Light Curve Plotting with AstroImageJ & Numbers

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 a **Numbers Spreadsheet**.

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 a Numbers 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

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

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.

$$magnitude = -2.5 \times \log_{10} flux$$

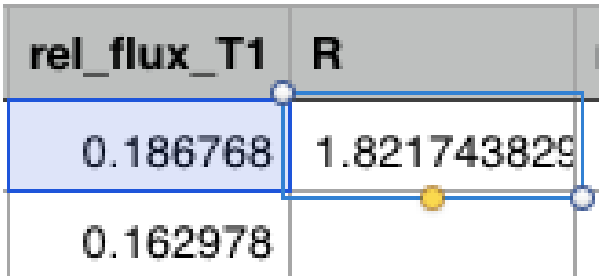
2 Hold control and click on the 'rel_flux_T1' column. Select **Add Column After**. This should add a new column to the right of 'rel_flux_T1' column.

3 Name this column as "mag" (for magnitude).

4 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.

5 Drag this box from the yellow circle at the bottom of the box to the bottom of the spreadsheet, as shown in Figure 2.

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

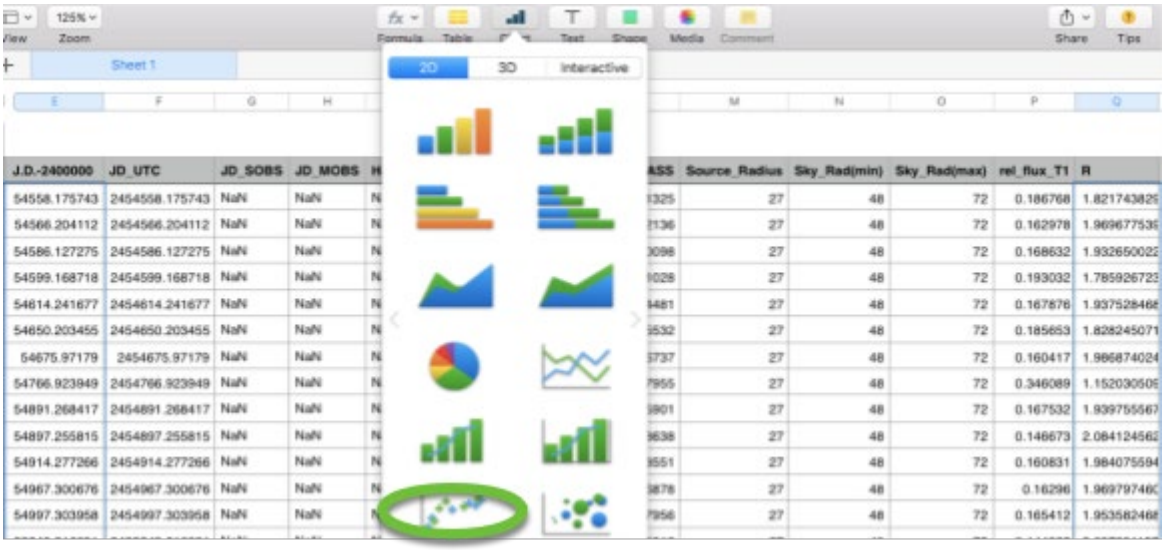


Plotting your Light Curve

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

7 Go to **Chart -> 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 Numbers.



8 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.

9 To do this, create another new column to the right of the magnitude column you've created. Label this "-[letter representing filter]".

10 In the first box of this column, type "=-", then click on the first box in the magnitude column you created in Step 2. After this, press Enter.

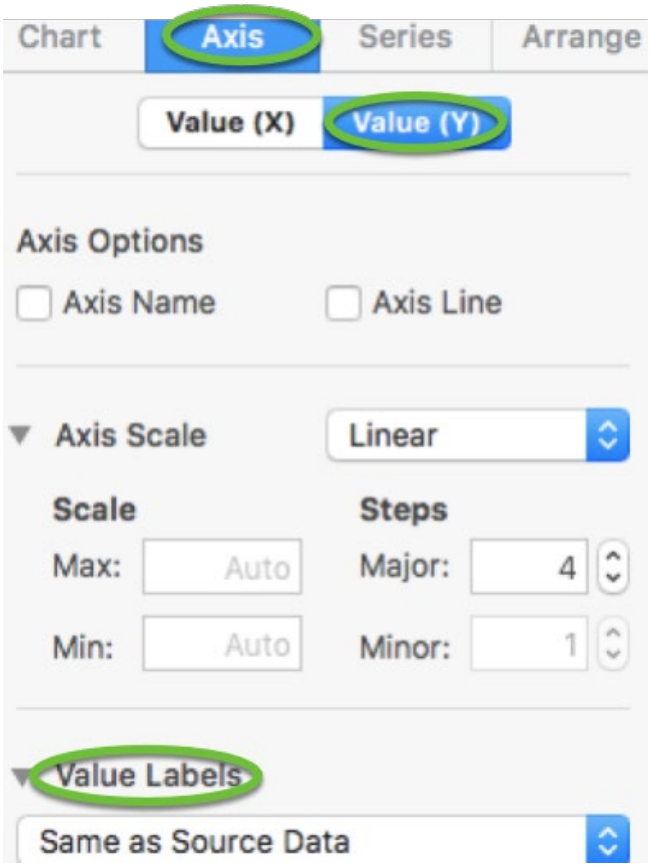
11 Drag this box to the bottom of the spreadsheet.

12 Plot a new scatter chart with 'J.D.-2400000' and this newest column.

13 Click on your new graph.

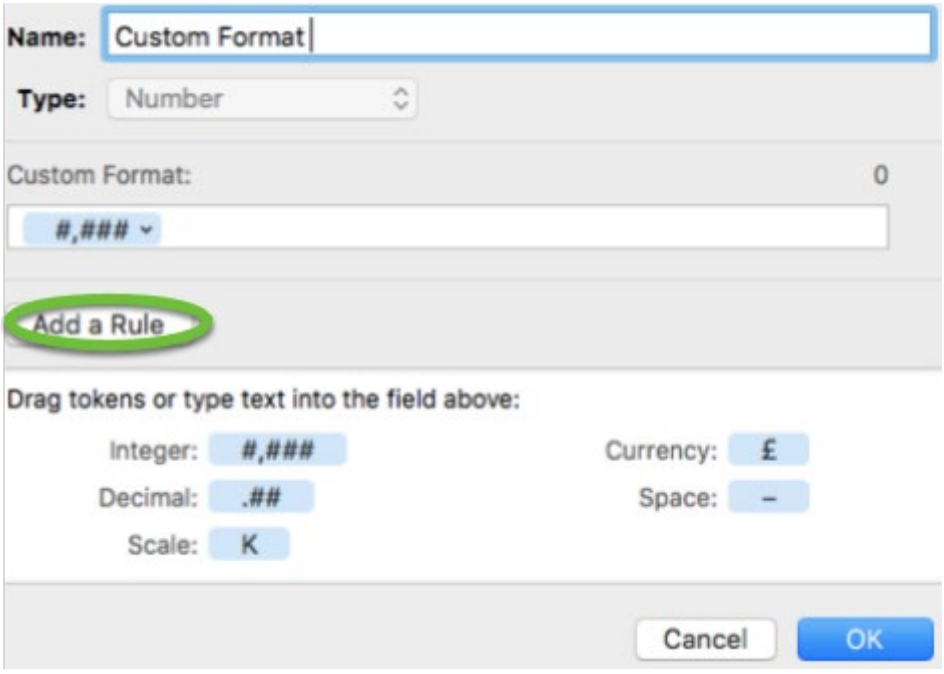
14 On the right-hand menu, select **Axis**, then **Value (Y)** towards the top. In the 'Value Labels' drop-down menu, choose **Create Custom Format**. This is shown in Figure 4.

Figure 4 – Creating a Custom Format for Y-axis values in Numbers.



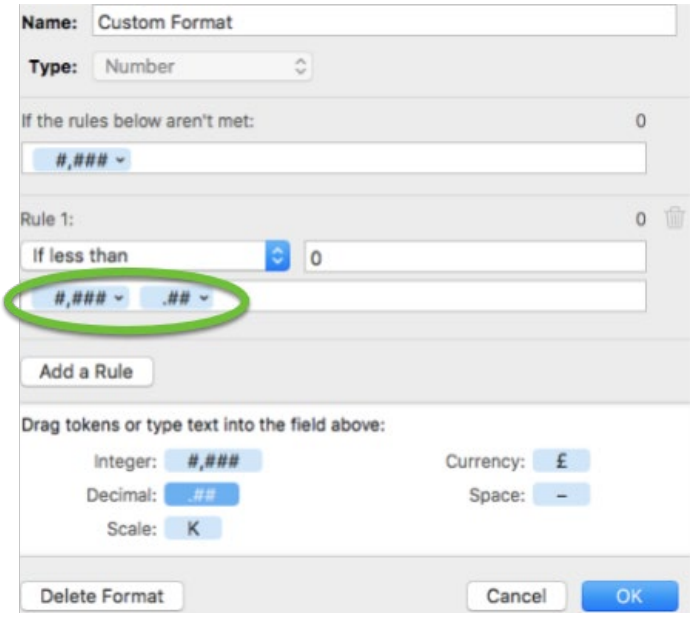
15 In the pop up menu that appears, select Add Rule as in Figure 5.

Figure 5 - Choosing to Add Rule in a Custom Format of data in Numbers.



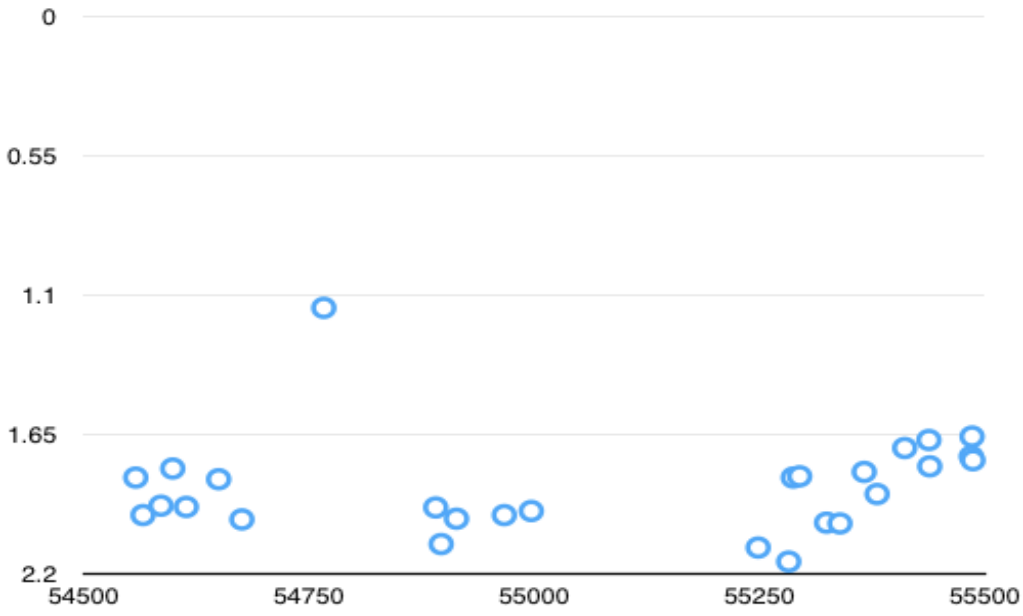
16 In the box under 'If less than', drag the 'Decimal' text to place it after the text that's already there so that it looks like Figure 6. Then press OK.

Figure 6 - Editing negative data values so that no minus sign appears on a graph in Numbers.



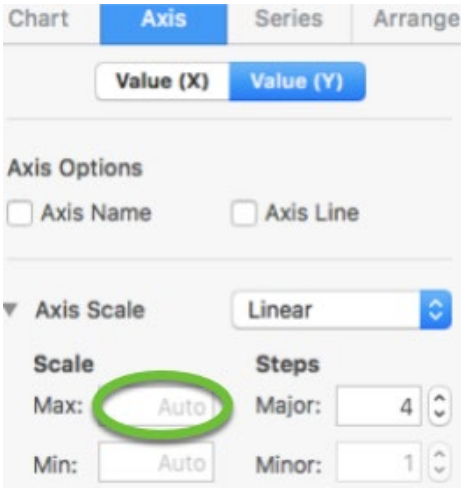
17 If there's lots of white space in your graph, like in Figure 7, you may want to manually change the y-axis so that it doesn't go to 0.

Figure 7 - An example of a graph with too much vertical white space, produced in Numbers.



18 To manually change your y-axis, type your desired maximum y value in the 'Max' box, shown in Figure 8. Remember to write a minus sign in front of the number. For the example shown in Figure 7, we might choose to type -1 so that there's a convenient spacing of 0.3 between each y-axis line.

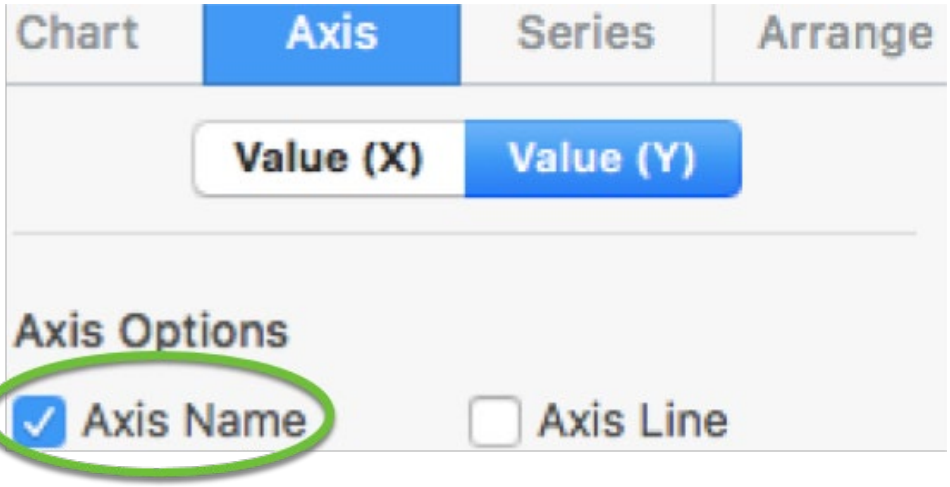
Figure 8 - Manually changing the maximum value of the y-axis in Numbers.



19 Experiment with your max y-axis value until you're happy with how your light curve looks.

20 To add a label to your y-axis, tick 'Axis Name', as in Figure 9.

Figure 9 - Adding a label to the y-axis in Numbers.



21 Click on your graph, then double click on the y-axis label that's been added.

22 Type 'magnitude' as your y-axis value.

23 Click on your graph again

24 On the right-hand menu of Figure 9, choose **Value (X)**.

25 Do the same process for the x-axis as in Steps 18-19.

26 Name the x-axis 'J.D.-2400000'..

27 On the right-hand menu of Figure 9, choose **Chart**.

28 Now tick **Title** under 'Chart Options'.

29 Double click on the "Title" that's been added above your graph.

30 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 & Numbers**’ activity. This can be found on the Faulkes Telescope website.