

New tool with GUI for fitting O-C diagrams

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O-C diagrams

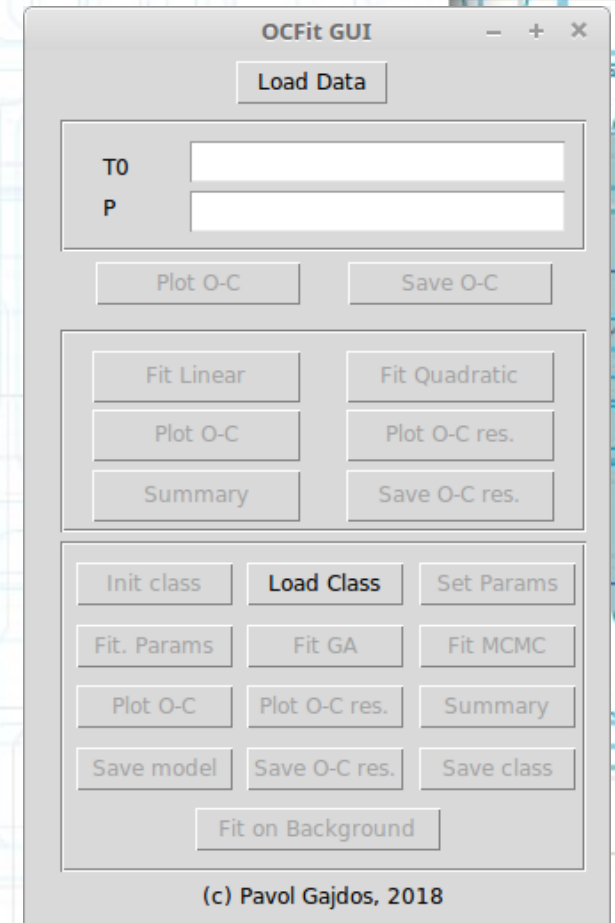
- O-C diagram – difference between observed time and calculated time of minima
- precise timing of minima of EBs → mass transfer, 3rd body, etc.
- exact physical model of these changes is complicated and strongly non-linear
- we present new method and graphical user interface for fitting O-C diagrams

Fitting O-C diagrams

- using standard methods is problematic
- many free parameters
- our algorithms:
 1. genetic algorithms
 - without any starting values (only interval)
 - initial estimation of parameters
 2. Monte Carlo method
 - final values and errors of parameters

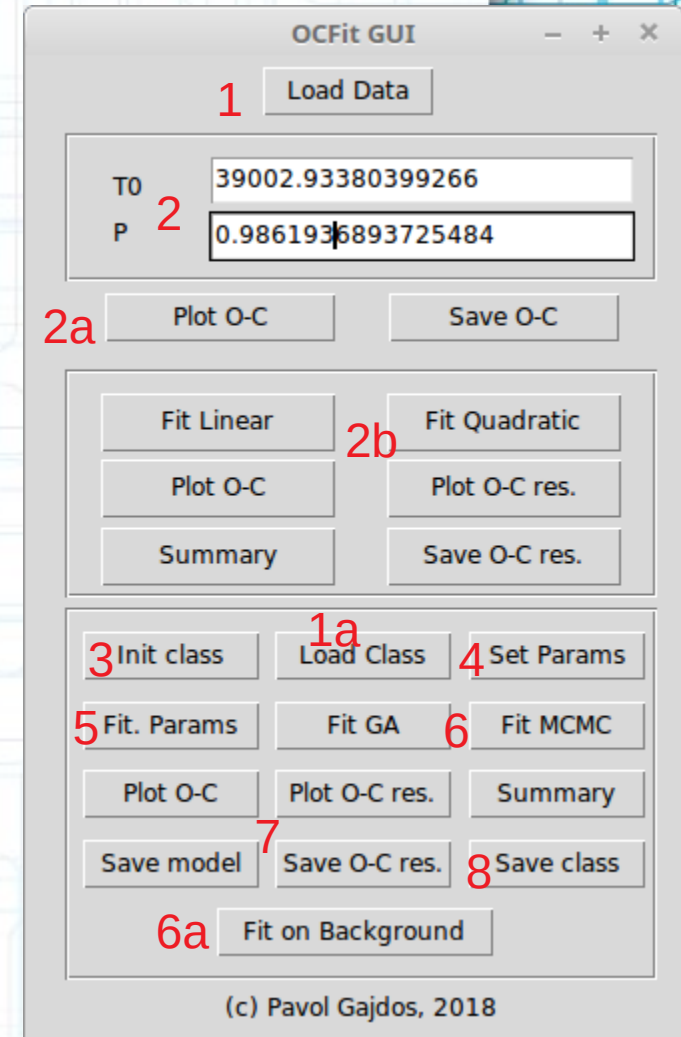
GUI

- basic control of OCFit class:
- load data, fitting, show results
- intuitive, buttons available after running necessary function
- python tkinter (python 2 & 3)
- version for Windows (exe file)



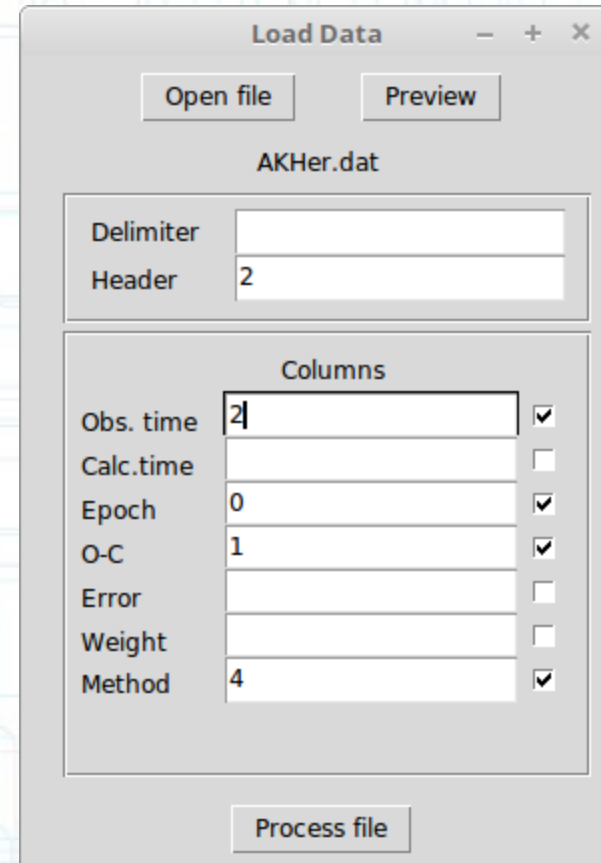
GUI - workflow

1. Loading data from file
 - a. Load saved class (go to 4)
2. Set linear ephemeris
 - a. Plot or save initial O-C
 - b. Linear / quadratic fitting
3. Init class
4. Set parameters of model
5. Set fitting parameters
6. Fitting model – GA +MCMC
 - a. Fit on background (go to 1a)
7. Working with results
8. Save class to file



GUI – loading data

- from text file
- data in columns
- no strict structure
- setting errors / weights of individual methods



Load Data

Open file Preview

AKHer.dat

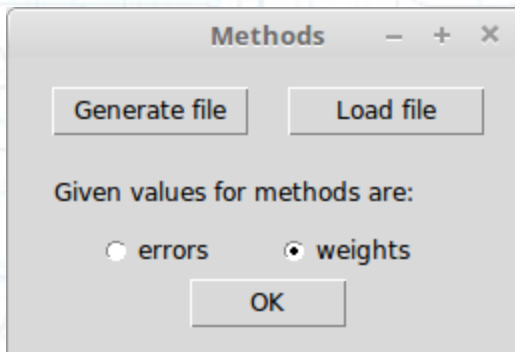
Delimiter

Header 2

Columns

| | | |
|-----------|---|-------------------------------------|
| Obs. time | 2 | <input checked="" type="checkbox"/> |
| Calc.time | | <input type="checkbox"/> |
| Epoch | 0 | <input checked="" type="checkbox"/> |
| O-C | 1 | <input checked="" type="checkbox"/> |
| Error | | <input type="checkbox"/> |
| Weight | | <input type="checkbox"/> |
| Method | 4 | <input checked="" type="checkbox"/> |

Process file



Methods

Generate file Load file

Given values for methods are:

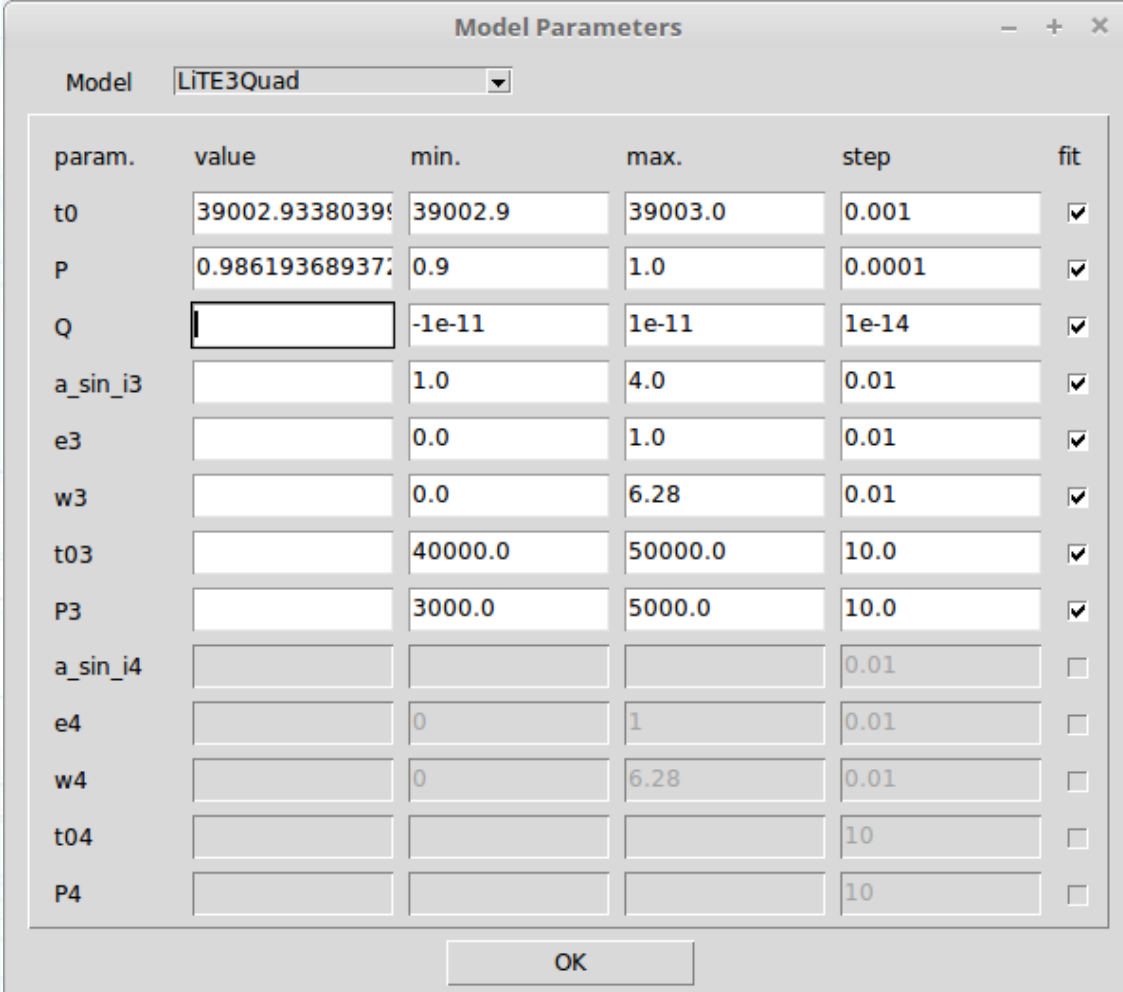
☐ errors ☒ weights

OK

```
# Write errors / weights for each used method to next column!
pg      3
vis     1
pe      5
Vis     1
V       10
B       10
Y       10
R       10
BV      10
ccd     10
U       10
```


GUI – model parameters

- 9 available models:
 - LiTE – 3rd, 4th body + quadratic trend
 - Agol's models (Agol et al., 2005)
 - apsidal motion
- setting values, limits and steps of params



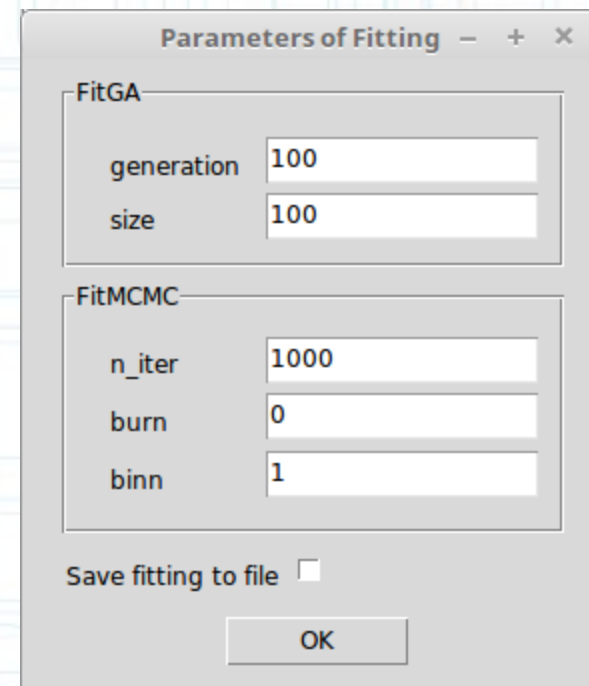
The screenshot shows a window titled "Model Parameters" with a dropdown menu set to "LiTE3Quad". Below the menu is a table with 7 columns: "param.", "value", "min.", "max.", "step", and "fit". The table lists 15 parameters. The first 9 parameters have their "fit" checkboxes checked, while the last 6 have them unchecked. The "value" column contains numerical values or empty text boxes for editing. The "min." and "max." columns contain numerical limits, and the "step" column contains numerical step sizes.

| param. | value | min. | max. | step | fit |
|----------|----------------|---------|---------|--------|-------------------------------------|
| t0 | 39002.93380399 | 39002.9 | 39003.0 | 0.001 | <input checked="" type="checkbox"/> |
| P | 0.986193689372 | 0.9 | 1.0 | 0.0001 | <input checked="" type="checkbox"/> |
| Q | | -1e-11 | 1e-11 | 1e-14 | <input checked="" type="checkbox"/> |
| a_sin_i3 | | 1.0 | 4.0 | 0.01 | <input checked="" type="checkbox"/> |
| e3 | | 0.0 | 1.0 | 0.01 | <input checked="" type="checkbox"/> |
| w3 | | 0.0 | 6.28 | 0.01 | <input checked="" type="checkbox"/> |
| t03 | | 40000.0 | 50000.0 | 10.0 | <input checked="" type="checkbox"/> |
| P3 | | 3000.0 | 5000.0 | 10.0 | <input checked="" type="checkbox"/> |
| a_sin_i4 | | | | 0.01 | <input type="checkbox"/> |
| e4 | | 0 | 1 | 0.01 | <input type="checkbox"/> |
| w4 | | 0 | 6.28 | 0.01 | <input type="checkbox"/> |
| t04 | | | | 10 | <input type="checkbox"/> |
| P4 | | | | 10 | <input type="checkbox"/> |

OK

GUI – parameters of fitting

- setting parameters of fitting function:
- genetic algorithms (GA)
- Monte Carlo (MCMC)
- save fitting sampling to file (for detailed analysis)



The screenshot shows a window titled "Parameters of Fitting" with standard window controls (minimize, maximize, close). The window is divided into two sections: "FitGA" and "FitMCMC".

FitGA section:

- generation: 100
- size: 100

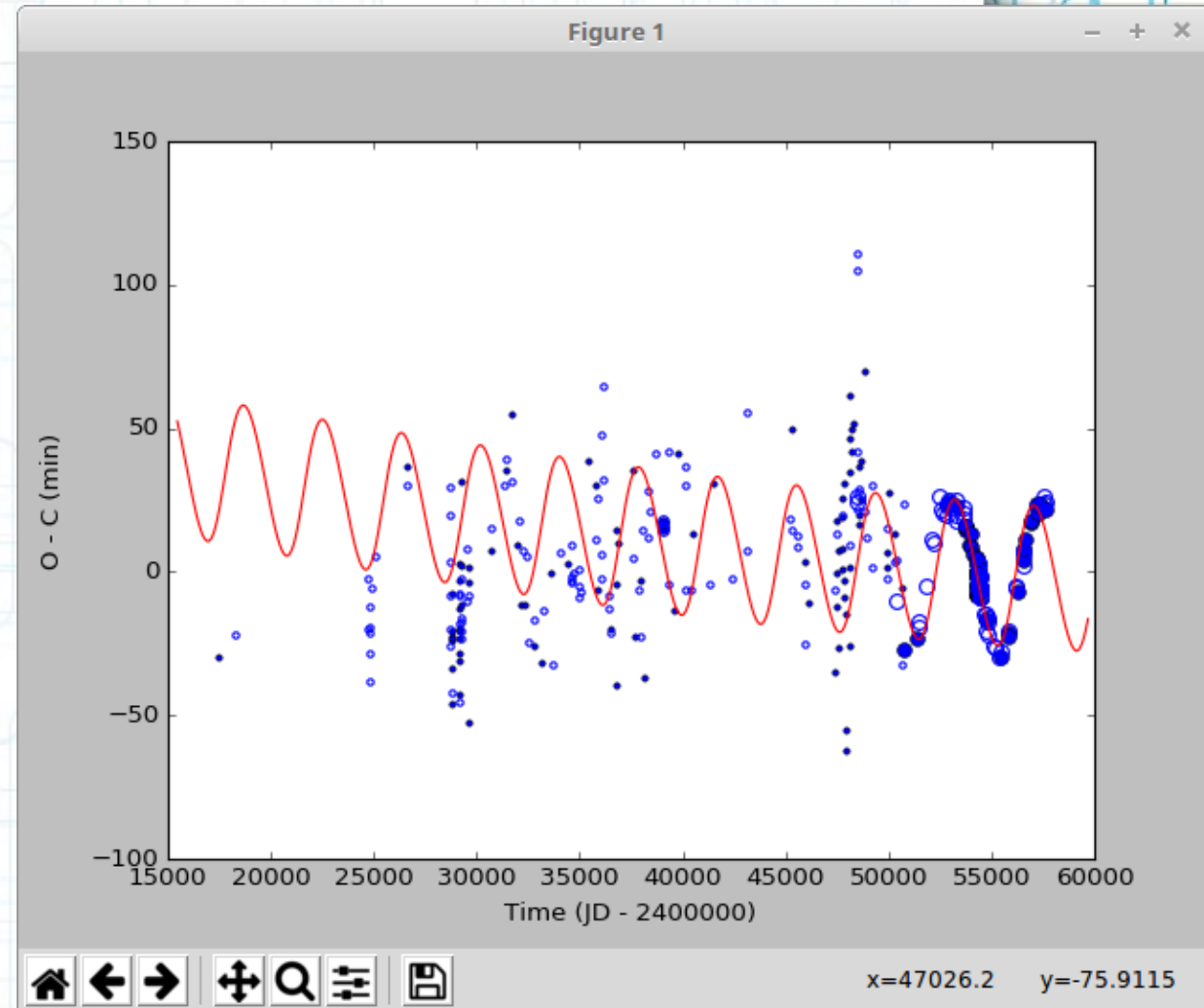
FitMCMC section:

- n_iter: 1000
- burn: 0
- binn: 1

At the bottom of the window, there is a checkbox labeled "Save fitting to file" which is currently unchecked, and an "OK" button.

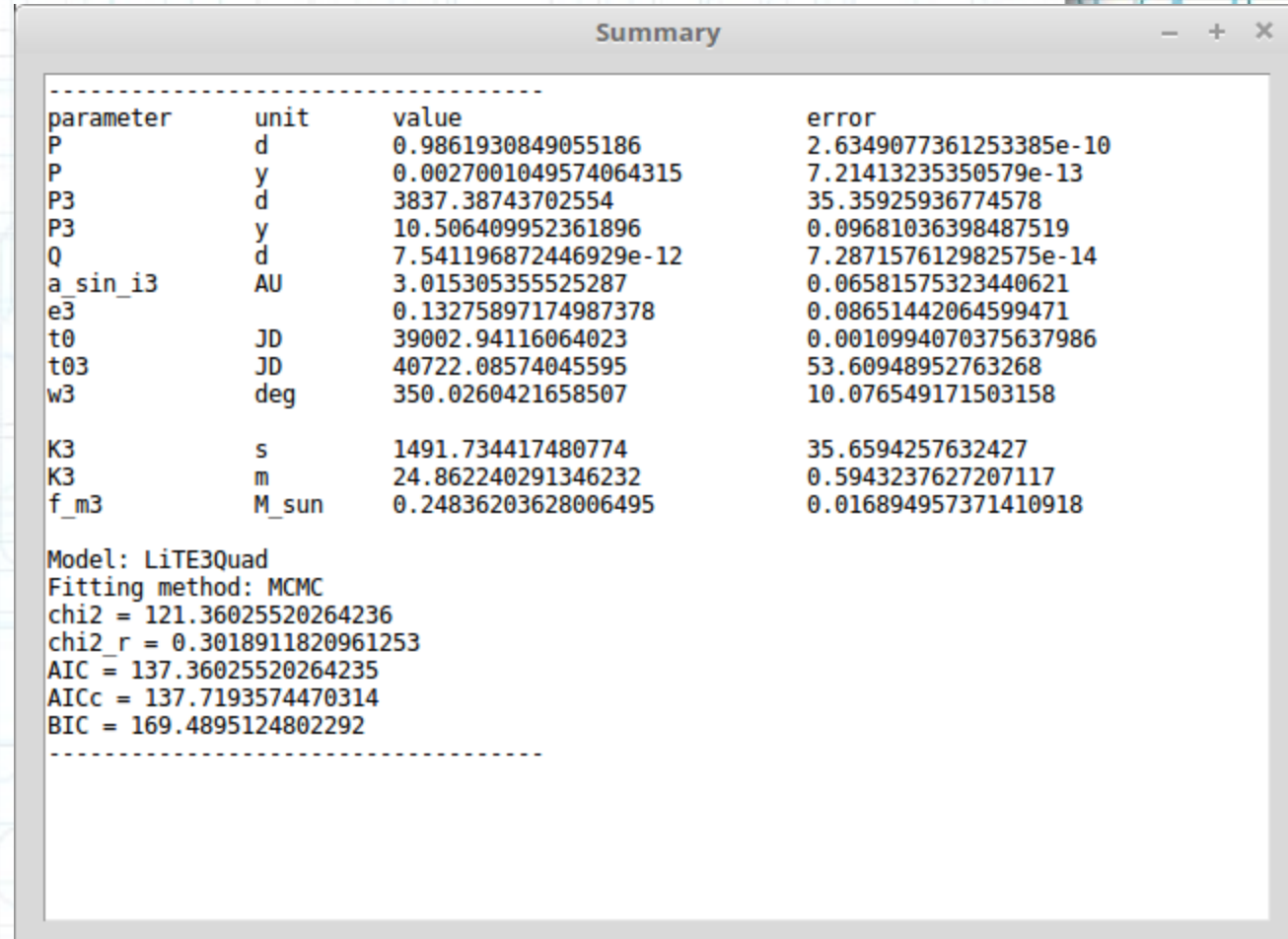
GUI – plot results

- plotting model with O-C data
- zoom, pan
- save to file
- plot residual O-C



GUI - summary

- list of model parameters – values & errors
- some other calculated parameters
- statistics



The screenshot shows a window titled 'Summary' with a table of model parameters and their associated values and errors. Below the table, it lists the model name, fitting method, and various statistical values.

| parameter | unit | value | error |
|-----------|-------|-----------------------|------------------------|
| P | d | 0.9861930849055186 | 2.6349077361253385e-10 |
| P | y | 0.0027001049574064315 | 7.21413235350579e-13 |
| P3 | d | 3837.38743702554 | 35.35925936774578 |
| P3 | y | 10.506409952361896 | 0.09681036398487519 |
| Q | d | 7.541196872446929e-12 | 7.287157612982575e-14 |
| a_sin_i3 | AU | 3.015305355525287 | 0.06581575323440621 |
| e3 | | 0.13275897174987378 | 0.08651442064599471 |
| t0 | JD | 39002.94116064023 | 0.0010994070375637986 |
| t03 | JD | 40722.08574045595 | 53.60948952763268 |
| w3 | deg | 350.0260421658507 | 10.076549171503158 |
| K3 | s | 1491.734417480774 | 35.6594257632427 |
| K3 | m | 24.862240291346232 | 0.5943237627207117 |
| f_m3 | M_sun | 0.24836203628006495 | 0.016894957371410918 |

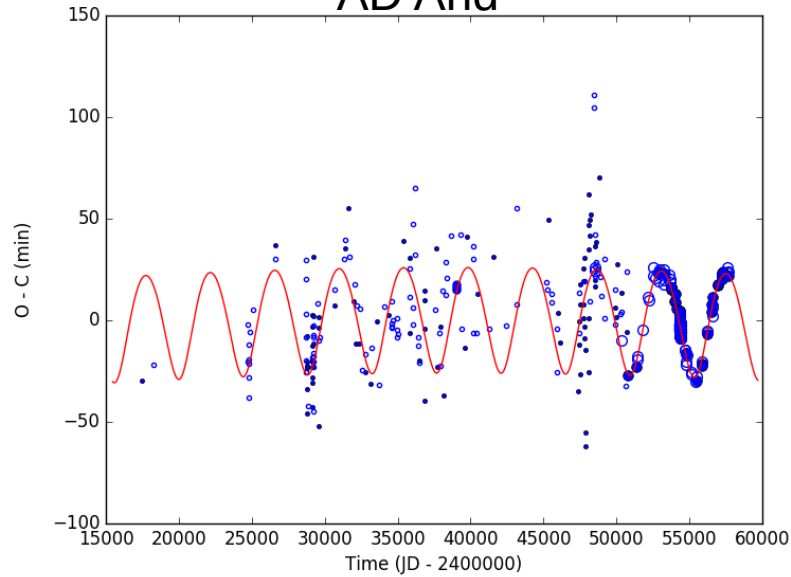
Model: LiTE3Quad
Fitting method: MCMC
chi2 = 121.36025520264236
chi2_r = 0.3018911820961253
AIC = 137.36025520264235
AICc = 137.7193574470314
BIC = 169.4895124802292

Some hints...

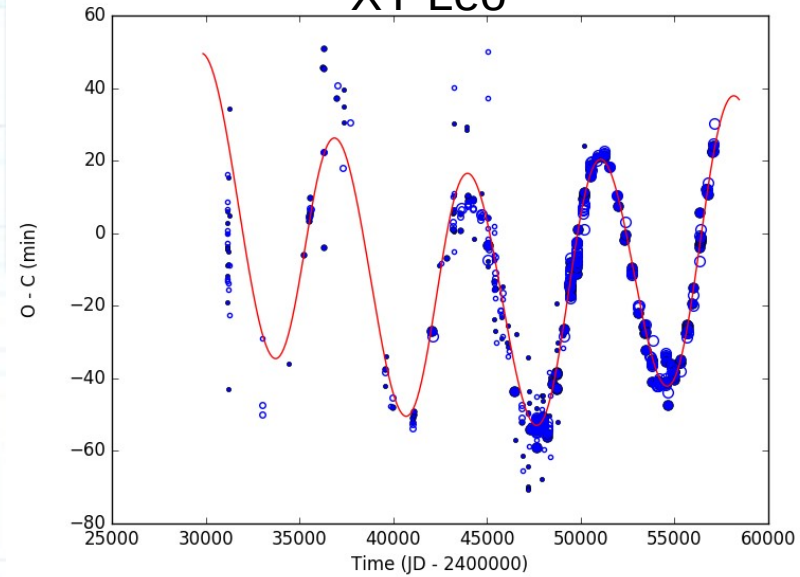
- use errors (instead of weights)
- good initial ephemeris!
- NOT fit linear ephemeris, if it isn't necessary
- if fitting ephemeris, use very small interval
- set appropriate fitting parameters:
 - for testing: GA (100, 100); MC (1000, 0 , 1)
 - for good results – at least: GA (1000, 1000); MC (1e6, 1e3, 10)
- save class to file

Examples

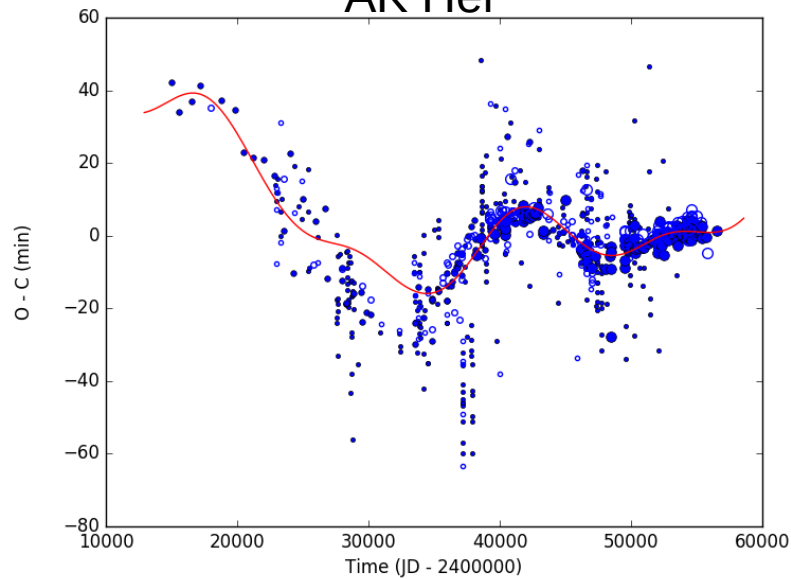
AD And



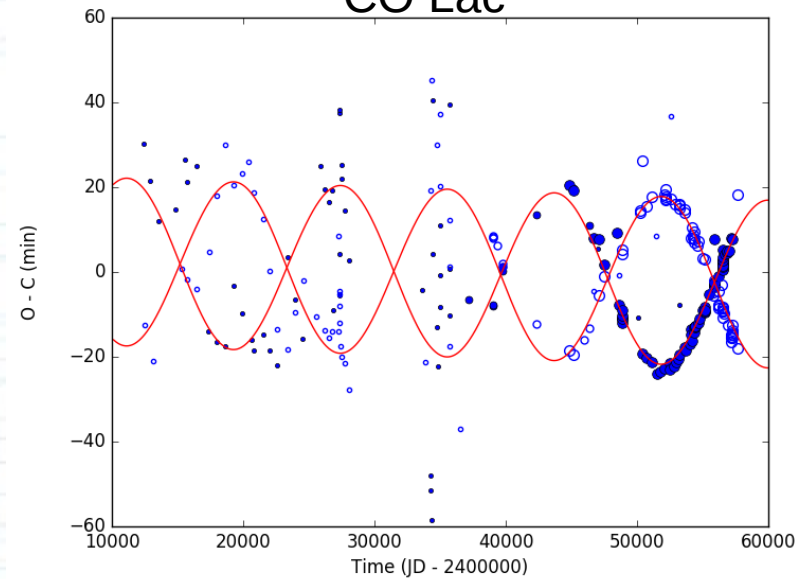
XY Leo



AK Her



CO Lac



Conclusion

- without entering exact starting values
- time and computationally intensive
- possibility to include more models of O-Cs
- already used in papers Gajdoš et al. (2017), Parimucha et al. (2018)
- available at: <https://github.com/pavolgaj/OCFit>
- if you have any problems with this program, please, contact me:
[pavol.gajdos \(a\) student.upjs.sk](mailto:pavol.gajdos (a) student.upjs.sk)

Thank you for your attention!