The computerisation of the Variable Star Section records

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Introduction

Since its formation in 1890, the Association's Variable Star Section (VSS) has collected about two million variable star observations from its members. In spite of the fact that these records form a potentially valuable source of data for research, many of them have never been analysed or published.

The great bulk of the observations consists of visual magnitude estimates recorded on hand-written report forms. Each includes, at least, the name of the star observed, the date and time of the observation, the estimated brightness of the star, and the name of the observer. Before they can be analysed and published, the observations need to go through a process of checking, sorting, reduction and plotting. Until the 1970s all of this had to be done by hand and it was only through the efforts of a small band of dedicated helpers that the Section's Directors were able to publish what they did. However, since 1978, a lot of work has been carried out 'behind the scenes' in the VSS in implementing a computer system to automate this processing. The purpose of this paper is to give an account of this work.

The first phase: 1978 to 1986

The first investigation into the possibility of computerising the VSS records was carried out by Greg Coady in 1978, under the directorship of Ian Howarth. The main aim was to reduce the workload of the section Secretary, Doug Saw, who was manually checking and plotting all the observations of the stars on the Main Programme each year as they were received. The BBC microcomputer was adopted as the standard machine for this work. A trial run was carried out at the end of 1978 in which observers were asked to submit all observations of Nova Cygni 1978 (V1668 Cyg) on 'experimental' computer report forms.

In 1980, Doug Saw became Director and Greg Coady took over as Secretary. The first batch of 'proper' computer report forms were distributed to observers and the reporting frequency was changed from yearly to half-yearly to ease the data entry. In 1981 Greg appealed for help with the annual data entry in letters in the *Journal*[1] and in *The Astronomer*.[2] A good response was received and sample plots of the 1981 results were prepared for the 1982 Exhibition Meeting. In view of these successes, the BAA Council agreed to fund a larger pilot trial of data preparation methods. There were some minor problems, though. Some observers were still finding the new computer report forms rather difficult to fill out.

In 1983, all the observations of Main Programme stars for the previous year were entered as received and the resulting light-curves were published in the Section *Circulars*.[3,4,5] The same was done in 1984.[6] Then Melvyn Taylor, who had been Secretary of the Binocular Programme, took over the Main Programme also and Greg Coady became Assistant Secretary for the Telescopic Programme. In 1985 a new improved method was used to plot the 1984 Main Programme light-curves (see Figure 1) which were published in the form of a separate booklet.[7] However, the computerisation work came to a halt in 1986 when other commitments forced Greg to stand down from his post as Assistant Secretary.

As well as the above work, which was mainly aimed at dealing with observations as they were received, a start was made on the backlog of archival data. In 1984, David Swain entered about 20,000 observations for the years 1971–72. These were observations which the Variable Star Section had inherited from the Binocular Sky Society when the latter was absorbed into the Section in 1974. The format of these observations was particularly simple which made the entry easier. For this work, David used the EDT text editor running under the VMS operating system on a VAX 11/750 minicomputer. He then downloaded the files to a PC.

The second phase: 1990 to the present

In late 1989 John Isles, who had become Director in 1987, appealed[8,9] for a volunteer to carry on and extend the work of Greg Coady. In 1990 one of the present authors (McAdam) was appointed to the newly created post of Computer Secretary. His duties were to coordinate the entry of the archival observations as well as the most recently received ones. He had previously done astrophotography over a number of years and maintained a computerised index of his negatives for cross-checking purposes. One result of this work was his discovery of 'Nova' Andromedae 1988 (PQ And)[10] which was later shown to be a dwarf nova similar to WZ Sagittae.[11,12]

The first year of the new Computer Secretary was taken up with studying various written records and program listings and in programming an experimental archiving system on a BBC Master computer. At the same time he entered and plotted a small number of observations including a 10-year run of AH Draconis which was published in the Section *Circular*.[13]

In 1991 the BAA Council agreed to fund the purchase of an IBM-compatible PC for the purpose of processing and storing the Section records. The PC was obtained in August

of that year and some light-curves were hastily prepared for display at the VSS meeting at Crayford in October. Early in 1992, another appeal for helpers was made[14] and this, too, drew a big response. By the end of the year, over 24 people had helped in the data entry. The computer archive was further expanded when, with the help of Greg Coady and Storm Dunlop, a large number of the existing BBC Micro format records were transferred to MSDOS format and incorporated into the new system.

In 1993 the Binocular Sky Society observations, that had been entered by David Swain, were also retrieved for incorporation into the archive. In addition, several observers, some of whom had already been logging their observations by computer, responded to a call to submit their observations in a computer-readable form. By the second half of 1993, the number of observations in the archive was over 300,000. Although this was only about 15 percent of the total number of observations, it was already beginning to produce some useful results (as we describe below).

The current system

At present the archive system is implemented on a Viglen SX20 IBM-compatible PC with 1 megabyte of RAM and a 40 megabyte hard disk. The operating system is MSDOS version 5 and the programmes are written in QuickBasic version 4.5. The PC is equipped with both 3.5-inch and 5.25-inch floppy disk drives which can each work at high density and at double density. This allows data to be submitted on a variety of disk formats. In addition, data can also be submitted via electronic mail. Light-curves are plotted using a recently purchased Epson LQ570 dot-matrix printer.

Observations are input into the archive in the form of ASCII character files. This allows the input of data which has been generated on a wide variety of text editors and word processors. The system currently accepts four different observation formats or 'styles'. These are designated B, V, W and Z. The B-style is based on the current handwritten observation report form layout. This is illustrated in Figure 2. Each B-style file contains observations of various stars made by a single observer. V-style files are similar but they each contain observations of a single star made by various observers. Some of the existing paper records are in this form. The W-style format is based on that used when observations were published in BAA *Memoirs* in the first half of this century. This format was also used until recently for the chronological lists of observations (known as 'memoir lists') compiled by hand during the preparation of Section reports. The final format is the Z-style which consists simply of lists of Julian dates, magnitudes and observer abbreviations. Only a small proportion of the existing paper records are in this form.

On entry to the archive the files go through a series of semi-automated checks. These include a check that the comparison stars used in each observation are actually listed on the chart used. For some stars the multiplicity of charts that have been used over the years makes the identification of comparison stars quite difficult (especially when the observers have not recorded which charts they have used!). Guy Hurst, Melvyn Taylor and John Toone have helped solve some of these problems by supplying copies of various charts. After checking the identity of the comparison stars, the system re-reduces the variable's magnitude using the comparison star magnitudes listed on the chart. If the result differs by 0.1 mag or more from the value given by the observer then the processing is halted to allow further investigation. Most of these discrepancies can be resolved by reference to the original paper report form. The system finally re-reduces the estimate to the current comparison star magnitudes and this is the value that is stored.

A further check is made to detect and remove the duplicate observations which arise when the same observations are inadvertently entered by two different routes. Fortunately, this occurs only occasionally.

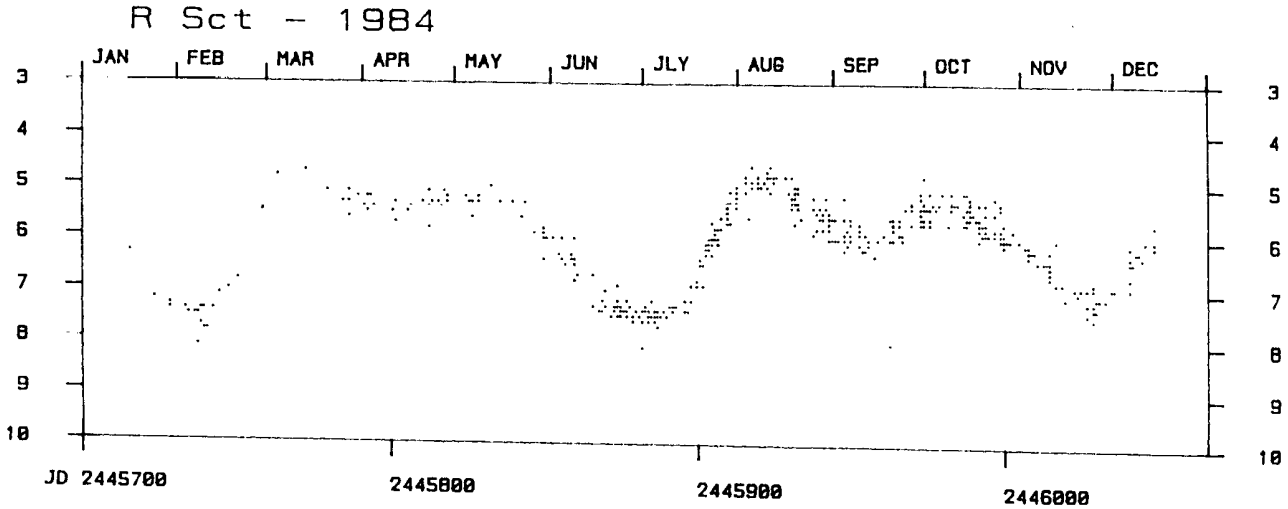


Figure 1. Light-curve for R Scuti from the 1984 light-curves booklet.[7]

Data entry

The typing up of observations into a computer is an essential but not very glamorous part of this project. It is both repetitive and time-consuming. John Howarth reported[15] that the entry of 20,000 observations of W Cygni was greatly eased by sharing the work between the members of the Crayford Manor House Astronomical Society. Working together, with some people reading the observations out loud and other people typing them up, they achieved an entry rate of up to 300 observations per hour. However, this was for records consisting just of Julian dates, magnitudes and observer abbreviations. Most of the Section's records contain more details and so a rate of 100 per hour would be more realistic for entering them.

The fact that the Crayford group tended to work together also meant that they were not faced with the distribution problems that arise when the helpers are scattered over a wide geographical area. It is not a good idea to send the original report forms out to the helpers because the originals may be lost or, at least, become very awkward to retrieve. The obvious answer is to photocopy them. This also allows the data to be 'compressed' to a certain extent. During the copying the forms can be reduced in size and those which contain small numbers of observations can be combined into single sheets. However, in spite of these measures, the photocopying and postage of observations still accounts for a significant proportion of the total costs of the project as a whole.

A wide variety of types of people have helped with the data entry. They all have access to computers (obviously) and most have a fair bit of time to spare. Many have done some variable star observing themselves but, surprisingly, there are few currently active observers amongst them. Presumably, this is because active observers are too busy observing to have any spare time. An exception to this rule are those observers, such as Gary Poyner, who submit their own observations ready typed-up on disks or via electronic mail. This saves the Section officers so much work that we would like to encourage all observers to do this where possible.

The most active helper in the data entry has been Herbert Joy who has been involved in the work of the Variable Star Section since the 1950s. He started off as mainly an observer but was soon helping in the manual preparation of lists of observations prior to their analysis and publication. He complains that none of the directors that he has worked for have been able to supply him with enough work to keep him busy! In the early 1960s he helped the director R. G. Andrews trace and print many new variable star charts and it was for this work that he was awarded the Merlin Medal and Gift in 1966.

Herbert is now retired and lives in a quiet village in Oxfordshire. He has entered over 100,000 observations over the past two years using an old BBC microcomputer. He uses a relatively simple word-processor and has only recently upgraded from tape storage to floppy disks.

Further up the technological ladder comes Mike Carson-Rowland who works for the Midland Bank in Sheffield. He is part of the team that supports all of the bank's PC hardware and software in that city and the surrounding area. Like Herbert he has been involved in the manual processing of observations but he now uses a 386/25 PC running 'Word for Windows'.

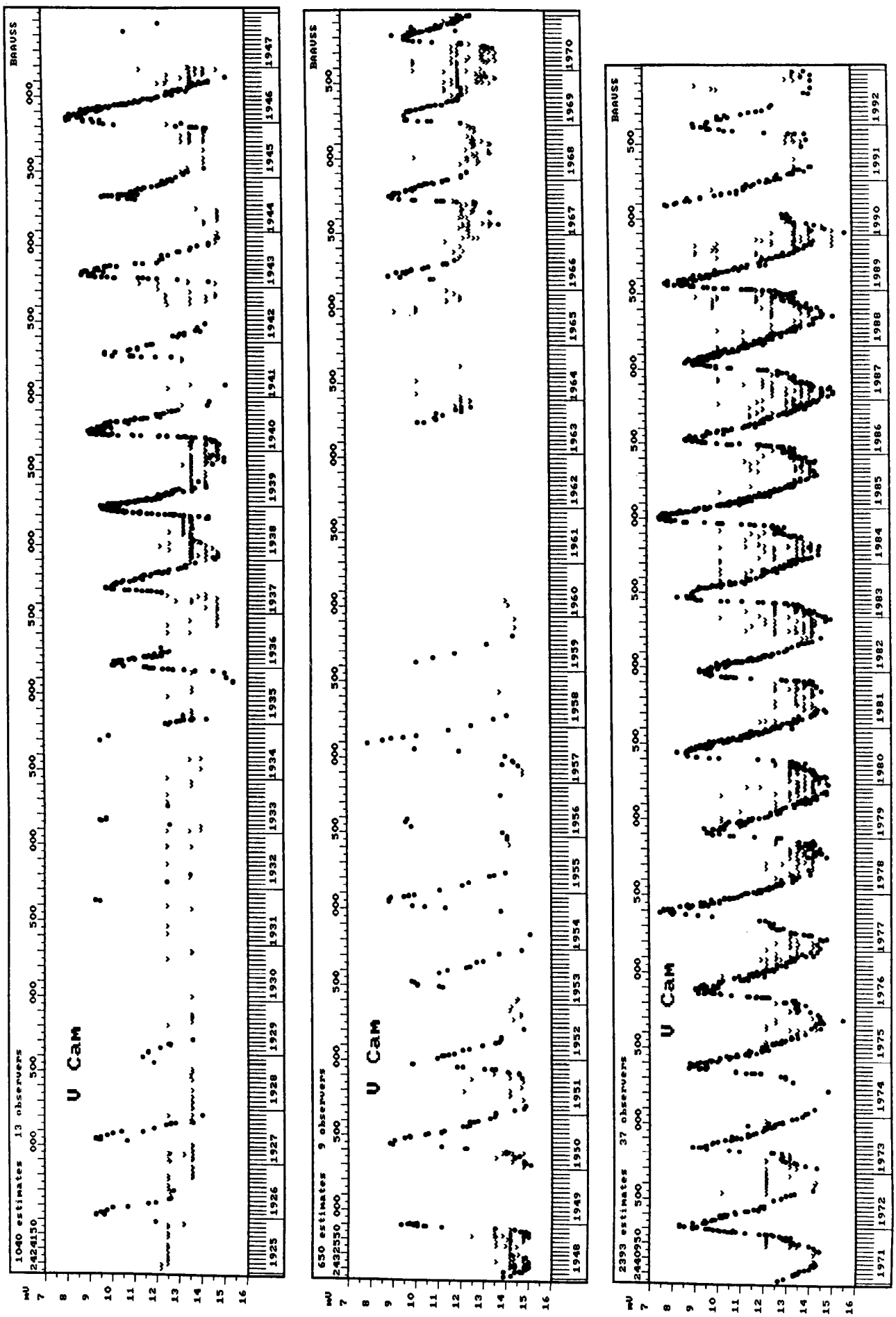
```
*BAAVSS*
*YEAR* 1992  Second Half
*NAME* Gary Poyner
*ADDR* 67 Ellerton Rd, Kingstanding, Birmingham
*LOCATION* 2w 32n  (52 32' 32" N : 01 52' 30" W)
*INST* 1 = R400, 2 = R220, 3 = R200, 4 = B10X50
*STAR* RW And
*CHART* 022.01
*GMAT*
Jly19,1406/        N-3          /   14.5  /1/1/
Aug03,1218/        N-4          /   14.6  /1/ /
Aug22,1235/        R-3          /   14.9  /1/ /
*STAR* RX And
*CHART* 001.02
*GMAT*
Jly10,1242/      D(2)v(1)E      /   11.3  /1/1/
Jly19,1409/      L(3)v(1)M      /   13.6  /1/ /
Jly22,1120/        M-2          /   14.0  /1/ /
*STAR* W And
*CHART* 035.01
*GMAT*
Jly19,1421/      Y(2)v(2)Z      /   12.7  /1/1/
Aug03,1344/      Z(2)v(2)BB     /   13.3  /1/ /
Aug22,1250/      CC(1)v(2)DD    /   14.1  /1/ /
*STAR* V603 Aql
*CHART* GMH 861024
*GMAT*
Jly10,1024/        M+2          /   11.3  /1/1/
Jly14,1309/        M+2          /   11.3  /1/ /
*STAR* UU Aql
*CHART* 002.02
*GMAT*
Jly19,1308/        [P           /  [14.7  /1/1/
*STAR* VYAqr
*CHART* GMH 871025
*GMAT*
Jly19,1311/        [W           /  [15.0  /1/1/
Jly21,1318/        [U           /  [14.6  /2/ /MC
*END*
```

Figure 2. An example B-style observation input file.

He is currently in the middle of entering the Section records on R Coronae Borealis for 1921 to 1982, which consist of over 30,000 observations. In a recent Section Circular,[16] he described some of the short-cuts he has developed to speed up his entry rate. These include the substitution of equivalent characters requiring fewer key-presses and the use of 'macros' and 'glossaries' (or 'boiler-plates'). While the details he gives are often specific to the word-processor he uses, the general principles are more widely applicable and anyone who is planning to enter a lot of observations would do well to read this article.

Results so far

One of the first results to emerge from the computerisation project was the appearance of lots of computer-generated light-curves in the Section *Circulars* and in displays at various meetings. While this is good because it provides the observers with feed-back and encouragement, it is not the main aim of the project. Indeed, it may be that the earlier emphasis on producing annual light-curves actually delayed the appearance of more significant results. For it to be worthwhile carrying out a detailed analysis of any particular star the complete data set for that star has to be


U Cam
1040 estimates 13 observers
650 estimates 9 observers
2393 estimates 37 observers
BAAVSS
mV

available. Entering the observations star-by-star will lead to such complete data sets becoming available earlier than if they are entered year-by-year. This has been made difficult by the way that the paper records were stored, with the observations for different years being held in different places. However, these problems are being sorted out and complete data sets going back many decades are now available for some stars (see Figure 3).

The main aim of the computerisation is to allow the observations to be analysed. These analyses will undoubtedly reveal quite a few surprises. One such surprise was provided by RX Cephei which is catalogued[17] as a possible yellow semiregular variable with a visual range of 7.2 to 8.2. Photoelectric observations by Endre Zsoldos of the Konkoly Observatory in Budapest had shown that this star was constant to within a few hundredths of a magnitude in 1990 and 1991.[18] The Section's records on this star, which stretch back to 1968, were entered and analysed[19] and showed no evidence for any variations on the scale suggested by the catalogued range. A subsequent investigation[20] of all available observations of this star, going back to the 1880s, revealed that the earlier reports of its variability were dubious and that there is no good evidence for the star ever having been variable.

This might seem a bit of a non-result but it is useful in that it means that observers need not waste their time observing this star in the future. The importance of carrying out a careful analysis of **all** of the available observations is brought out by the fact that quite a few of the visual observers were convinced, from their own observations, that this star was varying.

Analyses of other, truly variable, stars are also under way and the results of these will be published in the *Journal* and in the Section *Circulars*.

Another result of the computerisation is that requests from professionals for our data can now be met more quickly and the data supplied in a more convenient form. An example of such a request is one received, via Guy Hurst, from a group at Sussex University led by Martin Hendry. They are interested in looking for chaotic behaviour in the distribution of the long and short outbursts of dwarf novae. Cannizo and Mattei[21] concluded from an analysis of AAVSO visual data for SS Cygni that the distribution of the outbursts of that star are probably not chaotic. The Sussex group would like to check whether this holds for other dwarf novae and, in particular, those of the SU Ursae Majoris sub-class which show two very different types of outburst. We were able to supply them with over 50,000 observations of 17 stars. These included about 10,000 observations of SU Ursae Majoris going back to 1926. Initially, the observations are being used to test the algorithms and to check that the methods are feasible but they hope eventually to get down to investigating individual stars and then they will probably need even more observations.

Plans for the future

Ideally, we would like to clear the backlog of past observations within a few years and also keep up to date with the entry of the current observations. This would require a significant increase in the annual data entry rate which, in turn, means that we need to have more people involved. Anyone who is interested in helping should write to Dave McAdam giving details of the computer they have access to. This work is well suited to people who used to be active observers but who have been forced to give up, because of old age, light-pollution, or other reasons.

Although you do not have to have done any variable star observing yourself, it does help if you have some idea of what is involved. Where possible, you will be given credit for your work in reports which use the data you enter. We consider this work to be almost as important as that of the observers who made the observations in the first place (if the observations are never published then they might as well have never been made!). As complete data sets become available, some of them will be analysed and the results published in the *Journal* or in the Section *Circulars*.

However, even if the data entry were only to continue at the present rate, it would still produce complete data sets at a faster rate than they could be analysed. This, in itself, is not particularly worrying but it would be useful to have a few more people helping in the analyses. Surely some observers would be interested in helping some of their observations into print? In its simplest form this work involves writing a short report on the Section's observations of a 'non-variable' star, such as RX Cephei. You would not even need a computer to do this. The more mathematically-minded might like to try producing periodograms or carry out other statistical analyses on 'proper' variables. Guidance can be provided on how to carry out the analyses and on how to prepare the results for publication. If you are interested, them write to Tristram Brelstaff giving details of the type of work (and stars) that you are interested in and the type of computer you have (if any).

We also invite requests from professional astronomers and serious amateurs outside the Section to use our observations in their research. We can supply the observations as lists of Julian dates, magnitudes and observer abbreviations (the 'Z-style' mentioned above) on a disk. If the observations have already been entered then they could be supplied within a few days; if they have not yet been entered then it may take a few weeks or months, depending upon the quantity involved. Requests for observations should also be sent to Tristram Brelstaff.

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Figure 3 (opposite). Long-term light-curve for the Mira star V Camelopardalis.

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