EPJ Web of Conferences **101**, 06032 (2015)
DOI: 10.1051/epjconf/201510106032

Kepler and the Long Period Variables

E. Hartig[1,a], J. Cash[2,b], K. Hinkle[3], T. Lebzelter[1], J. Mighell[3], and D. K. Walter[2]

[1] University of Vienna, Department of Astrophysics, Türkenschanzstrasse 17, A-1180 Vienna, Austria
[2] Department of Biological and Physical Sciences, South Carolina State University, P.O. Box 7296, Orangeburg, SC 29117,USA
[3] National Optical Astronomy Observatories, P.O. Box 26732, Tucson, AZ 85726 USA

Abstract. High precision *Kepler* photometry is used to explore the details of AGB light curves. Since AGB variability has a typical time scale on order of a year we present methods for the removal of long term trends and quarterly changes in *Kepler* data. While undergoing long period variations of many magnitudes, the light curves are shown to be smooth at the millimagnitude level over much shorter time intervals. No flares or other rapid events were detected down to the sub-day time scale.

1 Removing Instrumental Effects

We tested a large variety of techniques to handle the extraction of the photometry and the combining of the observing quarters in the optimum way. In brief, we note the following caveats: the method of co-trending is of no use for long period variables. We do not recommend to use the SAP and PDC pipeline data without a detailed check since we noticed that they do not always give correct results. The TPD data are more reliable. Superstamps can be used to fill gaps in the observed light curves.

Fig. 1a shows the pixel maps of Q6 to Q9 for the small amplitude variable V621 Lyr (KIC 2570059). The pipeline target mask is indicated by the black squares, the black cross gives the expected star location converted from the star's celestial coordinates. Different gray intensities indicate different flux levels. The target mask, marked by black squares, is obviously not covering the star's image correctly. We used a re-defined target mask for extracting the photometry.

Kepler light-curves of three suspected RGB variables of the old open cluster NGC 6791 with low intrinsic variations are shown in Fig. 1b. They nicely illustrate the so-called *Kepler*-year of 372.5 d. The third curve from top gives the *Kepler* pipeline background measurements for V607 Lyr. The *Kepler*-year is the strongest periodic signal in these stars and its proper removal is one of main issues for analysis of *Kepler* light-curves in low-brightness objects. There are clear star-to-star variations. The *Kepler*-year in bright objects is likely a problem of the SAP data extraction. We show this in Fig. 1c where we compare SAP data from [1] showing the *Kepler*-year with TPD data extracted in our way giving a more or less flat curve.

A combination of V621 Lyr (Fig. 1d) TPD and superstamps (where available) allows to produce nice and continuous light curves. We show the raw and chained SAP light curve for comparison.

2 Results

With high time resolution, a lack of seasonal gaps, and observations covering up to four years the properly combined *Kepler* data provide a unique set of LPV light curves. Although the time span

[a] e-mail: erich.hartig@univie.ac.at
[b] e-mail: jcash@physics.scsu.edu

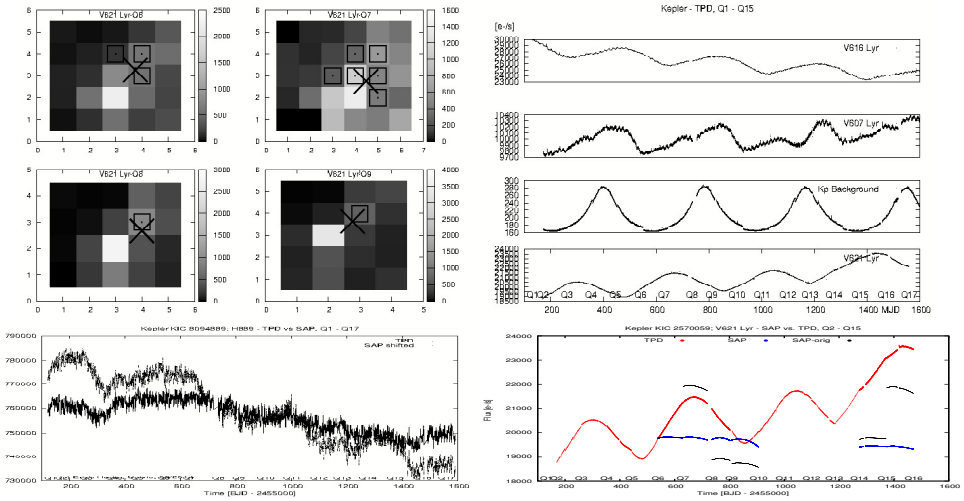

Fig. 1. a) top left: V621 Lyr Pixel Map of Q6 to Q9, b) top right: NGC 6791 suspected RGB stars compared with the *Kepler*-year, c) bottom left: SAP versus TPD, d) bottom right: V621 Lyr, for more details please refer to the text.

observed is not sufficient for a conclusive study of semiregular variability, the data form a valuable contribution to its understanding. For instance, supporting previous studies, we find no indication for variability on time scales of hours. Many features of semiregular light curves, for instance times of maxima and minima and amplitude variations, can be explained by a combination of typically 3 to 4 periods. Multiperiodicity is expressed in three ways in our data set:

- Our stars are generally pulsating in both the fundamental and the first overtone mode.
- Period ratios of ≈ 1.1 are also present indicating multiperiodicity in the dominant pulsation mode in about half of our sample stars.
- Long secondary periods (LSPs), the least understood part of red giant variability, are present in several stars in our sample. Our small study suggests that stars having two periods with a ratio close to 1 typically do not show a LSP. LSPs seem to be directly related to the periodicity pattern on shorter time scales.

For further details we refer to our recent paper [2].

EH thanks the University of Vienna for support (FA538905). TL was funded by the FWF project P23737.

References

1. Bányai, E., Kiss, L. L. and Bedding, T. R., et al., Proc. of IAU Symposium **301**, (2013) 381
2. Hartig, E., Cash, J., Hinkle, K., Lebzelter, T., Mighell, K., and Walter, D., AJ **148**, (2014) 123