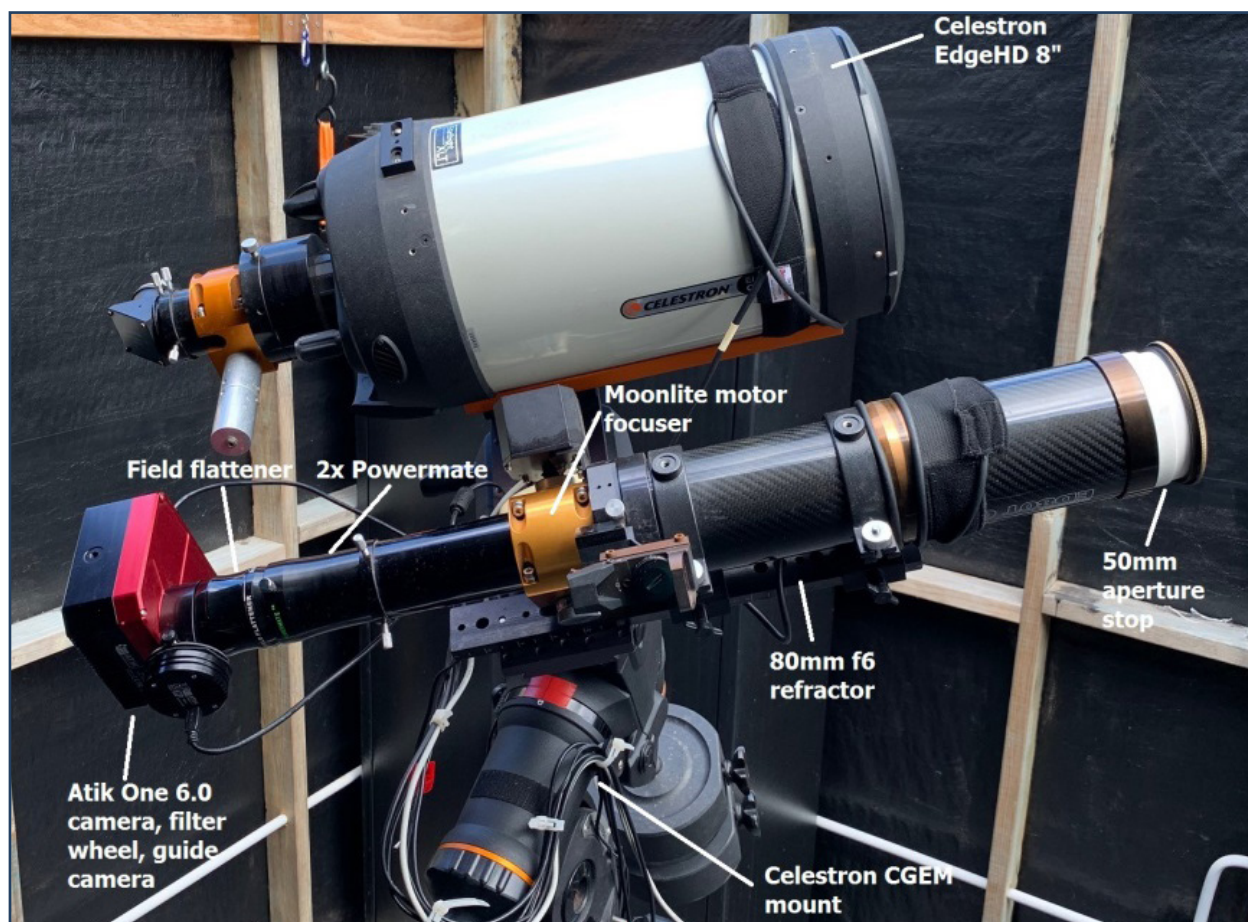




Mark Blackford's equipment setup for imaging the very bright binary eta Carinae - see Mark's article on this new VSS project on page 12.

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From the director – *Mark Blackford*

Welcome to this second VSS Newsletter for 2019. I hope you find the various articles informative and interesting.

Mati Morel has completed his project to scan and archive the publications of VSS, RASNZ (mentioned in this column in the January 2019 Newsletter). Not satisfied with that achievement he expanded the project to also include the available copies of the Circulars of VSS, RASNZ. All are available on the VSS website, for details see Mati's article later in this Newsletter.

In late January Prof. Augusto Damineli (Instituto de Astronomia, Geofísica e Ciências Atmosféricas da Universidade de São Paulo) contacted me requesting assistance from Variable Stars South with photometry of the bright southern variable eta Carinae. Since 2003 La Plata Observatory has been intensively monitoring eta Car as it continues to brighten after it's minimum in the 1930 but it is now too bright for the instruments at La Plata. Amateur photometrists with small (or stopped down) telescopes are ideally suited to continuing this monitoring program. A new VSS Project called "Eta Carinae Photometric Campaign: 2019+2021" has been created and details can be found at:

<https://www.variablestarssouth.org/eta-carinae-photometric-campaign-20192021/>

A few observers have submitted data so far and Prof. Damineli reports that short term features in the light curve seem to be correlated with variations in certain spectral features, a new finding that will help professional astronomers model the complex interaction of stellar winds in the binary system. The project will continue for at least the next couple of years as the binary passes through periastron. I strongly encourage anyone with the requisite equipment to participate.

Another exciting campaign ideally suited to southern visual and electronic observers was recently announced by the AAVSO. Dr Bradley E. Schaefer (Louisiana State University) requests frequent monitoring of the recurrent nova U Scorpii which is predicted to undergo a very-fast eruption within the next year or so. It would be really great if someone from the southern hemisphere was able to detect the predicted outburst before the Northerners - it is a Southern Hemisphere object after all. For details see the AAVSO [Alert Notice 664](#).

As I mentioned in my previous Newsletter column, we are considering re-introducing an annual membership renewal. It will most likely involve filling out a short form to update contact details and re-subscribe to the VSS Google Group. Whether that includes a small fee has not yet been decided. I'd love to hear your opinions on this before making a final decision.

Meanwhile back at Congarinni Observatory conditions over summer were not particularly good for photometry but I did manage a few interesting observations. See my article on FQ Canis Majoris elsewhere in this Newsletter.

Wishing you all clear skies,

Mark Blackford



A study of period and possible period change in the eclipsing binary BS Mus.

Introduction

BS Muscae is a bright ($V = 10.9$ - 11.6) close binary of the Beta Lyrae type, with the stars sufficiently close to be distorted into ellipsoids by their mutual gravitational attraction. Although it appears to have been discovered in 1928 as noted in the GCVS entry for the system (Samus *et al*, 2017), there appears to be no study of this system since. The present article discusses VSS research into its period and period change.

Observations

We have compiled observations of six primary minima in 2018-19 and eight secondary minima in 2017-18. This discussion confines itself to the primaries, as listed in Table 1. (The secondary minima do occur at exactly half phase.)

Table 1. Primary minima obtained in the VSS campaign.

HJD of min	HJD error (d)	Filter	Observer
2458188.092	0.003	V	RJ
2458204.230	0.002	r'	TR
2458221.130	0.002	V	TR
2458228.042	0.003	V	RJ
2458231.116	0.003	V	RJ
2458559.174	0.002	V	TR

In addition, a phased light curve was compiled from TR's observations (Figure 1).

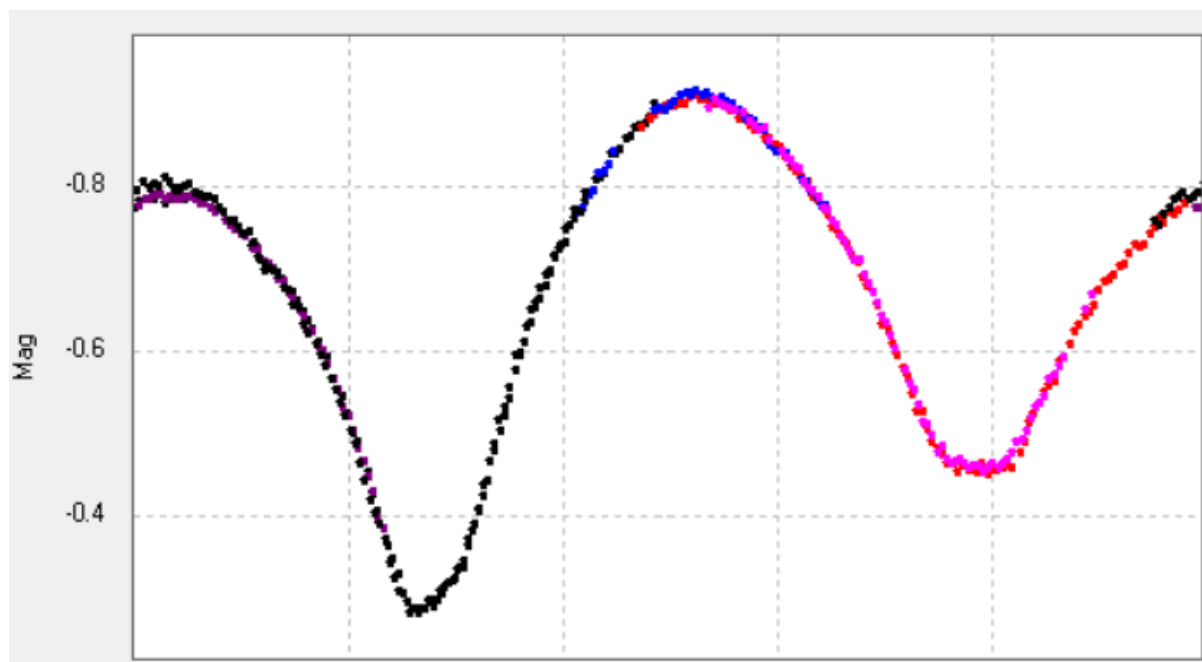


Figure 1. *Phased light curve of BS Mus from TR's observations. The different colours represent data points from different nights.*

There is much of interest in this curve. First, the maxima are very unequal yet these are the phases

¹Pretty Hill Observatory, Kangaroo Ground, Vic., Australia

²Theta Observatory, Salisbury, SA, Australia.

where we see the two stars side on. If the stars were each uniformly bright, the maxima would be equal. The difference may indicate starspots, bright areas, the presence of an asymmetrical stream connecting the two stars, or a circumbinary disc. The constancy of the maxima – indeed of the whole light curve – over the three years we have observed it does count against mobile spots and a disc.

Secondly, the feet of the minima are asymmetrical. The primary minimum is noticeably deeper on its ingress (left) edge, while the secondary is nearly flat (which would indicate totality) but slopes downward slightly. Adequate astrophysical modelling of this curve will be interesting – and tricky. But in this article only orbital periods are discussed.

Period analysis

Primary minima were estimated for the VSS data using 5th-order polynomial fitting in PERANSO (Vanmunster, 2015), as recorded in Table 1.

From the VSS minima epochs the following ephemeris of primary minima was derived by linear regression:

$$E_n = 2458559.1736(12) + 0.768283(3) \times n \quad (1)$$

On that ephemeris, the original discovery epoch (GCVS in the table) has an O-C (Observed – Calculated epoch of minimum) of -0.087(8) days and is the epoch of a secondary eclipse (calculated to the half-period). Possible – the methods were photographic with a very sparse cadence – but suspicious.

Table 2. *Primary minima estimates in the VSS campaign, plus the original discovery epoch.*

HJD of min	HJD error (d)	Eclipse Type	Filter	Observer
2425354.284	0.000	P		GCVS
2458188.092	0.003	P	V	RJ
2458204.230	0.002	P	r'	TR
2458221.130	0.002	P	V	TR
2458228.042	0.003	P	V	RJ
2458231.116	0.003	P	V	RJ
2458559.174	0.002	P	V	TR

By adding a half-period to the GCVS epoch (to obtain its primary minimum epoch) and including it in the regression we now get

$$E_n = 2458559.1746(5) + 0.76828493(4) \times n \quad (2)$$

This gives much better – and believable – O-C results as the next table shows. All but one of the O-C values are less than their 1-sigma errors, and the anomalous one hardly misses.

Table 3. *O-C results on the Table 1 data, using the ephemeris (2).*

HJD of min	HJD error (d)	Eclipse Type	Filter	Observer	O-C (d)	O-C error
2425354.668		P		GCVS	0.0000	0.0018
2458188.092	0.003	P	V	RJ	-0.0004	0.0031
2458204.230	0.002	P	r'	TR	0.0027	0.0021
2458221.130	0.002	P	V	TR	0.0008	0.0021
2458228.042	0.003	P	V	RJ	-0.0015	0.0031
2458231.116	0.003	P	V	RJ	-0.0007	0.0031
2458559.174	0.002	P	V	TR	-0.0009	0.0021

On these results, we can conclude the period of BS Mus has been unchanging since 1928.

The ASAS3 data

Enter ASAS3, (Pojmanski, 2002) which provides V-band photometric data from 2005 to 2009. Figure 2 shows the ASAS3 data folded on a calculated epoch of HJD 2454232.252(5) near the mean HJD of the data set. An ANOVA period search in PERANSO yielded $P = 0.76828(2)$ d for the data set. The equation

(2) period lies well within that error. Although noisy, the tightness of the curve indicates no significant period change over the time span of the observations.

The trouble with the ASAS3 epoch is that its O-C on equation (2) is 0.058(5) days. The vertical line in Figure 2 shows where the primary minimum should be if its O-C = 0.0. There is no way of obtaining a linear regression on the GCVS, ASAS3 and VSS epoch data together that lies anywhere near the epoch error bars.

The simplest alternative hypothesis is that the period is changing constantly, which is represented by a parabolic regression in the O-C diagram, as in Figure 3. Note the linear regression (now including the ASAS3 epoch) does not now pass close to any data points.

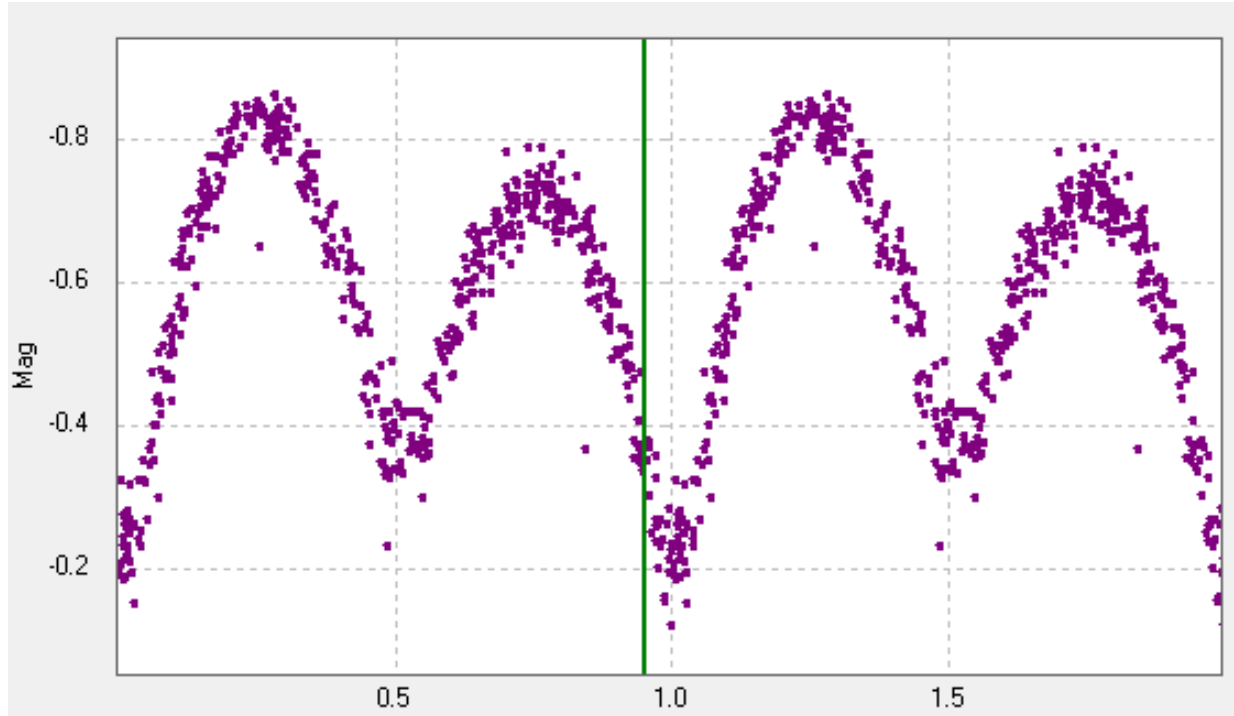


Figure 2. The ASAS3 light curve for BS Mus, phased on $P = 0.76828$ d at $E = \text{HJD } 2454232.252$, and showing a double phase view for clarity. The abscissa shows phase values, the ordinate V magnitude differences from the comparison star used. See the text concerning the vertical line.

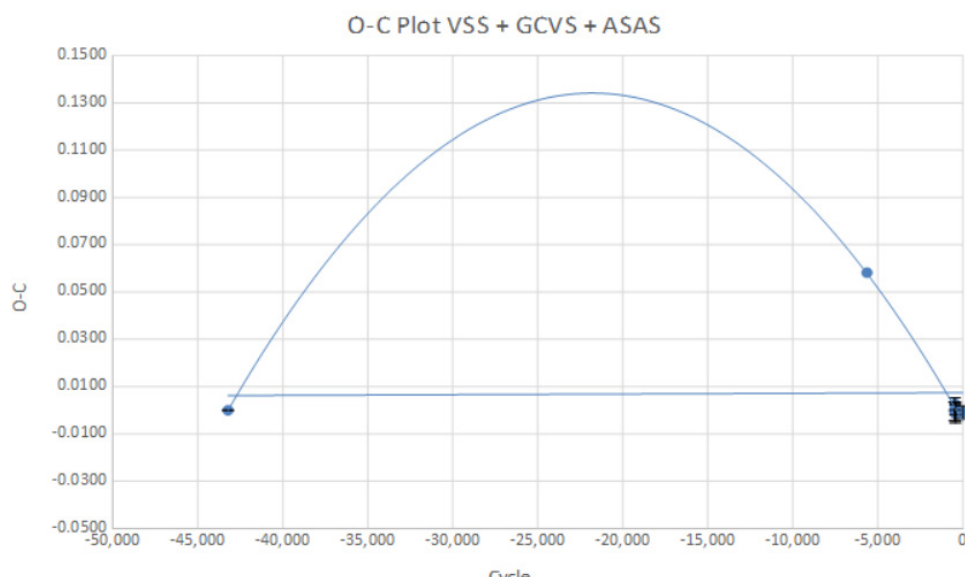


Figure 3. O-C diagram for GCVS, ASAS3 and VSS primary minima epochs, showing linear and parabolic regression lines.

So is the constant-change hypothesis – represented by the Figure 3 parabola – at all plausible? A parabola after all can be drawn through any three points. But the fit to the VSS epochs is very good – except for the sole 2019 data point on the right. See Figure 4. At least one more 2019 primary minimum is needed to see what’s going on. Will it line up with the present 2019 data point – discrediting the parabola hypothesis – or will it lie close to the parabola – leaving the present 2019 data point as an inexplicable discrepancy?

Time will soon tell.

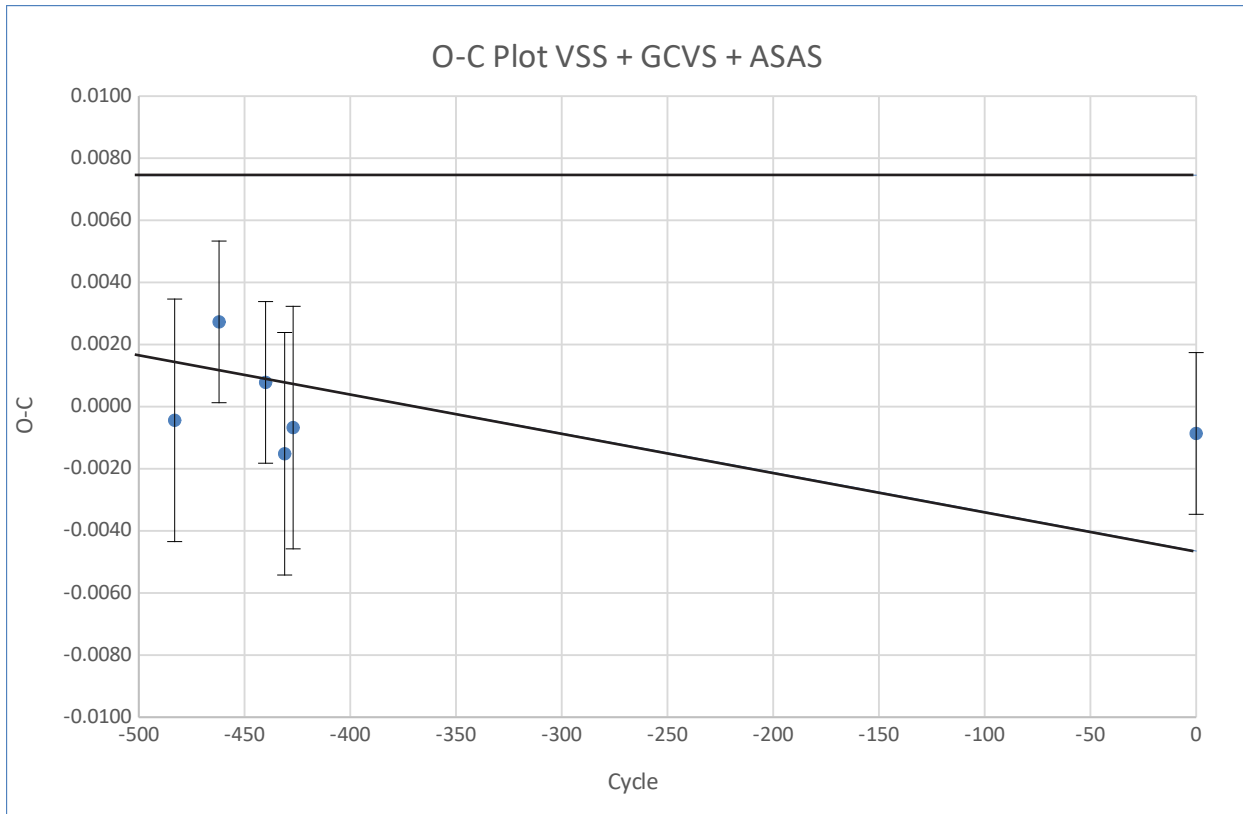


Figure 4. The O-C diagram of Figure 3 showing only the VSS epochs. The upper horizontal line is the linear regression; the lower – actually curved – line shows the parabolic regression.

References

- Pojmanski, G., 2002. *Acta Astronomica* 52, 397. [2002AcA....52..397P](http://www.astrouw.edu.pl/asas/?page=acvs). Online at <http://www.astrouw.edu.pl/asas/?page=acvs>
- Samus N.N., Kazarovets E. V., Durlevich O.V., Kireeva N.N., Pastukhova E.N., (2017) *General Catalogue of Variable Stars: new version*. GCVS 5.1, *ARep*, 2017, 60, 1. [2017ARep...61...80S](http://www.sai.msu.ru/gcvs/gcvs/) Online at <http://www.sai.msu.ru/gcvs/gcvs/>
- Vanmunster, T. 2015. *PERANSO Light Curve and Period Analysis Software*, (<http://www.peranso.com>).

Summary

This paper describes a project to scan extant copies of **Circulars** and **Publications** of the VSS, RASNZ published before 2000, and make many articles about particular variables freely available again.

VSS Circulars, 1935 -1972

The old style *Circulars* were numbered 1 to 199, then replaced by the *Publications*. Circs. 1, 2 and 3 provided instructions on methods, observing and recording. A complete index to all issues was prepared by Venimore.(1974). Up till 1950 virtually all *Circulars* were devoted to the dissemination of raw visual observations. The observations made by VSS members, focusing mainly on long-period variables (M and SR), were listed in the following *Circulars*: 4-48, 50, 52-65, 67-71, 73-77, 81, 83-86, 89-93, 95, 98-100, 106, 109-118, 120, 127, 133.

The early issues, up till about 1960, were the work of a small band of 6 or 7 New Zealand observers under the direction of Frank Bateson. From 1961 this number jumped sharply to about 25, and continued at this level till about 1970. A majority of the new observers were from Australia, from the more populous eastern states. After 1970 the number of observers doubled again.

This seems to mirror the ‘space-race’ and various technological developments at that time.

Although these old issues go back to the 1930s, the raw observations are not lost as they are now available with complete attribution (observer id.) via the AAVSO’s International Database. The very oldest paper *Circulars*, with a circulation limited perhaps to only a few dozen, may be very hard to retrieve now, even if one knew where to look. I know that Bateson was sending copies to the BAA, NSW Branch in Sydney in about 1949-50. In 1950 he commenced a practice of issuing circulars devoted to the analysis and discussion of stars of particular astronomical value. *Circular 49* was the first such paper, devoted to the visual observations made by VSS members of Nova Puppis 1942 = CP Pup. **Table 1** lists the scanned *Circulars*, and **Table 2** lists those which are currently unavailable, as they predate my own holdings.

Scanning of Circulars 92-199

A total of 75 Circulars exist in my holdings. Of these, 19 consist of routine observations of Mira and SR variables, mainly. There is little point in copying these, as the actual observations are all in the AAVSO International Database. These 19 issues are summarized (synopses), see **Table 3**. A few other issues, which would otherwise be worthy of preserving, are missing. The final count: astronomically/historically unique Circulars = 59, totalling 208 pages. The scanning was done between January 16 and 23, 2019 using my Epson Perfection V500 scanner, at 300 dpi, in B & W mode. The earliest issues (92 - 97) were somewhat faded, as the ink had no lasting properties. Nevertheless, by adjusting the scanner settings it was possible to restore the legibility to a satisfactory level, but at the cost of rather large file size.

A persistent problem was the paper size used in these old circulars - 8.5 x 14". This is a pre-metric size, somewhat longer than A4. Modern scanners are designed for A4 paper. By taking care with each page it has been possible to ensure that no important content has been inconveniently cropped. In a number of instances it has been a tight squeeze! For some papers the print quality of the original is very poor, requiring re-typing the page. Refer to *Circs 130 & 132*.

Table 1 : *List of scanned Circulars.*

Circ.	Year	Subject / Title
96	1959	1152-78 T Chamaeleontis
97	1959	0809-76 Z Chamaeleontis
121	1966	Recurrent Nova 090031 T Pyxidis
122	1966	090031 T Pyxidis
123	1967	Visual Observations of 090032 T Pyxidis
124	1967	Nova Delphini 1967
130	1968	Nova Vulpeculae 1968
132	1968	A Possible Flare Star
137	1969	The Flare Star V645 (Proxima) Centauri
138	1969	Visual Observations of EX Hydrae at Minimum
139	1969	The Flare Star UVCeti
140	1970	Flare Star Programmes 1970
141	1970	U Crucis
142	1970	66 Ophiuchi (BD+4°3570)
143	1970	Photoelectric Observations
144	1970	RY Piscis Austrini
145	1970	The Semi-Regular Variable, T Reticuli
148	1970	Sequence Determination
152	1970	66 Ophiuchi (BD+4°3570)
154	1970	Observations of Nova Vulpeculae 1968
156	1970	V442 Centauri
157	1970	FQ Scorpii
160	1970	MU Centauri
161	1970	Nova Scuti 1970
162	1971	Flare Star Programmes 1971
163	1970	New Variable in Musca
164	1971	FN Sagittarii
165	1971	Observations of Recurrent Novae
166	1971	Photoelectric Observations
167	1971	RW Centauri
169	1971	Observations of Novae
170	1971	WW Centauri
171	1971	The Recurrent Nova U Scorpii
172	1971	SS Indi
173	1971	BR Pavonis
174	1971	SU Pavonis
175	1971	X Pavonis
176	1971	Nova in Large Magellanic Cloud
177	1971	Sequences for Southern Variables
178	1971	RZ Indi
179	1971	Notes on Programmes for Visual Observers.
180	1971	CH Puppis
181	1971	Z Crucis
182	1971	TU Puppis
183	1971	W Chamaeleontis
184	1971	Photoelectric Observations at Auckland Observatory
185	1971	UW Centauri
187	1972	Sequences for Southern Variables
188	1972	BH Crucis - Photoelectric Observations
190	1972	SU Doradus
191	1972	Observations of Orion Variables
192	1972	RT Apodis
193	1972	GU Sagittarii
194	1972	V442 Centauri
195	1972	RX Microscopii
196	1972	RY Microscopii
197	1972	T Microscopii
198	1972	RS Microscopii
199	1972	V436 Centauri

Table 2. List of unavailable *Circulars*, (apart from “Observations”).

Circ.	Year	Contents
49	1950	Nova Pup 1942. Observations & Lightcurve. JD 2430673 to 2432392 (1947.07.25)
51	1951	[Apparently missed by Venimore (1974). VSX cites for NSV 4663. Comp. 94 for Z Vel.]
72	1956	VW Hvi. Chart and lightcurve.
78	1956	BV Cen. Chart and lightcurve.
79	1957	EX Lupi. Chart, sequence, lightcurve.
80	1957	U Hor; SU Dor. Observations, charts, lightcurves.
82	1957	VW Hvi. Obs., chart, sequence, lightcurve.
87	1958	RS Oph. 1958 outburst. Chart, observations.
88	1958	Z Apodis
94	1958	Charges for 1959.
101	1960	RY Lupi. Observations.
102	1960	RU Lupi
103	1960	AK Scorpii. Observations.
104	1960	UY CMa. Observations, lightcurve, chart .
105	1960	Section Policy.
107	1960	Kappa Pav, Lambda Pav, Xi Pav. Observations.
108	1960	X TrA chart; BO Mus chart, sequence. Beta Dor sequence.
119	1966	S Aps, Statistical analysis of observations

Synopses of “Observations” *Circulars*.

Table 3(a) details the “Observations” *Circulars* (those seen by me) from 92 to 118, from 1958 to 1962. The roster of programme stars is shown in the index at the beginning, initially ~200 stars. Following the index I give the period covered by each Circular. Whenever extra stars appeared, for the first time, these are noted as “extra stars”.

Table 3(b) details *Circulars 127 to 189*. Some northern stars, which were observed in Table 3(a), have been dropped, in favour of more southerly stars. The general index lists stars, generally, for Circs. 127-189. After Circ. 189 the volume of observations received had become so great that it was no longer practical to report them in this fashion.

After 1972 VSS research interest shifted more towards eruptive variables (CVs) and RCB stars, which required timely summaries of their recent activity, in the *Monthly Circulars*.

Scanning *Publications of VSS*.

Around the beginning of this year two colleagues in the US, Brian Skiff and Matthew Templeton, broached the idea of scanning past issues (25) of *Publications*. Obviously, if bibcodes were to be created for many PVSS articles it would be virtually obligatory to have the same articles online. Mark Blackford soon drew me into this discussion, via an exchange of emails, and within days the scanning of all 25 issues of *Publications* was under way.

Consider the total number of pages: 1775. Not surprisingly nobody had previously taken up the challenge. I assessed what would be required in terms of time, and concluded it was doable. I had the complete set of PVSS, and two scanners. I did *PVSS 1 & 2* as dry-runs, with 200dpi resolution and B&W mode, there being no half-tone images to deal with. At the lower resolution the results were still quite acceptable while allowing a reasonably rapid throughput of 1 page/35sec. As the pages were all part of the original books, all leaves had to be turned manually. I soon found that merely scanning, and saving as a PDF, is not enough. What if several pages end up with the wrong orientation? You need special PDF editing software. The software I used is called FlexiPDF, which allows you to open up a PDF and manipulate pages - rotate them, add or delete pages. Starting on January 5, I tackled 2 to 4 books each morning. By the end of day 8 (Jan. 12) the task had been completed.

Table 3(a). *Synopsis. VSS Circs. 92, 93 and 95; 109-118.*

Index.

Aps :S, T, V, Z, RR, UZ, VV	Lup :R, Y, EX
Aql :TV, TX, VW, DX, DY, EM	Mic :R, S, U
Aqr :R, Z, TX, VV, VX, WW	Mon :U, RS, RX, SW
Ara :U	Nor :R, T
Cae :R	Oct :R, S, T, U
Cap :RR, RX	Oph :W, RS, RY, TT, TX, UX, UZ, VV
Car :R, S, T, Z, RR, RS, RV, RW, RY, RZ, AF, BO, CL, IW, Eta	Ori :S, RR, UV, CN, CZ
Cen :R, T, U, W, X, RS, RT, RX, AD, BV	Pav :R, S, T, W
Cet :U, Omicron	Phe :R, T, V
Cha :R	Pic :R, S, T, RR
Cma :Z	PsA :S, U
Col :R, S, T	Pup :W, U, Y, Z, L2
CrA :R, S, T, TY	Ret :R
CrB :T	Sco :R, S, Z, RR, RS, RT, RU, RW, SV, SX, TV, CL, V380, Alpha
Crv :R	Scl :R, S, T, U, V, X
Dor :R	Sct :R, ST
Eri :T, U, W, RW	Ser :UZ
For :R	Sex :S
Gru :R, S, T	Sgr :R, S, RR, RT, RU, RV, RW, RX, RY, ST, SW, TY, VX, AR, AZ, BH, V348
Hor :R, T, U	Tau :RV
Hya :R, W, RS, RT, RU	Tel :R, S, RR
Hyi :VW	Tuc :R, S, T, U
Ind :R, S	Vel :W, Y, Z, WY
Leo :RY	Vir :S, RV, SU
Lep :R	Vol :R, S
Lib :U, W, RU	

Circ Period covered

92.	JD 2,436,386 to 2,436,477	1958 Jul 1 to 1958 Sep 30
93.	JD 2,436,478 to 2,436,569	1958 Oct 1 to 1958 Dec 31
95.	JD 2,436,570 to 2,436,659	1959 Jan 1 to 1959 Mar 31
109.	JD 2,436,995 to 2,437,116	1960 Mar 1 to 1960 Jun 30
<i>Extra stars:</i> RT Car, l Car, T Cha, Beta Dor, U Gem, V446 Her, Kappa Pav UV Pav, EQ Sco, HK Sco, HL Sco, HN Sco, X TrA, EK TrA		
110.	JD 2,437,117 to 2,437,208	1960 Jul 1 to 1960 Sep 30
111.	JD 2,437,209 to 2,437,300	1960 Oct 1 to 1960 Dec 31
<i>Extra star:</i> AN Car		
112.	JD 2,437,301 to 2,437,390	1961 Jan 1 to 1961 Mar 31
113.	JD 2,437,391 to 2,437,481	1961 Apr 1 to 1961 Jun 30
<i>Extra star:</i> Z Cha		
114.	JD 2,437,482 to 2,437,573	1961 Jul 1 to 1961 Sep 30
115.	JD 2,437,574 to 2,437,665	1961 Oct 1 to 1961 Dec 31
116.	JD 2,437,666 to 2,437,846	1962 Jan 1 to 1962 Jun 30
<i>Extra star:</i> S Dor		
117.	JD 2,437,847 to 2,437,999	1962 Jul 1 to 1962 Nov 30
118.	JD 2,438,000 to 2,438,181	1962 Dec 1 to 1963 May 31

Table 3(b). Synopsis. VSS Circs.127, 133, 147, 168, 186 & 189.

General Index

Ant :U	Lup :R, Y, RU, RY, EX
Aps :S, T, V, Z, UZ, VV	Mic :R, S, U
Ara :U	Nor :R, T
Cae :R, T	Oct :R, S, T, U
Cap :RR	Oph :RS
Car :R, S, Z, RR, RS, RT, RU, RV, RW, RY, RZ, AF, AG, AN, BO, CK, CL, ER, EV, GV, HR, IW, Eta.	Ori :CN, CZ
Cen :R, T, U, W, X, RS, RT, RV, RX, AD, BV, V396	Pav :R, S, T, V, W, X, UV, Kappa, SVS3543
Cha :R, T, Z	Phe :R, S, T, V
CMA :Z, UY	Pic :R, S, T, RR
Col :R, S, T	PsA :R, S, U
CrA :R, S, T, TY, AM, SVS4467	Pup :W, Z, RS, L2
Cru :S, X	Ret :R
Dor :R, Beta	Sco :R, S, U, Z, RR, RS, RT, RU, RW, SV, SX, TV, AK, CL, V380, Alpha
Eri :T, U, W, RW	Scl :R, S, T, U, V, X, Y, RR, SW
For :R	Sct :R
Gem: U	Ser :UZ
Gru :R, S, T	Sgr :RR, RT, RU, RV, RY, SW, TY, AR, AZ, V348
Hor :R, T, U, V	Tel :R, S, RR
Hya :R, W, Y, RS, RU	TrA :X, EK
Hyi :VW	Tuc :R, S, T, U
Ind :R, S	Vel :W, Y, Z, WY
	Vol :R, S

Circ Period covered.

127.	JD 2,438,913	to	2,439,307	1965 Jun 1 to 1966 Jun 30
133.	JD 2,439,308	to	2,439,672	1966 Jul 1 to 1967 Jun 30
147.	JD 2,439,673	to	2,440,312	1967 Jul 1 to 1969 Mar 31 (Part 1)
168.	JD 2,440,313	to	2,440,860	1969 Apr 1 to 1970 Sep 30 (Part 1)
186.	JD 2,439,673	to	2,440,952	1967 Jul 1 to 1970 Dec 31 (RA 00h-06h)
189.	JD 2,439,673	to	2,440,952	1967 Jul 1 to 1970 Dec 31 (RA 06h-12h)

Concluding remarks

All scanned *Circulars* have been uploaded to the VSS website, under **Community**. Go to

<https://www.variablestarssouth.org/vss-community/rasnz-variable-star-section-circulars/>.

The complete set of 25 *VSS Publications* has been available as of January 20. Go to

<https://www.variablestarssouth.org/vss-community/publications-of-variable-star-section-rasnz/>.

Reference

Venimore, C.W. 1974 *Publ. VSS, RASNZ* 2,44

Photometry of eta Carinae – *Mark Blackford*

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As mentioned in my “From the director” column in this issue, a new VSS project called “Eta Carinae Photometric Campaign: 2019+2021” has been created to monitor the continued brightening of this iconic southern variable. Eta Car is a binary composed of two massive stars in an eccentric 5.5yr orbit within a bipolar nebula known as the Homunculus. In this article I won’t go over the reasons for setting up the project, for that I refer the reader to the project webpage on the VSS website (see link below). Here I will outline how I have had to modify my normal imaging procedure to allow useful photometry to be obtained.

For targets brighter than 10 V mag I’ve been using an 80mm f6 refractor with field flattener coupled to an Atik One 6.0 monochrome CCD camera with built-in filter wheel containing Astrodon BVRI photometric filters. The main aim of the project is to acquire V filter photometry. However, at ~4.4 V mag eta Car is too bright for this setup so I added a 2x Powermate to increase the focal length to 960mm thereby spreading the starlight over more pixels and stopped the telescope aperture down to 50mm (Figure 1).



Figure 1. Photometry setup used for imaging eta Carinae.

At sharp focus (FWHM 1.5-2 pixels) the CCD pixels still saturate with exposures of 1 second, so I deliberately defocus slightly to FWHM ~4 pixels. Exposure times of 2 sec typically result in maximum pixel values of between 45,000 and 55,000 ADU which is well within the linear range of my CCD camera. I am considering using a smaller aperture mask (say 25mm diameter) to allow longer individual exposures.

At these short exposure times atmospheric scintillation is likely to be the dominant source of noise so I record 60 x 2 sec V filter images, or more on nights of relatively poor seeing. Each calibrated image is checked for saturation and image quality with poor images rejected. The remaining images are divided into four groups which are average stacked then measured in MaxIm DL using aperture photometry. The final reported V magnitude is calculated by averaging the four measurements from the stacked images, ± 1 standard deviation of the four measurements is taken as the V magnitude error.

The light curve below (Figure 2) shows my measurements since starting observations on February 26th, 2019 through until April 15th, 2019. There was a temporary brightening of ~ 0.05 mag before eta Car settled back to a steady value of 4.43 V mag over the last week. This brightening was also observed by Giorgio Di Scala and similar events have been noted in the past.

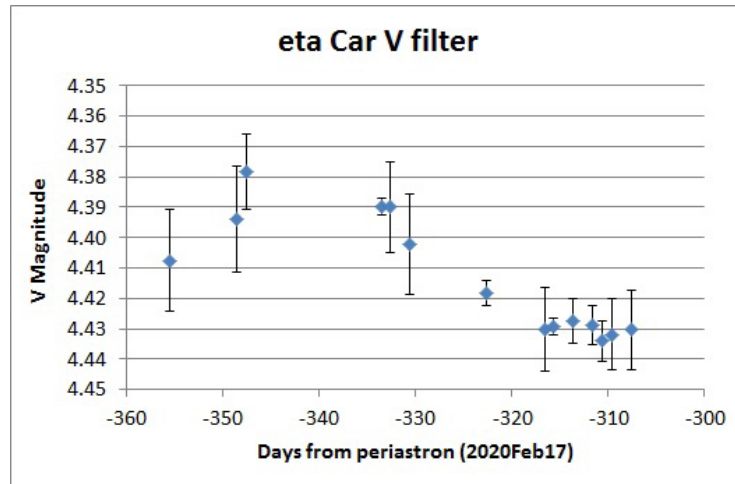


Figure 2. Recent light curve of eta Carinae recorded by the author.

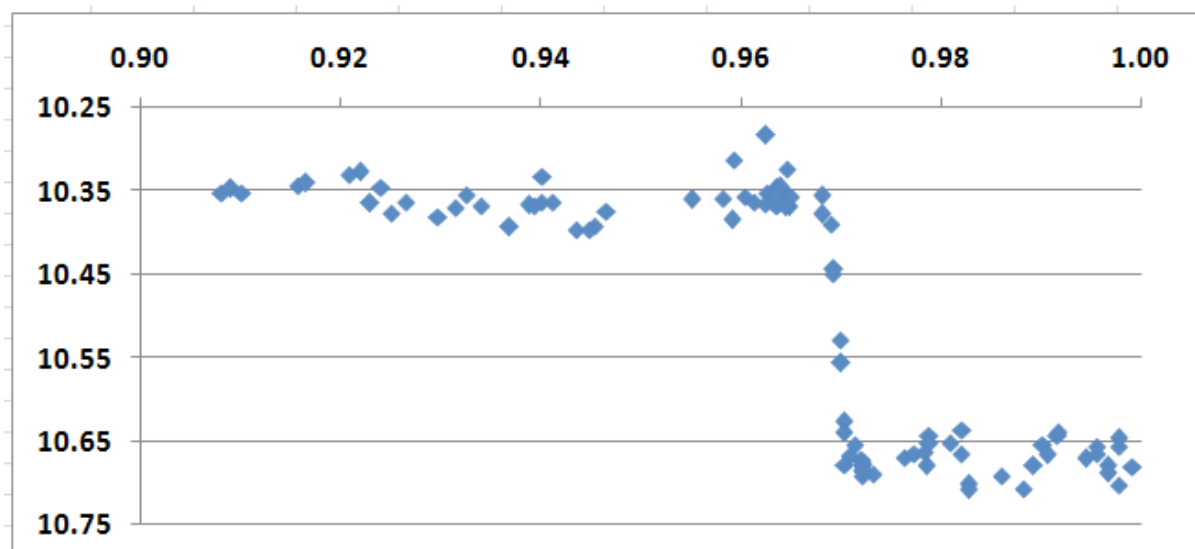
As the binary approaches its predicted periastron the brightness is expected to show significant short term variations, as seen during previous periastron passages. The aim of the project is to obtain a detailed V light curve to compliment spectroscopic observations by Prof. Augusto Damineli and other professional astronomers. You are invited to contribute to this important work. Please visit the project webpage <https://www.variablestarssouth.org/eta-carinae-photometric-campaign-20192021/> or contact the author.

V777 Sag - a successful campaign – *S Walker, M Blackford, E Budding*

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Measures of eclipse 31 of V777 Sagittarii in October, 2018, were spread from New Zealand to South Africa with measures from Carl Knight, Mark Blackford, Terry Bohlsen, Greg Bolt (BSM Berry) and Dave Blane, travelling from east to west in longitude. Exactly 100 observational datasets were made, mostly in B and V with a few U measures from Terry Bohlsen. Of these 100 sets, 9 were made during ingress which allowed the shape and duration of ingress to be determined very well.

The eclipse is deeper at shorter wavelengths so in the phase plot below we show observations through the B filter which also has the advantage that it is a close match to the blue sensitive photographic magnitudes that Henrietta Swope used in her analysis in 1940.



This graph doesn't seem very exciting but a preliminary analysis shows that in conjunction with the 2016 VSS measures and those from Auckland in 1985, along with some V measures by ASAS3, the main attributes of this interesting binary system can be determined. The critical measures are those of ingress and this is well covered as can be seen.

But why is this star interesting? It's one of a group of less than a dozen stars where a non-variable K class supergiant has a small hot companion which undergoes periodic eclipses. Zeta Aurigae is the prototype of the group. Because of the large radius of the supergiant star the eclipses have a long interval, 936 days in this case, and a long duration, 55 days or so for V777. There have been 31 cycles from the 1940 epoch published by Henrietta Swope which was derived from 50 years of photographic images.

We can derive a good value for the total time of ingress from the 2018 measures. The Auckland measures of 1985 with help from the other datasets set a maximum length on the overall eclipse from first to fourth contact. From all of these we can begin by determining the radii of both components in solar units which allows the total mass of the system, the size of the orbits and the separation of the stars to be estimated.

Using Swope's 1940 values for mid-ingress and the 2018 observations we can derive a very good value for the period, 935.93 days - a little shorter than Swope's value of 936.07, but over 31 cycles this amounts to 4.34 days and casts some doubt on the epoch she derived which was based on measures from 1889 to 1939. But rather than being critical it lends a sense of companionship to think of the number of astronomers over 130 years who have helped to understand this star.

Much of the unravelling of the observations is based on data from Allen's Astrophysical Quantities, first published by an Australian astronomer in 1955 and, after several editions, still widely used. There we find average radius and brightness values for B7V and K5I stars although the 400 solar radii of the latter is much larger than the tentative figure of 120 solar radii that appears likely for the supergiant in V777. But then the spectral class of K5Ib is less luminous and since ~80% of K stars seem to be classed as either K0 or K5 this star may well be K3 with a smaller radius and slightly hotter temperature.

There are other areas of interest - whether there is any slight variation of the cool star and also the depth of the atmosphere of this star which can be determined from the period prior to ingress. But Mark and Ed are both travelling overseas for the next month so there will be a little delay in working on the formal paper.

Now we can predict that eclipse 32 begins on 28 April, 2021, 23 days later in the year than in 2016 - so easier to observe. Unlike 2018 the entire 56 day eclipse will be observable in 2021. Any starters?

It is now over fifty years since theoreticians put together computer programs that would predict the sequence of events in pairs of stars so close to each other that their evolution would involve direct physical interaction. In other words, the early modelling of single star evolution could not be simply transferred to the binary context. The nearby presence of the other (by implication less massive) companion would prevent that. Crucial to this line of thought was the idea of what has become known as 'Roche Lobe Overflow' (RLOF). In the strict 'letter of the law', RLOF is an oxymoron. Because the Roche Lobe concept strictly applies only to models that are in hydrostatic equilibrium, while 'overflow' implies a breakdown of that condition. Nevertheless, the relative scale of the masses involved in RLOF compared with the controlling influence of the stellar mass centres deep within either component permits realistic approximations to the process to be calculated. And it is a process that has become central to a wide variety of contexts where interactive evolution occurs.

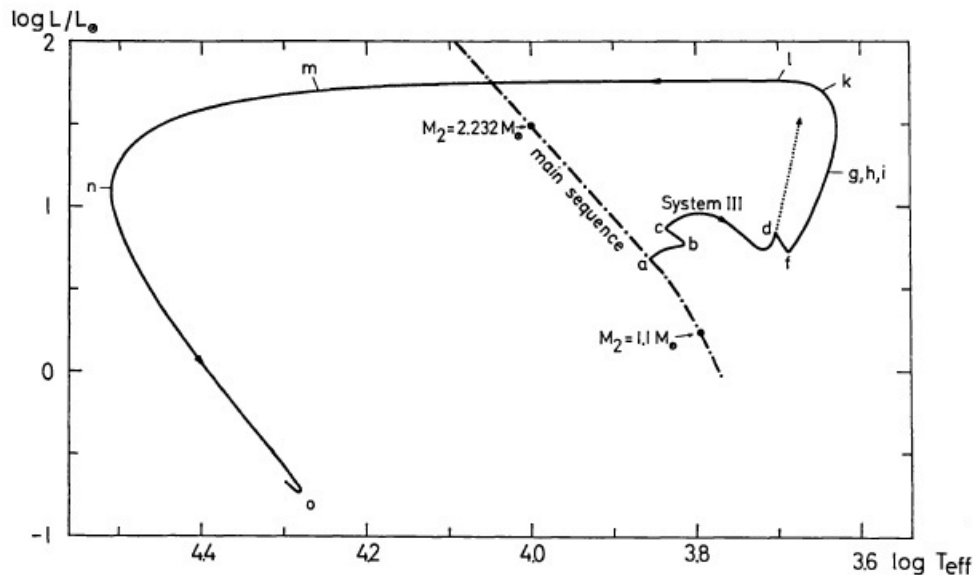


Figure 1. Calculated evolution track of the primary in a classical Algol binary (from Refsdal & Weigert, 1969)

The above diagram -- following the interactive evolution of one of the binary model sequences (System III) -- allows one to see the steady ascent of the mass-gaining component M_2 as it slowly ascends the Main Sequence (dot-dash line), while the primary embarks on its wild peregrinations over the Hertzsprung-Russell plane (full line), that would have been a slow and steady ascent up the Red Giant Branch (dotted line) had the primary been a single star. In System III it is apparent that immediately after the surface of limiting stability is encountered (point d) the primary drops in luminosity for a time (section d-f), before the shell-burning of hydrogen picks up to drive the expansion of the envelope that stokes up the scale of RLOF over the f-k region of the track. Refsdal and Wiegert published details of their modelling for intermediate points (indicated as g,h,i) showing that the actual rate of mass transfer varies over this range and may be sensitive to assumed initial conditions.

All this bears on the timing of eclipse minima (ToMs) for Algol type binaries and the consequent O–C diagrams constructed from such ToMs. In Budding & Demircan's *Introduction to Astronomical Photometry* (Ch 8), about a third of the listed Algol systems for which ToM data is available show period increases indicative of ongoing RLOF, sometimes *a fortiori*. The other two thirds show little or no variation or even a tendency for period decrease.

Among the strong RLOF candidates is R Arae, which was the subject of a VSS campaign in 2018. R Arae has the basic characteristics of a classical Algol, but its mass transfer appears to be on a significantly enhanced scale (Nield et al., 1986; Reed, 2011). The period steadily increased from about 4.42495 d in the year of its discovery by Roberts (1894) to the 4.425132 d given by Nield (1987; for HJD 2446585.161) and continues to do so according to Reed (2011). Reed deduced, from this period extension, that the Roche-Lobe filling component in the binary was shedding matter to its companion at a rate of about $3.06 \times 10^{-7} M_{\odot} \text{ y}^{-1}$. Reliable parametrization of R Arae has been compromised by the significant ($\sim 10\%$) level of short term variability that adds into the light curve. Such variations can occur even in one night's observations, as noted by Forbes et al., (1988), and confirmed in more recent studies.

Light curves of R Arae were produced in Jun 2018 (DB) and Jul-Aug 2018 (MGB) as contributions to the Southern Binaries Programme of the VSS, stimulated by a new data request (PAR). These data were submitted to the IBVS by the above authors a few months ago, and hopefully will appear in published form before too long. The authors received disturbing news from the IBVS editorship recently, however. This is summarized thus:

.... I'd like to notify you that due to lack of human and IT resources and a lowering number of submissions, we decided to close the publication of IBVS at the (Konkoly) observatory. We are quite backlogged with the remaining manuscripts, so I let you decide if you want to publish your paper (elsewhere) or wait for us to process it here.

L. Molnár

Editor, IBVS

Konkoly Observatory

Budapest

Naturally, the authors indicated their desire to persist with the aim of an IBVS publication, as with previous similar reports, at least for some reasonable period to clear the backlog.

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Two new pulsating discoveries – *Mark Blackford*

(markgblackford@outlook.com)

In February 2019 I observed FQ Canis Majoris with the aim of measuring primary and secondary eclipse Times of Minimum for the VSS Eclipsing Binaries project. These could then be used to determine the orbital period more precisely and establish a more accurate epoch. There appear to be only a few Times of Minimum available in the literature.

The AAVSO Variable Star Index (VSX) lists it as a β Lyrae-type (EB) eclipsing system with a period of 0.724734d and epoch 30 Jan 2004 (HJD 2453034.646). Using these light elements a secondary eclipse was predicted for the night of February 12th. A 14" f8 RC telescope and SBIG STT 3200ME CCD camera were used to record V filter images. The light curve showed the secondary eclipse was noticeably later than predicted, and there was a pronounced oscillation prior to the start of eclipse.

FQ CMA was observed again on February 16th (primary eclipse) and March 5th (from maximum brightness into a secondary eclipse). All three nights were combined into the phased light curve shown in Figure 1. Each data point is the average of 3 measurements and error bars are +/- 1 standard deviation (barely visible). Weather and circumstances have prevented further observations.

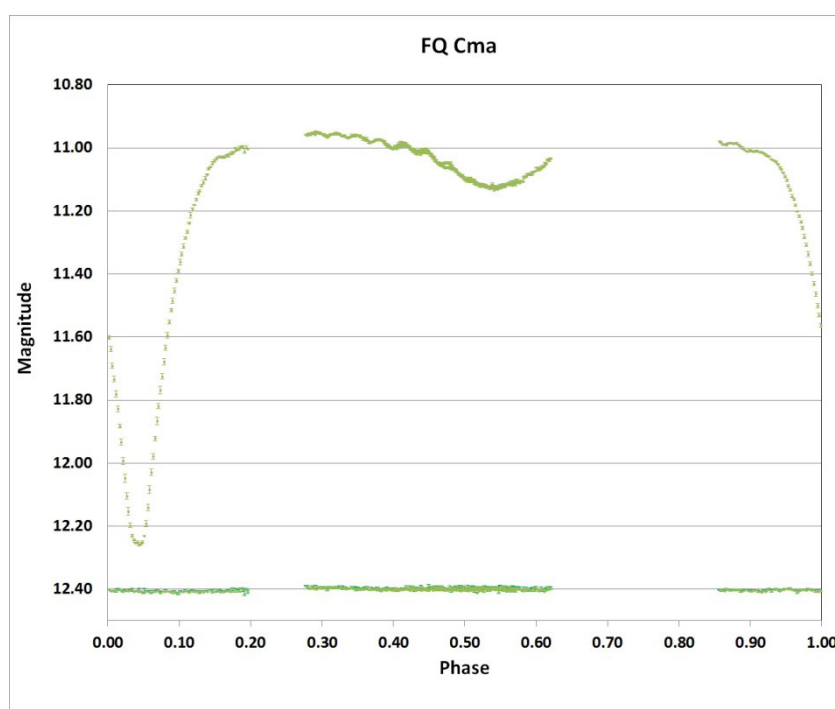


Figure 1. *Phased light curve of FQ CMA using light elements listed in the AAVSO Variable Star Index. The check star light curve is shown at the bottom (shifted by -0.756 for display purposes).*

The primary eclipse is at phase 0.042 (approximately) indicating the true period is slightly longer than that listed in VSX. The check star light curve is flat except for a very small zero point offset from one night to the next. Therefore oscillations on the FQ CMA light curve are real, possibly due to delta Scuti type pulsations of one component of the binary. I believe this to be a new discovery since no previous reference could be found in the literature. The pulsation frequency appears to be correlated with the binary orbital period because the lead-in to each secondary eclipse is quite closely aligned.

The AAVSO Variable Star Plotter does not show any comparison stars in the field of view of my CCD camera so I used the AAVSO SeqPlot tool to select my own check and comparison stars from the APASS database. Figure 2 is a finder chart for the check and comparison star ensemble I used. It also shows the location of a star I believe to be a new variable (TYC 6535-2018-1).

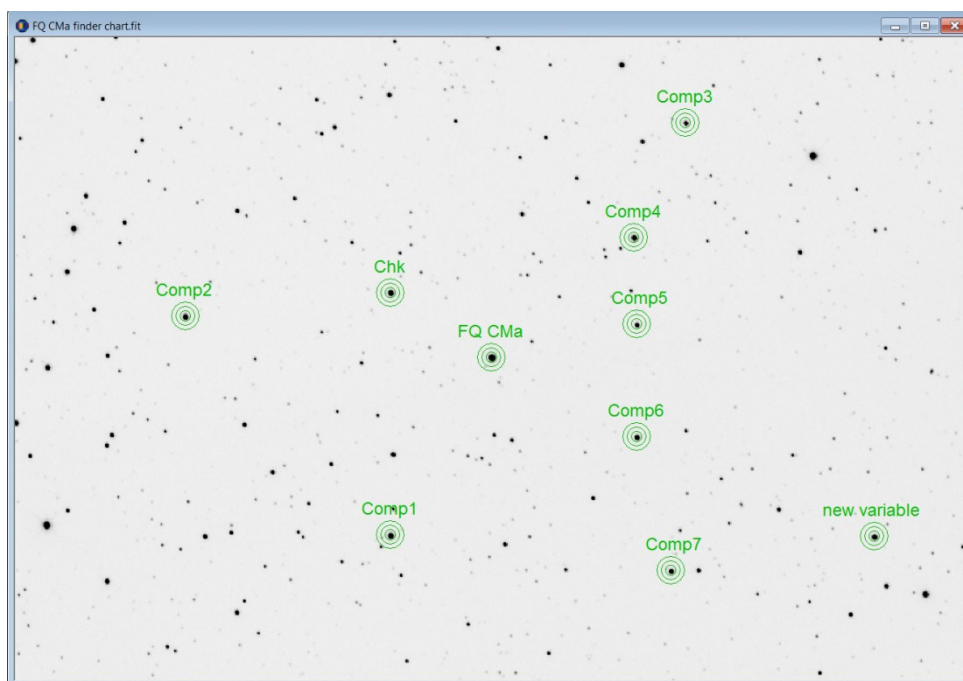


Figure 2. Finder chart for FQ CMa showing check and comparison stars as well as a new variable. Field of view is 18.1 x 12.2 arcmin.

I originally included TYC 6535-2018-1 in the ensemble of comparison stars but inspection of its light curve showed variability of several tens of millimags on a time scale of several hours (Figure 3) and somewhat larger variability over the 21 day interval of my observations (Figure 4).

To confirm the longer term variability I retrieved V filter observations of TYC 6535-2018-1 from the All-Sky Automated Survey for Supernovae (ASAS-SN) database. These showed significantly greater scatter than the similarly bright check star (Figure 5) over the 2.5 year span of observations. Figure 6 is an expanded view of the interval from JD 2458155 to JD 2458220 (February 5th, 2018 to April 11th, 2018) which clearly shows a sinusoidal variation of about 0.09 mag with a period of approximately 11 days.

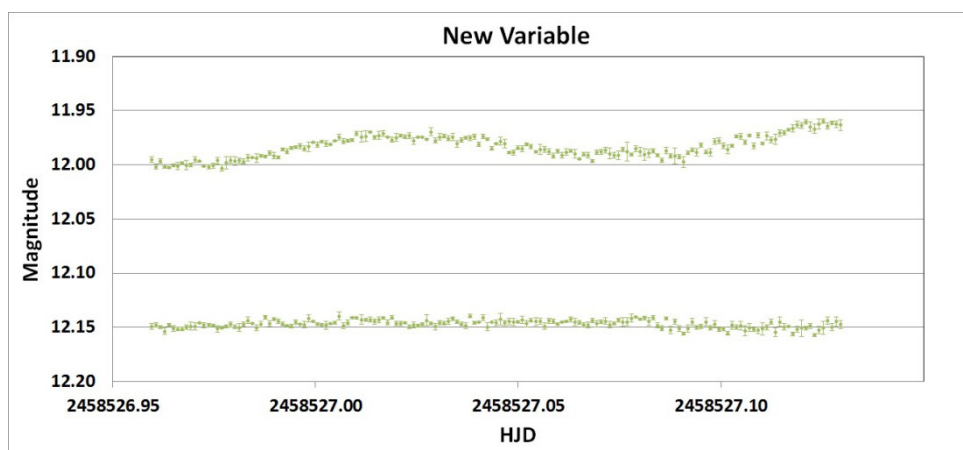


Figure 3. Light curve of TYC 6535-2018-1 on the night of February 12th, 2019. Average check star magnitude adjusted to 12.15 for display purposes (same for Figures 4 through 6).

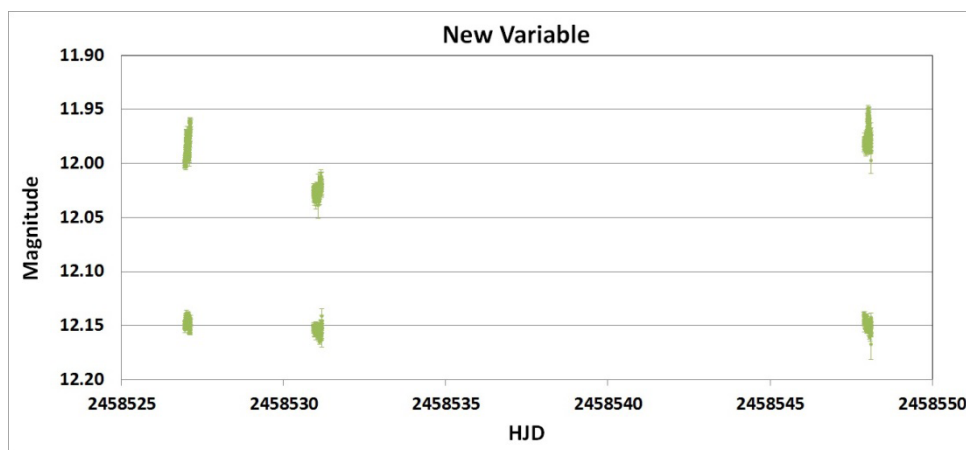


Figure 4. *Light curve of TYC 6535-2018-1 over the period of my observations.*

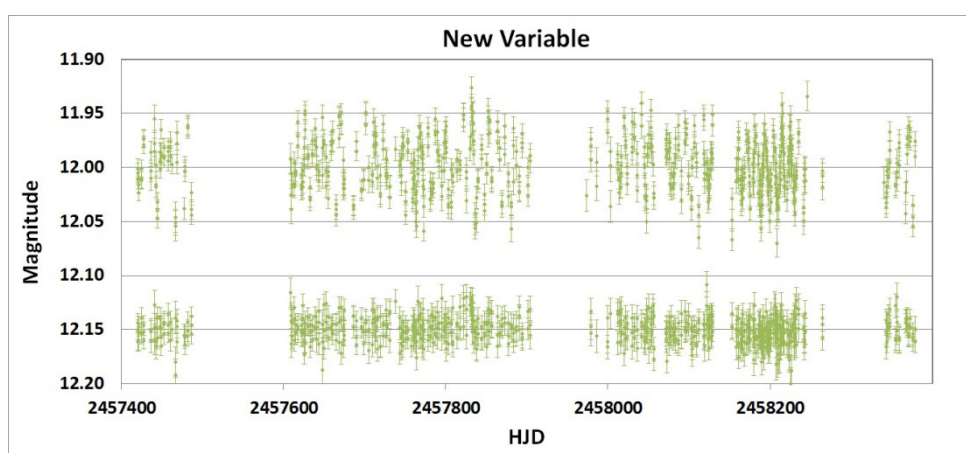


Figure 5. *ASAS-SN light curve of TYC 6535-2018-1 from February 2016 to September 2018.*

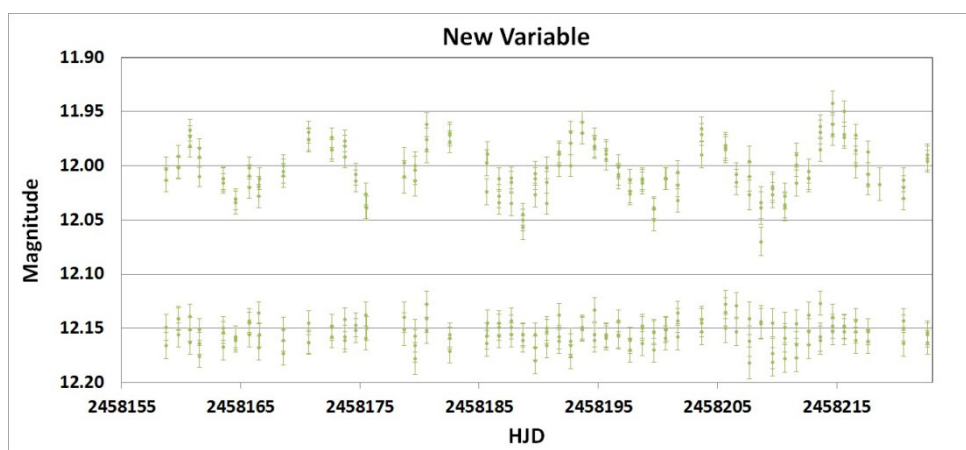


Figure 6. *ASAS-SN light curve of TYC 6535-2018-1 from February 2018 to April 2018.*

So to conclude, the eclipsing binary FQ Canis Majoris has a period slightly longer than the VSX value and one of the component stars is a pulsating variable. Furthermore, the star TYC 6535-2018-1 is a multi-periodic pulsator. I'll leave it to more qualified researchers to fully characterize these two very interesting southern variables.



The topic of “lightning” may seem to reside firmly in the field of meteorology, and well outside the interests of astronomers; at least until lightning reaches out to destroy some of our astronomical equipment. Such is what happened to me following a nearby lightning strike, leaving me with replacement costs of around \$15,000. Furthermore, time taken replacing equipment, including the need to send back some equipment ordered, put my observatory out of action for months.

So, what is lightning and what defence against it is possible? In this article I intend to address only the most common form of lightning strike; cloud to ground, and the threat it presents to our equipment. I must say at the outset that I am not an electrical engineer, nor a person with long years of experience in the topic, so anyone who wants to comment or correct what I have written is welcome to do so. I introduce a theory of lightning only to explain the courses of action I have taken. I have run this article by an electrical engineer, but any errors in it are mine, not his. I have successfully passed exams as an amateur radio operator, but that puts me way, way down the totem pole.

What is lightning?

Prescientific understandings

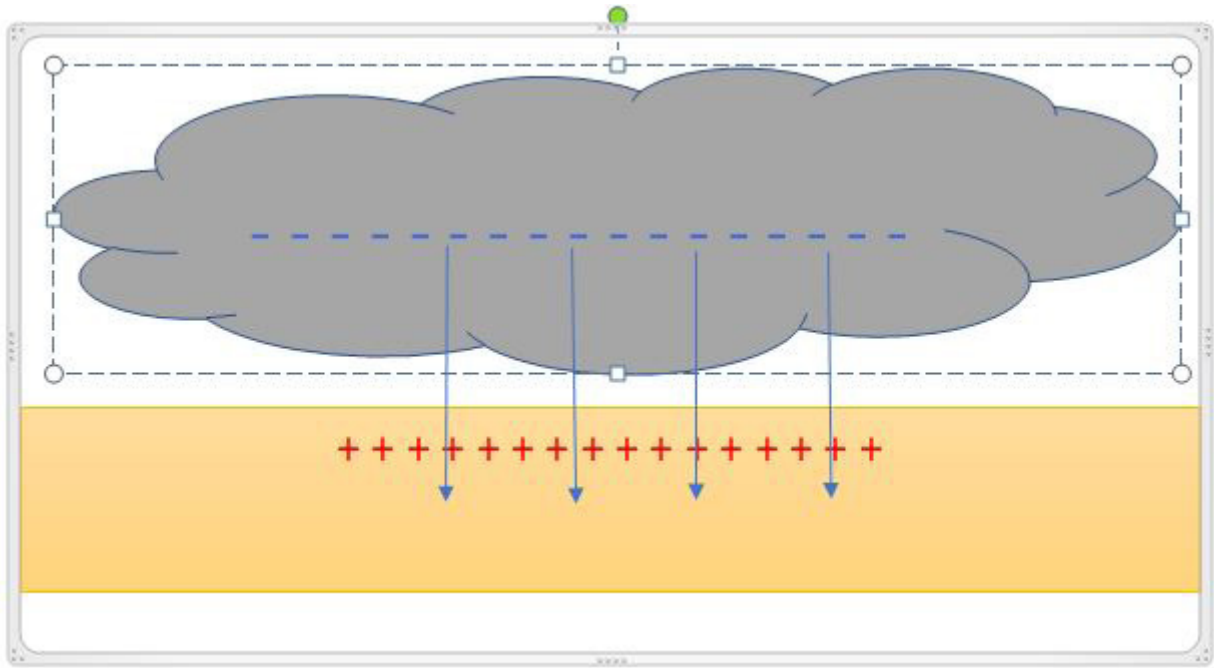
The ancients often concluded that lightning was caused by the wrath of the gods who were displeased by the behaviour of humans. Since just about everybody felt guilty about something or other, this seemed a convincing conclusion.

Many of us with northern European ancestry will be familiar with the pantheon of gods in our ancient ancestral past. Odin or Woden, the king of the gods, would send disapproving messages to humans through the activity of his son, Thor, the god of thunder and lightning. While such beliefs have been discarded, there remain traces of it in the names of the days of the week which link us to this past. Wednesday is “Woden’s Day” and Thursday is “Thor’s Day”.

In the Judeo-Christian tradition which subsequently took hold in the West, the presence of God for the giving of the 10 commandments to Moses is associated with lightning and thunder. However, in later tradition¹, when a prophet retreats from persecution to this mountain in the hope of gaining reassurance, he discovers that the voice of God is not found in the lightning, but in the “still small voice” within. Clearly, there was an evolving understanding of the genre of these ancient stories which led to a separation of a theological conviction from the symbolism in which it was encased. This should have opened the door to an exploration of the physical phenomenon, but it would be centuries before this took place in the West. Some disagreements between experts have led me to suspect that there is still a lot of mythology about lightning. However, I’ve been assured that we have in fact made progress and our understanding is based on solid science.

Scientific understandings of lightning

As the Sun heats the Earth, the areas at the equator are heated more than that of the poles and Nature seeks to remedy this disequilibrium. The heated surface of the ground at the equator heats the air above it, which causes the air to rise. The heated equatorial oceans give up water vapor to rise with the heated air and form clouds. Combined with the rotation of the Earth, this heated, humid air proceed towards the poles in swirling circles of high and low barometric pressure. In a process not fully understood, clouds typically accumulate a negative charge on their underside and a positive charge on their topside. This results in an electric field between the underside of the cloud and the ground below it.



The negative charge in the bottom of the cloud repels the ground electrons so they go deeper into the earth, and an electric field is developed between the subsequently positively charged ground and the negatively charged cloud base. This disequilibrium is maintained by the resistive power of the air. However, when the potential difference between the cloud base and the ground reaches around 50-100 million volts, the resistance of the air is overcome and current will flow from the cloud base to the earth. This breakdown of air resistance is a two-stage process. 'Leaders' consist of electrons from the clouds and protons from the earth ionising the air between them. This ionisation breaks down the resistance of the air allowing for a much more powerful strike, known as the 'return stroke'. The leaders are not normally visible to the observer and only occur milliseconds before the return stroke.

The consequent release of power is colossal. The air is heated beyond the temperature of the Sun in a fraction of a second causing a shockwave we hear as thunder.

The damaging effect of lightning

In the first instance, lightning is a threat to life. The human body uses signalling and motor movement by millivolt signals through the nervous system to muscles, etc. A strike by lightning overrides those signals and produces tearing of the muscles and horrendous pain. One anaesthetist wrote up his experience of making contact with high voltage when he accidentally caused the mast of his boat to contact high voltage power lines overhead. He explained that even pain killers more than three times the amount normally used were unable to stop the pain. We can only imagine that the higher voltage and current of a lightning strike would be even worse. Lightning and other high voltages also have another effect. When voltage pushes current through highly resistant objects like the human body, it generates heat in the resistive body. This means that the fluids of the body would boil. So, we should all agree to avoid being struck by lightning ourselves.

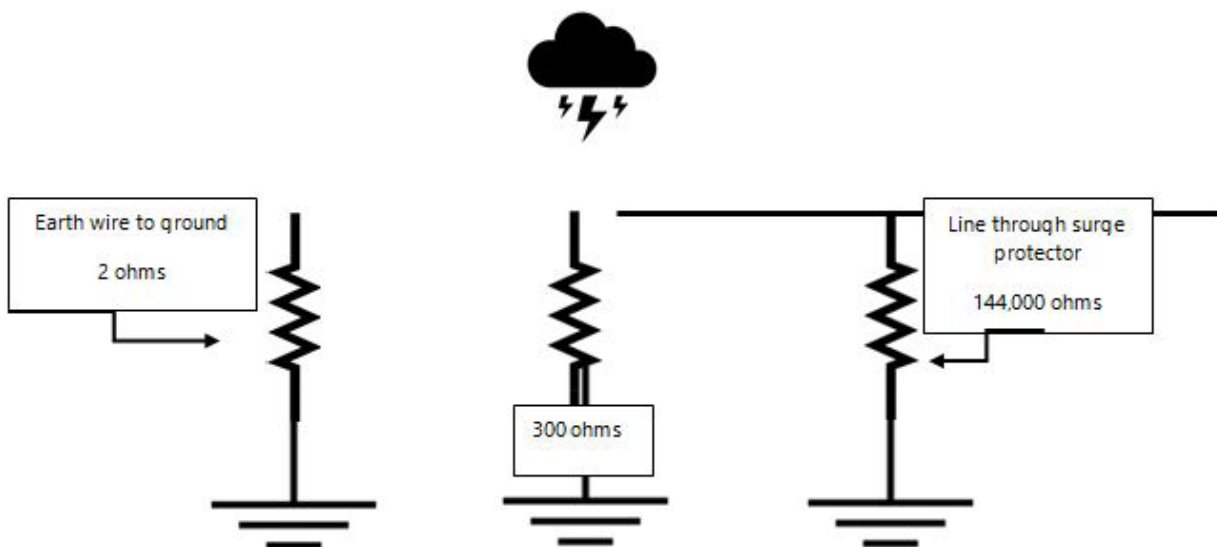
So, with that issue out of the way, what about protecting our electronics from a lightning strike? In

the case of a *direct* lightning strike, the answer is we cannot. The power of such a strike is so colossal it overwhelms all our efforts. The only possible protection in this case is a good insurance policy. However, many cases of damage are caused by *nearby* lightning strikes and it is possible to take precautionary steps to protect our electronics against such strikes as these. To do so we must venture into electrical theory.

Electric fields, voltage, current and magnetic fields

An exploration of the massive effects of lightning takes us into the microscopic world of sub-atomic particles, and in particular, electrons and protons. It is nowadays common knowledge that protons exhibit a positive charge and electrons, a negative charge. These charges create electric fields in which like charges repel and opposite charges attract. The process by which lightning forms is described above in terms of these electric fields. As the amount of charge builds up through the accumulation of these charged particles, the force of attraction (or repulsion) increases and is measured in terms of **voltage and is conceived of as potential difference**. Nature seeks to neutralise these forces by bringing them into equilibrium. This equilibrium is achieved by the negatively-charged particles flowing through conductive material to meet and neutralise their positively-charged counterparts. The number of electrons which flow is measured in amperes or **amps**. However, the air that intervenes between the negatively-charged cloud base and the positively-charged ground, offers resistance to current flow until the voltage or potential difference reaches the high value quoted above. Such a potential difference is necessary for any current to flow in an electrical circuit. Where there is no potential difference, no current flows. Where there is a potential difference, current will flow if it can overcome resistance. This seemingly innocuous statement is important when considering the grounding of electrical circuits.

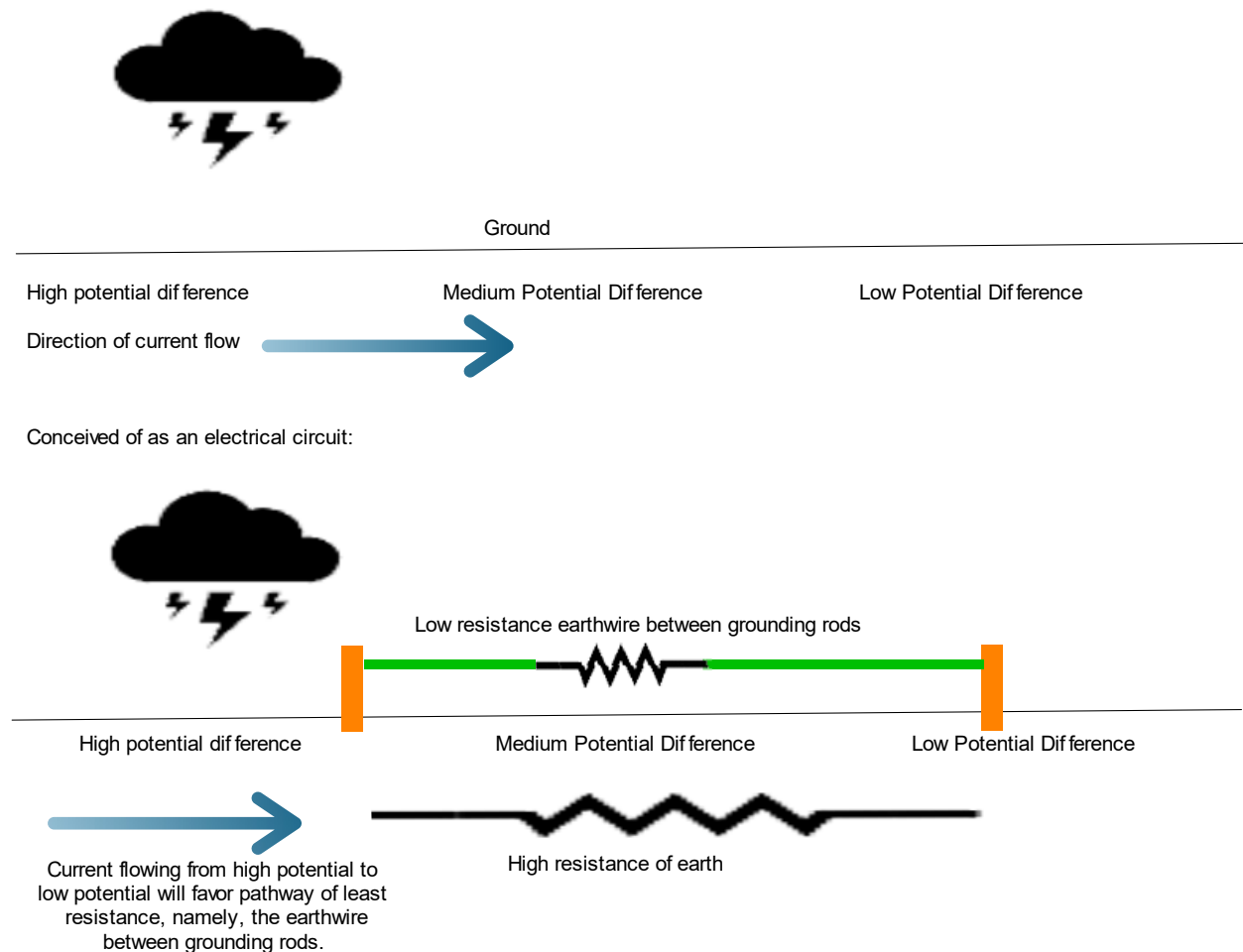
The typical household power supply or mains is made up of three conductors: the ‘active’, the ‘neutral’, and the ‘earth’. The earth is connected to a grounding rod hammered into the ground and is intended to be one line of defence against the risk of shock or electrocution. The electrons flowing toward the positively charged ground will seek the line of least resistance and this is going to be the grounded earth connection. However, this does not mean that there will be no current flowing through other channels. Rather, it will mean that a higher proportion of current will take the easy path. This can be understood in terms of an electrical circuit diagram. The many *pathways* to earth for the lightning current are in effect resistors in parallel. The situation can be represented by the following circuit diagram:



To calculate the current that flows through each path to an earth ground, we can use Ohm's Law: $I = E/R$. For the sake of the illustration, let us suppose a lightning bolt of 100 million volts strikes the above circuit of parallel resistors. Resistors in parallel have the same voltage across them, so since $I = E/R$, the earth wire will have $100,000,000/2$ or 50 million amps through it; the path with 300 ohms resistance will have $100,000,000/300$ or about 333,333 amps flowing through it; and the surge protector with 144,000 ohms resistance will have $100,000,000/144,000$ or about 694 amps flowing through it. (These values are for conceptual purposes only.) The idea is to redirect most of the lightning current through a low resistance pathway to earth.

At first it may seem appropriate to have as many earthing rods as possible scattered around the household system and one's observatory so that an excess of electrons may flow into the ground. However, the fallacy of this is revealed when it comes to a lightning strike. When lightning strikes nearby, the ground at the point of impact temporarily achieves a certain potential difference which is lowered in steps as one moves away from the point of impact. This means that earthing rods hammered into the ground around the house and observatory will have potential differences between them, and whenever there is a potential difference, there is likely to be current flow.

Picture two earthing rods hammered into the ground some distance apart. A nearby lightning strike causes a transient rise in earth potential which reduces as one moves away from ground zero. This means that there is a potential difference between the two earth rods and the excess of electrons will be looking to flow from the high potential ground to the lower potential ground. These electrons have two paths before them. One is through the highly resistive earth and the other is through the low resistance earth wire between the two earthing rods. Naturally the electrons avail themselves of the earth wire path and one's earthing system suddenly becomes a source of danger.



The origin of a lightning strike described above begins with the creation of an *electrostatic field* – the forces of attraction and repulsion between electrons and protons. Even before a lightning strike occurs, this electrostatic field is in existence and capable of influencing potential difference in electrical circuits. Given the transitory nature of this build up, there are likely to be surges in electrical circuits within the electric field's sphere of influence. Once the lightning strike occurs another field emerges and has influence on electric circuits. This is the electromagnetic field.

In 1750, English clergyman, John Michell, wrote a paper entitled “Treatise of Artificial Magnets” in which he described how an electrical current produces a magnetic field which decreases in strength according to the inverse square law. Michell was something of a scientific genius in several fields, including astronomy. In 1767 he delivered a paper in which he demonstrated how statistics can be used to show how binary stars are gravitationally bound; and in 1783, Michell became the first to propose the existence

of Black Holes² in *Philosophical Transactions of the Royal Society of London*. However, it is his work on magnetic fields which interests us here.

As Michell demonstrated, the flow of electrons in an electrical circuit produces a magnetic field with similar properties of attraction and repulsion to an electrostatic field, but at right-angles to it. We experience the consequences and interaction of these two fields every time we receive a radio or television broadcast. A transmitter transmits an alternating electric field into an antenna. The alternating electric field flowing in the antenna generates an electromagnetic field at right angles to it. The electromagnetic field travels through space until it encounters the receiver's antenna, in which it conversely generates an electric field.

The transition from electrical field to magnetic field in lightning is described as follows:

For each discharge, a tree-like streamer (or leader) carries charge toward the ground until the "striking distance" (30 to 100 meters) is reached. The oppositely charged return stroke transforms electrostatic potential energy into electromagnetic energy (radio and light waves), heat, and acoustic energy (thunder).³

The relevance of this to our discussion on lightning comes with the realisation that the flow of electrons in a lightning strike can generate a powerful magnetic field capable of inducing a current in an electrical circuit with which it has no electrical connection.

Avenues of lightning damage

The above explanations point to several ways in which lightning can access the electrical circuits of our equipment. The consequences of a *direct* strike are colossal and unavoidable. A *nearby* strike can cause current surges through the mains supply, varying ground potential, electric fields, and magnetic fields. The surge may come through the mains power supply, or even in long leads disconnected from a power supply, but still connected to equipment.

Preventing lightning damage

(1) Surge Protection

One word which occurs throughout this analysis is the word "surge". What kind of surge is a threat to our electronics? In Australia, mains electricity is nominally 230 volts AC. However, the voltage remains within specification as long as it falls within +10%/−6%, of that figure. Nowadays input into the grid from power stations is supplemented by rooftop solar panels and wind generation. Demand for power varies greatly according to weather and the increasing demand for electricity from our electronic devices. Consequently, both supply and demand are volatile throughout the day.

On the other side of the equation, our electronic devices are extremely sensitive. Silicon transistors begin to operate at 0.6 volts and germanium transistors at 0.2 volts. Zener diodes, often used for voltage regulation, are operated with reverse polarity up to their 'peak inverse voltage' beyond which they are destroyed, and electrolytic capacitors will explode if voltage is applied in the wrong direction. Sometimes damage is immediate and total, and sometimes it is gradual over time.

A typical setup in an observatory may have a mains supply to the observatory, with AC to DC regulated power supplies powering equipment, as well as USB and ethernet cables for signalling and sometimes supply of power.

Consequently, surge protectors, usually in the form of **surge protected power boards**, become one of the first lines of defence against surges of various kind, whether they be the daily rise and fall of voltage in the grid, or the more powerful effects of a nearby lightning strike. In my own case, it appeared that a power surge entered my equipment through a single AC/DC power supply plugged directly into a power point, and from there travelled down a number of USB leads to the affected equipment. I have now added a **surge protected USB hub**.

However, given the ability of the electromagnetic field generated by a nearby lightning strike to induce current flow in a lead, without the lead being connected to a power supply, it may also be preventative to

unplug all leads from threatened equipment. However, this is a laborious task and there is the risk that on any one occasion not all the leads required to be disconnected are disconnected if they are numerous.

(2) Uninterruptible power supplies (UPS)

Given the frequency with which people suggest Uninterruptible Power Supplies (UPS) it is surprising to find how unsuitable they are for the purpose of countering nearby lightning strikes. The normal purpose of a UPS is to provide power to devices should the mains service fail. Usually a UPS might provide around 10-20 minutes of power when the mains supply fails, in order for files to be saved and computers shutdown properly. Both when devices are connected to a working mains supply, and when the mains fails, a UPS provides a filtered source of AC current through the use of a battery and various filters. The mains supply AC charges the battery of the UPS, which then inverts its DC current to AC. Device power supplies plug into the AC and dutifully convert the AC to (typically) low voltage DC.

Lightning and Surge Technologies advise us:

While it is true that some UPS equipment provides a degree of isolation and surge filtering, this is typically limited to internal RF filtering components which are unlikely to attenuate transients that are brought about through lightning activity which are very dV/dT , and are of a completely different bandwidth to power frequencies.⁴

So, it seems that most UPSs have filters which smooth out the sine wave of their power out. However, these filters are aimed at eliminating radio frequency spikes, not the kind of spikes caused by lightning strikes, which are typically between 5 to 50kHz. *Lightning and Surge Technologies* further advise:

What is more disturbing is that UPS systems often include an internal static bypass as standard inclusion in their design, which automatically transfers the critical load over to raw mains, in order to protect the UPS in the event of fault conditions, depleted battery autonomy, or during repair or annual maintenance requirements.⁵

So, it seems that if you were hoping the UPS would sacrifice itself to protect your equipment, it is more likely to sacrifice your equipment in order to save itself. Observatory devices may easily cost into the thousands of dollars to replace, while surge protectors may cost under \$100. Of course, the compromise is to have a surge protector precede a UPS in a line from the mains.

Long power and signalling cables

As mentioned above, both electrostatic fields and magnetic fields can induce a surge in long leads, even when the leads are not connected to a power source. Prevention of lightning damage therefore requires that the number of long leads be reduced as far as possible and those that exist be disconnected from devices during a lightning storm. The problem here is that a typical observatory has many leads – both power and signalling – to equipment in the observatory. Many devices in the observatory are run using AC to low voltage DC power sources. Signalling cables might be USB or Ethernet leads.

To some extent, there is pressure to reduce the number of leads going to the mount and telescope so that guiding will not be affected by drag, and that entanglement of leads may not occur when slewing or using a rotator. On the other hand, there is pressure to reduce clutter around the telescope by taking leads from the scope and mount away to another point where surge protection boards and power supplies are more conveniently located. This results in longer leads and vulnerability to lightning induced power surges. For the sake of lightning protection, a rationalisation of one's setup may ultimately involve reducing leads as far as possible, so that there are just a few leads which need to be disconnected in the event of a lightning storm. Everyone's setup may be different. However, it is possible for USB and Ethernet hubs and switches to be located on the mount and telescope.

Summary of actions to reduce the risk of lightning damage

The information explored above leads to some fairly simple conclusions about what to do to reduce the risk of lightning damage. It comes down to this:

- Use surge-protected power boards and USB hubs

- Reduce the number of long leads and disconnect them during a lightning storm
- Obtain insurance that covers lightning induced surge damage
- Obtain funeral insurance to cover a direct strike

Relative versus absolute

In most of the above thoughts there exist two relative states: “nearby” and “surge”. How does one define “nearby”, and how does that definition affect the effectiveness of our attempts at mitigation? How capable does a surge protector need to be to protect against a lightning surge?

My actions

In my own case I have ensured that every DC power source is plugged into a surge-protected power board available from electrical retailers, and the USB 3 hub I use is also surge-protected. But are these surge-protected boards up to the task of protecting against a lightning-induced surge? My electrical engineer friend has suggested that they may not be, and he has pointed in the direction of more capable – and more expensive – units. My surge protected power boards claim to be able to deal with surges of 144,000 amperes. According to the [Wikipedia article on surge protection](#), while some lightning-induced surges may fall within this range of protection, other surges will exceed it.



Another action I have taken is to have one 14-volt power lead come to the top of the mount pier and plug into a power distribution box there. At that location, individually-fused terminals⁶ take power to mount equipment through rather short leads. The fuses are not intended to protect against a lightning induced surge. Even the fastest of fast blow fuses is not fast enough to react to prevent surge damage. The purpose of the fuses is to prevent the power supply and connected lines from overheating in the event of a short.

This arrangement means my 14 volt power source must be able to deliver enough **amps** to power all the equipment connected to it. It was easy to find one able to deliver 8 amps, but I have others which will deliver 11 amps and 35 amps as the need arises. In constructing the power distribution box atop the mount, I included a meter to measure voltage, current draw (amps), wattage at any moment, as well as all of these over time.

For signalling, I have one USB 3 lead come to the surge-protected USB 3 hub atop the mount. The USB 3 hub provides connection for USB devices; and for Ethernet devices, through USB 3 to gigabit Ethernet adapters. In the event of a thunderstorm, I unplug the single power lead and the single USB lead, to prevent electrostatic or electromagnetic induced current in the two longer leads from reaching my equipment. In the rush to disconnect, I do not need to remember all the long leads that need to be unplugged. There are just these two.

The best insurance is insurance

On a number of occasions people have suggested that my house and contents insurance may cover lightning-induced surges. Indeed, it does. I am yet to see if my claim will be successful. So, my last suggestion is that people have such a policy and make careful note of the date and time of nearby strikes followed by equipment failure.

An eye to the future

There is little doubt that the world is going through a period of climate change. In my part of the world, this appears to be resulting in more frequent and more severe thunderstorms. Taking some action to protect against the threat this poses to our astronomical equipment would therefore seem prudent.

References

1. This story is found in 1 Kings 19:10-12. This story insinuates that the voice of God is not found in extreme weather events, but in the “sounds of silence”.
2. Michell, J in Philosophical Transactions of the Royal Society of London, 27 November 1783.
3. *Mitigating Lightning Hazards* in Science & Technology Review May 1996 https://str.llnl.gov/str/pdfs/05_96.1.pdf
4. Lightning and Surge Technologies: Uninterruptible Power Supplies
5. Ibid.
6. The fuses do nothing to protect against surges. Even the fastest of fast blow fuses is not fast enough to prevent surge damage. The purpose of the fuses is to prevent the power supply and power supply lines from super-heating in the event of a short.

Publication watch

Since the last newsletter our director, Mark and colleagues have a publication accepted 2019 April 10 for publication in Monthly Notices of the Royal Astronomical Society

Absolute Parameters of Young Stars: HX Velorum

M. G. Blackford, A. Erdem, D. Surgit, B. Ozkardes, E. Budding, R. Butland, O. Demircan.

Abstract

We present combined photometric and spectroscopic analyses of the southern multiple star HX Vel. High-resolution spectra of this system were taken at the University of Canterbury Mt. John Observatory in the years 2009-15. Absolute parameters for HX Vel tend to confirm its young and near-Main-Sequence nature. We specify the main adopted parameters of the (non-eclipsing) close binary as follows: $M_1 = 8.5 \pm 1.7$, $M_2 = 5.4 \pm 1.2$, $R_1 = 5.0 \pm 0.3$, $R_2 = 3.1 \pm 0.2$, ($\odot$); $T_1 25000 \pm 1300$, $T_2 20000 \pm 2500$ (K); systemic $M_V -4.2 \pm 0.2$. These parameters are sensitive to the low inclination, where we find a small disparity between the photometrically optimal $28^\circ \pm 2^\circ$ and an adopted value of 26° that gives better consistency with Main Sequence stellar modelling.

The relationship of HX Vel to the galactic cluster IC 2395 and OB association Vela OB1C is also considered, in the context of photometric parallaxes found for HX Vel and other cluster members.

Phil Evans is a co-author on two exoplanet papers

KELT-23b: A Hot Jupiter Transiting a Near-Solar Twin Close to the TESS and JWST Continuous Viewing Zones

Authors: **Daniel Johns**, et al. arXiv:1903.02804

Abstract

We announce the discovery of KELT-23b, a hot Jupiter transiting the relatively bright ($V = 10.3$) star BD+66 911 (TYC 4187-996-1), and characterize the system using follow-up photometry and spectroscopy. A global fit to the system yields $T_{\text{eff}} = 5900 \pm 49$ K, $M_* = 0.945^{+0.060}_{-0.054} M_\odot$, $R_* = 0.995 \pm 0.015 R_\odot$, $L_* = 1.082^{+0.051}_{-0.048} L_\odot$, $\log g_* = 4.418^{+0.026}_{-0.025}$ (cgs), and $[\text{Fe}/\text{H}] = -0.105 \pm 49$. KELT-23b is a hot Jupiter with mass $M_P = 0.938^{+0.045}_{-0.042} M_J$, radius $R_P = 1.322 \pm 0.025 R_J$, and density $\rho_P = 0.504^{+0.038}_{-0.035} \text{ g cm}^{-3}$. Intense insolation flux from the star has likely caused KELT-23b to become inflated. The time of inferior conjunction is $T_0 = 2458149.40776 \pm 0.00091 \text{ BJD}_{\text{TDB}}$ and the orbital period is $P = 2.255353^{+0.000031}_{-0.000030}$ days. Due to strong tidal interactions, the planet is likely to spiral into its host within roughly a Gyr. This system has one of the highest positive ecliptic latitudes of all transiting planet hosts known to date, placing it near the *Transiting Planet Survey Satellite* and *James Webb Space Telescope* continuous viewing zones. Thus we expect it to be an excellent candidate for long-term monitoring and follow-up with these facilities.

WASP-92, WASP-93 and WASP-118: Transit timing variations and long-term stability of the systems

Authors: **Pavol Gajdoš**, Martin Vaňko, Marián Jakubík, Phil Evans, Marc Bretton, David Molina, Stéphane Ferratfiat, Eric Girardin, Snævarr Guðmundsson, Francesco Scaggianti, Štefan Parimucha.
arXiv:1903.02804

Abstract

We studied three exoplanetary systems with transiting planets: WASP-92, WASP-93 and WASP-118. Using ground-based photometric observations of WASP-92 and WASP-93 and Kepler-K2 observations of WASP-118, we redetermined the orbital and physical parameters of these planets. The precise times of all transits were determined. We constructed O-C diagrams of transits and analysed possible transit timing variations. We did not observe any significant deviation from a linear ephemeris for any of the selected exoplanets. We put upper-mass limits for other hypothetical planets in these systems. Using long-term numerical simulation, we looked for stable regions where another planet could exist for a long time. We used the maximum eccentricity method for this purpose. We discuss the influence of values of initial inclination and eccentricity on the shape and size of regions of stability.

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 Mark Blackford

Treasurer/Membership Bob Evans

Newsletter Editor Phil Evans

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

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Newsletter items

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

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

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