Asteroseismology in action

II: Dynamical asteroseismology

Dr. Cole Johnston

29/09/2022

Radboud University

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

Asteroseismology & binaries

We're going to look at g mode pulsators

- γ Doradus variables
- Slowly Pulsating B (SPB) variables

And binaries are everywhere

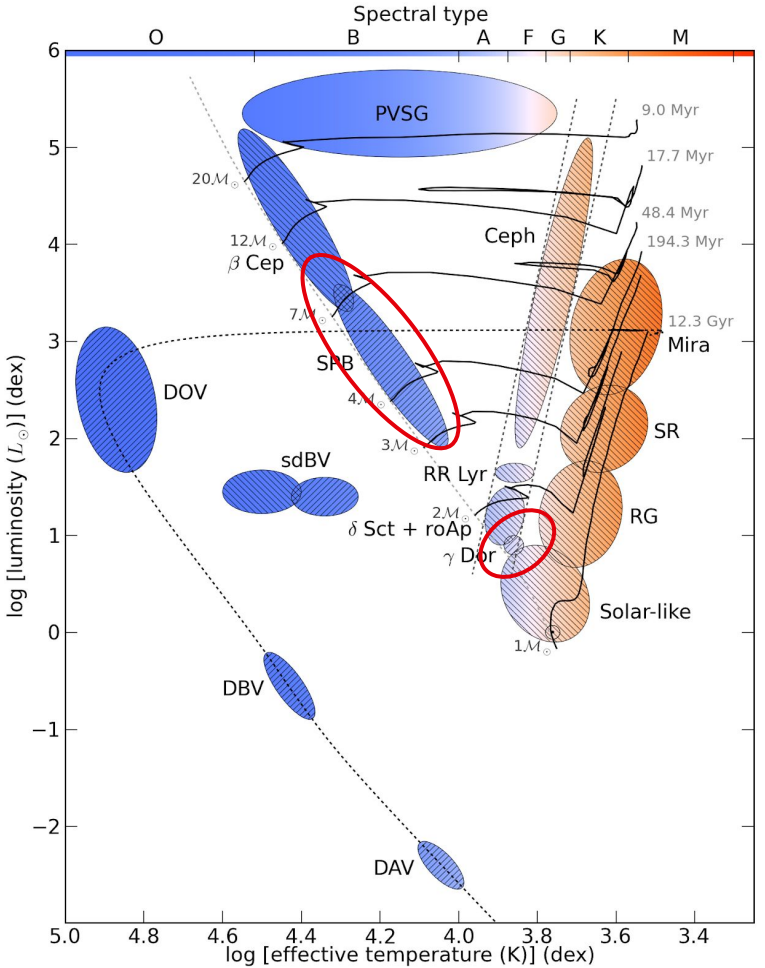
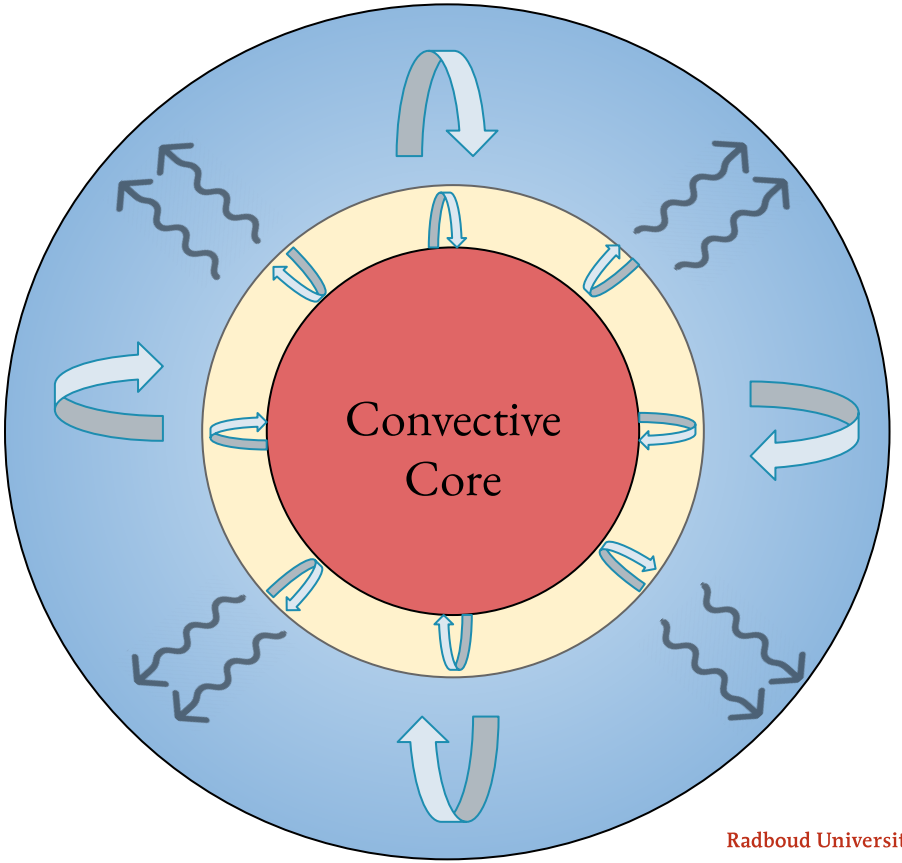
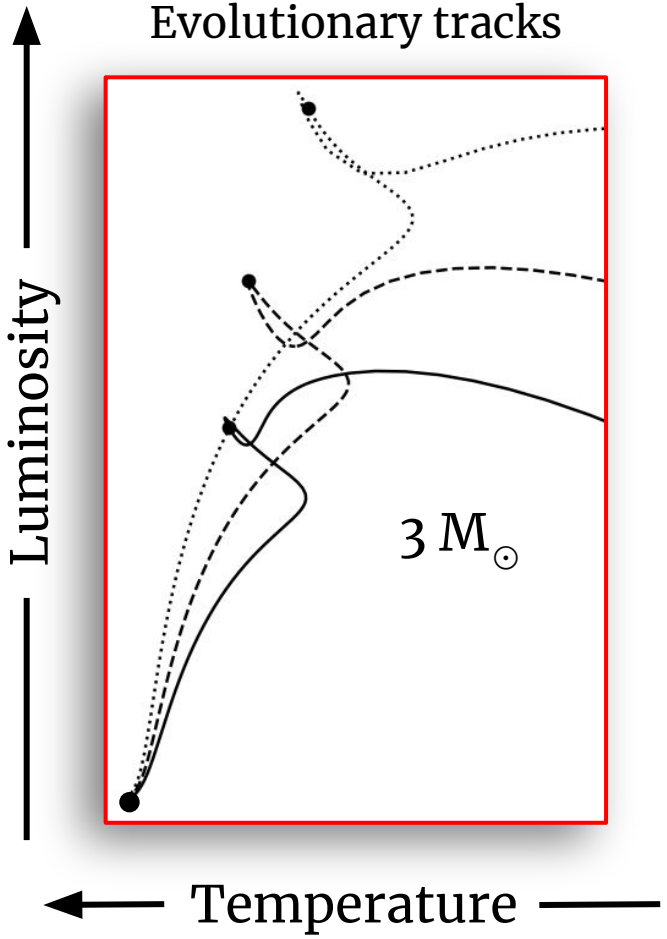


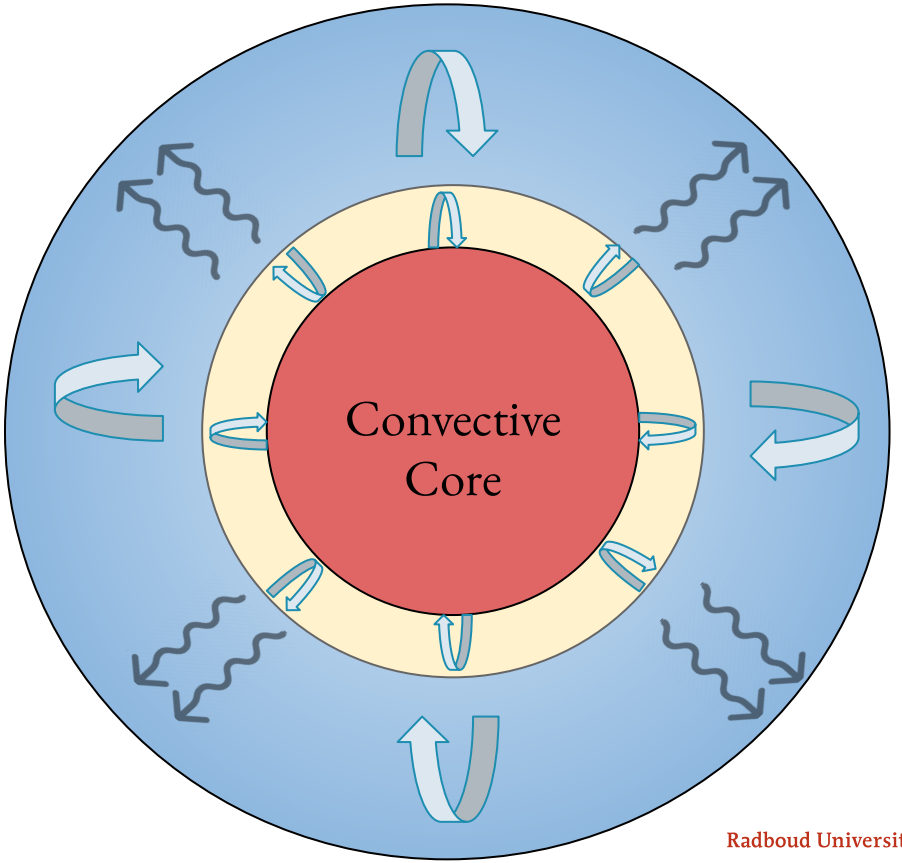
Image credit: Dr. P. Papics

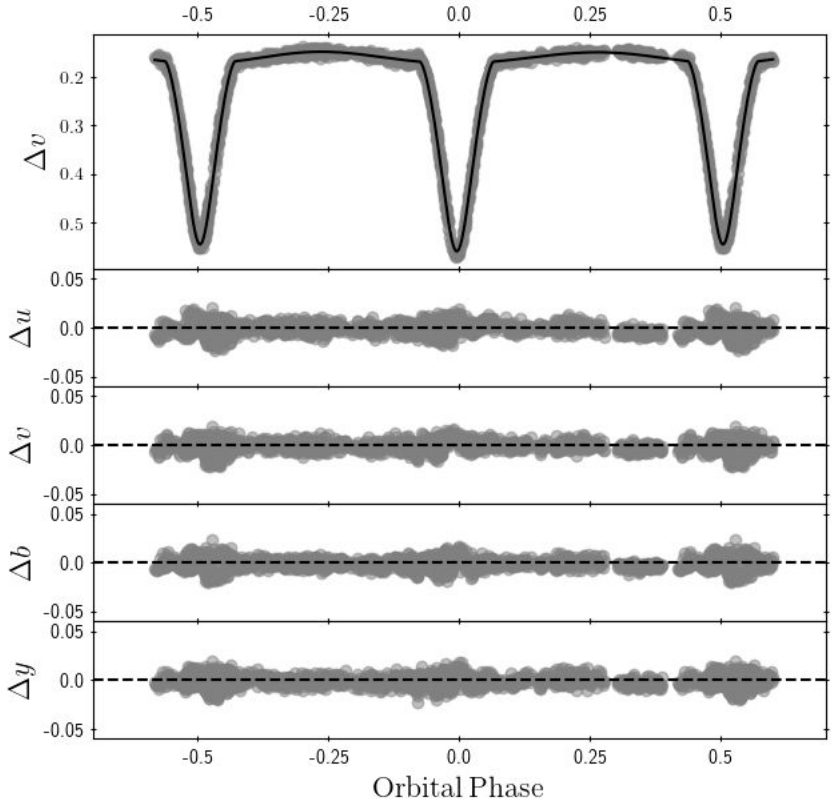
Internal chemical mixing





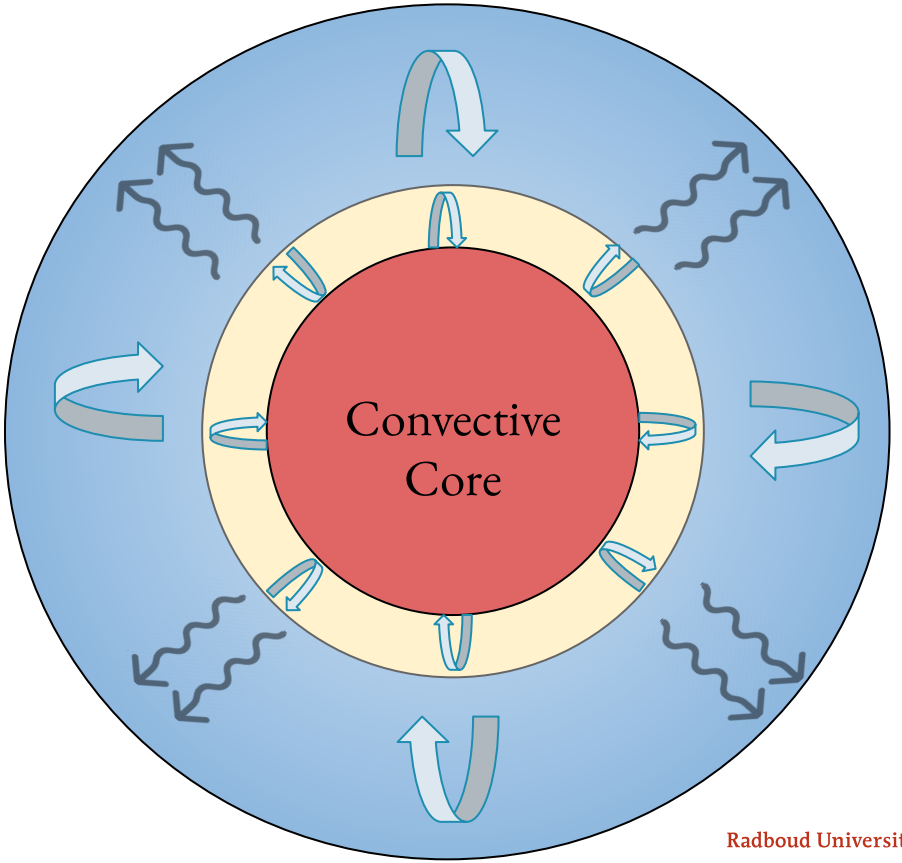
Eclipsing binaries

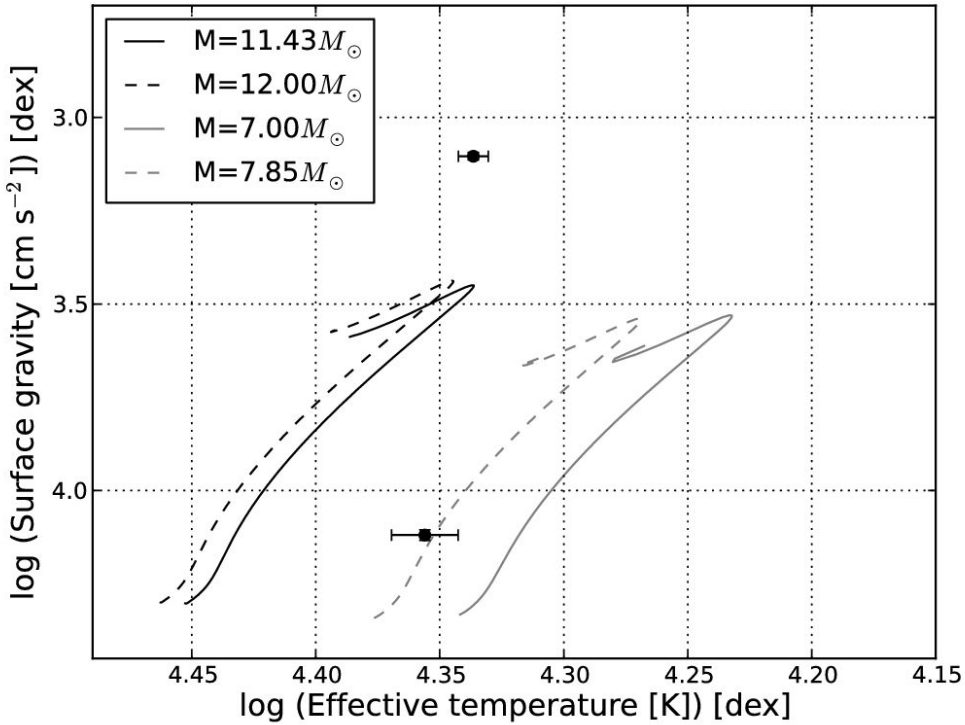




Johnston et al. 2019a

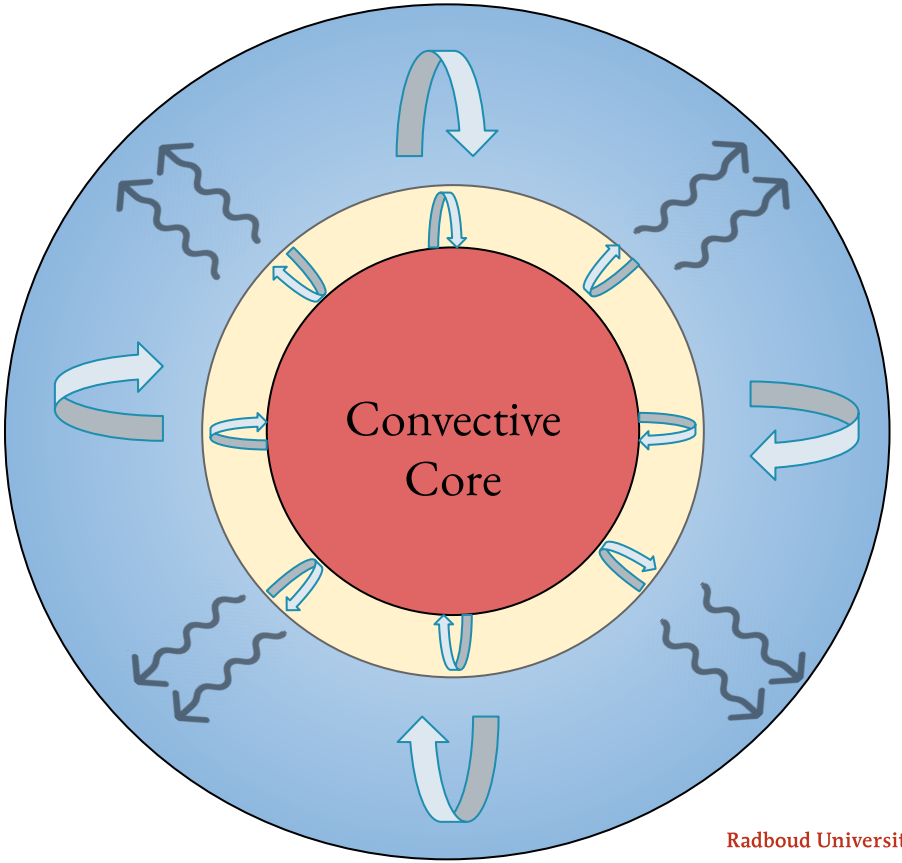
Eclipsing binaries

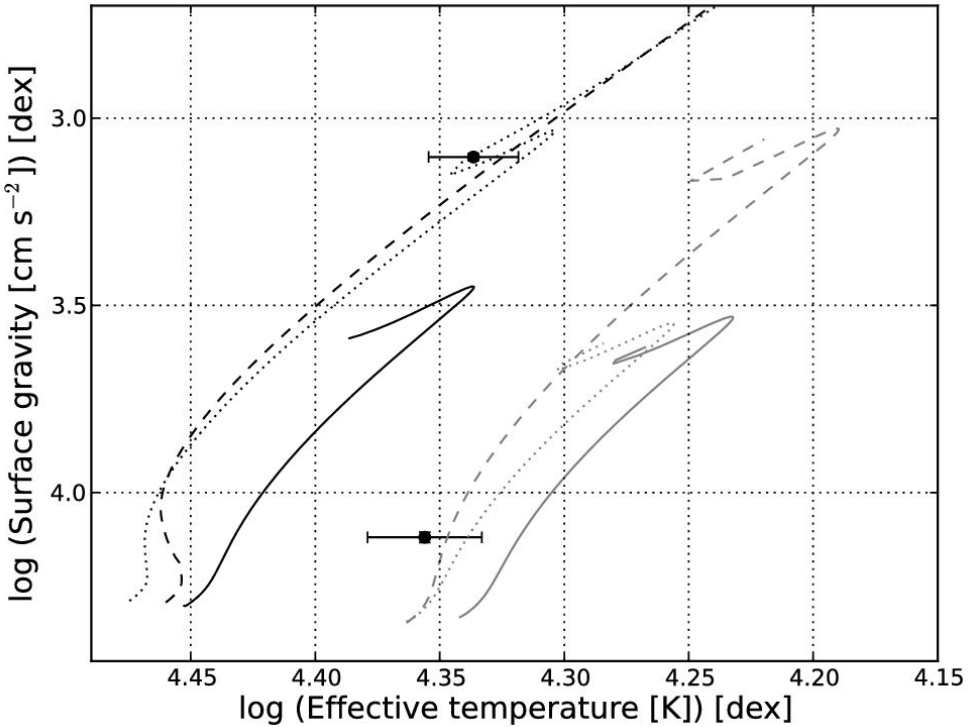




Tkachenko et al. 2014

Eclipsing binaries





Tkachenko et al. 2014

Asteroseismology

We need to identify (*n*,*l*,*m*)

What are **(*n*,*l*,*m*)**?

$n \rightarrow$ number of radial nodes

$l \rightarrow$ number of surface nodal lines

$m \rightarrow$ number of longitudinal surface nodal lines

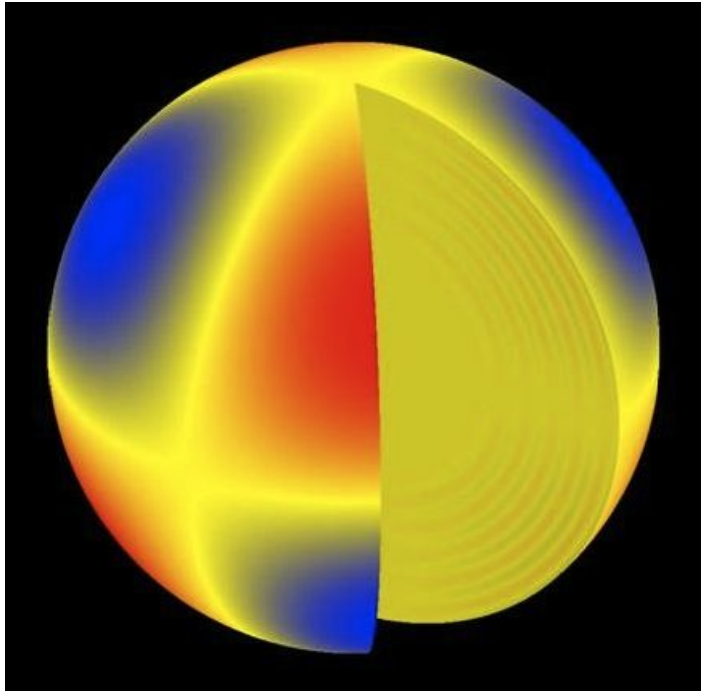
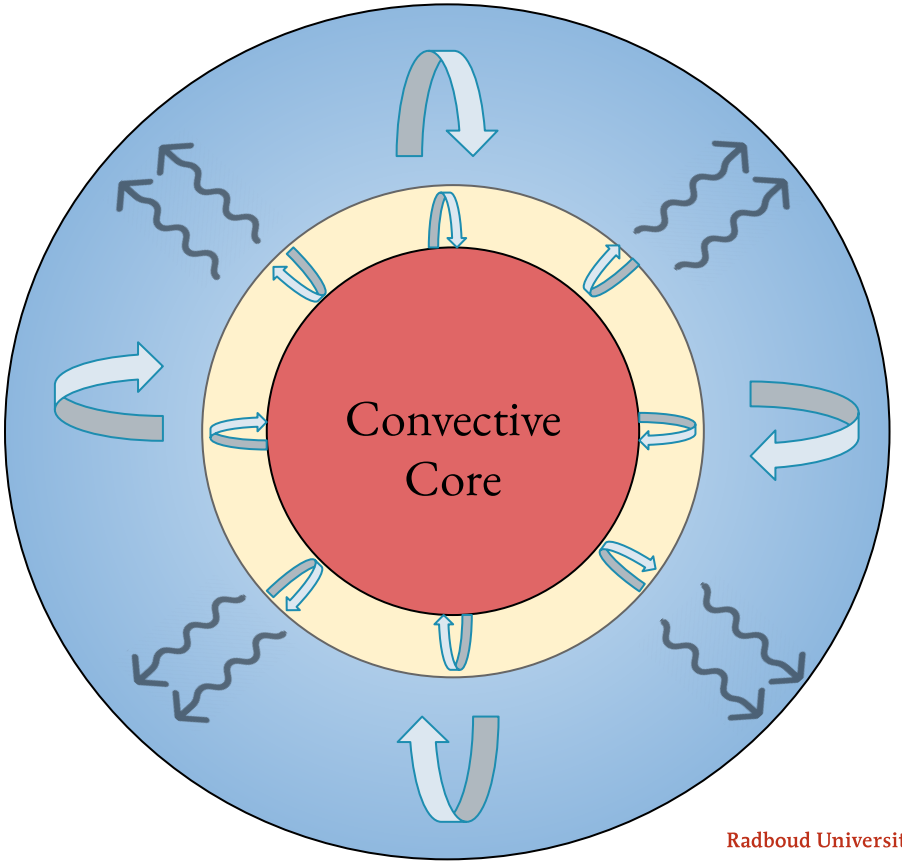
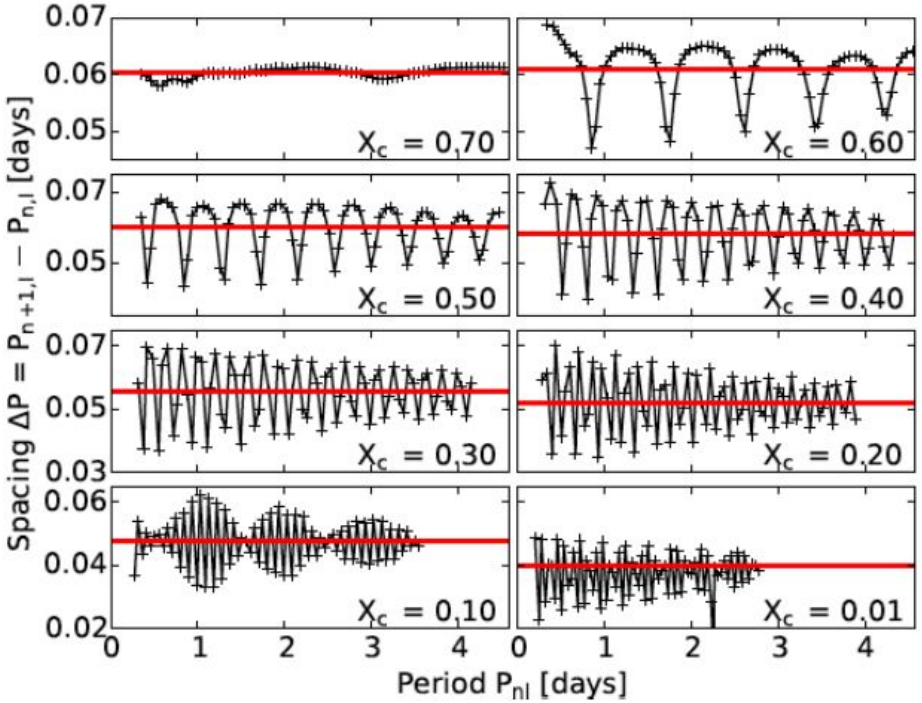


Image credit: NASA

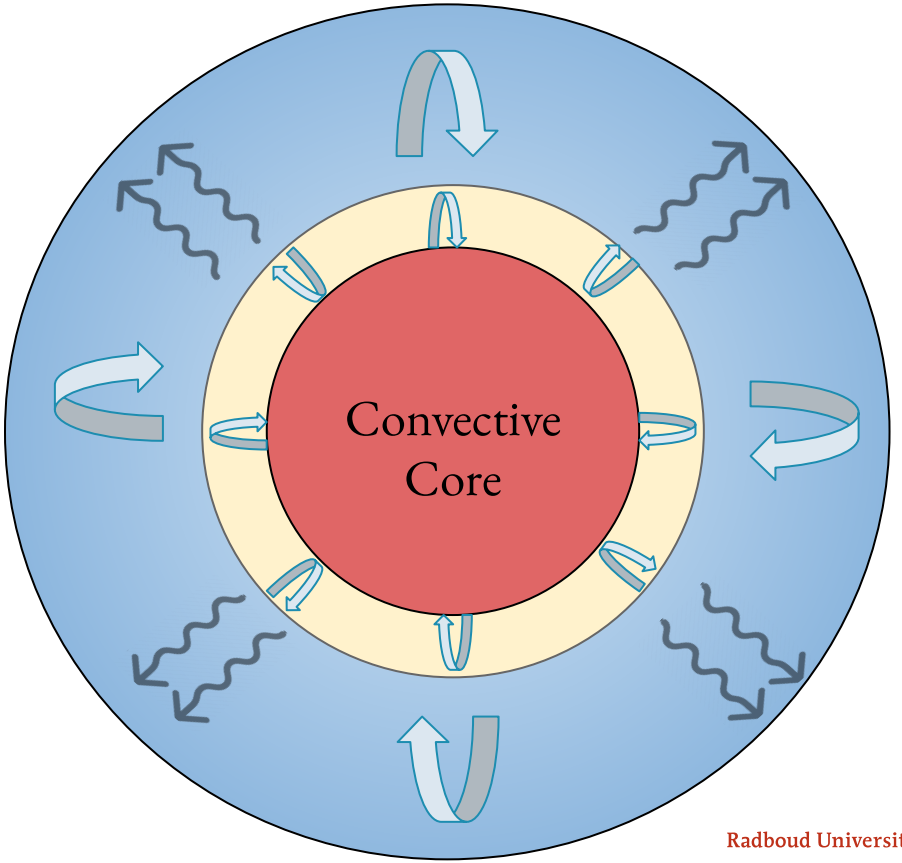
g mode asteroseismology

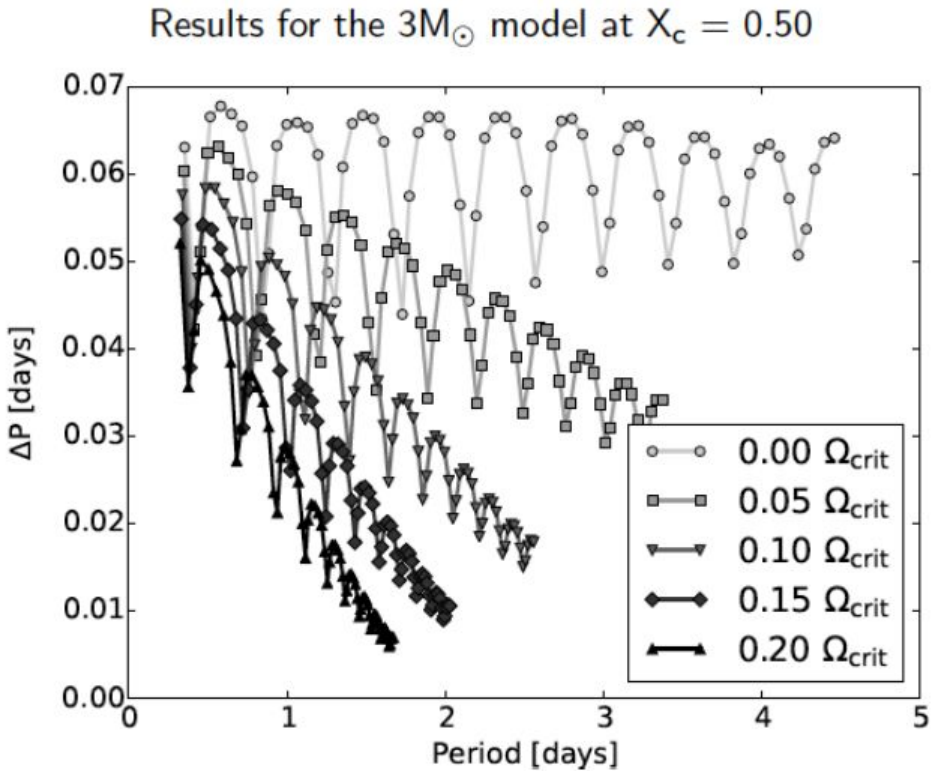


$$(n, \ell, m) - (n+1, \ell, m) \approx (n+1, \ell, m) - (n+2, \ell, m)$$



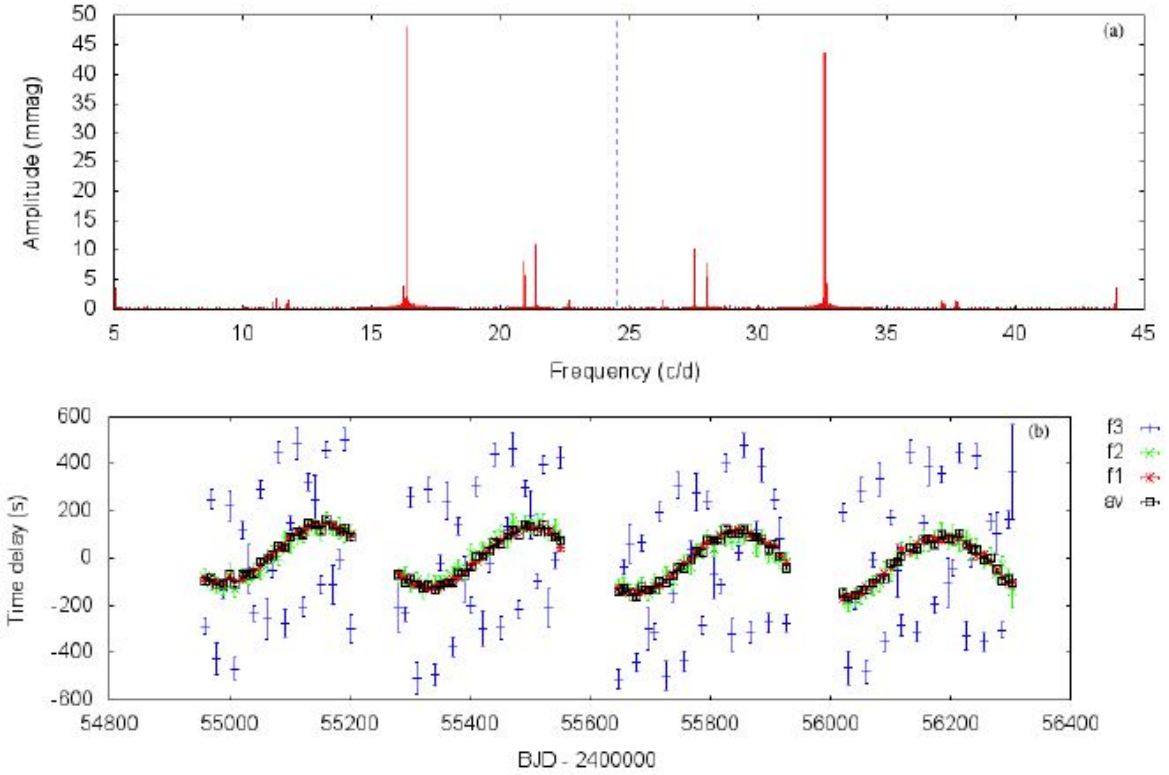
g mode asteroseismology





What else can we get?

Time delays = RVs



Murphy et al. 2014

Dynamical asteroseismology

Seismology

- Mass, radius, relative age
- Near core mixing history
- Core mass
- Core rotation

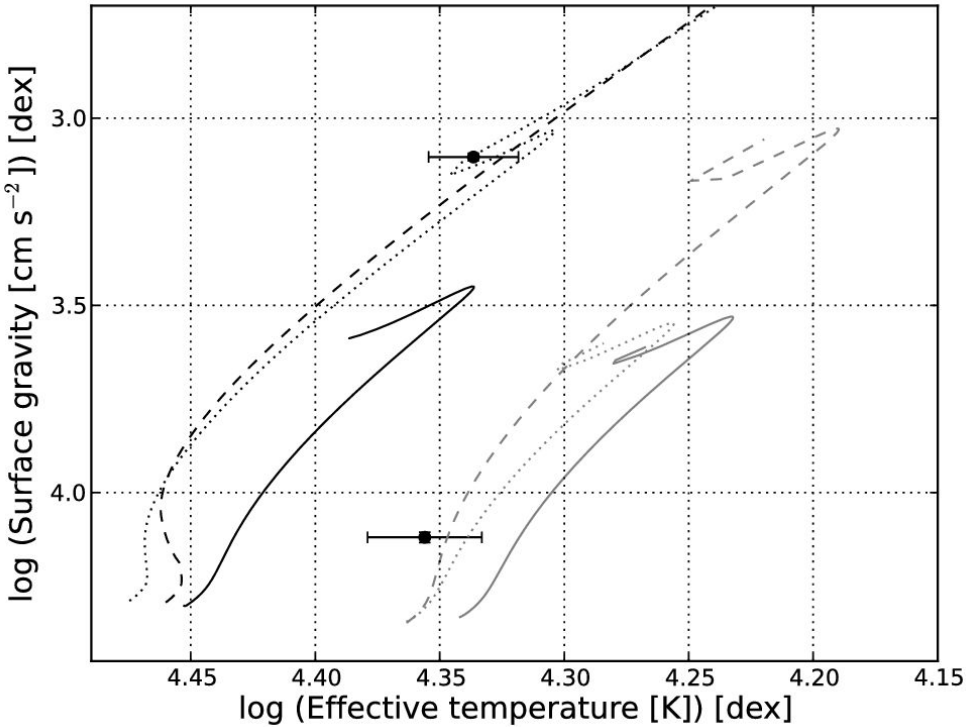
Binary modelling

- Mass*, radius*, age
- Core mass
- Metallicity**
- Luminosity

* Masses and radii to ~1%
** Common initial metallicity

Dynamical asteroseismology

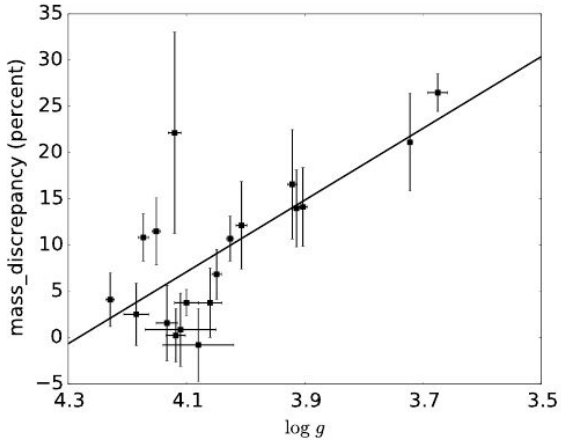
- Dynamical mass
- Evolutionary mass

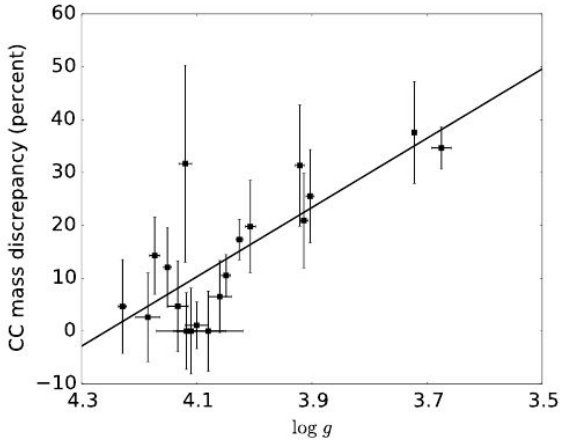


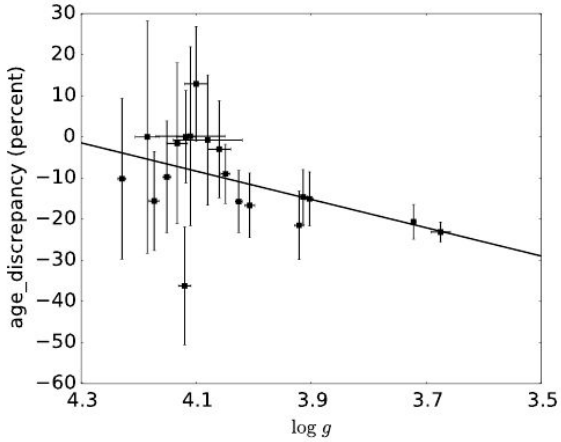
Tkachenko et al. 2014

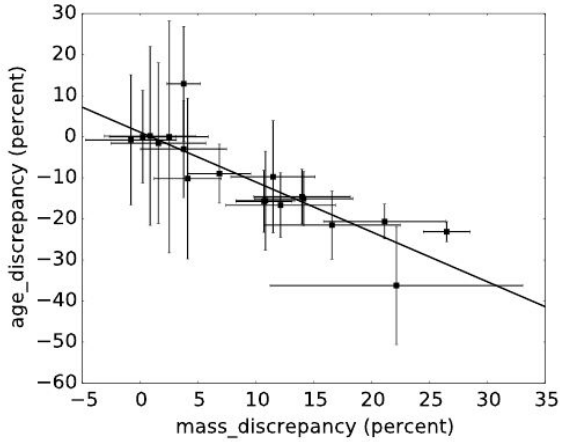
Dynamical asteroseismology

- Dynamical mass
- Evolutionary mass
- 20 EB systems





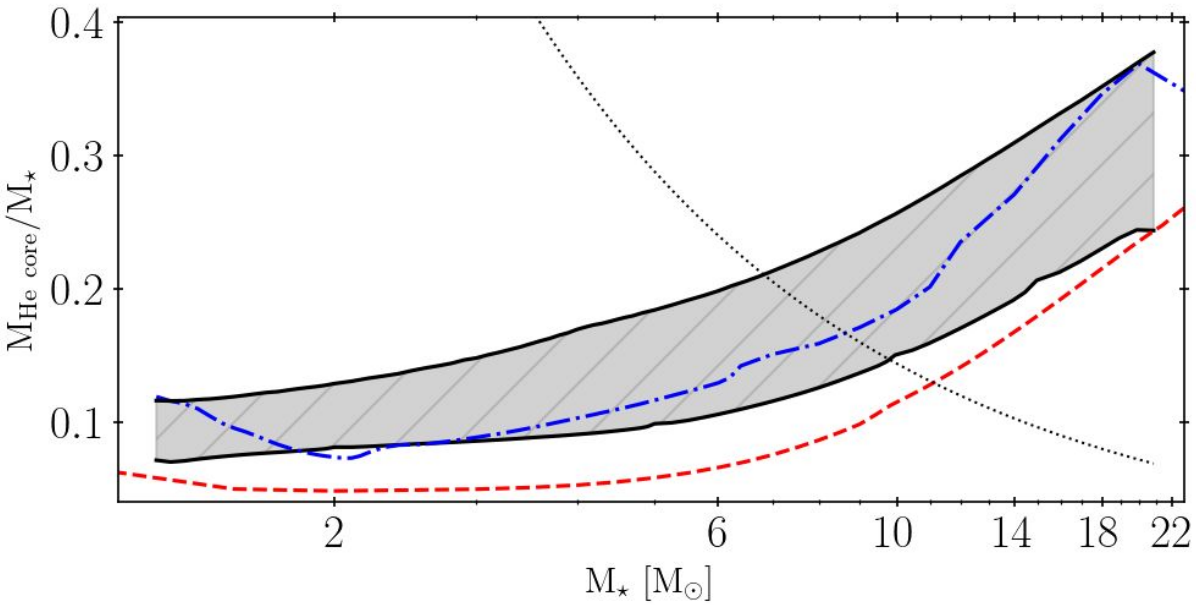




Tkachenko et al. 2020

Dynamical asteroseismology

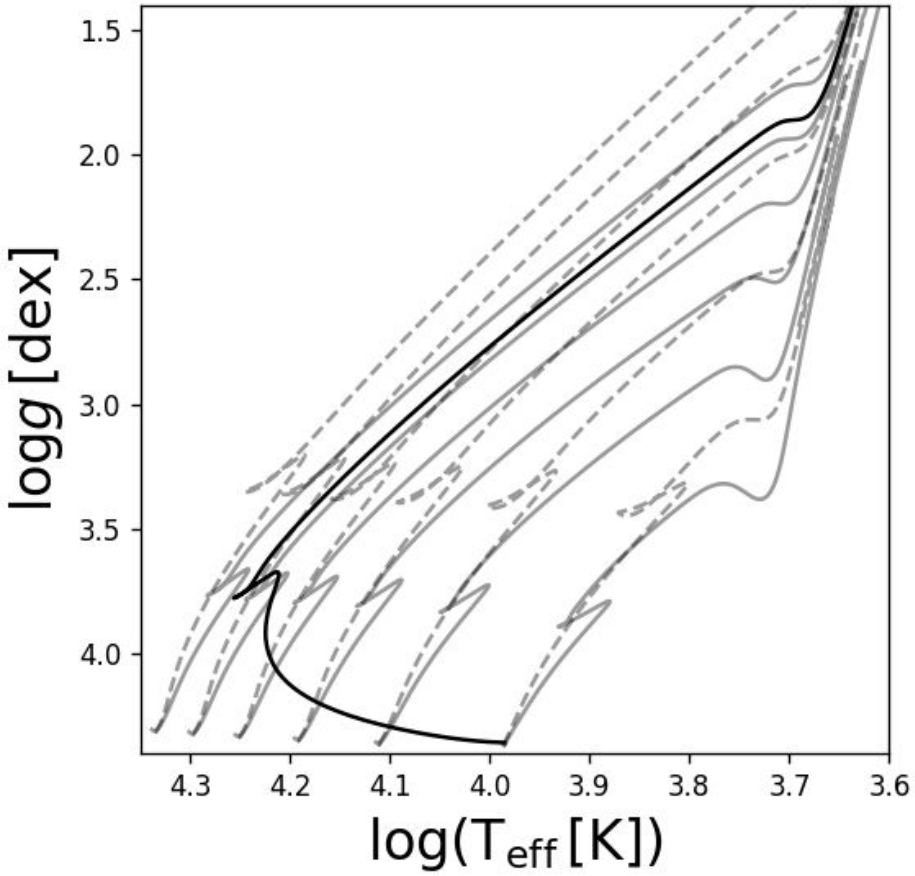
Implications for post-MS



Johnston 2021

Dynamical asteroseismology

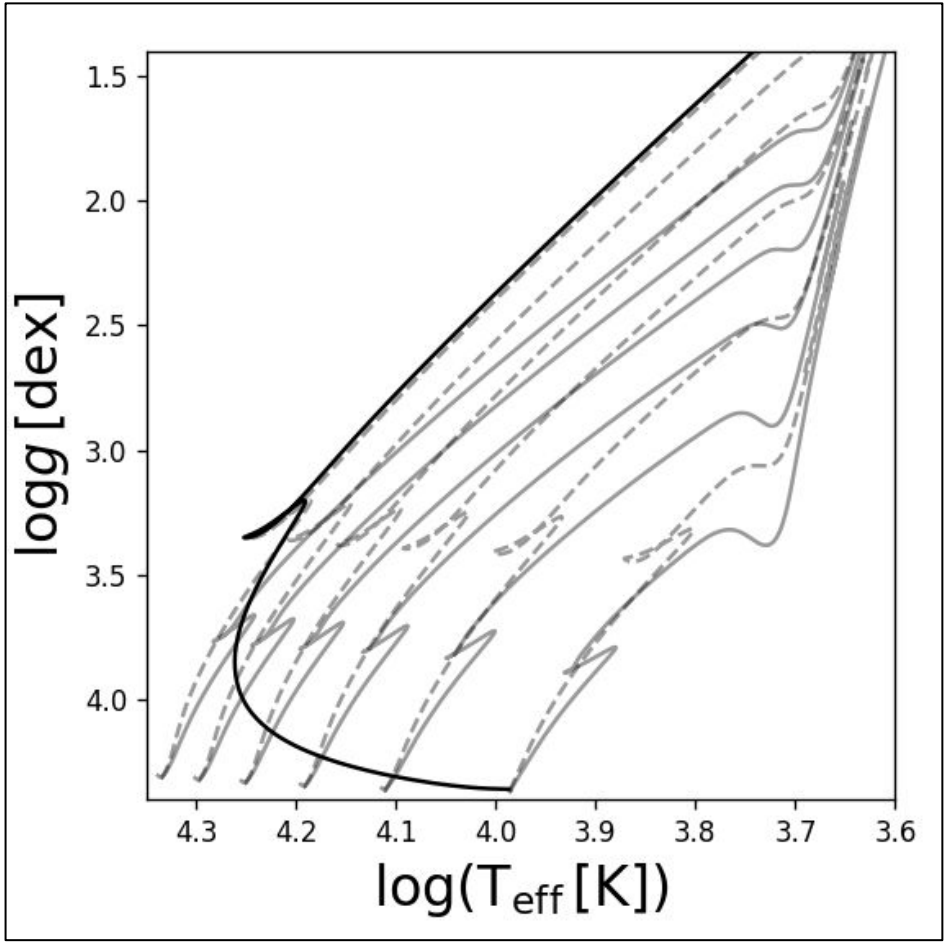
Implications for stellar aging



Johnston et al. 2019b

Dynamical asteroseismology

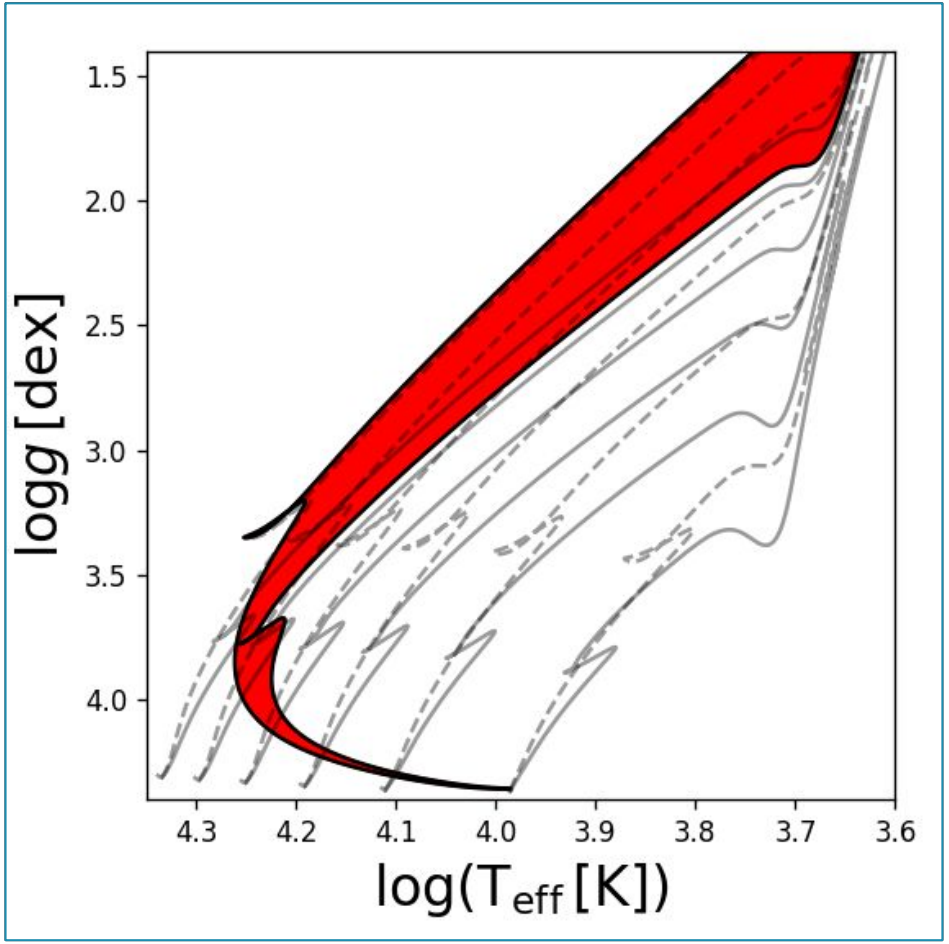
Implications for stellar aging



Johnston et al. 2019b

Dynamical asteroseismology

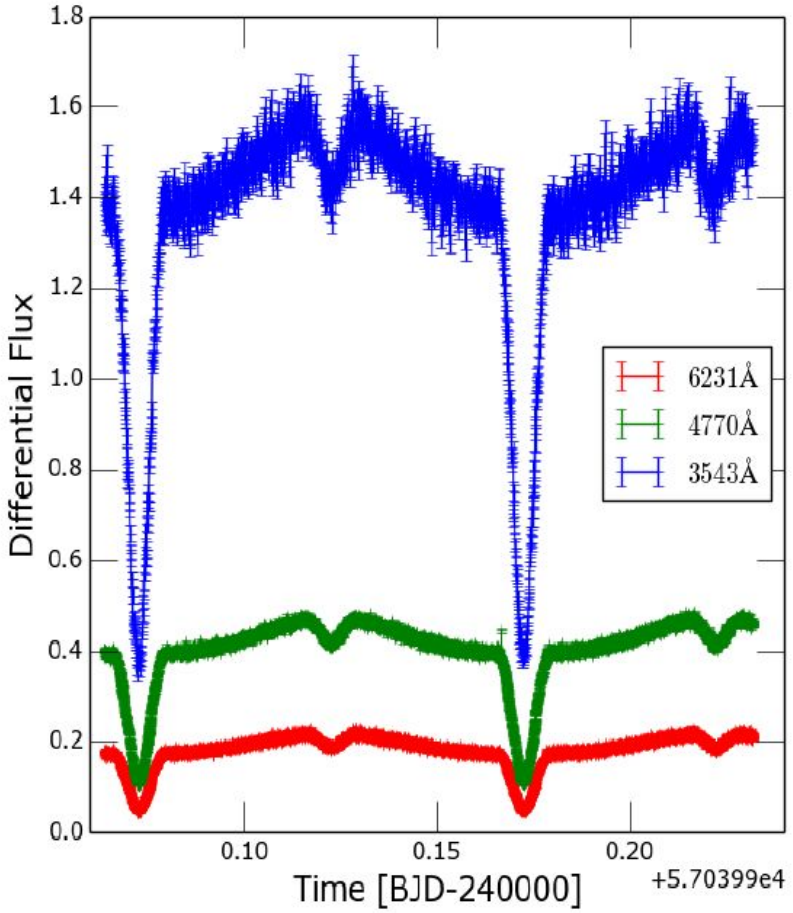
Implications for stellar aging



Johnston et al. 2019b

How do we actually do it?

1. Phase fold & bin the lightcurve
2. Model the eclipse signal
3. Subtract eclipse model
4. Run iterative pre-whitening
5. Subtract IPW model from original lightcurve
6. Repeat



How do we actually do it?

1. Phase fold & bin the lightcurve
2. Model the eclipse signal
3. Subtract eclipse model
4. Run iterative pre-whitening
5. Subtract IPW model from original lightcurve
6. Repeat
    a. How do you know when to stop?