



Photometry with SalsaJ

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



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

Step 1: First, open the SalsaJ software programme. Go to **File** → **Open** select all your FITS files of the observations from the Faulkes Telescopes you wish to analyse.

If you do not already have it on your computer, you can download it from the link below:

<http://www.euhou.net/index.php/salsaj-software-mainmenu-9>

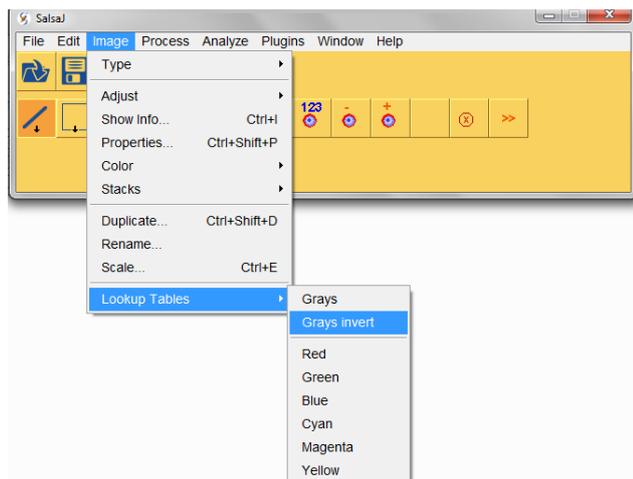
Viewing your Images

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

Step 2: Go to **Image** → **Lookup Tables** → **Grays Invert**, as shown in Figure 1.

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

Figure 1 – Selecting the inverted gray scale on SalsaJ



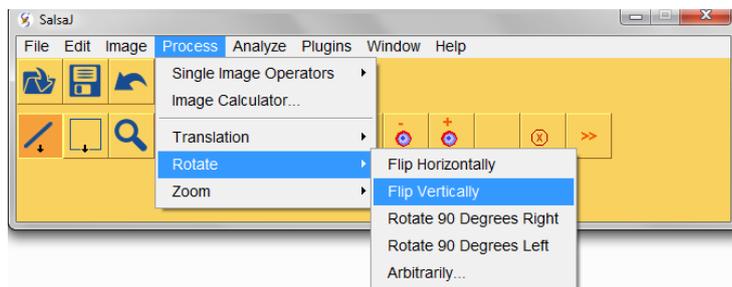
As telescopes use mirrors, the image is the reverse of how it actually appears. Therefore if the image was not automatically flipped, your image may appear upside-down compared with your finder chart.

Step 3: To flip your image, go to **Process** → **Rotate** → **Flip Vertically**.

<https://gaia.ac.uk/alerts>



Figure 2 – Flipping your image on SalsaJ



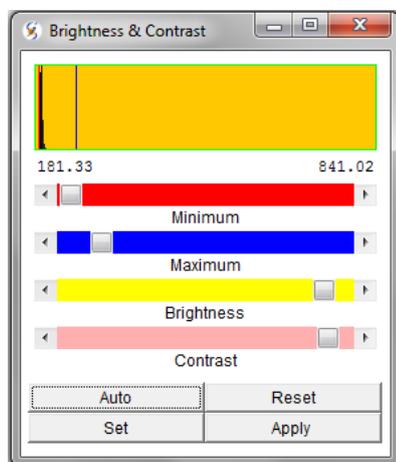
You may also notice that your image appears very dark. We can make the image more distinguishable by adjusting the brightness and contrast.

Step 4: To do this go to **Image → Adjust → Brightness and Contrast**. Or click on the symbol:



This will open the pop-up box shown in Figure 3. Here you can click and drag the sliders to alter the brightness and contrast on your image. Or you can click Auto for the software to do it for you. Clicking on this multiple times will provide various pre-sets.

Figure 3 – Adjusting the brightness and contrast of images on SalsaJ



Selecting your Comparison Stars

If you are performing photometry on multiple images in order to see how the magnitude of an object changes over time, any variability that is measured must be analysed. This is so that we can be sure we are measuring “**true variability**” and not variations caused by other factors.

Even for a star with a constant magnitude, the number of photons that fall onto the pixels within a CCD will vary across images. As a result the intensity that is read also varies and the star would appear to change in magnitude.



There are a number of environmental factors that influence the intensity of a star. To account for these variations we use **comparison stars**.

Note: See worksheet 'Photometry in Astronomy' for more information.

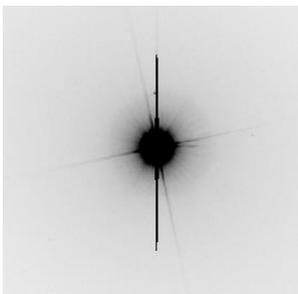
Comparison stars are stars that have been measured to establish that they are reliable, non-variable stars. Comparison stars appear in the same field of view as your target object and therefore will be affected in the same way by additional influences unrelated to the stars themselves (see "Photometry in Astronomy" worksheet).

Once you have determined that the comparison stars are not variable stars (we will do this in the 'Supernovae with SalsaJ' worksheet), and variations that they display 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**.

Step 6: Select **3 or 4 stars** to be comparison stars in your image. They should be roughly the **same brightness** as your target object and should not be saturated or close to the edge of the image.

A saturated star will appear similar to Figure 3. There is a limit to how many electrons each pixel can store, so for an exceptionally bright star or a long exposure, 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 Figure 3. When this happens, we are unable to get a reliable measure of how bright the star really is.

Figure 3 – A saturated image of a star.



You will need to use the same comparison stars when measuring all your observations so you may want to check your chosen comparison stars are visible across all your images.

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.

It is possible that you will need to **zoom in two or three times** to get a better view of your target. To zoom in select the **magnifying glass** button and then click on the region of your image you wish to magnify.





Refer to your **Finder Chart**. Of your chosen comparison stars, you will need to select **just one** 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.

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**.

Note: See *Photometry in Astronomy* for further explanation.

The SalsaJ software automatically sets this radius as the Full Width Half Maximum (FWHM) of the stars within the image.

Note: See *Appendix 1* for an explanation and how this is automated.

However, in order to obtain the most accurate results, you will **manually** set your aperture radius after experimenting with different sizes.

To do this you will make measurements and record the intensity values for each set radius for you to compare. You will only need to use **one of your images** and **one comparison star** to do this.

Step 7: On the SalsaJ toolbar, go to **Analyse → Photometry Settings**.

You will see these settings are all set to Auto, as described earlier.

Step 8: Next to the Star Radius and Sky options, change the settings from Auto to **Forced Star Radius** and **Forced Sky Radius** (see Figure 4).

You can leave the **Star's Center** as **Auto**. The Sky Radius and Sky Value measure the background light in the image within the set radius. These values are then subtracted from the light from the object you are measuring in order to determine its brightness.

Figure 4 – Applying the photometry settings on SalsaJ



The most important parameter is the **Star Radius**, as this determines the radius within which the intensity of the star is measured.



Step 9: Begin by inputting the following values into the corresponding boxes (as seen in Figure 4):

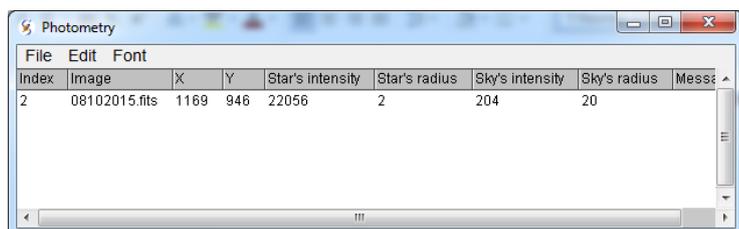
Forced Star Radius: 2

Forced Sky Radius: 20

Step 10: Now go to **Analyse → Photometry**. A pop up box titled Photometry will appear. Click on the centre of one of your comparison stars in the image.

You will see a circle appear on the image and an entry will appear in the Photometry box as seen in Figure 5.

Figure 5 – Results of photometry measurements on Salsal



Step 11: Repeat Steps 9 and 10, **increasing** the Forced Star Radius by **2 until you reach 18**. Make sure you leave the Forced Sky Radius as 20 throughout and you always use the **same comparison star** and only **one image**.

When you have done this you should have 9 lines of results in your Photometry box.

Step 12: At the top of your Photometry box, go to **File → Save As**, and save the data under an appropriate name. This will save the data as a CSV file that is compatible with Microsoft Excel and other spreadsheet programmes (See Appendix 2).

Interpreting your Data

Step 13: Now open the saved file into an **Excel Spreadsheet** (or similar software).

Note: As the data will save as a .CSV file, Excel might not recognise it straight away. You will have to search for 'All Files' rather than 'All Excel Files'.

The data that you will need is in under **Star's intensity** and **Star's radius** (columns E and F as shown in the blue square in Figure 6). The star's intensity represents how much light fell onto the pixels within the given aperture radius (star radius), minus the background sky light.

Figure 6 – Aperture photometry measurements made with Salsaj presented in a Microsoft Excel spreadsheet.

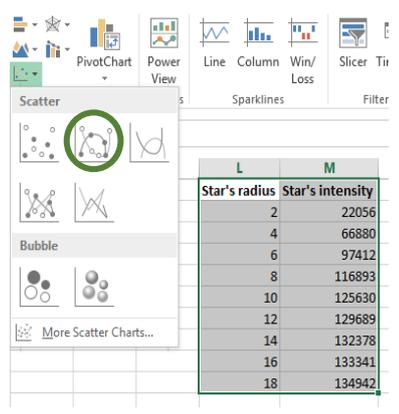
	A	B	C	D	E	F	G	H	I
	Index	Image	X	Y	Star's intensity	Star's radius	Sky's intensity	Sky's radius	Message
1	1	08102015.	1169	946	22056	2	204	20	
2	2	08102015.	1169	946	66880	4	168	20	
3	3	08102015.	1169	946	97412	6	144	20	
4	4	08102015.	1169	946	116893	8	129	20	
5	5	08102015.	1169	946	125630	10	122	20	
6	6	08102015.	1169	946	129689	12	119	20	
7	7	08102015.	1169	946	132378	14	116	20	
8	8	08102015.	1169	946	133341	16	116	20	
9	9	08102015.	1169	946	134942	18	114	20	



Now we will use the data in these columns to plot an XY Scatter chart with **star's radius on the X-axis** and **star's intensity on the Y-axis**.

Step 14: To do this, highlight the data in the 2 columns and go to **Insert → Chart → Scatter**

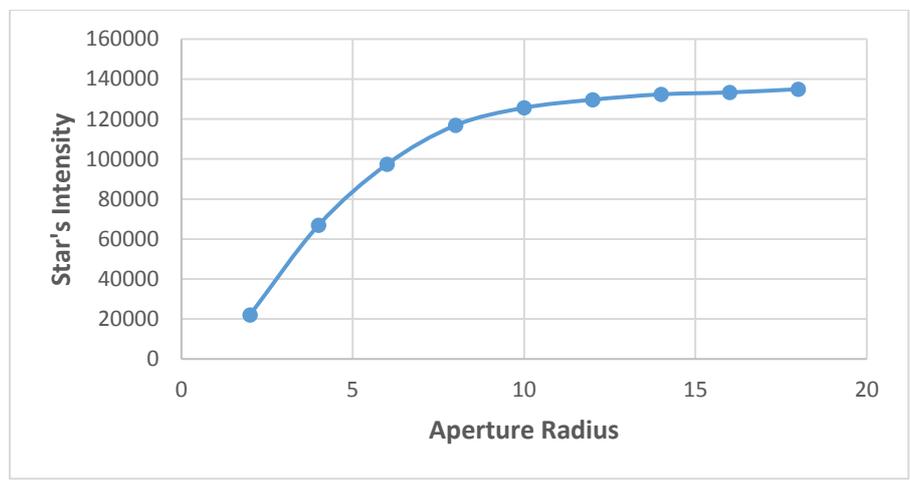
Figure 7 – Inserting a scatter chart on Microsoft Excel.



Step 15: Adjust the **minimum and maximum values** on the axis to make your graph clearer. Do this by double-clicking on the Y-axis and selecting **Axis Options → Values in Reverse Order**.

You should then have a graph that appears similar to Figure 8.

Figure 8 – Example of a graph of aperture photometry measurements displaying aperture radius against intensity



Step 16: Can you explain what is happening in the graph and the reason for its shape?

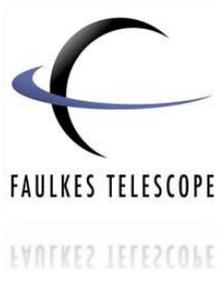


Step 17: Use your graph to identify the radius at which the majority of the star's intensity is included within the aperture radius, and minimal amounts of background sky.

Hint: Look for the area where the graph begins to plateau.

Step 18: What part of your eye is comparable with the aperture radius used in photometry?

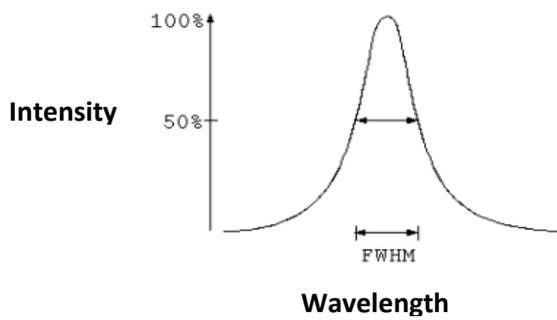
Now that you have found an appropriate aperture radius using one of your comparison stars, you are ready to perform your photometry measurements on your target supernova. Refer to the **Photometry of Supernovae with SalsaJ** worksheet to do this.



Appendix 1 – Full Width Half Maximum (FWHM)

FWHM describes the width of an object within an image. When stars are imaged we can plot a graph of their pixel values. This presents a specific profile which is similar for all stars in that image. The profile will appear like the one shown in Figure 1.

Figure 1 – A plot to display the Full Width Half Maximum of a star





Appendix 2 – CSV Files

CSV files are “comma separated values” files. These are used to store data in a table structured format that can be imported into a spreadsheet software for analysis.