Light Curve Photometry with AstroImageJ

How to perform photometry using the free image processing software, AstroImageJ

AstroImageJ is an image processing software which is used to analyse FITS file images. These are the files that are produced by the Faulkes Telescope that you will be using in your investigation.

If you do not already possess the programme, you can download it from the link below:
http://www.astro.louisville.edu/software/astroimagej/installation_packages/

Setting up the data.

STEP 1: Open the AstroImageJ software programme.

STEP 2: A tab should appear; then **File -> Import -> Image Sequence**.

STEP 3: In the pop-up menu that appears, select and double click the first FITS file in the sequence.

STEP 4: In the window which appears, make sure "**Use virtual stack**" and "**Sort names numerically**" are both ticked, then press **OK**.

Viewing your Images

We want to make the images clearer, so the objects stand out and are more easily resolved.

STEP 5: Click on "**display as image negative**" to invert the colours (shown in Fig.1).

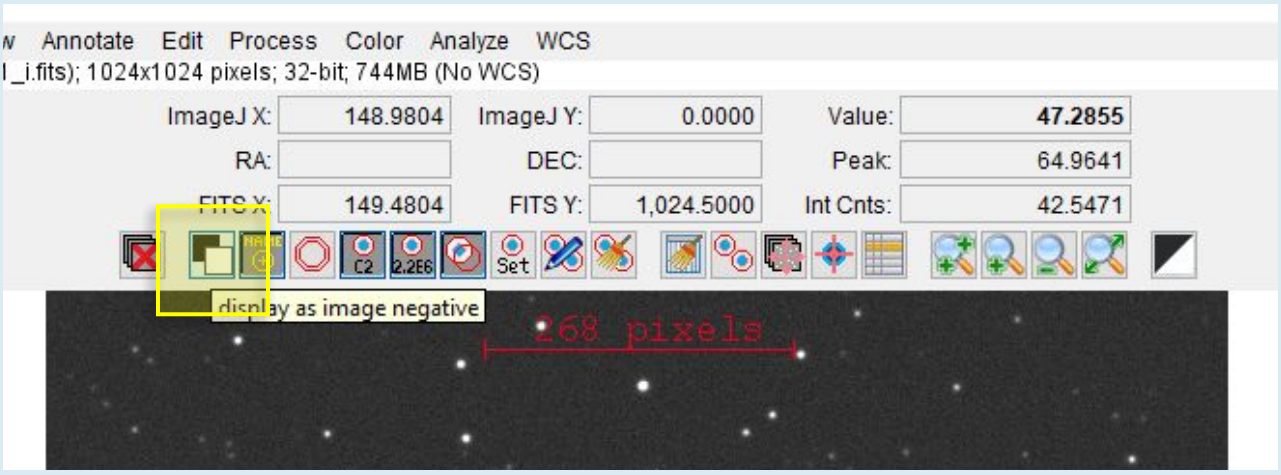

FIG.1 Selecting "display as image negative" in AstroImageJ

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This is commonly used by astronomers as it shows individual objects more clearly, with a greater contrast to the background.

STEP 6: Open your **Finder Chart**.

This is the document which tells you which star your target is, and which stars are your comparisons.
As many telescopes use mirrors, the image may be reversed. Therefore, if the image was not automatically flipped, your image may appear upside-down compared with your finder chart.

IF you need to flip the image: Go to **View -> Invert Y**.

IF you image isn't clear enough: Adjust the brightness and contrast using the sliders at the bottom (shown in Fig.2).

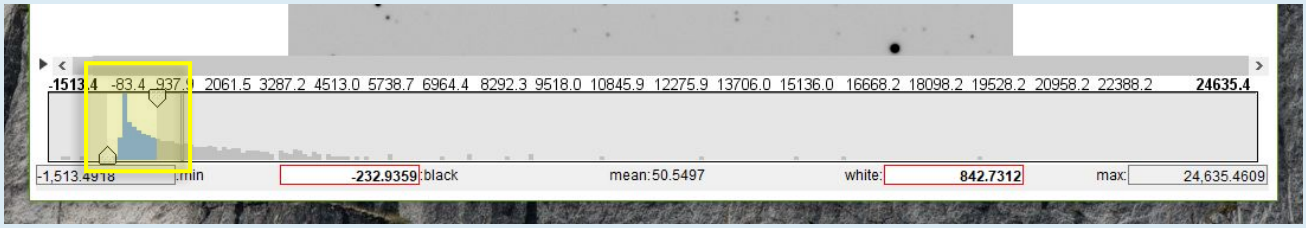

FIG.2 Adjusting the brightness and contrast of images in AstroImageJ

Selecting your Comparison stars

When preforming photometry on multiple frames to see how magnitudes change over time, the measured variability must be analysed. The analysis ensures we are measuring "**true variability**" and not variations caused by other factors. Comparison stars should be indicated on your **Finder Chart** and are **constant** throughout the images.

*Even for a star with constant magnitude, the number of photons that fall onto the pixels within a CCD will vary across images. As a result, the counts that are read also vary and the star would appear to change in magnitude. There are several environmental factors that influence the counts of a star. To account for these variations, we use **comparison stars**.*

Comparison stars are stars that have been measured to establish that they are reliable, and non-variable. They appear in the same field of view as your target object and therefore will be affected in the same way by additional influences unrelated to the stars themselves (see "Photometry in Astronomy" worksheet for more information on environmental factors).
So we select 3-4 stars, as we do not know if they are variable stars or non-variable stars, in the hope that at least two of them will be non-variable stars.

*Once you have understood more about the variations that comparison stars display that can be attributed to environmental factors/seeing effects, their magnitude can be subtracted from the magnitude of your target object. This allows you to obtain the **differential magnitude** of your target and determine its **true variability**.*

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STEP 7: Identify or select 3-4 stars you will be using as a comparison. You will need to use the same comparison stars when measuring all your observations.

(**THEY SHOULD BE A SIMILAR BRIGHTNESS AND NOT SATURATED NOR CLOSE TO THE EDGE OF ANOTHER IMAGE**)
Note: We select 3 or 4 stars as we do not know if they are variable stars (varying magnitude) or non-variable stars (constant magnitude), this is in the hope that at least two of them will be non-variable stars.

There is a limit to how many electrons each pixel can store, so for an exceptionally bright star or a long exposure time, the pixel will reach its capacity and additional electrons will have to spread into the surrounding pixels. This is when the CCD becomes saturated and the resulting image will appear similar to Fig.3.

When this happens, we are unable to get a reliable measure of how bright the star really is.

FIG.3 A saturated image of a star

You MAY want: Check that the comparison stars are visible across all the images, by using the scroll underneath the image (shown in Fig.4).

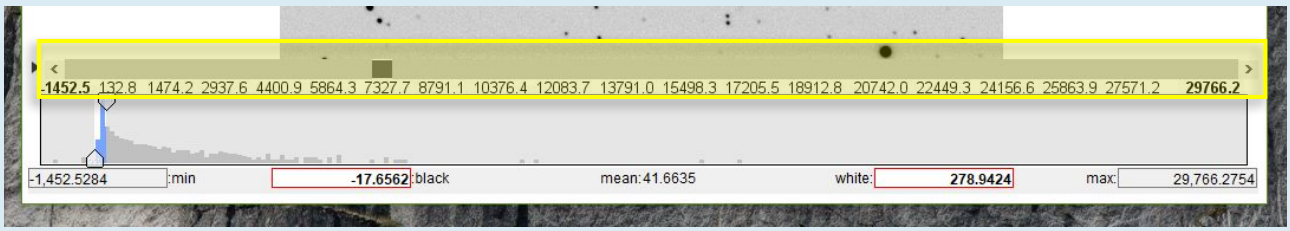

FIG.4 Inspecting a sequence of images in AstroImageJ

Of the target objects in each of the different images, select the image in which the target appears biggest to carry out the remaining steps of this worksheet.
You only need to use one star in one image as all of your comparison stars should be of similar size and brightness.

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Setting your Aperture Radius

Before we can begin to take measurements of objects in the image, we must first find the most appropriate **aperture radius**.

This describes the radius of a circle that surrounds an area on an image in which the pixel values are counted (see photometry in astronomy for further explanation).

STEP 8: Select the line tool in the main menu window (shown in Fig.5).

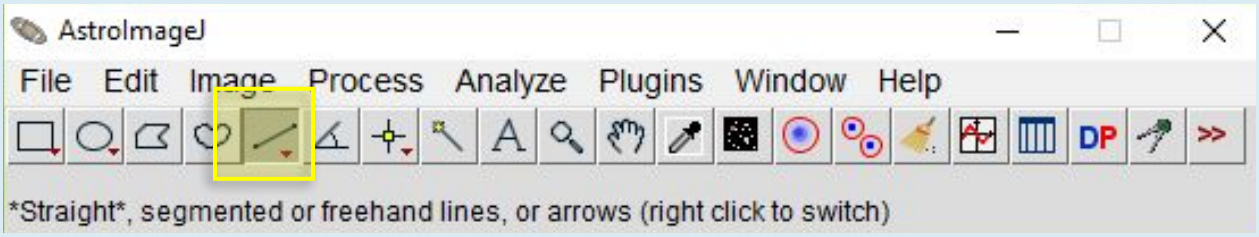

FIG.5 The line tool in AstroImageJ

STEP 9: Draw a line over the target star going through the centre ensuring it's diameter only includes the target. (shown in Fig.6).

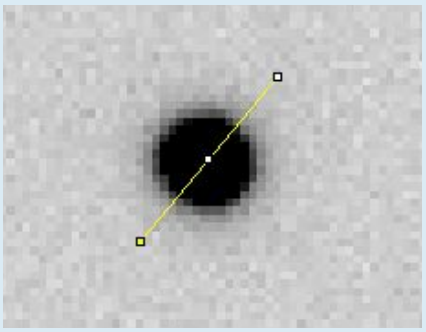

FIG.6 Using the line tool in AstroImageJ

STEP 10: Click **Analyse -> Plot seeing profile** and press **OK** in the pop-up window.

STEP 11: Record the three values in red at the bottom of the graph.

Photometric Analysis of your target

STEP 12: Viewing the first image, select the **Multiple Aperture** tool (shown in Fig.7).

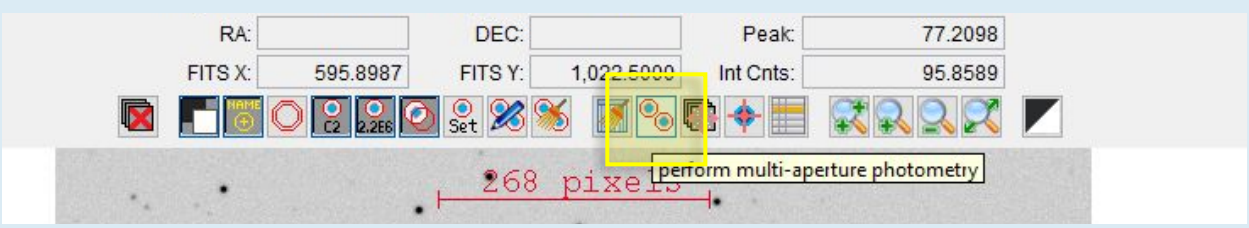

FIG.7 Selecting the multi-aperture tool in AstroImageJ

This will open another window in which you will set the object and sky apertures.

STEP 13: Use the previously recorded values in the new tab and ensure all sections are matching, then click "**Place Apertures**" (**shown in Fig.8**).

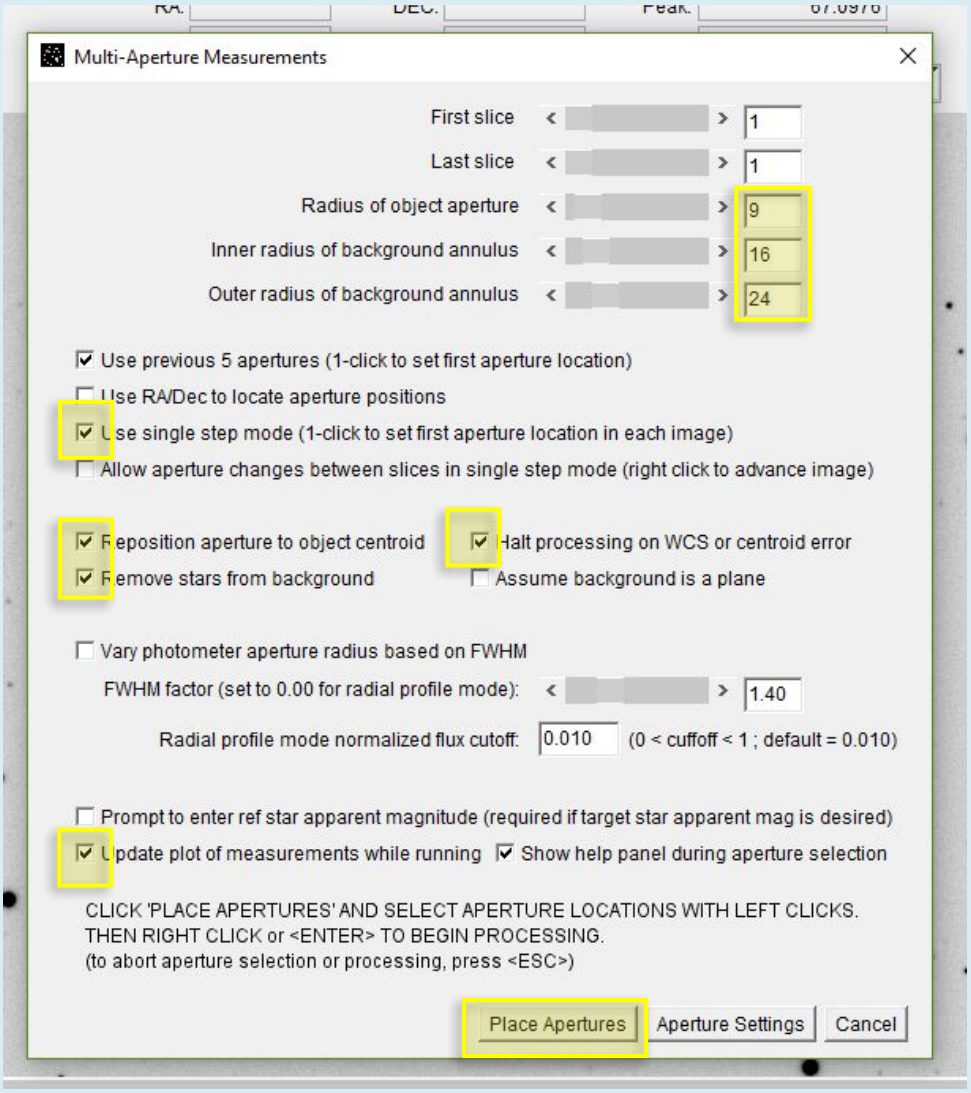

FIG.8 Indicating pop-up window and related sections in AstroImageJ (only all yellow boxes should be ticked)

You cannot have a radius of object aperture that is a larger value than the inner radius of background annulus, nor can you have an inner radius of background annulus that is a larger value than the outer radius of background annulus.

The Inner & Outer radius of background annulus parameters measure the background light in the image within the radius that is set.
These values are then subtracted from the object's light to determine its brightness.

*The most important parameter is the **Radius of object aperture** as this determines the radius within which the counts of the star is measured.*

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STEP 14: Returning to the images, select the target object, then all the comparison stars by clicking on them. (Fig.9 shows an example of this – you may not have the same image!)
If a mistake is made, click on it again to remove it. After selecting the stars press the **Enter key**.

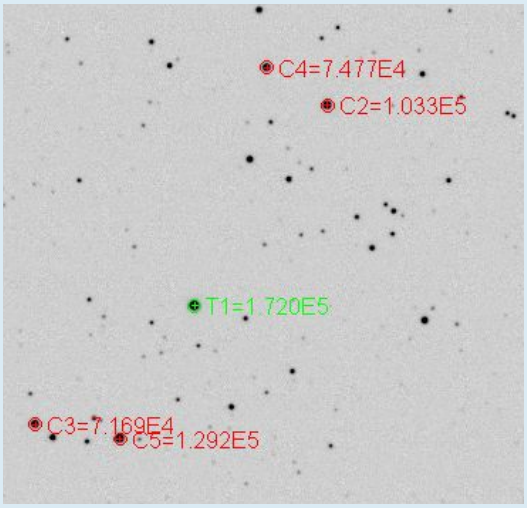

FIG.9 Selecting target and comparison stars in AstroImageJ

STEP 15: With all stars highlighted, in the next image frame, click on the target object again. Repeat this up to and including the last frame.

STEP 16: Once the last frame has been reached, in the **Multi-Plot Main tab** go to **File -> Save data to file.**

You are now ready to analyse your photometry measurements. Refer to the **Light curve plotting with AstroImageJ** worksheet to do this.