Lcvis Instructions for Use

Overview

This document contains instructions on running the lcvis program and how to use it, as well as explaining what the program does once executed. The program was originally written by Grant Donnelly and has been updated by Jacob Juvan. Feel free to contact me with any questions at either jjuvan25@jcu.edu or jacobajuvan@gmail.com.

–Jacob Juvan

About Lcvis

Lcvis, which means "**l**ight**c**urve **vis**ual", provides a way to manually assign a period to a star and compare it to a specific fit. The software takes data from a .dat file and fits it to some initial period, *usually the period output by Unconex*. The first observation within the .dat file is marked as the epoch and its time of observation is set to 0. Each subsequent observation's timestamp is adjusted to mark the time between the epoch and the current observation, which is then adjusted by the period given to the program. Each observation is plotted on a Phase vs. Magnitude plot to show the variation and period of the object. In addition, each observation is compared to its expected value on a curve fit, and the chi-square per degree of freedom value of the lightcurve compared with the fit is displayed in the figure.

Using Lcvis

To run lcvis.py, you will need a .dat file with the lightcurve for your object as well as the lcvis program itself. It is best that both items are within the same directory. If both items are in different directories, either copy lcvis.py to the directory containing the .dat file, or memorize the paths to each item.

The lcvis program contains three inputs:

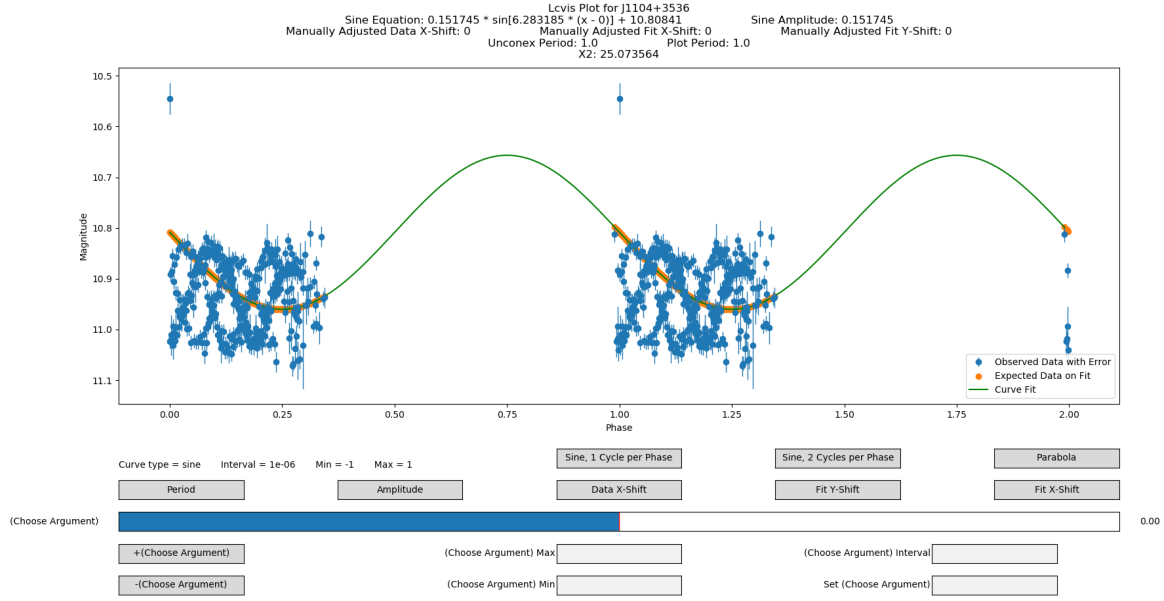
- ***data***: the .dat file to be examined
- ***obj_name***: the name of the object that is being examined
- ***period_initial***: the Unconex period of the object

Below are the general inputs of the program and examples of how to run the program.

- General:
  - > python3 lcvis.py data obj_name period_initial
- Assume you are looking at object J1126+4356 and the lightcurve file name is J1126+4356_lc.dat, with an Unconex period of 0.5 days, and both the .dat file and lcvis are in the same directory:
  - > python3 lcvis.py J1126+4356_lc.dat J1126+4356 0.5
- Now assume the same scenario, but lcvis.py is located in the *pytools* directory:
  - > python3 pytools/lcvis.py J1126+4356_lc.dat J1126+4356 0.5
- Now assume the .dat file is in the *stars* directory:
  - > python3 pytools/lcvis.py stars/J1126+4356_lc.dat J1126+4356 0.5

Generating a phased plot for a star object

Once the program is executed and reads the .dat file and other inputs, a plot of the lightcurve is generated. An example of a generated lightcurve, with an initial period of 1 day, is shown below.



The plot displays two phases for the lightcurve of object J1104+3536 with a period of 1 day. **Blue points** represent the magnitude of the observed data within a phase, along with the error of magnitude for each observation (observed data). The **green curve** represents a generic sine function and the fit that the program will compare observations to. The **orange points** represent the magnitude of an observation if it were to follow a perfect sine curve (expected data). *Note that the magnitude axis is inverted, that is the values increase downward. This is because the magnitude of a star increases positively when its apparent brightness decreases.*

Adjusting a phased plot

There are a few different buttons, sliders, and text boxes that can be used to provide different adjustments to the plot. Some cannot be used until an input argument is chosen.

The following curve fits are available:

- ***Sine, 1 Cycle per Phase***: changes the green curve fit to a sine function with a frequency of 1 cycle per phase. This is the default curve fit.
- ***Sine, 2 Cycles per Phase***: changes the green curve fit to a sine function with a frequency of 2 cycles per phase.
- ***Parabola***: changes the green curve fit to a parabolic function.

The following arguments are available:

- ***Period***: adjusts the period of the lightcurve. Default is the given initial period.
- ***Amplitude***: adjusts the amplitude of the fit. Default is data dependent.
- ***Data X-Shift***: adjusts the phase shift of the lightcurve. Default is 0.
- ***Fit Y-Shift***: adjusts the magnitude shift of the curve fit. Default is 0.
- ***Fit X-Shift***: adjusts the phase shift of the curve fit. Default is 0. *Note that this becomes unavailable in a parabolic fit.*

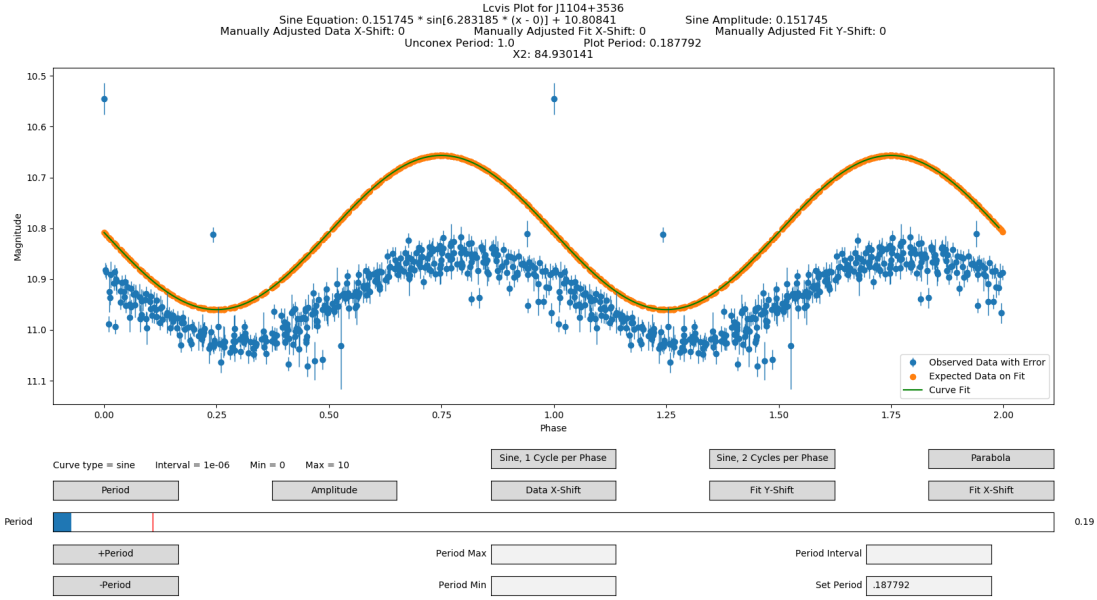
Once an argument is selected, different parameters can be changed and the plot can be adjusted. A slider is available to scroll through different values of one argument. Each of these values are stored and displayed for each argument. The following adjustments and parameters are available:

- ***Interval***: sets how much a value changes per step. Default is 0.000001.
- ***Set***: manually set the value of an argument.
- ***Max***: set the maximum value for the slider. Default is argument dependent.
- ***Min***: set the minimum value for the slider. Default is argument dependent.
- ***+ (Add Interval)***: increase the value by one interval step.
- ***- (Subtract Interval)***: decrease the value by one interval step.

Any adjustments made are displayed in the title of the figure, and the plot is updated accordingly.

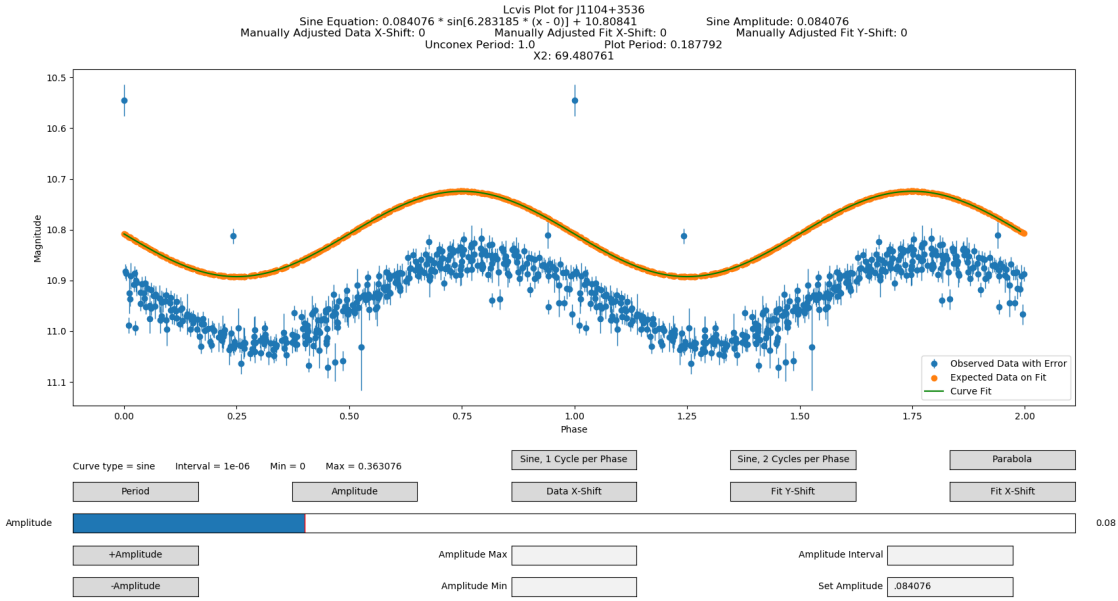
Period

Selecting "Period" will allow for a manual adjustment of the period of the lightcurve. Below displays the same object, J1104+3536, but with a period of +0.187792 days, the period output by Unconex.



Amplitude

Selecting "Amplitude" will allow for a manual adjustment of the amplitude of the curve fit. The amplitude of the sine function in the J1104+3536 plot has changed to +0.084076 magnitude below.

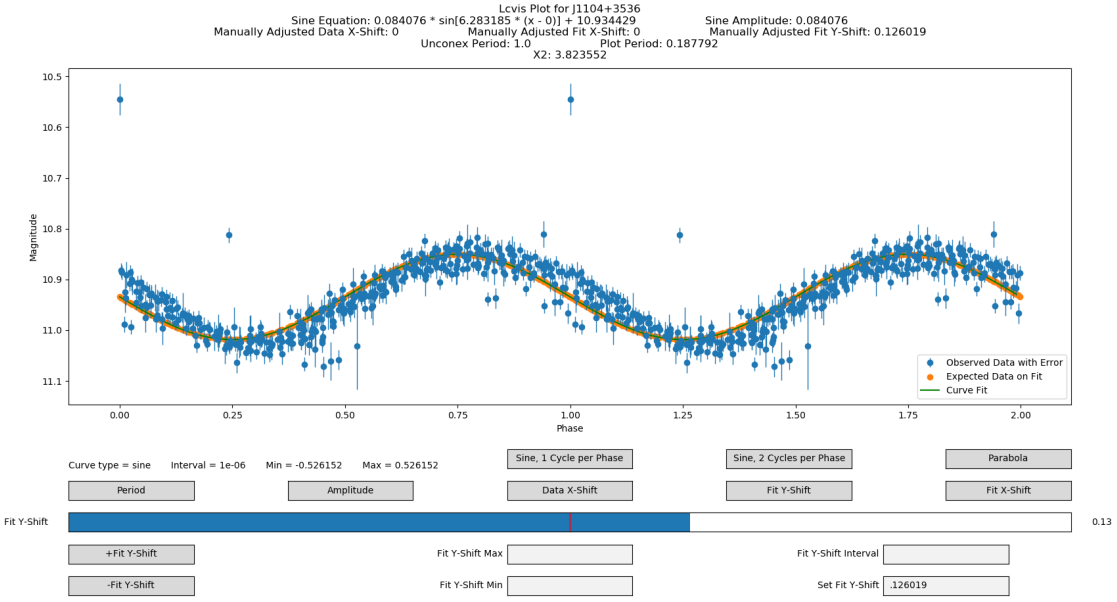


Data X-Shift

Selecting "Data X-Shift" will allow for a manual adjustment of the observed data's position in the phase. The plot of J1104+3536 did not require this shift, so an example image of the shift will be displayed further below for object J1125+4234.

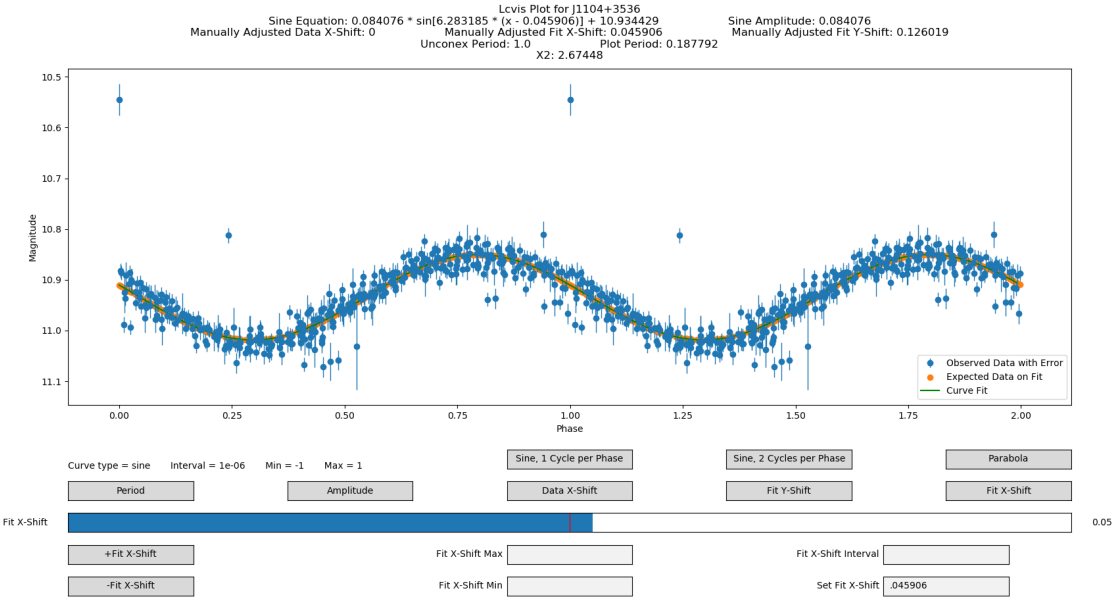
Fit Y-Shift

Selecting "Fit Y-Shift" will allow for a manual adjustment of the curve fit's magnitude position in the plot. The curve fit of J1104+3536 has shifted down in magnitude by +0.126019, shown below.



Fit X-Shift

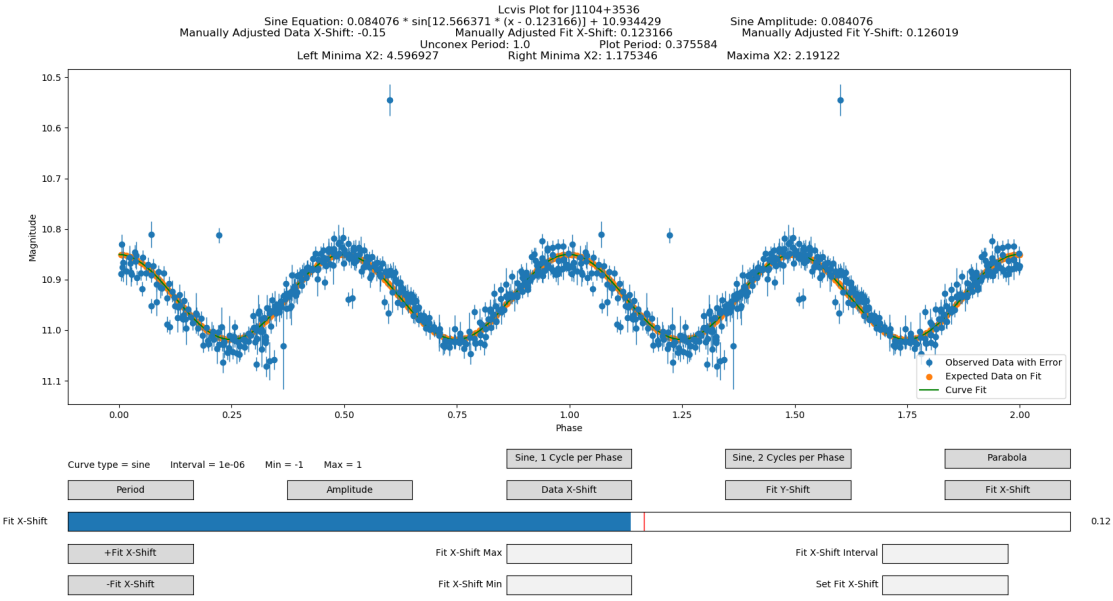
Selecting "Fit X-Shift" will allow for a manual adjustment of the curve fit's phase position in the plot. The curve fit of J1104+3536 has shifted right in phase by +0.045906, shown below.



Once all adjustments have been made to the plot, the chi-square per degree of freedom can be recorded to check the shape of the lightcurve.

Double-frequency sine curve fit

The curve fit can be changed to a double-frequency (2 cycles/phase) sine curve. This fit is used to compare the minimas of an object whose lightcurve shows some sinusoidal behavior. Below shows the same object, J1104+3536, but with a doubled period of +0.375584 days. *Note that it is very important that the minimas are centered around 0.25 and 0.75, otherwise the program will not output chi-squared values correctly*.

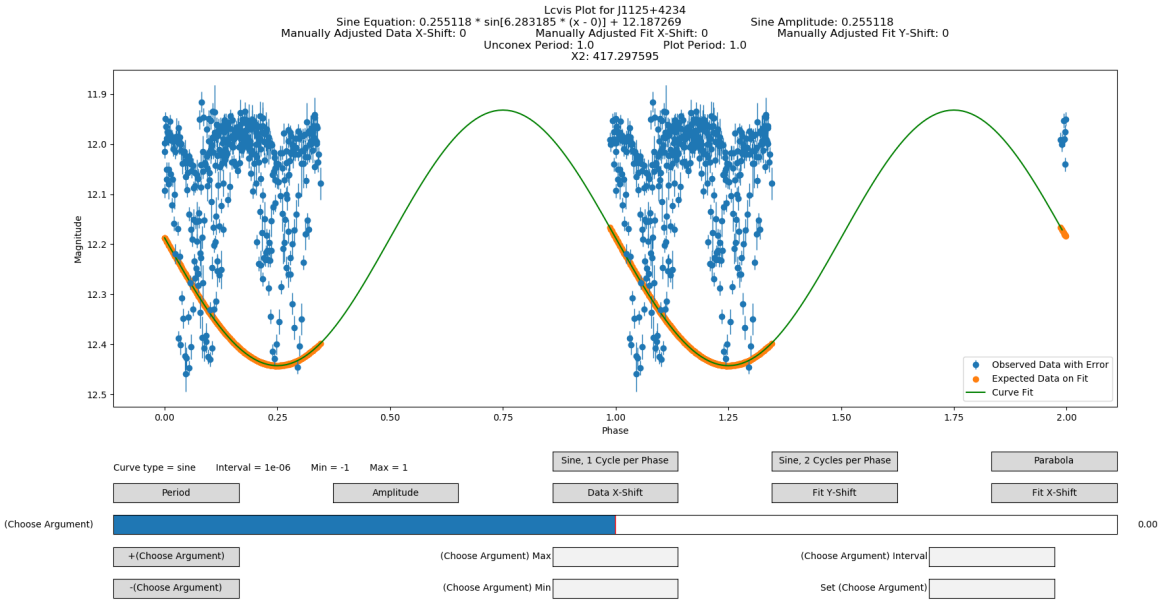


Instead of outputting a single chi-squared value for the entire lightcurve, the chi-squared value for both the left minima (centered around 0.25) and the right minima (centered around 0.75) are displayed, as well as the chi-squared value of the maxima (centered around 0.50) for alignment purposes.

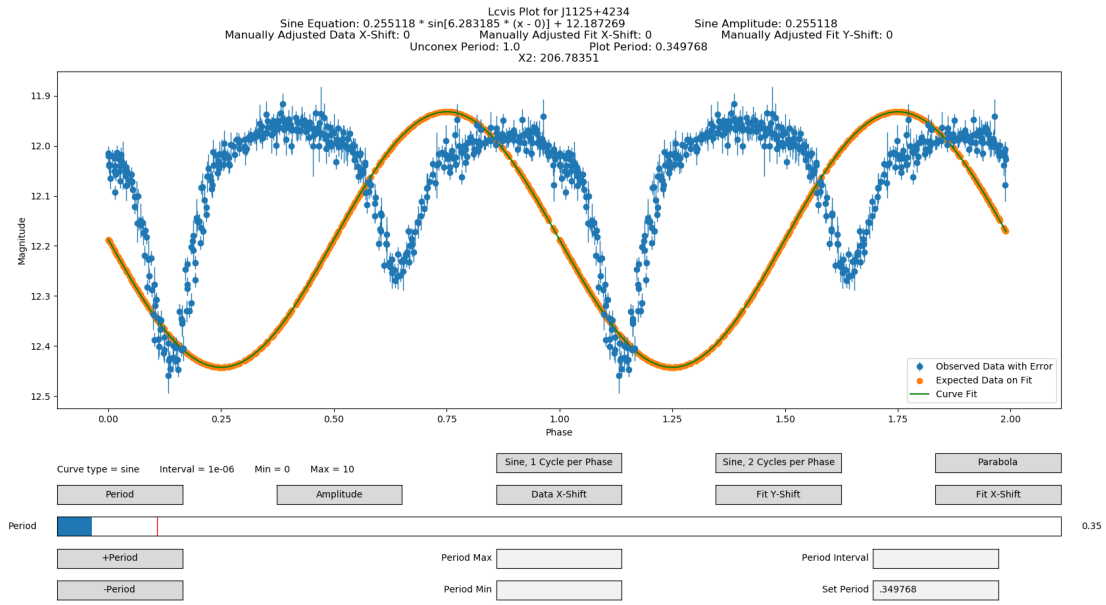
Parabolic fit

The curve can additionally be changed to a parabolic fit to compare the minimas of a suspected contact binary object. *Note that these lightcurves follow a cubic spline behavior and not a parabolic behavior, and thus this fit is purely for an initial check of the minima*. When doing a parabolic fit, the "Fit X-Shift" becomes unavailable, as the program specifically looks at data around the minimas centered at 0.25 and 0.75.

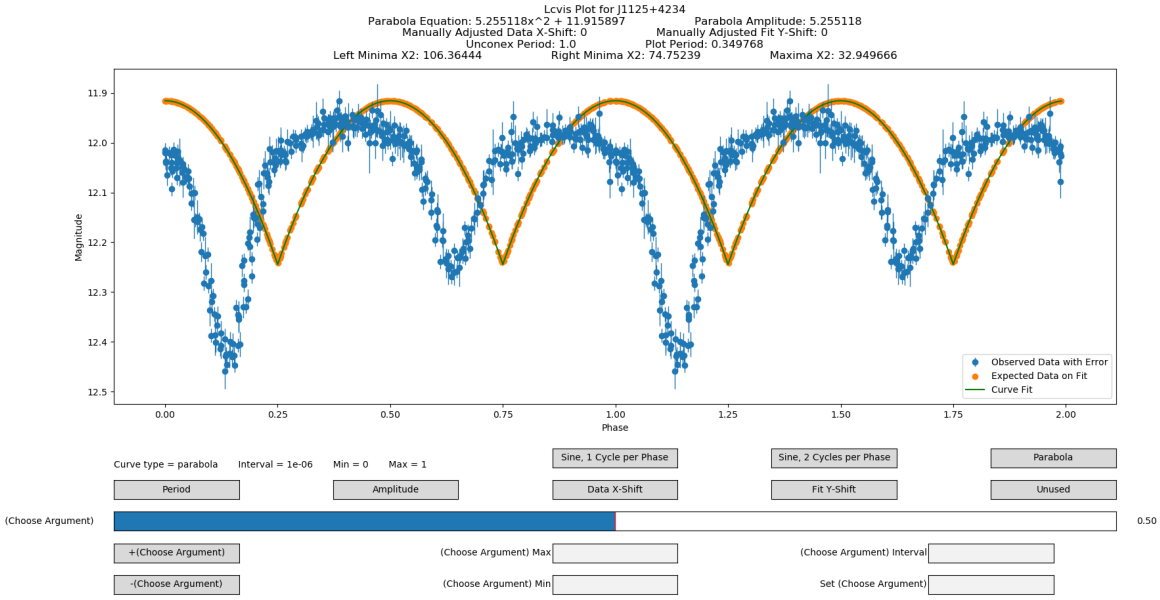
Below is the initial output for object J1125+4234 with an initial period of 1 day.



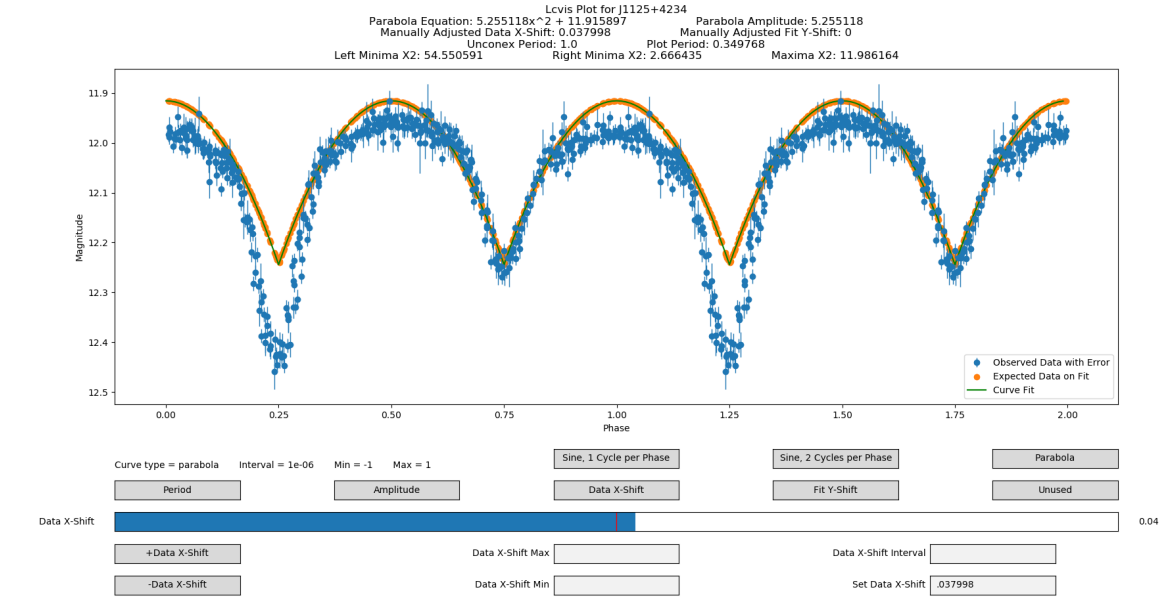
Adjusting the period to the Unconex period of +0.349768 days:



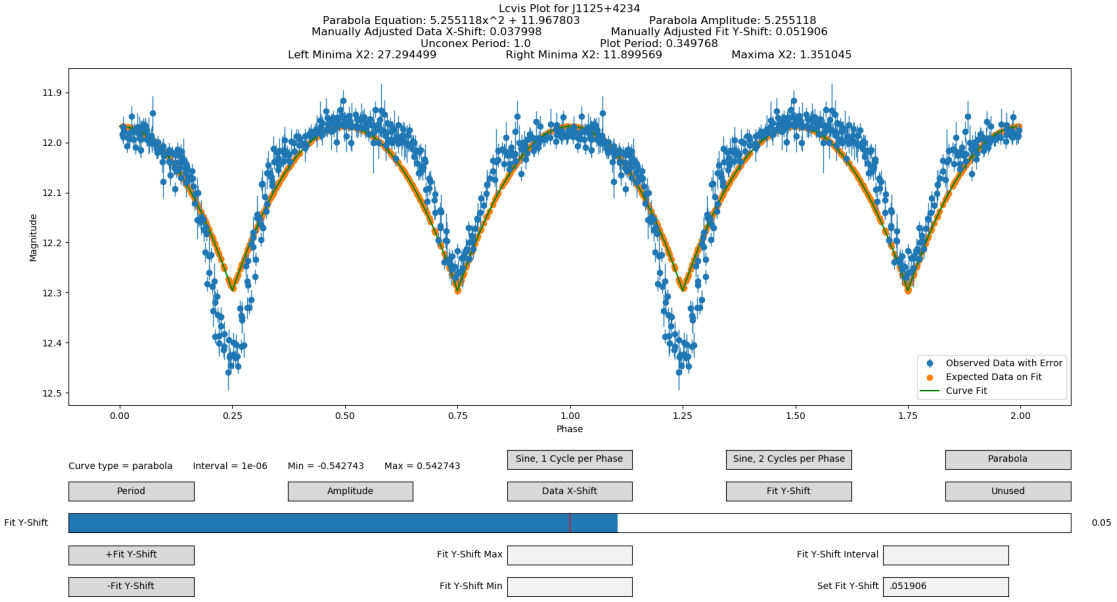
Changing the curve fit to "Parabola":



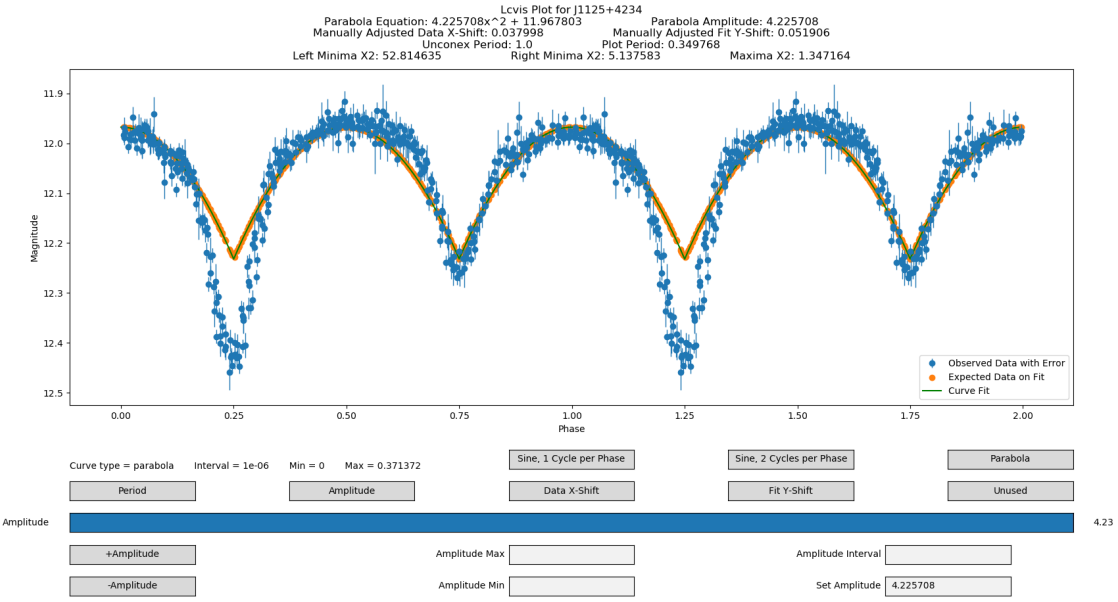
Adjusting the phase shift of the data to align the observed minimas with the fit minimas. This is a data x-shift, as the observation data has shift to the right in phase by +0.037998:



Adjusting the magnitude shift of the curve fit to minimize the chi-squared value of the maximas. The curve fit has shifted down in magnitude by +0.051906:



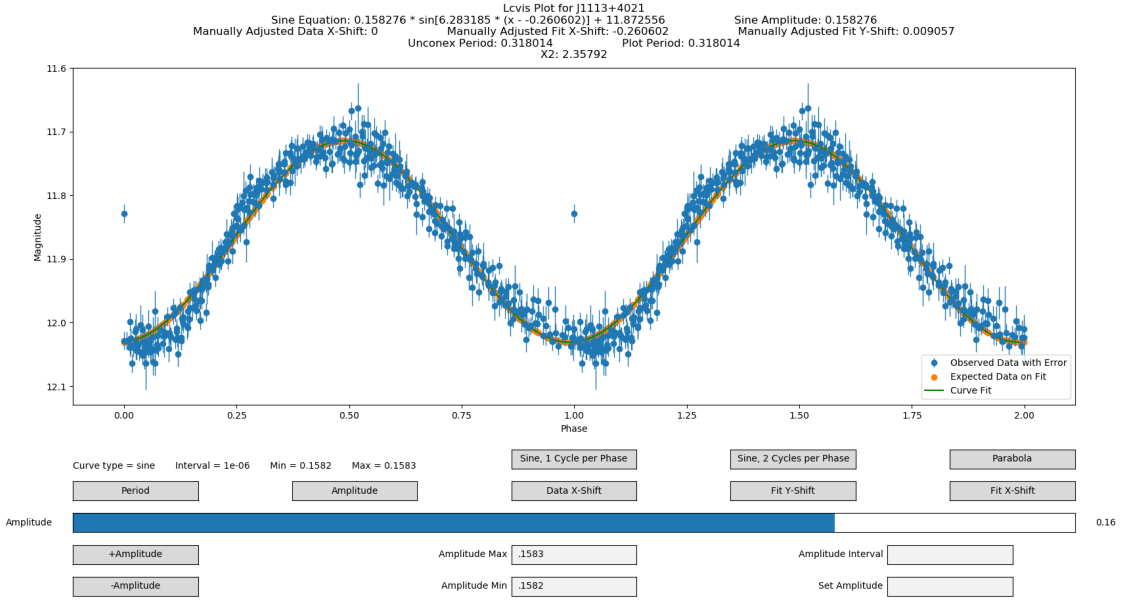
Adjusting the amplitude of the curve fit to minimize the right minima's chi-squared value. (The curve can also be adjusted to minimize the chi-squared value of the left minima). The amplitude has decreased to +4.225708:



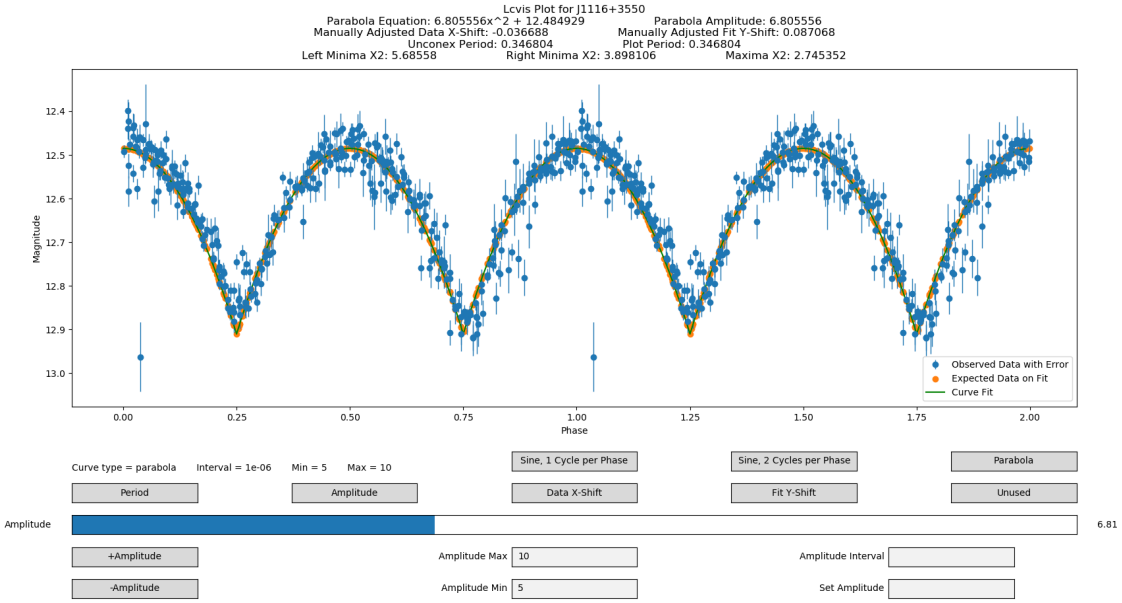
Additional Plots

Below are other example plots using Lcvis. Each plot's title contains the adjustments made to minimize the chi-squared value.

J1113+4021:



J1116+3550:



J1120+4353. The top plot is with the Unconex period, and the bottom plot is after the period was adjusted: