B-V Color Calibration using Aladin Filters

A guide of Bernhard Hubl, 2009-01-30
(Aladin Filters by Wolfgang Piracher)

1. INTRODUCTION

The standard G2 star method for color calibration, which is described in detail at http://astrophoton.com/tips/color_balance.pdf, works in most cases very well. There are two situations, where this method fails:

1. Bad transparency: A bad transparency of the sky can induce color shifts, which cannot be compensated with the standard G2 star method.

2. No measurement of a G2 star: If you do not have measurements of a G2 star, but you have raw data, which you want to process and you have no idea of the appropriate color weights, then you need an alternative to the G2 star method.

A possible alternative to the G2 star method is the calibration with B-V values. The advantage is, that you do not need additional measurements. The image itself can be used for the calibraton.

2. IDEA

The idea is based on two articles by Peter Riepe and Harald Tomsik, which were published in the German magazine 'VdS-Journal'.

The aim is to get a color balance, which leads to a white color of a G2 star, which is not affected by interstellar extinction. The exposure time of object images is often so long, that all bright G2 stars in the image field run into saturation, so that these stars cannot be used for the calibration. The not saturated G2 stars in the image are faint. Since the spectral type of faint stars is often unknown, the search for not saturated G2 stars is often unsuccessfully. If you have luck and you can identify a faint unsaturated G2 star, then there is the risk that this star is maybe affected by interstellar extinction, which can ruin the color balance.

It makes sense to disengage oneself from the spectral type G2 and to turn towards photometry. The brightness of a huge number of faint stars was measured through different broadband filters and these measurements are available in several databases in the internet. The most important filter system is the Johnson UBVRI system, whereas U stands for Ultraviolet, B for Blue, V for Visual (Green), R for Red and I for infrared. We are only interested in B, V and R. The difference between B and V gives the so called B-V color index, which characterises the color of the star. A G2 star has a B-V value of 0.65mag. Red stars show B-V values above 0.65, and blue stars values below 0.65. A further color index is built by the difference between V and R. The typical value of V-R of a G2 star in the Johnson filter system is 0.52mag. Usually, the Johnson UBV

filters are not used in combination with the Johnson RI filters, but with the Cousins RI filters. This combination of filters leads to the Johnson-Cousins color index $V-R_C$ = 0.36mag of a G2 star.

The first step of the B-V method is to search unsaturated stars in the image, which have a B-V value between 0.6mag and 0.7mag. At the same time you should check the color index $V-R_C$, which is a not so critical factor: Values between 0.2mag and 0.6mag for $V-R_C$ are acceptable.

3.   PRACTICAL EXECUTION

The practical execution is described in the following lines using an image of M83. The raw data were captured in La Palma by Christoph Kaltseis with a SBIG ST4000XCM in combination with an ASA 10" Newtonian telescope.

3.1.   Object images

The object images can be processed as usual until the combining step is reached.

First, the raw data are calibrated with a master dark and a master flat. Then the images are registered, normalised and combined using the Mean method. Afterwards you have an averaged red, green and blue image, which are the base for the B-V color calibration.
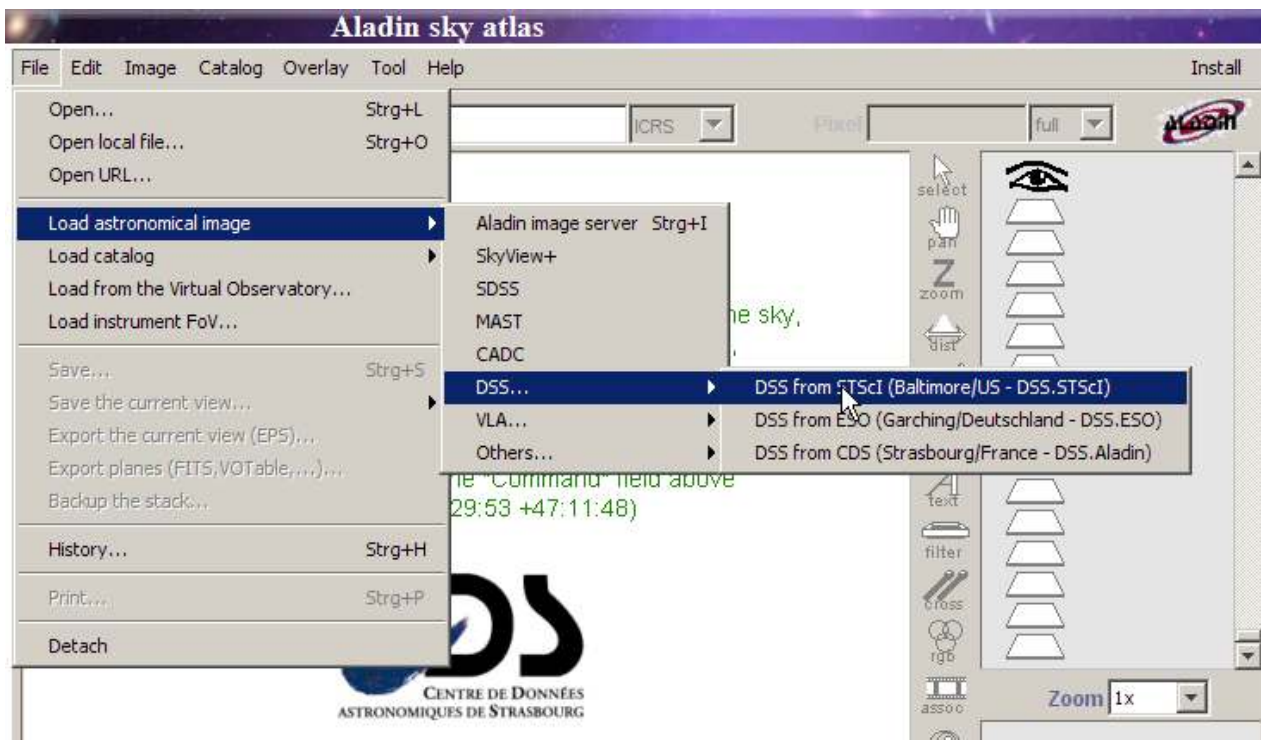
3.2.   Aladin

First, open Aladin: http://aladin.u-strasbg.fr/aladin.gml and start the Aladin Applet.

The next step is to load a DSS image.

File -> Load astronomical image -> DSS

The following window appears.

You have to put in the image centre (M83) and the desired dimension of the DSS image.

The Submit button starts the loading process of the image. The window can be closed by clicking the Close button.

The result looks like this:
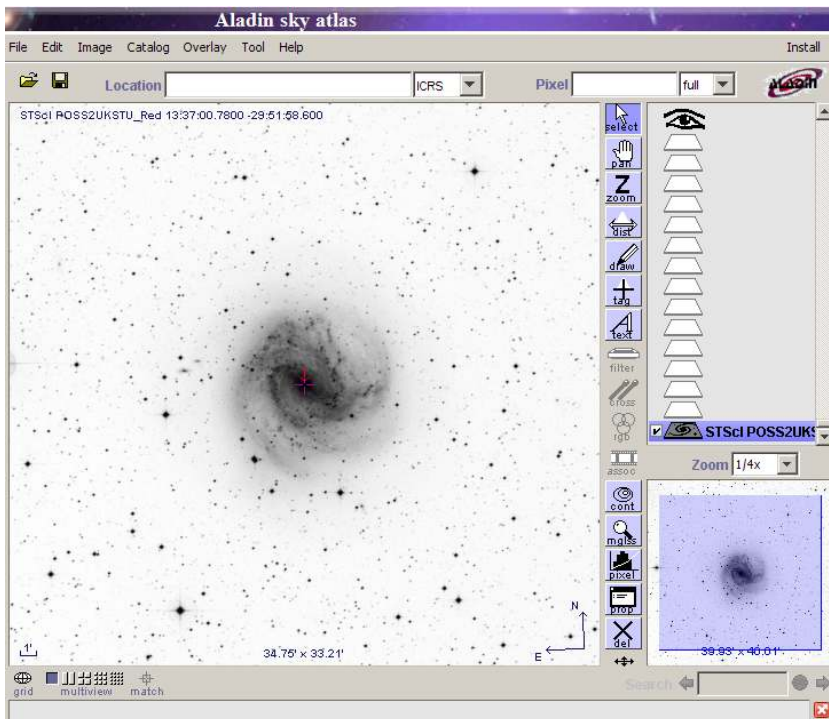
Next step: Load the NOMAD1 catalogue:

File->Load catalog->Surveys in Vizier -> NOMAD1
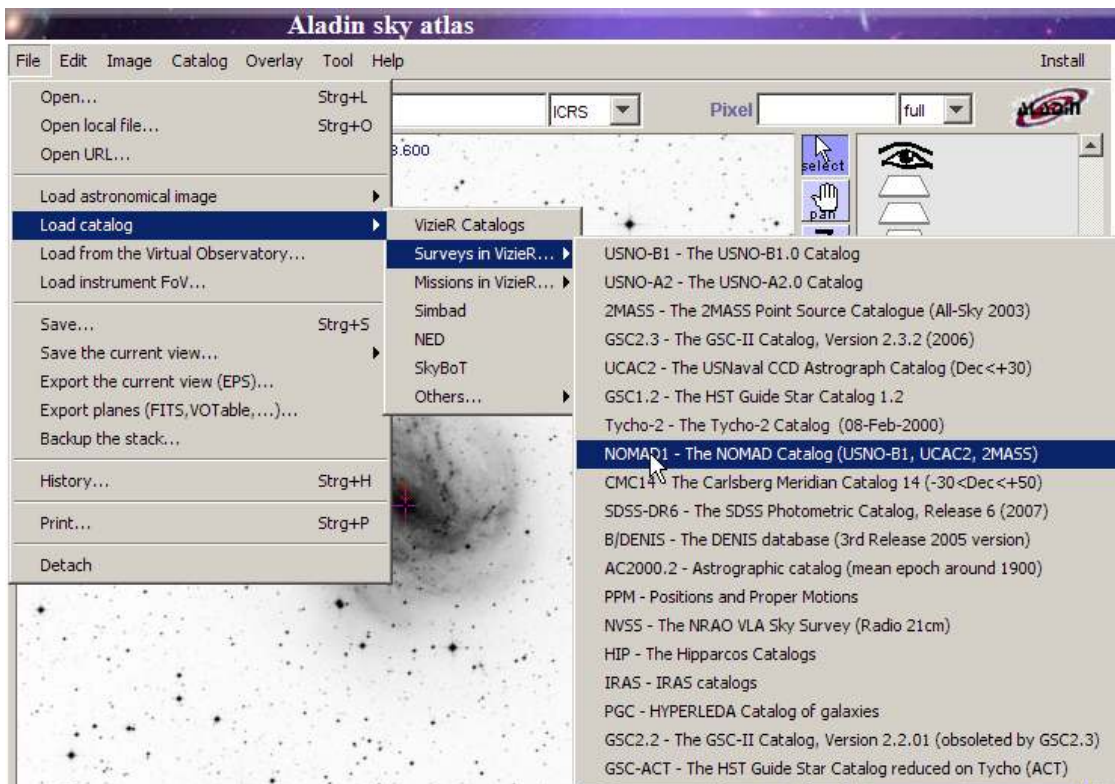
Input target and radius, then start the loading process by clicking on Submit, close the window by clicking on Close.

After loading the NOMAD1 catalogue, we want to select stars, which have a B-V value between 0.6mag and 0.7mag and a V-R value between 0.2mag and 0.6mag. Wolfgang Piracher has written an Aladin filter, which does this selection:
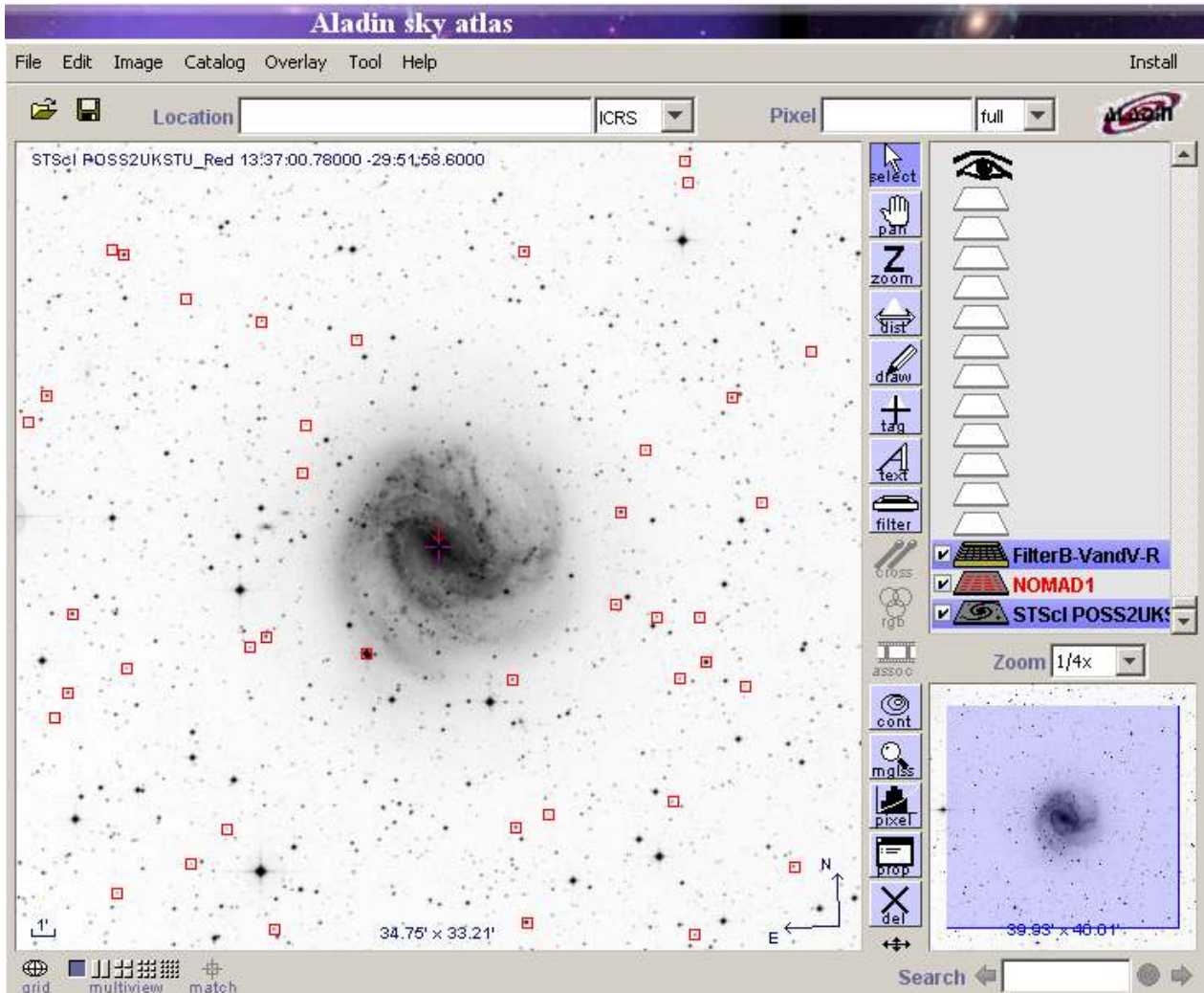
www.astrophoton.com/tips/Filter_B-V_and_V-R.ajs

This filter should be saved on your hard disk.

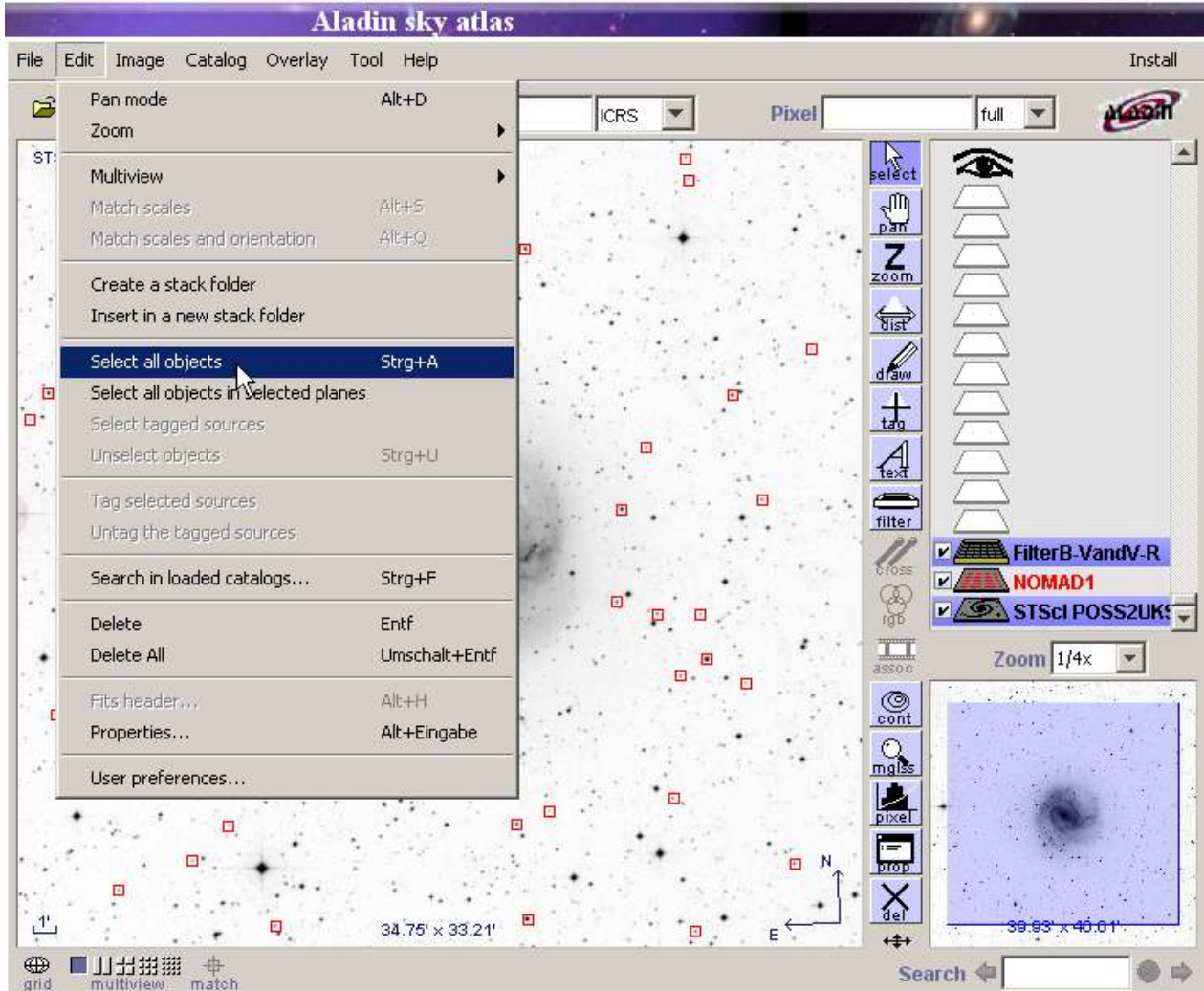Now, you can load this filter into your Aladin Stack: File -> Open local file:
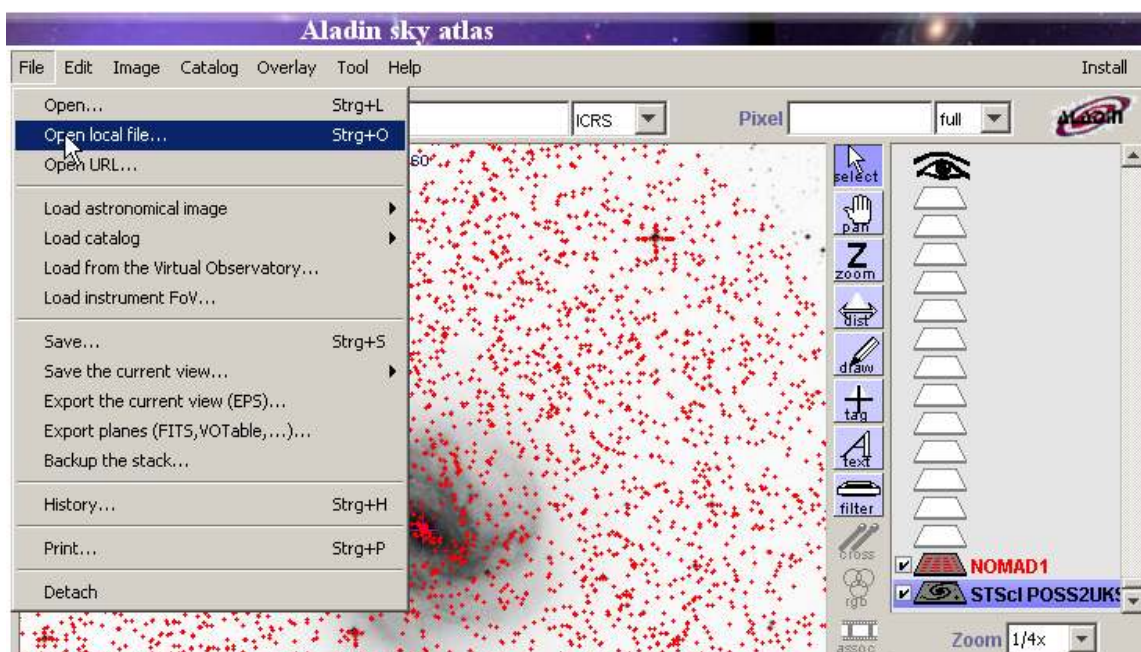
You can see all stars, which are usable for a B-V calibration, in the following screen shot.

These stars can be selected via: Edit -> Select all objects

Then we can click the Vmag column and all stars are sorted by brightness. Now we can easily select the stars for the determination of the color ratios.

3.3.   Measurement of the color weights

One can measure the brightness of the star through each filter with a standard CCD software (e.g. AIP4WIN, AstroArt,…). You get 3 signal levels.

E.g: The star 0599-0308989 was measured in AstroArt. The following ADU values were got:

Red 48,298 / Green 56,917 / Blue 51,635.

This star, which should be white, is in green and in blue brighter than in red. So the color channels has to be multiplied with the following factors:

Red 1.00 / Green 0.85 / Blue 0.94.

The following table summarises the calculation of the multiplication factors of 4 stars:

star	Red	Green	Blue
0599-0308989	1.00	0.85	0.94
0600-0311360	1.00	0.86	0.96
0601-0308222	1.00	0.85	0.93
0603-0308334	1.00	0.83	0.89
Average	**1.00**	**0.85**	**0.93**

The factors in the row 'Average' were used for the color calibration. The following image shows the four stars, which were used for the color calibration.

The finished image in high resolution can be found here:
http://astrophoton.com/M083.htm

4.   AN ALTERNATIVE TO THE B-V CALIBRATION

The NOMAD1 catalogue is very inhomogeneous and is based on a big number of different catalogues, which often show a bad photometric accuracy. This fact leads to a big variance of the color weights determined by different stars in the image field. So, the good match of the color weights in the above example of M83 is not typical. Usually, the differences are much higher.

A possible alternative is the usage of the SDSS catalogue (Sloan Digital Sky Survey). This catalogue is much more accurate, but at the moment the SDSS is far away from covering the whole sky. If your image field is covered by the SDSS, then you can do a color calibration using the SDSS in a very similar way as the B-V color calibration.

The following modifications to the B-V workflow are necessary:

- You have to load the SDSS-DR6 catalogue instead of the NOMAD1 catalogue.

- The SDSS does not use the UBVRI filter system but the ugriz filter system. A G2 star shows the following color indices in the ugriz system: u-g=1.43mag and g-r=0.44mag. So, the Aladin filter "Filter_B-V_andV-R" has to be replaced by the following filter: www.astrophoton.com/tips/Filter_u-g_and_g-r.ajs