Stars and their variability observed from space
C. Neiner, W. W. Weiss, D. Baade, R. E. Griffin, C. C. Lovekin, A. F. J. Moffat (eds)

ECLIPSING BINARIES HIDING IN THE BACKGROUND: THE *KEPLER* PIXEL PROJECT

A. Forró[1,2,3] and R. Szabó[1,3]

Abstract. The aim of the Kepler pixel project is to discover new pulsating and other types of variable stars in the individual pixels of the original *Kepler* mission. In the framework of the project, 1272 eclipsing binary candidates were identified in the background pixels. After eliminating false positives and those stars that are already present in the *Kepler* Eclipsing Binary Catalog, we were left with 776 new eclipsing binaries. This is a substantial and significant addition to the 2922 eclipsing binaries present in the catalogue. The methods applied are automatic, and can therefore be used in the future for exploring the vast amounts of data that other space missions (e.g. *TESS*, later *PLATO*) produce.

Keywords: Stars: binaries, methods: photometry

1 Introduction

During its original mission, the *Kepler* space telescope measured the brightness of more than 150000 stars, producing quasi-continuous 4-year-long observations with unprecedented photometric precision. Though usually the main targets, those that are listed in the *Kepler* Input Catalog (Brown et al. 2011) were already investigated, but more findings indicate that even the background pixels of *Kepler*'s data hold interesting new information waiting to be mined.

2 The *Kepler* Pixel Project

The aim of the *Kepler* Pixel Project (Szabó 2018) was to discover new pulsating and other types of variable stars in the original *Kepler* field. Since Q4 was a relatively quiescent observing period, we decided to start our search using its dataset.

We downloaded each individual pixel of the long-cadence (30 min) files, which resulted in more than 6 million light-curves. All the pixels were examined, regardless of whether or not they belonged to a main (KIC) target. The initial goal was to look for faint background RR Lyrae stars, so we specified the filtering criteria accordingly. Those pixels were included in our potential candidate list whose light-curves showed a period between 0.25 and 1 day, and whose Fourier spectra exhibited at least two harmonics of the main frequency with decreasing amplitude.

3 Results

The above criteria yielded ∼12500 candidate pixels. However, one pixel does not equal one candidate, and in the majority of cases a couple of pixels were available for each candidate. Despite our specific criteria, ∼90% of our candidates were eclipsing binary stars. We identified successfully 1272 target pixel files containing an eclipsing binary candidate; in most cases they were located in the background.

Since the goal was to find new variable stars in the field, those candidates that are already listed in the *Kepler* Eclipsing Binary Catalog (Prša et al. 2011; Abdul-Masih et al. 2016) were excluded. This cross-match left us with 777 candidates. One of our candidates' light-curve was in fact the result of contamination by a neearby bright star, so that was removed from our candidate list too. The final list of potentially new eclipsing binaries in the original *Kepler* field had 776 candidates, consisting of 2778 individual pixels in total. Figure 1 shows one of our eclipsing binary candidates (DR2 2073865026641810944). It was found in the background of not just one but two main targets, namely KIC 5898935 and KIC 5898983.

[1] Konkoly Thege Miklós Astronomical Institute, Research Centre for Astronomy and Earth Sciences
[2] Eötvös Loránd University, Department of Astronomy
[3] MTA CSFK Lendület Near-Field Cosmology Research Group

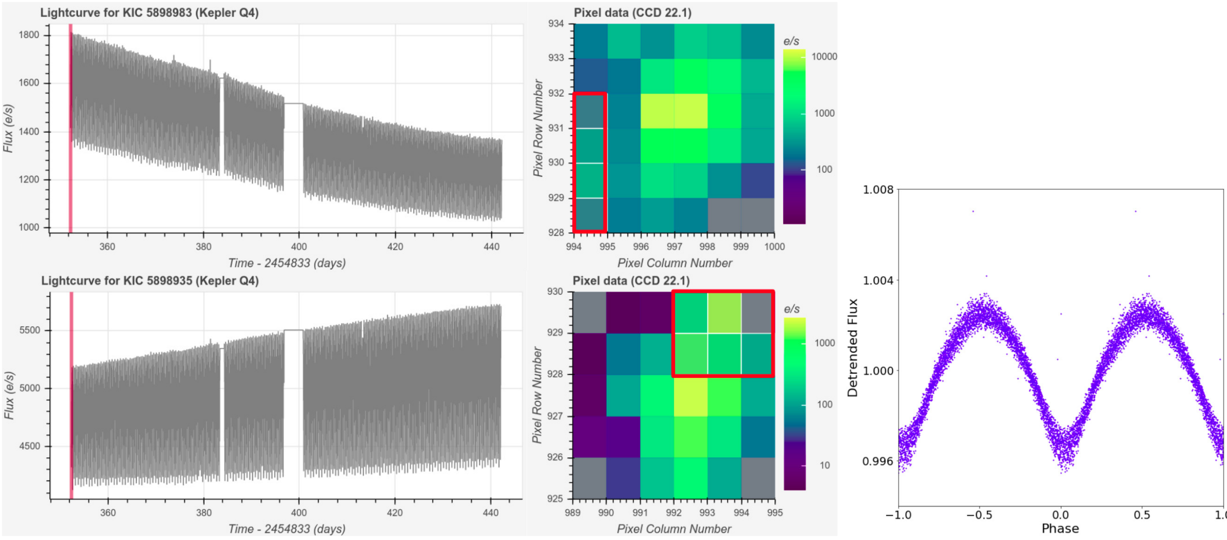

Fig. 1. Left: Light-curves of the candidate, as observed in Q4. The pixels containing the signal of the eclipsing binary are marked with red edges. The candidate is located near two apparently close main targets, so it is present in the background of both target pixel files. **Right:** Folded light-curve of the candidate.

4 Conclusions

By investigating each individual pixel of the original *Kepler* mission's Q4 quarter, the *Kepler* Pixel Project succeeded in finding 1272 new eclipsing binary candidates in the original *Kepler* data, of which 776 turned out to be new candidates. We also btained data from the other quarters for the candidates, thereby creating 4-year-long light-curves. The unprecedented photometric precision enabled us to investigate the systems we had discovered in more detail. The algorithms developed for the project can be used analogously for exploring other space-mission data as well (e.g. *TESS*, later *PLATO).*

The research leading to these results has received funding from the LP2018-7/2019 Lendlet grant of the Hungarian Academy of Sciences and from the NKFIH K-115709 grant of the National Research, Development and Innovation Office of Hungary. It made use of Lightkurve, a Python package for Kepler and TESS data analyses (Lightkurve Collaboration et al. 2018).

References

Abdul-Masih, M., Prša, A., Conroy, K., et al. 2016, AJ, 151, 101

Brown, T. M., Latham, D. W., Everett, M. E., & Esquerdo, G. A. 2011, AJ, 142, 112

Lightkurve Collaboration, Cardoso, J. V. d. M., Hedges, C., et al. 2018, Lightkurve: Kepler and TESS time series analysis in Python, Astrophysics Source Code Library

Prša, A., Batalha, N., Slawson, R. W., et al. 2011, AJ, 141, 83

Szabó, R. 2018, in The RR Lyrae 2017 Conference. Revival of the Classical Pulsators: from Galactic Structure to Stellar Interior Diagnostics, ed. R. Smolec, K. Kinemuchi, & R. I. Anderson, Vol. 6, 119–123