

Instructions

0. Clone the GitHub repository:

```
git clone https://github.com/kateivshina/transit_timing_protocols.git
```

Go to the directory of the repository:

```
cd transit_timing_protocol/
```

1. In tess_params.txt file, specify the parameters of the planetary system as well as where to store the output data.

--path_to_data_file = .fits file with the light curve

--parent_dir = where to save the output

--cadence = cadence (2 or 30 mins)

--refolded=False (change to True when dealing with refolded data)

Example:

--mission=TESS

--planet=WASP 12b

--cadence=2

--radius=0.2

--semi_major_axis=3.14

--impact_parameter=0.5

--period=1.09142

--parent_dir=/Users/ivshina/Desktop/usrp/orbital_decay

--

path_to_data_file=/Users/ivshina/Desktop/usrp/orbital_decay/tess2019357164649-s0020-0000000086396382-0165-s_lc.fits

--refolded=False

2. To preprocess the data, run in the terminal:

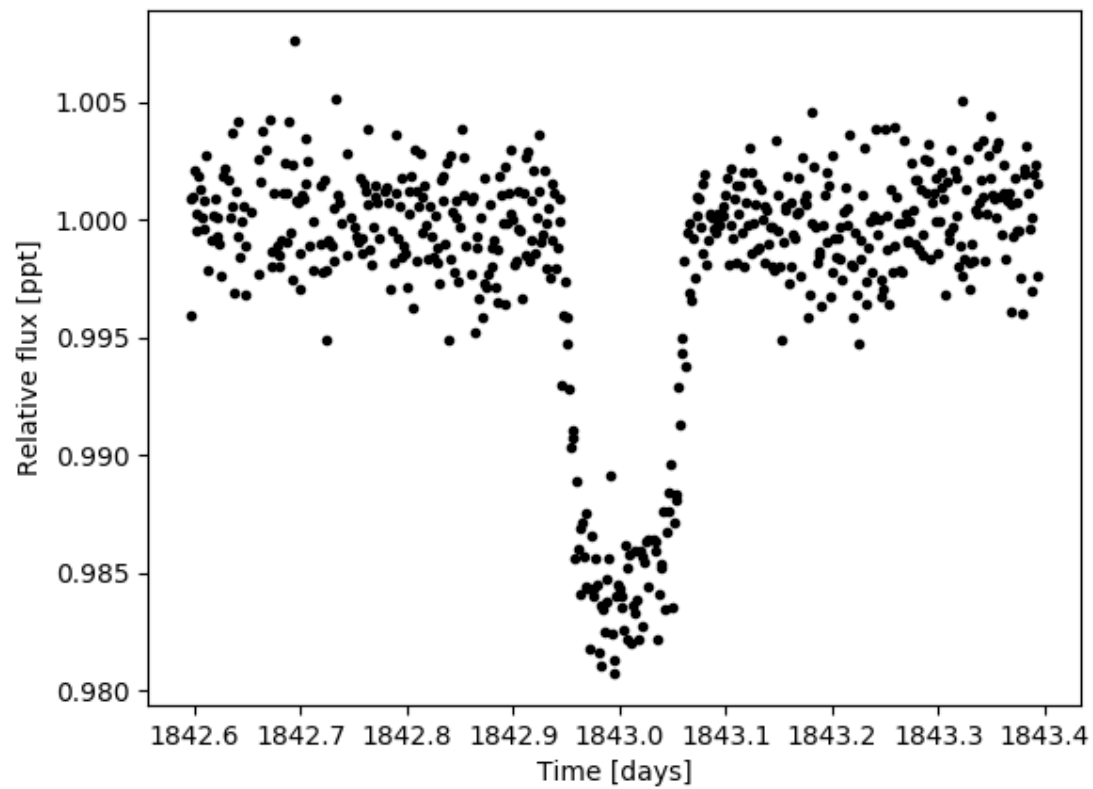
```
python3 process_tess_data.py @tess_params.txt
```

It will create the following files in the output directory:

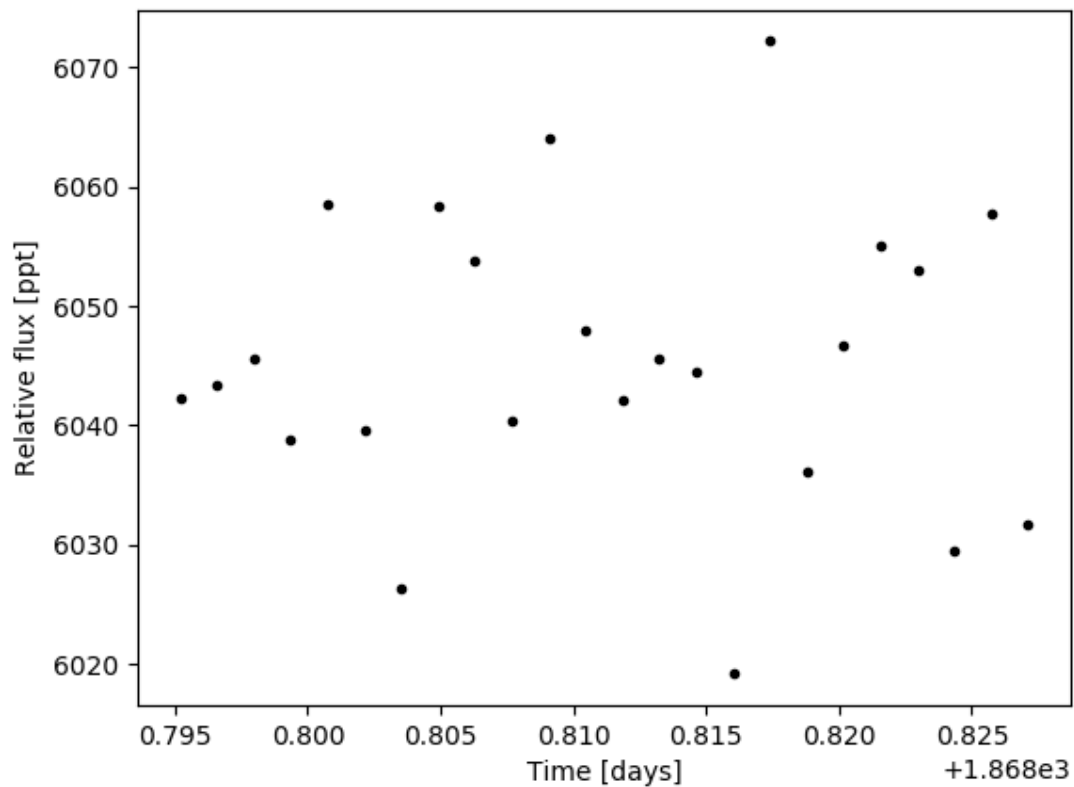
- `~/transit/times.txt` - transit time data
- `~/transit/flux.txt` - transit flux data
- `~/transit/time_folded.txt` - transit mask
- `~/transit_masked/folded_time_masked.txt` - mask for out of transit data
- `~/transit_masked/time_masked.txt` - time for out of transit data
- `~/transit_masked/flux_masked.txt` - flux for out of transit data
- `~/transit/individual_flux_array.npy` - separate arrays of fluxes for each transit
- `~/transit/individual_time_array.npy` - separate arrays of times for each transit
- `~/transit/individual_time_folded_array.npy` - separate arrays of transit masks for each transit
- `~/transit_masked/individual_flux_array.npy` - separate arrays of fluxes for each out of transit data
- `~/transit_masked/individual_time_array.npy` - separate arrays of times for each out of transit data
- `~/transit_masked/individual_time_folded_array.npy` - separate arrays of masks for each out of transit data
- `~/transit/corrected_flux.npy` - initial de-trended flux (separate array for each transit)
- `~/transit/stds.npy` - standard deviation of out-of-transit points outside of each transit
- `~/transit/coeffs.txt` - linear model coefficients used to de-trend the data

This script will also generate figures of transits in the `~/transit/individual_transits_figures` folder as well as figures of de-trended transits in the `~/transit/transits_after_detrending` folder.

Example:



3. In the `~/transit/individual_transits_figures` folder, check the found transits and note indices of events that were accidentally selected as transits, e.g.



Put these indices into ~/clean.txt file as the --delete_arrs argument.

Example:

```
--mission=TESS
--planet=WASP 12b
--parent_dir=/Users/ivshina/Desktop/usrp/orbital_decay
--delete_arrs=11 21
```

Then, to remove these events, run

```
python3 remove_non_transits.py @clean.txt
```

It will create the following files:

- ~/transit/individual_flux_array_clean.npy
- ~/transit/individual_time_array_clean.npy

- ~/transit/individual_time_folded_array_clean.npy
- ~/transit/corrected_flux_clean.npy
- ~/transit/stds_clean.npy

4. Run MCMC on phase-folded data (assuming no timing variations):

```
python3 mcmc_run_a.py @tess_params.txt
```

This will output the following files:

- ~/transit/MCMCfit.png - a figure of the folded light curve and the transit model
- ~/transit/theta_max.txt - a file containing the found rp , a , b , $u1$, $u2$ parameters

5. Run MCMC on each individual transit:

```
python3 mcmc_run_b.py @tess_params.txt
```

This will output ~/transit/t0_k_c.txt file that contains $\{t0, k, b\}$ for each transit where

$t0$ - mid-transit time

k and b - de-trending polynomial coefficients.

6. Run the following script to refold the data with the newly derived mid-transit times:

```
python3 refolding.py @tess_params.txt
```

It outputs the following files:

~/transit/corrected_flux_refolded.npy
 ~/transit/stds_refolded.npy
 ~/transit/individual_flux_array_clean_refolded.npy
 ~/transit/individual_time_array_clean_refolded.npy
 ~/transit/individual_time_folded_array_clean_refolded.npy

7. Change **--refolded=False** to **--refolded=True** in the *tess_params.txt* file to indicate that you're analyzing refolded data.

Run MCMC on phase-folded data again:

```
python3 mcmc_run_a.py @tess_params.txt
```

This will output the following files:

- `~/transit/MCMCfit.png` - a figure of the folded light curve and the transit model
- `~/transit/theta_max.txt` - a file containing the found rp , a , b , $u1$, $u2$ parameters

8. Run MCMC on each individual transit:

```
python3 mcmc_run_b.py @tess_params.txt
```

This will output `~/transit/t0_k_c.txt` file that contains $\{t0, k, b\}$ for each transit where

$t0$ - mid-transit time

k and b - de-trending polynomial coefficients.

The script will also produce corner plots for each transit in the `~/transit/corner_plots` folder.

9. To plot O-C (constant period model), run

```
python3 o_c.py @tess_params.txt
```