathered and utilised- but not necessarily *how* those data are gathered. Whether it's done visually with binoculars or a small telescope, or with a CCD camera and a 20" telescope is not, in essence, the main point; rather, that the available tools are used appropriately, where peoples' different interests lie, and that progress is made.

Thus, some of the targets will be suited to visual studies, whilst some will need other detectors. Some will be amenable to useful study by both. Some data may make direct contributions toward intended papers for publication; other data may be of a monitoring nature, most important in their ability to trigger other types of observation when the time is right, with that time not being able to be known without those routine monitoring observations...

Continued on page 30

My initial plan is to get to know our capabilities, strengths and interests. To this end, I would ask those interested in taking part in observations on CV's to get in touch with me with the following details (and these are as a guideline- please also mention other details that you may feel are relevant!).

- preference for visual or instrumental observations
- equipment with regard to the above; general sky conditions (e.g. urban, suburban, country)
- if known, magnitude limits for your typical observations
- geographical location
- some idea of observation frequency (e.g. daily, once a week, a couple of nights a month); a few hours available on a night, or is the whole night feasible?
- existing or favoured targets, i.e. are you already doing work on particular targets?
- level of experience

With regard to the last point, newcomers to the field are to be encouraged (we all had to start at some time), whether one is completely new to astronomy in general, or has much experience already, but just in a different area.

With these details in mind, people and Projects can be matched together in ways that will aid both the progress and success of the various Projects, and satisfy observers' interests and allow them to

CCD TERMINOLOGY

Tom Richards

(See the "CCD Column" on page 16)

CCD, Charge-Couple Device. A type of light-sensitive electronic chip covered by an array of **pixels**, each of which records an electron charge proportional to the light falling on it. Also a camera utilising a CCD. Don't ask why it's so called!

FWHM, Full Width at Half Maximum. A useful way of measuring the diameter of a star's image. View the star's profile (see PSF below), note the maximum brightness of that profile. In Figure 2 on p.16, top curve, that's ~17,000 units. Then measure the full width of the profile at half that maximum. In Figure 2, a half-profile, the width is ~1.2 pixels at 8500 units, so the FWHM is ~2.4 px.

Measurement Apertures. In measuring the brightness of stars in a CCD image, the software places a 3-ring "aperture" over each of the stars to be measured, the same size for each star. The outer or "sky" annulus (between circles 2 and 3 counting from the inside) is used to measure the background sky brightness. The inner or "star" area (inside circle 1) measures the light from the star and of course the skylight therein; but that can be subtracted by using the skylight data from the sky annulus, leaving just brightness data for the star. The "dead" zone between the star circle and sky annulus is there to ensure no light from the measured star interferes with the skylight in the sky annulus.



PSF, Point Spread Function. The shape of a star's image in a camera. Due to image movement caused by atmospheric seeing, that is never as small as the theoretical "diffraction image" of a point source such as a star, but spread out. The half-profiles in Figure 2 on p.16 show two (half) PSFs.

SNR or S/N, Signal to Noise Ratio. When any signal, such as starlight or the sound of a flute, reaches a sensor (eye, ear, CCD,...) there will be in addition "background" variations of a totally random nature (called noise, hiss, static, salt-and-pepper). SNR is a measure of the strength of the signal compared to the average strength of the noise. In CCD photometry a conventional target for SNR is 100 or better, because that produces an error in signal measurement of 0.01 mag or less.

*“Studying Southern Variables” Colloquium
RASNZ Conference, Wellington, 22 May 2009.*

Programme

For more information about this Colloquium and the RASNZ Conference hosting it, visit <http://www.rasnz.org.nz> and follow the links.

Start	Presenter	Title
10:00	MORNING TEA	
10:30	Grant Christie	Welcome
10:45	Stan Walker	Changing Periods In Mira & Similar Stars
11:15	Denis Sullivan	Observing Southern Variable White Dwarfs over an Extended Period
11:45	Roland Idaczyk	Absolute Parameters of Young Stars: V831 Centauri
12:00	Tom Richards	Bad Contacts: An attempt to classify some little-studied southern eclipsing contact binary variables that aren't.
12:30	LUNCH	
1:30	Stan Walker	Near Infra-Red J & H Band Photometry at Wharemaru
2:00	Marc Bos	Teaching Old Dogs New Tricks: Retro fitting geriatric equatorial mounts with digital setting circles and autoguiding for long exposure CCD imaging.
2:30	Bill Allen	Eta Carinae
3:00	AFTERNOON TEA	
3:20	Grant Christie	Microlensing
3:50	Stan Walker and Tom Richards	Variable Stars South: Projects and Plans
5:00	CLOSE	

VSS Membership Application Form

See next page for information.

First Name		Surname	
Mailing Address			
City/Suburb		State	
Country		Postcode	
Email Address			
Type of Membership (tick one)	Ordinary (20 NZD)		
	Foundation (50 NZD)		

Join Variable Stars South

What is VSS?

VSS aims to be an organization for southern variable star observers and researchers (which doesn't mean you have to live south of the line!), bringing them together in close communication to discuss and carry out research on southern variable stars. Whether you are observing visually or electronically, whether your interest is observing or desk research, VSS needs you!

What can I do as a member?

- As a VSS member you will be able (indeed expected) to sign up to work in one or more of its Projects, in the manner that suits best your equipment, interests, skills and situation.
- You will have access online to training and mentoring. In your chosen Projects you will receive close advice, assistance and feedback from the other Project members on what you're doing. This is the best way to learn variable star work!
- As a member of an essentially online organization, you will have access to its online communications (egroups, blogs, forums, and more). In the Projects you sign up for, you will have very interactive data input, access and manipulation. You will have access to all internal documentation such as guides, work-in-progress documents, and research support documentation.
- You will be able to involve yourself in the Programme areas of your choice. You will be able to set up and run new projects within that Programme, (but so will qualified non-members who want us to help their research).
- You will be able to be involved in paper preparation and authoring.
- You will be able to help shape and implement VSS activities, plans and policy, including the all-important area of Information and Communications Technology especially our Varstars website (up and running shortly!).
- You will be eligible to borrow VSS equipment.

How do I join?

To join VSS you do not need to be a member of RASNZ. You can sign up as an Ordinary Member (NZ\$20 p.a.). **Or support the startup of VSS as a Foundation Member for NZ\$50 if you join by the end of the RASNZ Conference, 24/5/09.** Foundation Members will be helping greatly in setup costs, and will be known forever afterwards as Foundation Members, as a badge of distinction and a thank-you.

The current Membership Year expires on 30th April, 2010, then annually on 30th April. You can join up online or postally. To join postally, please fill in the form on the previous page, and post it with a cheque or bank draft for your fee (NZ\$ please), to Bob Evans, 15 Taiepa Rd., Otatara RD 9, Invercargill 9879, New Zealand.

To join online, please email a filled-in image of the form on the previous page as an attachment to accounts@varstars.org. Or of course, just type the information requested into the body of the email. You will then receive an email from Paypal requesting payment by Visa, Mastercard or transfer from your bank. You simply click the Paypal icon in that email to enter their online secure payment facility, and it's all done.