



A group of year 10 girls from Iona Presentation College, Perth who have completed a project on the photometry of RR Lyrae variables under the guidance of Paul Luckas (far left) from the International Centre for Radio Astronomy Research, University of Western Australia and with their teacher, Katrina Pendergast (second left). Their report is presented on page 6.

Contents

From the director - Stan Walker	2
Recovery of FW Carinae – Mati Morel	3
SPIRIT – Paul Luckas	6
RR Lyrae light curve project – Victoria Wong	6
Nova discovered in Scorpius	11
ST Puppis revisited 3 June, 2016 – Stan Walker	12
Changes in L2 Puppis reflected in historic AO data - part 1 – Aline Homes, et al	19
The stellar detective – Tom Richards	24
Old friends and new mysteries – Tom Richards	27
The colours of BH Crucis – Stan Walker	29
Publication watch	32
About	33

From the director – *Stan Walker*

astroman@paradise.net.nz



This seems to be an unusually wet winter - certainly in northern New Zealand and maybe the eastern Australian areas judging by the weather maps and the news. In New Zealand's far north region we were supposed to have the usual semi-drought conditions in January to March yet got 400 mm in those three months. And the year to date has just passed the 800 mm mark here. So it seems that some projects are suffering a bit. But there are a few bright spots.

The V777 project is almost complete for this eclipse. Carl Knight, David Moriarty and Mark Blackford managed to make observations and Mark observed enough of the egress to allow measures in Auckland and by ASAS3 to be suitably related to the ingress and egress. A little work is still required to get the magnitudes to match and we're waiting for some good spectroscopy to identify the spectral class of the blue star to be determined. Unfortunately it's quite distant and I'm not clear how near Gaia is to producing values for objects like these. Once those are available the measures can be used to provide a much wider range of information.

QZ Carinae observations are also suffering a little. At sixth magnitude it's too bright for most CCDs unless the telescope is stopped down a lot. But some progress is being made - I think we're beginning to realise that some of the conventional models do not fit a system like this - instead we have to fit the models to the measures.

In the visual area V854 Centauri has been in the news a lot. It seems to be hovering around the eighth magnitude mark - not as bright as normal but not entering into a dramatic decline. These R Corona Borealis stars also pulsate but in a rather irregular manner - sometimes resembling RV Tauri objects, at other times very erratic SR objects but always there is the possibility of a spectacular fading. Once a star evolves off the top of the AGB branch they become very interesting and rather unpredictable objects. ST Puppis seems to be another of these.

Paul Luckas has been working with a group of students from a college in Perth and the results are featured elsewhere in this newsletter. Doing rather than talking about it is a much more effective way of encouraging young people to be interested in astronomy and these results speak for themselves.

Which in turn is a reminder that I should get my own equipment into action. The changes to the observatory have been completed - the run off roof replaced with lightweight shutters - all it needs is an astronomer to use it! I wonder if I can remember how to do it all?

Regards,

Stan

Summary

A search of original Harvard plates (Bruce 24-inch doublet) has pinpointed the exact position of FW Carinae, hitherto unknown. Its classification as a possible Mira variable can be discounted in the light of archival plates and more recent images of the Eta Car region.

History

Harvard College Observatory's Bruce 24-inch telescope first saw service at Cambridge, Mass. from 1893 to 1895. It was then moved to Harvard's southern station at Arequipa, Peru from 1896 to 1929, then to South Africa from 1929-1950. The Eta Car region was a frequent target, with exposure times ranging from only 5-10min up to 150min. Most exposures were about 60 minutes, mag. limit ~15p. The long exposures, 120-150min, were uncommon, but reach nearly 17.0p.

HV 3987 = FW Carinae

Constance Boyd (HB 842,1927) reported the discovery of two new variables, as now designated; HV 3986 = FU Car and HV 3987 = FW Car. Only the latter has remained unknown to this day, as regards position and class. It was stated that just two plates were compared in the blink microscope to make these discoveries. No dates were given, nor plate numbers, so verification was not possible. By using the online DASCH system, I succeeded in locating the original plates. Only the very long-exposure Bruce plates (120-150min) were capable of showing FW Car at maximum. It is clear from annotations on at least six other plates that the Harvard workers had searched these for FW Car, but the exposure times (60min, limit 15p) were always insufficient to show FW Car.

Recovered plates

The two Bruce plates which are of interest with regard to FW Car are as follows.

- **a1743** 1896-04-11. 150min exp. FW Car is identified, lying on a straight line between stars A and B. A = CPD-58 2585, B = CPD-58 2584 = HD 303290. See Figure 1.

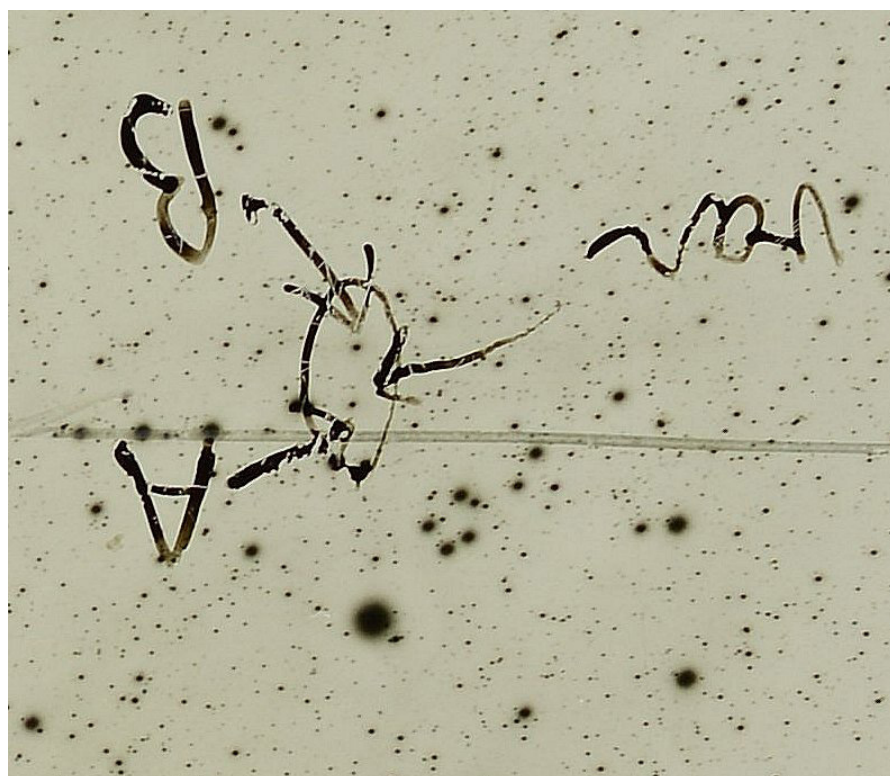


Figure 1. Extract from Harvard plate **a1743**, exposed 1896-04-11. Original annotations, with FW Car marked as "var". North up, and east to left. A and B are in CPD (see text), separation 127".

The figure is shown N up to match the orientation of Figure 2

- **a11987** 1922-05-20, JD 2423194.534. 120min exp., limit 17.0p. This is one of the best Bruce plates. FW Car is quite invisible, <17.0p. See Figure 2.

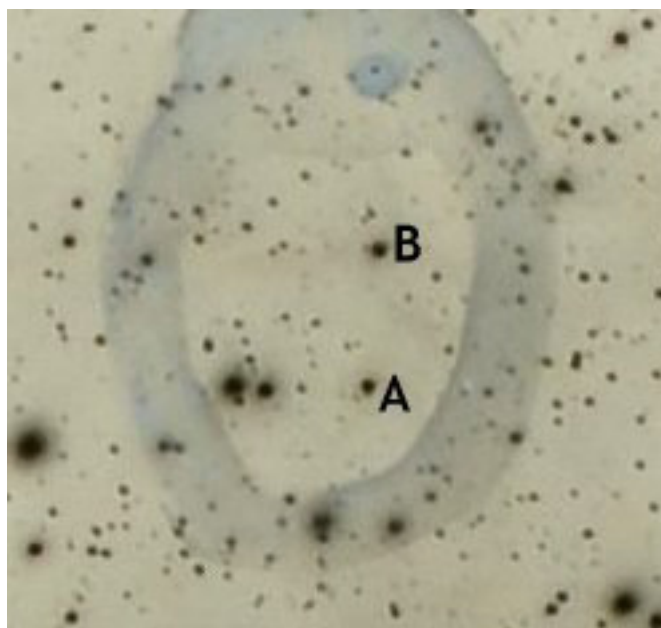


Figure 2. *Extract from Harvard plate a11987, exp. 1922-05-20. North is up, east is to left. FW Car inv. <17.0p. Compare with Fig. 1.*

Plate **a1743** shows FW Car just above the plate limit, at 15p. As alluded to in HB 842 the range seemed to be at least 2 magnitudes. The lack of suitable long-exposure plates prevented further study, but I can confirm the published range. I retrieved 14 other Bruce plates, from 1913 to 1920, but exposure times were all too short (~60min) to show FW Car. The region of FW was often marked in ink, nevertheless.

Other plate series

After 1928 only the “mf” series (10-inch Metcalf triplet) were useful. Six plates were retrieved, with various exposure times, up to 45min. Each one showed FW Car at 15p. They were -

mf13186 (1929-06-04, 45.0min); mf18999 (1934-03-15, 45.0); mf32346 (1944-04-15, 45.0); mf32076 (1944-01-20, 31.0min); mf33459 (1944-11-18, 45.0). b54258 (1930-05-21, exp. ?). The smaller aperture camera series (*am*, *b*, *rb*) generally fail to reach 15p.

FW Car identified

As marked on plate **a1743** the variable lies 38.1" north of A=CPD-58 2585. Photometric data, from APASS, is as follows: V = 14.53 (0.029); B-V = 0.71 (0.057); B = 15.24

Table 1. Data for FW Car and close companions

Star	(J2000)	V	B-V	Sources
FW Car	10 42 47.78 -59 04 17.7	14.64CCD	0.64	ICRS/SPM4
1	10 42 49.08 -59 04 16.7	16.11CCD	0.83	SPM4/2MASS
2	10 42 50.33 -59 04 18.5	14.96CCD	0.88	SPM4/2MASS

As FW Car is somewhat crowded by its two companions, there is a risk that the APASS photometry may be slightly contaminated. Therefore, for the sake of argument, I adopt the rounded magnitudes, V = 14.6 B = 15.3.

Contemporary results

In recent times, with the advent of large aperture Schmidt cameras, and also more sensitive imaging systems in the hands of non-professionals, deep images of the Eta Car region are commonplace and are likely to show FW Car clearly. Images published in popular magazines in the last few decades turn out to be useful. In all instances FW Car can be seen at a fairly constant level, at 14.6V or 15.3B. No other fading event has been found. An enlargement of a published colour image is shown. See Figure 3. FW Car is very similar to star 2, but about 0.3 mag brighter, providing a very useful comparison.

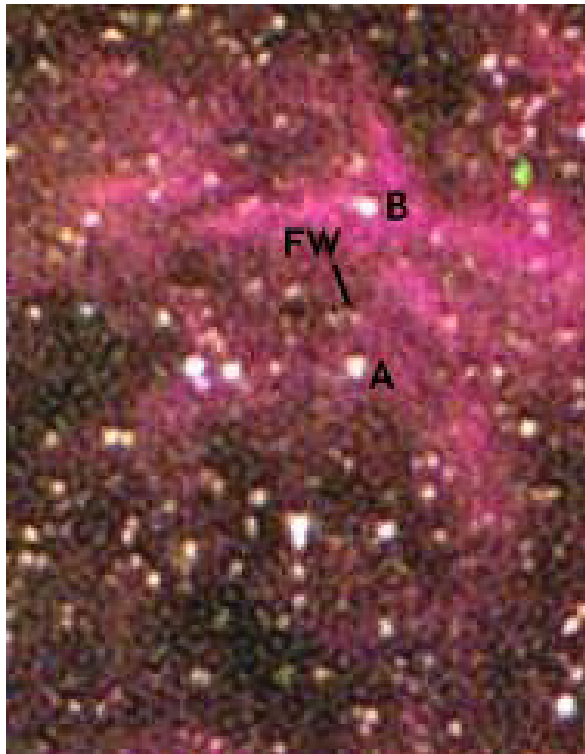


Figure 3. Extract from a colour image, of region of FW Car. N is up. The two following companions are visible. Original image was secured by 24-inch Curtis-Schmidt telescope, Chile, and printed in Sky & Telescope, April 1973.

FW Car is identified with a nearby red 2MASS object in VSX and GCVS, but this is clearly erroneous; in addition the variable does not appear in the GDS (=Galactic Disk Survey) catalogue of new variables (Hackstein 2015).

Conclusion

The exact position of FW Car is now established. On the face of it, FW Car appears to have experienced a single fading event, of large amplitude, on 1922 May 20. It is possibly an eclipsing variable of long period? No other similar event has turned up in the plate record, and the star appears to be essentially constant at 14.6V (or 15.3B). The plate record, and B-V colour, weigh against the possibility of a Mira variable.

Acknowledgements

This research made use of DASCH project data (supported by NSF grants AST-0407380, AST-0909073 and AST-1313370).

This research was made possible through the use of the *AAVSO Photometric All-Sky Survey (APASS)*, funded by the Robert Martin Ayers Sciences Fund.

References

- APASS 2016. AAVSO Photometric All Sky Survey. <https://www.aavso.org/apass>
- DASCH 2016. Digital Access to a Sky Century @ Harvard. <http://dasch.rc.fas.harvard.edu/>
- Hackstein, M., Fein, Ch., Haas, M. et al 2015 Astron. Nach. 336,590
- Luyten, W. J. 1927. Harvard Bulletin 842, p9

SPIRIT

Inspiring the next generation of astronomers is what the SPIRIT initiative is all about (spirit.icrar.org). In this month's edition of the VSS newsletter, we highlight a variable star project undertaken by a group of year 10 girls at a local high school in Perth Western Australia. Paul Luckas, the SPIRIT programme manager at the International Centre for Radio Astronomy in Perth, spent the first term of this year, guiding the girls through the process of acquiring data, and then creating light curves of southern RR Lyrae stars. As comparatively short period variable stars, RR Lyraes are ideal for student work, and in themselves represent some of the most interesting photometric targets for variable star monitoring. A report, prepared by one of the students, Victoria Wong appears below. – Paul Luckas.

RR Lyrae light curve project – Victoria Wong

Galileo Galilei once said, "All truths are easy to understand once they are discovered. The point is to discover them."

Several Year 10 Challenge Science students from Iona Presentation College in Perth were involved in a project on the topic of photometry. The goal of this project was to collect the light from a variable star and then try to create a light curve. The University of Western Australia's SPIRIT telescopes (Figure 1) were used to collect the data, which was then analysed using the photometry functions in the software Maxim DL in order to create the light curve.

Photometry is used in astronomy to measure the emission or intensity of an astronomical object such as variable stars, minor planets and supernovae. The data from photometric measurements can help determine the luminosity of an object if the distance is known and vice versa. Variable stars of the type RR Lyrae are the easiest to observe, as they have a short period – often only a few hours.

Differential photometry is widely considered to be the simplest for basic time observations using a photometric filter such as the V band. This branch of photometry measures the change in magnitude of a target object over time and the data gathered is usually presented as time series graph or light curve.

An RR Lyrae star is a special term given to a type of variable star whose brightness changes with a regular emission period of a few hours to a few days. The amount of light that a star emits is dependent on its surface area and temperature - with larger and hotter stars being the brighter. RR Lyrae stars pulsate, expanding (low temperature) and contracting (high temperature).

An RR Lyrae star's emission period can assist astronomers in figuring out the absolute luminosity of

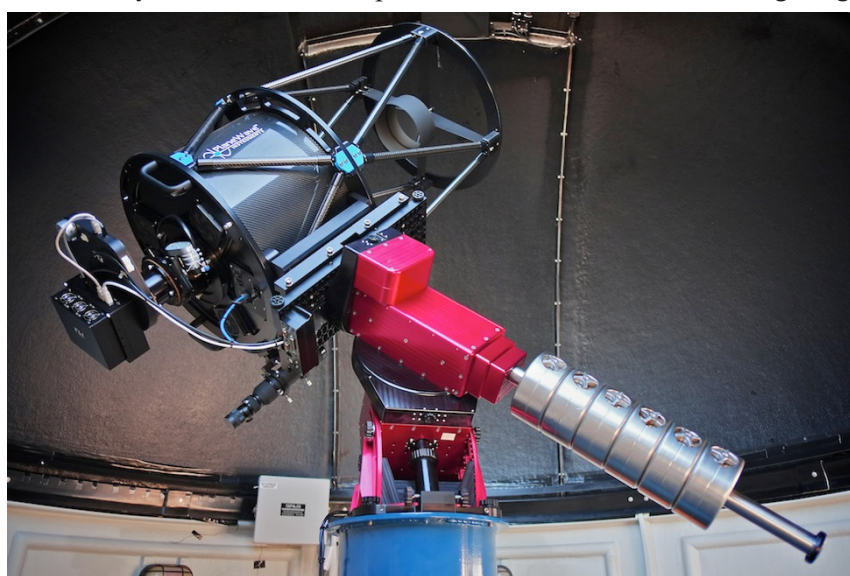


Figure 1. The SPIRIT II telescope, a Planewave CDK 17 on a Paramount robotic telescope mount, is housed on the roof of the Physics School at the University of Western Australia, Perth.

the star (how bright the star would be a certain distance away from Earth). The absolute luminosity of the star is then compared to the measurement of the how bright the star appears. With this information, astronomers can determine the distance to the star as well as other physical characteristics, such as age.

The process of the project was quite involved. The aim was to choose a handful of targets from a list of southern hemisphere RR Lyrae stars. The next step was to carefully locate the stars using a planetarium program called Stellarium, to check if they were

visible on the date of imaging, and if they could be imaged over the course of the entire night, see Figure 2.

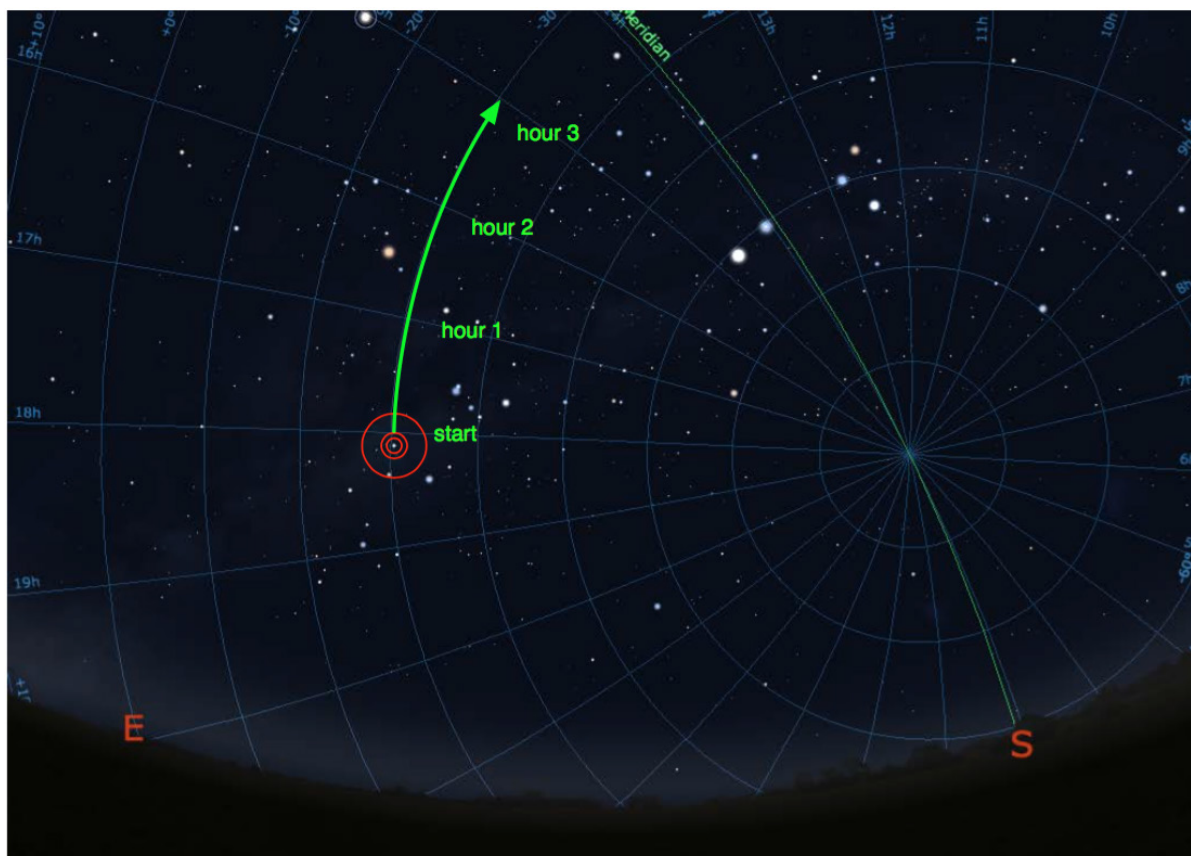


Figure 2. A screen grab from the planetarium program Stellarium showing how stars move during the night.

In order to automate the process of acquiring the data, the targets were formatted as an imaging plan (Figure 3) using accurate coordinates (right ascension and declination) and a pre-determined exposure which we figured out by taking some test exposures on previous nights. The imaging plans were created using the same format and in UTC (Universal Time Coordinated). Each plan is set to one specific filter, in this case V. The binning (resolution) of the SPIRIT telescope was also configured to optimise the signal under the skies of Perth. The plans were then uploaded to the SPIRIT telescope using the internet.



Figure3. Creating an imaging plan using ACP (Astronomers Control Program).

The SPIRIT telescopes are fully web-enabled robotic telescopes which can be accessed in real time using a web browser. We started our plans, watched the progress of the telescope moving and taking our images. The SPIRIT telescopes continued taking our images while we slept.

Once the images were downloaded the next day, we used an on-line sky atlas called Aladin (Figure 4) to confirm the actual RR Lyrae star in our images. We did this by comparing the location of the star in the atlas with that of the SPIRIT image displayed in Maxim DL.

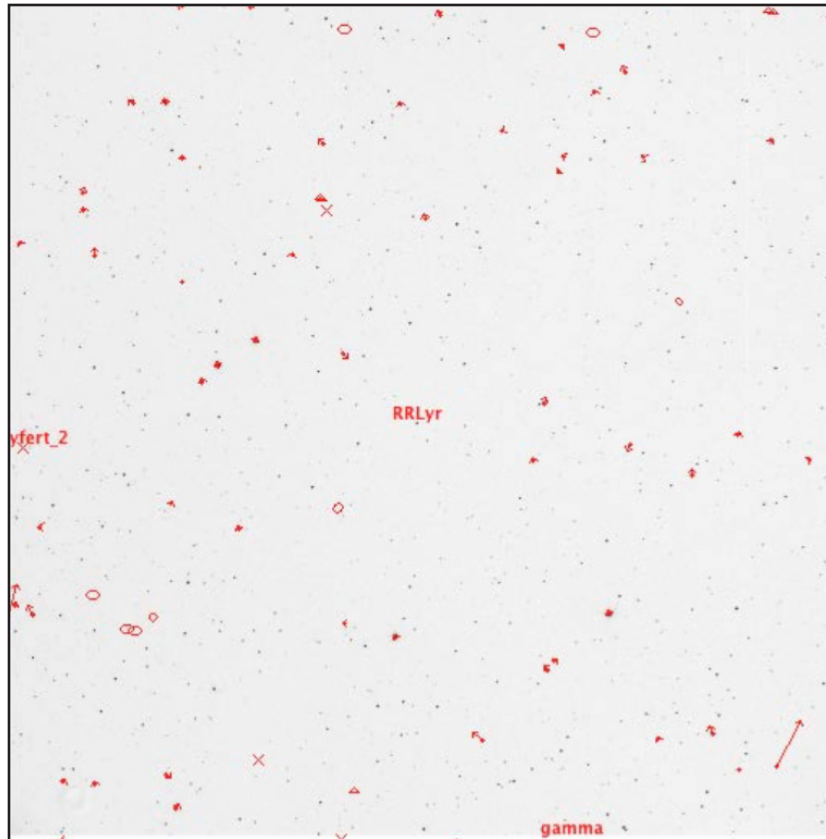


Figure 4. The field of view of the target RR Lyr star from Aladin.

Images are then loaded into Maxim DL's photometry tool. Using a process where reference and check stars are specified, the software then creates a light curve of the target RR Lyrae star.

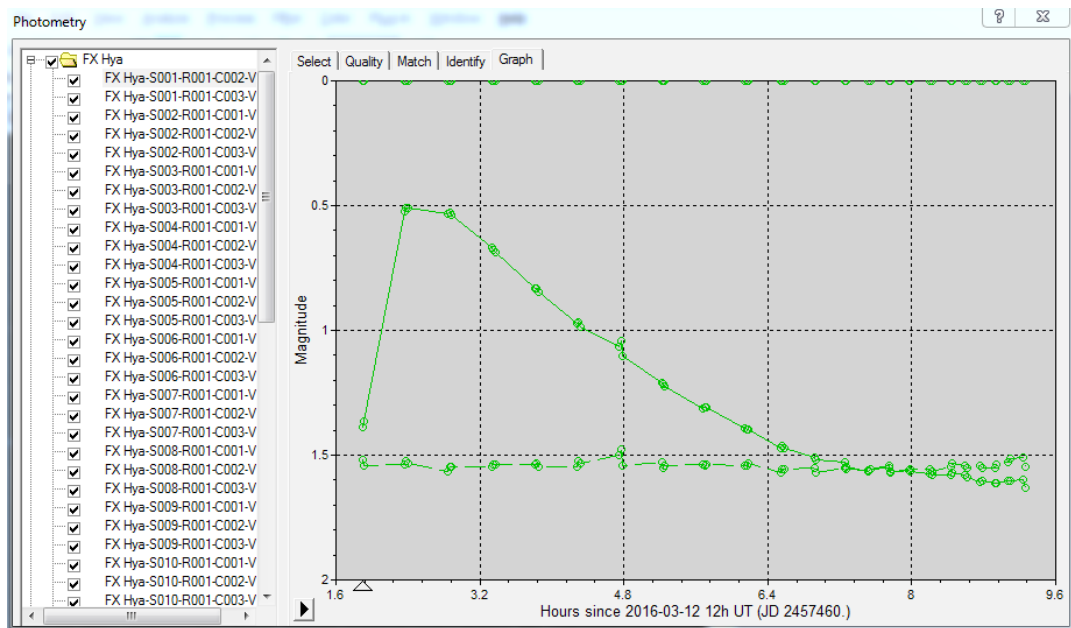
Light curves

The following light curves (Figures 5 to 7) show some of the better examples we obtained during this project. The stated magnitudes are raw instrumental magnitudes from Maxim DL, and do not show the actual apparent magnitude of the stars.

FX Hya (Figure 5)

- Constellation: Hydra
- Date: 12 March 2016
- Time (AWST): 21:30 – 05:30
- Telescope: SPIRIT II
- Magnitude range ~ 1

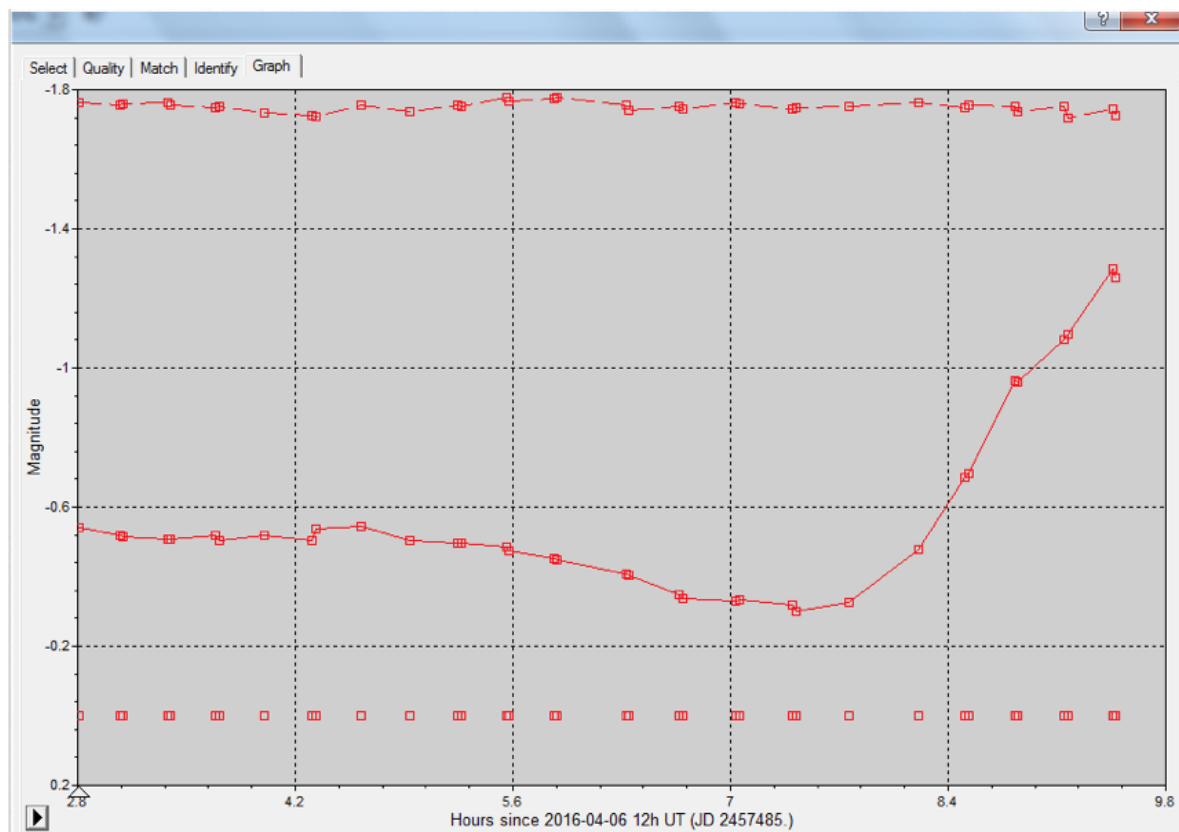
Negative magnitudes are brighter than those with positive magnitudes. After a sudden outburst, the magnitude of FX Hya slowly decreases in a gradual slope, relaxing into its lowest point at approximately 1.45 around the 6.7 hour mark. The difference between the highest and lowest point of magnitude as displayed on the graph is 0.95. The spike in emission at the beginning of the night is very interesting, alluding to some powerful processes in this star.



FX Hya, Victoria Wong, 12 March 2016

AZ Lib (Figure 6)

- Constellation: Libra
- Date: 6 April 2016
- Time (AWST): 21:30 – 05:30
- Telescope: SPIRIT II
- Magnitude range ~ 1.3



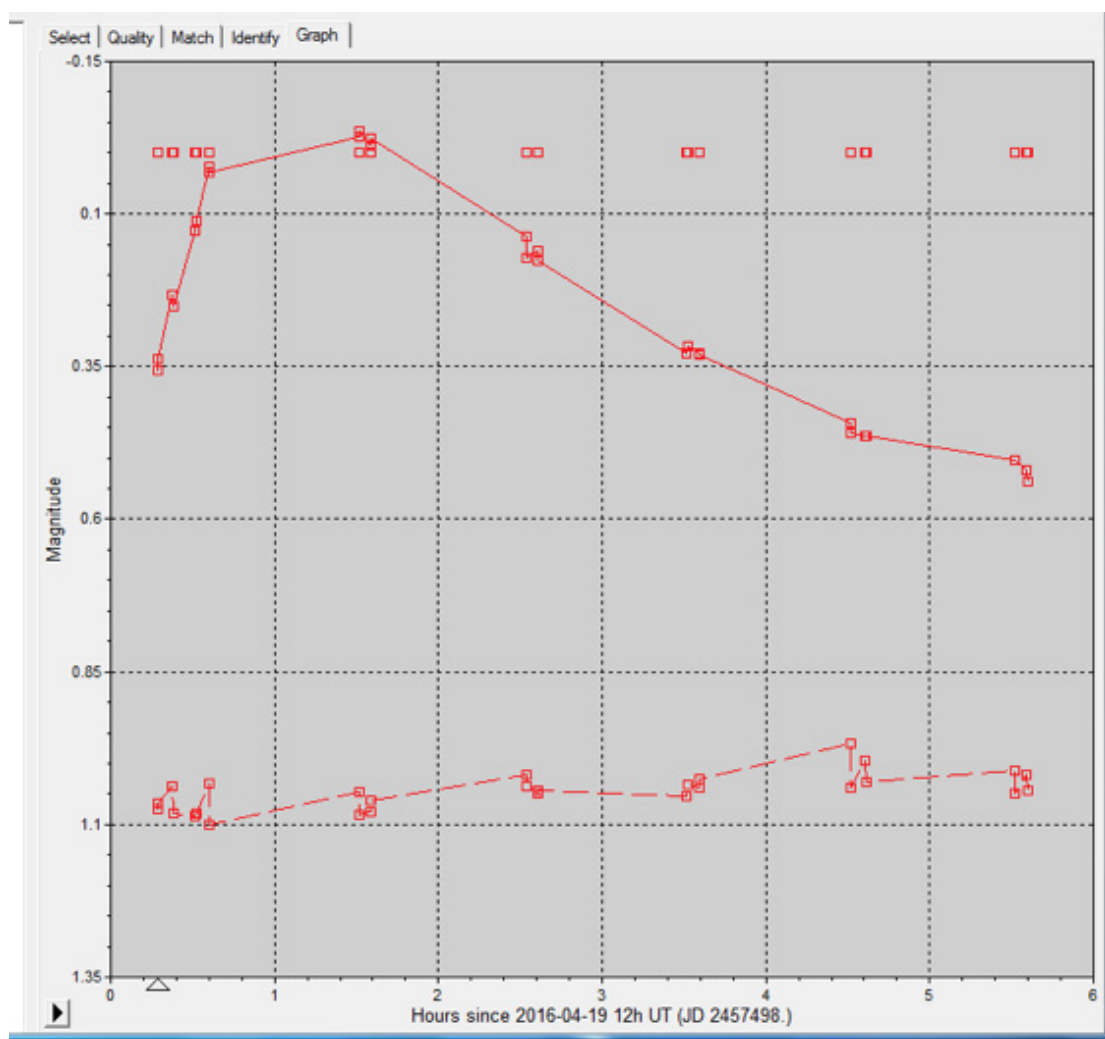
AZ Lib, Isabelle Nella, 6 April 2016

The light curve is steadily decreasing throughout night before a gradual increase in brightness is

observed. From the steady shape of the graph, we can make an inference that the star pulsates and emits light at a relatively steady rate.

SW Cru (Figure 7)

- Constellation: Crux
- Date: 19 April 2016
- Time (AWST): 21:30 – 05:30
- Telescope: SPIRIT II
- Magnitude range ~ 0.75



SW Cru, Emma Paterson & Alexandra O'Brien, 19 April 2016

SW Cru's initial curve is steep, implying that the star emits sudden bursts of light. The brightness then fades over a 5 hour time span.

Conclusion

The next steps are for us to gather more data of these stars so that we can complete the light curve and determine the period of these brightness changes. More data points would also improve the quality of our data, so that we can observe smaller changes, such as 'shock bumps' in some of the stars.

Overall, the project has been an interesting and worthwhile one, using the SPIRIT telescopes and learning about variable stars.

Nova discovered in Scorpius

Advice of nova announcement from Alan Baldwin (Palmerston North)

The American Association of Variable Star Observers (AAVSO) has reported in Alert Notice 544 (13 June 2016) the discovery of a nova in Scorpius; the following information has been taken from the AAVSO announcement. “Scorpii 2016 was discovered by Hideo Nishimura (Kakegawa, Shizuoka-ken, Japan) and reported by S. Nakano, Sumoto, Japan, via CBET 4285). The nova was discovered 2016 June 10.629 UT. The discovery magnitude was 12.4 using unfiltered CCD on three 10-s CCD frames, using a 200-mm-f.l. f/3.2 lens with a Canon EOS 5D digital camera. A spectrum shows the star to be a nova in its early stages of outburst. Coordinates (2000.0): R.A. 17 38 19.31, Dec. -37 25 08.7 (from VSX); a chart can be obtained from AAVSO Variable Star Plotter (VSP)”. Refer to the announcement at AAVSO for instructions on plotting and the website for updates.

Status early July

The AAVSO database up until this point shows on average about five observations (electronic and visual) per night, but the nova is fading relatively quickly and so some observers will drop out. Those with larger instruments are encouraged to observe regularly (weather permitting).

Carl Knight in the Manawatu has managed to find gaps in the clouds to observe the nova. His comments are: “Nova Sco 2016 is located in a typically crowded central Milky Way field (Figure 1). Last night’s observation (UTC = 2016/07/03 08:23) with CCD camera are shown in table 1.

Table 1 Magnitudes with B, V, R and I filters.

Time (JD)	B	V	R	I
2457572.849593	14.23	13.00	11.42	10.23

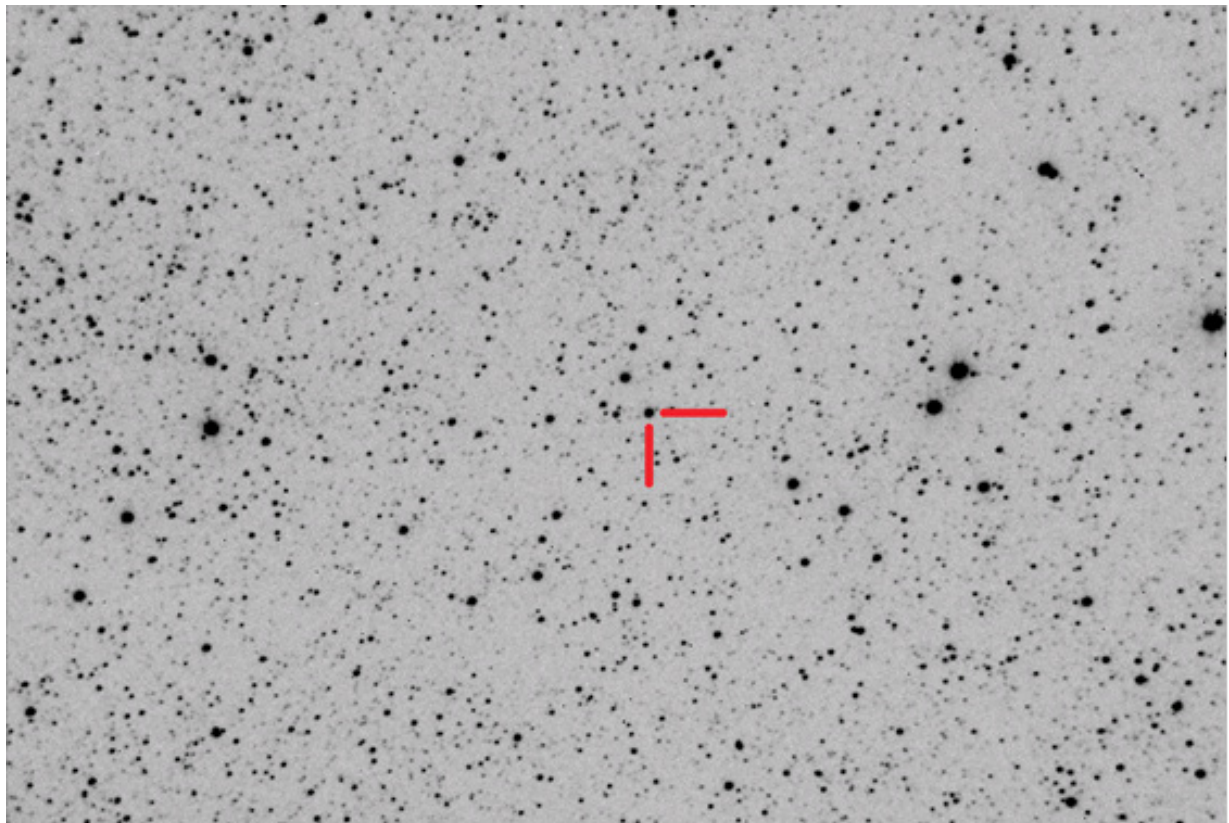


Figure 1. Nova Sco 2016 field taken by Carl Knight with Cousins I filter. In this image North is up and East is left.

Coverage in the AAVSO database at this time is looking sparse, possibly reflecting the nova's southerly location relative to the greater population of observers in the northern hemisphere, and probably the necessity to shoot holes in clouds for the rest of us for whom it is otherwise well placed!"

"It is a classical nova according to the spectra reported by Terry Bohlson. Presently the domination of R and I over B and V magnitudes as reported above indicates the expanding opaque nebula phase in the nova's evolution".

Information from spectrographic observations – Terry Bohlson (Armidale, NSW)

I took spectra of Nova Sco 2016 on 13/6, 14/6, 25/6 and 28/6 as well as BVRI measurements. The initial spectrum was consistent with an Fe II nova past maximum but still in the permitted line phase. During this phase the expanding shell is still relatively dense and the spectrum is dominated by emission lines arising from permitted transitions. In this nova these lines were the Balmer lines that are present in all nova plus Fe II lines. The H α line was the strongest emission feature as usual. It had an expansion velocity of 1350km/s typical of a nova. The Fe II lines were the next strongest. The Fe II lines 5018, 5169, 5276, 5317, 6148, 6248 and 6453 were all present. This classifies the nova as a Fe II nova.

When the nova expands enough and the density of the emitting region falls, forbidden emission lines will begin to appear. These include [O III] 4363 and [N II] 5755. These lines are not visible on the spectrum from 13/6/16 but the [N II] line has started to appear by 28/6/16. The V magnitude was 12.39 on 14/6 and has only slightly fallen to 12.63 by 28/6. I will continue to take spectra weather permitting until it fades beyond the range of my spectrograph.

ST Puppis revisited 3 June, 2016 – *Stan Walker*

astroman@paradise.net.nz

Abstract

The behaviour of the type 2 Cepheid ST Puppis is reexamined in order to illustrate the concept that the major period variations have little in common with those of other Cepheids. The light curve since 1900 has been dominated by two major excursions which may result from internal events. But from 1969 to 1995 it was remarkably stable. The unchanging period during this interval supports the 410.4 day orbital period which largely rules out any substantial interaction at this time although it has probably occurred in the past.

Introduction

One of the interesting facts about ST Puppis is that it is a binary system, Gonzales & Wallerstein, 1996. (G&W), with a period of 410.4 days. In binary Cepheids there is always the possibility of some interaction - the pulsations of Polaris diminished dramatically in the 1990s as periastron approached but that seems to have been a coincidence. The separation of the pulsation radial velocities from the orbital velocities is not trivial and the apparently erratic period behaviour of ST Puppis could be ascribed to tidal disturbances if the period were much shorter or the orbit eccentric.

Kiss et al, 2007, (K2007) offered such an explanation involving a revised orbital period of 25.67 days based upon a pulsation period of 18.4298 days from their Figure 6. This was examined to a limited extent in Walker et al, 2015, (W2015) but these values are unlikely for reasons which are further developed in this paper. It is interesting to note that in using Google to search for information about the anomalous Type 2 Cepheid ST Puppis that Figure 6 of K2007 has been added to the references without any supporting comments. This figure, repeated below, shows a rather different behaviour pattern to that of Figure 4 in W2015. In section 4.1 of K2007 there is also reference to 3 'period jumps'. Unfortunately it is not clear how the periods shown in Figure 6 were derived. The accuracy is stated to be 'better than the size of the points' which translates to +/- 0.025 days.

The Walker et al Figure 4 is reproduced as Figure 2 here for comparison.

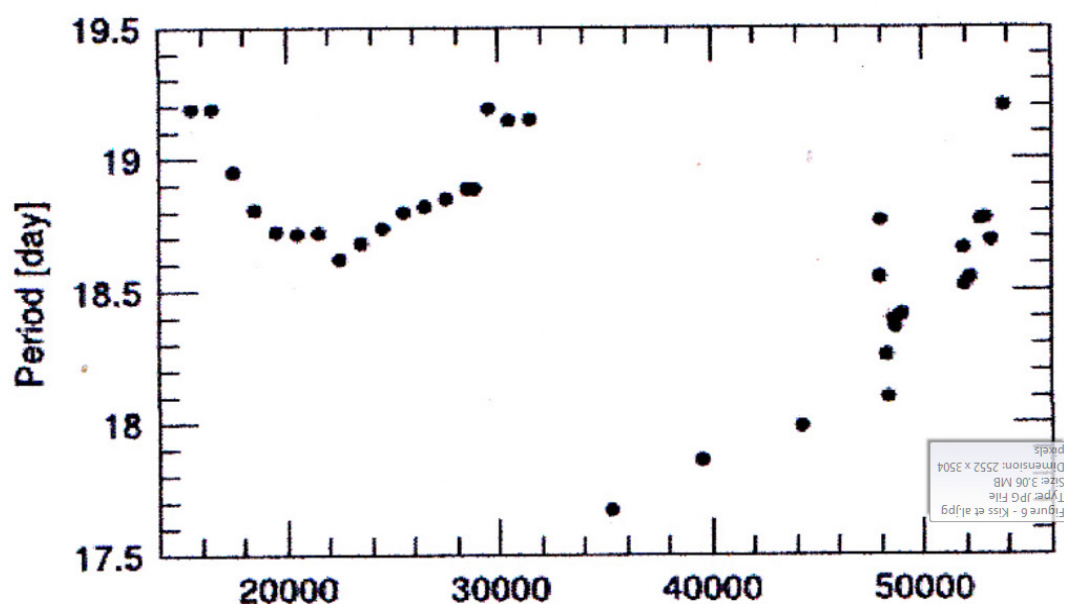


Figure 1. Figure 6 of Kiss et al, 2007.

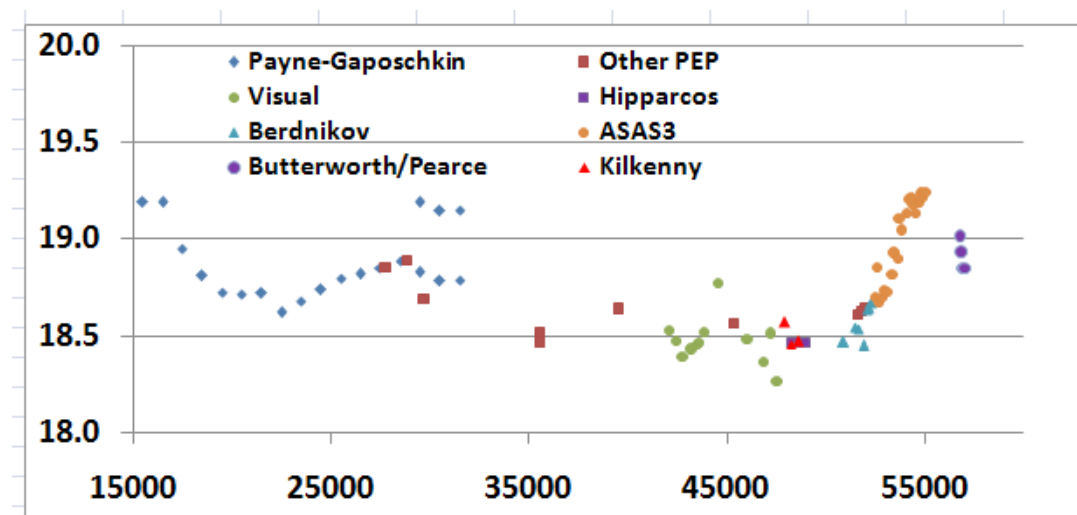


Figure 2. Figure 4 of Walker et al, 2015. The derivation of these periods is discussed carefully in that paper. There seems no real evidence of period jumps and the derived periods show much smoother - though still erratic, period changes.

Can the conflict be explained or resolved?

Sources of data

Quite clearly there have been different interpretations of the published measures and some different data have been used in each analysis. A reanalysis seems appropriate to resolve the discrepancies. The data sources are set out below.

Kiss et al:

Irwin	1961	Identical to Mitchell et al, 1964, Tonantzintla.
Walraven et al	1968*	Not in standard UBV system
Landolt	1971	
Harris	1980*	Not accessible at present
Kilkenny et al	1993	
Hipparcos	1997	
Berdnikov & Turner	2001*	Later compilation used in this analysis
ASAS3 (omitted from list in section 4.1 of that paper but used in their Figure 6)		

Walker et al

* Not used - the others above were used. This paper adds:

AAVSO	1973-1989	Visual measures
McSaveney	2003	
Berdnikov	2007	
Cousins - in this article	1990-1992	This seems to be the data used in Kilkenny et al

The visual measures, whilst not nearly as accurate as PEP and CCD, provide a very useful background to those measures - by allowing an accurate cycle count and indicating periods with a reasonable degree of accuracy. This was their main use in W2015. Their reanalysis will show that periods of less than 18 days cannot exist in the interval examined.

The electronic measures examined

The Tonantzintla data indicate that by $\sim$ JD 2435200 the period shortening was moving toward the later period of 18.4622 days. This earlier data is not well fitted by that later period. It should also be noted that McSaveney, 2003, quotes Schaltenbrand & Tammann, 1971, as determining a period of 18.559 days and an epoch of JD 2445395.430. The individual measures are not available. These measures do not fit well and could usefully be reanalysed. G&W give periods of 18.54694 up to JD 2441064 and 18.4647 thereafter. Their analysis took place well before the period increase beginning $\sim$ JD 2449000. Their earlier period may have been based only on two epochs which are not provided.

There is a datapoint at $\sim$ 35600 in the K2007 paper with a period of $\sim$ 17.65 days. This appears to be based on Tonantzintla data which is in two blocks, 12 measures from 35164-257 and 8 measures from 35532-617. The total dataset is much better fitted by a period of 18.52 days, or one cycle different as shown in Figure 3.

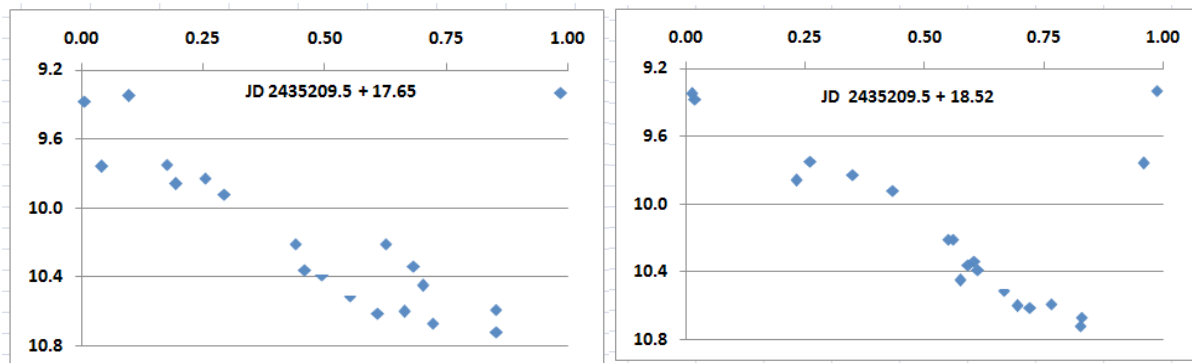


Figure 3 a, b. Kiss et al's period and epoch is shown at the left. Notice the point 9.76 at 0.04 phase and its far better placement in the right hand graph. The scatter at phase 0.65 - 0.75 disappears as well with the longer period.

The next datapoint of 17.85 days in the K2007 paper seems to be based on Landolt's data for which he derived 17.4 days. There are 24 observations over 31 days. Given the probably accuracy of ± 0.03 magnitudes and the short interval they cover any period between 17 and 19 days can be fitted.

Cousins also observed this star over three seasons from 47920 to 48659. His data are phased to a period of 18.4567 days in the McMaster archive. There is no real evidence of period change over this relatively short interval. This data is not mentioned in the Kiss et al paper but seems to be the measures in the Kilkenny et al, 1993, paper

Table 1 of W2015 examines the data from Hipparcos and Kilkenny over the interval 47362 to 48252 and derives 4 periods averaging 18.46008 although there is some instability in the latter stages. The marked lengthening of the period probably began after these at $\sim$ JD2449000.

Visual measures

These appear to be very important in allowing the rather fragmentary electronic datasets to be correctly judged. The International Database lists 317 visual measures between JD 2441361 and 2452963. During the most active period of these observers, in the interval to JD 2445000, 207 measures were made. These cover a critical period when there were no photoelectric measures and have been used in determining the periods during that interval.

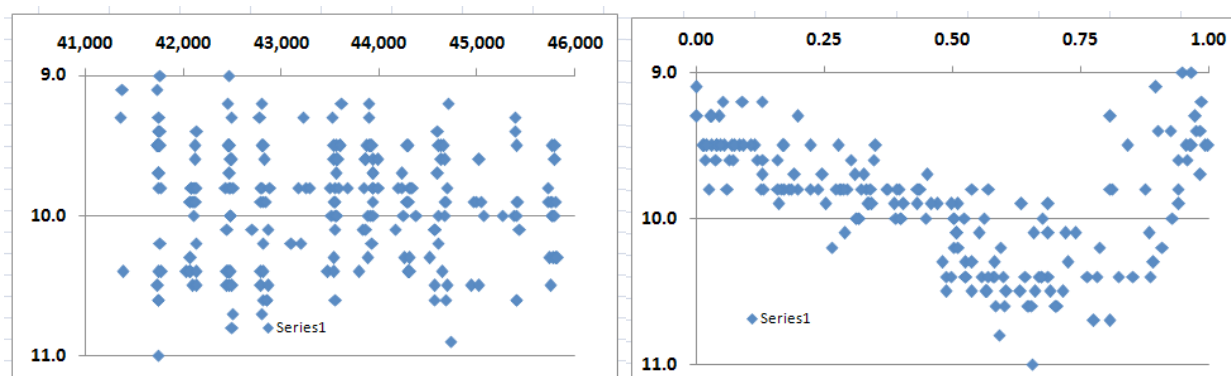


Figure 4 a, b. At the left the measures are displayed in date order to show the coverage, at the right they are folded using the ephemeris $JD\ 2441383.7 + 18.468E$

The light curve is typical of visual measures with a mean deviation of ~ 0.3 magnitudes. But there are no indications of any long term period substantially different from those used in W2015. These measures have now been divided into 1000 day increments and presented using the same epoch and period as shown in Figure 4b. These are much longer intervals than those used in W2015 and show much less scatter, although fewer points.

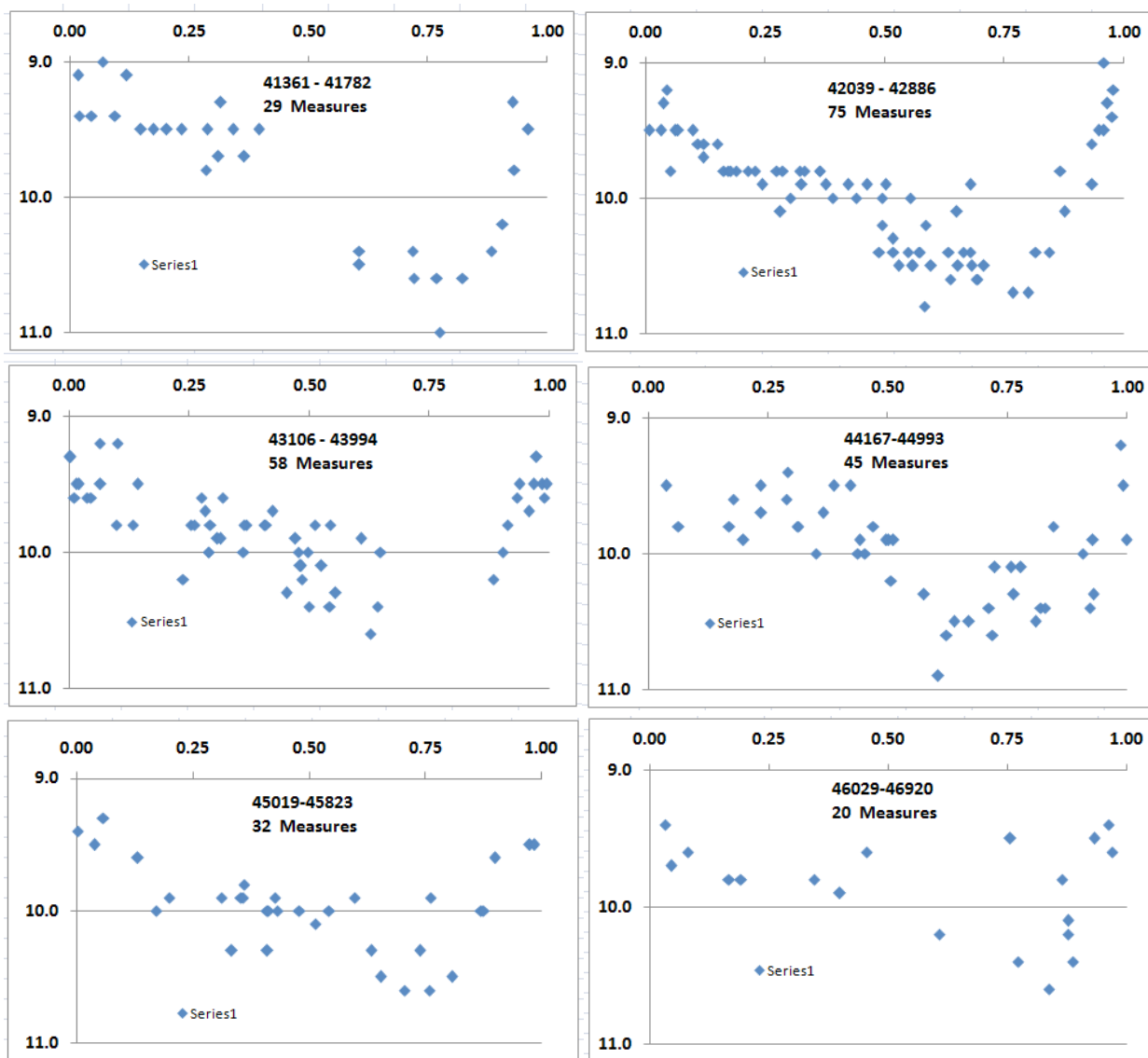


Figure 5. This figure shows the visual light curve in 1000 day increments from 41000 to 47000. The same period has been used. During the last interval the main observer was suffering from ill-health and declining eyesight and the effects of this are clear.

All of these revised epochs have been used in the O-C diagram of Figure 6. They show that for a considerable period, perhaps 25 years, the period was essentially stable. Why then, the major period changes before and after this?

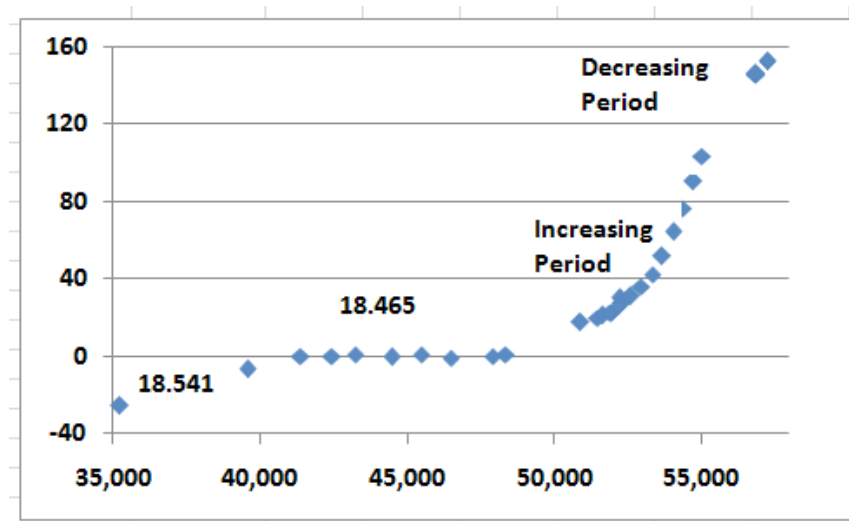


Figure 6. The O-C diagram of ST Puppis during the photoelectric era plotted to JD 2447920.4 + 18.465. The vertical scale is days early or late, horizontal JD - 2400000. This can be separated into four sections - a longer period to somewhere near JD 2440000, a stable period of 18.465 days to ~JD 2449000 (24.65 years), an increasing period to ~JD 2455000 and a declining period from ~JD 2456500.

Has there been a colour change?

To study this we took all the available B-V measures and plotted them on the basis of phase which overcame the problem of different periods. These are shown in Figure 7. Superimposed on these are the V measures of Cousins offset by -9.3 magnitudes. There is no believable evidence of any colour changes. The final set of measures, those by Butterworth using DSLR photometry, are at the limit of his system and show considerable scatter.

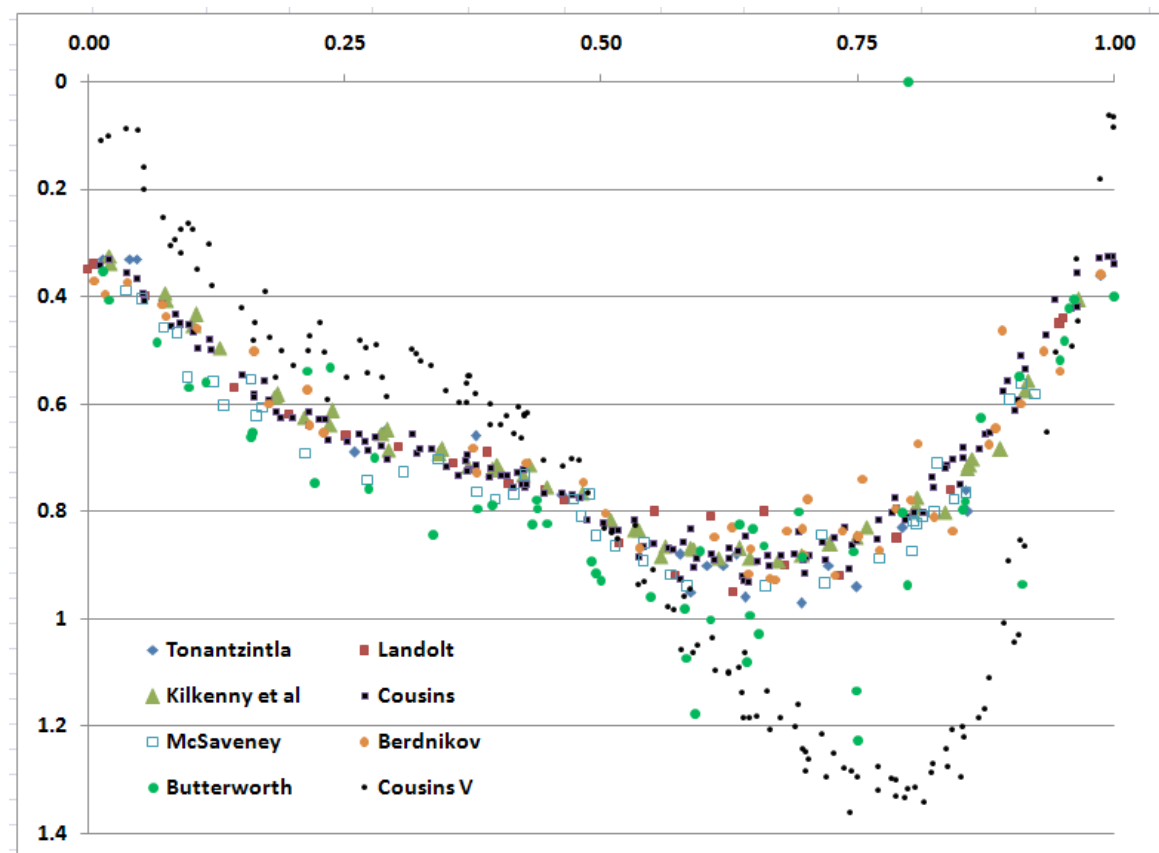


Figure 7. All available B-V measures are plotted by phase. For comparison the V amplitude, as measured by Cousins, is shown in black squares. This covered several cycles and there seems to be some variations near maximum.

The overall period variation is ~19.22 less 18.46 or 0.76 days. This is 4% of the mean period. Unfor-

tunately most of the reliable colour measures occurred in a range of ~ 0.25 of that mean change so any variations due to changes in radius associated with period variations would be undetectable, even more so given the variety of detectors.

The hump in the descending B-V curve does not match the visual hump on the decline. G&W showed that the V-I colour gives a better match to this. This is interesting from a physical viewpoint but beyond the scope of this analysis.

An alternative explanation

The long period of comparative stability from ~ 40000 to 49000 (1969 to 1995) is quite different from the conclusions of the K2007 paper. It suggests that ST Puppis is often similar to most CW stars with a regular period subject to small deviations in the O-C diagram but that some internal event causes a striking period change at intervals. This has not been seen in other Type 2 Cepheids so do other pulsating variables offer any ideas?

A number of Mira stars have shown substantial period changes, usually ascribed to a 'helium flash'. R Hydri is the only example where a long term period change, perhaps beginning ~ 1670 and ending ~ 1940 has now seen the star return to a stable period with the normal alternations around the mean period. The similar period shortening of R Aquilae may also be ending as period alternations are now apparent, Walker, 2009. The period may now have stabilised, Greaves, 2016. R Centauri is the only star where the onset of this helium flash event may have been observed but the measures are fairly inconclusive and do not cover the early interval well.

The dramatic period changes of the Miras BH Crucis and LX Cygni appear completely different - both have shown a *lengthening* of period in two decades or so - this may possibly be merely a mode change. Uttenthaler et al, 2016, suggest that it is related to a recent third dredge up after a helium event and the greater abundance of carbon has caused the dramatic increase in the star's radius, hence in the period as well. This change began in 1975 and unfortunately the database goes back only to 1969 so there is no way to relate this to an associated thermal pulse. Interestingly, the database shows a steady decline in the overall brightness of LX Cygni since 2000, whereas BH Crucis increased in brightness with the period change.

ST Puppis shows a period maximum at 1900 at the start of the measures. What went before? The second maximum, at around the same value of 19.2 days, probably reached a peak in 2009-10. Are these caused by some type of internal disturbance which may not affect the overall brightness to a discernible extent, but merely the radius? A less distinct period maximum of ~ 18.9 days occurred in 1938-39 but this may be associated with the first event. .

G&W state that there is evidence of mass exchange in the system in that the spectrum shows unusual abundances of various elements. This also may have some bearing of the star's behaviour.

Another interesting CW star is kappa Pavonis. This has been observed since 1871, but more consistently since 1890. The O-C diagram is shown in Figure 8. The maximum period reached 9.12 at ~ 25000 , falling to 9.08 in ~ 35000 . This diagram is reminiscent of parts of the periodogram of ST Puppis but on a much smaller scale.

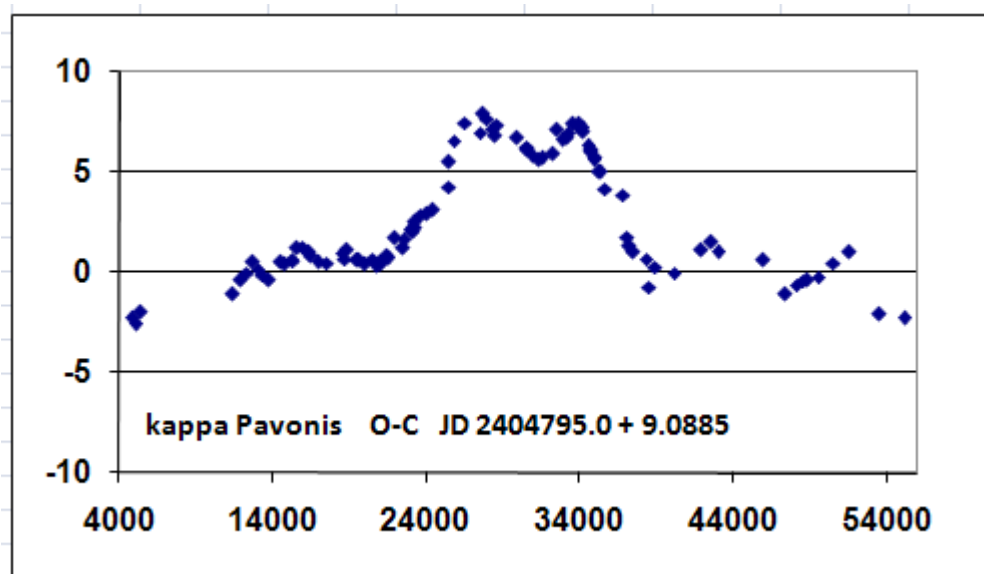


Figure 8. The O-C light curve of kappa Pavonis up to JD 2456000. It shows erratic low amplitude period variations but a rather larger amplitude event lasting lasting 25-30 years.

Conclusions

The period changes of ST Puppis are unusual but except for the two events shown they are gradual and there is no evidence of period jumps or highly erratic periods as stated by Kiss et al. Nor is there any reason to change the Gonzalez & Wallerstein orbital period of 410.4 days to the much shorter period of 25.67 days which would allow interaction to explain the erratic period and period jumps which do not seem to exist. The overall radial velocity variations of G&W seem to favour a much slower orbital speed than the shorter period would require.

After a star's departure from the AGB it seems to enter a region where a variety of different types of variability are seen. All these star types show a much greater luminosity/mass ratio than main sequence stars and this appears to affect smooth evolution. Even in the earlier Mira phase of evolution observation seems to reveal more period changes than theory suggests. Perhaps there are other factors at work, not necessarily linked to the commonly ascribed helium flash events?

The unusual period variations of ST Puppis may be one example of this.

References:

- Greaves, J., 2016. BAA VSS Circular 167, 12
- Gonzalez, G & Wallerstein, G., 1996. Mon Not R Astron Soc 280, 515
- International Database, 2016, AAVSO
- Kiss, L L, Dereka, A, Szabo, G M, Bedding, T R & Szabados, L., 2007. Mon Not R Astron Soc 375, 1336
- Uttenthaler, S., et al. Astronomy and Astrophysics, 2016, 85, 145
- Walker, S 2009. VSS Symposium 2
- Walker, S, Butterworth, N, Pearce, A., JAAVSO 2015, 43, 217

Changes in L2 Puppis reflected in historic AO data – part 1

– *Aline Homes, Pauline Loader, John Homes, Stan Walker*

Abstract

205 photometric observations of L2 Puppis in V, B-V and U-B obtained at Auckland Observatory (AO) over the period JD2446051 to JD2451320 (December 1984 to May 1999) have been analysed. Results so far indicate that the primary period remained essentially unchanged over the period of the observations, while visual and V magnitudes declined dramatically from 1995 on, but magnitudes in both B-V and U-B remained essentially the same. This is consistent with a major dust emission event that led to the formation of the recently discovered dust disc around the star.

L2 Puppis, J(2000) 07:13:32.3187 -44:38:23.06, spectral class M5 IIIe, is a mid-life pulsating red giant of under two solar masses and with a surface temperature of 3380° K. It is classified as a type SRb semi-regular with a magnitude range of 2.6-7.54 in V (AAVSO) but has remained below naked-eye visibility for the past two decades. The primary period is given as 140.6 days and there is no reported secondary period. The star has undergone a number of fades since discovery, probably due to dust emission (Bedding *et al.* 2002), but largely recovered within a few years. The published range is misleading since it does not correct for these fades. The current dimming event is therefore unprecedented. Recently published observations (Kervella *et al.* 2015) offer an explanation.

Analytical methods

The present analysis is of 205 photoelectric photometric measures in V, B-V and U-B made at Auckland Observatory in 1984-1985 and 1993-1999. Analysis was carried out using a spreadsheet (LibreOffice Calc), the V-Star program from AAVSO and the self-correlation program from John Percy's website (Percy *et al.*, 2006). Self correlation was used to cross-check periods from Fourier analysis (V-Star) because it is usually less prone to aliasing when dealing with discontinuous data. For analytical purposes the data was divided into three blocks: 1984-1985, 1993-1996 and 1997-1999.

Light curves

Light curves for the 1984-85 and 1993-9 are given in Figure 1. The 1984-85 data (46 observations) covers one complete cycle and parts of two others (V). There is a phase difference of about half a cycle between V and U-B curves. Visual brightness over the 1984-85 season varied from 3.919 to 5.693. Variation in B-V is slight and seems to show a somewhat longer cycle length, but the observation period is too short to draw definite conclusions.

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

In V, there is a marked hump or stillstand on the rise in the 1994-5 light curve, arrowed in the plot. This is not apparent in either B-V or U-B. Examination of the light curves for 1993-99 suggests that this feature is not always present. Its significance is unclear.

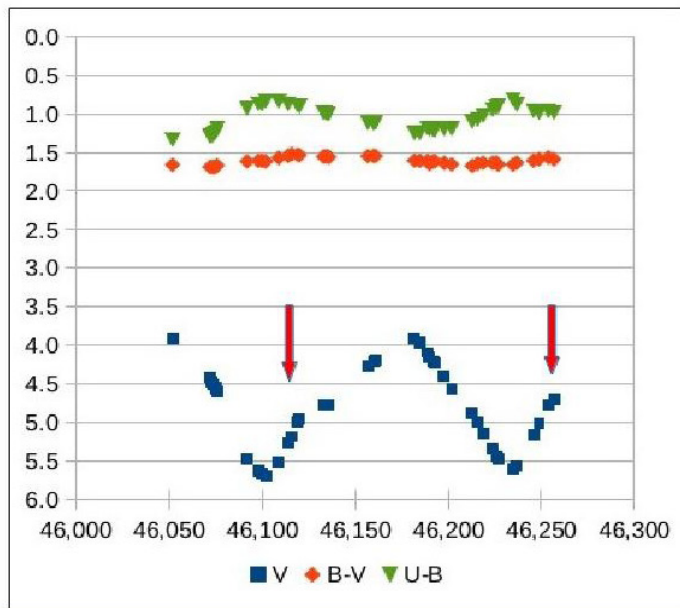
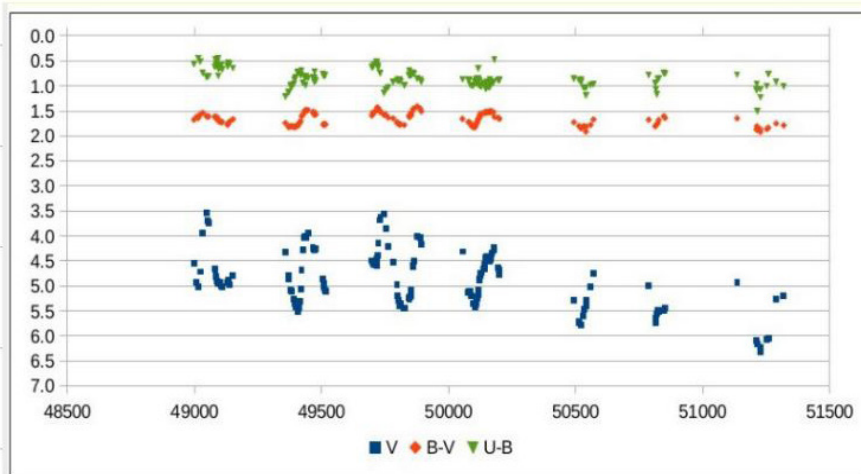


Figure 1. 1984-5. Note time lag between maxima in B-V and U-B and that in V; also possible hump on the rise in V (arrowed).

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



Plotting maxima and minima for each season from 1984-5 to 1999 (Figure 2) makes the decline in brightness of L2 Pup apparent. This decline continued beyond the end of Auckland Observatory's observations, and the star is now too faint for naked eye observation at any stage of its cycle.

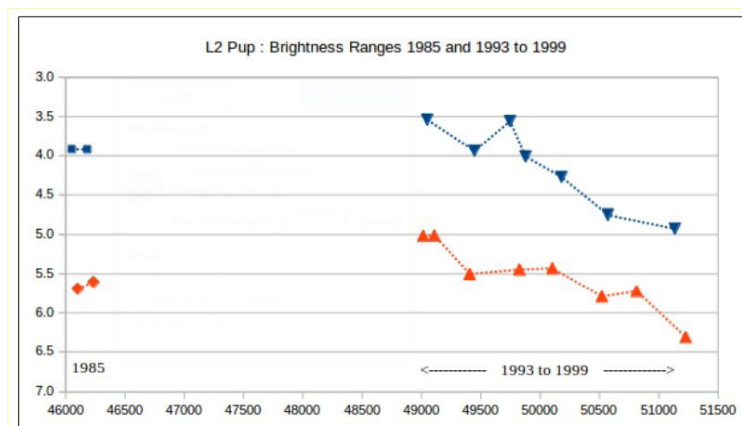


Figure 2. Plot of maxima (blue) and minima (orange) for 1984-85 and 1993-99

The decline in both maxima and minima is marked and at the end of the observation period the trend was still downward. This is strongly suggestive of dust emission as the cause.

Analysis

1984-85 season: A self-correlation plot (V) for 1984-85 is shown in Figure 3. The first minimum indicates a cycle of about 130 days (red arrow), and another at about 180 days (blue arrow), although the latter may be an artifact of the dataset coverage. A K value of 0.83 derived from this plot indicates a high degree of regularity although how far this can be trusted is unclear given the limited data available.

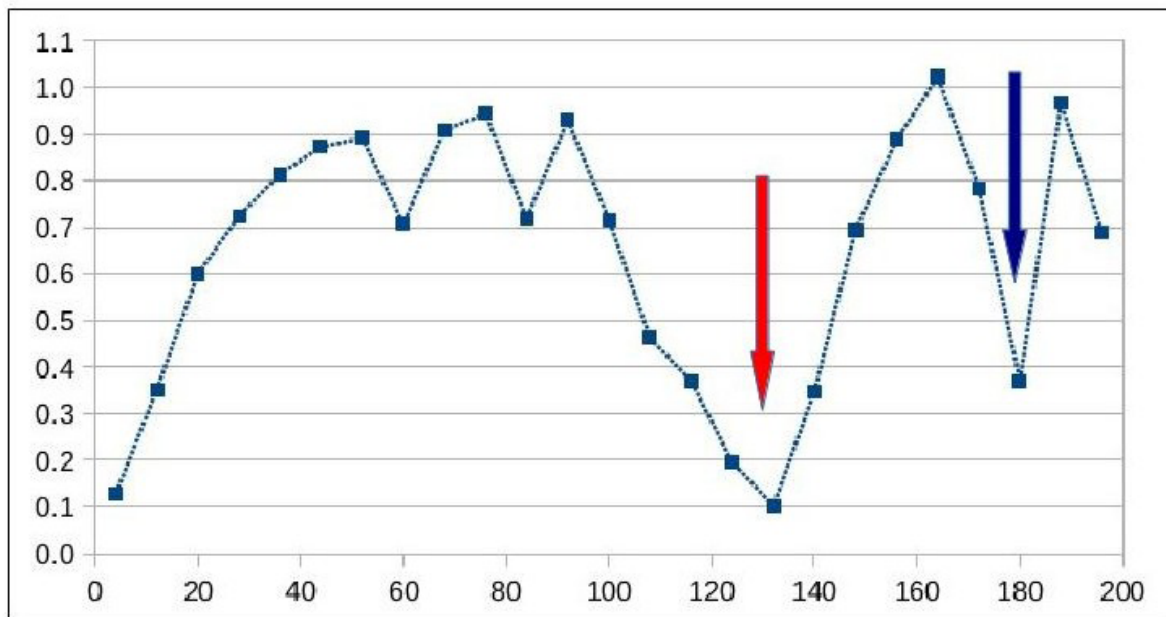


Figure 3. Self correlation plot (V data) for 1984-85. Red arrow – primary period, blue arrow – possible secondary period.

In B-V, SCS reports a cycle of about 137 days and in U-B one of about 125 days. All these values are lower than the published period of 140.6 days, but Bedding *et al.* (2005) analysed 77 years of visual observations of L2 Pup and found a long-term variation in period within an envelope of about 130 to 150 days.

The data were also analysed using V-Star DC-DFT. Figure 4 shows a power spectrum for the V observations. The most marked frequency is 0.0084, equating to a period of 119.105 days. A reanalysis omitting the single outlying point from the following season gave a value of 119.97 days. Other periods are weak.

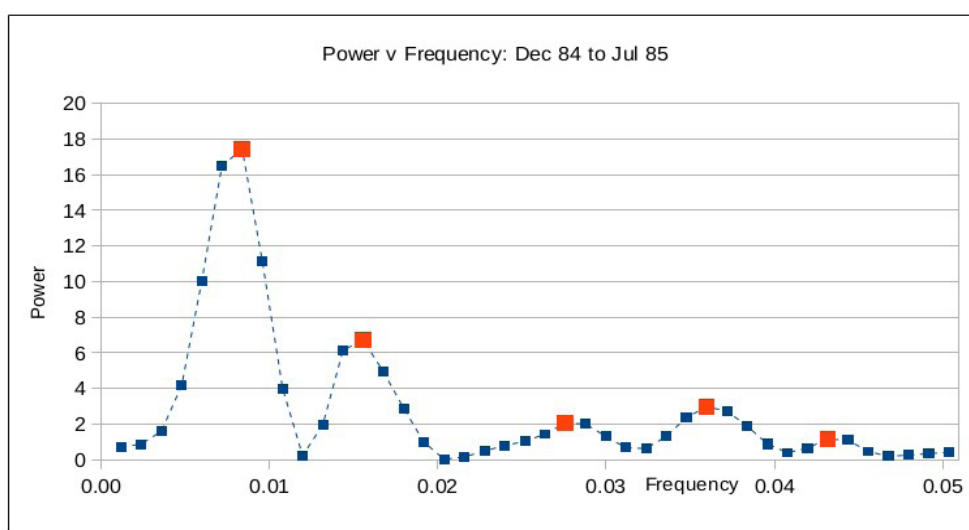


Figure 4: V-Star DC-DFT power spectrum plot for 1984-85 V data.

The output from V-Star DC-DFT analysis is summarised in Table 1.

V-Star results for V

Frequency	Period	Power	Amplitude
0.008396	119.104661	17.430211	0.759604
0.015593	64.133279	6.718174	0.408223
0.035983	27.791087	2.981493	0.292542
0.027587	36.249245	2.060887	0.243559
0.043179	23.15924	1.138628	0.222836

V-Star results for B-V

Frequency	Period	Power	Amplitude
0.007197	138.955437	16.621549	0.06697
0.04198	23.820932	6.608817	0.038412
0.014393	69.477719	4.217593	0.030826
0.031185	32.066639	2.186318	0.022895
0.025188	39.701554	2.020344	0.025549
0.02039	49.043096	1.168502	0.017213

V-Star results for U-B

Frequency	Period	Power	Amplitude
0.008351	119.741794	16.950743	0.199869
0.01551	64.47635	6.856428	0.12748
0.035791	27.939752	3.441856	0.090993
0.02744	36.443155	1.815819	0.066555
0.041757	23.948359	1.381158	0.053866
0.047722	20.954814	1.043287	0.056582
0.001193	838.192555	0.817669	0.100669

Table 1: Output from V-Star DC-DFT analysis of 1984-5 data, B-V and U-B

It is noted that the results are similar for V and U-B, but B-V is substantially different.

For B-V, the dominant frequency equates to a period of 138.96 days, within the accepted envelope of variation. U-B returns a period of 119.74 days, however, similar to that obtained for V. The 119 day periods are anomalous since they accord neither with published periods or with those obtained from SC analysis. The cause of this anomaly is unclear and should be investigated. The similarity in period obtained from analysis of V and U-B is probably due to the two light curves being half a cycle out of phase.

A phase plot for 1984-85 V data with model based on a period of 119.104 days is given in Figure 5. The observations are in good agreement with the model.

1993-1999 data: Analyses of the AO data from 1993 to 1999 are still in progress, but currently indicate no change in period. U-B data will not be analysed due to problems experienced with the U filter (S. Walker, pers. comm.). These problems have resulted in an excessively noisy light curve. Results of the analysis will be discussed in part 2 of this paper, along with consideration of more recent work eg. Kervella et al. 2015.

Interim conclusions

Overall, the form of the 1984-85 season light curves fits well with the pattern evident in the long-term data plotted by Bedding et al. (2005). Although the V light curves for 1993-1999 are noisier, and based in some cases on relatively sparse data, they too seem to fit the overall pattern. The variability of L2 Puppis appears to be too regular for the published classification of SRb. In their detailed analysis of the variability of this star, Bedding et al. (2005) conclude that once corrected for fades due to dust emission the amplitude of variation is under 2 magnitudes and the star is intermediate in nature between a Mira and a semi-regular. This suggests a better classification would be SRa.

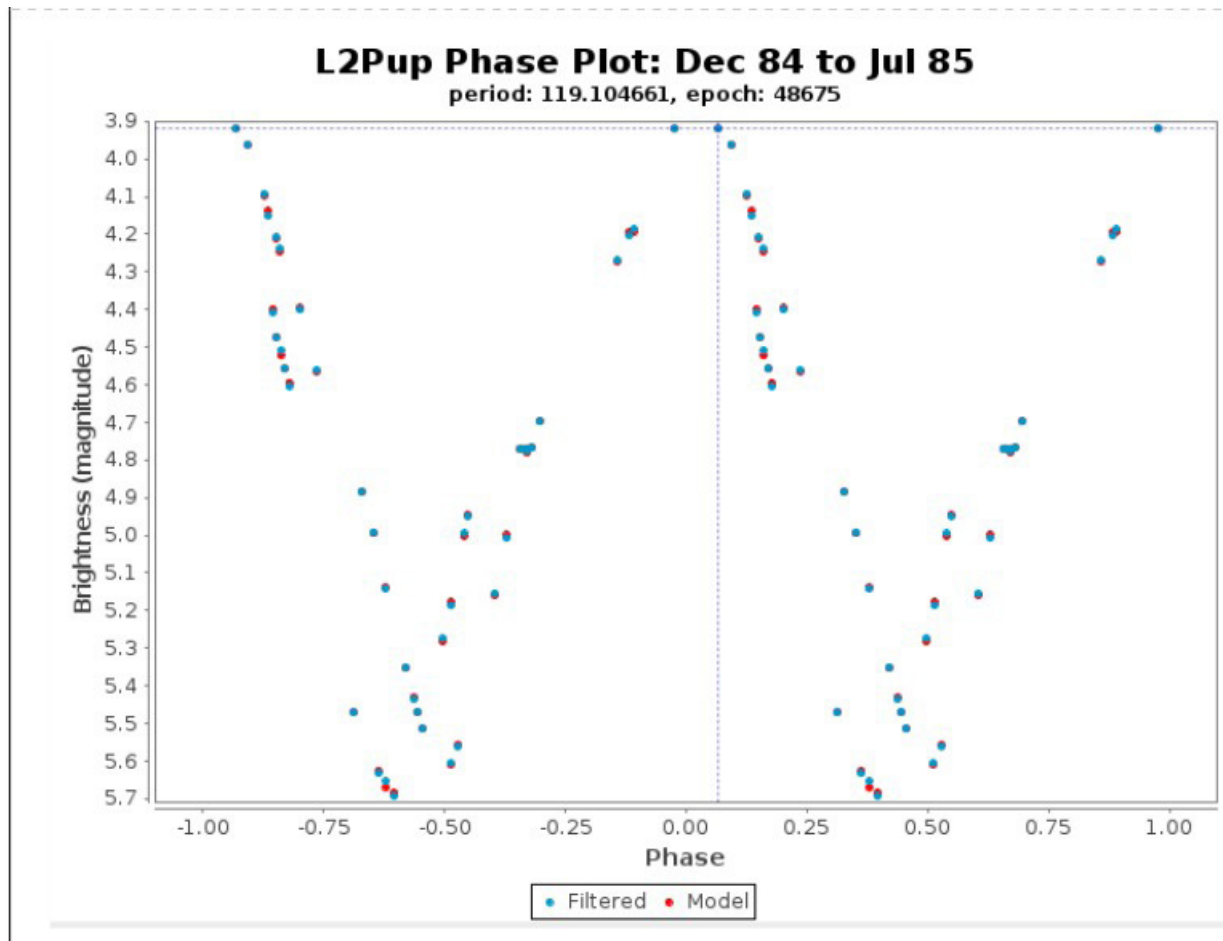


Figure 5. Phase plot (V) for 1984-85, observational data yellow points, model red.

References

- Bedding, T.R. et al., 2002. MNRAS 337: 79-86
- Bedding, T.R., et al., 2005. MNRAS 361: 1375-1381
- Kervella, P., et al., 2015. arXiv1151.0444v1[Astroph.SR]
- Percy, J.R. et al., 2006. Pub. Ast. Soc. Pac. 118:1390-1395

Reading the clues in light curves of eclipsing binaries

Part I – finding star sizes

Capturing a light curve of stellar eclipses, transits, or occultations - by stars or planets - can often be done in a single night with electronic imaging. Although sophisticated software is available to help you derive astrophysical information from the light curve, a thoughtful contemplation of it can yield a very great deal of information about the system. This series of articles, based on my presentation to NACAA XXVII, Sydney, Easter 2016, will show how.

Introduction – how do you model an eclipsing binary?

The age of computers and two-dimensional photovoltaic detectors has opened up the study of fast-changing and low-amplitude variables. Today amateurs with very limited equipment (even just a DSLR camera) can make magnitude measurements minute by minute throughout the night, with near to millimagnitude precision. This has revolutionized the study of eclipsing binaries, as well as other types of variables that could not be studied with any precision visually or photographically – either because they changed too quickly or because they changed so little. Even photoelectric photometers, though accurate, could not match the speed which CMOS or CCD cameras could take measurable images. No wonder many amateurs are turning to this fruitful area of variable star research.

In the course of one night, an observer may collect up to 1000 images of a variable, then measure its brightness on all those images the next day in the course of minutes. (Most astronomical camera control and imaging software applications will do this.) The result is a light curve which, for eclipsing binaries, may cover an entire eclipse, or even an entire orbital cycle. Sometimes, for longer period eclipsers, it may be necessary to stitch together the work of several nights to get the entire orbital cycle. Figure 1 is an example, combining measurements from several observers. The orbital period P of that system, CU Hya, is 0.719 days.

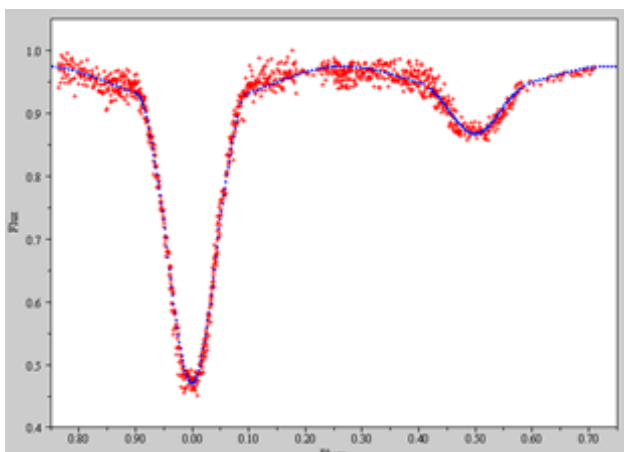


Figure 1. Light curve of CU Hya, derived from CCD observations by several observers. (Richards et al, 2013)

But before even obtaining a full light curve, you can still measure P by capturing two or more minima and using software that will find the times of minima in your eclipse curves. So now, armed just with (a) a complete light curve and (b) knowledge of the orbital period, what can you deduce about the eclipsing binary you are studying? The answer is, a surprising amount (and you don't really even need (b)).

The light curves of eclipsing binaries are, to a first approximation, determined just by the star shapes and sizes, and their orbit – plus of course the angle of your line of sight to the system. Interpreting a light curve is, to that extent, an intuitively geometrical matter accessible by common-sense reasoning. Forget Euclid and trigonometry. Highly mathematical algorithms do exist for doing a proper modelling job on a light curve, telling you in detail about the star shapes, relative sizes and masses, temperatures, spot cover-

age, and much more. Allied with spectra, especially to measure orbital radial velocity, these programs will also calculate the absolute sizes of the stars and the orbital parameters, as well as delivering their spectral classifications. But in these articles we will eschew such sophisticated aids and play Sherlock Holmes, just deducing what we can from what we see. Plus a bit of simple arithmetic here and there.

This is what makes eclipsing binaries such fun – you can find out so much about the stars just from reasoning about the light curves, because the cause of the light curve is mainly geometrical. With other types of variables, such as pulsators, this is not so. The cause of their variation lies deep inside them, accessible only to sophisticated astrophysical theorizing – left to the experts.

So let's make a start with our amateur detective work, and see what we can deduce about the sizes of stars in an eclipsing system.

Star sizes from total eclipses

Once you have a full light curve, it is not hard to estimate the relative sizes of the two stars. Figure 2 illustrates how to use the durations of entry and exit from a total transit (A) or equally, a total occultation (B). The illustration shows a smaller, brighter star and a larger, dimmer star in a system with inclination to the line of sight $i = 90^\circ$ (orbital plane is edge-on). The time to go from position 1 to 2, ingress, given by the left descent of the eclipse, equals the diameter of the smaller star relative to the length of the orbit – as the light curve below the star diagrams reveals. *Assumptions:* the orbit is circular (which it most often is, especially for stars close together); and the direction of the smaller star's movement is across the line of sight, with no line-of-sight component (safe enough if the stars are far apart). (Quick check – if the smaller star were appreciably advancing towards us during ingress, would the time taken for ingress be longer or shorter than to move through its own diameter?)

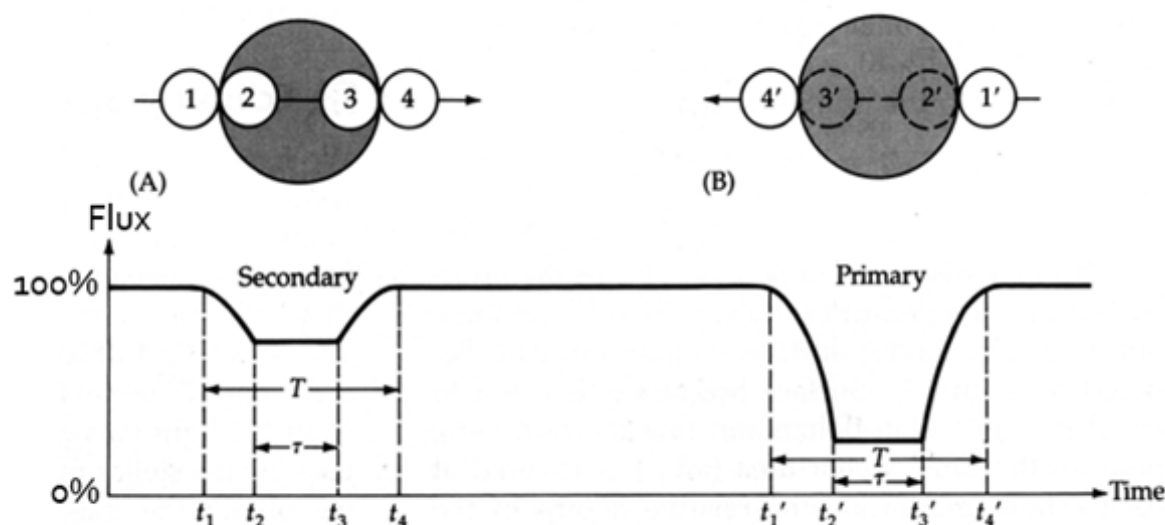


Figure 2. An edge-on ($i = 90^\circ$) total transit in (A), and total occultation in (B), showing how ingress and egress shapes the light curve ascents and descents

The same sort of deduction shows that the time (relative to P) to move from position 1 to position 3 gives the diameter of the larger star, again relative to the length of the orbit. Note in Figure 2 (B), the geometry of the stars in the primary eclipse is identical to that in the secondary – reversing the stars front to back makes no difference. This symmetry is true independently of i , so ascents and descents in the light curve are *always* of the same duration. Lurking behind that claim is another *assumption*: the stars are radially symmetrical in their brightness distribution across their disks. Starspots for example could distort an ascent or descent curve, widening the shoulder.

For the same geometrical reason, the two totalities must be of the same duration.

Not edge-on?

Plainly, the chance of your light curve representing a binary with $i = 90^\circ$ is very small, even for total

eclipses. So what happens in more realistic situations? Figure 3 shows an ingress edge-on ($I = 90^\circ$) and another at a lesser inclination. In the second case, by the time the smaller star has moved through its own diameter, it is still far from second contact (point of first contact is arrowed). So for the ingress time to be the same as the $I = 90^\circ$ case, it would have to be a much smaller star. Deduction: assuming $I = 90^\circ$ the calculated diameter of the smaller star is an upper bound of its actual size (relative to size of orbit of course). (Quick check: We used the $I = 90^\circ$ simplification to calculate the relative diameter of the larger star too. Is that an upper or a lower bound on its size?)

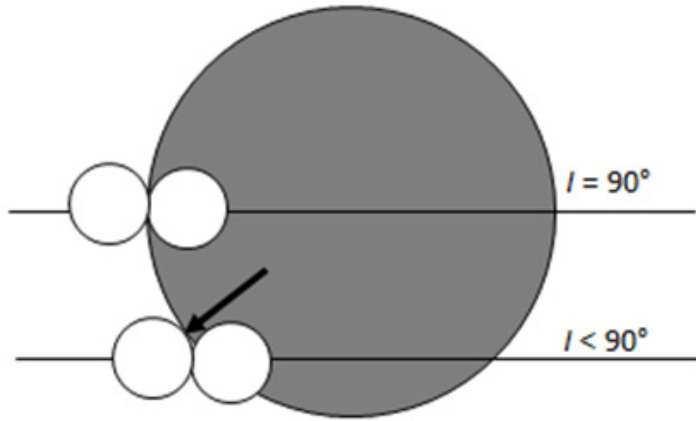


Figure 3. The effect of inclination on time of ingress.

What's the clue for totality?

So now, knowing P and just thinking about the geometry of total transits and occultations, you have been able to put limits on the sizes of the stars relative to the orbital length. But how do you know the transits (hence the occultations) were total? Well, looking at the primary eclipse curve in Figure 2, why does it have a flat bottom? It can only be because the smaller star has disappeared completely for that time – a total occultation. If it remained visible during the occultation, never completely hidden, there would be a continuous change in the amount of light it delivers to us. Since the front-to-back orbital geometry is symmetrical, the flat bottom of the secondary eclipse shows the smaller star is transiting across the uniformly bright disk of the larger star; so again there is no change in total brightness. Then how come we have cases like Figure 4, where only the secondary eclipse has a flat bottom?

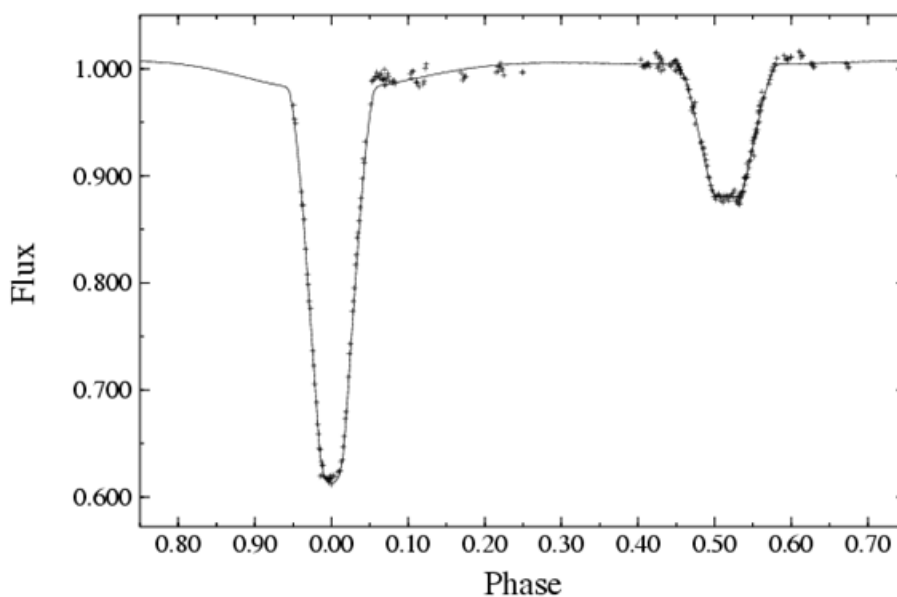


Figure 4. Light curve of IQ Peg. From CALEB (Bradstreet 2004).

From symmetry, we know that a total occultation (in the secondary eclipse) *must* be matched by a total

transit (primary eclipse) of equal duration. So the total transit *must* be across a non-uniformly bright star. You have detected limb darkening!

Next instalment

Understanding eclipse depths.

References

Bradstreet, D., 2004. Catalog and Atlas of Eclipsing Binaries. <http://ebola.eastern.edu>. Accessed 1 March 2016.

Richards, T., et al, 2013. "CU Hydrae – a neglected bright eclipsing binary star". J Br Astron Assoc, 123, 3.

Old friends and new mysteries – *Tom Richards*

tomprettyhill@gmail.com

SEB CCD targets for August to October 2016

Well, judging by the minima records coming into the SEB Dropbox, some enviable people are getting clear skies this winter. Terry Bohlsen, Simon Lowther, and Robert Jenkins and especially Neil Butterworth have brought the total for the year up to 39. Mark Blackford is keeping a lot of analyses in his Pending tray until he gets his house shift to his dark-sky retirement property more under control. I sympathize. My contributions were definitely not from the winter of my discontent – the last observable night I had was May 2nd with YY Aps. Neil has discovered an apparent primary/secondary minima reversal for V883 Sco compared to GCVS data. There are two possible reasons for switching minima – the stars did it or the original observer did. Mistakes happen. (Definitely not by Neil!) Anyway it needs following up, if only because the partial light curve Neil has looks to me very like an EA, not the listed EB/KE.

For this three-month period I have chosen target systems of magnitude 10-12 in the RA band of 21-02 hours inclusive and south of -30° declination. Brighter targets are better handled by DSLR equipment.

Some EA friends

We begin with some EAs (detached, semi-detached) that the SEB group has worked on already, but need more data. Using data from the former VSS EA/SPADES project, Streamer *et al* (2015) provided revised light elements of 25 southern EAs. These systems need more minima measurements as confirmation, so they are all good and useful targets. Two of these (RU Gru and CT Phe) are within our RA band.

Star	RA 2000.0	Dec 2000.0	Vmag	VSS E0	VSS P	Please observe	Note
Gru RU	22 27 0.55	-37 11 8.2	11.01	2455805.1032(5)	1.8932001(18)	Secondary eclipses	Tiny sec. ecl. Model in CALEB needs confirming.
Phe CT	01 25 46.35	-39 56 0.6	11.422	2456195.0750(5)	1.2608260(25)	Primary eclipses	ASAS3 LC suggests period change. Tiny secondary eclipse.

Some known unknowns

Next, I went looking for some systems about which very little is known, and what is said to be known by the GCVS might be very wrong (Samus et al, 2007-15). It lists them all as E, which means it's unknown what type of eclipser they are (EA EB or EW). Some even have the colon of uncertainty, so doubly dubious. An interesting bunch, worth some papers in this Newsletter if we can pin down anything interesting. (A literature search might throw up some more information.) Why is AF Gru said to be an

eclipses if its period and epoch are unknown? BO Gru and AR Phe presumably have had only one minimum observed. And what is the very red AW Gru, with a presumed 120 day period? That one is certainly worth a long campaign as is the nearby long period BF Gru. If you would like to take that pair on, email me and we'll work out a campaign together.

GCVS	RA J2000	Dec	Type	Max	Min	Band	Epoch HJD 2400000+	Period	Spectrum
BM Oct	213045.3	-790356	E	11.4	12.2	p	28702.55	3.70898	
AW Gru *	221908.8	-480206	E:	10.5	11	p	36758	120:	M4III
AF Gru	225629.2	-472147	E:	11.9	12.4	p			
BF Gru	225652.3	-484823	E:	11.2	11.8	p	36731.57	55.8:	
BO Gru	230658.6	-435438	E	12.1	12.6	p	36814.34		
S Hyi	001856.0	-795455	E/SD:	12	13	p	25452.56	0.90312	
RW Phe	003016.3	-462759	E	12.4	14	V	25859.34	5.4129	
AR Phe	012355.6	-413002	E:	11.5	12	p	36764.63		

If you want to work on these targets and you're not in the SEB group, have a look at the Southern Eclipsing Binaries subweb of our website (or go directly there at www.eclipsingbinaries.prettyhill.org). There you will find comprehensive guidelines on eclipsing binary work. The first step is to find a time of minimum in your data. Once you have some data, please contact me and I'll send you an invitation to share the VSS EB-EW Dropbox folders. There you will find project information, useful papers, and our data for each target under observation. You can add yours will, and you will be a co-author when we publish anything with your data in it..

References

Samus, N.N. et al, 2007-2015, VizieR online data catalogue B/GCVS. <http://vizier.u-strasbg.fr/>
 Streamer, M. et al, 2015, "Revised Light Elements of 78 Southern Eclipsing Binary Systems", JAAVSO 43, 1, 67-73.

BH Crucis has been observed in a reasonable range of filters since 2007 and it's now possible to combine all of these. This star when discovered by Ron Welch of Auckland in 1969 had a period of 421 days and showed distinct double maxima. Since then it has undergone a major change to what seems a stable period of 505 days. It has also become slightly brighter and the first maximum has almost disappeared.

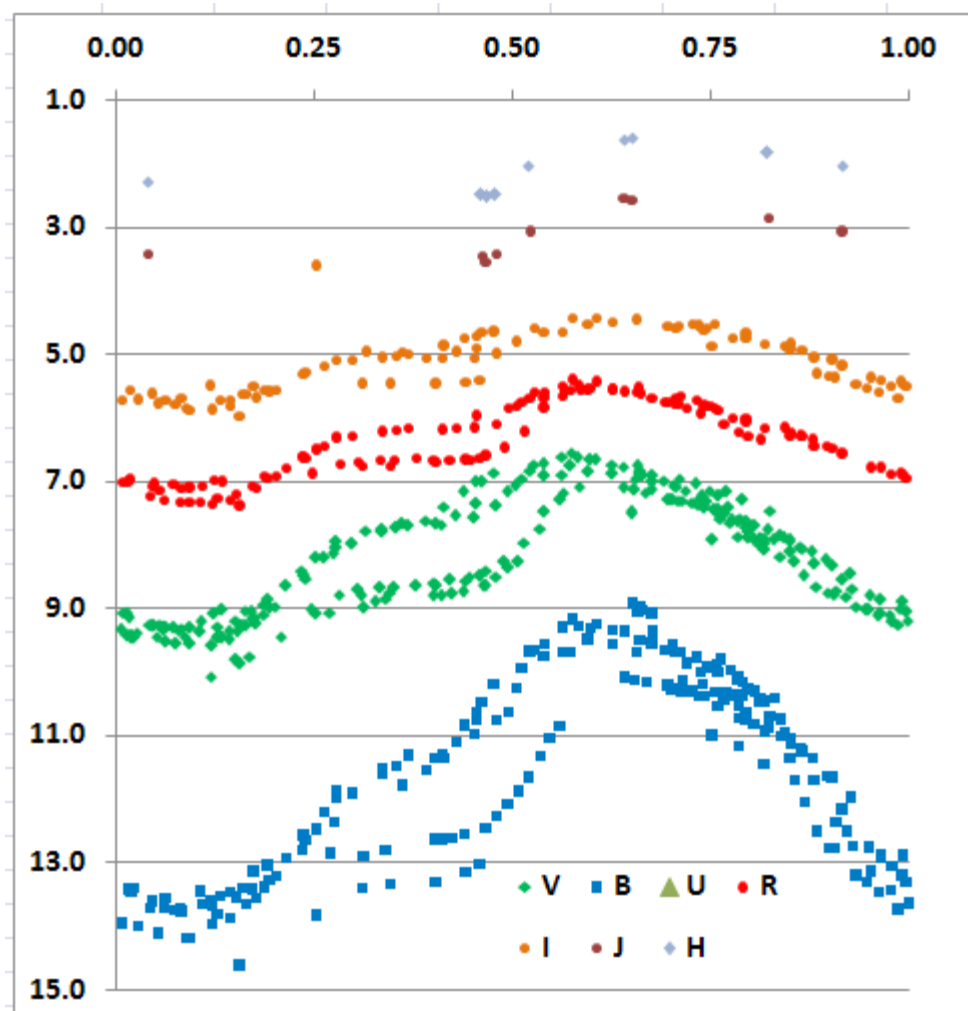


Figure 1. Light curves during the interval JD 2454241 - 57496 through various filters with the longest wavelength at the top - H, J, I, R, V and B. The blank item in the legend is U which is difficult for CCD cameras and is also very faint in this star. But it has been measured in the past.

Figure 1 shows the light curves through 6 filters. There is a pronounced hump on the rise followed by a standstill, the beginning of which occurs at the phase where a second hump existed in the 1970s. Since many Mira variable stars have humps on the rise it's possible that what has been seen here is part of a normal evolutionary process.

It's almost certain that the period change is not the result of a helium flash. In a study of LX Cygni, which showed a similar increase in period over a similar interval, Uttenthaler et al, 2016, speculate that these changes may result from a third convective dredge up of carbon and other elements from lower regions of the star causing an expansion of the envelope and a change in period. This may result from a helium flash but that is merely a suggestion which needs further observational evidence. R Hydrae, having seen a period change ending ~1940, may well be a useful target for observers. R Aquilae is believed to be in the terminal stages of a similar event.

The object of multicolour photometry is to examine various wavelength distributions revealed by the filters. These also indicate temperature changes. For this it's normal to use pairs of filters to define colours.

V as the base, then B-V, V-R, R-I and V-I with J-H farther into the infrared. This last has been omitted from Figure 2 as there are inadequate measures and the curve is quite flat.

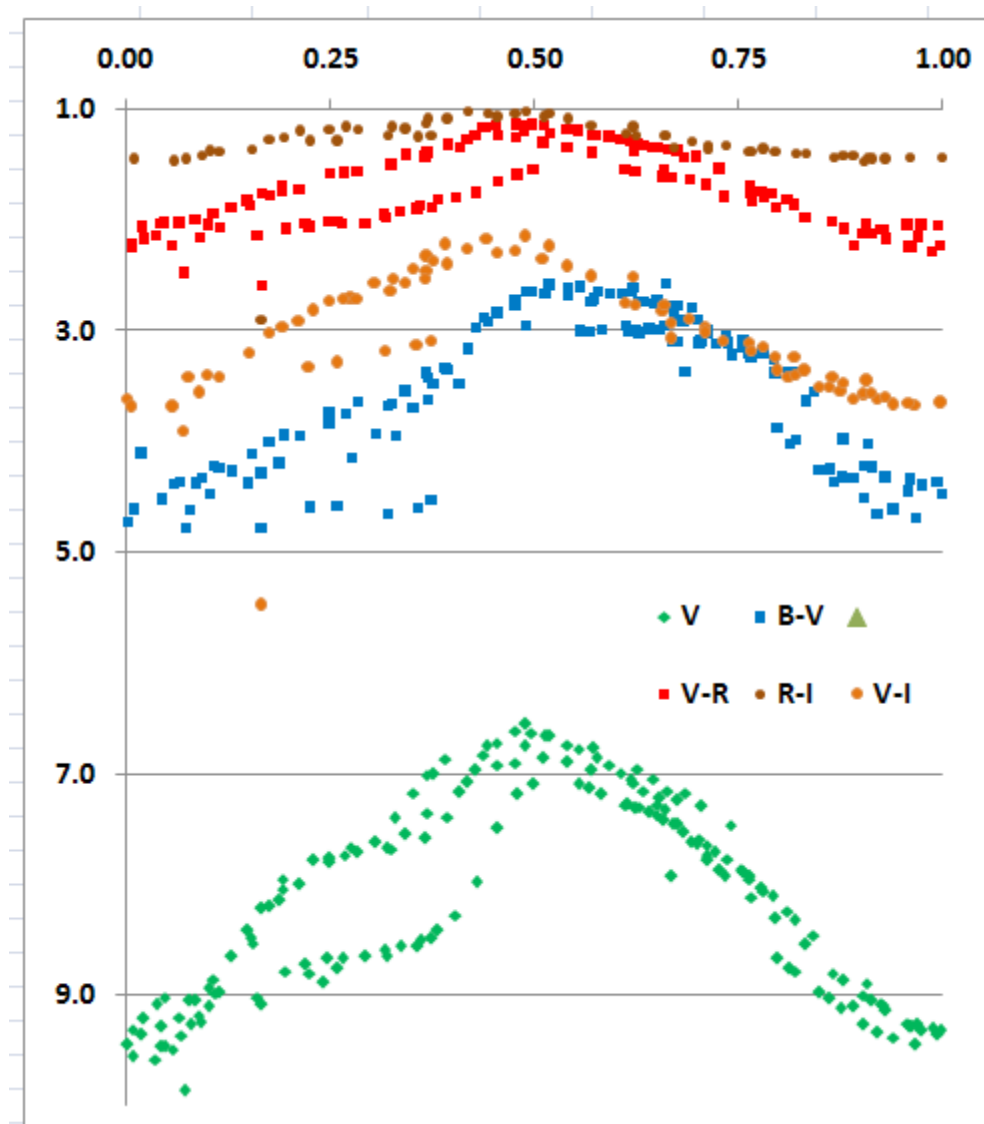


Figure 2. *V* and the colours mentioned over 6.44 cycles. There is some scatter in the *B-V* due to transformation problems at times but the important parts of the cycle - the hump on the rise from phase 0.30 to 0.45 is not affected. Cycles do not repeat exactly.

The most interesting aspects are the large amplitude in *B-V* and in *V-I*. The star has become redder, or cooler, since the 1970s, as shown in Walker, 2009. At the earlier time *U-B* measures showed a very weak *U*, which increased dramatically as the second maximum - now the only maximum - approached. The first maximum was also weaker in *B* than its *V* magnitude suggested.

Since all of this suggests that some dual maxima Miras have much in common with stars with humps on the rising light curve let's examine one in the news at present - Andrew Pearce drew attention to the long standstill which *R Telescopii* is undergoing at this time. Figure 3 is based upon a very comprehensive set of *BVRI* measures by Giorgio di Scala. These have been downloaded from the International Database and converted into *V*, *B-V*, etc.

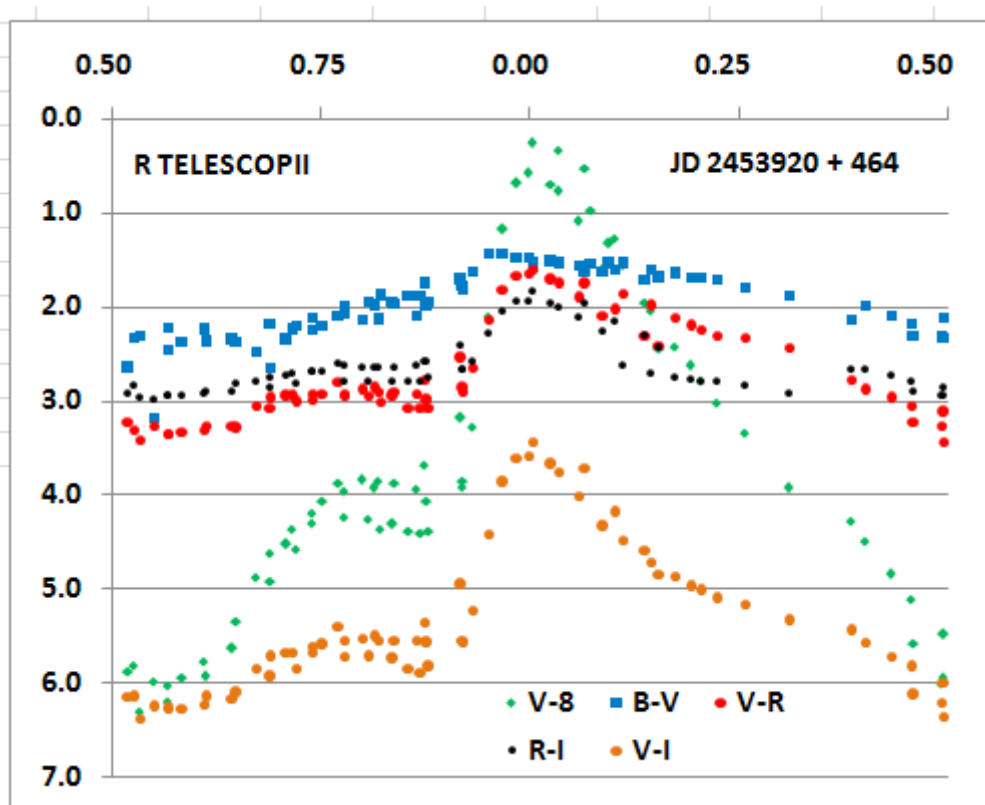


Figure 3. Measures of *R Telescopii* folder to the light elements of JD 24 53920 + 464 days which is the best fit to these 71 BVRI datasets over 7.1 cycles.

The hump on this star is rather more distinct and even gives the appearance of being a separate feature in that there is a decline in brightness at its end which is terminated by the main rise to maximum. There are attempts to explain features like this by involving the interaction of different frequencies but there may be other explanations.

Back in the 1970s X-radiation in some stars was a puzzle. One of the suggested possibilities was that Mira stars were ejecting material near minimum when the radius is large and surface gravity lower, to be accreted onto blue companions. A simpler explanation was found and the idea disappeared. But could these humps be associated with dust ejection and/or formation in some manner? The brightness in I is suggestive of this. Or are we seeing an obscuring event of some type?

Marsakova & Andronov, 2007, discussed aspects of humps on a few Miras and SR stars using visual data. Their conclusions were a little confusing, perhaps because of the relatively small sample. But they implied that humps were only a feature of the rising branch. This present article uses an even smaller sample. Even more confusion is introduced by the Mira star *R Centauri* where it is the second maximum which is the less stable - at times resembling only a rather strong hump.

There is clearly an opportunity for BVRI measures of these stars through a cycle or two to gather more information about what is happening at different wavelengths. For colour photometry full transformations should be made, including primary and secondary extinction corrections if necessary. Due to the long periods, usually in excess of 400 days, a set of measures every 20 days is probably adequate, reducing to 10 days during the interesting phases.

The observational contribution of Giorgio di Scala with both of these stars is acknowledged, as well as Terry Bohlsen, Neil Butterworth, Rolf Carstens, Michael Heald and Robert Jenkins.

References

- International Database 2016 AAVSO
- Marsokova, V I, Andropov, I L., 2007 Astrophysics, Springer Press 50, 76
- Walker, W S G., 2009, JAAVSO 237, 87
- Uttenthaler, S., et al., Astronomy and Astrophysics, 2016, 85, 145

Uttenthaler S, et al. *LX Cygni: A Carbon Star is Born*. *Astronomy and Astrophysics*, 2016, 585, 145

Abstract

The Mira variable LX Cyg showed a dramatic increase of its pulsation period in the recent decades and appears to undergo an important transition in its evolution. **Aims:** We aim at investigating the spectral type evolution of this star over the recent decades as well as during one pulsation cycle in more detail and discuss it in connection with the period evolution. **Methods:** We present optical, near- and mid-IR low-resolution as well as optical high-resolution spectra to determine the current spectral type. The optical spectrum of LX Cyg has been followed for more than one pulsation cycle. Recent spectra are compared to archival spectra to trace the spectral type evolution and a Spitzer mid-IR spectrum is analysed for the presence of molecular and dust features. Furthermore, the current period is derived from AAVSO data. **Results:** It is found that the spectral type of LX Cyg changed from S to C sometime between 1975 and 2008. Currently, the spectral type C is stable during a pulsation cycle. It is shown that spectral features typical of C-type stars are present in its spectrum from ~ 0.5 to $14\ \mu\text{m}$. An emission feature at $10.7\ \mu\text{m}$ is attributed to SiC grains. The period of LX Cyg has increased from ~ 460 d to ~ 580 d within only 20 years, and is stable now. **Conclusions:** We conclude that the change in spectral type and the increase in pulsation period happened simultaneously and are causally connected. Both a recent thermal pulse (TP) and a simple surface temperature decrease appear unlikely to explain the observations. We therefore suggest that the underlying mechanism is related to a recent third dredge-up mixing event that brought up carbon from the interior of the star, i.e. that a genuine abundance change happened. We propose that LX Cyg is a rare transition type object that is uniquely suited to study the transformation from O- to C-rich stars in detail.

This very readable 9 page paper, which is readily accessed through Google, is interesting in that it suggests an alternative mechanism for period changes in cool, pulsating variable stars - particularly the surprisingly quick and large changes in LX Cygni and BH Crucis. It involves an increase in the depth of the convective envelope with a dredge-up of more evolved elements from deeper in the star. Well worth reading for anyone involved with LPVs. Available at: <http://arxiv.org/abs/1511.02159>

Pavlov, H et al. *Times of Minima and New Ephemerides for Southern Hemisphere Eclipsing Binary Stars Observed in 2015*. *JAAVSO* 44, No 1,

Abstract

Observers from Australia and New Zealand used video equipment to time eclipses of short-period binary stars. The objects were typically south of -20° declination and had periods of less than a day. Many of those systems had very few observations since their discovery and some of them had not been observed for 50 or more years. We present 44 times of minima of 42 stars, provide revised ephemerides for 7 of these systems and characterize an orbital period change for RW PsA.

About

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

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

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

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

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

Who’s who

Director Stan Walker, FRAS.

Treasurer/Membership Bob Evans

Newsletter Editor Phil Evans

Webmaster David O’Driscoll

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

Membership

New members are welcome. There is no annual subscription but donations would be gratefully received. Find out how to join by visiting the VSS website. There you will find out how to join by post, email, or directly online. If you join by email or online and wish to make a donation you will get a link to pay by PayPal’s secure online payment system, from your credit card or bank account.

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

Newsletter items

These are welcomed and should be sent to the Editor (phil@astrofizz.com). Microsoft Word (or compatible) files with graphics sent separately are preferred. Don’t use elaborate formatting or fancy fonts and please do not send your contribution as a fully formatted PDF file.

Publication dates are January, April, July and October, nominally on the twentieth day of these months and the copy deadline is the thirteenth of the month though earlier would always be appreciated.

Reproduction rights

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

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