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A. Siebert, K. Baillié, E. Lagadec, N. Lagarde, J. Malzac, J.-B. Marquette, M. N'Diaye, J. Richard, O. Venot (eds)

TESSIPACK: AN INTERACTIVE PYTHON-BASED TOOL TO FIND STELLAR VARIABILITY FROM TESS FFIS.

D. B. Palakkatharappil[1] and O. L. Creevey[1]

Abstract. TESS Transiting Exoplanet Survey Satellite (NASA exoplanet space mission) Full Frame Images (FFI) cover 85% of the sky with a cadence of 10 and 30 minutes. The light curves from the FFI can be used for studies of astrophysical phenomenon such as exoplanets, binaries, supernovae, etc. We developed a graphics-based python tool that combines various available pipelines (`Eleanor` and `LightKurve`) to generate a light curve from the FFIs. With this tool, one can interactively inspect the target pixel files and select aperture pixels to generate a light curve. Aperture selection helps to identify and remove the contamination on the light curve due to neighbouring sources. The tool is also integrated with Ds9 and the Gaia DR2 catalogue, with which we can inspect the environment of the target source. As a first example of the tool, we analyse a crowded young open cluster Collinder 69 using Gaia DR2 proper motions to identify members. We identify and present variable star cluster members comprising binaries and oscillating stars.

Keywords: TESS, FFI, variable stars, binaries

1 Introduction

The NASA Transiting Exoplanet Survey Satellite (TESS) was designed to search for exoplanets. It is an all-sky survey that covers 85 % of the sky. TESS not only provides short cadence (SC) data in 2 minute intervals for ∼200,000 targets and 20 second intervals for 1000 pre-selected targets, but also Full Frame Images (FFI) with 30- (Cycles 1 and 2) and 10- (Cycles 3 and 4) minute cadence. TESS has already confirmed 129 exoplanets, however the light curves from TESS can be used to study various other physical phenomena such as stellar rotation, flares, binaries, oscillations, and comets.

2 `tessipack`

The SC data is processed by the Science Processing Operations Center pipeline which extracts photometry and astrometry for each target star after removing the systematic errors. For FFI images only raw pixel correction is done. There are a number of packages available to obtain corrected light curves from FFI such as `TESScut` (Brasseur et al. 2019), `Eleanor` (Feinstein et al. 2019), and `lightKurve` (Lightkurve Collaboration et al. 2018). But none of the packages allows the user to select custom apertures interactively. `tessipack` is a publicly* available package that enables the user to interact directly with the pixels to obtain an optimal light curve and check for contamination of nearby stars.

`tessipack` acquires target pixel files (TPFs) with square target masks of 13 pixels on each side and a square background mask of 31 pixels on each side using the `Eleanor` and `lightKurve` packages. The optimal aperture of the target source can be defined interactively, and a systematic-error-corrected light curve can be obtained. Defining custom apertures improves the light curve, as seen in the light curve of the Gaia DR2 3337966050361143168 source (Fig. 1 top panel). Custom apertures also help to identify contamination from a nearby source: In Fig. 1 lower panel, a nearby source (blue custom aperture) contaminates the light curve of a non-variable star Gaia DR2 DR2333617130808368652 8 (red default aperture for given coordinates). `tessipack` allows one to quickly confirm the origin of the variability. A 1-minute demonstration video can be viewed on the conference site or here.

[1] Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Bd de l'Observatoire, CS 34229, 06304 Nice cedex 4, France
*`https://github.com/dinilbose/tessipack`

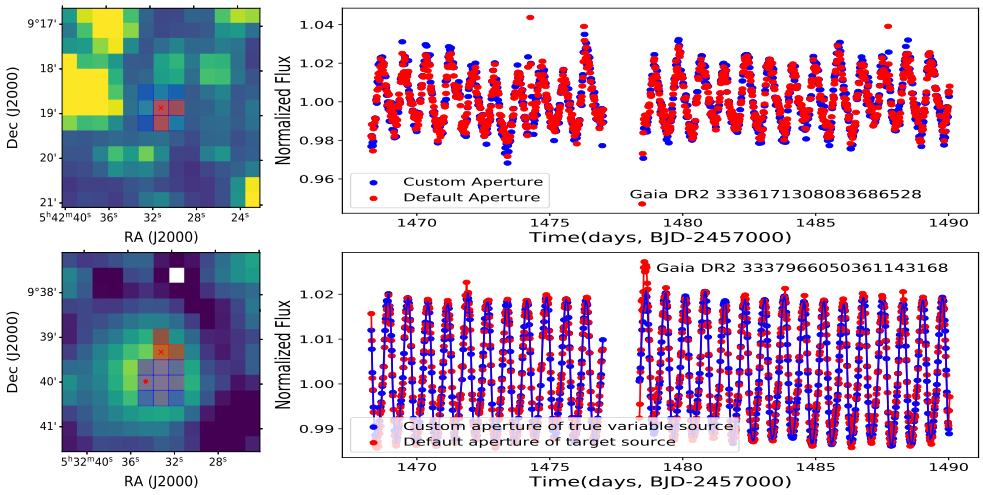

Fig. 1. Left: Custom (red) and default (blue) apertures overlayed over the TPFs. **Right:** Light curve obtained for Gaia DR2 3337966050361143168 (top) and Gaia DR2 DR23336171308083686528 (bottom, red only, see text for details).

3 Collinder 69

Collinder 69 is a young open cluster (6 Myr) at a distance of 400 parsecs. The 711 cluster members identified from Gaia DR2 (Cantat-Gaudin et al. 2018) were analysed using the `tessipack` package. We identified 44 variable stars and 30 candidate binary stars and these are shown in the colour-magnitude diagram (Fig. 2). The light curve of a variable star and a binary are shown in Fig 2b. The light curves and table of parameters are publicly accessible from github[†].

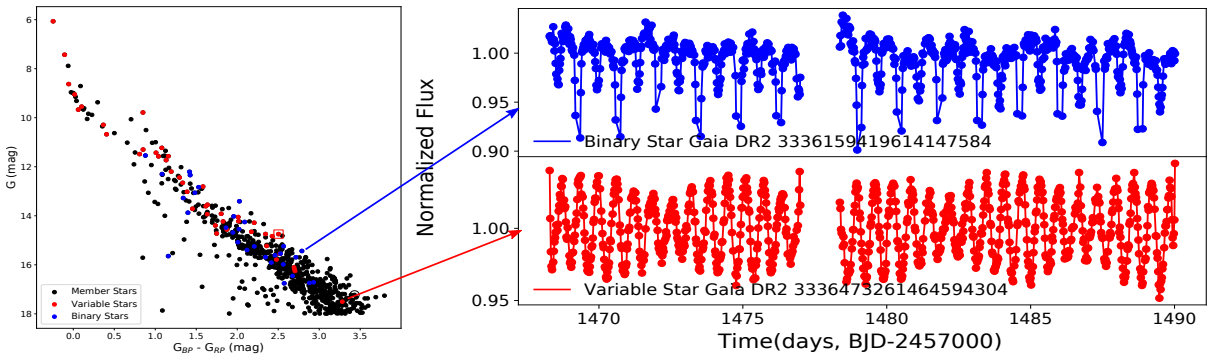

Fig. 2. Left: Color-magnitude diagram of Collinder 69 along with the identified variable source and binary stars. **Right:** Light curve of binary star Gaia DR2 3336159419614147584 and variable star Gaia DR2 3336473261464594304. The variable sources from Fig. 1 are shown as the red square (Fig. 1 top) and black open circle (Fig. 1 lower), respectively.

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[†]`https://github.com/dinilbose/tessipack/tree/main/examples/Collinder_69`