# Light Curve Plotting with AstroImageJ & Excel

How to plot light curves using the free image processing software, AstroImageJ

Classroom Activity

## Outline

This worksheet describes how to use your photometry measurements to investigate the changing brightness of your target.

When you have carried out your measurements and obtained your data, you will present your results on graphs to display the **light curves** of the target.

Prior to carrying out this activity, if you have not used the AstroImageJ software previously or carried out photometry, it is recommended that you read through and complete the '**Light Curve Photometry with AstroImageJ**' worksheet.

## Procedure:

### Presenting your Data

1. When you have completed the photometric analysis for each of your images in one filter, open your data into an **Excel Spreadsheet**.

2. Choose **Yes** in the error message that appears.

3. If a 'Test Import Wizard' box appears, click **Finish**.



The online observatory collaboration consists of the following partners:
Baldone Observatory, Brorfelde Observatory, Cardiff University, Harestua Solar Observatory, Helsinki Observatory

Your results should look like those seen in Figure 1. Here the target and comparison stars have been recorded, where the first column represents the number of the frame.

Figure 1 - Photometry results obtained from AstroImageJ presented in an Excel spreadsheet.

| | Label | slice | Saturated | J.D.-2400000 | JD_UTC | JD_SOBS | JD_MOBS | HJD_MOB | BJD_MOB | ALT_OBJ | AIRMASS | Source_Ra | Sky_Rad(n | Sky_Rad(n | rel_flux_T1 | rel_flux_C | rel_flux_C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 006-c_e_2 | 1 | 0 | 55814.66297 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.038777 | 15 | 20 | 35 | 0.357342 | 0.188181 | 1.864217 |
| 2 | 010-c_e_2 | 2 | 0 | 55814.66701 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.044888 | 15 | 20 | 35 | 0.358019 | 0.18926 | 1.854087 |
| 3 | 016-c_e_2 | 3 | 0 | 55814.67302 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.054918 | 15 | 20 | 35 | 0.357152 | 0.189419 | 1.855231 |
| 4 | 021-c_e_2 | 4 | 0 | 55814.67819 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.064492 | 15 | 20 | 35 | 0.356327 | 0.189524 | 1.853442 |
| 5 | 027-c_e_2 | 5 | 0 | 55814.68425 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.076861 | 15 | 20 | 35 | 0.357712 | 0.189881 | 1.850629 |
| 6 | 030-c_e_2 | 6 | 0 | 55814.68748 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.083972 | 15 | 20 | 35 | 0.355816 | 0.188926 | 1.85289 |
| 7 | 032-c_e_2 | 7 | 0 | 55814.68961 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.088867 | 15 | 20 | 35 | 0.358017 | 0.188205 | 1.857318 |
| 8 | 034-c_e_2 | 8 | 0 | 55814.6917 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.093818 | 15 | 20 | 35 | 0.357595 | 0.189459 | 1.852204 |
| 9 | 036-c_e_2 | 9 | 0 | 55814.69378 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.098931 | 15 | 20 | 35 | 0.357045 | 0.188587 | 1.854797 |
| 10 | 040-c_e_2 | 10 | 0 | 55814.69777 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.109197 | 15 | 20 | 35 | 0.356184 | 0.189239 | 1.853001 |
| 11 | 042-c_e_2 | 11 | 0 | 55814.6998 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.114644 | 15 | 20 | 35 | 0.356792 | 0.18865 | 1.853654 |
| 12 | 044-c_e_2 | 12 | 0 | 55814.70181 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.120225 | 15 | 20 | 35 | 0.356033 | 0.188884 | 1.857478 |
| 13 | 046-c_e_2 | 13 | 0 | 55814.70391 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.126207 | 15 | 20 | 35 | 0.35418 | 0.1897 | 1.851917 |
| 14 | 048-c_e_2 | 14 | 0 | 55814.70592 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.132132 | 15 | 20 | 35 | 0.351482 | 0.188847 | 1.852352 |
| 15 | 050-c_e_2 | 15 | 0 | 55814.70798 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.138373 | 15 | 20 | 35 | 0.352666 | 0.190003 | 1.856683 |
| 16 | 052-c_e_2 | 16 | 0 | 55814.71001 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.14469 | 15 | 20 | 35 | 0.349652 | 0.189057 | 1.859622 |
| 17 | 054-c_e_2 | 17 | 0 | 55814.71195 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.150927 | 15 | 20 | 35 | 0.349813 | 0.19107 | 1.85068 |
| 18 | 055-c_e_2 | 18 | 0 | 55814.71293 | 2455815 | NaN | NaN | NaN | NaN | NaN | 1.154149 | 15 | 20 | 35 | 0.347954 | 0.188857 | 1.854182 |

## Julian Date

The column 'J.D.-2400000' is 'Julian Date minus 2400000'. Julian Date is a system made by astronomers to simplify calculating the difference between two dates. The Julian Date system assigned 1st January 4713BC to be "Day 0", and we've been counting up since then.

Imagine you want to know how many days are between 12th January 2003 and 24th March 2005. In our normal date system you'd have to consider how many days are in each month, as well as leap years. With the Julian Dates, you just have to subtract two numbers.

Since we're now at such a large number in Julian Days we subtract 2,400,000 from the Julian Date to give a more manageable number. Julian Date minus 2400000 is sometimes called "Modified Julian Date".

## Calculating Magnitude

We now need to calculate the Magnitude. This is calculated from rel_flux_T1.

The flux value refers to the number of photons that fell onto the CCD in a given area divided by the exposure time, and is a measure of how bright the star is. The area for 'rel_flux_T1' is the aperture radius that you set.

We convert this value into magnitude (the system astronomers use to describe a star's brightness) using Equation 1:

**Equation 1 - Calculating magnitude from flux**

$$magnitude = -2.5 \times log10flux$$

**4**

Right click on the column immediately to the right of the 'rel_flux_T1' column. Select **Insert**.

**5** In the pop up box choose **Entire column**. This should add a new column to the right of ‘rel_flux_T1’ column.

**6** Name this column as “mag” (for magnitude).

**7** In the first box of this column, type “=-2.5*log10(“, then click on the first box in the ‘rel_flux_T1’ column, followed by typing “)”. After this, press Enter.

**8** Drag this box from the little square in the bottom right to the end of the spreadsheet, as shown in Figure 2.

Figure 2 - Dragging a formula across multiple rows in an Excel spreadsheet.

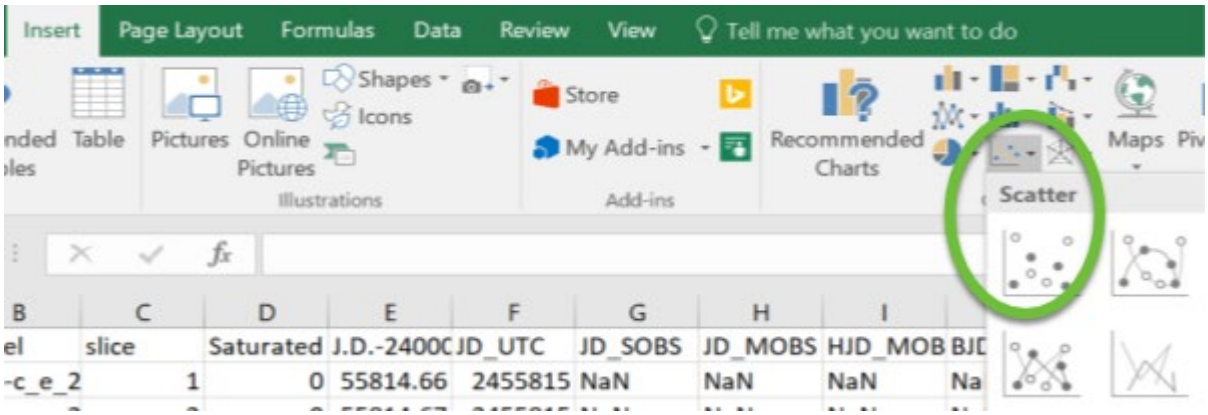
| N | O | P | Q | R |
|---|---|---|---|---|
| y_Rad(n | Sky_Rad(n | rel_flux_T1 | B | rel_flux_C r |
| 15 | 20 | 0.024401 | 4.0314809 | 0.38447 |
| 15 | 20 | 0.028651 | | 0.378879 |
| 15 | 20 | 0.027903 | | 0.384256 |
| 15 | 20 | 0.024838 | | 0.386036 |
| 15 | 20 | 0.026288 | | 0.373655 |
| 15 | 20 | 0.024083 | | 0.379086 |
| 15 | 20 | 0.024989 | | 0.38347 |
| 15 | 20 | 0.023389 | | 0.385285 |
| 15 | 20 | 0.027759 | | 0.381856 |
| 15 | 20 | 0.021858 | | 0.378986 |
| 15 | 20 | 0.032388 | | 0.382128 |
| 15 | 20 | 0.025211 | | 0.379149 |
| 15 | 20 | 0.027005 | | 0.382577 |

## Plotting your Light Curve

**9** To plot your graph, highlight the 'J.D.-2400000' column and the new column you've created whilst holding ctrl.

**10** Go to **Insert -> Scatter Chart** as in Figure 3**.** This should produce a graph displaying magnitude on the y-axis and 'J.D.-2400000' on the x-axis.

Figure 3 - Plotting a scatter chart to produce a light curve in Excel.




**11** You will need to **reverse the values of your y-axis**. This is because lower magnitude values represent brighter objects than higher magnitude values.

Note: See Calculating Magnitudes worksheet for further explanation.

**12** To do this, double click on your values on the y-axis of the graph. A toolbar on the right-hand side of the document should appear.

**13** To do this, double click on your values on the y-axis of the graph. A toolbar on the right-hand side of the document should appear.

**14** Tick the box that says '**Values in reverse order**'. This is shown in Figure 4.

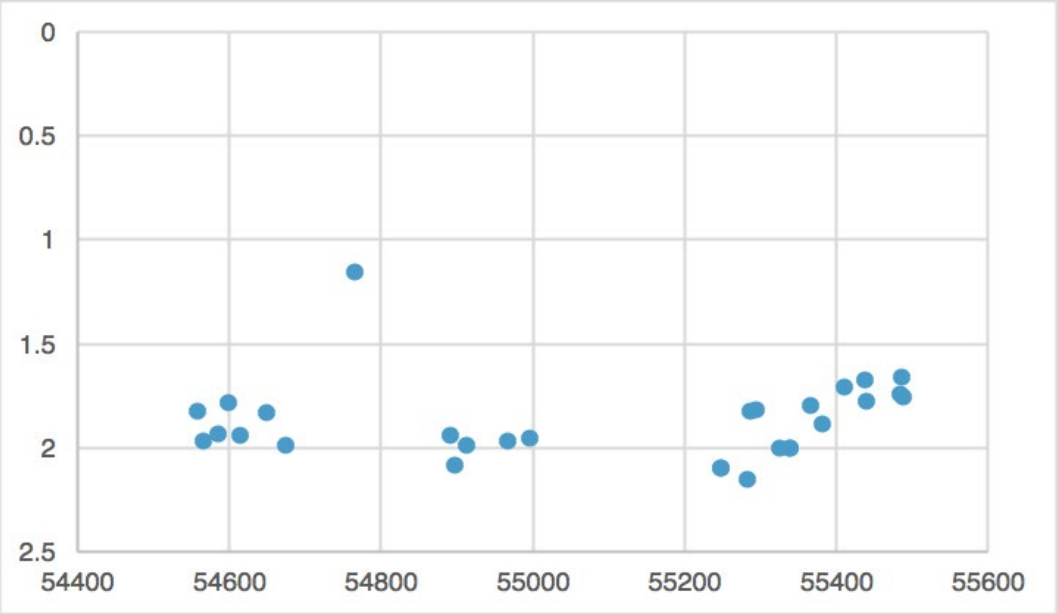
Figure 4 – Reversing the y-axis in Excel.


**15** After reversing the y-axis values, you will notice that the x-axis has moved to the top of your plot. To move it, double click on the y-axis to open the Format Axis toolbar as shown in Figure 4.

**16** Tick the **Maximum axis value** box under the 'Horizontal axis crosses' section.

**17** If there's lots of white space in your graph, like in Figure 5, you may want to manually change the y-axis so that it doesn't go to 0.

Figure 5 - An example of a graph with too much vertical white space, produced in Excel.

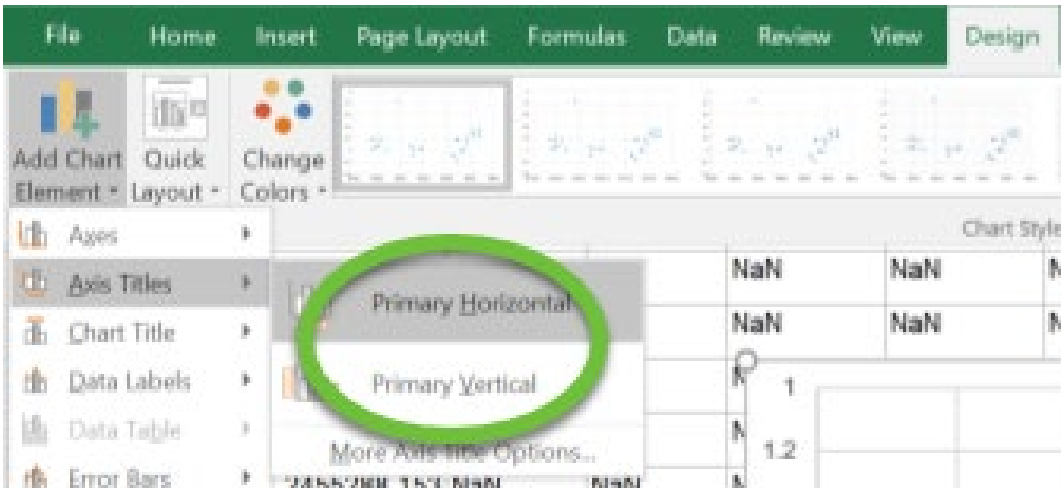



**18** To manually change your y-axis, type your desired upper limit of the y-axis in the 'Minimum' box under the 'Bounds' section as in Figure 4. For the example shown in Figure 5, we might choose an upper limit of 1.

**19** Experiment with the upper limit of your y-axis until you're happy with how your light curve looks.

**20** To add labels to your axes, click on your graph and select Design -> Add Chart Element -> Axis Titles as shown in Figure 6.

Figure 6 - Adding labels to your axes in Excel.




**21** Click on the y-axis label that's been added and type 'Magnitude'.

**22** Click on the x-axis label that's been added and name it 'J.D.-2400000'.

**23** To add a title to your plot, click on your graph and select **Design -> Add Chart Element -> Chart Title**

**24** Click on the title that's been added and type "[object name] Light Curve".

You now have a light curve of your target!

Note: For more information on magnitudes, see the 'Calculating Magnitudes' worksheet.

You can use your results in another activity to add error bars to your light curves.

To do this, refer to the '**Light Curve Error Bars with AstroImageJ & Excel**' activity. This can be found on the Faulkes Telescope website.