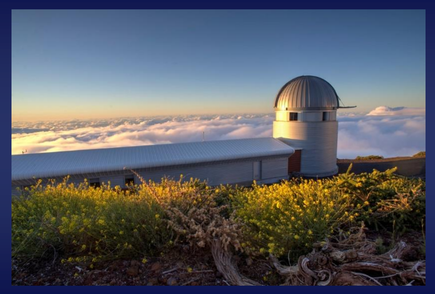


Spectroscopic Study of A/F-Type Candidate Hybrid Pulsators of the *Kepler* Mission

P. Lampens[1*], Y. Frémat[1], L. Vermeylen[1], Á. Sodór[2], M. Skarka[2], P. De Cat[1], Zs. Bógnar[2]

[1]Koninklijke Sterrenwacht van België (Royal Observatory of Belgium), Ringlaan 3, Brussel, Belgium *e-mail: patricia.lampens@oma.be
[2]Konkoly Observatory , MTA CSFK, Konkoly Thege M. u. 15-17, Budapest, Hungary

Observational campaigns

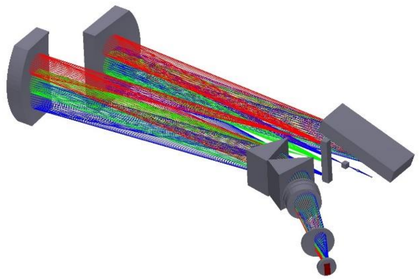


Fig. 1. The Mercator telescope is operated by the IvS, KULeuven at the Spanish observatory Roque de los Muchachos (La Palma, Canary Islands).

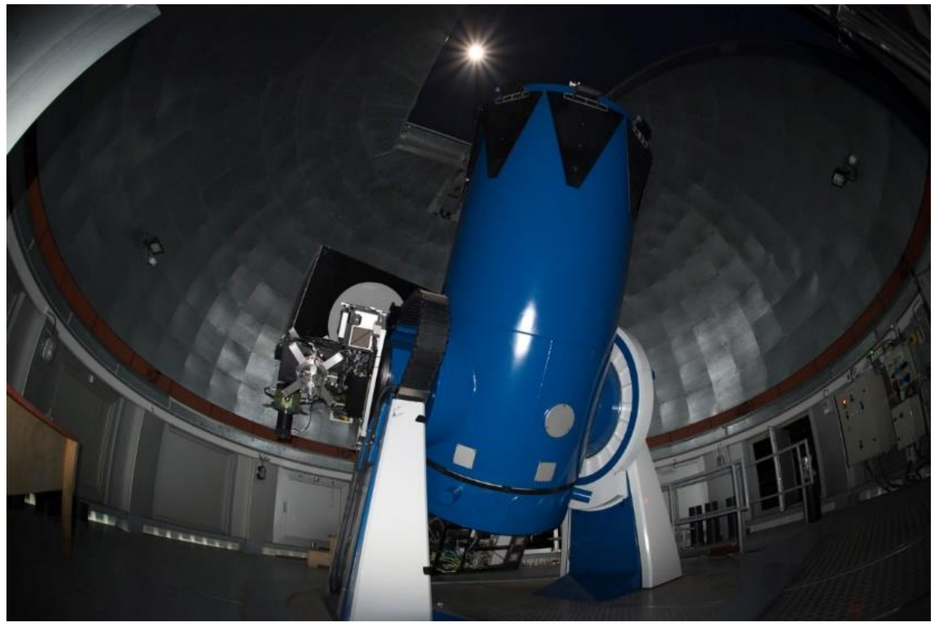


Fig. 2. The High-Efficiency, high-Resolution Mercator Echelle Spectrograph (HERMES) is available at the Coudé focus of the 1.2-m Mercator telescope for about half of the time.

Spectroscopic Study of A/F-Type Candidate Hybrid Pulsators of the *Kepler* Mission

P. Lampens[1*], Y. Frémat[1], L. Vermeylen[1], Á. Sodór[2], M. Skarka[2], P. De Cat[1], Zs. Bógnar[2]

[1]Koninklijke Sterrenwacht van België (Royal Observatory of Belgium), Ringlaan 3, Brussel, Belgium *e-mail: patricia.lampens@oma.be
[2]Konkoly Observatory , MTA CSFK, Konkoly Thege M. u. 15-17, Budapest, Hungary

50 A/F-type *Kepler* Cand. Hybrid Stars

- **Two regimes** of frequencies
- **Possible causes (low freq)**:

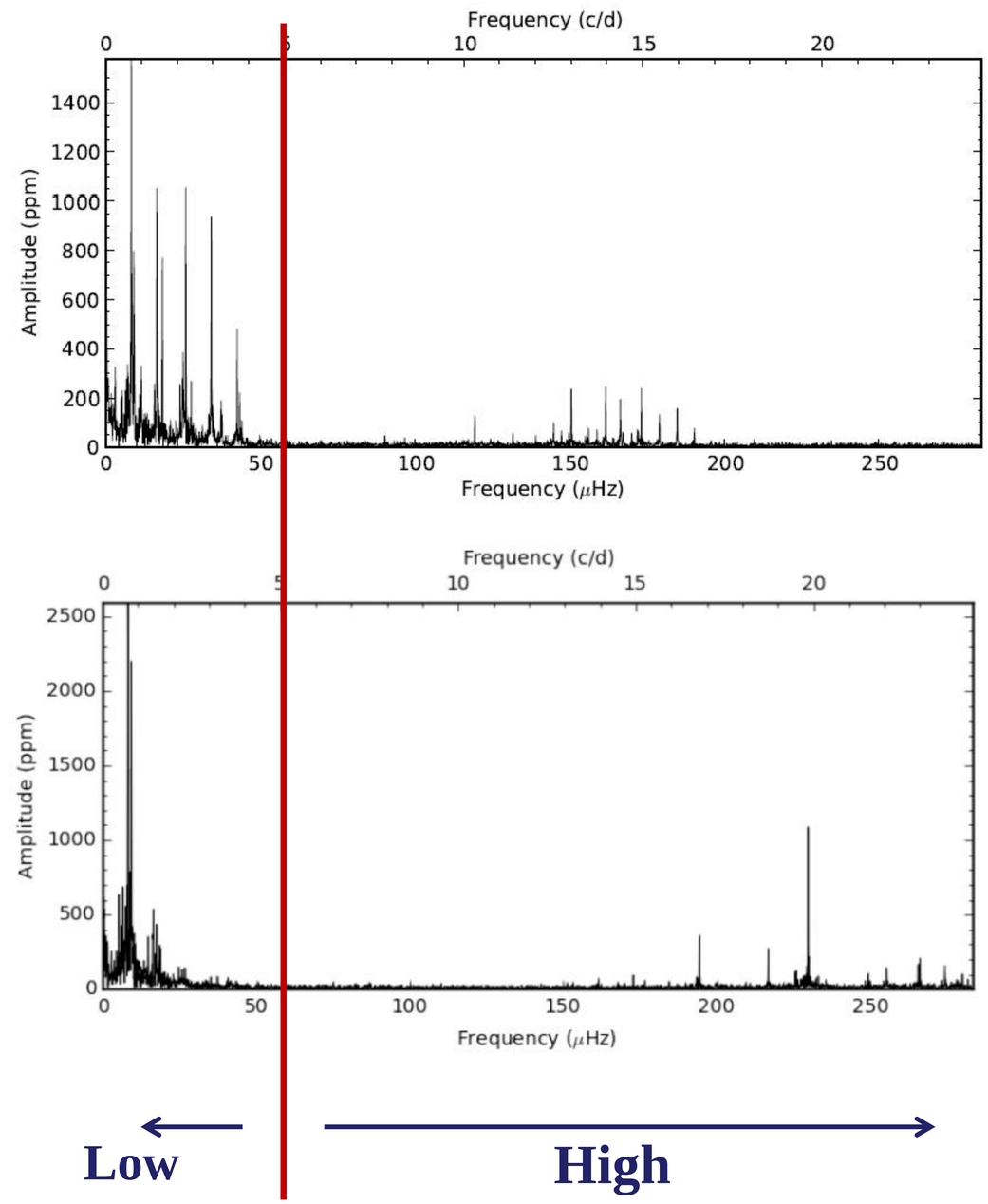
a. Pulsations (modes 'p' + 'g') ⇨ true γ Dor - δ Sct hybrid stars

b. Inhomogeneous surfaces modulated by (strong) rotation[1]

c. Ellipsoïdal or eclipsing binaries[1] (tidal effects, reflections, …)

d. Tidally excited 'g' modes in close binary systems with an excentric orbit[1]

[1] **+ short-period pulsations (type δ Sct)**



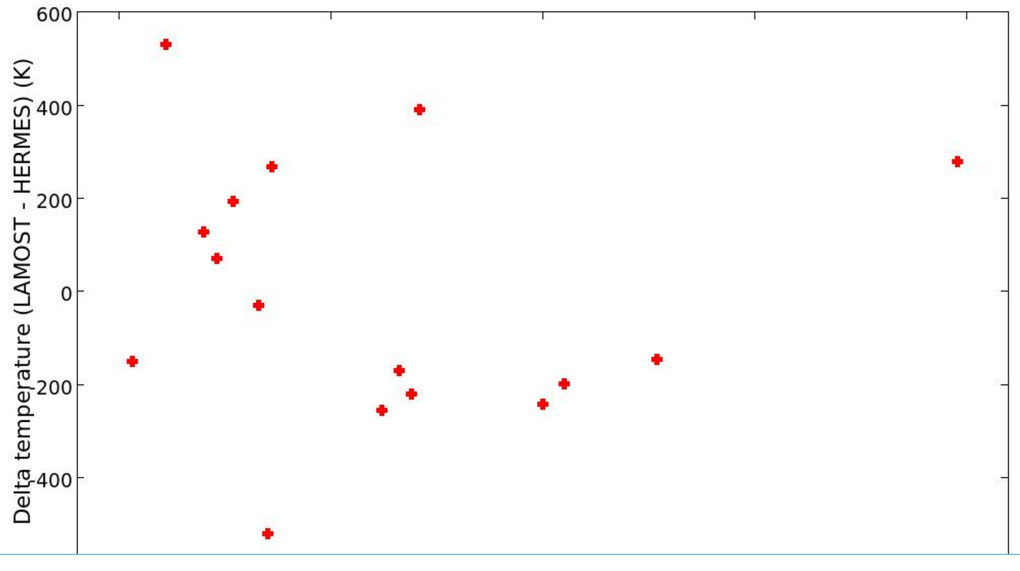
Spectroscopic Study of A/F-Type Candidate Hybrid Pulsators of the *Kepler* Mission

P. Lampens[1*], Y. Frémat[1], L. Vermeylen[1], Á. Sodór[2], M. Skarka[2], P. De Cat[1], Zs. Bógnar[2]

[1]Koninklijke Sterrenwacht van België (Royal Observatory of Belgium), Ringlaan 3, Brussel, Belgium *e-mail: patricia.lampens@oma.be
[2]Konkoly Observatory , MTA CSFK, Konkoly Thege M. u. 15-17, Budapest, Hungary

Stellar Characterization: New Atmospheric Properties

In an effort to understand the low frequencies showing in the light curves of the brighter A/F-type candidate hybrid stars of the *Kepler* mission, we started a systematic study. With min. 4-5 spectra per object, we determined their radial velocities, **atmospheric stellar properties & *v* sin *i***, including a classification scheme on the basis of their cross-correlation functions and radial velocity curves as a function of time.



⇨Usefulness of other spectroscopic determinations to demonstrate robustness (any systematics?) & quality of error determination, for example also LAMOST!

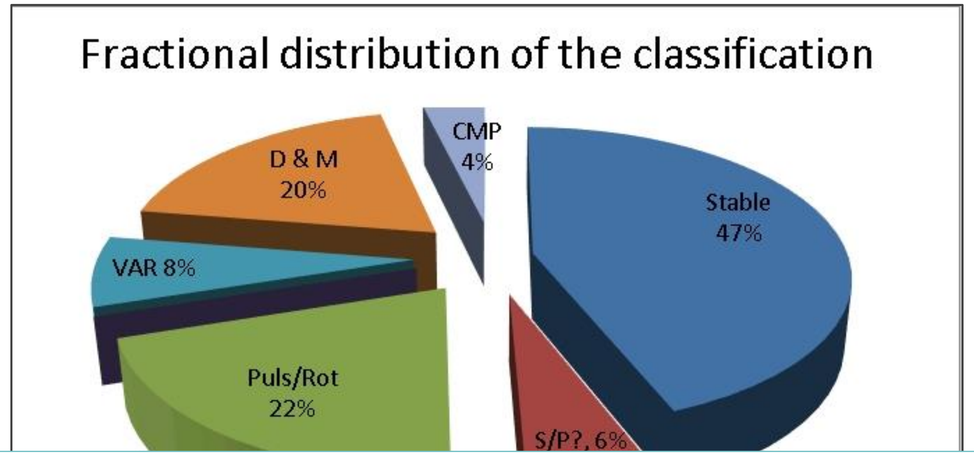
Spectroscopic Study of A/F-Type Candidate Hybrid Pulsators of the *Kepler* Mission

P. Lampens[1*], Y. Frémat[1], L. Vermeylen[1], Á. Sodór[2], M. Skarka[2], P. De Cat[1], Zs. Bógnar[2]

[1]Koninklijke Sterrenwacht van België (Royal Observatory of Belgium), Ringlaan 3, Brussel, Belgium *e-mail: patricia.lampens@oma.be
[2]Konkoly Observatory , MTA CSFK, Konkoly Thege M. u. 15-17, Budapest, Hungary

The Multiplicity Fraction

Our sample consists of 49 A/F-type *bona fide* candid. hybrid stars and one cool object. We identified **9 spectroscopic systems** (SB) and **3 objects with long-RV term variations** (VAR) ⇨ **spectr. multiplicity fraction of at least 24%.** Two other targets have a **possible companion or shell** (CMP). If we include the known eclipsing binary and add the new detections from the photometric time delays, we find a global multiplicity fraction of 33%.



⇨Probable multiplicity rate of ~30%. Presence of orbital frequencies & harmonics may explain (some) low frequencies.

Spectroscopic Study of A/F-Type Candidate Hybrid Pulsators of the *Kepler* Mission

P. Lampens[1*], Y. Frémat[1], L. Vermeylen[1], Á. Sodór[2], M. Skarka[2], P. De Cat[1], Zs. Bógnar[2]

[1]Koninklijke Sterrenwacht van België (Royal Observatory of Belgium), Ringlaan 3, Brussel, Belgium *e-mail: patricia.lampens@oma.be
[2]Konkoly Observatory , MTA CSFK, Konkoly Thege M. u. 15-17, Budapest, Hungary

Orbital Solutions

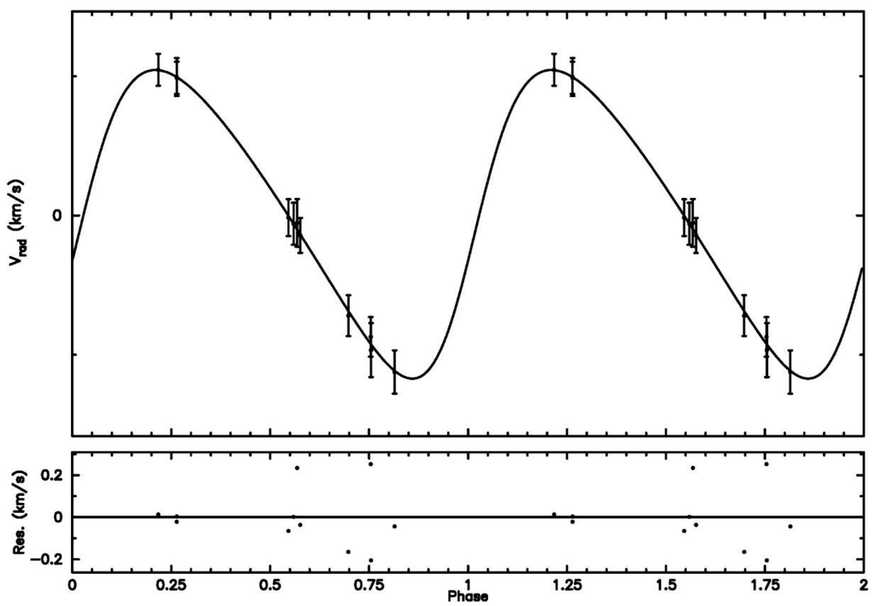


Fig. 3. The radial velocity curve and (prelim.) orbital solution for a SB1 system

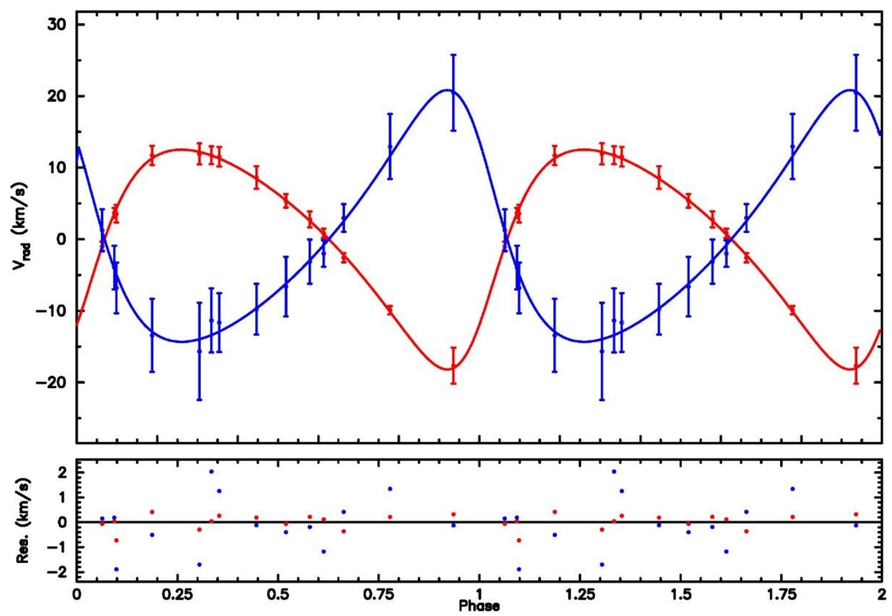


Fig. 4. The component radial velocities and orbital solution for a SB2 system

⇨Needs multi-epoch radial velocities. Usefulness of complementary data to better constrain the solution, such as LAMOST RV!

Spectroscopic Study of A/F-Type Candidate Hybrid Pulsators of the *Kepler* Mission

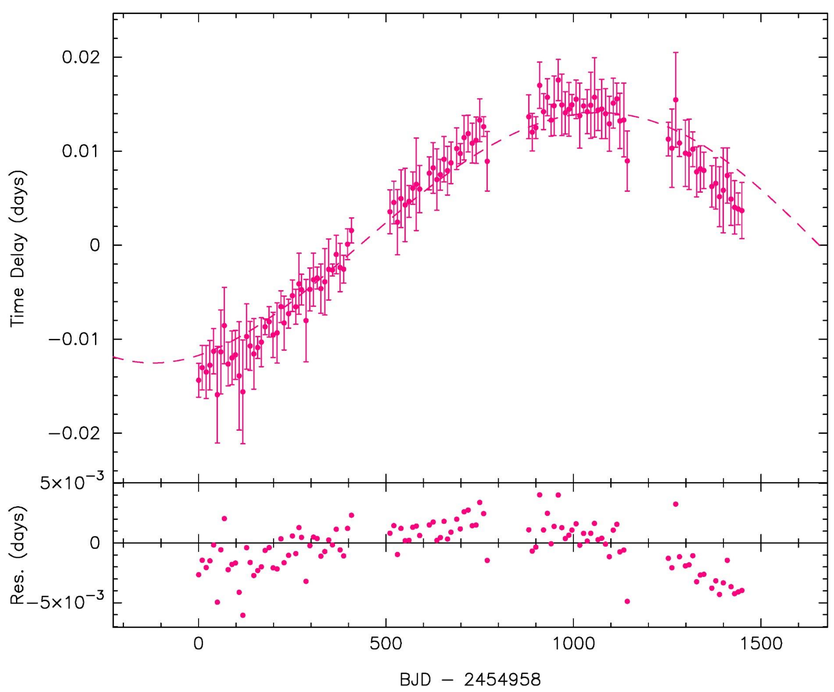
P. Lampens[1*], Y. Frémat[1], L. Vermeylen[1], Á. Sodór[2], M. Skarka[2], P. De Cat[1], Zs. Bógnar[2]

[1]Koninklijke Sterrenwacht van België (Royal Observatory of Belgium), Ringlaan 3, Brussel, Belgium *e-mail: patricia.lampens@oma.be
[2]Konkoly Observatory , MTA CSFK, Konkoly Thege M. u. 15-17, Budapest, Hungary

Improved Orbit Characterization

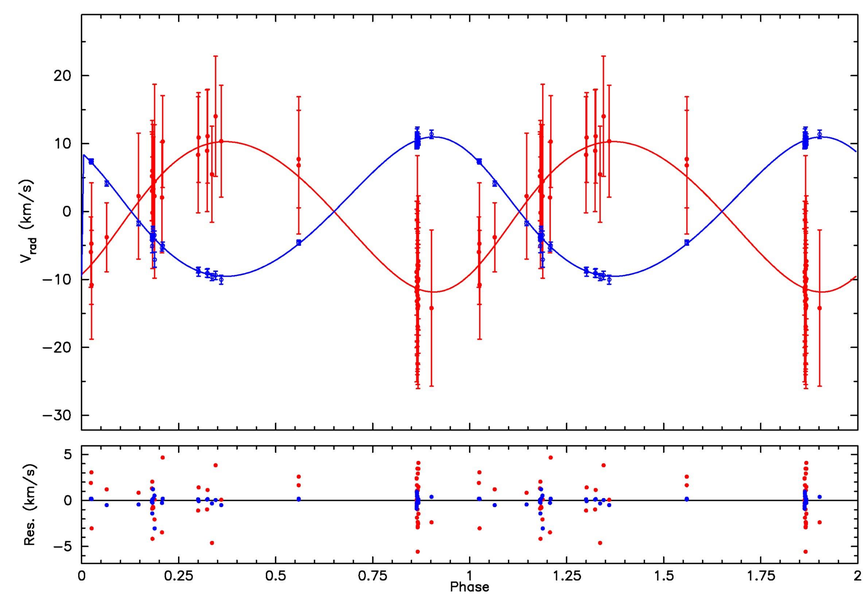
2009 – 2013

4 years of *Kepler* photometry:
Frequencies & Time Delays (pulsations)



2013 – 2016

4 years of *HERMES* spectroscopy:
Atmospheric properties (T_{eff}, log *g*, *v* sin *i*),
Radial Velocities, Variability, Multiplicity…



Lampens et al., to appear in A&A