Characterizing the variability of a sample of massive pulsators in eclipsing binaries

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Introduction

- Motivation: Mass discrepancy (Herrero et al. 1992)

- It is caused by underestimations of the masses of the stellar convective cores

- Most recent efforts:
  - Tkachenko et al. (2020)
  - Burssens et al. (2023)
  - Johnston et al. (2024)
  - Poster 75 by May Pedersen

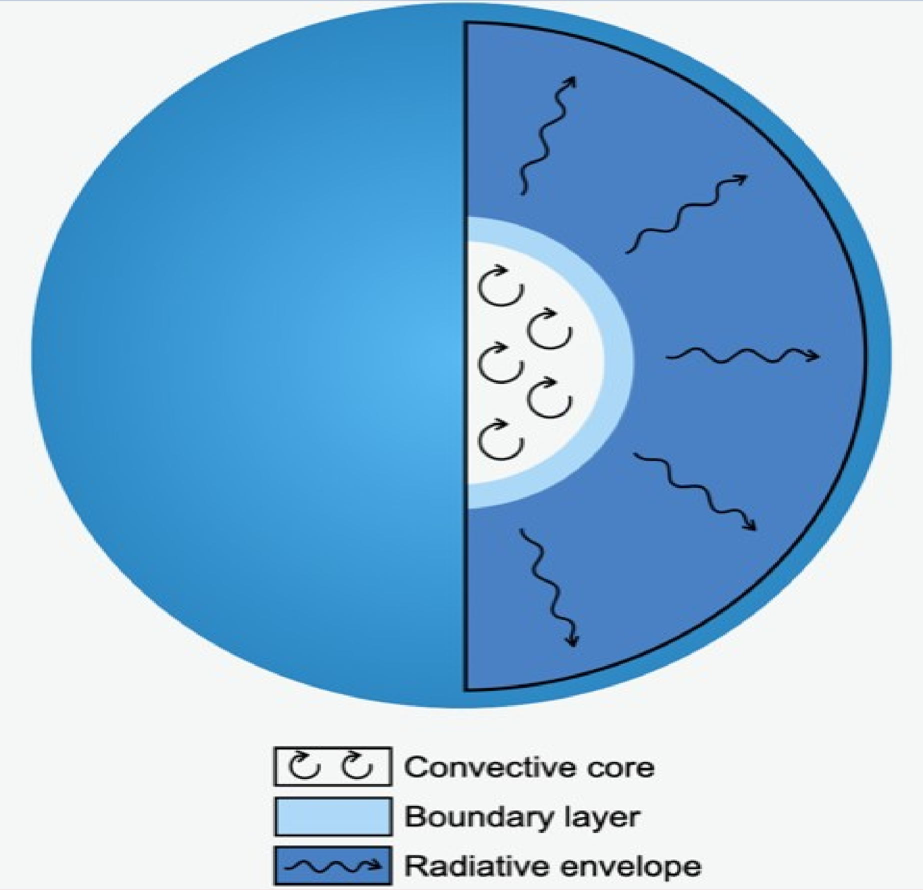
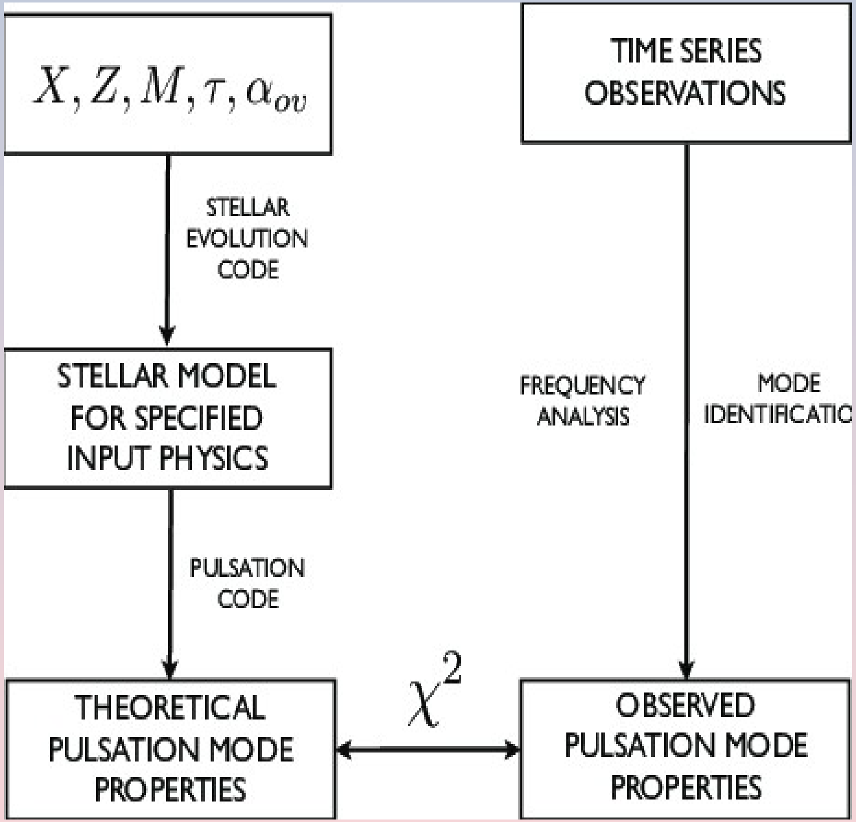


Image credit: May Pedersen

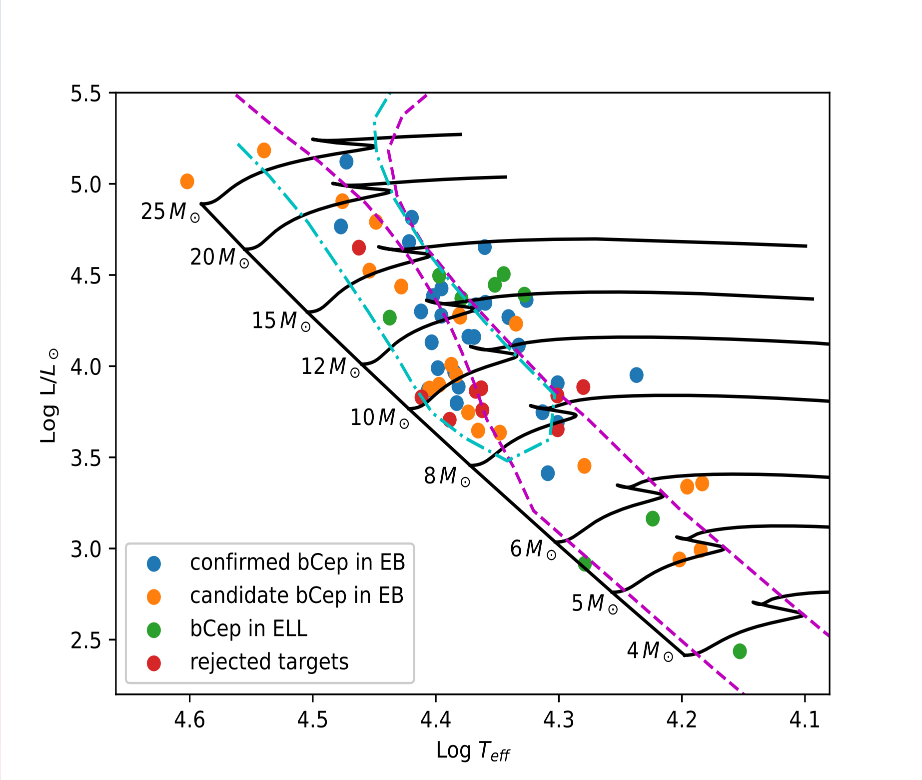
Asteroseismic modelling



- A snapshot of the principle of asteroseismic modelling, where the dependency on the chosen input physics of the equilibrium models is shown by the stellar model for specified input physics.

  Image credit: Katrijn Clémer.

β Cephei Pulsators in eclipsing binaries observed with TESS



Eze & Handler (2024), ApJS, 272:25

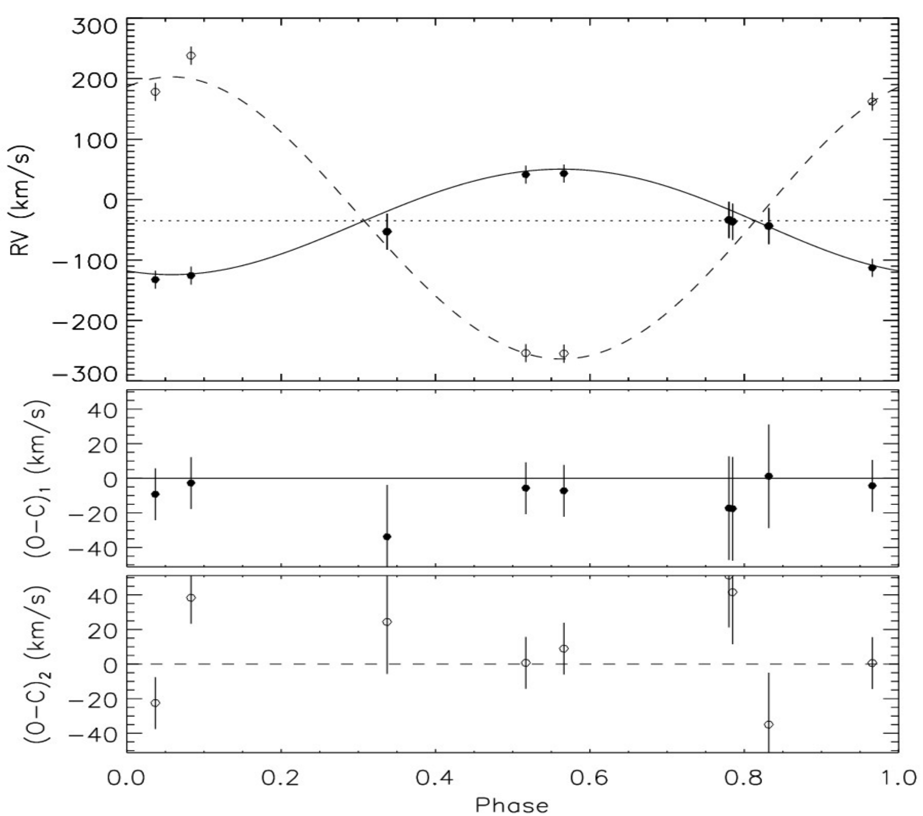
- Sample size: 8055 stars
- Criteria for selection: Spectral type B0-B3, Eclipses, Pulsations
- Photometric checks/blending analysis
- Pulsation analysis
- 78 β Cep in EB (59 new discoveries; 43 -definite and 35 -candidate pulsators in EB).

Spectroscopic Analysis (Eze+ In prep)

- Observations:
  - SALT (HRS)
  - CTIO (CHIRON)

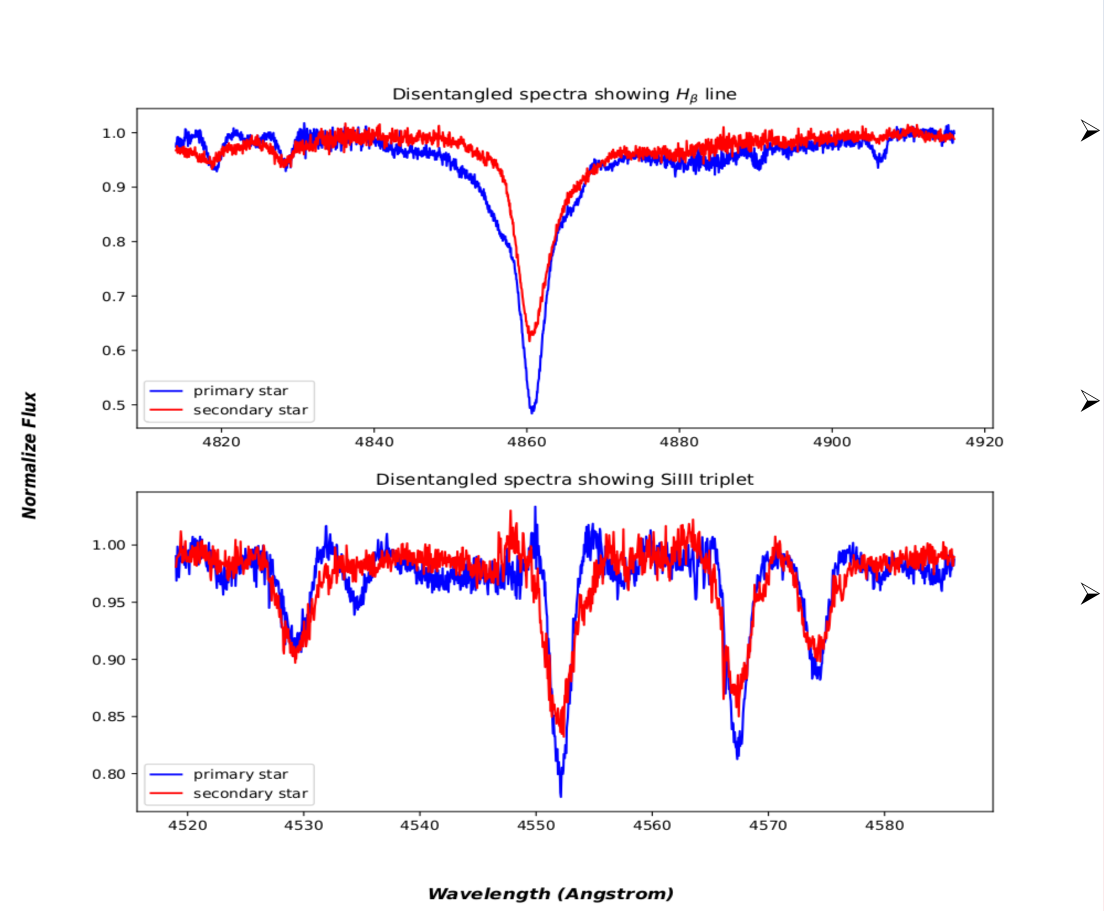
- RV extraction and fitting:
  - Cross correlation with a template spectrum using fxcor task in pyraf/iraf
  - spectrum code for synthetic spectrum with Isotope line list (Hotiso). Broadening done with spectrum ancillary code avsini (Gray, 1999)
  - RVFit (Iglesias-Marzoa et al., 2015)

- OrbitalVariability



Example figure of radial velocity fit of one of the SB2 binaries in our sample

Atmospheric solutions



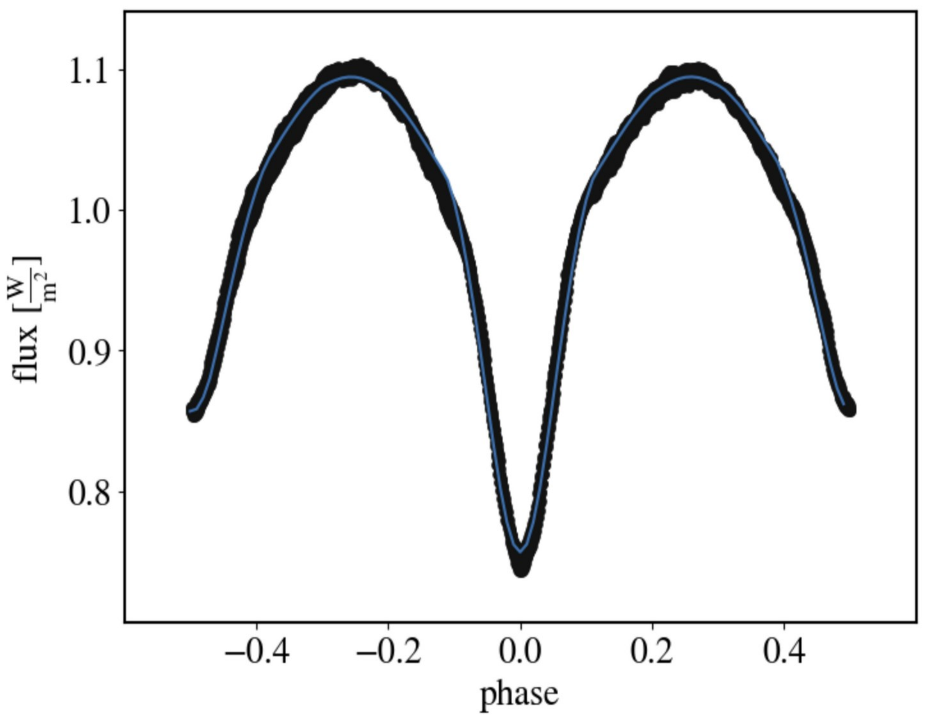
- Disentangling with FD3 binary (Ilijić et al., 2004) for SB2
- Teff, logg and vsini are determined
- (e.g. Teff1 =22000±1000K, Teff2= 20000±1500K)

An example figure showing the disentangled spectra of an SB2 (V1216 Sco) in our sample

Table 1: An excerpt from the table of orbital and stellar parameters of the targets showing Teff, logg, vsini and k for few selected SB1 in our sample

Target	Teff (K)	Logg	Vsini (km/s)	K (km/s)
CPD-45 3109	22000±1000	3.5±0.2	134±5	34.083±0.959
HD 101838	28000±1000	3.5±0.1	175±6	-23.879 ± 0.873
V1166 Cen	27000±1000	3.8±0.1	252±10	-49.637±1.160

Binary modelling



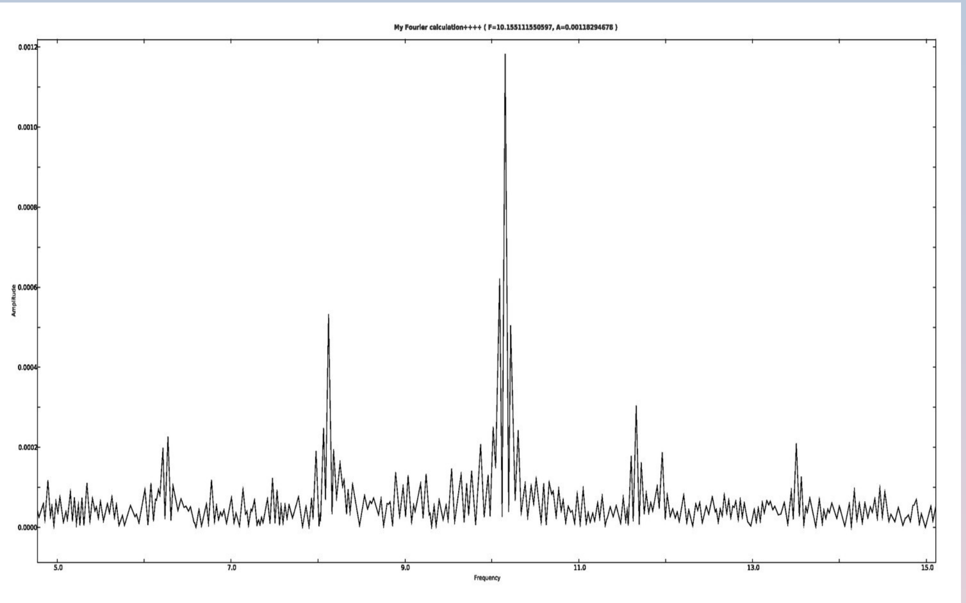
Preliminary light curve fit of V1216 Sco optimized with PHOEBE

- JKTEBOP (Southworth et al., 2004): detached systems with circular orbits

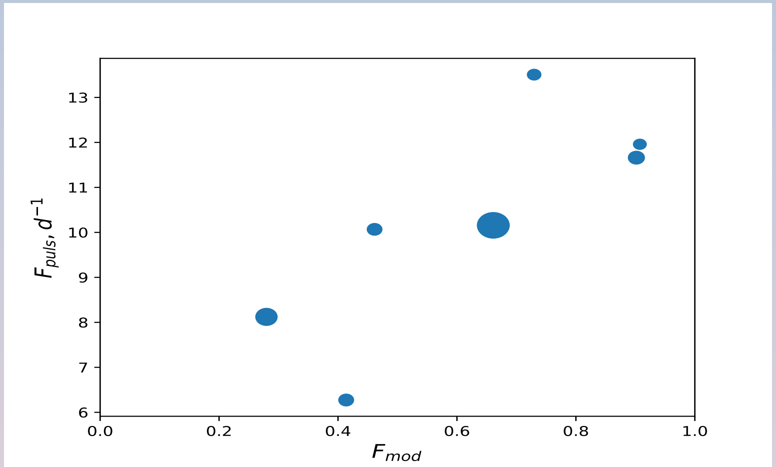
- PHOEBE (Conroy et al., 2020) or PYWD2015 (Guzel & Orkun, 2020): semi-detached and eccentric systems

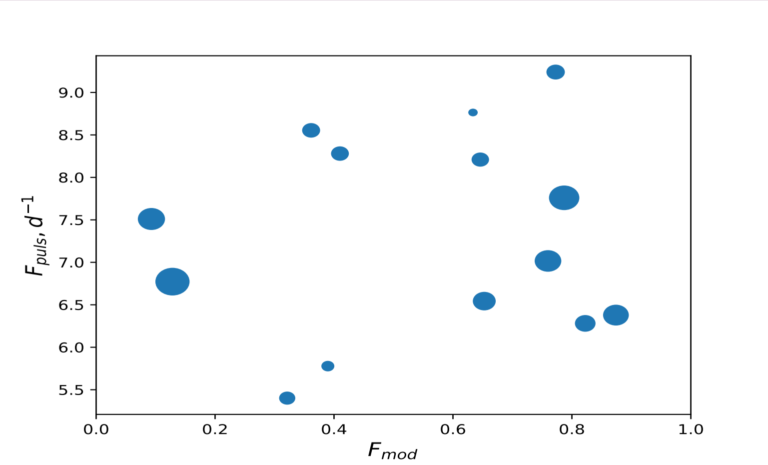
Poster 5 by *Amadeusz Miszuda discusses the properties of V1216 sco in details*

Pulsation Analysis



	Frequency (d^{-1})	Amplitude (mmag)	Phase
F1	10.1568	0.0011732	0.4307
F2	8.1218	0.0005161	0.5606
F3	11.6611	0.0002879	0.0082
F4	6.2737	0.0002431	0.5371
F5	10.0676	0.0002392	0.6719
F6	11.9588	0.0001806	0.8381
F7	13.5063	0.0002005	0.8029

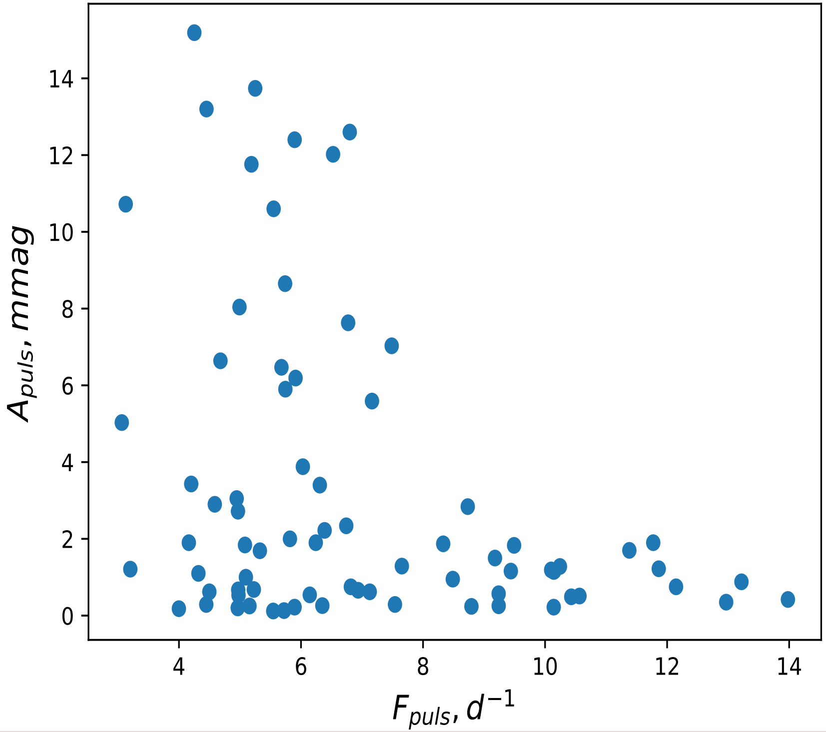




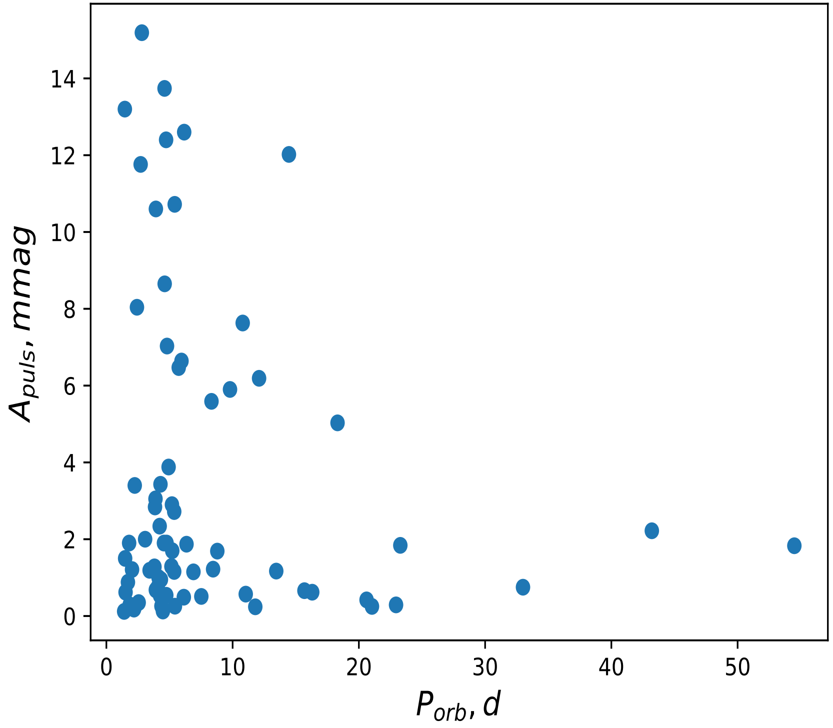
Echelle Diagrams of V1166 Cen (urp) and V1216 Sco (lrp)

Multicolour photometric observations conducted using SAAO 1.0 m telescope for mode identification are currently being reduced.

Pulsation Analysis Cont.



Frequency-amplitude relation for β Cep p modes



Period-pulsation amplitude relation for our sample of β Cep pulsators in EB

What’s next?

- Building stellar models of the targets using MESA

- Mode Identification

- Building the pulsation models with GYRE

Conclusion

- We have obtained the:
  - orbital and atmospheric parameters of targets in the sample
  - preliminary light curve and RV solutions (stellar parameters) of SB2 in our sample
  - pulsation frequencies of the targets in our sample
  - multicolour photometric observation for mode identification

- Some systems (e.g. V1166 Cen) show asymmetric rotational splitting
- The amplitude of the dominant pulsation frequency appears to decay exponentially with the pulsation frequency as well as the orbital period of the systems