

# Asteroseismology in action

III: Tidal asteroseismology

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29/09/2022

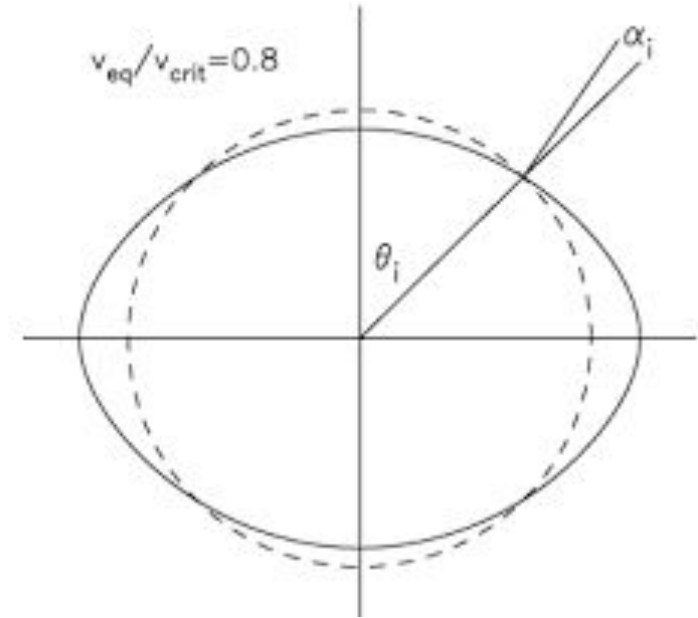
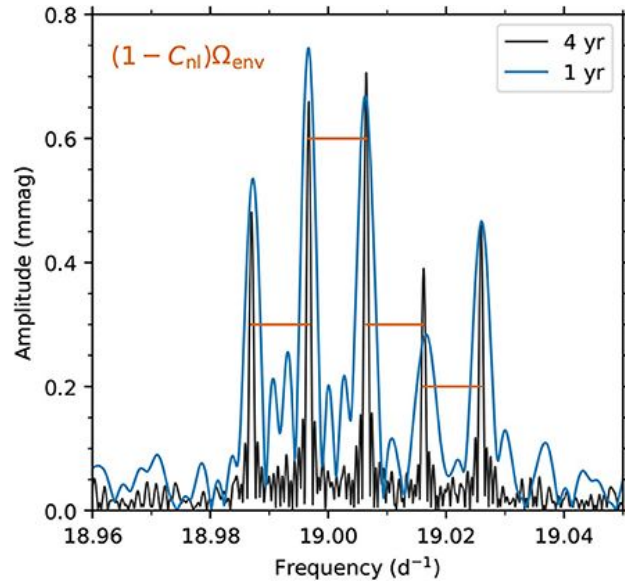
# Asteroseismology

**Asteroseismology** – study of stellar interiors using stellar pulsations

**Dynamical asteroseismology** – asteroseismology combined with information obtained from binary modelling

**Tidal asteroseismology** – asteroseismology of modes influenced by tides in a binary

# Forces on a star: Rotation

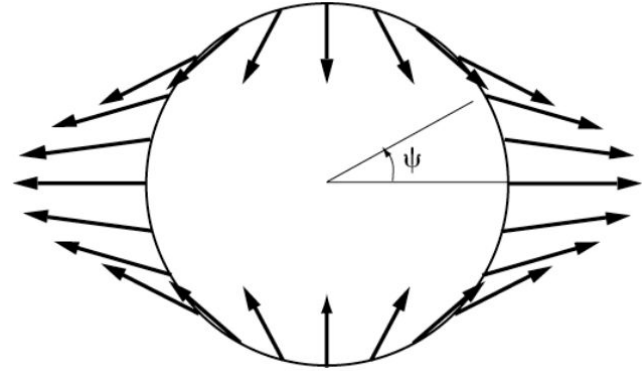


Bowman 2020

# Forces on a star: Tides

Differential force

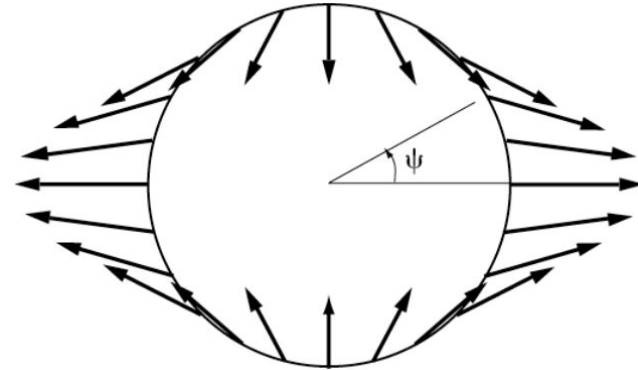
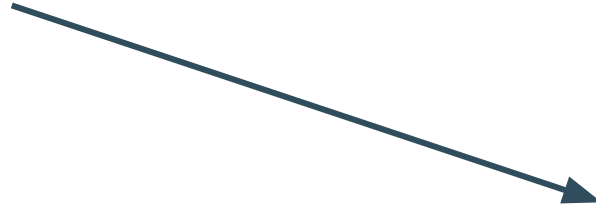
- Tidally excited oscillations
- Tidally tilted pulsations
- Tidally perturbed pulsations
- Geometric shenanigans



# Forces on a star: Tides

Two types of tides

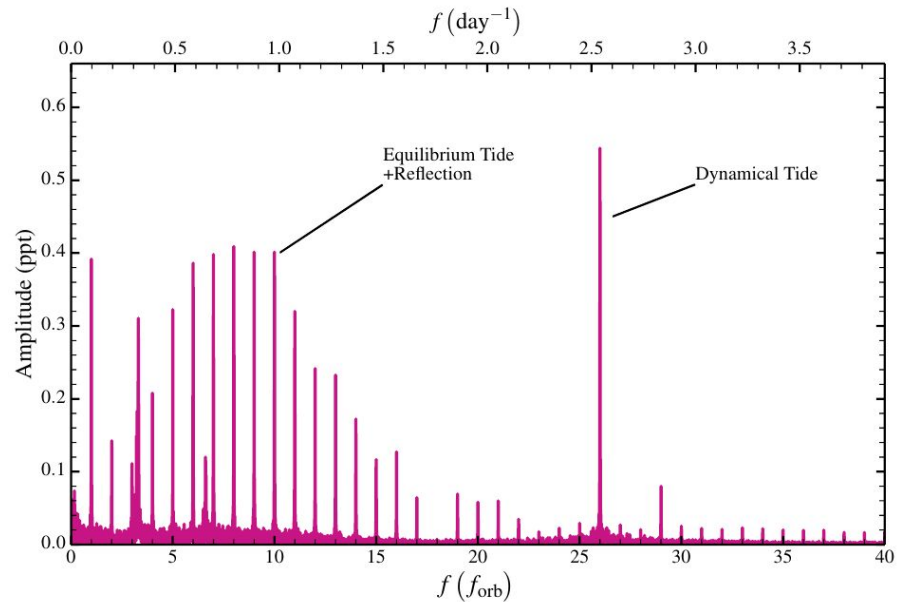
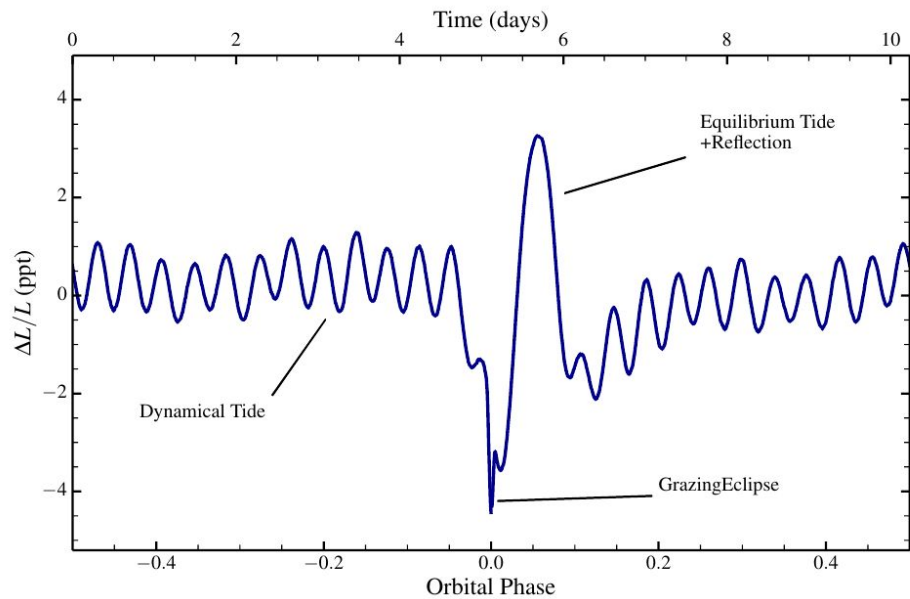
1. Static or Equilibrium tide
2. Dynamic tide



“The equilibrium tidal distortion is simply the hydrostatic deformation of the star due to the companion, i.e. the steady-state distortion that would be produced in the absence of orbital motion. The dynamical tide is the additional non-hydrostatic oscillation of the star that is produced due to the time variable nature of the tidal forcing.”

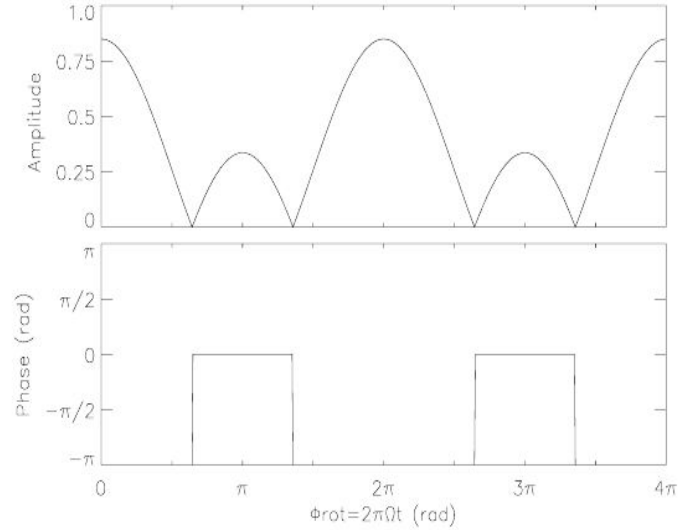
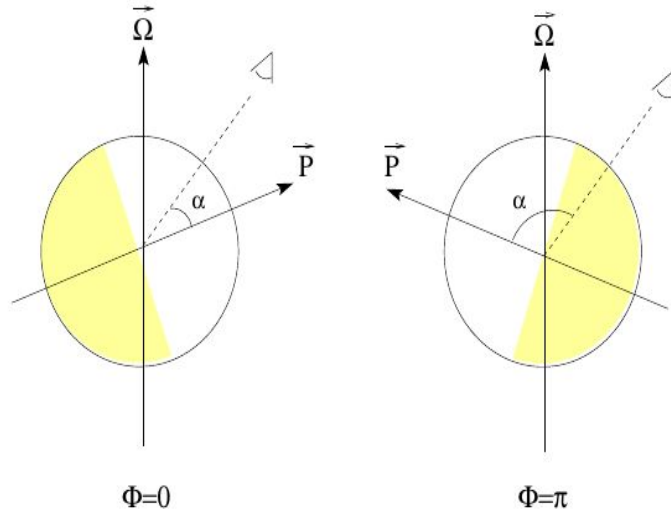
- Time dependent response to orbital motion
- Tidally excited oscillations (TEOs)

# Tidally excited oscillations

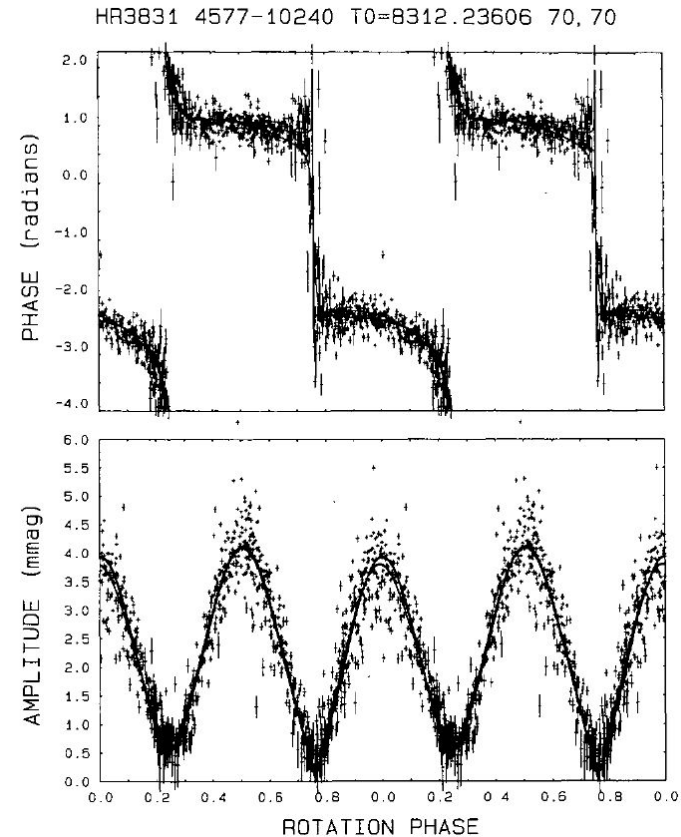
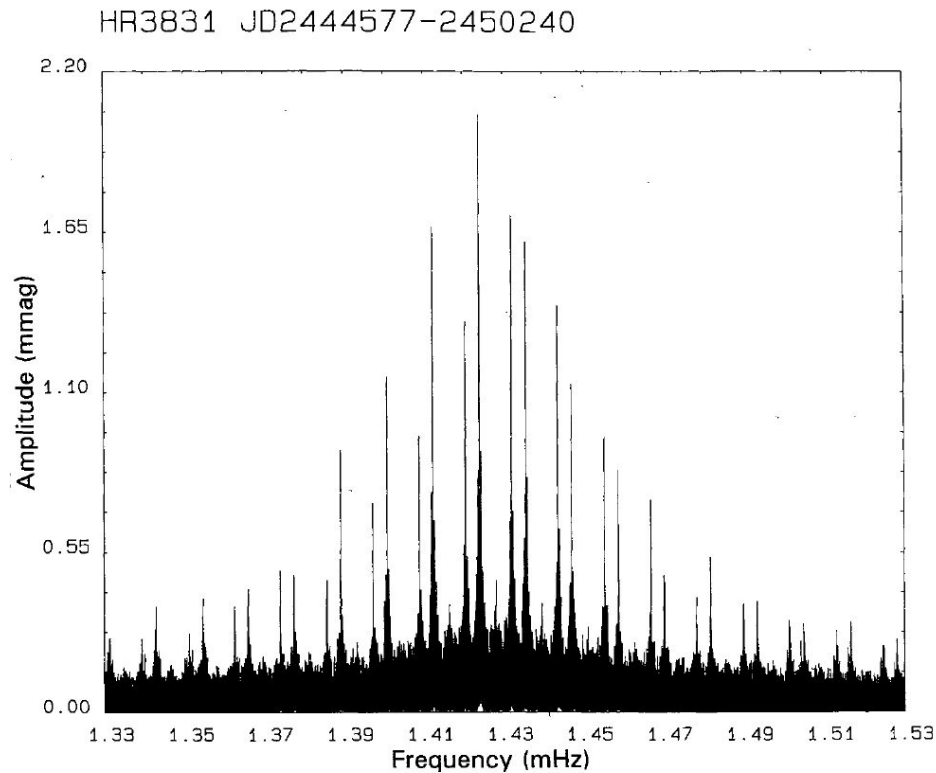


Forced oscillations at  $f = N \Omega_{\text{orb}} (-m \Omega_{\text{spin}})$

# Tidally tilted pulsations



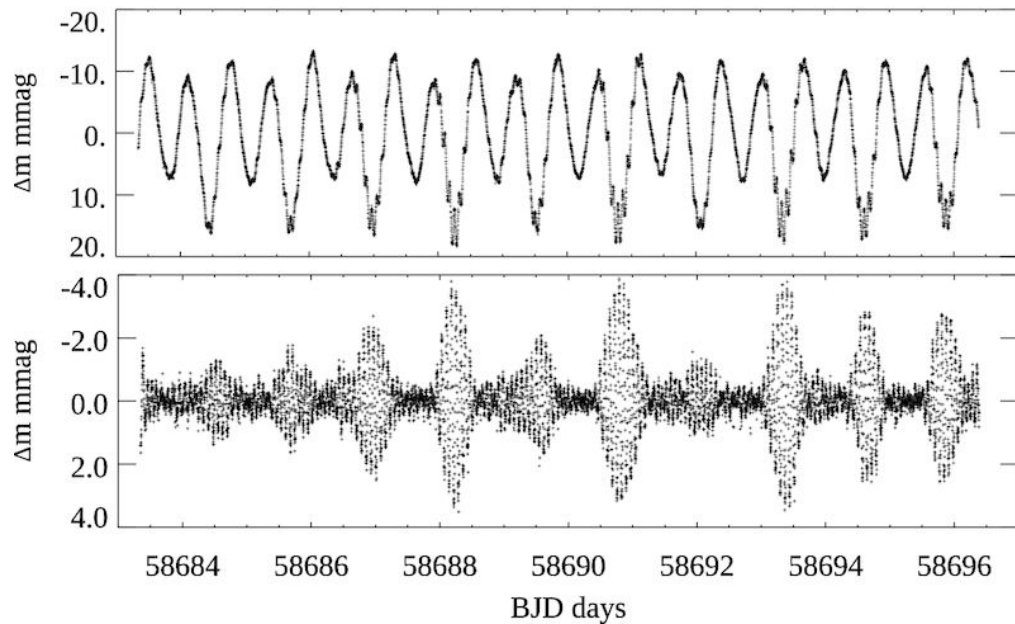
# Tidally tilted pulsations



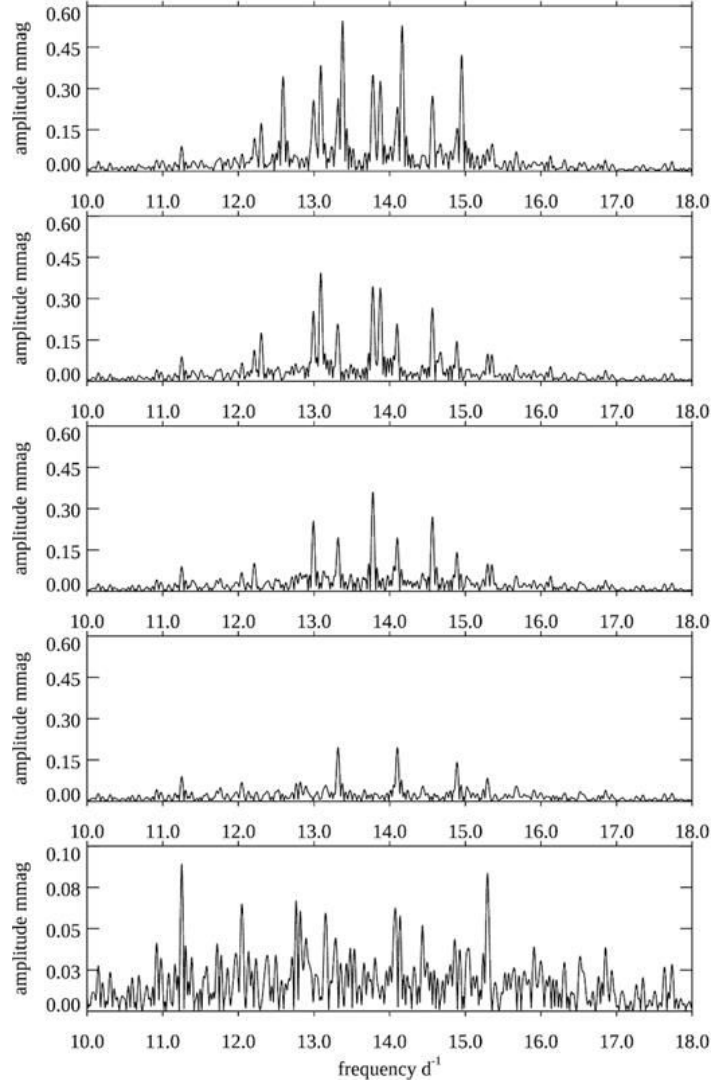
Kurtz et al. 1997



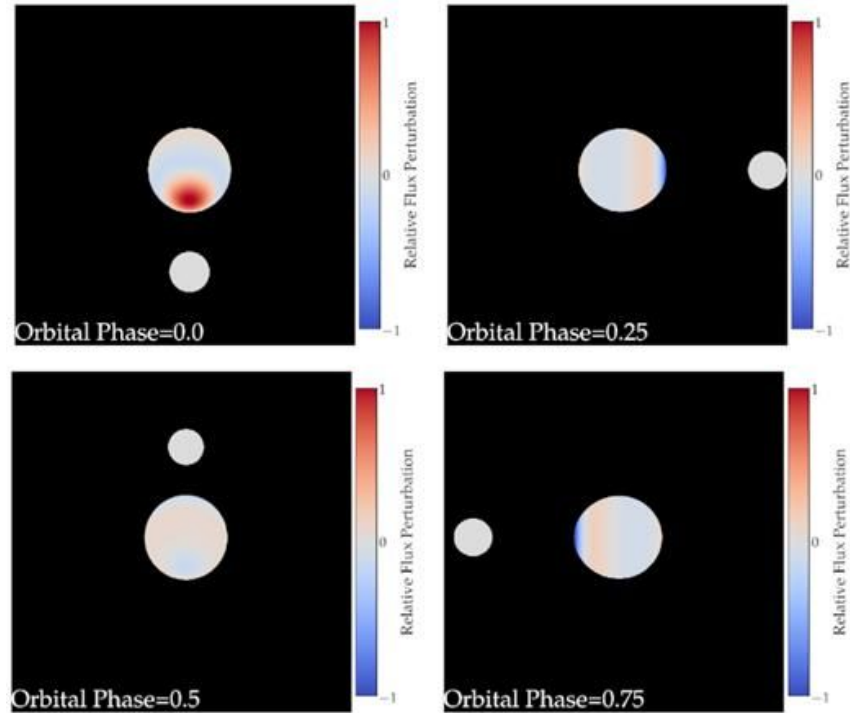
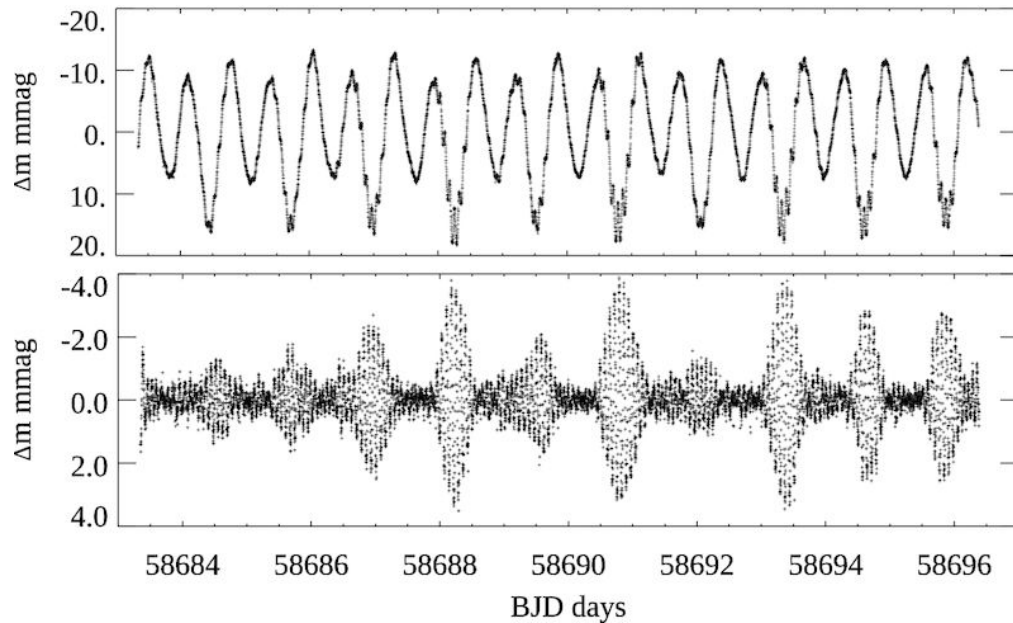
# Tidally tilted pulsators: CO Cam



Kurtz et al. 2020



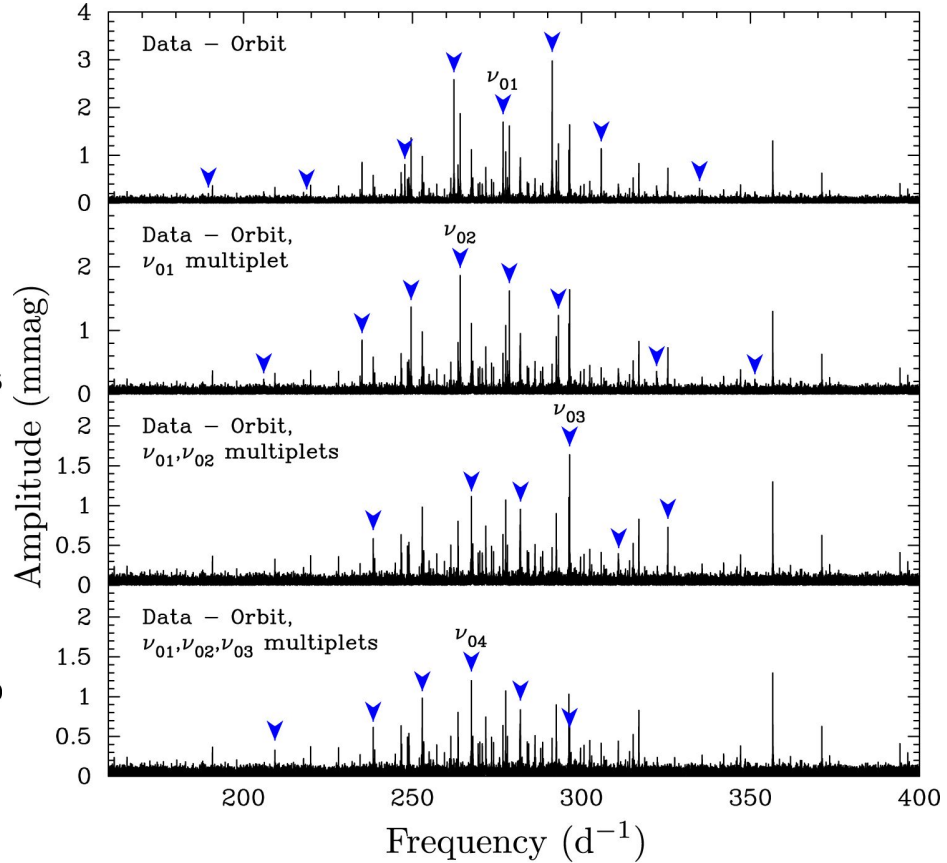
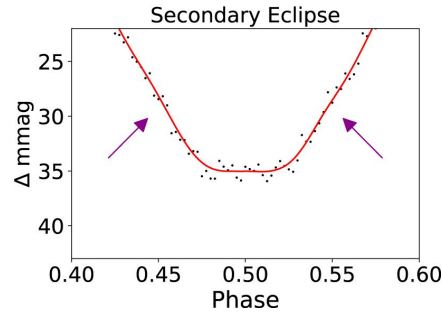
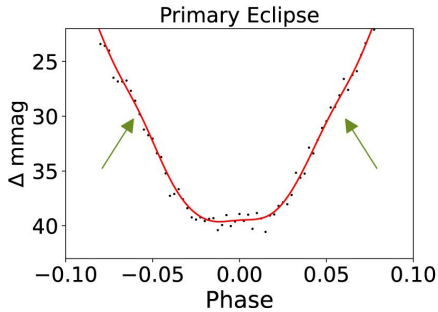
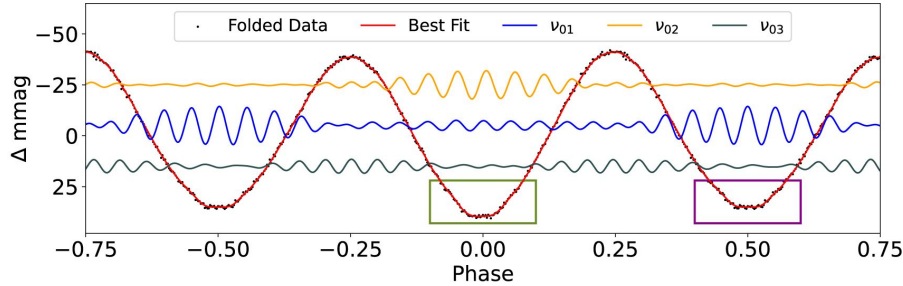
# Tidally tilted pulsators: CO Cam



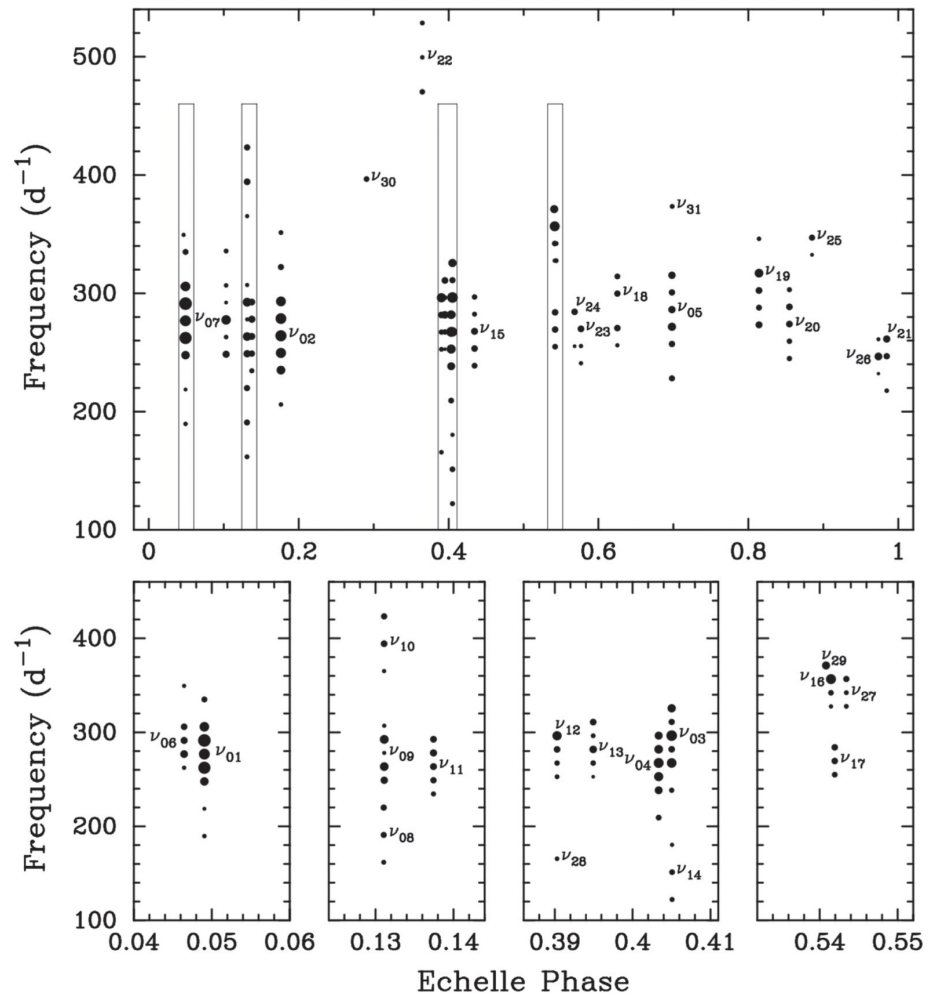
Kurtz et al. 2020

Fuller et al. 2020

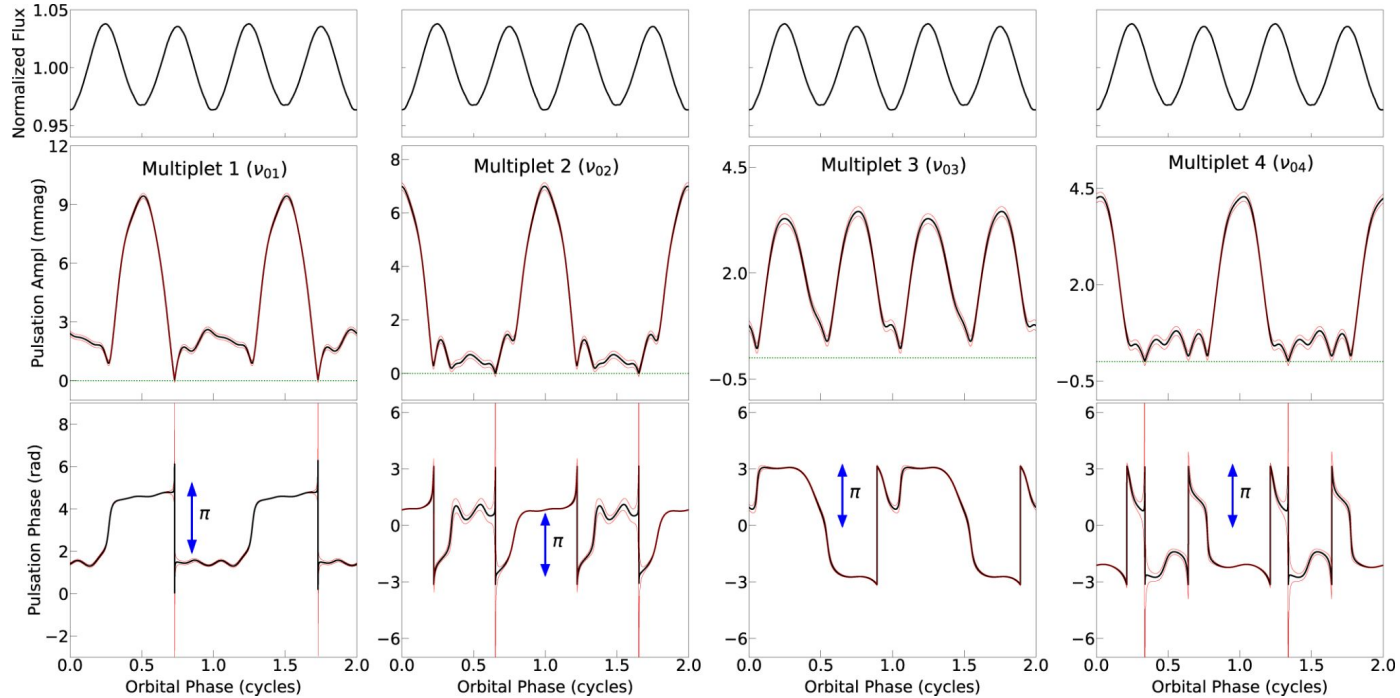
# Tidally tilted pulsators: HD 265435



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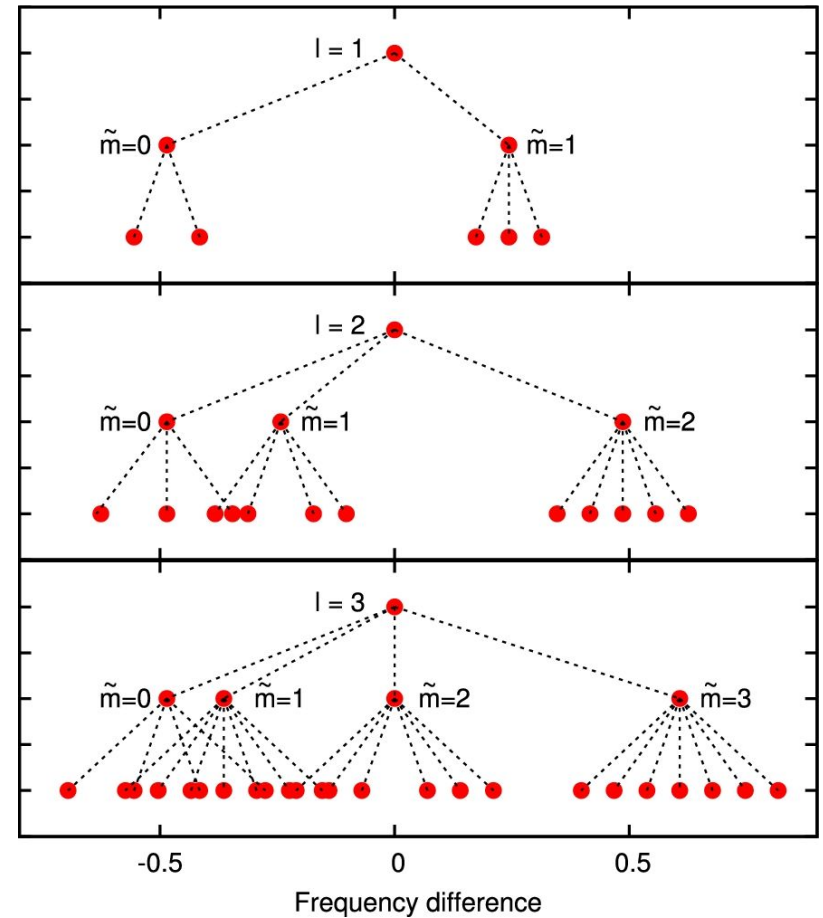


# Tidally perturbed pulsations

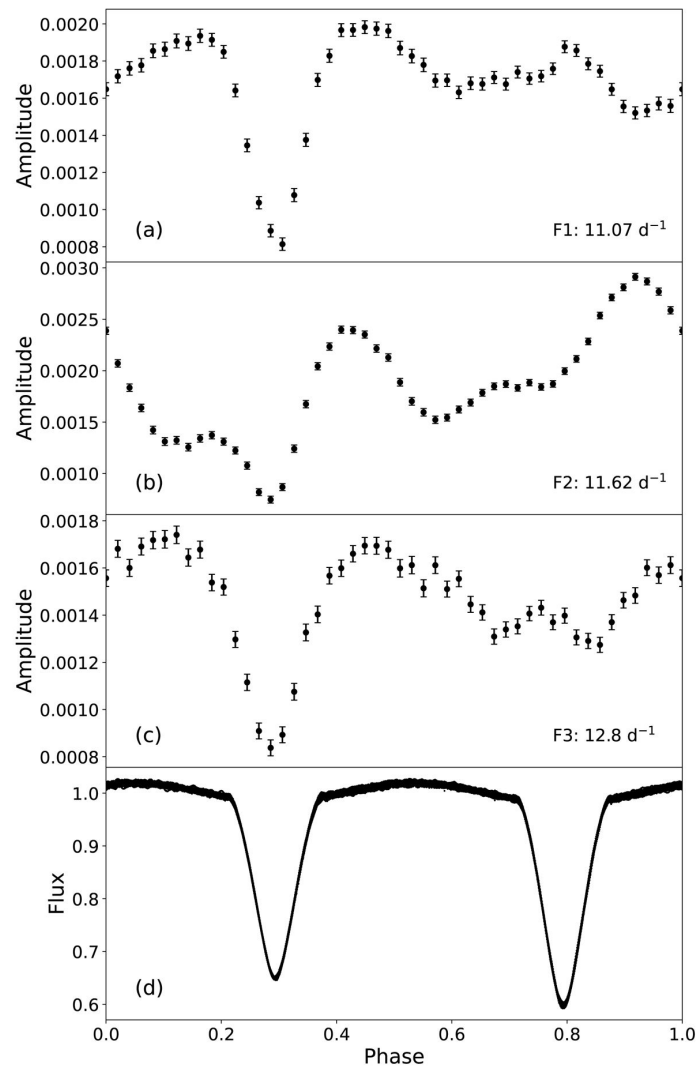
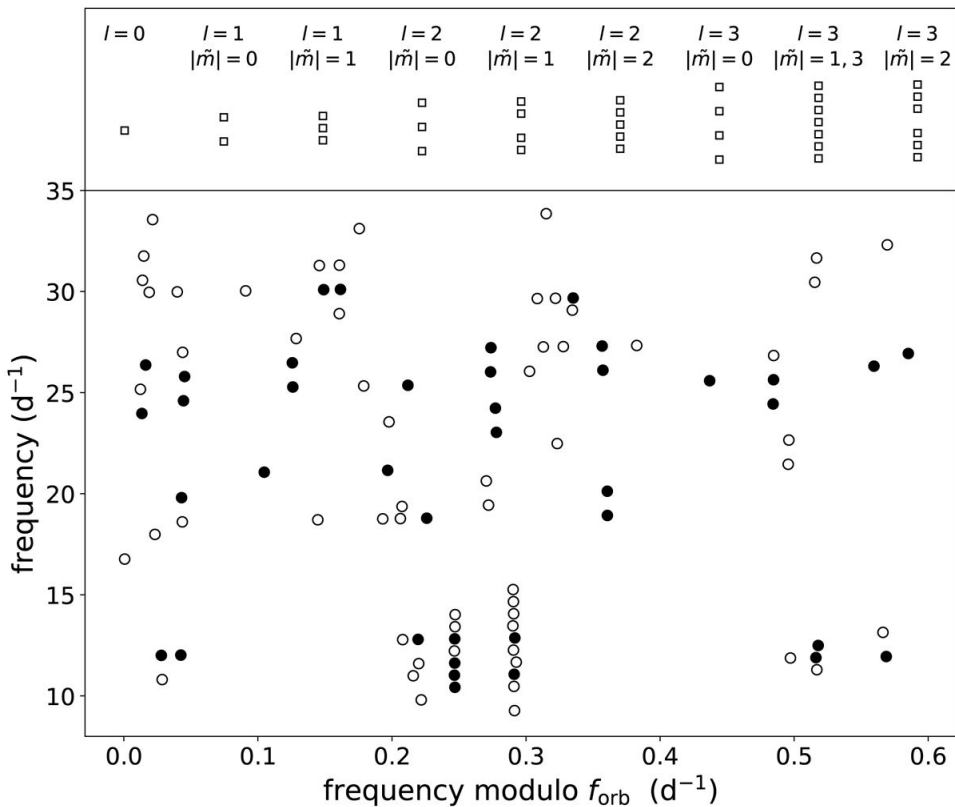
“Tidal distortion leads to a splitting of frequencies according to  $|m|$ , where  $m$  is the azimuthal spherical harmonic number. Each of these components is, in turn, split into equidistant frequencies spaced by a multiple of the orbital frequency.”

“The multiplets generated by the tidal force are fictitious frequencies dependent on the frame of reference of the observer and do not exist in the corotating frame.”

- Balona 2018

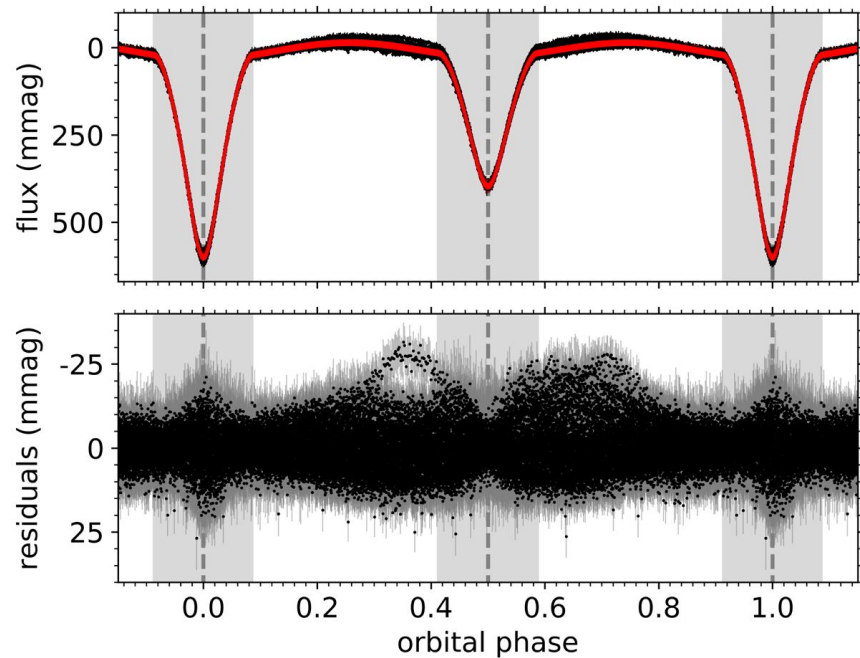
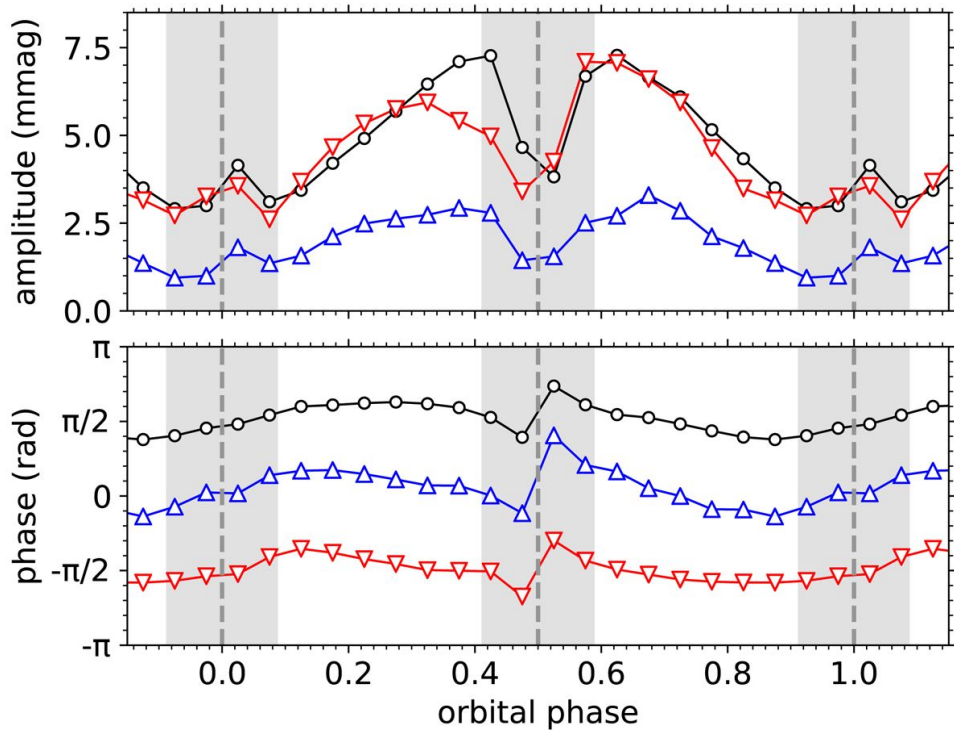


# Tidally perturbed pulsators: RS Cha



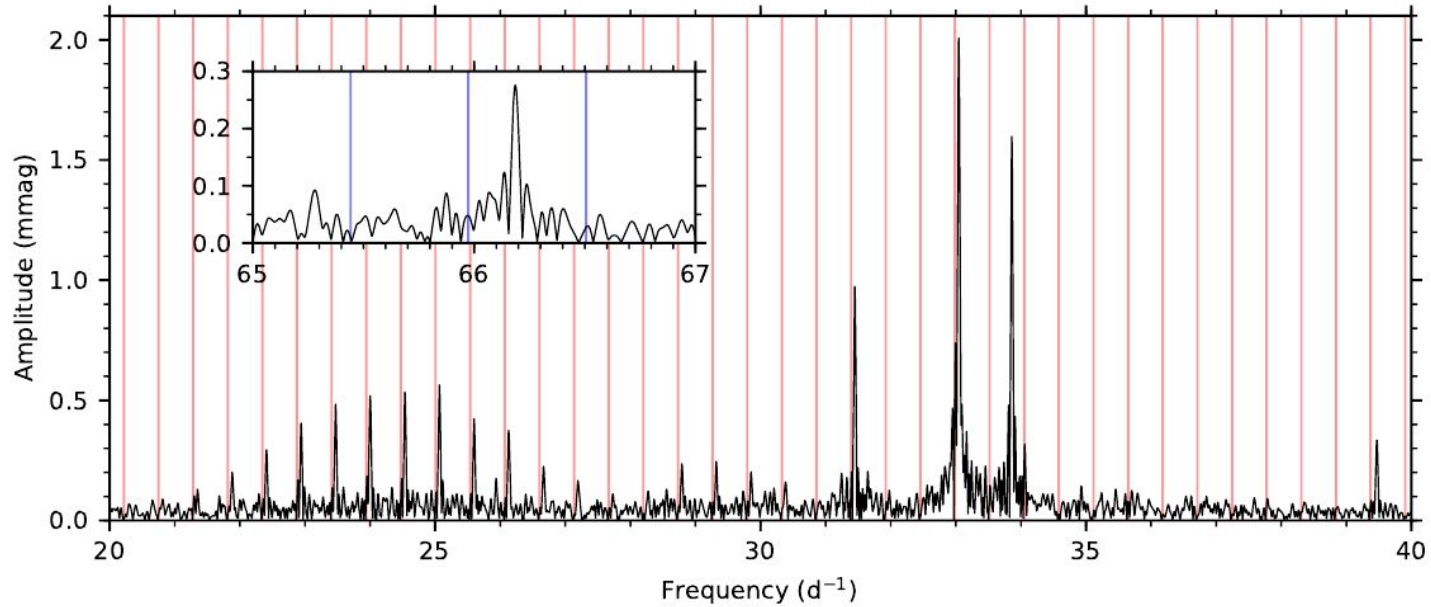


# Tidally perturbed pulsators: V456 Cyg ; g modes

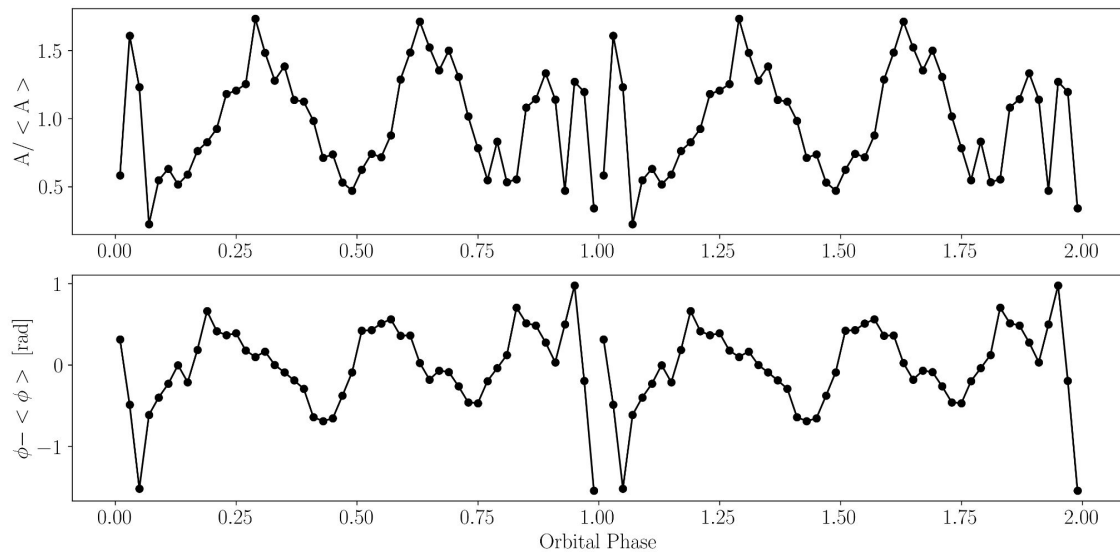
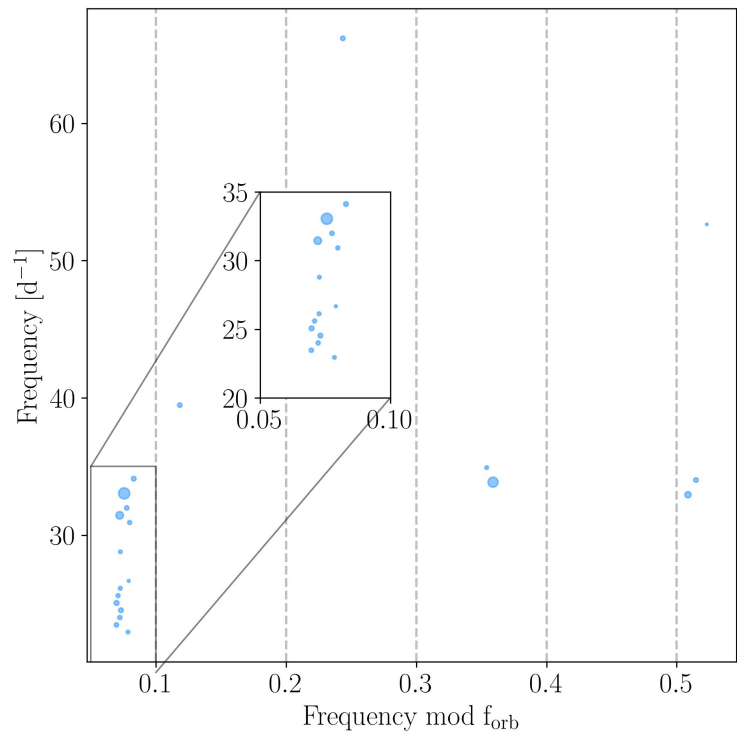




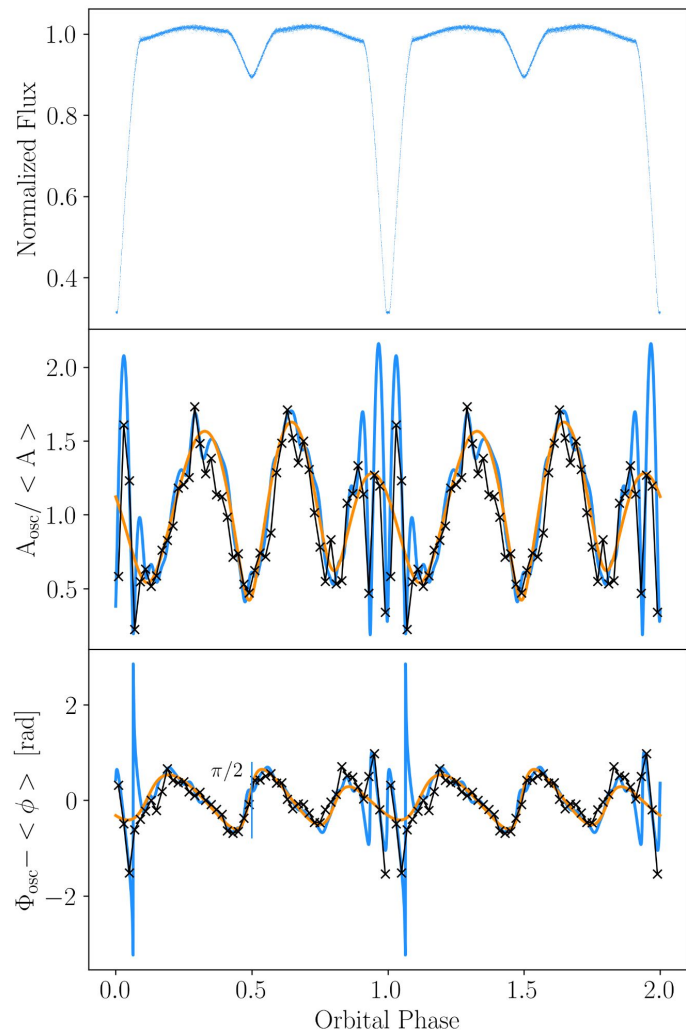
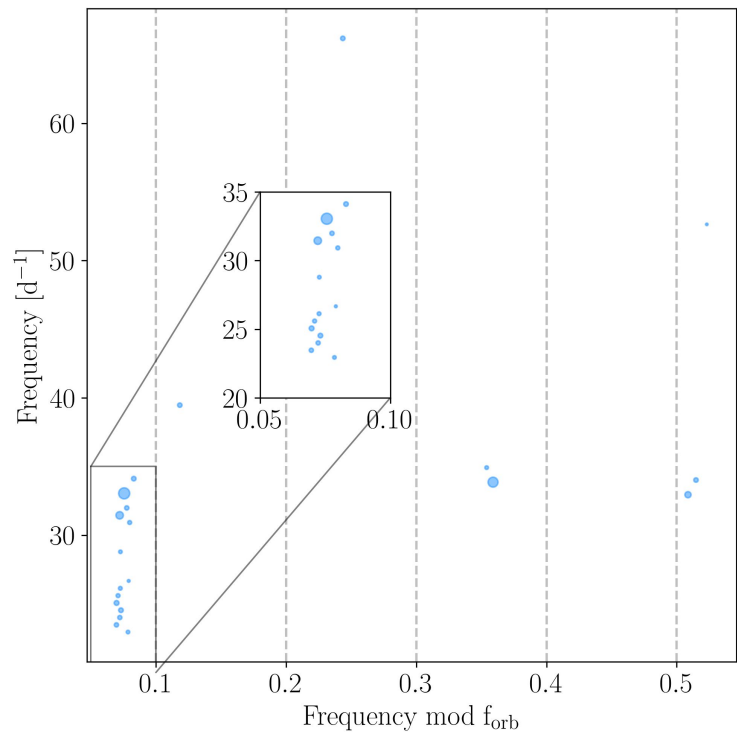
# Tidally perturbed pulsators: U Gru



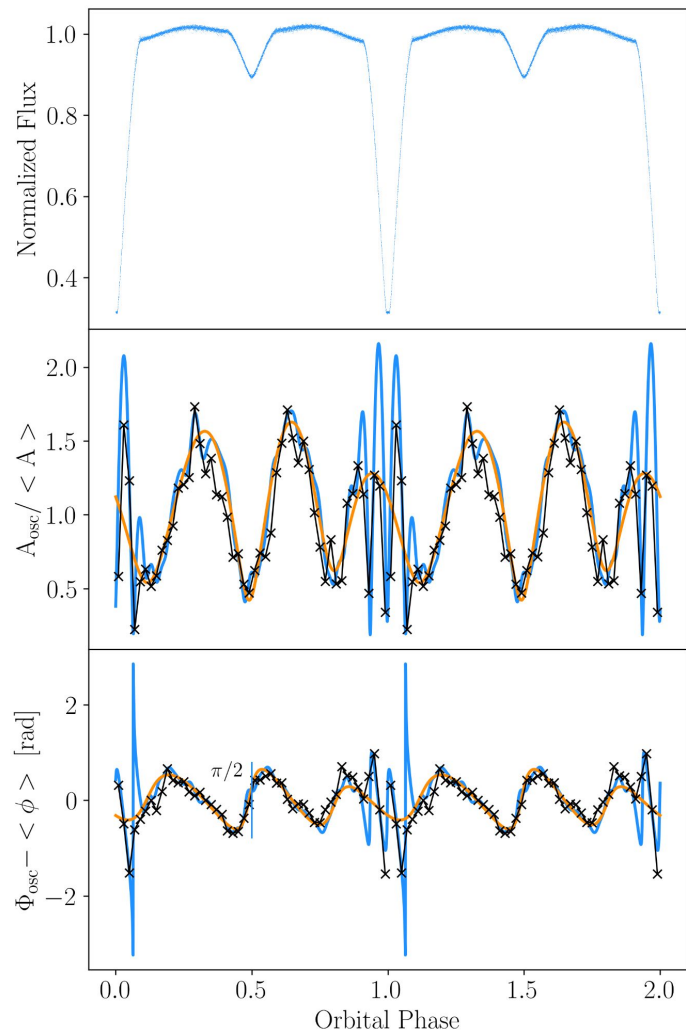
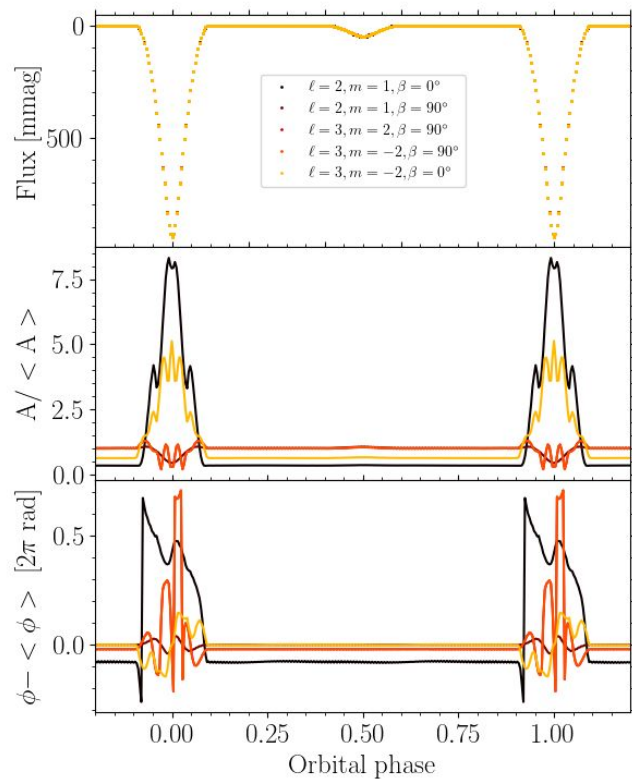
# Tidally perturbed pulsators: U Gru



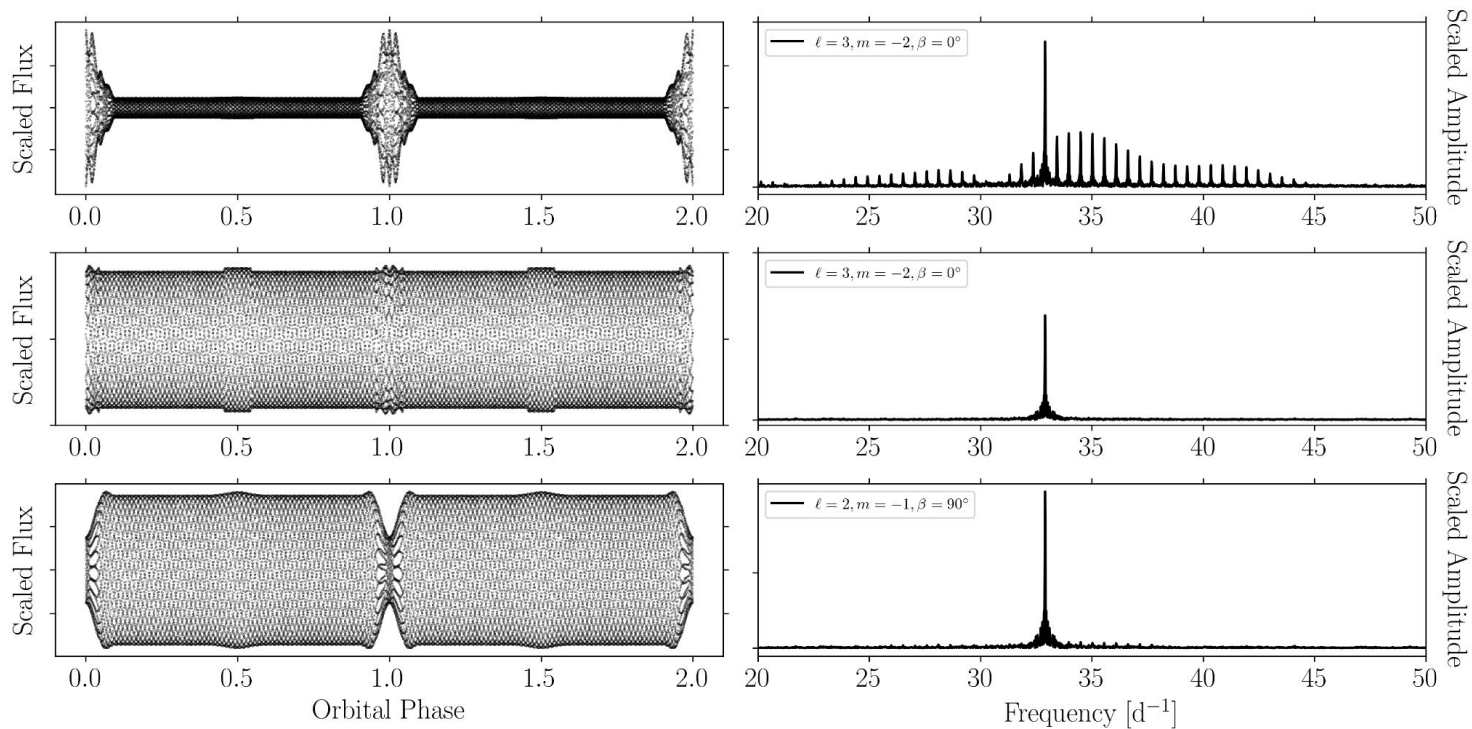
# Tidally perturbed pulsators: U Gru



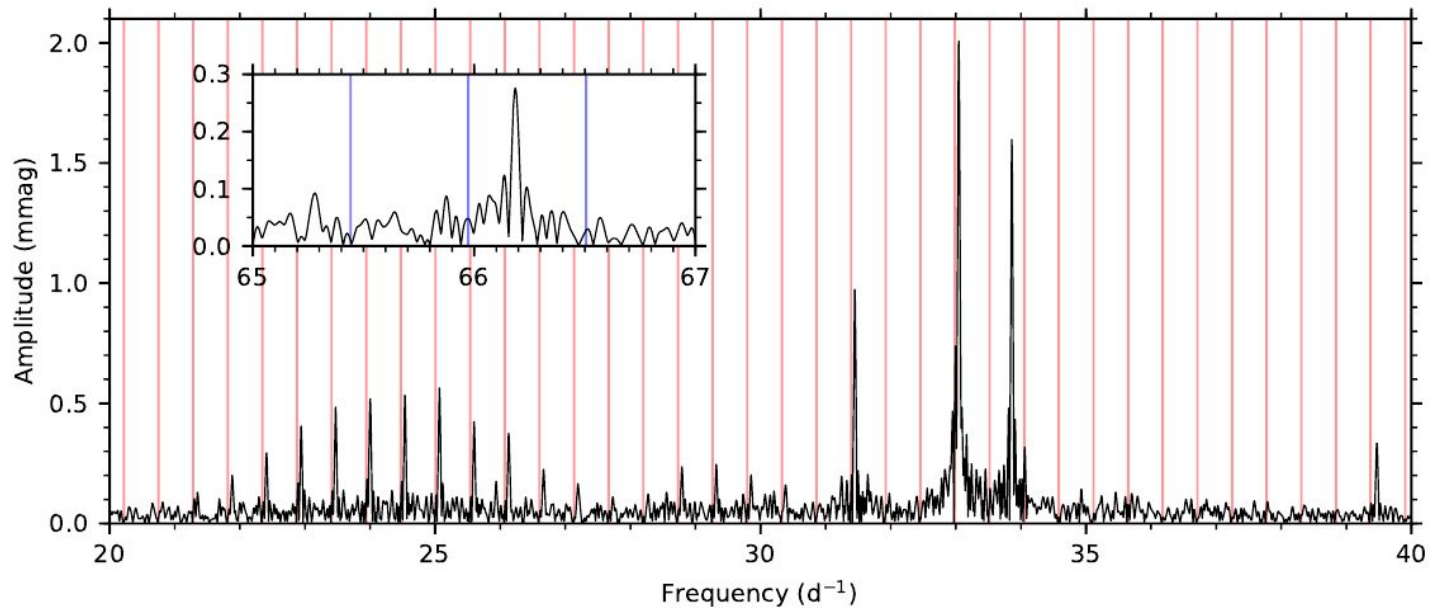
# Geometric shenanigans: U Gru



# Geometric shenanigans: U Gru



# Geometric shenanigans: U Gru



# Summary

- Tidally excited oscillations
- Tidally tilted pulsations
- Tidally perturbed pulsations
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These phenomena occur at  $f = N \pm f_{\text{orb}}$

If you remove data in eclipse, you muddy the waters