

# Light curves analysis with Lightkurve

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**Abstract.** This study aims to treat light flux data, resulting in more accurate light curves. We use Lightkurve as a tool for refining light curves to, from there, accomplish many analyses, such as identifying planetary transits and false positives. Applying the library functions to the light curve and Target Pixel File (TPF) data of the stars TIC 55525572, with confirmed exoplanet presence, and TIC 142105308, which has brightness drops in its light curve caused by the existence of a binary system in the background, it was possible to clearly verify the characteristics mentioned.

**Resumo.** Este estudo tem como finalidade o tratamento de dados de fluxos de luz, resultando em curvas de luz mais precisas. Utilizamos o Lightkurve como ferramenta de refino de curvas de luz para, a partir delas, realizar diversas análises, como a identificação de trânsitos planetários e de falsos positivos. Aplicando as funções da biblioteca aos dados de curva de luz e Target Pixel File (TPF) das estrelas TIC 55525572, com presença de exoplaneta confirmada, e TIC 142105308, que possui quedas de brilho em sua curva de luz provocada pela existência de um sistema binário no fundo, foi possível constatar com clareza as características citadas.

**Keywords.** data analysis – Catalogs – Photometric

## 1. Introduction

The light curves, i.e. the time series plot of star's brightness, can provide information about the several stellar types, allowing even the detection of exoplanets via the planetary transit method (Fischer et al. 2014), whose signature is revealed by periodic dips in the target star's brightness caused by the passage of the planet in the front of the host star.

The Kepler/K2 and Transiting Exoplanet Survey Satellite (TESS) missions had as main objective the search for exoplanets by the planetary transit method, making available to scientific community a massive amount of data about the star's brightness (Feinstein et al. 2019). During the first two years of its mission, TESS identified 2241 exoplanet candidates (Guerrero et al 2021), while the Kepler mission confirmed the presence of five new exoplanets during the first six weeks of observations (Borucki et al. 2010).

This study has the objective of using the functions of Lightkurve package, available in the Python programming language, to carry out the data treatment from light fluxes, resulting in more accurate light curves. We were able to detect the characteristics of the planetary transit present in the light curve of the star TIC 55525572, as well as the finding that the supposed transit present in the light curve of the star TIC 142105308 is a false positive for the presence of exoplanet.

## 2. Lightkurve functions

The Lightkurve package has many functions with which we can process data obtained from the Mikulski Archive for Space Telescopes (MAST) (Lightkurve Collaboration et al. 2018). Through the function `search_targetpixelfile()`, the Target Pixel File (TPF) data of the stars are searched directly from MAST; TPF's are FITS files in which each cadence, that is, TPF frame, is constituted by a pixelated image, with for example 5 pixel  $\times$  5 pixel, containing information about the flux of the target star.

Target ID: 55525572, Cadence: 151577

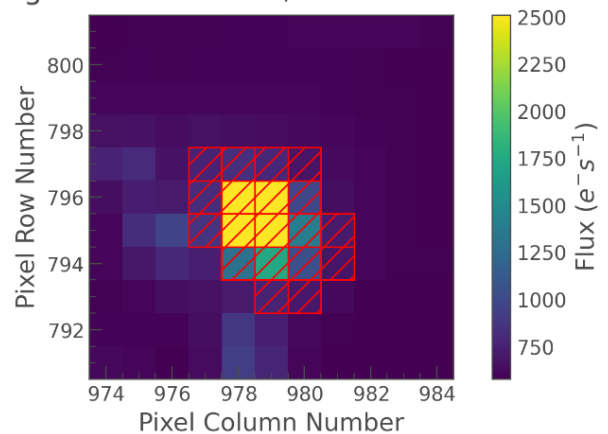


FIGURE 1. TPF of TIC 55525572.

Using Simple Aperture Photometry (SAP) technique, which consists of basically in integrate the flux values available in each pixel of the target, it is possible the construction of the light curve of the object from the TPF which, with Lightkurve, is made using the command `to_lightcurve()`. In figure 1 we can see an example of TPF for the star TIC 55525572. In figure 2 shown its lightcurve star built from your TPF.

With the target light curve, we can refine the data using several functions, such as `flatten()`, `remove_outliers()`, `remove_nans()`, `fold()` and `bin()` available in the Lightkurve package.

Each function has a different utility, namely (Lightkurve Collaboration et al. 2018):

- `flatten()`: Remove long term trends using a Savitzky–Golay filter;
- `remove_outliers()`: Remove outliers using simple sigma clipping;

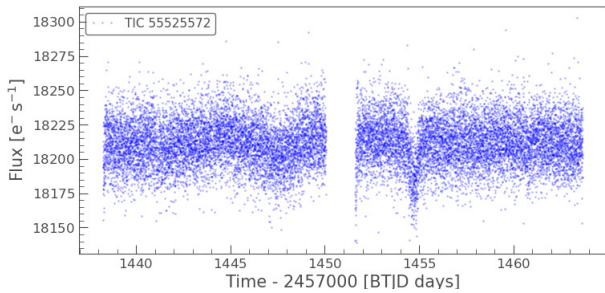


FIGURE 2. TIC 55525572 light curve built from *to\_lightkurve* command.

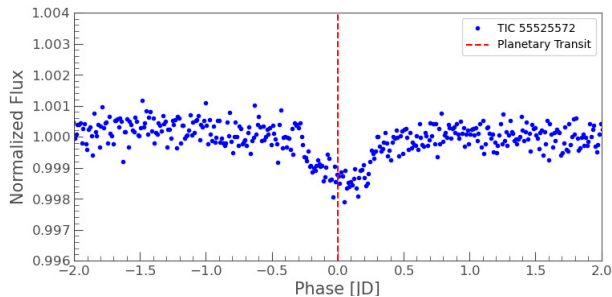


FIGURE 3. Treated light curve of TIC 55525572.

- *remove\_nans()*: Remove infinite or NaN values;
- *fold()*: Fold the data at a particular period;
- *bin()*: Reduce the time resolution of the array, taking the average value in each bin..

In the light curve of figure 2, built with the *to\_lightkurve* command, the following filters were applied automatically, through the aforementioned command: *flatten()*, *remove\_outliers()* and *fold()* (Lightkurve Collaboration et al. 2018). These are basic filters used to improve the visualization of light curves in general, so that, for the visual detection of a possible planetary transit, it is necessary to use other functions, such as *fold()* and *bin()*.

### 3. Results and discussions

With the use of the mentioned commands, an analysis of the data of TIC 55525572 and TIC 142105308 was carried out.

For the first star, after building the light curve with the command *to\_lightkurve*, we use the commands *fold()* and *bin()* to, respectively, fold the data into around the exoplanet’s period and decrease the graph’s temporal resolution to 15 minutes. Done, we can see the result in the figure 3, where we can clearly see the planetary transit in the light curve of TIC 55525572.

For TIC 142105308, we made use of a series of commands to build a light curve for each pixel of the TPF (Lightkurve Collaboration et al. 2018). With this we can see, from figure 4, that the dips in the brightness of the light curve do not come from the target star, but from background stars, which are, most likely, a binary system (Lightkurve Collaboration et al. 2018), thus constituting a typical case of false positive.

### 4. Conclusion

The use of the Lightkurve package made it possible to recognize the characteristics of the planetary transit present in the light

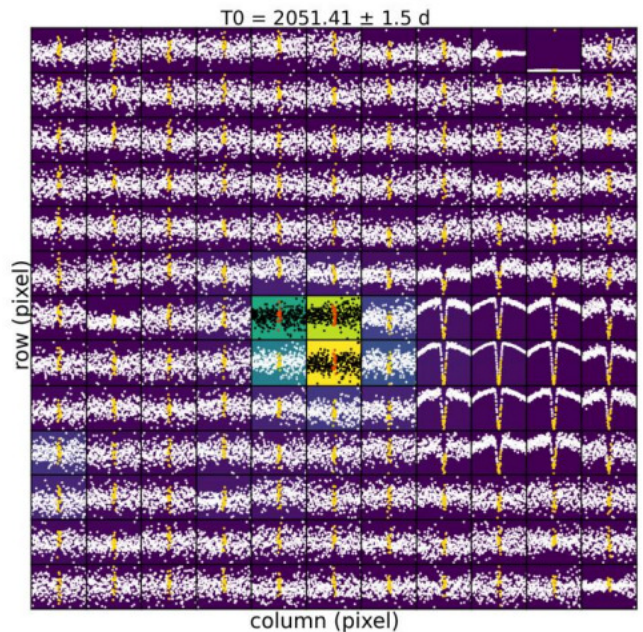


FIGURE 4. Light curve for each TPF pixel of TIC 142105308.

curve of TIC 55525572, as well as verifying that the target TIC 142105308 contains a false positive for planetary transit, i.e., the drops in target brightness being caused by the presence of an eclipsing binary system in the background.

Therefore, we infer that Lightkurve proves to be a remarkable tool for astrophysical studies in general, and especially in exoplanetology, since it allows a clear, fast and objective analysis of the light curves of the stars, as well as identifying the possible physical causes of the characteristics present in the stars, mentioned curves.

*Acknowledgements.* To IFCE and FNDE, for the institutional and financial support.

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