Automatized Extended Aperture Photometry of RR Lyrae stars observed in K2

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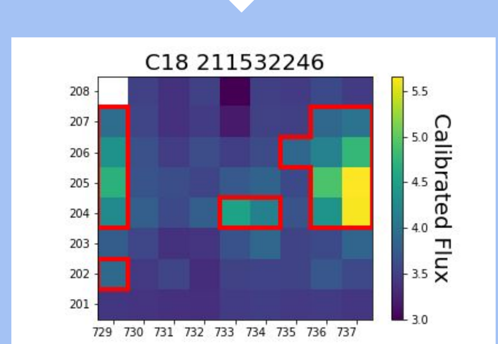
Abstract

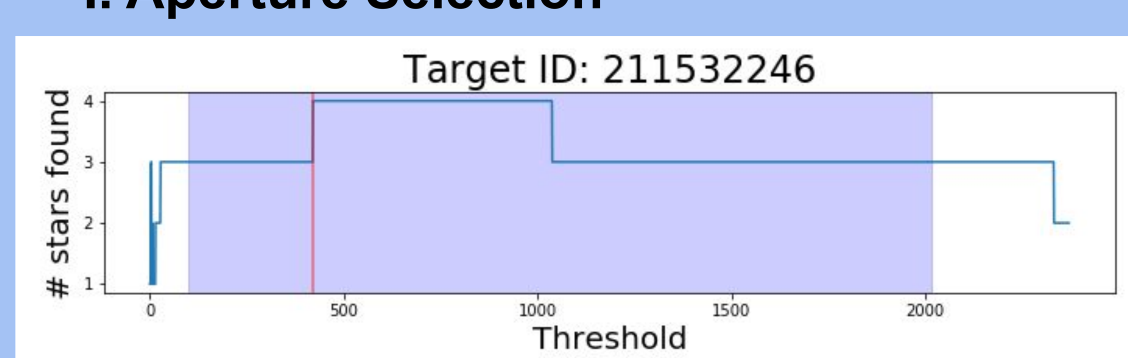
Light curves for RR Lyrae stars can be difficult to obtain properly in the K2 mission due to the similarities of timescales of the observed physical phenomena and the instrumental signals appearing in the data. We developed a new photometric pipeline we call MASSAAP, a key element of which is to extend the aperture to an optimal size to compensate for the motion of the telescope and to collect all available flux from the star before applying further corrections. We used this pipeline on the nearly two thousand RR Lyrae targets observed in the K2 mission. Here we present the outline of our pipeline *(down)* and make some comparisons with other photometry solutions *(right)*.

MASSAAP Pipeline Steps

This example shows how the LC for the faintest target shown on the right was obtained.

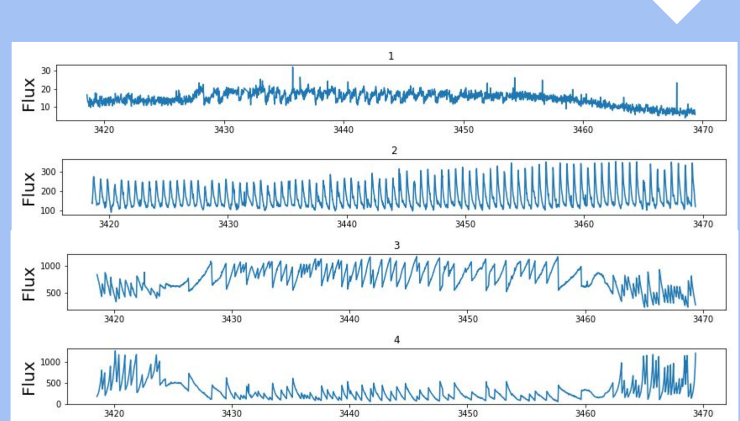
I. Aperture Selection



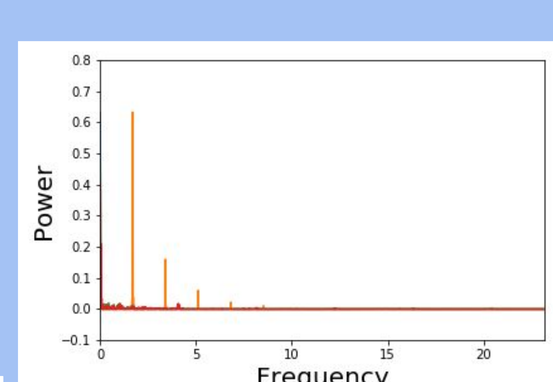


1: Fit apertures to most frames of the TPF by standard **`astropy`** methods.

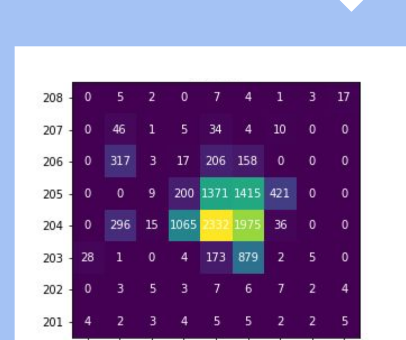
2: A pixel is said to cover a star if selected to be part of an aperture more than *x* times. We plot the number of stars we find as the function of *x*. Choose an *x* that separates the most stars.
(We disregard very high and very low possibilities for our choice of *x*.)

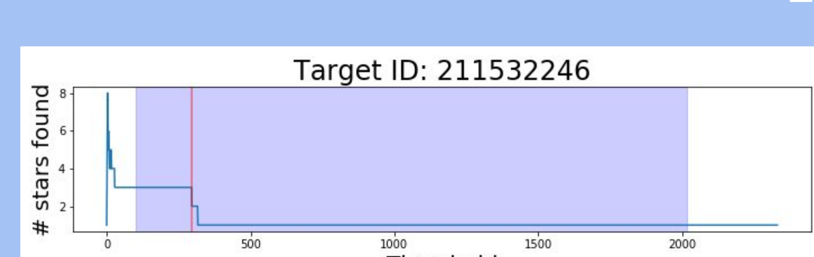


3: Produce LC for each candidate, select the variable star by Fourier methods.



4: repeat step 1 and 2. Plot how many times a pixel was selected. Set the values of those pixels to 0 which were part of a non-variable star previously.





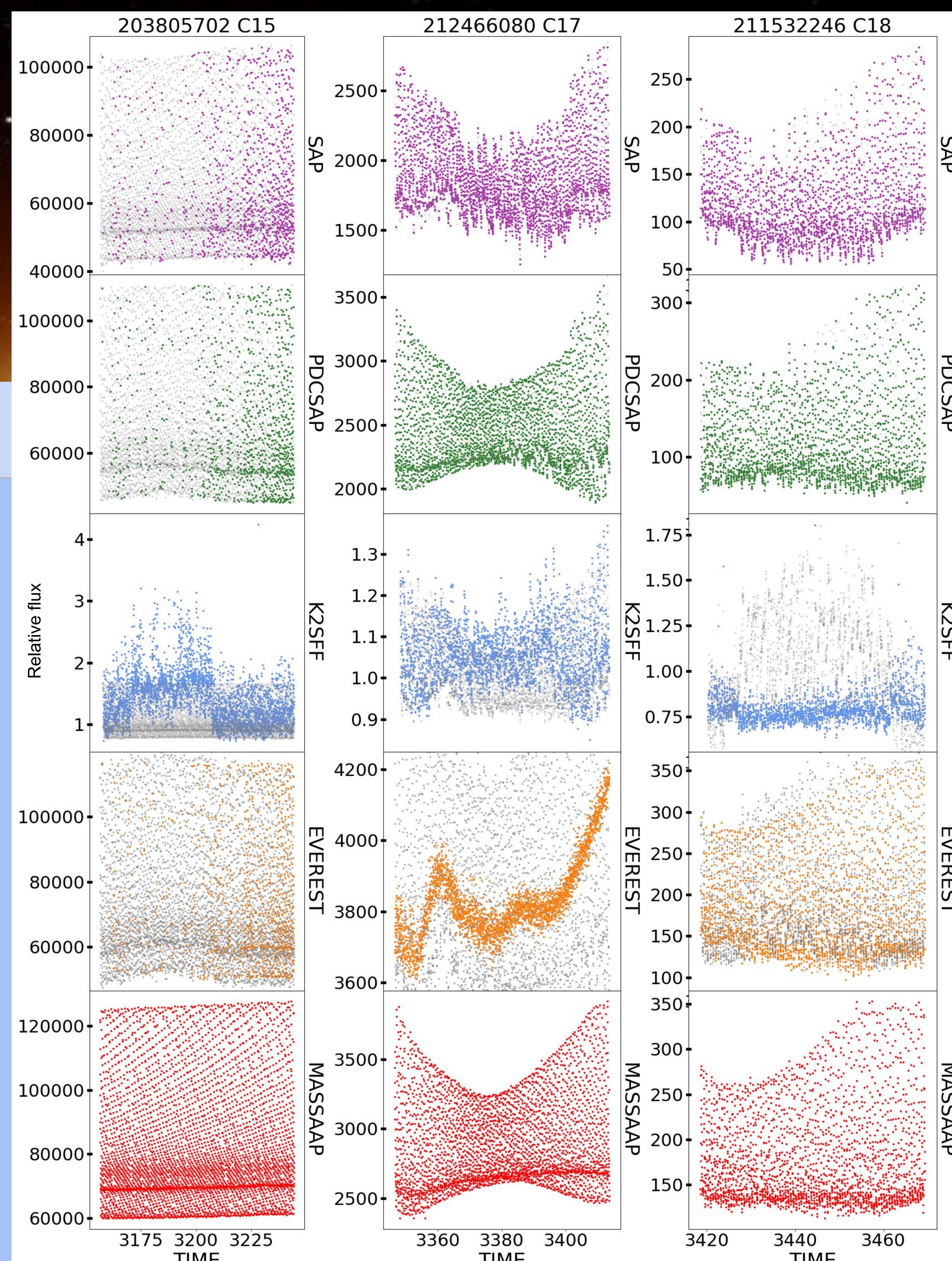
Replot number of stars vs selection threshold. Choose a selection threshold separating the most stars.

Repeat the steps above until 1 star is found, no matter the threshold chosen.

Computationally easy
Computationally hard

II. Corrections

After photometry with the selected aperture, we apply the K2 Systematics Correction (K2SC) method that can effectively separate pulsation from systematics. A spline fit might be subtracted, but one must keep in mind not to kill slow variations with it.



Comparison of the light curves produced by different pipelines for three targets with very different luminosities. Ours is the bottom one. Units are in fluxes (e⁻/s), time is in BJD.

Grey dots:
SAP and PDCSAP plots: data-points with a nonzero quality flag
K2SFF & EVEREST plots: raw flux, before light curve corrections

Comments on the 3 cases:
- High luminosity case: the quality of MASSAAP LC and EVEREST raw flux is comparable, though the former is slightly better
- Medium luminosity case: by inspection, MASSAAP offers the best LC
- Low luminosity case: MASSAAP quality is comparable to EVEREST, no significant improvement

*It is our general observation that to maximize the likelihood of choosing a good quality light curve, **MASSAAP** offers the best choice: it does not always offer a significantly better LC than other pipelines, but it does offer good quality LCs with higher consistency. **MASSAAP** quality is worse in very little proportion of the cases.*

Acknowledgements
Funding for the Kepler and K2 missions are provided by the NASA Science Mission directorate. EP was supported by the Bolyai János Research Scholarship, LM by the Premium Postdoctoral Research Program of the Hungarian Academy of Sciences. This research received funding from the Hungarian National Research, Development and Innovation Office grants K-115709, PD-121203, 2018-2.1.7-UK_GYAK-2019-00009, and from the Lendület LP2014-17 and LP2018-7/2019 grants of the Hungarian Academy of Sciences. This research made use of Lightkurve, a Python package for Kepler and TESS data analysis (Lightkurve Collaboration, 2018).

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K2SFF: Vanderburg, A., Johnson, J. A., 2014, PASP, 126, 948
EVEREST: Luger, R., Kruse, E., Foreman-Mackey, D., Agol, E., Saunders, N., 2017, AJ, 156, 99

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