Stars and their variability observed from space
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THE SPECTROSCOPIC MULTIPLICITY FRACTION IN A SAMPLE OF A/F-TYPE (CANDIDATE) HYBRID STARS FROM THE *KEPLER* MISSION

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Abstract. By means of a study based on multi-epoch high-resolution spectra of 83 A–F-type candidate hybrid pulsating stars from the *Kepler* mission, collected at various observatories, we derive a (lower) estimate of the fraction of hybrid stars which belong to spectroscopic binary and multiple systems. In the first part of the study (49 hybrid stars) we derived a global spectroscopic multiplicity fraction of 27% (Lampens et al. 2018). In the second part we intend to obtain the same information for another 46 candidates. From a preliminary classification of 43 new targets, we are finding a spectroscopic multiplicity fraction of ∼30%. Spectroscopic observations are on-going. As a bonus, we identified systems for which a combined analysis of time delays (TDs) with radial velocities (RVs) enable one to derive accurate orbital elements and mass ratios and also an identification of the pulsating component. Furthermore, we will analyse the low-frequency regions of the periodograms of these stars using the exquisite data collected by *Kepler*.

Keywords: technique: spectroscopy, stars: spectroscopic systems, oscillations

1 Introduction

Our goal is to characterize the spectroscopic variability of an unbiased sample of *Kepler* hybrid pulsators in the γ Dor–δ Sct region. We need at least 4–6 spectra per target to be able to detect binarity or multiplicity at different time-scales, with orbital periods ranging from a few days to several years, and to establish a meaningful classification. We aimed to determine the orbits for systems having good phase coverage. The acquisition of the spectra was, and is, performed with telescopes at different sites equipped with an échelle spectrograph: HERMES (La Palma, Spain) (Raskin et al. 2011), ACE spectrograph (Piszkés-tető Observatory, Hungary) (Derekas et al. 2017), TCES (Thüringer Landessternwarte, Tautenburg, Germany), OES (Ondřejov Observatory, Czech Republic) (Kabáth et al., in prep.) and at the Observatorio Astronómico Nacional (San Pedro Mártir, México).

2 The spectroscopic multiplicity fraction

We completed an extensive study of a first sample from the *Kepler* mission (49 A–F *bona fide* hybrid stars and one cool hybrid object from Table 3 in Uytterhoeven et al. (2011)). In this report we have identified 10 spectroscopic systems (3 single-lined or SB1, 4 double-lined or SB2, 3 triple-lined or SB3), and 3 objects with long-term RV variations (VAR). Two other hybrid stars may have a companion or a shell (CMP). Including the known *Kepler* eclipsing binary, we found a global multiplicity fraction of *at least* 27% (Fig. 1, left) (Lampens et al. 2018). The distribution of detected orbital periods is dominated by those in the range 1500–2500 days (based on the 13 new systems). Our second sample of A–F candidate hybrid stars was based on a re-analysis of all *Kepler* targets with $5500 < T_{\rm eff} < 10000$ K. That sample consisted of 46 poorly-studied hybrid stars satisfying Kp < 10.5 mag. Among 43 objects we identified 9 SBs, 2 objects with long-term RV variations (VAR) and 2 targets with a companion or a shell (CMP). We derived a spectroscopic multiplicity fraction of ∼30% (Fig. 1, right).

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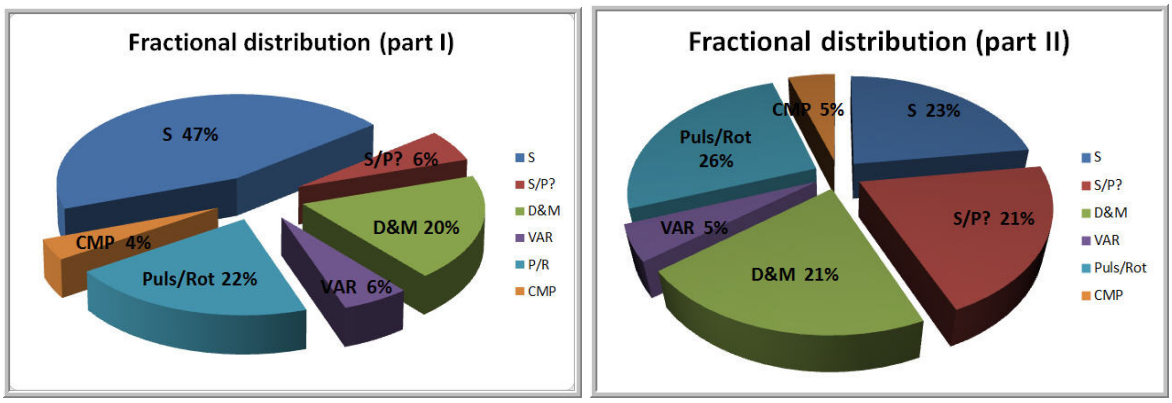

Fig. 1. Classification results based on 83 (candidate) hybrid pulsators. Classes are S: stable, S/P?: stable or pulsating?, D&M: binary/multiple, CMP: composite, Puls/Rot: pulsating/rotating star, VAR: with long-term RV variability. **Left:** Part I. **Right:** Part II. Note: this is *on-going work*.

3 Conclusions

- At least **one out of four** *Kepler* hybrid stars is part of a binary/multiple system. The multiplicity fraction derived from two samples of A/F-type hybrid stars is in excellent agreement with the results obtained by Nemec et al. (2017) (i.e. 33% of binary/multiple systems in a sample of SX Phe stars). *For an asteroseismologist, whether or not the (hybrid) pulsator is in a binary or multiple system matters.*
- The TDs obtained from the *Kepler* light curves and the RVs obtained from the spectroscopic monitoring provide the long time base needed for a precise determination of the orbits. This in turn allows one to derive fundamental-component properties (e.g. the mass function or mass ratio). In addition, we can identify the pulsating component(s). Armed with this information as well as with improved atmospheric parameters and $v \sin i$, our study provides crucial knowledge for a future asteroseismic modelling of some truly interesting hybrid pulsators.
- Immediate objectives for this project are to perform combined (RV+TD) analyses as well as frequency-searches of the *Kepler* data (low-frequency regime); to determine the (global) multiplicity fraction and to spectroscopically follow up on particularly worthwhile long-term targets.

This study is based on spectra obtained with (i) the Hermes spectrograph installed on the Mercator telescope, operated by the IvS, KULeuven, funded by the Flemish Community and located at the Observatorio del Roque de los Muchachos, La Palma, Spain of the Instituto de Astrofísica de Canarias, (ii) the ACE spectrograph of Konkoly Observatory, Piskés-tető, Hungary, and (iii) the coudé spectrograph on the 2-m Alfred Jensch telescope of the Thüringer Landessternwarte, Tautenburg, Germany.
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