

Flare Star Photometry

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STEP 1) Take DARK, FLAT and DARK-FLAT images beforehand. Make a library of DARK files of varying exposures.

STEP 2) Acquire images of the flare star field using NINA. Make sure you put in the

RA and DEC of the location so that plate solving using ASTAP is faster.

A filename that includes the date and time.

Use exposures of about 3 - 60 seconds. Check to see that pixel values are not saturating. When using a 16-bit camera, this means pixel values in the target star that are less than 50,000 and ideally 5-10K.

Use minimal gain.

STEP 3) Use ASTAP to plate solve for each image

Press Alt-P and select all the fits files. It should take a few minutes for 1000 images. I have a short document explaining how to set up ASTAP for plate solving.

STEP 4) If you simply want to check a series of images for the presence of a flare, skip now to STEP 5. Continue here if you want to properly calibrate the images. Load images into the DP of AstrolImageJ. Make sure you have ready the DARK, and FLAT-DARK files for calibration. Make sure the entries in the CCD Data Processor and DP Coordinate Converter are correct

Open AstrolImageJ

Open DP (Look for the DP button along the top right of the menu)

Direct the Science Image Processing filepath to the raw images.

Select *.fits in Filename/Pattern

Do the same for the Dark Subtraction and the FLAT Division.

In Image Correction, make sure Remove Outliers is not selected.

Make sure Polling Interval (at bottom left) is set to 0

Under Fits Header Updates,

Select General

Target Coordinate Source, select FITS header target RA/DEC (J2000)

Observatory Location Source, select manual entry

In the DP Coordinate Convert, add the Lon, Lat and Alt (ADD YOUR LONG ADD YOUR LAT ELEV)

Under Save Calibrated Images,

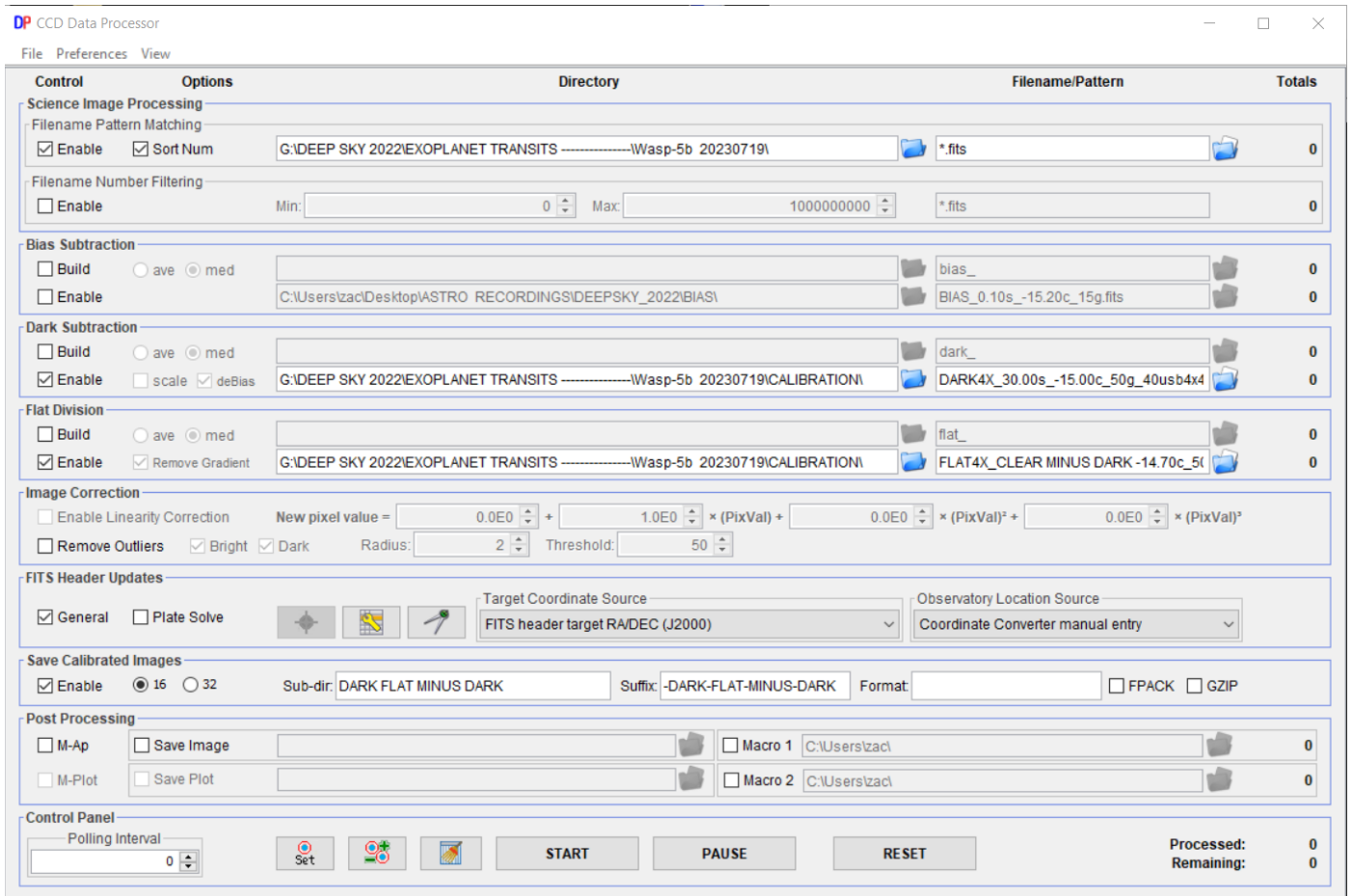
Select Enable

select 16

In Sub-dir, add DARK-CORRECTED or something you like

In Suffix, add -DARK or something you like

The DP page should look like this



Go to the DP Coordinate Converter and select Auto under Dynamical Time.

In the CCD Data Processor box, select the yellow wrench

Make sure all the words correspond to the words in the FITS header (eg for RA, DEC, Latitude and Long and BJD(TDB))

NOW PRESS START IN THE CCD DATA PROCESSOR

General FITS Header Settings

FITS Header Input Settings

Target Name Keyword:

Target RA Keyword: Degrees

Target DEC Keyword:

Observatory Name Keyword:

Observatory Latitude Keyword: negate

Observatory Longitude Keyword: negate

FITS Header Output Settings

Target J2000 RA Keyword: enable

Target J2000 DEC Keyword: enable

Target RA Keyword: enable

Target DEC Keyword: enable

Target Altitude Keyword: enable

Target Azimuth Keyword: enable

Target Hour Angle Keyword: enable

Target Zenith Distance Keyword: enable

Target Airmass Keyword: enable

JD (UTC) start-Obs Keyword: enable

JD (UTC) mid-Obs Keyword: enable

HJD (UTC) mid-Obs Keyword: enable

BJD (TDB) mid-Obs Keyword: enable

Observatory Latitude Keyword: enable

Observatory Longitude Keyword: enable

DP Coordinate Converter

File Preferences Network Help

Current UTC-based Time

UTC: 2023-06-26 00:32:13 Local: 2023-06-26 10:32:13 AM JD: 2460121.522375 LST: 04:59:56

SIMBAD Object ID (or SS Object) Time Zone UTC offset: 10 Observatory ID Custom Lon, Lat, and Alt entry

Target Proper Motion (mas/yr) pmRA: 0 pmDec: 0 Geographic Location of Observatory Lon: Lat: Alt:

Standard Coordinates

J2000 Equatorial RA: 00:00:00 Dec: +00:00:00 **J2000 Ecliptic** Lon: 00:00:00 Lat: 00:00:00

B1950 Equatorial RA: 23:57:26.234 Dec: -00:16:42.28 **Galactic** Lon: 96:20:14.17 Lat: -60:11:18.79

Epoch of Interest

UTC-based Time

Now UTC: 2023-06-19 09:59:55 UT 05:56 PM JD: 2460114.916603 LST: 14:01:34

Lock Local: 2023-06-19 07:59:55 PM 05:43 AM HJD: 2460114.916358 dT: -00:00:21

Dynamical Time

Update Auto Leap-secs: 37.0 OSU/internal BJD: 2460114.917108 dT: 00:00:44

Equatorial RA: 00:01:11.559 Dec: +00:07:46.43 **Ecliptic** Lon: 00:19:30.34 Lat: 00:00:01.04

Horizontal Alt: -50:04:22.83 Az: 128:37:16.21 **Direction - Hour Angle - Zenith Distance - Airmass** Dir: SE HA: -09:59:37 ZD: 140:04:23 AM: N/A

Phase - Altitude - Proximity

	Moon	Mercury	Venus	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Down	Down	3.83	8.80	Down	Down	Down	Down	Down	8.89
100.65	73.92	131.95	137.01	36.79	23.00	50.98	2.97	60.82	

STEP 5 Import the calibrated files into AstrolImageJ as a virtual stack

File / Import / Image sequence

Choose the directory with the images

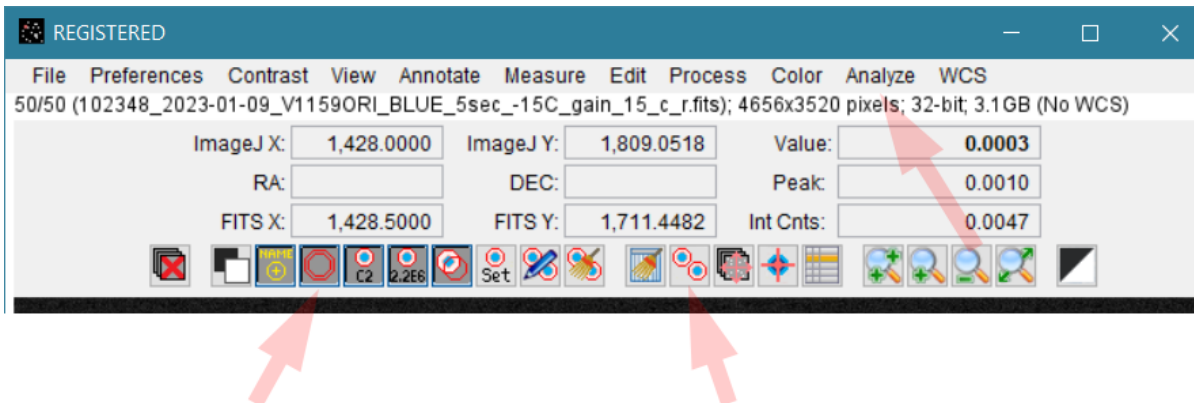
In Filter, put a key word to help determine which ones you want.

Start can be 1

Count can be --- which means all the files.

Step of 1 means consecutive images.

Use virtual stack.



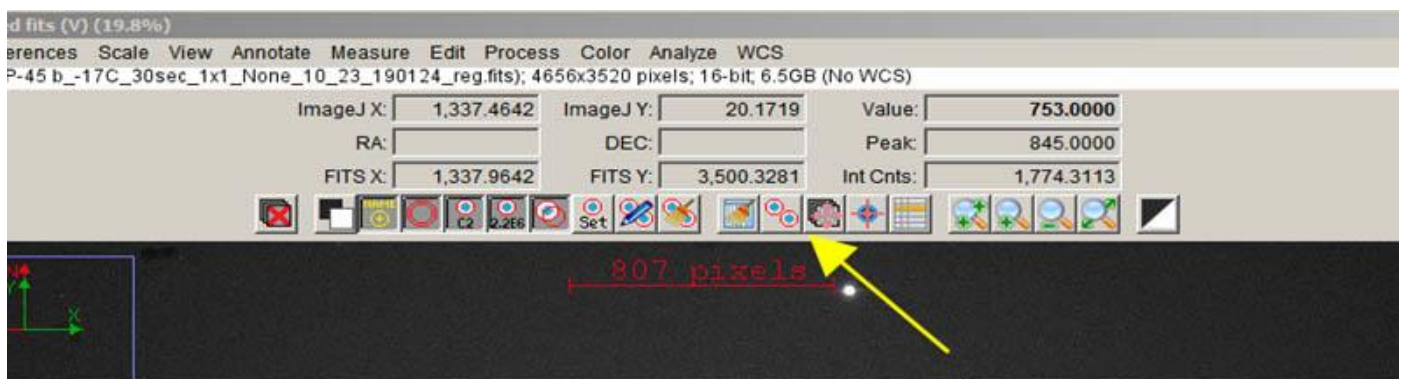
The mouse wheel will zoom the image in or out.

Press ALT and click on any NONSATURATED star in the image

Click Save Aperture and close the window. This will define an optimal aperture based on the profile of a star image.

Press the broom icon with the two apertures to clear the image.

Just above the image, click on the icon with two circles ("Perform Multiple Aperture Photometry")



Make sure First and Last slice are what you want (1, and maximum)

Decide if you want Fixed Apertures (yes you do)

Decide if you want "Use previous apertures..." This actual number will depend on how many previous apertures you last used. If you are learning this process, select "Place all new apertures"

Uncheck "Auto Comparison Stars" unless you know what you are doing.

Select Use RA/Dec to locate aperture positions

Uncheck "Prompt to enter ref star apparent magnitude". For actual photometry, it is needed if you are using Standard Star Magnitudes.

Select Update plot while running. This will draw the light curve as it goes through the images.

Select Aperture Settings

Put in the CCD gain (e/count). If you don't know it, put in 1

Put in the CCD readout noise (get from your camera based on its gain). If you don't know it, put in 0

Put in the CCD dark current per sec. If you don't know it, put in 0

Put in the Linearity warning (determine your cameras linearity). If you don't know it, put in 59,000

Click OK

Uncheck "Halt processing on WCS or centroid error"

Click Place Apertures

Click on "Place Apertures"

Use the "toggle display of sky aperture background.." icon (it looks like two concentric red rings). This shows either full aperture or central aperture only.

Place first aperture on the target star

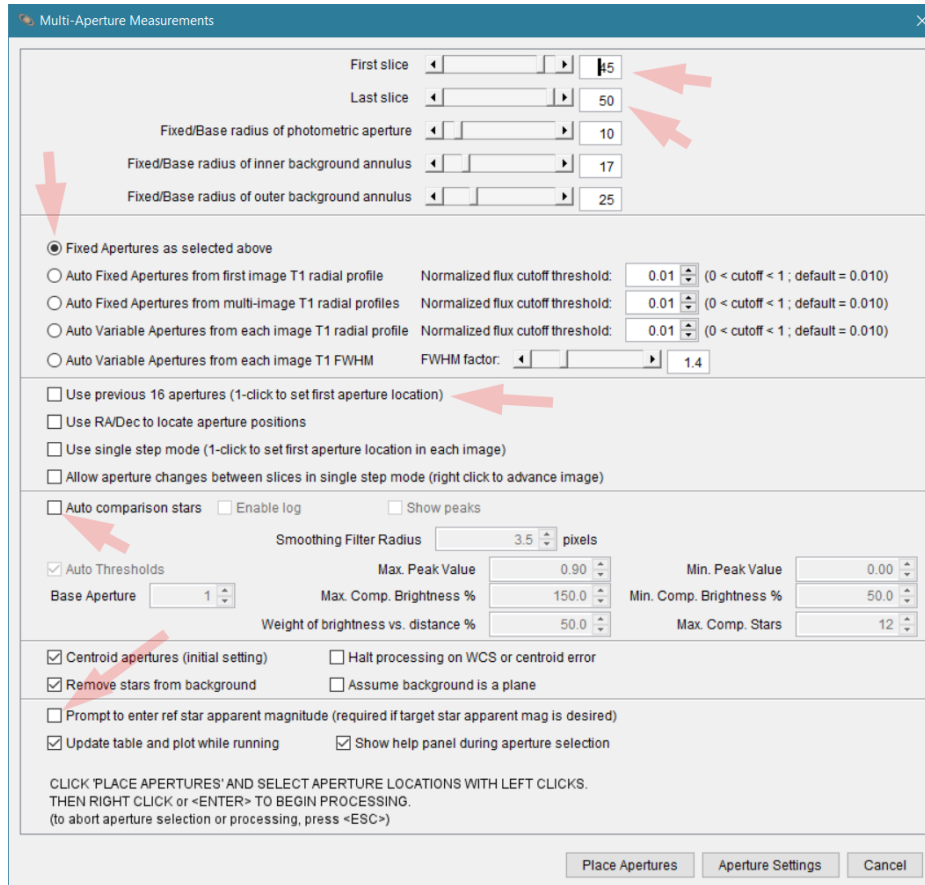
Place many apertures on nearby stars, both a little fainter and a little brighter (but not saturated)

Press ENTER

Now, the program will go through your list of images and do differential photometry on the target star using the reference stars you selected. This will take several minutes and during this time, the program will produce a graph, the light curve, of your target stars light. If a flare had occurred, it will appear as a sharp peak. Good work!

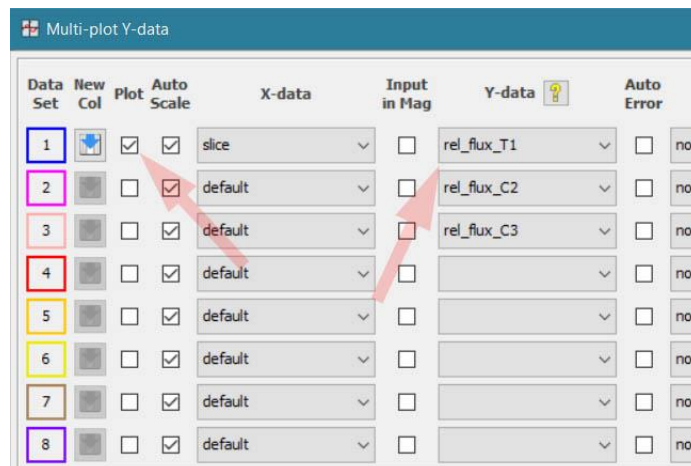
The program will produce a Measurements box and a graph (and several other bewildering windows).

Use File/Save As to save this as FLARESTAR_20231123.tbl (example filename).



In the window "Multi plot Y-data"

tick the box for DataSet 1. This is rel_flux_T1



Lines - will change if a line between data points is shown.

	Symbol	Lines	Input Average	Smooth	Length	Fit Mode	Trend Select	Trend Coefficient	Trend Dataset	Norm/ Mag Ref	Out Ma
	dot	<input checked="" type="checkbox"/>	1	<input type="checkbox"/>	31	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/>	0		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	dot	<input type="checkbox"/>	1	<input type="checkbox"/>	31	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/>	0		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	dot	<input type="checkbox"/>	1	<input type="checkbox"/>	30	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/>	0		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	dot	<input type="checkbox"/>	1	<input type="checkbox"/>	31	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/>	0		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	dot	<input type="checkbox"/>	1	<input type="checkbox"/>	31	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/>	0		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	dot	<input type="checkbox"/>	1	<input type="checkbox"/>	31	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/>	0		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	dot	<input type="checkbox"/>	1	<input type="checkbox"/>	31	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/>	0		<input checked="" type="checkbox"/>	<input type="checkbox"/>
	dot	<input type="checkbox"/>	1	<input type="checkbox"/>	31	off	<input checked="" type="radio"/> <input type="radio"/> <input type="radio"/>	0		<input checked="" type="checkbox"/>	<input type="checkbox"/>

In the window "Multi-plot Main", for Y axis scaling, select custom Y range and put in values of Ymax and Ymin that suit you.

The screenshot shows the 'Multi-plot Main' software interface. The 'Data (Measurements)' section is active, showing 'Default X-data' as 'J.D. -2400000', 'Y-datasets' as '18 sets', 'Detrend Vars' as '3', and 'Rel. Mag. Reference' as '10 samples'. The 'Y-axis Scaling' section is highlighted, showing 'Custom Y-range' selected with 'Y-max' at 1.4 and 'Y-min' at 0.9. Other sections include 'Title', 'Subtitle', 'Legend', 'X-axis Label', 'Y-axis Label', 'Trim Data Samples', 'X-axis Scaling', 'Plot Size', 'Phase Folding', 'Meridian Flip', 'Fit and Normalize Region Selection', and 'Other Panels'.

After you have done differential photometry, you should have saved **the measurements file as measurements.tbl**. You can use a specific filename like **FLARESTAR_20231012.tbl**