

An introduction to variable star observing

by Roger Pickard

At the start of the 19th century very few variable stars were known, certainly less than a few dozen. Nowadays, the 'Bible' for all types of variable star (the *General Catalogue of Variable Stars*) lists over 40,000 variables! Even simple observation of these stars can yield information about their mass, radius, luminosity and evolution. And what's more it can be done with the simplest of equipment.

We usually observe variable stars by watching (measuring or estimating) their variations over time, be it hours, days, weeks, months or even years. These variations take the form of changes in brightness (magnitude) and are viewed pictorially by means of graphs termed lightcurves (Figures 1 and 2), where the magnitude (y axis) is plotted against time on the x axis.

Instrumentation

The simplest instrument to use to make observations is the naked eye, although this is rather limiting as there are not too many variables available. However, the most basic pair of binoculars will open up hundreds of variables for you to observe and of course the larger the binoculars the more stars you can follow. The same of course applies to telescopes.

Binoculars of 10x50 or 7x50 are good, as are 8x40s which are also lighter. Anything giving more than x10 magnification is difficult to hold steady and therefore should be mounted. Even a simple temporary support will suffice. If you're not sure if you really are going to take up binocular observing don't spend more than about £50-£100 unless you know you might also want them for say bird watching.

You can also use any telescope. A wide field of view is good so that you can observe the variable and the comparison star(s) in the same field of view. A Dobsonian or similarly mounted telescope which can be made ready to observe in a minute or two will allow you to make use of those short gaps in the cloud.

For the more advanced observer a telescope with a CCD camera is particularly valuable.

Observing basics is a series of articles by BAA Section Directors and other experts, designed to help you get started in observing, whether you are a newcomer to astronomy or an 'old hand' thinking of taking up a new area of interest. Look out for more articles in the series in future issues of the *Journal*!

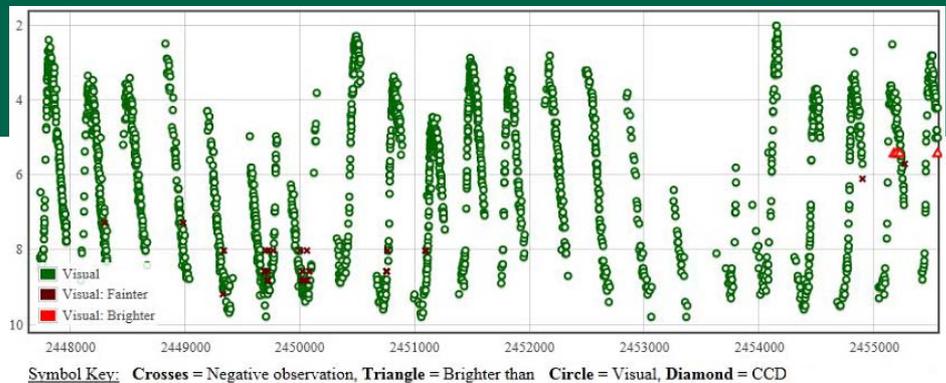


Figure 1. BAAVSS lightcurve of the LPV Omicron Ceti (Mira).

The VSS observing programmes

The Variable Star Section (VSS) splits its observational programmes into several different categories, which include the telescopic, binocular, eclipsing binary, nova/supernova search and CCD programmes. The latter is designed to help those with CCDs to obtain scientifically useful results. Further details of each of these programmes can be found on the VSS website.

Tables 1 and 2 give examples of stars in the binocular and telescopic programmes. With the binocular programme, Table 1, we see that the name of the variable star comes first followed by its position in hours and minutes of right ascension and degrees and minutes of declination, given for the epoch 2000. Don't worry if you're not familiar with these terms. They are not necessary when you first set out, as you have charts to help you find your chosen variable (see below). Next comes the star's type (you can learn about these later); its range of magnitudes; its period (if one is known) and finally the chart you'll need to help find the star and estimate its brightness.

The telescopic programme, Table 2, is similarly set out except you have two extra columns: 'Prog' for whether or not the star is on the Recurrent Objects Programme (ROP), indicated by an 'R'. This is a special programme designed to detect outbursts in stars some of which have never been seen in outburst but are strongly suspected of doing so, perhaps brightening by several magnitudes, often in only one night. The last column is for an indication as to whether or not you should alert the Director if the star is seen in outburst, indicated by an asterisk.

Charts

The VSS publishes charts for most of the stars on its programmes. Each chart shows the position of the variable against the background sky pattern, and the positions and magnitudes of a series of standard comparison stars (the 'sequence') against which you make your magnitude estimates. Computer generated star charts are excellent for producing finder charts for those variable stars which are difficult to locate, although the official sequence should always be used for making estimates, so

Table 1. A sample of the binocular programme

Star	RA (2000)	Dec	Type	Range	Period	Chart
X Cnc	08 55	+17 04	SRb	5.6-7.5	195d	231.01
RS Cnc	09 11	+30 58	SRc	5.1-7	120d?	269.01
RT Cnc	08 58	+10 51	SRb	7.1-8.6	60d?	1972Jul29

Table 2. A sample of the telescopic programme

Star	RA (2000)	Dec	Type	Range	Period	Chart	Prog	Alert
T UMa	12 36	+59 29	M	6.6-14.2	57d	066.01		
SU UMa	08 12	+62 37	UGSU	10.8-15	19d	018.03		
SW UMa	08 37	+53 29	UGSU	9.7-16.5		019.03		*

that your results can be compared or combined with those of other observers.

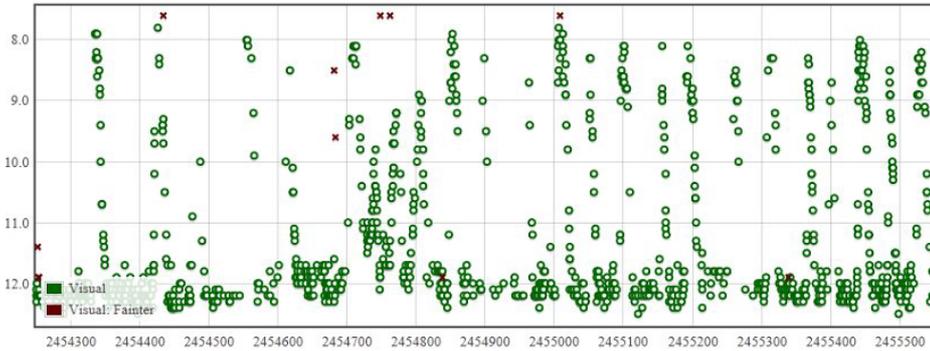
The VSS mentoring scheme

This programme was set up to help those new to VS observing – both visual and CCD. Communication is via email, telephone, sharing observing sessions or even by snail mail. Further information is available on the website or from the Director.

CCD observing

The introduction of CCDs to the amateur market has revolutionised the way many observers take their observations. The VSS has therefore introduced a CCD target list of variable stars

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Symbol Key: Crosses = Negative observation, Triangle = Brighter than Circle = Visual, Diamond = CCD

Figure 2. BAAVSS lightcurve of the frequently-outbursting CV SS Cygni.

suitable for different levels of interest, equipment and observer skills. Again, further details can be found on the website.

variable discovered in a constellation, e.g. R Andromedae, the next S And, and so on, all the way to Z And. However, this proved insufficient and the sequence was continued by using RR And,

RS And... down to ZZ.

When even more letters were required, the sequence went back to the beginning of the alphabet using AA to AZ, BB to BZ, through to QZ. Only then did sense prevail and so the 335th variable discovered in any one constellation was labelled V335 plus the constellation name.

Assignment of these numbers to newly discovered variables is the responsibility of the Sternberg Astronomical Institute in Moscow, which waits until the variability and its type has been confirmed before issuing a number. Meanwhile the big professional surveys, which now discover many thousands of new variables every year, issue their own labels for their discoveries, hence the 'telephone number' designations e.g. SDSS J093249.57+472523.0, which appear so often in the titles of variable star observing papers in the *Journal*.

What are variable stars?

Three main types of variable star are observed by members of the Section: Pulsating, Eclipsing and Eruptive.

Pulsating stars (Miras, semi-regulars [SRs] etc.)

The variations are caused by the star physically pulsating, like a balloon blowing up and down, but only the outer layers are involved. Periods range from hours to years, depending on the type. The variation in brightness can be from about 0.5 magnitudes to over 10.

Eclipsing binary stars (EBs)

The variations are caused by two stars in our line of sight that physically revolve around each other. Periods range from hours to many years. Some may be seen to undergo an entire eclipse in a single night.

Eruptive stars (CVs, novae and supernovae)

These stars show sudden increases in magnitude known as 'outbursts', sometimes quite gentle and relatively frequent, and sometimes the gigantic explosions we call supernovae. Many CVs ('cataclysmic variables') are actually binary stars in which the eruptions are due to an exchange of material from one star to the other, often via an accretion disc. There are many subtypes of CVs, including UGSS, UGSU, ZAND, etc. They form one of the most interesting areas of observing.

Nomenclature

Classical variable star nomenclature is somewhat confusing. By the beginning of the 17th century Bayer had designated the brightest stars in each constellation using Greek letters e.g. α (alpha) Cas, and lower case roman letters, and the first part of the alphabet had also been used for other purposes. When F. W. Argelander (1799–1875) instigated a formal naming convention for variable stars he assumed there would be no need to name more than nine variables in each constellation! He started with the letter R, for the first

217.02 9° FIELD DIRECT
 RY URSAE MAJORIS 12h 20m 27.4s + 61° 18' 35" (2000)
 Z URSAE MAJORIS 11h 56m 30.2s + 57° 52' 18" (2000)

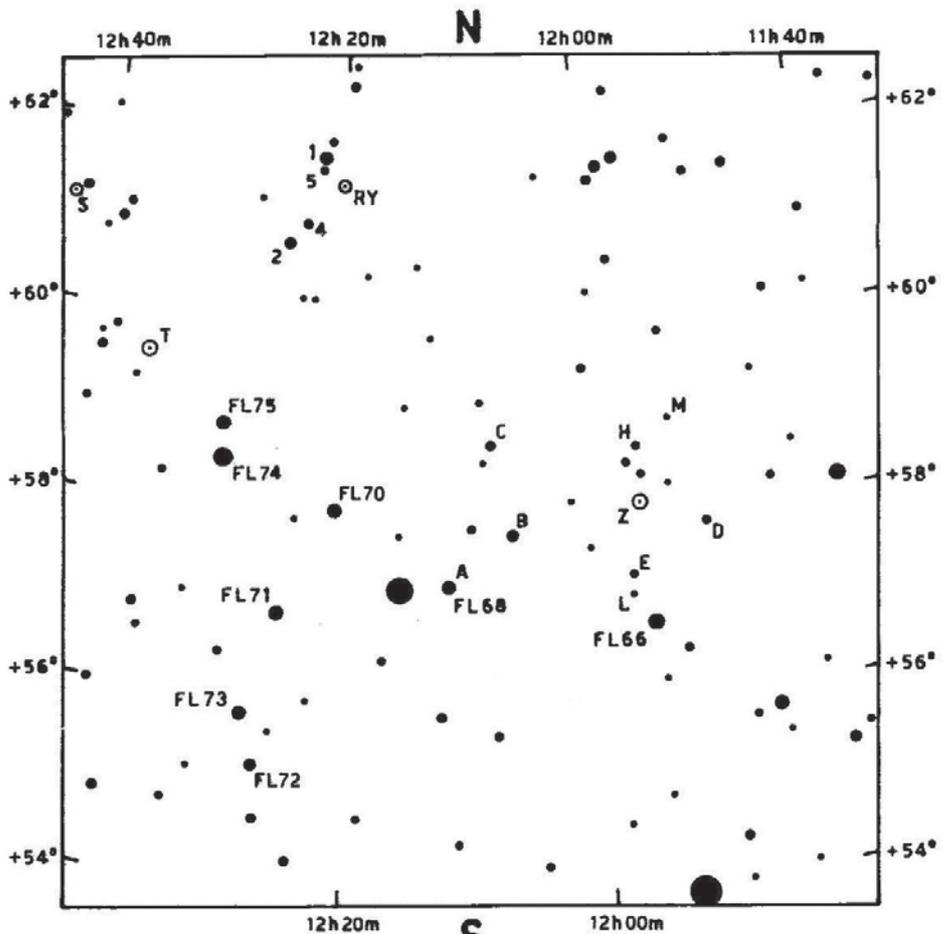


CHART: A 6.3 L 8.9 BAA VSS
 ATLAS BOREALIS B 7.3 M 9.5 EPOCH: 2000
 SEQUENCE: C 7.5 1 6.7 DRAWN: JT 06-08-06
 TYCHO 2 VJ D 7.9 2 7.4 APPROVED: RDP
 E 8.4 4 7.7
 H 8.7 5 8.3

Figure 3. The BAA VSS chart for Z UMa

How to find and estimate the brightness of a variable star

Finding the variable – e.g. Z Ursae Majoris (Z UMa)

As stated previously, modern planetarium programs can be very useful in helping you find your way around the night sky and even print out charts of specific areas of interest. BAAVSS charts to help you locate the variable against the background stars can be downloaded from the Internet or requested from the Chart Secretary (Figure 3).

Estimating the magnitude – the fractional method

How do we estimate the brightness of a variable star? There are two methods used within the VS community, the fractional and the Pogson step methods.

With the fractional method you compare the variable with one star that is slightly brighter and one slightly fainter. These ‘comparison stars’ are stars of known and consistent brightness, shown on the chart (Figure 3) with lettered labels. With the variable designated ‘V’ and using the comparisons C and D (of magnitudes 7.5 and 7.9, see the table on the chart), you can represent the estimate thus: C(1)V(1)D, if through the eyepiece you estimate the variable as half way in brightness between C and D. However, if it seems that the variable is nearer to C than D in magnitude you could write C(1)V(3)D, indicating that you saw it one ‘step’ fainter than C but three ‘steps’ brighter than D.

Now you need to convert these records into a magnitude. Take the first estimate C(1)V(1)D. This is easy to compute as it lies half way in brightness between the two comparison stars, which equals magnitude 7.7.

In the second estimate of C(1)V(3)D the ‘steps’ between C and D total 4 (1+3) and the difference between D and C is $7.9 - 7.5 = 0.4$. Therefore one step is equal to 0.1 magnitudes, so V is estimated to be $7.5 + 0.1 = 7.6$. Remember, it is **fainter** than the brighter comparison and so we have to **add** 0.1 to 7.5. We could have worked this out by subtracting three quarters of the difference between C and D ($0.4 \times 3/4 = 0.3$) from the brightness of D ($7.9 - 0.3 = 7.6$, giving the same result).

The Pogson step method

This is a different method of estimation in which you try to judge the brightness difference between the variable and just one comparison star in steps of tenths of a magnitude. It is an essential technique for occasions when the variable has become fainter than the faintest star on the sequence that you can see. So if the variable were considered to be two-tenths of a magnitude fainter than a comparison star C, for example, but you couldn’t see D, then you would write this down as C–2. If the variable was one tenth of a magnitude fainter than

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Burlington House, Piccadilly, London, W1J 0DU

VARIABLE STAR SECTION

FOR OFFICE USE Rec'd _____
Obs'r abbr _____ Ack'd _____

STAR: _____ OBSERVER'S NAME _____

Chart Sequence Number: _____ ADDRESS _____

(e.g. 053.01 or latest date if no number)

YEAR _____ Post Code _____ Long _____ Lat _____

1st/2nd half

Instrument Code Number:

Sheet no. ___ of ___ 1= _____ 2= _____ 3= _____ 4= _____

	DATE		TIME (UT)		Light Estimate	Ded. Mag	Class	Instr. Code no	Standard Comments
	m	d	h	m					
1									
2									
3									
4									
=====									
27									
28									
29									
30									

DEDUCED MAGNITUDE [= FAINTER THAN,] = BRIGHTER THAN
CLASS: 1 = GOOD, 2 = FAIR, 3 = POOR
STANDARD COMMENT C = CLOUDY, E = EXTRAFOCAL, H = HAZE (OR FOG/MIST), M = MOON
P = PHOTOGRAPHIC, T = TWILIGHT/DAWN
OTHER COMMENTS LABELLED X01 = _____

Figure 4. A paper report form.

D, you would write D–1. Remember in this case when calculating the actual magnitude, with an estimate of C–2, if C is mag 7.5 you must **add** two-tenths of a magnitude to C to obtain your result (7.7) because the star is **fainter** than C.

Reporting your observations

For your observations to be of real value they should be sent to the VSS so that they can be added to the database. This now contains 1,515,216 observations of more than 2000 variable stars from more than 900 observers, dating from before the foundation of the Section in 1890.

The Section provides suitable report forms which can be requested from the Director or simply downloaded from the Internet (see Figure 4). You can also use an *Excel* spreadsheet and this too is available via the Internet or on CD-ROM. These days most people prefer to send their observations via email and the Secretary has a preferred format for the transmission of data, which again can be downloaded from the Internet or requested from the Director.

Common sources of error

Bias – over observing

Do not observe a star too frequently (over observe). For example, Mira stars only change slowly in brightness, perhaps only one magni-

tude in a couple of weeks at most. Over observing can lead you to subconsciously expect the star to brighten or fade when in fact it has stopped changing.

The recommended frequency of observing depends on the type of variable:

- LPVs (Long period variables, or Miras) roughly every 7 days
- SRs (Semi-regulars) 10 days
- CVs (Cataclysmics) every night

For eclipsing binary stars the recommended minimum interval can be as little as 30, 20 or even 10 minutes during eclipse, depending upon the rapidity of the fade and rise.

The Purkinje effect

If you have two stars of different colour, one red and one green but equal in brightness, and both increase by the same amount, the red appears brighter than the other (and conversely if they decrease in brightness). In practical terms, a red star will be overestimated in brightness in a bright sky – twilight or moonlight.

Misidentification

Make sure you have identified the field correctly! This is one of the most common sources of error.

Some hints and tips

- When writing down the estimate the brightest star is **always** written first.
- It is quite legitimate to write =A (or what-

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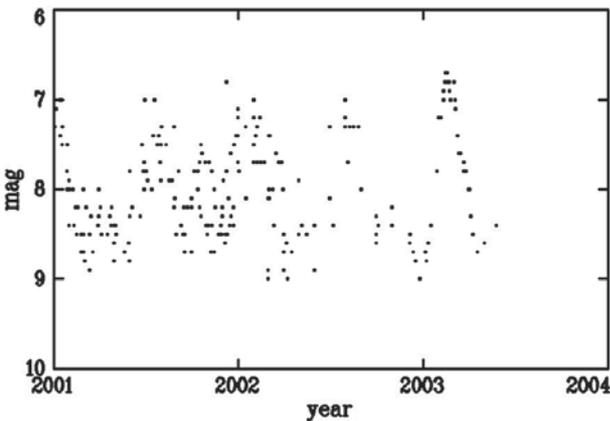


Figure 5. A personal lightcurve for Z UMa.

ever) if you think the variable is equal in brightness to a comparison.

- If the variable is faint use a higher power and/or averted vision.
- A deduced magnitude is recorded to the nearest 0.1 mag and is rounded down, *i.e.* 9.45 becomes 9.5 but 9.44 becomes 9.4.
- ‘Class’ (on the report form) refers to the quality of the observation and not the seeing conditions, although they can affect it. Class 1= Excellent, 2= OK, 3= Poor. You should record class 2 if the variable or one of the comparisons is difficult to see, if you are tired or the Moon is close by, etc. Record class 3 only if fleetingly glimpsed or hampered by cloud etc.
- Know the size of your field of view (telescope or binoculars). Charts are produced for different fields of view depending on the expected brightness of the variable.
- Don’t use comparisons near the edge of the field of view but bring them to the centre alternately.
- Be aware that LPVs (Miras) at maximum and

SRs tend to be red, and take care to minimise the Purkinje effect.

- Use a faint red light to read charts. Wait until you are fully dark adapted before making an observation (this can vary from person to person and be as little as a couple of minutes to up to half an hour or more).
- Be comfortable and **warm**.
- Early morning observations are particularly useful as they tend to be less frequently made.

Establishing your own observing programme

As a first step to compiling your own programme establish the following: What is your possible magnitude range as dictated by your equipment? What type of stars are you interested in, or do you want to sample many types? How often do you want to observe, weather permitting?

What area of the sky is available to you? Do you have restricted views in any direction? What time of night do you prefer to observe? Try to select stars that are not already being observed often by others. If you have a large telescope then concentrate on observing stars that are relatively faint.

Once you have all this information, consult the list of stars on each of the VS programmes and observe your chosen star(s) for a couple of months (depending on type). Compare your results with those of your mentor, or other VSS members.

Once you have made a number of observations of the same star over a period of time it can be fun to plot your own lightcurve on graph paper or use a spreadsheet (Figure 5).

A list of suitable binocular and telescopic stars that can be observed in the autumn can be found in Tables 3 and 4.

Table 3. Suggested list of suitable binocular stars for autumn observing

Star	Type	Range	Period	Observing frequency
U Cam	SRb	7.7–8.8	?	5d
SS Cep	SRb	6.7–7.8	90d	5d
AF Cyg	SRb	6.4–8.4	92d	5d
Y Lyn	SRc	6.5–8.4	110d	7d
Z Psc	SRb	7.0–7.9	144d	7d

Table 4. Suggested list of suitable telescopic stars for autumn observing

Star	Type	Range	Period	Observing frequency
Z And	ZAND	8.0–12.4p	NA	Nightly
RX And	UGZ	10.3–15.1	14d	Nightly
X Cam	Mira	7.4–14.2	144d	5d–7d
o Cet	Mira	2.0–10.1	332d	7d–10d
RU Peg	UGSS	9.0–13.2	74d	Nightly

Conclusion – why observe variable stars?

Variable stars can tell us much about stellar evolution and ultimately, the fate of our own Sun. Professional astronomers need amateur observations as there are just too many variable stars for them to follow. Their telescopes are often too large, and observing time on them is scarce. This is one of the few areas where an amateur can make a real contribution to science.

It is simple and fascinating to watch stars that are billions of miles away changing in brightness, and to learn about these systems from data that is obtained using your own eyes.

Roger Pickard, Director, Variable Star Section

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 Where both members are under 65 on 1st August £50.00
 Where one or both members are 65 or over £35.00
 Family Membership is available for two people living at the same address. Only one

Journal and Handbook will be sent although both may attend meetings and have a vote.

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 Rest of World £10.00

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