The VSS CCD photometry spreadsheet

Introduction

This Excel spreadsheet has been developed and tested by the BAA VSS CCD Working Group for analysing results files produced by the multi-image CCD photometry procedure in AIP4WIN v1. However it can be used to analyse data from any photometry package which produces the same information. A new version of the spreadsheet will be developed to handle the output files from AIP4WIN v2. Once you have a copy of the spreadsheet, the following notes will help you understand and use it. These refer to version B1.6 of the spreadsheet.

Purpose

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 the BAA, the AAVSO or another organisation as part of an observing programme.

The spreadsheet is intended for use with time-series 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).

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 about you 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.

Buttons sheet

The Buttons sheet enables you to run some useful macros, one which automatically imports the AIP4WIN v1 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 a directory and 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 error estimates are mainly based on the number of photons from the objects which were recorded and are therefore sensitive to potential problems such as 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. Examples of these plots are shown below.

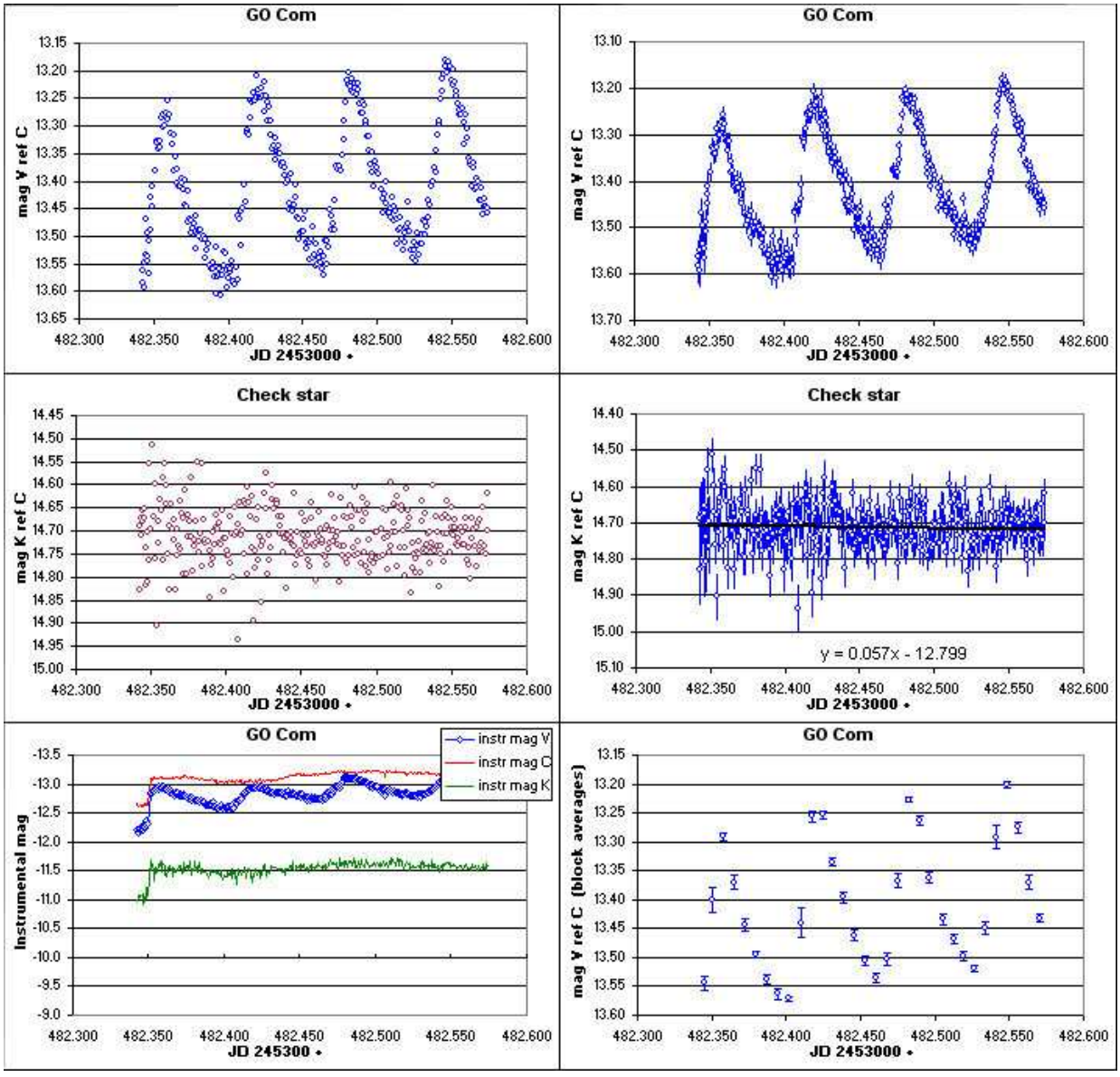
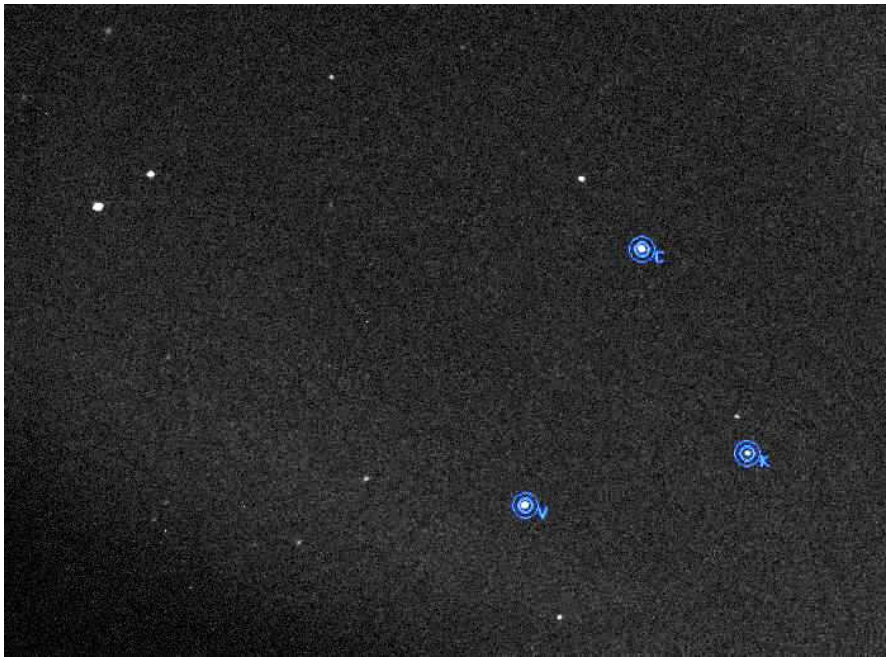


Image sheet

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. This is very good practice as it provides an unequivocal way of

remembering which stars you actually measured. When you are using the AIP4WIN v1 multi-image photometry routine to measure your images and have marked the positions of the V, C and K stars on the first image, use the Export button on the File menu to write out a copy of the image into a .jpg file. Note that this will cause the blue circles to disappear on the AIP4WIN screen but carry on regardless and the photometry process will continue correctly. This .jpg file can then be inserted into the Image sheet in the spreadsheet and positioned appropriately. Here is an example image with the V, C and K stars marked.



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, BAAVSS and AAVSO Report sheets. You can inspect these sheets to see what they contain. The BAAVSS sheet is used to create a report file which you can submit to the VSS and 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 estimates 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 they also take into account some parameters of your camera, namely gain, readout noise and dark current. You will need to fill in these parameters on the Results sheet. *The Handbook of Astronomical Image Processing* by Richard Berry and Jim Burnell, which includes the AIP4WIN software, tells you how to measure these. Note that they also refer to gain as conversion factor. You can sometimes find values for these parameters 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 the CCD equation which is described below.

The CCD Equation

This equation provides a way of estimating the signal to noise ratio for an instrumental magnitude measurement made using a CCD camera. It has been developed by professional astronomers over a number of years and is widely used to calculate errors on published data. There are several forms of the equation but one which is convenient for use with amateur cameras is as follows

$$S/N = Nstar / \sqrt{[Nstar + Npap * (1 + Npap / Npan) * (Nsky + Ndc + Nrn^2 + 0.289 * G^2)]}$$

where

Nstar = number of photons from the star recorded in the circular star aperture (= total ADU count from the star * CCD camera gain)

Nsky = number of photons per pixel from the sky recorded in the sky annulus (= ADU count per pixel from the sky * CCD camera gain)

Npap = number of pixels in the star aperture

Npan = number of pixels in the sky annulus

Ndc = number of dark current electrons per pixel

Nrn = number of readout noise electrons per pixel

G = CCD camera gain