

Photometry with the free-program IRIS

A case story from Goetheanum

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Case story

This is a case story of, how to find the magnitude of a star.

Is it bright, is it dim? How is the photometry done?

The star in question is R CrB¹, and the software is open source IRIS² (for the photometrical data reduction), and Cartes du Ciel³ (for stellar maps)

The hardware is the observatory at Goetheanum, Switzerland with its 18 cm refractor, and a Canon EOS 550D camera.

AAVSO

The association of Variable Star Observers⁴ provides very fine help for observing variable stars.

They present data for reference-stars⁵ and finder-charts⁶.

They maintain a huge database of the variable star observations from observers all around the world.

The light curves can be visualized⁷, and as an observer one can upload observations⁸.

The star

R Corona Borealis is the 8.th star in the Northern Crown. https://en.wikipedia.org/wiki/R_Coronae_Borealis

The brighter 7 stars lie like gems on a curved line east of Arcturus and west of Vega.

At the times of the Hipparcos mission (1991), the magnitude was $V_T = 5.959$ (Tycho2 catalog)

This means, that the star was visible to the naked eye under fine conditions (no moon, well-adapted eyes etc.)

¹https://en.wikipedia.org/wiki/R_Coronae_Borealis

²Version 5.59 June 2010: <http://www.astrosurf.com/buil/us/iris/iris.htm>

³The English edition is called SKY CHARTS <http://www.astrosurf.com/buil/us/iris/iris.htm>

⁴<https://www.aavso.org/>

⁵ <https://www.aavso.org/apps/vsp/photometry/?>

[fov=120.0&scale=C&star=R+CRB&orientation=ccd&maglimit=16.0&resolution=150&B=on&Rc=on&north=up&east=left&type=photometry](https://www.aavso.org/apps/vsp/photometry/?fov=120.0&scale=C&star=R+CRB&orientation=ccd&maglimit=16.0&resolution=150&B=on&Rc=on&north=up&east=left&type=photometry)

⁶<https://www.aavso.org/apps/vsp/chart/?>

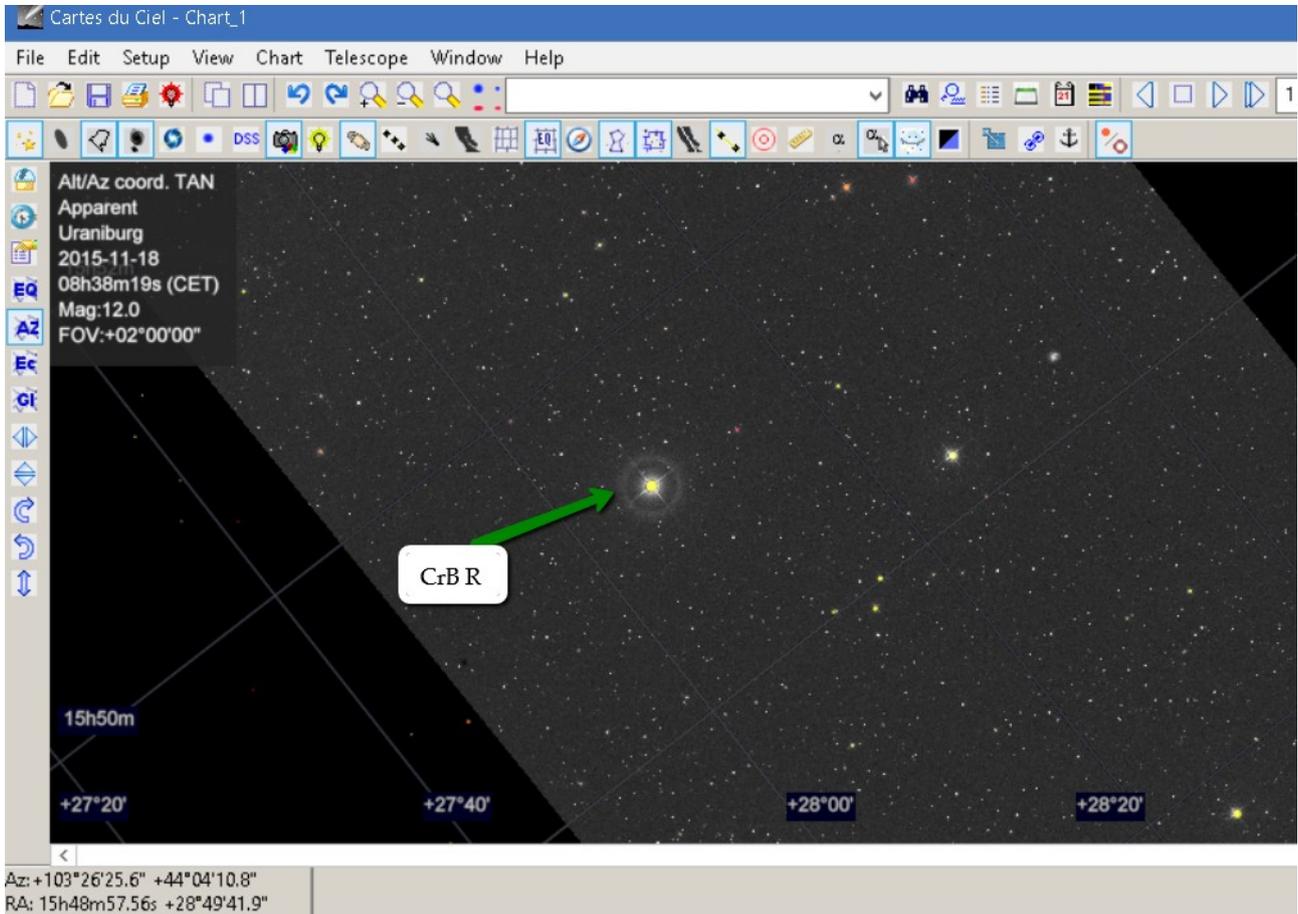
[fov=120.0&scale=C&star=R+CRB&orientation=ccd&maglimit=16.0&resolution=150&B=on&Rc=on&north=up&east=left&type=photometry](https://www.aavso.org/apps/vsp/chart/?fov=120.0&scale=C&star=R+CRB&orientation=ccd&maglimit=16.0&resolution=150&B=on&Rc=on&north=up&east=left&type=photometry)

⁷<https://www.aavso.org/lcg/plot?avid=000-BBW-575&starname=R>

[%20CRB&lastdays=400&obstotals=on&grid=on&pointsize=1&width=600&height=450&visual=on&uband=on&bband=on&v=on&r=on&iband=on&j=on&h=on&unknown=on&fainterthan=on&unvalidated=on](https://www.aavso.org/lcg/plot?avid=000-BBW-575&starname=R%20CRB&lastdays=400&obstotals=on&grid=on&pointsize=1&width=600&height=450&visual=on&uband=on&bband=on&v=on&r=on&iband=on&j=on&h=on&unknown=on&fainterthan=on&unvalidated=on)

⁸<https://www.aavso.org/webobs>

When one zooms in on the celestial position with Cartes du Ciel, one gets this map.



The many dim stars are from the Digitized Star Survey DSS⁹, a map in a map.

When I first observed the position for R CrB, no particular star was seen. It was August 2015.

Can a star hide itself from being seen?

Procedure for data reduction with Iris software

This is a supplement to the very detailed description by Mark Blackford found at the AAVSO website¹⁰ (March 2016).

The roadmap used here deviates on several points from the roadmap of Mark Blackford.

Case A:

- Take 1 picture of the star R Crb. T= 30 sec, ISO 12800
- Identify the star and a constant comparison stars on the finderchart from www.aavso.org

⁹<http://archive.eso.org/dss/dss>

¹⁰https://www.aavso.org/sites/default/files/publications_files/dslr_manual/AAVSO_DSLR_Photometry_software_tutorials_V1-0.pdf

- Do the reductions as mentioned below,
- Submit your data on the green magnitude TG to the AAVSO

Step 1. Take a picture of the star

The equipment is seen on page 1.

The telescope is a fine old Astro Physics StarFire EDT refractor with a 180 mm opening f/9.

The camera EOS550D is in prime focus, as can be seen on the picture. It is connected to the laptop-computer with at USB-cable. The “EOS Utility”-program from Canon is used, so that the camera is controlled mainly from the computer. The focusing procedure with the “live view” mode a very convenient.

As can be seen on the picture on page 1, the camera can be turned around the symmetry-axis of the telescope. It is convenient to have north up on the images taken. This means that one should rotate the camera in such a way, that if one moves the telescope in the East → West direction, the focused star should move along the long edge of the image.

The camera is used in Manual Mode with T=30 sec, ISO=12800 (witch is maximum), and the image was taken 2016-04-11 . It is saved as RAW-format on the computer, c:\Pictures\RCRB_2016_04_11_6859.cr2

Step.2 Identify the star

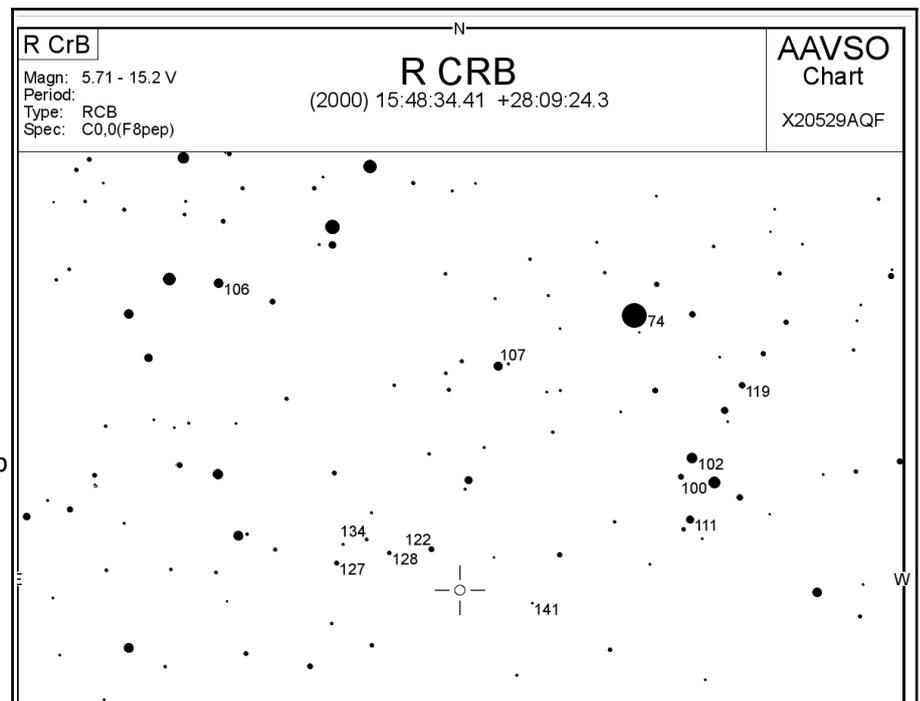
As mentioned earlier it can be a challenge to identify the star. The webpage www.aavso.org offers a great help in providing at finder-chart and a corresponding catalog of comparison stars.

On the front-page of www.aavso.org one chooses “Pick a star” and the starname R Crb is written. Then choose “Create a finderchart” . A print of this chart is of great help later, together with the Photometry Table that belongs to the chart.

The coordinates of the target star R Crb is seen at the top of the finderchart, and the position of R Crb is at the cross.

The star #127 (which later is chosen as comparison star) is seen close by. The name indicates, that the V-magnitude of the star is approximately 12.7 mag.

The asterism #111-100-102-119 is characteristic. It can be seen as “a little cannon” .



In the Photometry Table it is seen, that the AUID-name for the #127 is 000-BBW-592 and $V=12.666 \pm 0.021$ mag.

Field photometry for R CRB from the AAVSO Variable Star Database

Data includes all comparison stars within 0.5° of RA: 15:48:34.41 [237.143375°] & Dec: 28:09:24.3 [28.15675°]

Report this sequence as X18929BU in the chart field of your observation report.

AUID	RA	Dec	Label	V	B-V	Comments
000-BBW-559	15:47:40.80 [236.91999817°]	28:28:09.6 [28.46933365°]	74	7.427 (0.032) ¹	0.470 (0.057)	BINO_COMP
000-BBW-554	15:47:16.23 [236.81762695°]	28:16:46.2 [28.27949905°]	100	9.998 (0.044) ¹⁶	0.711 (0.078)	
000-BBW-556	15:47:23.09 [236.84620667°]	28:18:25.4 [28.30705643°]	102	10.192 (0.018) ¹⁷	0.591 (0.058)	
000-BBW-601	15:49:48.67 [237.45278931°]	28:30:22.0 [28.50811115°]	106	10.560 (0.051) ¹⁵	0.895 (0.096)	
000-BBW-570	15:48:22.62 [237.09425354°]	28:24:43.7 [28.41213989°]	107	10.665 (0.045) ¹⁵	0.677 (0.094)	
000-BBW-557	15:47:23.71 [236.8487854°]	28:14:13.7 [28.23713875°]	111	11.076 (0.036) ¹⁷	0.789 (0.121)	
000-BBW-553	15:47:07.62 [236.78175354°]	28:23:23.5 [28.38986015°]	119	11.885 (0.052) ¹⁵	0.268 (0.161)	
000-BBW-578	15:48:43.20 [237.17999268°]	28:12:12.7 [28.20352745°]	122	12.220 (0.014) ¹⁵	0.698 (0.030)	
000-BBW-592	15:49:12.16 [237.30065918°]	28:11:14.7 [28.18741608°]	127	12.666 (0.021) ¹⁵	0.505 (0.039)	
000-BBW-586	15:48:56.01 [237.23336792°]	28:11:56.8 [28.19911194°]	128	12.843 (0.019) ¹⁵	0.614 (0.036)	
000-BBW-587	15:49:03.03 [237.26261902°]	28:12:51.2 [28.21422195°]	134	13.412 (0.018) ¹⁵	0.558 (0.037)	
000-BBW-586	15:48:12.16 [237.05065918°]	28:08:30.1 [28.14189502°]	141	14.131 (0.011) ¹⁵	0.560 (0.027)	

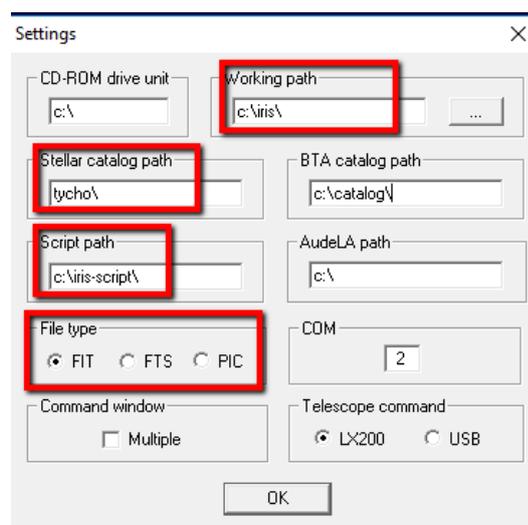
Step 3: Reduction with IRIS ver 5.59

The software is installed from <http://www.astrosurf.com/buil/us/iris/iris.htm>

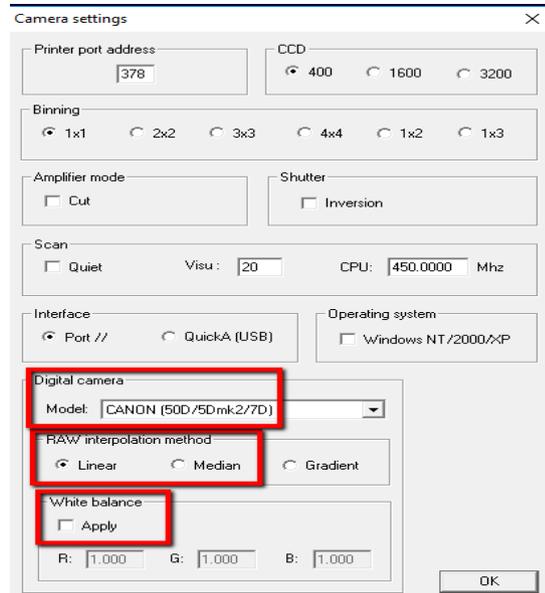
and the file libdcraw.dll is installed as described. The camera EOS 550D is compatible with EOS 50D

Step 3.2 Initializing of IRIS

MENU: File → settings



MENU: Find camera icon



These are my choices.

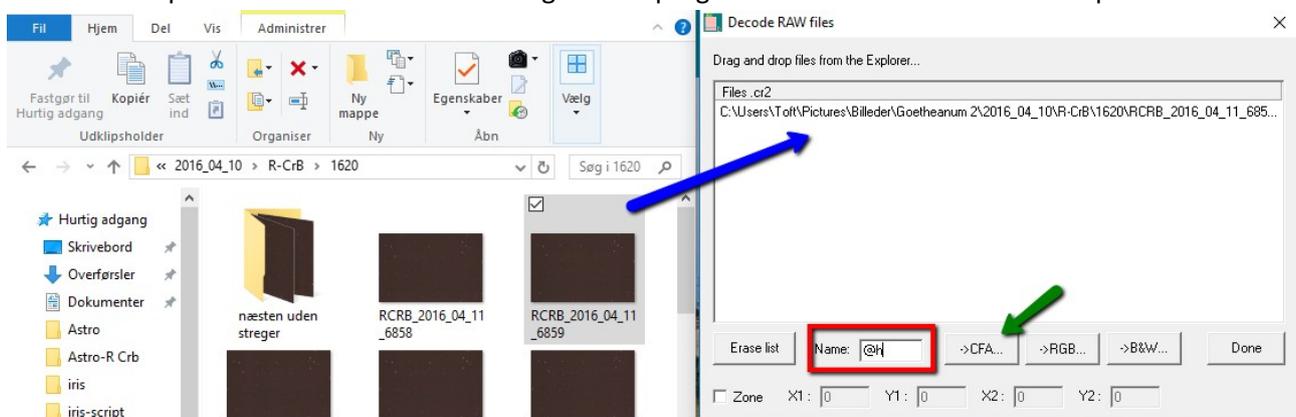
The Tycho2-catalog can be downloaded from www.astoft.dk/tycho2.zip

Step 3.3. Transformation of the image from RAW-format to CFA



In the MENU line one chooses Digital photo → Decode RAW

This makes it possible to draw the stellar image to the program area with the mouse and Explorer:



The new name is @h

Clicking the CFA bottom produces the CFA-image with the name '@h1'

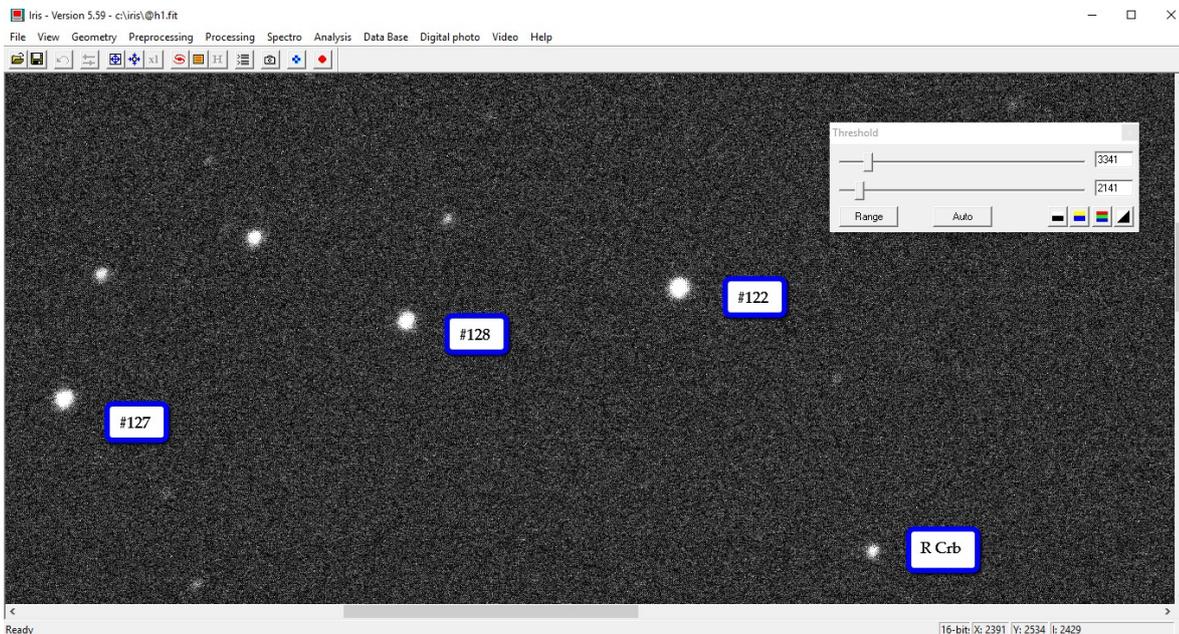
IRIS produces the index 1 automatically.

This pictures is now active on the screen.

Step 3.3 Visualization

One of the fine qualities of the IRIS program is, that it is possible to visualize the image on the screen without changing the image itself. MENU point View → Threshold

It changes the blackpoint and the whitepoint. Here the AUTO function has been used, and it is seen that the blackpoint is 2141 ADU (That means that all pixels with values below 2141 are black) , and the whitepoint is 3341 ADU. The maximum intensity in one image is $2^{14} - 1 = 16383$ ADU, (because the chip on the EOS 550D is 14 bit) but the first 2048 is an offset, so that an absolutely dark image has the value 2048 ADU. That is why the blackpoint is not near 0.

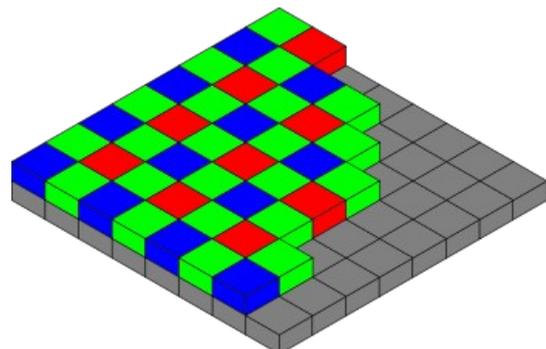


Step 3.4 Split the CFA image to 4 layers in FIT-format.

Now comes an important conceptual procedure:

This CFA image contains 3465 x 5202 pixels (approximately 32 MB on the hard-drive). But the pixels are organized in Bayer Matrix pattern, 2 x 2, with 2 green, 1 blue and 1 red pixels.

Since the camera is used as a photometer, it is important not to transform the values to JPEG or other nonlinear formats. We use RAW-format, and separate all four layers R G1 G2 B.



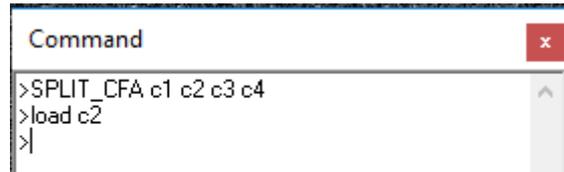
When a star has been observed, the difference between the G1 and G2 is a good measure of the accuracy of the measurement.

Now I split the image @h1 into the four Bayer Matrix layers R G1 G2 B. They are called c1, c2, c3 and c4. (each approximately 8.802 MB on the harddrive) .

Find the command icon in the MENU line



And enter the command
 >SPLIT_CFA c1 c2 c3 c4
 >load c2



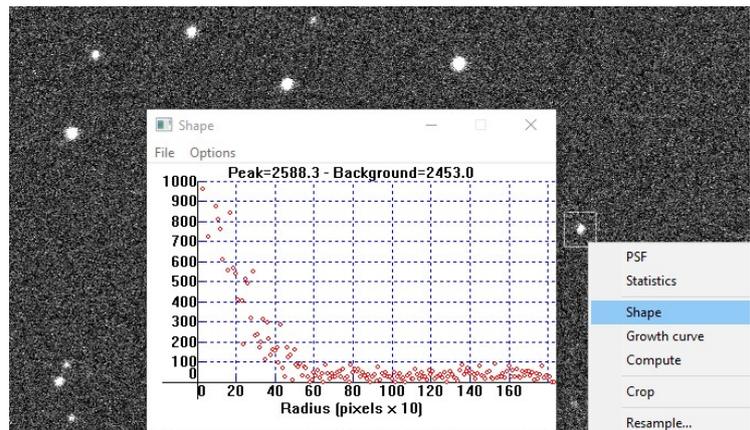
Now the original image is transformed to 4 fits files, and c2 and c3 should be very much alike, since the are both green.

Step 4. The instrumental magnitudes.

Now let us take a closer look at the image of the target star (R Crb).

Draw a rectangle around the star with the mouse.

Choose the menu-point *shape*



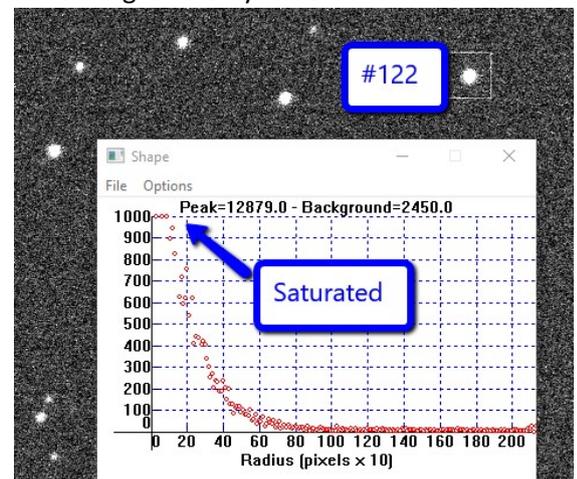
The diagram shows how the intensity decreases from the star center and outward. At a radius of $r \approx 2-3$ pixels the intensity as almost halved.

The peak-signal is 2588 ADU above the background (2453 ADU), but the dark signal is only $2453-2048 = 405$ ADU due to the offset of the chip on 2048.

The star is not saturated, because the peak is well below the limit 12.000 ADU

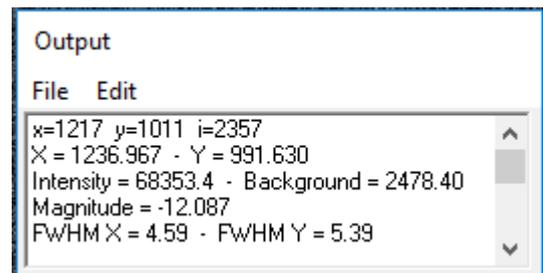
The star #122 is on the other hand saturated, as can be seen on a similar diagram for that star. It has a flat top. This is the disadvantage of using the high gain-factor with ISO 12800.

If a lower ISO-value of 200 ADU had been chosen, alle values would be 64 times smaller, but that would reflect the number of photo-electrons induced in the CMOS-chip better, and the dynamic range would have been extended.



4.1 The FWHM value

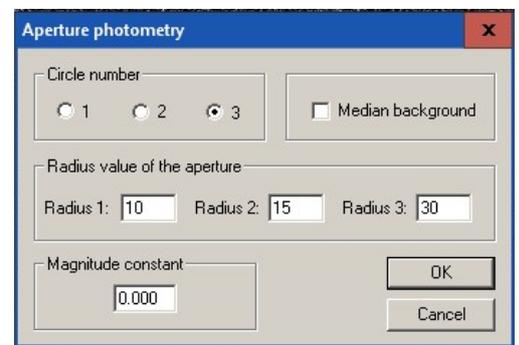
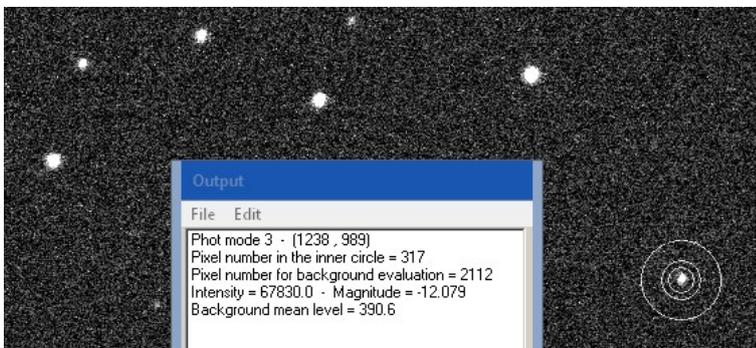
Let us return to the target star. Draw a rectangle around the star, right-click and choose this time the PSF option. This shows among other things that the FullWidthMaximum FWHM \approx 5 in both X and Y. This is the “diameter of the star”, in accordance with the $r \approx 2$ -3 pixels found from the Shape-diagram above.



4.2 The aperture magnitude.

There are two methods to calculate the instrumental magnitudes. The aperture Photometry method and the PSF-method (PointSpreadFunction).

The PSF-method calculates a gauss-curve that fits the stellar image. It is often used by professional astronomers with excellent optics. In DSLR photometry the optics may show some coma. In this case it is better to use the aperture method for calculating the magnitude.



See the three circles around the target star. The inner radius r_1 is 2 times the FWHM. The two outer circles define the ring that measures the local background (here 390.6 ADU/pixel). That is subtracted from the intensity measured in the inner circle. The result is 67 830 ADU

This is used to calculate the instrumental magnitude

$$m = -2.5 \log(I) = -2.5 \log(67830) = -12.079$$

This instrumental magnitude is relative to a (very faint) star with intensity 1 ADU.

This gives the result, that the PSF magnitude for the star in the g1 filter is

$$g_1(\text{star}) = -12.079$$

A similar procedure for the comparison star #127 gives

$$g_1(\text{comp}) = -13.668$$

This star has a known V magnitude ($V = 12.666 \pm 0.021$ mag.) on the catalog-scale where Vega has $V = 0.0$ mag. The observed magnitude of the star can now be calculated:

$$V(\text{star}) = V(\text{comp}) - g_1(\text{comp}) + g_1(\text{star}) = 12.666 - (-13.668) - 12.079 = \underline{14.255}$$

4.2 Time of observation

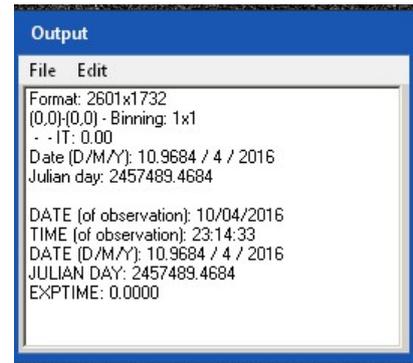
The image was taken 2016-04-11 01:14:33 CEST (UT + 2.00 h)
Central European Summer Time

The command

>INFO

As can be seen in the output-window shown to the right, the command INFO gives the time of observation as 2 hour earlier. This means that the time is correct in UT.

IRIS calculates this to Julian date.



4.3 The first spreadsheet

When the procedure mentioned is repeated on the other green layer, c3, one gets TG2= 14.055 mag. That is 135 mmag less than before. So the result is

TG = 14.12 ± 0.07 mag

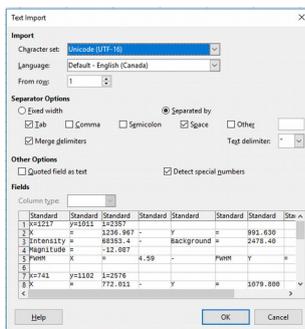
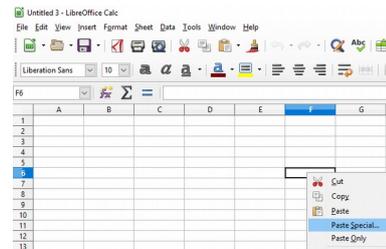
These many numbers can be picked in a spreadsheet.

I use Liberooffice Calc as a very powerful tool.

In the Output-window of IRIS one chooses Edit → copy

In Liberooffice Calc one chooses a cell “to the right” e.g F6.

Right click → Paste special



The text-import field comes forward. The “separator options” are important.

The idea is now to “pick” the relevant numbers from this area and collect them in the left part of the spreadsheet.

It is seen that the magnitude of the star in c2 is in the 4th line.

Here is an explanation of the spreadsheet “Photometry with IRIS ver 1”

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	#NAME	DATE	MAG	MERR	FILT	TRANS	MTYPE	CNAME	CMAG	KNAME	KMAG	AMASS	GROUP	CHART
2	R C _B	2457489.4684	14.12	0.07	IRG			127	-13.62	na	na	na	1	X186030
3			The resultant magnitude											
4						From the IRIS output-window:								
5														
6						x=1217	y=1011	i=2357						
7	Instrumental magnitudes:					X	=	1236.967	-	Y	=	991.63		
8		1	127			Intensity	=	68353.4	-	Background	=	2478.4		
9	c2	-12.087	-13.611			Magnitude	=	-12.087						
10	c3	-12.248	-13.637			FWHM	X	=	4.59	-	FWHM	Y	=	5.39
11			-13.624											
12						x=741	y=1102	i=2576						
13						X	=	772.011	-	Y	=	1079.8		
14	Observed magnitudes					Intensity	=	278240.2	-	Background	=	2481.56		
15	catalog		12.666			Magnitude	=	-13.611						
16	c2	14.190				FWHM	X	=	5.33	-	FWHM	Y	=	5.86
17	c3	14.055												
18						x=1212	y=1013	i=2294						
19	V	14.123				X	=	1237.434	-	Y	=	990.674		
20	ΔV	0.135				Intensity	=	79319.2	-	Background	=	2458.77		
21						Magnitude	=	-12.248						
22						FWHM	X	=	5.33	-	FWHM	Y	=	4.5
23	IRIS time of observation													
24			2457489.5101			x=738	y=1107	i=2512						
25	Correction		-0.0417			X	=	772.49	-	Y	=	1079.285		
26						Intensity	=	285021.6	-	Background	=	2467.51		
27	UT time of observation JD=	2457489.4684				Magnitude	=	-13.637						
28						FWHM	X	=	5.48	-	FWHM	Y	=	5.52
29														
30						Format:	2601x1732							
31						(0,0)-(0,0)		Binning:	1x1					
32								IT:	0					
33						Date (D/M/Y):	11.0101/			4/		2016		
34						Julian day:	2457489.5101							
35														
36						DATE (of observation):	2016-11-04							
37						TIME (of observation):	00:14:33							
38						DATE (D/M/Y):	11.0101/			4/		2016		
39						JULIAN DAY:	2457489.5101							
40						EXPTIME:	32							
41														

The instrumental magnitudes from the two green layers c2 and c3 are picked from H9, H15, H21, H26. (yellow). They can be seen in cells B9:C10.

The catalog-value for the comparison star is in cell C15, and the calculated magnitudes from the two layers are in cell B16:B17

The resultant V-magnitude is seen in cell B19, and this value is copied to the first line (C2) that contains the results in a form that corresponds the format of the AAVSO.

The time of observation is picked from the output-window (H39 blue), and corrected in cells A23:C27.

The resultant JD is copied to the first line (B2)

The CNAME and the CMAG is the name of the comparison star, and the corresponding instrumental magnitude. The check-star (KNAME and KMAG) is not available (n/a) in this first case-story.

Step 5 Reporting the observation to the AAVSO

It is recommended to become a member of the AAVSO -organisation, but it is also possible just to register (that is to get a OBSCODE).

The observation is submitted as a CSV-spreadsheet to <https://www.aavso.org/webobs/file>

The format is described here

<https://www.aavso.org/aavso-extended-file-format>

This is the full example from above

```

#TYPE=Extended
#OBSCODE=TSCB
#SOFTWARE=IRIS5.59
#DELIM=comma
#DATE=JD
#OBSTYPE=DSLR
#NAME DATE MAG MERR FILT TRANS MTYPE CNAME CMAG KNAME KMAG AMASS GROUP CHART NOTES
R CrB 2457489.4684 14.12 0.07 TG no std 127 -13.62 na na na 1 X18603O

```

The Chart X18603O indicates to the Photometry Chart with the standard catalog values.

The last line is copied from the Photometry spreadsheet with the “paste special” procedure.

This is the beginning of the observation protocol. Further observations can be added in the following lines.

Step 6 The procedure in short.

1. Menu Digital Photo → Decode RAW
 1. The RAW image is “drawn” with the mouse to the IRIS-program area.
 2. New name @h CFA
 3. command >load @h1
2. Split the image to c1 c2 c3 c4
 1. command >SPLIT_CFA c1 c2 c3 c4
3. The PSF magnitude
 1. Menu Analysis → Display Data
 2. Draw a rectangle around the star, click and choose PSF
4. The observed magnitude
 1. The PSF magnitude for the star and the comparison star are found from the c2 image and from the c3 image.
 2. The command >INFO
 3. The output-window is copied to the spreadsheet “Photometry with IRIS ver 1” in celle F6
 4. The observed magnitude and the JD observing time are calculated and presented in a form to be read at the AAVSO
5. Observation protocol
 1. The resulting line 2 in the spreadsheet is copied to the observation protocol
 2. Further observations can be added before sending the results to www.aavso.org

Step 7 Final remark

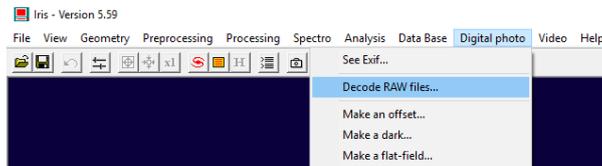
This is the end of the first case story, “the simple start”. It is highly recommended to continue reading to the next paragraph, where the images gets stacked, the background is subtracted, and vignetting is regarded by taking the flat-images. A more detailed spreadsheet is also presented to automatize the calculations of the magnitude and the error-estimate.

29-5-2017 ST

Case B:

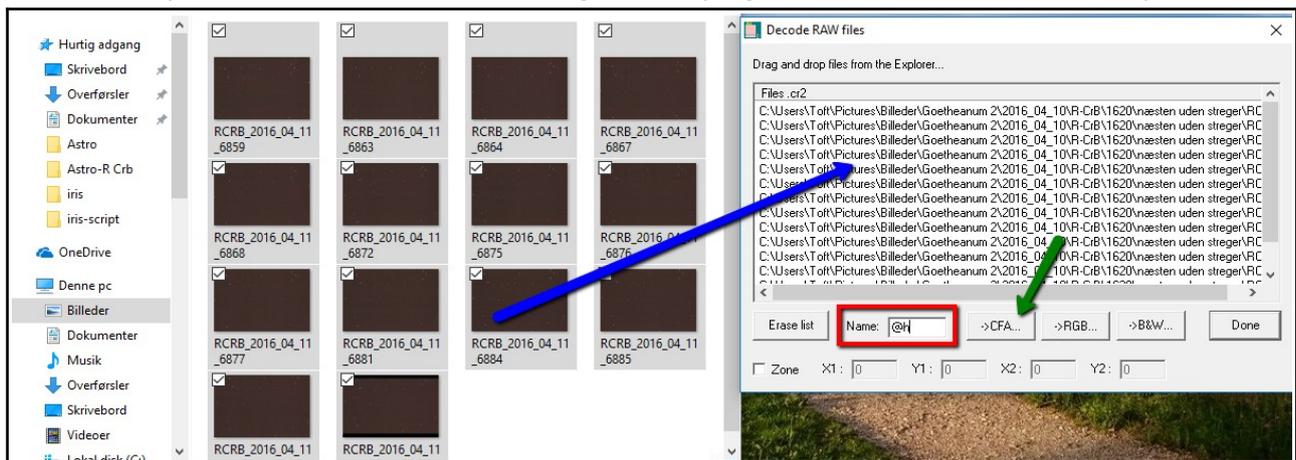
- Take 14 picture of the star R Crb. T= 30 sec, ISO 12800
- Make the traditional images : Dark, offset, flat in the four layers
- Do the reductions as mentioned below using a comparison star and more checkstars.
- Submit your data on the green magnitude TG to the AAVSO

Step 1: the image-series transforms from RAW til CFA and 4 fits-colour layers.



In the MENU line one chooses Digital photo → Decode RAW

This makes it possible to draw the 14 stellar images to the program area with the mouse and Explorer:



The new name is @h

Clicking the CFA bottom produces the CFA-image series with the name @h1, @h2, ... ,@h14

@h is now the name of a series of images, not just one image.

The 14 images are split into four colourlayers

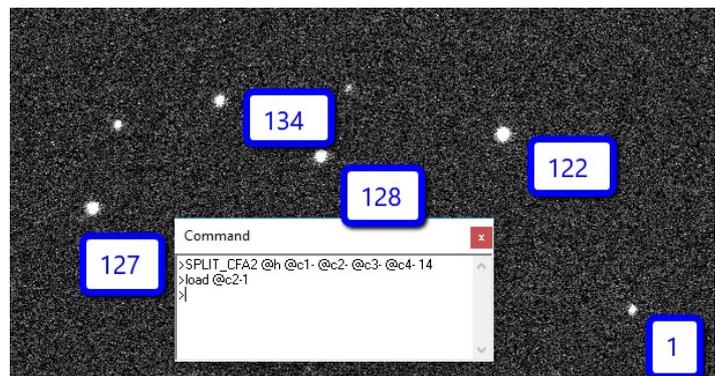
@1- @2- @3- @4- with the command

```
>SPLIT_CFA2 @h @1- @2- @3- @4- 14
```

and the first green image is visualized¹¹

```
>LOAD @2-1
```

and the stars from the finderchart are identified.



¹¹ See step 3.3 Visualization earlier

Step 2: Dark offset flat

These steps are usually made in CCD-astrophotography. Since we are only interested in the Photometry, it can be done rather simple:

The image on the screen is 2601x1732 pixels.

The offset file is set to 0 ADU in all pixels, and the four dark images are set to 2048. The flatfiles are set to 5000 in all four layers. These values can be refined further if necessary, but it takes many pictures in order not to introduce new sources of error. This is not done here.

```
>FILL 0
>SAVE offset
>FILL 2048
>SAVE dark1
>SAVE dark2
>SAVE dark3
>SAVE dark4
>FILL 10000
>SAVE flat-1
>SAVE flat-2
>SAVE flat-3
>SAVE flat-4
```

Step 3: Reduction

The series @1- is now reduced. First for the dark image, and afterwards for the flat-images

```
>OFFSET2 @1- @@ dark1 14
>DIV2 @@ flat-1 @a1- 10000 14
```

This is repeated for the other 3 color layers #=2,3,4

```
>LOAD @a2-1
```

The split and reduction procedure described above has been collected to a script SPLIT16 (See Appendix 1). It is called so

```
>RUN split16 14
```

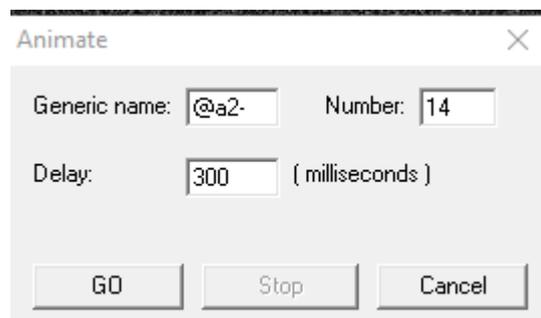
Step 4: Stacking

The 14 green images will normally have a little offset in the stars position from image to image. In IRIS this alignment is done with the REGISTER command. But first one has to know the limits. So the first thing to do is to animate the image-series @a2-

Menu View → Animate

The generic name is @a2-

When one presses the go-button, one sees an animation of the 14 images.



Choose an isolated non saturated star (like #122) and mark two imaginary points on a rectangle that contains the star, without the interference of other stars. The two points can be marked with the mouse, so their coordinates are seen in the output-window.

In this example $(x_1, y_1) = (1249, 1391)$ and $(x_2, y_2) = (1115, 1125)$

So the star moves 134 pixels in x and 266 pixels in y.

So a border of 300 pixels will leave a central part of the image fit for the PREALIGN procedure.

The image size is 2601 x 1732

```
>MOUSE_SELECT 300 300 2301 1432
```

```
>PREREGISTER @a2- @e2- 14
```

The new image-series @e2- is translated so that the stars has the same positions as in the first image.

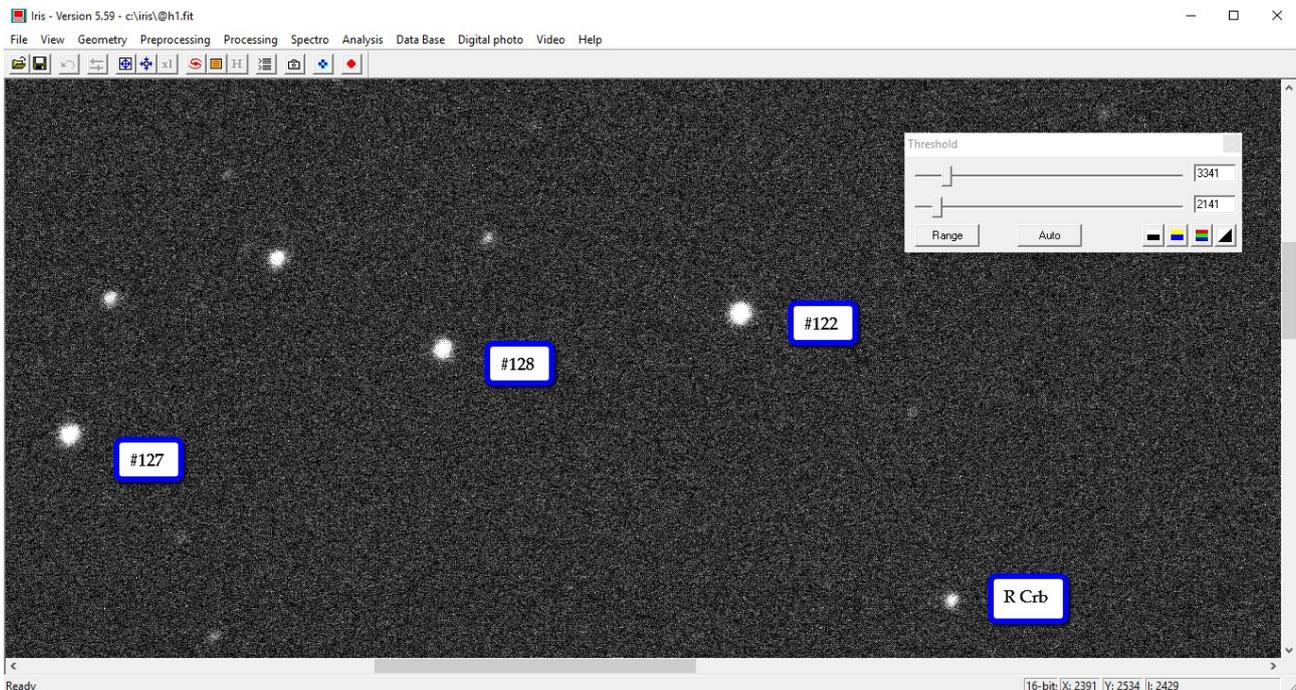
These images are then added, and if the intensity supersede the maximum 32767, they are normalized, and the normalization coefficient is shown.

The resulting image is called c2 as was the case in the first case story (A).

This is repeated for the 3 other layers. I have made a script PREALIGN (Appendix 2) that does this. It is called in this way:

```
>RUN prealign 14 300 300 2301 1432
```

Step 5 Automatic photometry



As described earlier, one has to check the stars for saturation. [draw a rectangle around the star #122, and left-click on "shape"] If the top is flat, the star is saturated. It cannot be used as a standard star or a comparison star.

Now it is time to chose the target star, the standard star and the comparison stars.

>LOAD c2

MENU Analysis → Select Objects

Pick the stars (in this order)

#1 (the target star R Crb)

#127 (The comparison star)

#128 (the check star)

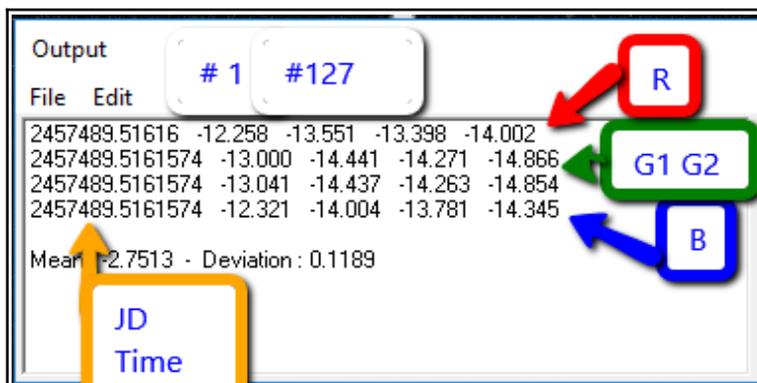
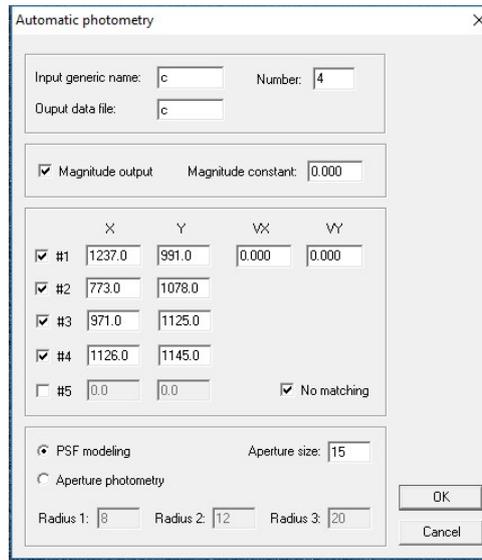
#122 (another check star)

The following procedure is usefull:

In the OUTPUT-window choose EDIT → ERASE

MENU: Analysis → Automatic Photometry

By choosing the generic name c, one gets photometry in all four colour-layers at the same time



It is seen that the instrumental green magnitude for the target star is

$g_1 = -13.000$

$g_2 = -13.041$

so $g = -13.020 \pm 0.020$ mag

The standardstar #127 has

$g = -14.439 \pm 0.002$ mag

These numbers are copied to a spreadsheet by choosing Edit → Copy in this Output-window.

It is convenient to copy that to a separate sheet "i-mag" (Copy special) and then making the calculations in the first sheet "Results"

The final result is seen in the first line as in caste study A

$TG = 14.085 \pm 0.023$ mag

	A	B	C	D	E	F	G	H	I
1	R CrB	2457489.474	14.085	0.023	TG	no	std	68W-592	-14.439
2									
3	Photometry with IRIS 5.59								
4									
5	Remark:	F-001	Nobs=14	t=30sek	ISO128 00	f=1620 mm	f/9	PSF	
6	F 1	Camera:	550D						
7		Aperture	PSF						
8									
9		2457489.516	CET time of observation						
10	JD	2457489.474	UT time of observation						
11	JDO	2415018.417	Sommerstime0						
12		2016-04-11 01:23:16	Observation time						
13		2017-06-01 16:15:49	Reduction time (ST)						
14									
15			Conclusion : Fine observation.						
16									
17			Comp *		Check *				
18	Instrumental results:		std						
19	Time	Star	1	127	128	122			
20	r	2457489.474	-12.258	-13.551	-13.398	-14.002			
21	g1	2457489.474	-13.000	-14.441	-14.271	-14.866			
22	g2	2457489.474	-13.041	-14.437	-14.263	-14.854			
23	b	2457489.474	-12.321	-14.004	-13.781	-14.345			
24									
25	Δg		-0.041	0.004	0.008	0.012			
26	g		-13.021	-14.439	-14.267	-14.860			
27	(b-v)		0.700	0.435	0.486	0.515			
28	(r-g)		0.763	0.888	0.869	0.858			
29									
30	TG		14.085	12.666	12.838	12.245			
31	TB		14.854	13.171	13.394	12.830			
32	TR		13.660	12.367	12.520	11.916			
33	(TB-TG)calc		0.978						
34	V-cat			12.666	12.843	12.220			
35	B-cat			13.171	13.457	12.918			
36	R-cat			12.367	12.488	11.810			
37									
38	Δ V		0.000	-0.005	0.025				
39	Δ B		0.000	-0.063	-0.088				
40	Δ R		0.000	0.032	0.106				

Appendix 1

```
*****
**      RUN SPLIT16 $1
**      where $1 is number of images named @h1, @h2, ... @h$1 in CFA format
**      ST 1.juni 2017
**      First procedure for evaluation of stellar images with IRIS version 5.59
*****
**      The stellar images are transformed form RAW-format (CR2) til fits choosing
**      Digital Photo -> Decode RAW Files
**      and the files is drawn with the mouse to the program-area.
**      The new name is @h (CFA)
*****
**      The results are the 4 colour layers R G1 G2 B ;
**      reduced image-series @a1- @a2- @a3- @a4-
*****
**      Assumptions:
**      Four layers of dark# (typicly 2048) are subtracted.
**      The images are divided by flat-1, flat-2 flat-3 flat-4
**      and multiplied by 10000
**      No hot-pixels ; #= 1,2,3,4 R G1 G2 B
**      the constant Offset is not used.
**      the intermediate series @@ is used
*****
Load @h1
info
echo split_@h_in_R_G1_G2_B_layers:
SPLIT_CFA2 @h @1- @2- @3- @4- $1
**
OFFSET2 @1- @@ dark1 $1
div2 @@ flat-1 @a1- 10000 $1
OFFSET2 @2- @@ dark2 $1
div2 @@ flat-2 @a2- 10000 $1
OFFSET2 @3- @@ dark3 $1
div2 @@ flat-3 @a3- 10000 $1
OFFSET2 @4- @@ dark4 $1
div2 @@ flat-4 @a4- 10000 $1
LOAD @a2-1
echo split_done
END
```

Appendix 2

```
*****
**      RUN preALIGN $1 $2 $3 $4 $5
**      where $1 is number of original images in CFA format
```

```

**      ST 29.maj 2017
**      A helping procedure, when alignment is difficult
**      The input are the four series @a1- @a2- @a3- @a4-
**      Before running ALIG the user must find the two corners ($2,$3) and ($4,$5) of the recktangel
**      that contains a caraktiristic stellar form
*****
**      The output of the procedure are the four series @e1- @e2- @e3- @e4-
**      and the mean of the four layers c1, c2, c3, c4
*****

echo preALIGN_procedure
echo _

load @a1-1
mouse_select $2 $3 $4 $5
preRegister @a1- @e1- $1
add_norm @e1- $1
save c1
echo 1
load @e2-1
mouse_select $2 $3 $4 $5
preRegister @a2- @e2- $1
add_norm @e2- $1
save c2
echo 2
load @a3-1
mouse_select $2 $3 $4 $5
preRegister @a3- @e3- $1
add_norm @e3- $1
save c3
echo 3
load @a4-1
mouse_select $2 $3 $4 $5
preRegister @a4- @e4- $1
add_norm @e4- $1
save c4
echo 4
**
**load @a1-1
**info
Load c2
echo c2_loaded
echo Select_stars_and_run_automatic_photometry
echo c_med_4_observationer
END

```