

**British Astronomical Association**



# **VARIABLE STAR SECTION CIRCULAR**

**No 121, September 2004**

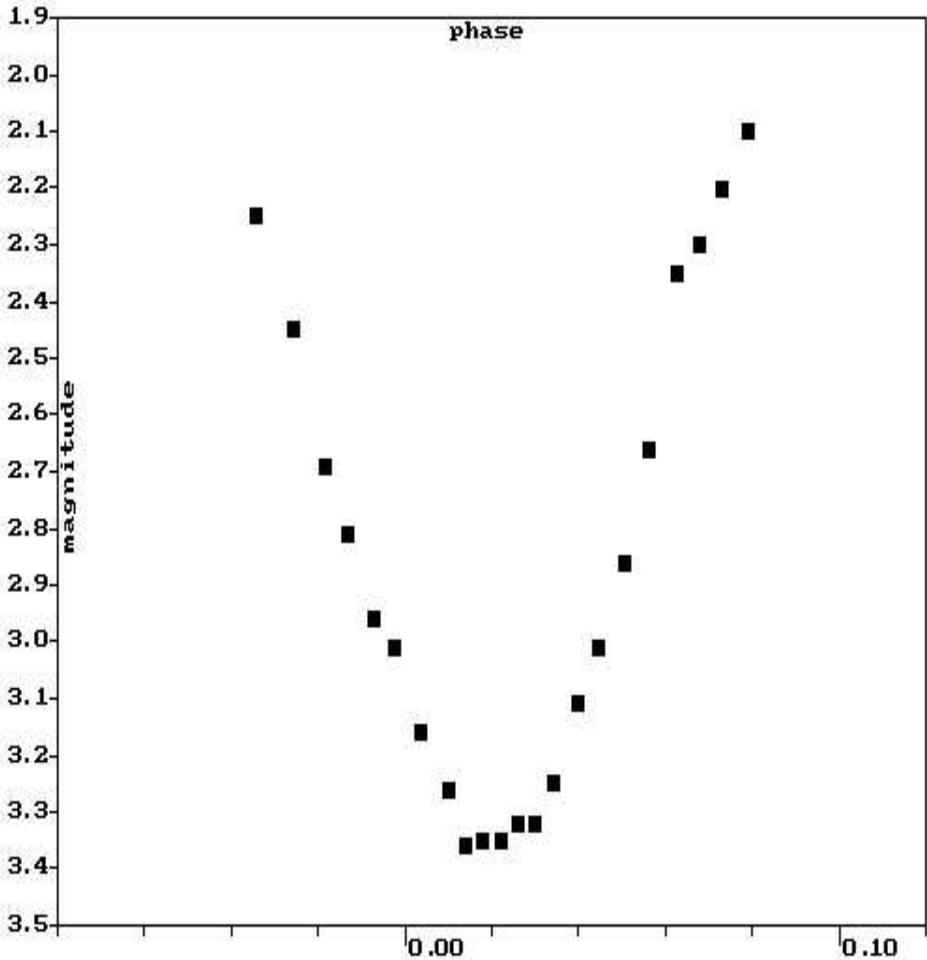
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**Office: Burlington House, Piccadilly, London, W1V 9AG**

# Primary Eclipse of Algol : 2003 Nov 3-4



**Eclipse of Algol, Observations by Tony Markham**

The deadline for contributions to the issue of VSSC 122 will be 7th November, 2004. All articles should be sent to the editor (details are given on the back of this issue)

Whilst every effort is made to ensure that information in this circular is correct, the Editor and Officers of the BAA cannot be held responsible for errors that may occur.

# FROM THE DIRECTOR

**ROGER PICKARD**

I thought there was going to be little to report in this Circular, it being the summer months with their long light evenings, but things have not been that quiet.

Firstly, there was the eruption of a new variable in Hercules. Yuji Nakamura, Japan, reported the detection of a variable object of photographic magnitude 11.5 in Hercules on June 13.63UT using a 200mm f4 lens. Thoughts at the time of writing, are that it may be a WZ Sge type star. The fact that such a relatively bright star should be unknown, shows how important it is to keep monitoring the skies.

Which brings me to the second discovery. This was by a relative newcomer to astronomy, and a BAA member of only two months standing, Richard Best, who noticed that a star in M27 in an image he had taken last year was absent in an image from this year. He sent a query to Stewart Moore (BAA Deep Sky Director), who relayed it to Guy Hurst and myself. Guy quickly traced it to NSV 24959, and later Owen Brazell added that the object was discovered by Leos Ondra in 1988 (there is a nice report at: [-http://leo.astronomy.cz/gl/gl.html](http://leo.astronomy.cz/gl/gl.html)). It's probably a Mira and it's certainly below V magnitude 16 at the moment, but in November 1994 it was at approx magnitude 12, so we need to keep monitoring it to determine its range and period.

So, all in all, don't give up on continuously monitoring the sky. You never know what will be discovered next.

## **Five Years as Director**

By the time you read this I will have completed five years as Director of the BAA VSS, having taking over from Gary Poyner on 1st September 1999. During that time there have been a number of problems to overcome, not least of which was Dave McAdam's retirement. This necessitated splitting the work he had done for the Section into two parts consisting of the database and the web pages, and I'm grateful to John Saxton for handling the former and initially Peter Moreton, and now Dave Grover the latter.

Other notable *events* during the last 5 years, have included the production of an index to Circulars 71-100; the first two-day Section Meeting; the mentoring scheme; the CCD target list; the production of the Circulars in pdf format and the introduction of an electronic alert service.

It is also interesting to note that the number of observations reported to the Section in 1998 (and summarised in the first Circular for which I was responsible) was approximately 31,000, which is almost the same figure as for 2003. It's good to see our visual observers are maintaining their enthusiasm.

If there is one disappointment, it is that our database is still not available on-line, but hopefully, through the efforts of Roger Dymock and his Project Quixote, this will not be too long in forthcoming now.

I wish to thank all the Officers for their support and for the tremendous amount of work they undertake to keep the Section running smoothly.

## Albert Jones DSc

I'm sure most members will be aware that Albert Jones is probably the greatest living variable star observer of our time, but for those that don't know, here is a very short biographical note.

Albert is now 84 years old, and still observes on every possible occasion which includes many early morning sessions using a telescope he built in 1948. Indeed, only last year he re-discovered a variable star in the field of nova V5114 Sgr (this turned out to be V1592 Sgr - there is a typo in the GSC which gives the declination 10 arcmins north of its true position, so Albert just happened to see V1592 around maximum). He's never totalled how many observations he's made but apparently it is over 500,000! He modestly says that if he has made more estimates than someone else, it is because he has been *at it* for ages. Indeed, in January of this year he celebrated the 61st anniversary of his first attempt at estimating the brightness of a star (Nova Puppis 1942). He also says that he thinks his time is best spent observing and forwarding the estimates to the VSS of the RASNZ, and latterly to the AAVSO, and to those with the knowledge of maths and astrophysics to do justice to the analysis of the data. He doesn't even make light curves of his own observations. "*In that way I can go to the telescope with an open mind, trying to forget what it was last time, and not expecting the star to be brighter or fainter*" he says. His observations are also very accurate and he has a regular request list for his observations from professional astronomers around the world. Even an observational programme using the Hubble Space Telescope was initiated following one of his recommendations.

Albert joined the BAA in 1945 and was Assistant Director of the Comet Section from 1952 to 1990. For his considerable work in establishing accurate magnitudes of comets he was awarded the Merlin Medal in 1968. Albert has also discovered two comets, the first in 1946 when he was 26, and the second in 2000 when he was 80, making him then the oldest person to find a comet at that time (Bill Bradfield may have been older when he found his latest comet). The 54-year gap between the two discoveries is also a record.

Apart from his joint discovery of SN 1987A, he was also awarded the OBE in the Queen's Birthday honours list. An asteroid was named after him in 1988 in recognition of his achievements, and then last May he received an honorary doctorate of science from Victoria University of Wellington, NZ. Ever the one to shun the limelight he said "*The ceremony was very emotional for me, being the centre of attention*".

Albert married Carolyn in 1984, his greatest discovery he says, and adds that the 20 years since then have been the happiest of his life.

The above information was gleaned partly from personal correspondence and from "*Albert Jones - The Quiet Achiever*" by Rodney R.D. Austin, Southern Stars, the Journal of the Royal Astronomical Society of New Zealand (INC.), 36, Numbers 1&2, December, 1994.

## Peter Wheeler

I mentioned in the last Circular that Peter had now retired from the Section, but I should have added that besides observing, he also produced the index to Circulars 12-70.

## Erratum

The editor apologises for the incorrect Alston Hall telephone number given on page 5 of VS120. The correct number is given on page 7 of this circular.



**Albert Jones at the award ceremony.**

# CHART NEWS

JOHN TOONE

The following new charts are now available from the Chart Secretary:

## **213.02 W CMa**

Formally 213.01. A V sequence sourced from Tycho 2 has been introduced with stars B, D and F dropped, and replaced with stars G (SAO152438), H (SAO152402), K (SAO152442) and L (SAO152424). The new 9 degree field chart shows improved detail in this crowded region of the sky.

## **272.01 MisV1147 Cep**

No previous BAA VSS chart existed for this recently discovered telescopic star (see VSS Circular 115, page 3). A 15 minute field chart has been drawn complete with a V sequence by Henden.

## **009.04 AH Her**

Formally 009.03. New 1 degree and 20 minute field charts have been drawn. The previous mv sequence has been replaced and extended by a V sequence sourced from Tycho 2, TASS, West and Henden.

## **011.02 AY Lyr**

Formally 011.01. New 1 degree and 15 minute field charts have been drawn. The previous mv sequence has been replaced and extended by a V sequence sourced from Henden.

## **024.02 RS Oph**

Formally 024.01. New 9 degree and 1 degree field charts have been drawn. The previous mv sequence has been replaced by a V sequence sourced from Tycho 2, ASAS3 and Henden.

## **012.03 CN Ori**

Formally 012.02. New 3 degree and 20 minute field charts have been drawn. The previous mv sequence has been replaced and extended by a V sequence sourced from Tycho 2 and Henden.

## **013.03 CZ Ori**

Formally 013.02. New 3 degree and 15 minute field charts have been drawn. The previous mv sequence has been replaced and extended by a V sequence by Henden.

## **277.01 X Per**

Formally MDT 1984 April 8. A new 9 degree field chart has been drawn. A V sequence has been introduced sourced from Tycho 2 and Pickard. Stars FL42, C and 12 have been dropped, and replaced with star D (SAO56951).

## **278.01 Z Psc**

Formally JEI 10.11.69. A new 9 degree field chart has been drawn. A V sequence has been introduced sourced from Tycho 2 and Pickard. Stars D, E, C and G have been dropped and replaced with star N (SAO74721).

## **276.01 TX Psc**

Formally MDT 72.05.27. A new 9 degree field chart has been drawn. A V sequence has been introduced sourced from Tycho 2. Stars F and H have been dropped, and replaced with star K (SAO128393).

### **017.03 SU Tau**

Formally 017.02. New 1 degree and 10 minute field charts have been drawn. The previous mv sequence has been replaced and extended by a V sequence sourced from ASAS3 and Henden.

### **271.01 TV UMa**

Formally MDT 1982 Aug 16. A new 9 degree field chart has been drawn. A V sequence has been introduced sourced from Tycho 2. Stars C (Groombridge 1830) and D (NSV19016) are both confirmed variables and have therefore been dropped. Stars G (SAO62635), H (SAO62590) and K (SAO62729) have been added.

### **270.01 BK Vir**

Formally DAP 74.01.21. A new 9 degree field chart has been drawn. V magnitudes sourced from Tycho 2 have been applied to the existing sequence.

Thanks are due to Chris Jones who drew the charts for MisV1147 Cep and BK Vir.

## **THE 2004 VARIABLE STAR SECTION MEETING**

**DENIS BUCZYNSKI AND ROGER PICKARD**

The British Astronomical Association Variable Star Section Residential weekend meeting for 2004 October 22-24, will be held at Alston Hall Residential College Longridge Preston, Lancashire PR3 3BP, from Friday early afternoon, until lunchtime Sunday.

To date the arranged speakers are as follows: **Professor Don Kurtz** (University of Central Lancashire), **Mike Simonson** (AAVSO), **Bruce Sumner** (AAVSO), **Dr Keith Robinson** (Lecturer in Astronomy), **Denis Buczynski** (CBO Lancaster), **John Toone** (BAA), **Gary Poyner** (BAA).

Other speakers have been invited and we await their replies. Time will be made available for any VSS members who would like to make a short contribution. There may be a session devoted to a debate, which members will be able to vote upon. The participants and the subject matter (contentious with some frivolity attached) are still under consideration. Any suggestions for this event would be welcomed!

All residential arrangements, which include accommodation, food/diet and any special needs have to be booked directly with ALSTON HALL. The basic cost for accommodation including all meals and refreshments is around 110 pounds, plus extra for supplements. Contact Dot Little at ALSTON HALL and discuss your requirements as soon as possible. The telephone number is 01772 784661; Fax number is 01772 785835; E-mail is [alston.hall@ed.lancscc.gov.uk](mailto:alston.hall@ed.lancscc.gov.uk)

As usual, residential space is limited to around 40 persons, so early reservation is essential. When you contact ALSTON HALL quote BAA Astronomy Weekend Oct 22-24. There will be spaces for any members who do not require accommodation but wish to attend on a daily basis. Anyone wanting to take this option should still book directly with ALSTON HALL to agree costs for any meals and refreshments. Anyone needing further details or anyone who would like give a short talk should contact Denis Buczynski (evening telephone 01524 68530 or E-mail [denis@cb978iau.demon.co.uk](mailto:denis@cb978iau.demon.co.uk)).

Residential/travel/direction/location details will be sent directly from ALSTON HALL to those who book. We look forward to seeing many of you at the meeting, and greeting you to beautiful Lancashire. It will be a great weekend, promise!

# THE BAA VSS CCD PHOTOMETRY SPREADSHEET

DAVID BOYD, RICHARD MILES, ANDREW WILSON

## Introduction

If you carry out time-sequence photometry of variable stars using a CCD camera, and subsequently use the AIP4WIN multi-image photometry routine to measure your images, then you might find this Excel spreadsheet useful for further analysing and reporting your observations. It also provides the most convenient route at present, for submitting your results to the new VSS CCD database. There will be an article about the CCD database in a future issue of the Circular.

The purpose of the spreadsheet is threefold. It lets you examine the content and quality of your data quickly, and so helps you to improve your observing technique; it provides a convenient way of recording all the relevant information about an observing run in one place for future reference, which is important if the data is to be of scientific use; and finally, it makes it very easy to submit your results to either the BAAVSS, the AAVSO or any other organisation as part of an observing programme.

The spreadsheet is intended for use with time-sequence differential photometry measurements of a single object (plus comparison and check stars), recorded with either no filter or a single photometric filter (eg U, B, V, R or I). We are also developing further spreadsheets which will support observing runs on single objects using multiple filters, analysis of data for multiple objects, and absolute photometry.

## The spreadsheet

After an extensive period of development and testing within the VSS CCD Working Group, the spreadsheet is now ready for exposure to a wider group of users. If you would like to try using it, you can obtain a copy by contacting the first-named author (DB) at [drsboyd@compuserve.com](mailto:drsboyd@compuserve.com).

Mostly the spreadsheet is self-explanatory if you spend a few minutes looking through it carefully. In particular, note the colour-coding of the various cells in the Results sheet. This tells you which cells you need to fill in with information about yourself and your equipment, your observing site, the objects being observed, and the observing session, and which cells the spreadsheet fills in automatically, either by importing data or by calculation. Some of the information, for example, about your observing site and equipment, will only need to be filled in the first time you use the spreadsheet and can then be copied for subsequent observing sessions. The information about the objects being measured will obviously need to be added each time. Don't be tempted to dive in and edit the contents of individual cells without first considering whether this is appropriate! We will now give a few words of explanation about each sheet in the spreadsheet.

## Results sheet

The main sheet of the spreadsheet is the one labelled *Results*. This stores all the relevant information about the observing session in the top section and then, lower down, it contains the results of analysing each image, one line per image. For each image it calculates the

differential magnitude of the V (variable) and K (check) stars relative to the C (comparison) star. There are lots of calculations embedded in this sheet so edit it with care! By studying these formulae you will be able to see how the results are being calculated. If you spot any mistakes, please let us know (see below).

### ***Buttons sheet***

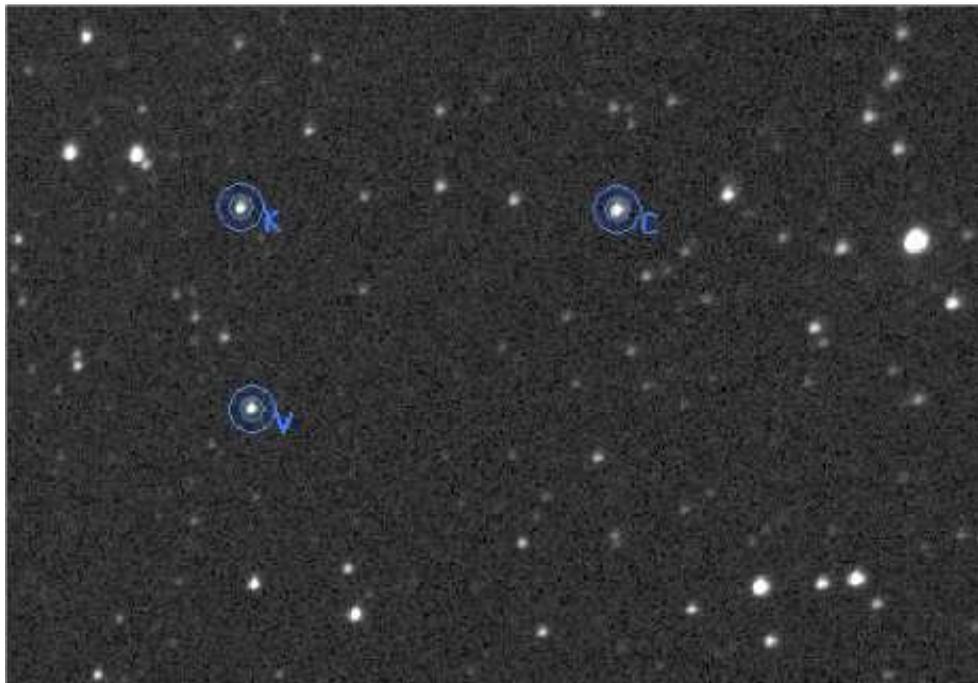
The *Buttons* sheet enables you to run some useful macros, one which automatically imports the AIP4WIN multi-image photometry output data file into the lower section of the Results sheet, and three which generate report files in various formats. You can specify names for these files as appropriate. It is not necessary to use the import macro if you want to load your data into the *Results* sheet manually, for example if you are using software other than AIP4WIN, but do take care not to overwrite formulae in the *Results* sheet. The cells which the import macro fills are coloured black in the *Results* sheet.

### ***Data charts sheet***

The *Data charts* sheet is useful for seeing at a glance what your data looks like. There are plots of the measured V-C differential magnitude, both with and without error bars (more about errors later), and similar plots for K-C, so you can check that everything is behaving itself. There is a plot of the V, C and K instrumental magnitudes, which is a good way of checking on the quality of the observing conditions. The presence of any thin cloud or haze will immediately make its presence obvious on this plot and allow you to make value judgements on whether any of your data should be rejected. You will also see any deterioration in the data quality reflected in the size of the error bars in the V-C and K-C plots. These errors are mainly based on the number of photons from the objects which were recorded, and are therefore sensitive to effects like haze or dewing of your optics. Finally, there is a plot of the measured V-C differential magnitude, in which blocks of consecutive results are averaged. This can be useful if the data is a bit noisy and you want to smooth this out, but beware that it might also smooth out any real short term variation in the data.

### ***Image sheet***

The *Image* sheet provides somewhere for you to store an image of the field with the stars you used as V, C and K marked by AIP4WIN. A convenient way to do this on a PC is as follows. First delete the image currently in the *Image* sheet. Then click in the cell which was at the top left of the old image so that when you are ready to store the new image, it will go in the same place. The next stage of the process happens when you are using the AIP4WIN multi-image photometry routine to measure your images. While doing this you will have an image on the screen with circles and labels marking the V, C and K stars. Use the Print Screen button on the keyboard to take a copy of this screen onto the clipboard. Start up Microsoft Paint (or any other similar image manipulation program). In the case of Paint, this starts up with an empty image window. Use Paste to load the information currently on the clipboard into this window, then click on the dotted box at top left to select the cursor function. Use the cursor to select the part of the image you want to store in the spreadsheet. This should contain enough local context to make it clear which stars you are using. Use the Copy function to make a copy of this section of the image. Now go back to the *Image* sheet of the spreadsheet and select Paste. This should put a copy of the selected section of your image into the spreadsheet. This sounds complicated but becomes simple with practice. It is, of course, optional to do this, and it does make the spreadsheet file somewhat larger, but it could be very useful to



**Figure 1, an example of image used for spreadsheet results**

resolve any uncertainty in the future about which stars were actually measured. It's not impossible to type an incorrect GSC number into the Results sheet! Figure 1, above, shows an example image.

### ***Reporting sheets***

There are three output file options for reporting your results, all activated using the Buttons sheet. These write out the contents of the Summary, AAVSO Report, Bulk Data and Individual Measurements sheets. You can inspect these sheets to see what they contain. The Bulk Data and Individual Measurements sheets are used to create another Excel spreadsheet file which you can submit to the VSS, and which will be used to load your data into the VSS CCD database. The AAVSO Report sheet is used to create a file which can be uploaded to the AAVSO WebObs on-line data entry system. It uses their *generic* data format. The Summary sheet contains sufficient information about your observations, including details of you and your equipment and the comparison and checks stars used, that you could send the Summary file to any other organisation to which you want to report your results. The time reported for each image in these output files is always the mid-exposure time. If necessary, this is calculated from the time given in the FITS header and the duration of the exposure.

## Calculating errors

Finally errors. We mentioned above that the spreadsheet calculates errors on the individual magnitude measurements which it produces. These are largely based on the ADU counts which you have measured from each image but also take into account some parameters of your camera, namely gain, readout noise and dark current. You will need to fill these in on the Results sheet. The Berry and Burnell book *Handbook of Astronomical Image Processing* (1), which includes the AIP4WIN software, tells you how to measure these. Note that it refers to gain as conversion factor. You can sometimes find theoretical values for these on the specification leaflet for your camera. If you don't know these, set the gain to 1 and the readout noise and dark current to 0 initially, but this will mean that your errors are not accurate. If you look in the cells which contain the errors you will see a complicated formula. This is based on an error formula, sometimes called the *CCD Equation*, which is widely used in the astronomical community and is written up in Howell's book *Handbook of CCD Astronomy* (2).

Error-calculation is a very big subject and we won't attempt to go into it further here. Suffice it to say that one of us (DB) has compared these calculated errors with the scatter of measurements of the check star in each of a large number of observing runs (the check star is supposed to have a constant magnitude so the scatter in these measurements gives an independent estimate of the actual measurement error) and finds that the error formula consistently slightly underestimates the actual error (3). This is to be expected since there will be other sources of error which the error formula does not take into account. For this observer, scaling the calculated errors up by 20% gives an excellent match to the actual observed errors. It is left as an exercise for the reader to see how these calculated errors compare with their own experience. What is in no doubt however, is that having an approximate estimate of the uncertainty on your measurements is much better than having no estimate.

## Conclusion

So now you know about the new VSS CCD photometry spreadsheet. If you think it might be useful for you, get a copy and try using it. We will endeavour to answer any questions and deal with any bugs which you find still lurking in the spreadsheet. We would also be very interested to hear how you get on. In the first instance, contact the first-named author (DB) at [drsboyd@compuserve.com](mailto:drsboyd@compuserve.com).

## References

- 1 Berry R. & Burnell J., *The Handbook of Astronomical Image Processing*, Willmann-Bell (2000)
- 2 Howell S. B., *Handbook of CCD Astronomy*, p53, Cambridge University Press (2000)
- 3 Boyd D., 'What photometric precision can I achieve?', *VSS Circular*, No.199, March 2004

# PHOTOELECTRIC MINIMA OF SOME ECLIPSING BINARIES

CAHIT YESILYAPRAK<sup>1</sup>, TIMUR SAHIN<sup>1</sup>

These binary stars were observed as a part of a project given to TUBITAK (The Scientific and Technical Research Council of Turkey) National Observatory (TUG). Some of the stars, such as **V2150 Cyg** and **OU Ser**, need much more data for both reliable O-C analysis, and defining the physical nature of these systems. The observations were performed in the Johnson V band, and reduction of the observations was made in the usual way (Hardie 1962). The standard error is included in each of the minimum times. The observations were reduced by using the method of Kwee and van Woerden (1956).

## Introduction and Literature

Contact binaries are the most frequent type of eclipsing binaries. Nevertheless, many of them escape detection due to their small inclination angles, and their light variations can be well below the general detection limit of searches for variable stars. The photometric survey of the HIPPARCOS satellite has confirmed many such variables, and has produced a substantial number of new ones. In this study, we have surveyed the list of periodic variables in the Variability Annex of The HIPPARCOS Catalogue (ESA 1997) for known and new contact binaries. Stars which were classified as EW were examined (these are listed opposite in Table 1). Some of our results are given in Table 2.

From season to season significant variations are seen in the light curves of many short period eclipsing binary systems, especially the W Ursae Majoris type stars. These stars also experience period changes, which may or may not be associated with the light curve activity. We are also thinking of performing a detailed calculation for period changes, especially for both **V2150 Cyg** and **OU Ser**. These stars need complete light curves for detailed analysis in order not to smear out variations occurring on a time scale of days. The W UMa-type star **AC Boo** was first reported by Schieven et al (1983) to have experienced a period change at some time between 1973 and 1982. **V2150 Cyg** is another new binary system discovered by the Hipparcos Project. The Hipparcos light curve shows variations only slightly above 0.1 magnitude, indicating a low orbital inclination for **V2150 Cyg**. As noted by Lu et al (2001), this system is important since it can provide an extension of the absolute magnitude calibration toward early spectral types.

## Observations and Results

For each star, the available times of minimum in the literature were used to predict times of minimum in order to determine the type of minimum. The minima times were computed with Kwee and van Woerden method (1956). The latter is given in column 4 (I = primary, II = secondary) for Table 2. Our present observations were taken with the TUG 0.40 m. reflecting telescope in conjunction with a (SSP5 type) PMT photoelectric photometer. Standard Johnson B and V filters were used. Reductions were made in usual way (Hardie 1962). Minimum times are corrected for light time effect.

<sup>1</sup>Akdeniz University, Art & Science Faculty, Physics Department, Campus, 07058, Antalya / Turkey.  
E-Mails: cahity@akdeniz.edu.tr, timursahin@akdeniz.edu.tr

**Table 1: Variable and Comparison Stars**

Var Star	Coords RA. (J2000) DEC	Comp Star	B mag	V mag.	Spec	Ep+Source (2400000+)	Period (d)
AC Boo	14 56 28 46 21 44	GSC 3474 0052	9.10	10.08	F8Vn	51588.0118 (2)	0.352444
FI Boo	15 22 06 51 10 55	HD 136578	10.15	9.48	G5	48500.0390 (1)	0.194999
V2150 Cyg	21 18 11 30 35 22	SAO 71155	8.40	8.00	A0	48500.4340 (1)	0.591856
OU Ser	15 22 43 16 15 41	HD 136440	8.84	8.25	G5	48500.2780 (1)	0.296765
HN UMa	11 15 57 37 38 36	Hip 55651	10.36	9.82	F8	48500.0781 (1)	0.382608

All stars in table 1 are of EW type as listed in GCVS

Sources:(1)Hipparcos and Tycho Catalogues (ESA 1997), (2) Nelson, R.H. (2001), IBVS 5040

**Table 2: Times of Minima**

Star Name	Time of min. HJD (2400000+)	Error	Type (d)	Filter	O-C	Remarks
FI Boo	52450.4010	0.0001	II	V	-0.0252	TS
FI Boo	52831.4353	0.0003	II	V	-0.0190	CY
FI Boo	52842.3404	0.0005	II	V	-0.0338	TS-HA
FI Boo	52846.4419	0.0002	II	V	-0.0273	TS
FI Boo	52859.3145	0.0010	II	V	-0.0246	TS
V2150 Cyg	52582.3189	0.0004	I	V	-0.1459	CY
V2150 Cyg	52885.4028	0.0007	I	V	-0.0923	CY
V2150 Cyg	52888.3674	0.0003	I	B	-0.0870	CY
V2150 Cyg	52888.3686	0.0006	I	V	-0.0858	CY
V2150 Cyg	52889.2518	0.0009	II	V	-0.0904	CY
V2150 Cyg	52890.4379	0.0005	II	B	-0.0880	CY
V2150 Cyg	52890.4374	0.0004	II	V	-0.0885	CY
OU Ser	52418.3493	0.0008	II	V	0.0380	CY
OU Ser	52437.4865	0.0004	I	V	0.0339	CY
OU Ser	52793.4535	0.0001	II	V	0.0319	CY
OU Ser	52827.4321	0.0002	I	V	0.0309	CY
HN UMa	52427.3685	0.0003	II	V	0.0106	CY
AC Boo	52830.4299	0.0000	I	V	0.0526	CY

Observer codes: Cahit Yesilyaprak (CY), Timur Sahin (TS), Halil Akteke (HA)

Acknowledgements:

The authors would like to thank the TUBITAK National Observatory (TUG) for the observing times and equipment support, and to Halil AKTEKE for contributions to observation of FI Boo.

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- 1 ESA, 1997, The Hipparcos and Tycho Catalogues, ESA SP-1200.
- 2 Nelson, R. H., 2001 , IBVS 5040.
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- 5 Lu, W., Rucinski, S. M., and Ogloza W. 2001, AJ, 122, 402.
- 6 Schieven, G., Morton, J., McLean, B., and Hughes, V., 1983, A&AS, 52, 463.

# FLICKERING IN S5 0716+714

JOHN TOONE

One of the early major successes of the BAAVSS Alert Group is the prediction, visual detection and CCD confirmation of flickering in S5 0716+714.

S5 0716+714 was first noted to be exceptionally bright on the 17 January 2004 by Gary Poyner. Gary's report read as follows:

*Have you seen S50716+71? Bright tonight at 12.3. Last observation was on Jan 14.897 at 13.4. I've been observing it since mid-1997, and this is the brightest I've seen it.*

Following confirmation of the outburst from other visual observers, Gary then put out the following alert on the 18 January 2004 requesting that observers monitor it closely for rapid variations:

*I think that during this active period, observations should be made hourly (or more frequently if possible). We've seen what happened in W Com and BL Lac a couple of years ago.*

On the 28 March 2004 I observed S5 0716+714 again in a bright state, but had difficulty making a confident estimate as it appeared to be unsteady in brightness. The following alert was posted on the morning of 29 March 2004:

*S5 0716+714 is continuing its active bright state.*

*28 Mar 1042GMAT Equal 3 12.4 C8*

*Comparison used:*

*3 = GSC 4368 930 = 12.43*

*Last night (28 Mar) S5 0716+714 appeared unsteady and I saw it alternately slightly brighter then fainter than comparison 3. The observation listed above is therefore a mean value.*

The following night (29 March 2004) David Boyd secured a 3 hour CCD run using a V band filter. Although the object had faded by around 0.5 magnitudes compared to the previous night, it was varying randomly over a range of 0.1 magnitude. David's report on the 2 April 2004 reads:

*I recorded two 3 hr CCD photometry runs on this object using a V-band filter on 29 and 30 March. Unfortunately it wasn't clear here at the time of the XTE TOO run on 28 March. It seems to be varying randomly by around +/-0.05 magnitudes. I've carried out a frequency analysis on the data but it didn't produce any significant peaks which were consistent in both runs, so it looks like there's no periodic component at a level I can detect.*

Light curves of David's CCD runs on the 28 and 29 March 2004 were published in The Astronomer, Vol 41, No 481 (May 2004).

The above is clearly conclusive evidence of classical flickering behaviour. I estimate that on the 28 March the flickering must have been in the range of 0.3 magnitudes for it to have been detectable visually. To the best of my knowledge this is the first time significant flickering behaviour has been detected in S5 0716+714.

# REPORT ON THE JOINT VS/I&I SECTION CCD PHOTOMETRY MEETING (PART 1)

MARK SHERBORNE (Sat am session) and STAN WATERMAN (Sat pm session)

The meeting was opened at 10:55am by Bob Marriott, who gave a brief introduction to the Variable Star Section and the Northampton Natural History Society. On display, and for attendees to examine later, was an *extinction photometer* used in the 19<sup>th</sup> century for variable star magnitude measurements.

Roger Pickard introduced the first speaker of the day, **Professor Tim Naylor** of the School of Physics at the University of Exeter, who talked about *New CCD Projects for Amateur Telescopes*.

Tim had worked for many years, at the University of Keele, which possessed a 24" telescope for the use of students and keen amateurs. This had been used, working in collaboration with amateurs to obtain lightcurves of the dwarf nova IP Peg and HT Cas, which are both eclipsing dwarf novae of great interest. Some of the most important work had been to discover whether the novae outbursts began at the inside of the accretion disc, expanding outwards with time, or the other way around. In practice, by monitoring the changing eclipse profiles, as the system progressed through its outburst, they were able to model the outburst's profile. As outbursts in these systems progress very rapidly, this is a field where amateurs can have a significant impact, by alerting other amateurs and professionals to the onset of outburst.

Tim explained that there were now 14 people in his Exeter University group working on a whole new set of problems associated with star and planet formation. The specific field of interest of the group is stars that are less than 10 million years old and are therefore pre-main sequence stars; low mass stars in this group (mass of < 1 solar mass) are known as T Tauri-type stars, whereas higher mass stars are known as Herbig Ae/Be type stars.

Exeter University students have access to a 10" Meade telescope, fitted with a ST7 CCD and guider system, and an SBIG spectrograph. The telescope is housed in a dome which is automatically controlled using Domeworks, which allows remote dome rotation, shutter operation, and also provides an interlock for the door. A PC which is located in the dome is remotely controlled from the control room. This equipment is funded by the Donald Barber Bequest. The seeing at the site was around 5 arcseconds which Tim described as being *disappointing*.

Tim then showed some H-R and Colour-Magnitude diagrams, that he had constructed using Hipparcos data, in which he emphasized the size of the spread of the pre-main sequence stars; the expectation is that the spread of stars shown on them would 'tighten' with time to drop onto the main sequence. However, there is still much that is not understood about pre-main sequence stars. As a star collapses during the formation process, and forms an accretion disc of the order of the size of the solar system, the inner part of the disc emits infrared radiation, and the magnetosphere of the star truncates the disk at 2-3 solar radii. It is thought that planets will later form in this disc.

Most star formation work done to date, concentrates on stars in the local area out to a distance of around 100pc, even though this is a star formation backwater. Most star formation

occurs in OB associations; the nearest of these is in Orion, at a distance of around 500pc, and most other known OB associations are further than 1000pc. Ultimately, if we are to understand how the Sun and Earth formed, we need to understand star formation in these OB associations.

Most pre-main sequence stars of interest at 1Kpc, would be of the order of 15.5<sup>th</sup> magnitude, which means that amateur telescopes capable of imaging such stars with a precision of 0.1 magnitude would be required for work on these systems. Tim stressed that whilst long-term monitoring of these systems might produce very valuable results, there was no guarantee that such work would be fruitful.

After several questions had been directed to Tim, **Dr Peter Wheatley** gave a talk entitled *Robotic Telescopes: a threat to amateur observers?*

Traditionally professional facilities have large telescopes in the 8-10m range, with narrow fields of view, inflexible scheduling and intense competition for time on them. A possible new future facility was the OWL (the Overwhelmingly Large Telescope) with an aperture of 100m! Amateur facilities are smaller but there are more of them, they have *unlimited access*, and they are good at long-term monitoring and alerting professionals of rare events. There were now, a new group of intermediate range telescopes including the Liverpool Telescope, which was a 2m aperture scope sited at La Palma which is fully robotic. The Liverpool Telescope has time allotted flexibly (down to seconds per night), and is queue-scheduled with hundreds of observations per night by potentially hundreds of observers. The telescope generates uniform, well-calibrated data with standard filters, and is capable of reaching a V magnitude of 21.5 in 20 seconds, and 23rd magnitude in 6 minutes; it also has a spectroscope and an infrared camera. Additionally, the Faulkes telescopes are a pair of similar 2m telescopes sited in Hawaii and Australia, that will be available for schools and amateurs to book time on.

Dr Wheatley went on to describe other medium size facilities currently in use or under construction, including REX (the Robotic Exoplanet discovery experiment), which consisted of 3x2m telescopes in the southern hemisphere; ROTSE-III, which consisted of small narrow field robotic telescopes of 45cm aperture, with 1.9 degree field of views, which are dedicated to gamma ray bursts; and the WASP (Wide Angle Sky Patrol) project, which would be able to follow up real-time alerts. The WASP telescope consisted of 8, 11cm aperture lenses, with 2048x2048 CCDs attached. These would be capable of reaching V=16.5 in 30 seconds with a field of view of 2% of the sky. The main current difficulty to overcome with this system was that of handling the massive amount of data that the system would generate each year - of the order of 30Tbytes!

Peter concluded that these searches represented both a threat and an opportunity for amateurs, in that many of the fields that had been traditionally covered by amateurs, might now be covered by other such instruments, but that there would, no doubt, be niches left available for amateurs, as well as the opportunity to trawl through the massive amounts of data from these systems that would be made publicly available.

**Dr Richard Beare** went on to present a talk on *The Faulkes Telescope Project*, funded by the Dill Faulkes Educational Trust. The aim of this project is to stimulate interest in science, maths and technology amongst young people. The two sites that have been selected for the two telescopes, in Australia and Hawaii, allow for daytime observations from the UK. These are the largest telescopes dedicated to education in the World, and are fully robotic, controlled through the internet, returning JPEG images for immediate inspection, with FITS format images

downloadable via the internet after the observing session. The two telescopes are identical to the Liverpool Telescope, and are of 2m aperture with Richey-Chretien optics, 4 cassegrain side ports and one cassegrain wide field. Tracking is better than 0.2 arcseconds, and they are fitted with 2048 x 2048 CCD chips with a field of view of 4.6 x 4.6 minutes of arc. A Sloan filter set is available, in addition to H-alpha and OIII filters, and a basic spectrograph with a resolution of 0.4nm. The dome is a clamshell, and the mount can slew from point to point in less than a minute.

Suitable projects for these telescopes, include measuring the surface brightness profiles of galaxies using DS9 software and spreadsheet packages, generating asteroid and comet light curves to permit analysis of rotational periods (checked in the classroom using an illuminated rotating potato known as a 'rotato'!), star cluster age estimation using H-R data, and classification and imaging of nebulae. The cost to amateurs, of using the telescopes is likely to be around £250 per hour.

The first talk of the Saturday afternoon was given by **Tonny Vannmunster**, on **CCD Photometry of Transient Objects**. Tonny explained that he wasn't only going to talk about transient objects and his subtitle was: *A Universe of Pro-Am CCD projects waiting for your co-operation.*

He started with a well known transient object, the Pro-Am study of the cataclysmic variable WZ-Sge. This system has very rare, long-lived eruptions, and a large outburst amplitude which makes it ideal for amateur observations. The amateurs have the time to watch and wait for the outbursts, and then many of their time-series photometric observations of an eruption can be combined to provide scientifically useful data for the professionals to study.

Tonny went into some detail describing a WZ-Sge light curve that had been collected by a group of amateurs. He highlighted the first 9 days of the outburst, and explained how high quality data can reveal information about such a star of great interest to the professionals. He used data from the next 11 days to show how to extract period information using his program, Peranso, and demonstrated it working in real time. *A lot of interesting stuff can be dug out of this data by detailed analysis.* He used the next 12 days of the data to show how to extract information about negative superhumps.

He then moved on to listing the recipe for success in Pro-Am collaboration, which was summarised as follows:

- Build up your credentials by doing good work, not necessarily in CCD photometry.
- Become a member of a Pro-Am team
- Learn the ins and outs of the objects of interest (TOO's)
- Practice, exchange and compare results with other amateurs before submitting to the professionals

Regarding the observation side, he emphasised the importance of high quality, averaged, flat-fields, and suggested that the observer should consider carefully the value of binning; exposure times should be optimised, and colour effects must be carefully considered, especially at low altitude. Unless a project demanded the use of filters, then he felt it was better to take unfiltered images in order to collect more photons.

When planning data reduction, the trade-offs between aperture and PSF-based photometry

should be carefully considered. Software is available, including the simple, but limited AIP4WIN and the more complete MIRA A/P and IRAF. Tonny discussed aperture photometry in some detail, reminding his audience of the importance of optimising circle size to maximise S/N and having close comparison stars.

The next topic was another case study, this time on the photometry of RR Lyrae type variables. The Blazhko effect (long period amplitude modulation of the light curve) has no sound physical explanation yet, and the professionals are very much interested in good data relating to this. The key, as usual, is to collect lots of high quality data.

Another example of a useful project is exo-planet photometry. There are Pro-Am partnerships available here: in particular see **transitsearch.org**. The main challenge in this area, was both managing to catch a transit, and the small degree of the modulation, which was typically 10-20 milli-magnitudes. Tonny went into some detail describing the difficulty of achieving the required accuracy (he under-emphasised that in the opinion of this reviewer!). The data reduction is even more demanding. He showed a plot of a transit of HD209458 to illustrate what could be obtained.

Next was NEA's (near earth asteroids) including binary asteroids. There are many good examples of Pro-Am partnerships in this area. There are also tumbling asteroids, fascinating light curves here. A program called Binary Maker is available to amateurs to study these. The challenge with many of these objects is that they move quickly!

To conclude the talk, Tonny showed us some pictures of his remotely controlled CBA observatory in Belgium which can run all night long without human interaction. With that set-up he has, so far, obtained 220,000 images, making up 165 full days of photometry - an impressive tally!

The CBA website is: <http://cba.phys.columbia.edu>. Tonny gave a really excellent and useful talk. This review must necessarily be just a brief summary of it: Any amateur wanting to get involved with a Pro-Am project would be well advised to review his talk when it is made available on the web pages in the near future.

**Nick James** then spoke on the topic of *Cometary Photometry - A difficult challenge*. He made the introductory observation that comets are difficult because they are not point objects. To illustrate this, he showed a beautiful image from 1996 of comet Hyakutake showing a bright nucleus, an extended coma and a very extended tail.

There are two common definitions of comet magnitude currently used by visual observers:

- $m_1$  is supposed to be the magnitude of the coma excluding the tail; difficult to be exact because the coma goes down to the sky background and that varies from place to place anyway.
- $m_2$  is the nuclear magnitude - but where does the nucleus end and the coma begin? A 10 arc-sec aperture is commonly used.

A further complication is introduced if considering the effects of filtering, as the various emission lines will give different answers with different filters and this complicates the issue a lot. *The whole thing is a mess!* It seems that neither of the above definitions is therefore really suitable for CCD work.

At the MACE 2000 meeting, Mark Kidger had suggested a compromise for CCD observers based on using an unfiltered image and a fixed aperture. Nick suggested the following key points be observed:

*The key points to consider when obtaining a suitable image:*

- For bright comets, filters must be used to get consistency and either Johnson V or Cousins I, properly calibrated for the CCD, are suitable.
- Use correct focal length to allow a complete coma and sufficient surrounding sky
- For large bright comets a short focal length is necessary
- The exposure must be long enough to give a good SNR but without saturating the coma
- Defocusing can be used but the same focus must be used for the comparison star(s)
- Always defocus if undersampled
- Accurate image calibration is essential (flats, biases, darks etc)
- Instrument
- For determination of  $m_1$ , use a short focal length so that the coma fits
- Sometimes a comet is so large that a short focal length camera lens is best

When it came to the determination of the aperture diameter, agreement was needed on a standard size. One possibility would be to use a constant physical size at the distance of the comet eg: 100,000km at the comet, 2 arc-min at 1 au, 20arc-min at 0.1au, although this could prove tricky if the comet gets very close.

When it came to measuring the image, stars in the coma must be removed before analysis or they would lead to errors. In most image processing software, this can be done manually eg the IRIS MAX command. The sky background should be determined using a median algorithm, and the integrated counts in the aperture must be measured and the background subtracted.

*Why make Life Difficult?* Nick argued that we should not be attempting to emulate  $m_1$  and  $m_2$  but should think seriously about following Mark Kidger's suggestion, and use a standard aperture, probably a 10 arc-sec one, which for large comets is in fact about  $m_2$ .

To reduce scatter, a large number of reference stars is a good idea using, for example, Astronomica and USNO A 2.0 or B 1.0. Without great care the scatter between measurements from different observers can be as high as 5 magnitudes! With care this can be reduced to about one magnitude.

Nick summarised by saying that CCD comet photometry is difficult if we try and emulate the  $m_1$  and  $m_2$  measures, but good results can be obtained if we use a standard aperture which, at least, gives internally consistent results.

The next speaker was **Richard Miles** talking about *Asteroid Photometry*. Amateurs can make a significant contribution towards collecting data on asteroids, and some of this data can be used to gain further scientific insights about the composition and history of these objects and thus provide more data about our solar system and its evolution.

Richard outlined some topics that were potentially useful for Pro-Am collaboration, as listed overleaf. Those marked with an asterisk were explored further:

- Rotation rates\*
- Size, shape
- Binary, triple\*
- Spin vectors
- Tumbling
- Phase curves\*
- Assist radar observations
- NEA's\*

Richard enthused about the excitements of asteroid photometry and encouraged his audience to *Get over the activation energy barrier!*

Richard covered some facts on rotation: apparently of the thousands of asteroids known, only 1700 have known rotation rates (2.2% of numbered ones) so there is a lot left to do. 72% have an amplitude of 0.1 to 0.5%; 52% have periods of 2-9 hours; the shortest period is 78 seconds; and 11% have periods of over 24 hours, which is difficult to observe. In particular, getting more data at the extremes, those that rotate unusually slowly or quickly, is particularly valuable scientifically.

Richard listed the basic techniques for obtaining rotation light curves including the necessity of obtaining lots of images; whether to use no filter, or use V, R, I filters, the importance of good flats and darks; image reduction; how to check for the possibility of contaminating faint stars by stacking images; using multiple comparison stars for photometry, and plotting differential magnitude vs time.

One of the easy things about asteroids compared to variable stars, is that they only reflect sunlight, so colour effects are negligible, hence good measurements can be made under poor (typical UK?) skies. As an example Richard showed raw data on 656 Beagle showing a 2 magnitude irregular variation. After processing, this became a beautifully smooth rotation curve. Richard emphasised the importance of stacking to identify faint stars on the track. Frames that include stars in very close proximity can then be ignored in a simple approach, although it is possible to compensate for them with a little extra effort.

Richard briefly discussed binary systems with reference to DP107 and 1089 Tama. The latter is a tidally locked system and the light curves show occultation and shadowing effects.

*If you really want to understand asteroids you must get to know phase curves!* It is important to make measurements at low phase angles, and then follow the object of interest around the sun to begin to get information about the surface constituents of the object. A lot more data is needed in this area. Richard said that he had begun to do a lot more work at low phase angles this year. He showed a plot containing a lot of information taken by a group of observers over just 8 days near the opposition of 656 Beagle.

Amateurs can help with co-ordinated observation programmes to catch Near Earth Asteroids whilst they are close by. This is not an easy project because of the rates of movement.

Richard finished by showing pictures of his new observatory containing an 11" SCT which fits into just one and a half cubic metres.

**Roger Pickard** then gave an introduction to the idea of the *The VS CCD Target List*. This programme is to assist and guide newcomers to CCD observing. All the details are on the VSS website. There are four levels of difficulty represented in the projects:

*Level 1: Basic, for those not using filters*

V1363 Cyg, 1454 Cyg, Cg Dra, V650 Ori

*Level 2: Good timing of data required, no filter required*

ES Dra, KV Cas, LL Lyr TZ Per

*Level 3: Approximate differential photometry, use of at least one good filter required, but no transformations necessary*

NSV 2249, HV Aqr, HT Cas, GO Cnc, NSV 4031

*Level 4: Precision Differential Photometry, use of good filters, with correct transformations being applied*

SS Cyg, VZ Cam, CO Uma, AT Dra, GY Cnc

The comparison stars to go with these are in two groups, those brighter and those fainter than magnitude 11.

The first group are all taken from Tycho. All the positions are J2000.0, and the photometric data is Tycho Vj. Three comparison stars are given for each, although only two are necessary. Roger showed a list for one of the target stars, AT Dra.

Data for comparison stars for those fainter than magnitude 11 are mostly taken from Arnie Henden's data set. Some of these stars are not in the GSC so charts are provided for them. Roger showed a list for CG Dra.

Roger introduced another list for those looking for a quick fix! This is based on the BAA VSS selected bright fast EB's, with magnitudes 9-10, and periods from 0.35 to 0.99 hours. With these you can get a result and a nice light curve within a few hours.

Roger mentioned that the VSS Mentoring scheme for visual observers has been extended to CCD observers. For more details contact Karen Holland.

**David Boyd** then gave a presentation on the reporting side of the *CCD Target List* scheme. There are three main aims:

1. To create a consistent record of the extracted data, and all necessary information about a CCD photometric observing session
2. To quickly check that the data is problem free
3. To automatically generate report files

David set up an Excel spreadsheet to do this, which has become the CCD Template (see page 6 of this circular for more details). He showed an example of the spreadsheet and how to input data, which I cannot reproduce in this review but it looked pretty straightforward!

**Andy Wilson** then went through some details on entering data to the template, which is

designed to make that process as easy as possible. Again all I can say about that is that it looked good!

Roger then came back and discussed plans for the future, which included

- Work to get data into a centralised database
- Produce a retrievable database and ensure long term safety of the data
- Eventual aim is a web-accessible data-base, perhaps available through the Astrogrid system

Roger noted that there are now many CCD articles in the VSSCs, and commented that we (the VS) want feedback - how can we help more, are we doing the right things?

The final question was: Do we want another CCD Meeting next year?

Answer: YES!

## **IBVS 5441-5488**

**GARY POYNER**

- 5441** **AY Lacertae** is a cataclysmic variable. (Kroll et al, 2003)
- 5442** A new double mode high amplitude delta Scuti star **GSC 2583-00504** (Wils et al, 2003)
- 5443** Photoelectric minima of some eclipsing binary stars. (Gurol et al, 2003)
- 5444** Period change in an RS CVn binary - what drives **CF Tuc**? (Innis et al, 2003)
- 5445** Multicolour observations of the primary and secondary eclipses of **OW Gem**. (Mikolajewski et al, 2003)
- 5446** Elements for 5 variable stars. (Haussler et al, 2003)
- 5447** A new EUVE-detected flare star (**EUVE J0613-23.9B**) Christian et al, 2003)
- 5448** On two unstudied large amplitude variables **DT Sco** & **DV Sco**. (Pastukhova & Samus, 2003)
- 5449** Brightness variations of **SAO 84309**. (Robb et al, 2003)
- 5450** **V597 Scorpii** and it's neighbour: A double Mira star? (Samus & Hazen, 2003)
- 5451** Photometry of **HR 1817** at two sites well seperated in longitude. (Budding et al, 2003)
- 5452** New SX Phe variables in the innermost region of M15. (Kravtsov & Zheleznyak, 2003)
- 5453** The R band light curves of eclipses of **U Gem** in outburst. (Simon, 2003)
- 5454** Optical spectrum of **CI Aql** in the plateau phase. (Matsumoto et al, 2003)
- 5455** Seven new eclipsing binary stars among the FASTT1 variables. (Garcia-Lastra et al, 2003)
- 5456** Times of minima of eclipsing binary systems **DO Cas**, **V1143 Cyg**, **GO Cyg** and **VW Cep**. (Dariush et al, 2003)
- 5457** Confirmation of variability of Bidelman-Macconnell suspected variables. (Wils, 2003)
- 5458** Confirmation of variability of FASTT suspected variables. (Greaves & Wils, 2003)

- 5459 Revised [Fe/H] and radial velocities for 28 distant RR Lyrae stars. (Pier et al, 2003)
- 5460 Stromgren photometry of the BE star **Theta CrB**: Variable again in 2003. (Adelman, 2003)
- 5461 Discovery of two new dwarf novae in Cepheus and Cygnus. (Antipin & Kroll, 2003)
- 5462 Photoelectric minimum times of some eclipsing binary stars. (AK & Filiz, 2003)
- 5463 Photoelectric minima of some eclipsing binary stars. (Muyesseroglu et al, 2003)
- 5464 New times of minima of some selected eclipsing binary systems. (Bakis et al, 2003)
- 5465 The gamma Doradus variable **HD 19684** - a spectroscopic binary. (Kaye & Fekel, 2003)
- 5466 On the possible 9-day periodic variability of **DI Cep**. (Ismailov, 2003)
- 5467 A CCD photometric search for pulsations in **SZ Her**. (Szekely, 2003)
- 5468 Detection of magnetic field variations over the pulsation period of the roAp star Gamma Equ from Fe II 6149 line. (Savanov et al, 2003)
- 5469 CCD photometry of DT UMa, V672 Her, V868 OPn and GSC 3135 0673. (Pejcha et al, 2003)
- 5470 Minimum times of several eclipsing binaries. (Deeg et al, 2003)
- 5471 Photoelectric minima of some eclipsing binary stars. (Selam, et al 2003)
- 5472 **GSC 2139 2190** is a slowly changing BE variable and not a hot low mass post asymptotic giant branch star. (John Greaves, 2003)
- 5473 Observations of the dwarf nova **X Leonis**. (Spogli et al, 2003)
- 5474 New variable star in the field of **EM Cygni**. (Spogli et al, 2003)
- 5475 **NSV 25610**: A high amplitude delta Scuti star. (Wils et al, 2003)
- 5476 Photoelectric minimum times of some eclipsing binary stars. (Bulut & Demircan, 2003)
- 5477 Optical CCD observations of **Eta Carinae** at La Plata observatory. (Fernandez et al, 2003)
- 5478 Six suspected variable stars identified as Asteroids. (Bedient, 2003)
- 5479 Limits on pulsations in two eclipsing binaries: **AY Cam & RW CrB**. (Derekas et al, 2003)
- 5480 New elements for 80 eclipsing binaries. (Otero, 2003)
- 5481 Four RR Lyrae stars with variable periods in Ophiuchus. (Haussler et al, 2003)
- 5482 Hipparcos eclipsing binaries showing apsidal motion. (Otero, 2003)
- 5483 A revised period for the Mira variable **AW Aurigae**, (Templeton, 2003)
- 5484 Photoelectric minima of selected eclipsing binaries, (Agerer & Hubscher, 2003)
- 5485 Photoelectric maxima of selected pulsating binaries, (Agerer & Hubscher, 2003)
- 5486 The first complete CCD light curves and orbital periods change of **IK Per**. (Zhu et al, 2003)
- 5487 Times of minima of eclipsing binary stars. (Lacy, 2003)
- 5488 Superhumps in the 2003 **UV Per** superoutburst. (Price et al, 2003)

The Information Bulletin on Variable Stars (IBVS) can be accessed through the WWW in HTML format at the following URL.... <http://www.konkoly.hu/IBVS/IBVS.html>

# SOURCES OF SCATTER AND ERROR (PART 4)

TONY MARKHAM

## Environmental Factors

### Light Pollution

Light pollution reduces the darkness of the sky background, reducing the limiting magnitude that can be seen when using a particular instrument. In addition, individual sources of light pollution can cause glare when a variable is nearby in the sky. Sources of light pollution that are directly visible from the observing site can affect the observer's dark adaptation. The effect of light pollution on the accuracy of variable star estimates depends on the colour of the light source involved. For example, the orange glow from low pressure sodium lighting will cause red variables to appear fainter relative to their whiter comparison stars than they would in skies free from light pollution.

### Change of Observing Site

Although it might seem like a good idea to occasionally observe from a location free from light pollution, bear in mind that this will probably introduce *jumps* in the estimated magnitudes for many variables, due to the change in the *colour* of the sky background from that of your usual observing site. The *Position Angle effect* can also be a factor, if at your alternative observing site you find yourself viewing the field of view in a different orientation from that which you normally would.

Thus, although it might be suggested that you take your binoculars on holiday with you so that you can make observations, this might in practice increase the scatter in your brightness estimates, but this would still be better than no observations at all.

### Twilight

For many variables there will be certain times of the year, before and after conjunction with the Sun, when they are only observable in twilight. In these circumstances, an observation made under these less than ideal circumstances can still be better than no observation at all.

Several factors come into play, in this case :

- The variable and comparisons will be seen against a sky background that is not as dark as usual (and red variables appear brighter relative to whiter comparison stars when observed against a bright background, than when observed against a dark background)
- The variable will be closer to the limiting magnitude and thus less easy to see
- The observer will not be fully dark adapted, and so is likely to be using mesopic rather than scotopic vision.

### Moonlight

The effect of moonlight is similar to that of twilight, with mesopic vision taking over from scotopic vision in bright moonlight. Fortunately, moonlight will only be a problem for part of each month. This can be mitigated by making observations at times when the moon is not in

the sky, either at a different time of the night, or on a different night. Sometimes, however, this is not feasible, especially when observing rapidly changing variables, or when local weather conditions typically mean that only a few nights are available for observing each month. In any case, analysers of variable star observations need to be wary of apparent low amplitude periodicities of about a month, as these could simply have been spuriously introduced by the changing brightness of the sky background during the moon's monthly cycle.

## **Aurorae**

For observers in high geomagnetic latitudes, aurorae can affect the accuracy of estimates. This effect depends on the brightness and colour of the display, as well as on the auroral forms present (glows, arcs, rays) in the area of sky containing the variable. Often, delaying the observation until the auroral form moves away, or the aurora itself dies down, is a solution. However, major displays may last all night, and this will need to be noted when recording the brightness estimate.

## **Cloud**

The problem with cloud is obvious - it dims the apparent brightness of a variable and/or its comparison stars. In general, observers will refrain from making observations through cloud, unless the variable is of immediate interest (e.g. a nova or dwarf nova outburst), or when skipping the observation would leave a significant gap in the observer's own light curve. However, when there is broken cloud there is the risk that a patch of thin cloud may affect the area of sky containing the variable, and the observer might not readily recognise this.

## **Haze, Mist and Fog**

These will dim a variable and its comparison stars, the effect being greater at lower altitudes. They can cause additional problems for observers in urban areas by scattering the glow of streetlighting across more of the sky.

## **Altitude Factors**

When observing variable stars or comparison stars that are low in the sky, the observer is looking through a thicker layer of atmosphere than when observing them when they are at higher altitudes. The greater thickness of atmosphere absorbs more light from the star and hence it appears dimmer. The solution is to use comparison stars that are at the same altitude as the variable whenever possible. Although some books do give correction factors for altitude, these should not be used, as they only apply under perfect atmospheric conditions and are incorrect under more typical atmospheric conditions.

An additional altitude-related problem, is that the thicker layer of atmosphere lower in the sky will absorb blue light more readily than red light (hence the red colour of the setting sun). Thus, as a variable sinks towards the horizon, the atmosphere will absorb less of its red light than it will for a non-red comparison star.

## Seeing

*Seeing* is a term well-known to planetary observers, and affects the ability to see detail on the planets. If the local atmosphere is unsteady, or if the telescope is significantly warmer than the surrounding air, then the image shimmers and detail is difficult to see. Poor *seeing* also affects variable star observing, causing stars to twinkle strongly. The effect is to cause variables and their companions to repeatedly appear to fluctuate in brightness by many tenths of a magnitude, making accurate estimates impossible. In such circumstances, there is rarely any point in making estimates, and it is a case of waiting to see whether the *seeing* improves later in the night (as it does in many cases).

## Instrumental Factors

### Quality of Optics

Obviously good quality optics aid accurate brightness estimates. Defects in the optics producing non-sharp images of stars or ghost images of nearby bright stars will reduce the accuracy of observations. If you've bought an expensive telescope, then don't downgrade its effectiveness by using cheap low quality eyepieces !

Remember that quality of optics also includes the eyes of the observer. Defects such as short sightedness can be corrected by adjusting the focussing of the telescope or binoculars, but other factors such as *floaters* in the eye can still affect the accuracy of brightness estimates.

### Cleanliness of Eyepieces

It is important to keep eyepieces clean. If they get dirty then the brightness of a variable and its comparison stars will depend on where they are located within the field of view.

### Steadiness of instrument

If the instrument is not kept steady (e.g. when using handheld binoculars or when observing in windy conditions), this affects the ability to see the faintest stars and hence the ability to make accurate estimates.

### Colour Sensitivity of the instrument

As has already been mentioned, there can be systematic differences between observers in brightness estimates, due to the colour sensitivity of the eyes varying from observer to observer. This can be compounded by differences between the colour sensitivity of different instruments. However, provided that the observer always uses the same instrument when observing a particular variable, the effect of this should be fairly constant and thus will be a systematic difference that can be taken into account when analysing observations.

## Stellar Factors

### Location of Comparison Stars

Ideally comparison stars should be located reasonably close to the variable, as if it takes time to locate the comparison after noting the brightness of the variable, the accuracy of the memorised brightness can quickly deteriorate. In most cases there will be sufficient comparison stars nearby. Problems can occur, however, when observing the brightest binocular variables (i.e. 4th and 5th magnitude) as potential comparison stars are likely to lie outside the field of view when observing the variable.

### Star Colours

If all stars were the same colour, this wouldn't be a problem. However, not all stars are the same colour. Variable stars are often red, but red stars often make unsuitable comparison stars because so many of them are variable to some extent. Accurately comparing the brightness of two light sources is harder when they are of different colours, than when they are of the same colour. Further difficulties arise in novae, when most of the light output is produced by a small number of emission lines.

### Comparison Star magnitudes

The comparison star magnitudes quoted on charts have been derived from a variety of sources. Some charts use comparison star magnitudes based on visual estimates; others are based on magnitudes quoted in star catalogues. Some charts use V magnitudes for comparison star magnitudes; others try to correct them to try to make them match the eye's visual response to different colours. Such corrections typically use some formula based on a combination of the V magnitude and the star's colour index (the difference between its B magnitude and V magnitude). As a result, the comparison star magnitudes quoted may differ between the charts of different variable star organisations. As time has passed and photometry has become more accurate, the catalogued magnitudes of some stars have had to be corrected and this is still an ongoing process.

If the comparison star magnitudes are incorrect then this will lead to increased scatter in the observations made. This will, in turn, make it difficult to correct for systematic differences between observers, as the *correction* will change when the observer changes the comparison stars used as the variable brightens or fades.

The problem with comparison star magnitudes can be most serious for very red stars as their strong colour index will lead to large differences between their V magnitudes and their visual magnitudes. This has now been recognised as a serious problem and many variable star organisations now have a policy of not using comparison stars with such large colour indices. However, older charts may still contain such problematic comparison stars.

Fortunately, older observations which used problematic comparison stars can be adjusted as long as the observer reported the light estimate as well as the deduced magnitude. Unfortunately, not all variable star organisations encourage their observers to record the complete light estimates.

## **Estimates made using Different Comparison Stars**

In general, it is better to always use the same comparison stars when the variable is around a particular magnitude, rather than to use certain comparisons on one occasion and different comparisons on another occasion. The scatter in the observations of an individual observer will be greater if the observer unnecessarily switches between comparison stars

## **Multiplicity of Comparison Stars**

In some cases a comparison star will have a close companion, which isn't resolved as a separate object at low magnifications. However, at higher magnifications, the comparison star will appear elongated, and thus fainter than its listed magnitude. Usually, this will merely increase the scatter between observers, as an individual observer is likely to always use the same instrument and magnification when the variable is at around that brightness.

## **Variability of Comparison Stars**

This can prove a disaster, if, after a variable has been observed for many years, it is found that one of the commonly used comparison stars varies significantly in brightness, and there is no record as to which brightness estimates made use of this comparison star. The problem can be significantly reduced by encouraging observers to report their full light estimates, rather than just reporting the deduced magnitude. In such circumstances, the affected estimates can be removed from the light curve, or if the Pogson Step method was used, it may be possible to recalculate the deduced magnitude based on the other non-variable comparison stars used on each occasion.

In practice, a decision has to be reached regarding how much variability can be tolerated in a comparison star. Since visual estimates are accurate to the nearest tenth of a magnitude (at best), variability by a few hundredths of a magnitude in a comparison star can be ignored, especially if the alternative is to use a different comparison star, which due to its colour or its distance from the variable might introduce greater levels of error.

## **Nearby astronomical objects**

Not all variable stars are conveniently located. Sometimes it will be the case that the variable and/or a comparison star is located close to a bright star and the glare from this star makes it difficult to assess the brightness of the variable or comparison. As long as the same comparison is used for a series of observations, this need not be a major problem, although it will probably lead to systematic differences between the estimates of different observers. In some cases, it may be possible to keep the nearby bright star outside of the field of view by using a higher magnification.

A different situation arises when the nearby bright object is moving from night to night. Variable star fields near the ecliptic will be, from time to time, visited by planets. Planets such as Mercury, Venus and Mars will pass by quickly, but slower moving planets such as Jupiter and Saturn may remain a problem for several weeks or even months.

## Testing your accuracy

You can use the fact that Cepheid and Eclipsing variables are highly predictable to give yourself an idea of the accuracy of your own observations. There will always be some scatter in light curves based on visual estimates, but it can be informative to see how brightness estimates that you believed to be good observations, are sometimes not as accurate as you believed at the time; such knowledge can be useful when making future observations, both in terms of being aware of the causes of errors, and also in avoiding deriving too many conclusions from single brightness estimates.

Simply choose such a variable with an amplitude of less than a magnitude that can easily be observed using your method of observation, and make a brightness estimate of it during each observing session. At a later date use the published ephemerides to calculate the predicted phases at the time of each observation. Then plot a light curve. The results can be rather disturbing - although the general shape of the light curve should be readily visible, the scatter of individual brightness estimates may take you by surprise. Sometimes the most *stray* estimates can be explained by poor sky conditions at the time, but sometimes an estimate that you recorded as class 1 will be displaced by several tenths of a magnitude from the magnitude of other estimates at that phase.

The fact is that everyone makes mistakes sometimes, even the most experienced observers. This should always be taken into account when considering reports of unusual activity seen by only one observer.

Most observers probably believe their brightness estimates to be more accurate than they really are. Observers sometimes announce a change in visual brightness estimates of 0.1 magnitudes as being a brightening or a fade of the variable, but it is generally not realistic to draw such conclusions given the uncertainties in individual brightness estimates. Although it is possible to visually detect brightness differences between stars of less than 0.1 magnitudes, individual brightness estimates are likely to be accurate to the nearest tenth of a magnitude at best, and under less than ideal conditions can be considerably less accurate. Indeed, bearing in mind the comments made earlier about systematic differences between observers for red variables, it is probably better to refer to *consistency* rather than *accuracy* of estimates.

## In Summary

Although we have seen that there are many potential causes of scatter and error, brightness variations can nevertheless be followed. When interpreting brightness estimates, however, it is important to be aware of the limitations of whatever method of observation has been used and thus to avoid drawing inappropriate conclusions.

# BINOCULAR PRIORITY LIST

MELVYN TAYLOR

Variable	Range	Type	Period	Chart	Variable	Range	Type	Period	Chart
<i>AQ And</i>	8.0-8.9	SRC	346d	82/08/16	<i>AH Dra</i>	7.1-7.9	SRB	158d?	106.01
<i>EG And</i>	7.1-7.8	ZA		072.01	<i>NQ Gem</i>	7.4-8.0	SR+ZA	70d?	077.01
<i>VAql</i>	6.6-8.4	SRB	353d	026.03	<i>X Her</i>	6.3-7.4	SRB	95d?	223.01
<i>UU Aur</i>	5.1-6.8	SRB	234d	230.01.	<i>SX Her</i>	8.0-9.2	SRD	103d	113.01
<i>AB Aur</i>	7.2-8.4	INA		83/10/01	<i>UW Her</i>	7.8-8.7	SRB	104d	107.01
<i>V Boo</i>	7-12	SRA	258d	037.01	<i>AC Her</i>	6.8-9.0	RVA	75d	048.03
<i>RW Boo</i>	6.4-7.9	SRB	209d	104.01	<i>IQ Her</i>	7.0-7.5	SRB	75d	048.03
<i>RX Boo</i>	6.9-9.1	SRB	160d	219.01	<i>OP Her</i>	5.9-6.7	SRB	120d	84/04/12
<i>ST Cam</i>	6.0-8.0	SRB	300d?	111.01	<i>R Hya</i>	3.5-10.9	M	389d	049.01
<i>XX Cam</i>	7.3-9.7?	RCB?		068.01	<i>RX Lep</i>	5.0-7.4	SRB	60d?	110.01
<i>X Cnc</i>	5.6-7.5	SRB	195d	231.01	<i>SS Lep</i>	4.8-5.1	ZA		075.01
<i>RS Cnc</i>	5.1-7.0	SRC	120d?	84/04/12	<i>Y Lyn</i>	6.9-8.0	SRC	110d	229.01
<i>V CVn</i>	6.5-8.6	SRA	192d	214.01	<i>SV Lyn</i>	6.6-7.5	SRB	70d?	108.01
<i>WZ Cas</i>	6.9-8.5	SRB	186d	82/08/16	<i>U Mon</i>	5.9-7.8	RVB	91d	029.03
<i>V465 Cas</i>	6.2-7.2	SRB	60d	233.01	<i>X Oph</i>	5.9-9.2	M	328d	099.01
<i>γ Cas</i>	1.6-3.0	GC		064.01	<i>BQ Ori</i>	6.9-8.9	SR	110d	84/04/12
<i>rho Cas</i>	4.1-6.2	SRD	320d	064.01	<i>AG Peg</i>	6.0-9.4	NC		094.01.
<i>W Cep</i>	7.0-9.2	SRC		83/10/01	<i>X Per</i>	6.0-7.0	GC+XP		
<i>AR Cep</i>	7.0-7.9	SRB		85/05/06					
<i>mu Cep</i>	3.4-5.1	SRC	730d	112.01	<i>R Sct</i>	4.2-8.6	RVA	146d	026.03
<i>O Cet</i>	2.0-10.1	M	332d	039.02	<i>Y Tau</i>	6.5-9.2	SRB	242d	84/04/12
<i>R CrB</i>	5.7-14.8	RCB		041.02	<i>W Tri</i>	7.5-8.8	SRC	108d	114.01
<i>W Cyg</i>	5.0-7.6	SRB	131d	062.1	<i>Z UMa</i>	6.2-9.4	SRB	196d	217.01
<i>AF Cyg</i>	6.4-8.4	SRB	92d	232.01	<i>ST UMa</i>	6.0-7.6	SRB	110d?	102.01
<i>CH Cyg</i>	5.6-10.0	ZA+SR		089.02	<i>VY UMa</i>	5.9-7.0	LB		226.01
<i>U Del</i>	5.6-7.5	SRB	110d?	228.01	<i>VUMi</i>	7.2-9.1	SRB	72d	101.01
<i>EU Del</i>	5.8-6.9	SRB	60d?	228.01	<i>SS Vir</i>	6.9-9.6	SRA	364d	097.01
<i>TX Dra</i>	6.8-8.3	SRB	78d?	106.01	<i>SW Vir</i>	6.4-7.9	SRB	150d?	098.01

# ECLIPSING BINARY PREDICTIONS

TONY MARKHAM

The following predictions, based on the latest Krakow elements, should be usable for observers throughout the British Isles. The times of mid-eclipse appear in parentheses, with the start and end times of visibility on either side. The times are hours UT, with a value greater than 24 indicating a time after midnight. D indicates that the eclipse starts/ends in daylight; L indicates low altitude at the start/end of the visibility; and << indicates that mid eclipse occurred on an earlier date.

Thus, for example, on Oct 3, U Cep D18(21)26 indicates that U Cep will be in mid eclipse at approx 21h UT (22h BST). The eclipse will be observable between approx 18h UT on Oct 3 and 02h UT on Oct 4, with the start of the eclipse having occurred during daylight. Please contact the EB secretary if you require any further explanation of the format.

The variables covered by these predictions are :

RS CVn	7.9-9.1V	Z Dra	10.8-14.1p	U Sge	6.45-9.28V
TV Cas	7.2-8.2V	TW Dra	8.0-10.5v	RW Tau	7.98-11.59V
U Cep	6.75-9.24V	S Equ	8.0-10.08V	HU Tau	5.92-6.70V
SS Cet	9.4-13.0v	delta Lib	4.9-5.9V	X Tri	8.88-11.27V
U CrB	7.7-8.8V	Z Per	9.7-12.4p	TX UMa	7.06-8.80V
SW Cyg	9.24-11.83V	Y Psc	9.44-12.23V	Z Vul	7.25-8.90V

Note that predictions for RZ Cas, Beta Per and Lambda Tau can be found in the BAA Handbook.

No long period eclipsing variables have eclipses due during this interval.

<b>2004 Oct 1 Fri</b>	Z Vul 00(06)02L	Z Dra 21(23)26	TX UMa L23(23)27
Y Psc 01(06)04L	RS CVn L04(00)05D	<b>2004 Oct 7 Thu</b>	<b>2004 Oct 9 Sat</b>
U Cep 04(09)05D	Z Dra 04(06)05D	X Tri 03(06)05D	X Tri 02(04)05D
Z Vul D18(19)24	S Equ D18(14)19	U Sge D18(15)21	Z Dra D18(17)19
<b>2004 Oct 2 Sat</b>	Y Psc 20(24)28L	U CrB D18(16)21	TV Cas D18(22)26
TV Cas D18(16)20	<b>2004 Oct 5 Tue</b>	S Equ 19(25)25L	SS Cet L20(24)29
TX UMa D18(20)21L	TW Dra 03(08)05D	TV Cas 22(26)29D	HU Tau L21(18)22
Z Dra 19(22)24	X Tri 05(07)05D	TW Dra 22(28)29D	<b>2004 Oct 10 Sun</b>
Z Per 20(24)29D	TX UMa D18(21)20L	SW Cyg 23(29)29D	X Tri 01(04)05D
TX UMa L23(20)24	RW Tau L19(23)28	<b>2004 Oct 8 Fri</b>	TW Dra D18(23)28
RW Tau 24(29)29D	Z Per 21(26)29D	X Tri 03(05)05D	U Sge 18(24)24L
<b>2004 Oct 3 Sun</b>	TX UMa L23(21)26	Y Psc D18(18)23	U CrB 21(26)22L
SW Cyg D18(15)21	<b>2004 Oct 6 Wed</b>	RS CVn D18(19)20L	Z Dra 23(25)28
U Cep D18(21)26	TV Cas 03(07)05D	U Cep D18(20)25	<b>2004 Oct 11 Mon</b>
RS CVn D18(24)21L	U Cep 04(09)05D	TX UMa D18(23)20L	X Tri 01(03)05D
SS Cet L21(25)29D	X Tri 04(07)05D	RW Tau L19(18)22	U Cep 03(08)05D
<b>2004 Oct 4 Mon</b>	Z Vul D18(17)22	Z Per 22(27)29D	Z Vul D18(15)20
U Sge 00(06)01L	SS Cet L21(25)29D	Z Vul 22(28)25L	TV Cas D18(17)21

TX UMa 19(24)20L X Tri 19(22)24 Z Dra 21(23)26 SS Cet L19(19)24  
 HU Tau L20(19)23 TV Cas 19(23)27 **2004 Oct 26 Tue** **2004 Nov 3 Wed**  
 TX UMa L23(24)29 SS Cet L20(22)27 HU Tau 01(05)06D Z Dra 01(03)05  
 Z Per 24(28)29D **2004 Oct 19 Tue** TV Cas 01(05)06D U Sge D17(16)22  
 X Tri 24(26)29 Z Dra 02(05)05D U Cep 02(07)06D Y Psc 23(27)26L  
**2004 Oct 12 Tue** TW Dra 04(09)05D SW Cyg D18(12)18 **2004 Nov 4 Thu**  
 SW Cyg D18(19)25 X Tri 18(21)23 X Tri D18(16)19 TV Cas 03(07)06D  
 SS Cet L20(23)28 RW Tau L19(19)24 **2004 Oct 27 Wed** U CrB L04(06)06D  
 X Tri 23(26)28 HU Tau 21(24)28 TX UMa 03(08)06D S Equ D17(12)18  
**2004 Oct 13 Wed** Y Psc 21(26)27L HU Tau 21(24)28 SW Cyg D17(15)21  
 RS CVn D18(14)20L **2004 Oct 20 Wed** X Tri D18(15)18 Z Vul 22(28)23L  
 TW Dra D18(18)23 TV Cas D18(19)23 TW Dra D18(19)24 **2004 Nov 5 Fri**  
 Z Dra D18(18)21 X Tri 18(20)23 U Sge D18(22)23L TW Dra 00(05)06D  
 U Cep D18(20)25 U Sge 22(27)24L RS CVn 18(24)19L U Cep 02(07)06D  
 Z Vul 20(25)25L TX UMa 24(29)29D SS Cet L19(20)25 RW Tau 05(10)06D  
 HU Tau L20(20)24 TV Cas 21(25)29 TV Cas 21(25)29 Z Per D17(15)20  
 X Tri 23(25)28 U Cep 03(08)05D RW Tau 22(27)30D Z Dra 18(20)23  
**2004 Oct 14 Thu** Z Per 04(08)05D **2004 Oct 28 Thu** SS Cet L19(18)23  
 RW Tau 02(06)05D HU Tau 02(06)06D TV Cas 22(26)30D  
 U CrB D18(13)19 RS CVn L02(00)06D **2004 Nov 6 Sat**  
 S Equ D18(22)25L U CrB L05(09)06D RS CVn D17(14)18L  
 X Tri 22(24)27 S Equ D17(15)21 U Sge 19(25)23L  
 TX UMa L22(26)29D Z Dra D17(17)19 Z Dra 02(05)06D  
**2004 Oct 15 Fri** Z Dra 00(03)05 X Tri 23(25)28 X Tri 05(08)06D  
 Z Per 01(06)05D **2004 Oct 29 Fri** Z Vul D17(15)20  
 TV Cas 04(08)05D TV Cas D17(20)24 U CrB D17(17)20L  
 SS Cet L20(23)27 TV Cas D18(14)18 Z Dra 23(25)28 U Cep D17(18)23  
 HU Tau L20(22)26 X Tri D18(19)21 **2004 Oct 30 Sat** Y Psc D17(22)26L  
 X Tri 21(24)26 RW Tau L18(14)18 HU Tau 03(07)06D S Equ 17(23)23L  
**2004 Oct 16 Sat** **2004 Oct 23 Sat** TV Cas 18(22)26  
 Y Psc 03(07)03L RS CVn L02(05)06D TW Dra 19(25)30  
 U Cep 03(08)05D Z Dra 04(06)06D RW Tau 24(28)30D  
 TW Dra D18(14)19 X Tri D18(18)21 **2004 Nov 8 Mon**  
 RW Tau 20(25)29D U Cep D18(19)24 X Tri 05(07)06D  
 X Tri 20(23)25 Y Psc D18(20)24 TX UMa D17(14)18L  
 TV Cas 24(28)29D Z Vul D18(21)24L Z Per D17(17)21  
**2004 Oct 17 Sun** HU Tau 23(27)30D SS Cet L18(18)22  
 SW Cyg 02(08)05L **2004 Oct 24 Sun** SW Cyg 23(29)28L  
 U Sge D18(18)24L TX UMa 02(06)06D **2004 Nov 9 Tue**  
 Z Dra D18(20)22 Z Per 05(10)06D X Tri 04(07)06D  
 U CrB 18(24)21L U Sge D18(13)18 SW Cyg L06(05)06D  
 X Tri 20(22)25 X Tri D18(18)20 TV Cas D17(17)21  
 HU Tau L20(23)27 U CrB D18(22)21L Z Dra 19(22)24  
 TX UMa 22(27)29D TW Dra 19(24)29 Z Vul 20(26)23L  
**2004 Oct 18 Mon** SS Cet L19(21)25 **2004 Nov 2 Tue** **2004 Nov 10 Wed**  
 Z Per 02(07)05D S Equ 24(29)24L TW Dra 05(10)06D U Cep 01(06)06D  
 RS CVn 03(10)05D **2004 Oct 25 Mon** Z Per D17(14)19 X Tri 03(06)06L  
 U Cep D18(20)25 RW Tau 04(08)06D Z Vul D17(17)22 TW Dra D17(20)25  
 Z Vul 18(23)25L X Tri D18(17)19 RW Tau 18(23)28

**2004 Nov 11 Thu**  
X Tri 03(05)06L  
RS CVn 03(09)06D  
U CrB L04(04)06D  
Z Dra 04(06)06D  
TX UMa D17(15)18L  
Y Psc D17(16)20  
Z Per D17(18)23  
SS Cet L18(17)22  
HU Tau L18(15)19  
**2004 Nov 12 Fri**  
X Tri 02(05)06L  
Z Vul D17(12)18  
Z Dra D17(15)17  
U Cep D17(18)23  
**2004 Nov 13 Sat**  
X Tri 01(04)06L  
TV Cas 04(08)06D  
TW Dra D17(15)20  
RW Tau D17(17)22  
SW Cyg D17(19)25  
U Sge D17(19)22L  
HU Tau L18(17)20  
Z Dra 21(24)26  
**2004 Nov 14 Sun**  
X Tri 01(03)06  
U CrB D17(15)19L  
TX UMa D17(17)18L  
Z Per D17(19)24  
S Equ D17(20)23L  
SS Cet L18(16)21  
Z Vul 18(23)23L  
TX UMa L20(17)22  
TV Cas 24(28)30D  
X Tri 24(26)29  
**2004 Nov 15 Mon**  
U Cep 01(06)06D  
Z Dra 06(08)06D  
HU Tau L18(18)22  
X Tri 23(26)28  
**2004 Nov 16 Tue**  
RS CVn L01(05)06D  
TW Dra 06(11)06D  
Z Dra D17(17)19  
TV Cas 19(23)27  
X Tri 23(25)28  
**2004 Nov 17 Wed**  
U Cep D17(18)23  
TX UMa D17(18)18L  
Z Per D17(21)25  
SS Cet L18(16)20  
HU Tau L18(19)23  
TX UMa L20(18)23  
X Tri 22(24)27  
Z Dra 23(25)28  
**2004 Nov 18 Thu**  
SW Cyg 03(09)03L  
U CrB L03(02)06D  
SW Cyg L05(09)06D  
TV Cas D17(19)23  
X Tri 21(24)26  
**2004 Nov 19 Fri**  
Y Psc 00(05)01L  
TW Dra 01(06)06D  
RW Tau 02(06)06D  
Z Vul D17(21)22L  
HU Tau L18(21)25  
X Tri 21(23)26  
**2004 Nov 20 Sat**  
U Cep 01(06)06D  
U Sge D17(14)19  
TV Cas D17(14)18  
Z Dra D17(18)21  
TX UMa D17(20)17L  
Z Per 17(22)27  
RS CVn 17(24)18L  
SS Cet L18(15)20  
TX UMa L20(20)25  
X Tri 20(22)25  
**2004 Nov 21 Sun**  
RS CVn L01(00)06  
U CrB D17(13)19  
S Equ D17(17)22  
HU Tau 18(22)26  
X Tri 19(22)24  
RW Tau 20(25)29  
TW Dra 20(25)30D  
**2004 Nov 22 Mon**  
Z Dra 01(03)05  
TV Cas 06(10)06D  
U Cep D17(17)22  
SW Cyg D17(22)27L  
X Tri 19(21)24  
Y Psc 19(23)25L  
**2004 Nov 23 Tue**  
TX UMa D17(21)17L  
U Sge 17(23)22L  
SS Cet L17(15)19  
X Tri 18(20)23  
Z Per 18(23)28  
HU Tau 20(23)27  
TX UMa L20(21)26  
**2004 Nov 24 Wed**  
TV Cas 01(05)06D  
Z Vul D17(19)22L  
RW Tau D17(19)24  
TW Dra D17(21)26  
X Tri 17(20)22  
U CrB 18(24)19L  
Z Dra 18(20)23  
S Equ 22(27)22L  
**2004 Nov 25 Thu**  
U Cep 00(05)06D  
U CrB L03(00)05  
RS CVn D17(19)17L  
X Tri D17(19)21  
TV Cas 21(25)29  
HU Tau 21(25)29  
**2004 Nov 26 Fri**  
RS CVn L00(<<)01  
Z Dra 02(05)06D  
Y Psc D17(17)22  
X Tri D17(18)21  
SS Cet L17(14)19  
TX UMa L20(23)28  
Z Per 20(25)29  
**2004 Nov 27 Sat**  
SW Cyg 06(12)06D  
SW Cyg D17(12)18  
RW Tau D17(14)18  
TW Dra D17(16)21  
U Cep D17(17)22  
X Tri D17(18)20  
TV Cas D17(20)24  
HU Tau 22(26)30  
**2004 Nov 28 Sun**  
U CrB 05(10)06D  
S Equ D17(14)19  
X Tri D17(17)19  
Z Dra 20(22)24  
**2004 Nov 29 Mon**  
TV Cas D17(16)20  
X Tri D17(16)19  
Z Vul D17(17)22L  
SS Cet L17(13)18  
TX UMa 20(24)29  
Z Per 21(26)31D  
HU Tau 24(27)31D  
**2004 Nov 30 Tue**  
U Cep 00(05)07D  
RW Tau 03(08)07D  
Z Dra 04(07)07D  
TW Dra 06(11)07D  
RS CVn D17(14)17L  
X Tri D17(16)18  
U Sge D17(17)21L  
**2004 Dec 1 Wed**  
del Lib L06(06)07D  
X Tri D17(15)17  
Z Dra D17(15)17  
U CrB D17(21)18L  
S Equ 19(24)21L  
SW Cyg 20(26)26L  
**2004 Dec 2 Thu**  
HU Tau 01(05)06L  
U CrB L03(<<)03  
SW Cyg L04(02)07D  
U Cep D17(17)22  
SS Cet L17(13)17  
TX UMa 21(26)31D  
Z Dra 21(24)26  
RW Tau 22(27)31D  
Z Per 23(27)31D  
**2004 Dec 3 Fri**  
TW Dra 02(07)07D  
TV Cas 03(07)07D  
U Sge 21(26)21L  
**2004 Dec 4 Sat**  
HU Tau 02(06)06L  
Z Dra 06(08)07D  
Z Vul D17(15)20  
TV Cas 22(26)30  
U Cep 24(29)31D  
**2004 Dec 5 Sun**  
U CrB 02(08)07D  
RS CVn 03(09)07D  
Z Dra D17(17)19  
RW Tau D17(21)26  
TW Dra 21(26)31D  
TX UMa 23(27)31D  
Z Per 24(29)31D  
**2004 Dec 6 Mon**  
HU Tau 04(08)06L  
SW Cyg D17(16)22  
TV Cas 18(22)26  
Z Vul 20(26)21L  
Z Dra 23(25)28  
**2004 Dec 7 Tue**  
U Sge D17(11)17  
U Cep D17(16)21

Y Psc 20(25)24L  
**2004 Dec 8 Wed**  
 HU Tau 05(09)06L  
 del Lib L06(05)07D  
 RW Tau D17(15)20  
 TV Cas D17(17)21  
 U CrB D17(19)18L  
 S Equ D17(21)21L  
 TW Dra D17(22)27  
**2004 Dec 9 Thu**  
 TX UMa 00(05)07D  
 Z Per 01(06)07D  
 Z Vul D17(13)18  
 Z Dra D17(19)21  
 RS CVn L23(28)31D  
 U Cep 23(28)31D  
**2004 Dec 10 Fri**  
 TV Cas D17(13)17  
 U Sge D17(21)20L  
 SW Cyg 23(29)26L  
**2004 Dec 11 Sat**  
 Z Dra 01(03)06  
 SW Cyg L04(05)07D  
 RW Tau 05(10)06L  
 TW Dra D17(17)22  
 Y Psc D17(19)23  
 Z Vul 18(23)21L  
**2004 Dec 12 Sun**  
 TX UMa 02(07)07D  
 U CrB L02(06)07D  
 Z Per 03(07)07L  
 TV Cas 04(08)07D  
 U Cep D17(16)21  
**2004 Dec 13 Mon**  
 Z Dra 18(20)23  
 RW Tau 24(28)30L  
 TV Cas 24(28)31D  
**2004 Dec 14 Tue**  
 X Tri 03(06)04L  
 Z Vul L06(10)07D  
 TW Dra D17(12)17  
 RS CVn L23(23)30  
 U Cep 23(28)31D  
**2004 Dec 15 Wed**  
 Z Dra 02(05)07D  
 X Tri 03(05)04L  
 TX UMa 03(08)07D  
 Z Per 04(09)07L  
 del Lib L05(05)07D  
 Y Psc D17(13)18  
 U CrB D17(17)17L  
 S Equ D17(18)20L  
 SW Cyg D17(19)25  
 TV Cas 19(23)27  
**2004 Dec 16 Thu**  
 X Tri 02(05)04L  
 HU Tau D17(14)18  
 Z Vul D17(21)21L  
 RW Tau 18(23)27  
**2004 Dec 17 Fri**  
 X Tri 01(04)04L  
 TW Dra 03(08)07D  
 del Lib 07(13)07D  
 U Sge D17(15)20L  
 U Cep D17(16)21  
 TV Cas D17(19)23  
 Z Dra 20(22)24  
**2004 Dec 18 Sat**  
 X Tri 01(03)04L  
 TX UMa 05(10)07D  
 Z Per 05(10)06L  
 HU Tau D17(16)19  
**2004 Dec 19 Sun**  
 X Tri 00(03)03L  
 U CrB L01(04)07D  
 Z Dra 04(07)07D  
 Z Vul L06(08)07D  
 TV Cas D17(14)18  
 RW Tau D17(17)22  
 TW Dra 22(27)31D  
 RS CVn L23(19)25  
 U Cep 23(28)31D  
 X Tri 23(26)27L  
**2004 Dec 20 Mon**  
 SW Cyg L03(09)07D  
 Z Dra D17(15)18  
 HU Tau D17(17)21  
 U Sge 18(24)20L  
 X Tri 23(25)27L  
**2004 Dec 21 Tue**  
 TV Cas 06(10)07D  
 TX UMa 06(11)07D  
 Z Vul D17(19)20L  
 Z Dra 21(24)26  
 X Tri 22(25)27  
**2004 Dec 22 Wed**  
 del Lib L05(05)07D  
 U CrB D17(14)17L  
 S Equ D17(15)20L  
 U Cep D17(15)20  
 HU Tau D17(18)22  
 TW Dra 17(22)27  
 X Tri 21(24)26  
 Y Psc 22(26)23L  
**2004 Dec 23 Thu**  
 TV Cas 01(05)07D  
 Z Dra 06(08)07D  
 X Tri 21(23)26  
**2004 Dec 24 Fri**  
 Z Vul L06(06)07D  
 del Lib 06(12)07D  
 U Sge L06(09)07D  
 Z Per D17(13)18  
 Z Dra D17(17)19  
 HU Tau D17(20)24  
 SW Cyg D17(23)25L  
 X Tri 20(22)25  
 TV Cas 21(25)29  
 U Cep 22(27)31D  
**2004 Dec 25 Sat**  
 RW Tau 01(06)05L  
 SW Cyg L03(<<)05  
 TW Dra D17(18)23  
 X Tri 19(22)24  
 Z Dra 23(26)28  
**2004 Dec 26 Sun**  
 U CrB L01(01)07D  
 Z Vul D17(17)20L  
 TV Cas D17(20)24  
 Y Psc D17(20)23L  
 HU Tau 17(21)25  
 X Tri 19(21)24  
**2004 Dec 27 Mon**  
 Z Per D17(14)19  
 U Cep D17(15)20  
 U Sge D17(18)19L  
 TX UMa L17(14)19  
 X Tri 18(20)23  
 RW Tau 20(25)29L  
**2004 Dec 28 Tue**  
 TW Dra D17(13)18  
 TV Cas D17(16)20  
 Z Dra D17(19)21  
 X Tri 17(20)22  
 HU Tau 19(22)26  
**2004 Dec 29 Wed**  
 RS CVn 02(09)07D  
 del Lib L04(04)07D  
 Z Vul L05(04)07D  
 U CrB 06(12)07D  
 SW Cyg 06(12)07D  
 S Equ D17(12)17  
 SW Cyg D17(12)18  
 X Tri D17(19)22  
 U Cep 22(27)31D  
**2004 Dec 30 Thu**  
 Z Dra 01(03)06  
 Y Psc D17(15)19  
 Z Per D17(15)20  
 X Tri D17(18)21  
 RW Tau D17(19)24  
 TX UMa L17(16)20  
 HU Tau 20(24)28  
**2004 Dec 31 Fri**  
 TW Dra 03(08)07D  
 del Lib 06(12)07D  
 U Sge L06(03)07D  
 Z Vul D17(15)20L  
 X Tri D17(18)20

# NEW CHART

JOHN TOONE

004-03

3° FIELD INVERTED

Z CAMELOPARDALIS 08h 25m 13.2s +73° 06' 39" (2000)

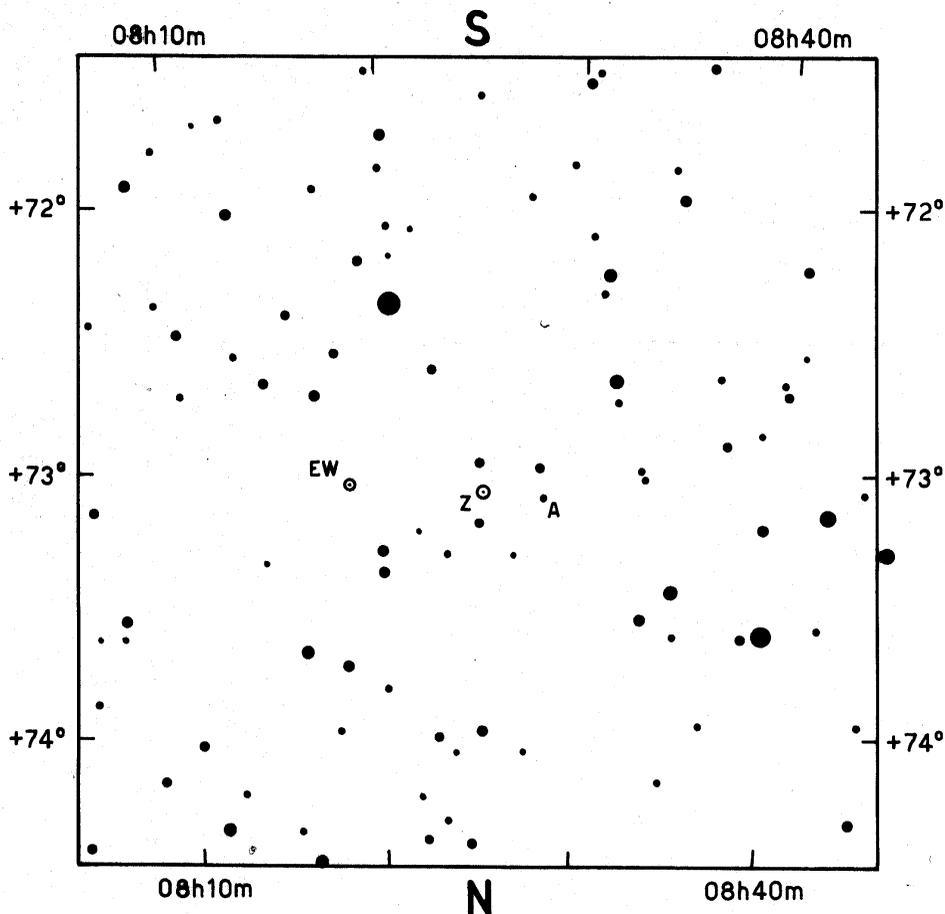


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MILLENNIUM SA

BAA VSS  
EPOCH : 2000  
DRAWN : JT 26-01-03  
APPROVED : RDP

## SECTION OFFICERS

**Director** Roger D Pickard  
3 The Birches, Shobdon, Leominster,  
Herefordshire HR6 9NG T:01568 708136  
E:rdp@star.ukc.ac.uk

**Secretary** John Saxton  
11 Highfield Road, Lymm,  
Cheshire, WA13 0DS T:01925 758009  
E:lymmobservatory@hotmail.com

**Chart Secretary** John Toone  
Hillside View, 17 Ashdale Road,  
Cressage, Shrewsbury, SY5 6DT.  
T:01952 510794 E:john.toone@dial.pipex.com

**Binocular Secretary** Melvyn D. Taylor  
17 Cross Lane, Wakefield, West Yorks, WF2 8DA  
T:01924374651 E:melvyn.taylor@breathemail.net

**Nova/Supernova Secretary** Guy M Hurst  
16 Westminster Close, Basingstoke,  
Hants, RG22 4PP .  
T& F:01256 471074 E:Guy@tahq.demon.co.uk

**Eclipsing Binary Secretary** Tony Markham  
20 Hillside Drive, Leek, Staffs, ST13 8JQ  
T: 01538 381174

E: tonymarkham@compuserve.com

**Recurrent Objects Co-ordinator** Gary Poyner

67 Ellerton Road, Kingstanding,  
Birmingham, B44 0QE.  
T:0121 6053716

E:garypoyner@blueyonder.co.uk  
**CCD Advisor** Richard Miles  
Grange Cottage, Golden Hill, Stourton Caundle,  
Dorset, DT10 2JP  
T:01963 364651  
E:rmiles@baa.u-net.com

**Circulars Editor** Karen Holland  
136 Northampton Lane North, Moulton,  
Northampton, NN3 7QW  
T: 01604 671373 Fax: 01604 671570  
E: karen.holland@xcam.co.uk

**Webmaster** David Grover  
12 Lonewood Way, Hadlow, Kent, TN11 0JB  
T: 01732 850864

E: david.grover@virgin.net

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