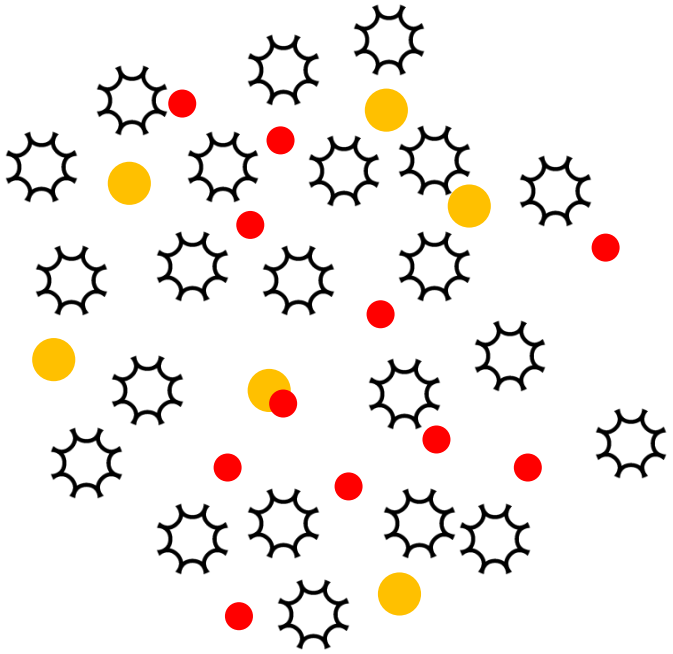
Testing Asteroseismic Scaling Relations using Eclipsing Binaries in Star Clusters and the Field



Karsten Brogaard et al.

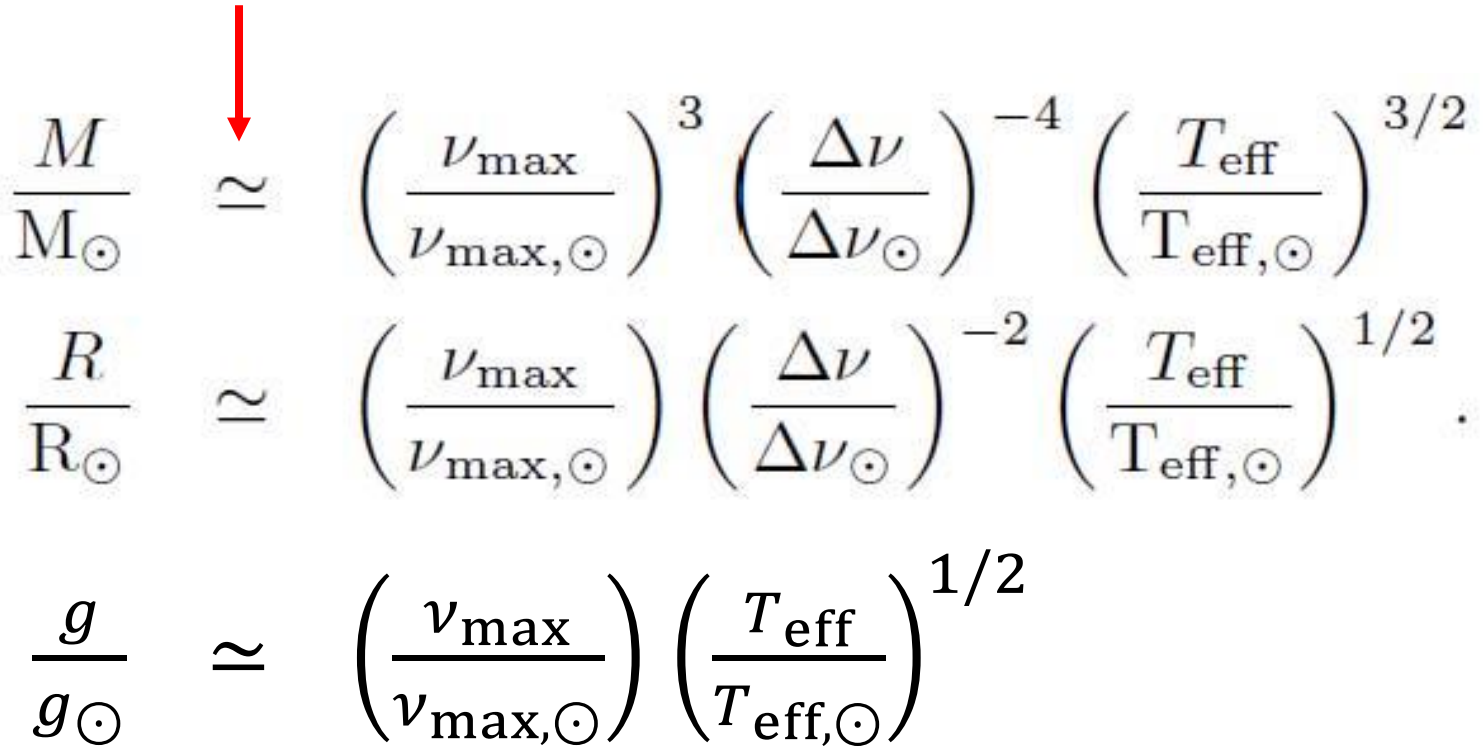
STELLAR ASTROPHYSICS CENTRE

Outline

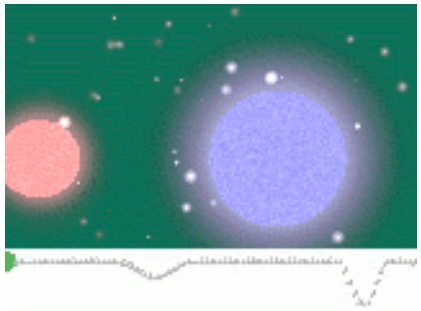
- The asteroseismic scaling relations for mass and radius
- Why?
- How?
- Results so far!

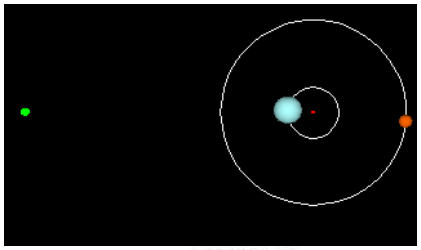
Introduction

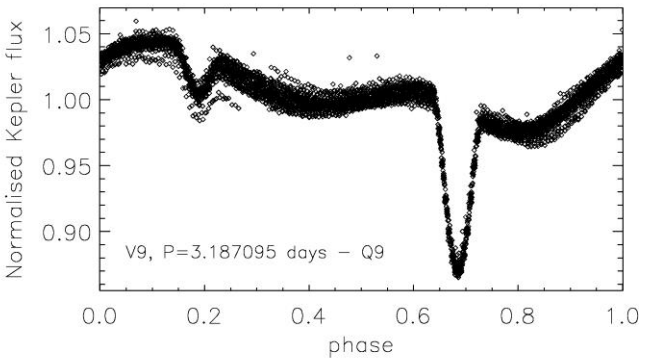
tests of the asteroseismic scaling relations

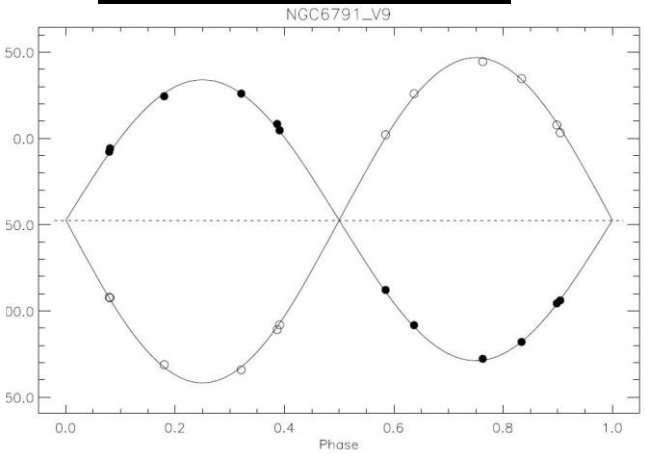


How : Detached eclipsing binary measurements









$[Fe/H]$

T_{eff}

$\log g$

$R_{1,2}/a$

i

P

$+$

$M_{1,2}\sin^3 i$

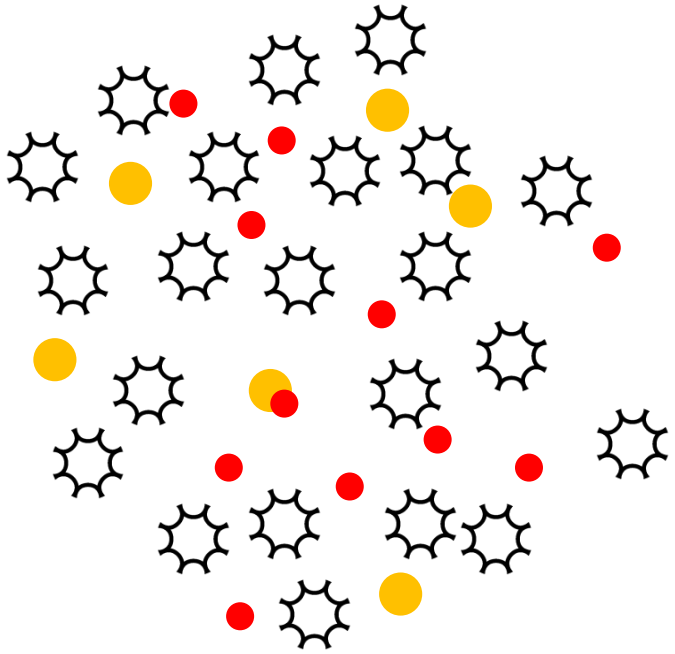
$a\sin i$

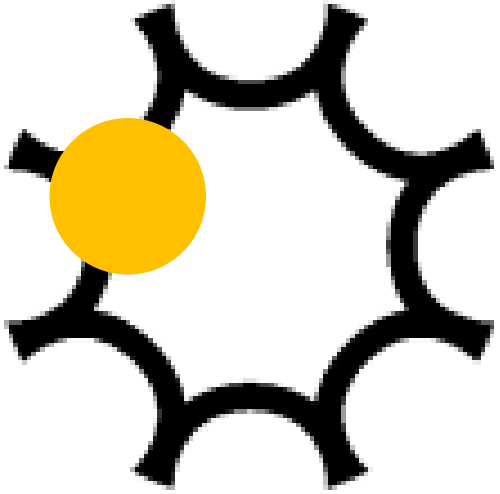
$=$

$M_{1,2}$

$R_{1,2}$

Where can we compare?





4 Open Clusters in the *KEPLER* FOV

(+1 in CoRoT and more in K2 fields!?)

Synergy:

Multiple detached eclipsing binaries+

Ensemble asteroseismology+

Cluster CMD+

Ensemble spectroscopy with known logg

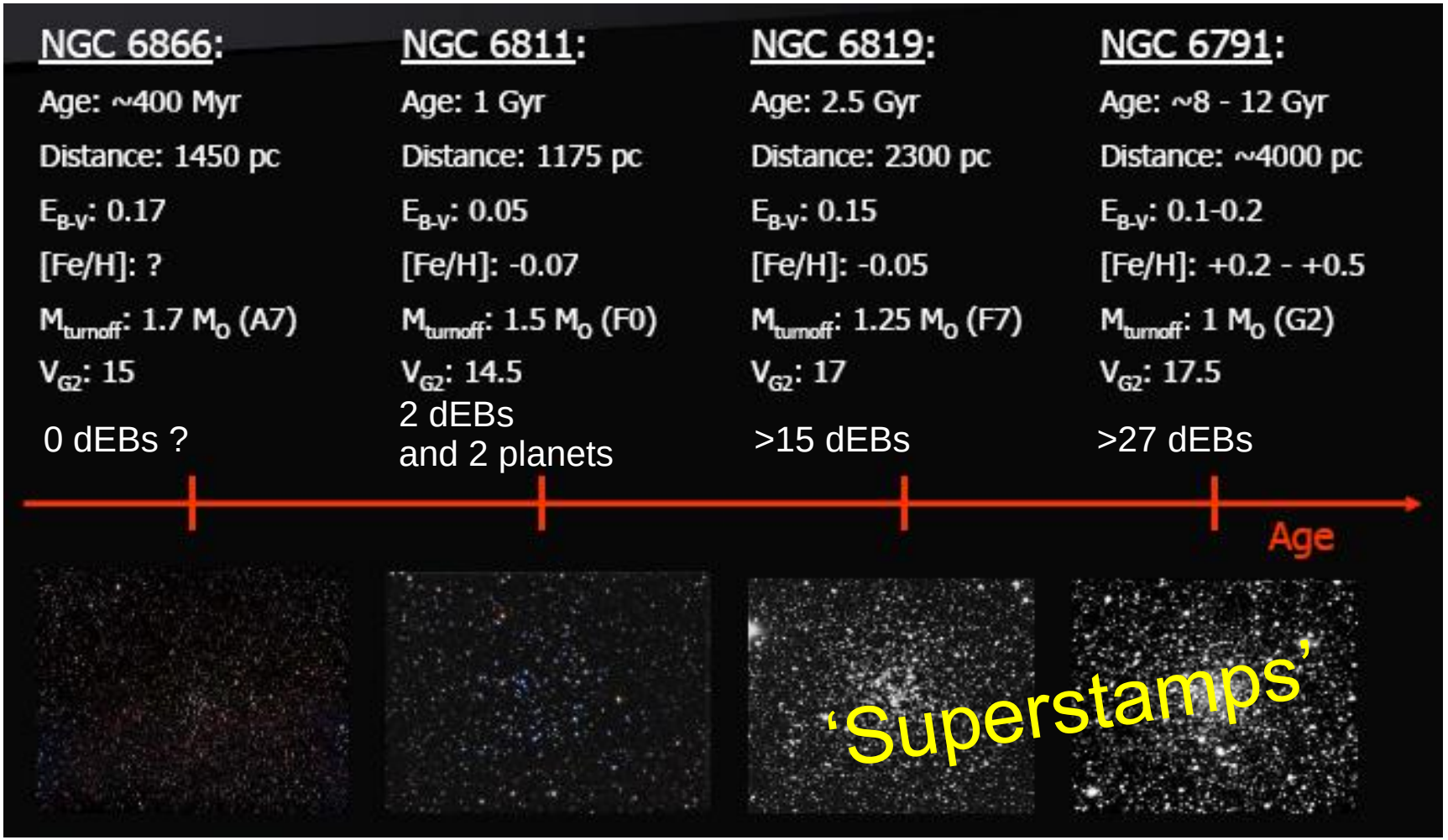


Illustration from a talk by Søren Meibom. dEB = detached eclipsing binary

NGC6791

Spectroscopic Teff!:

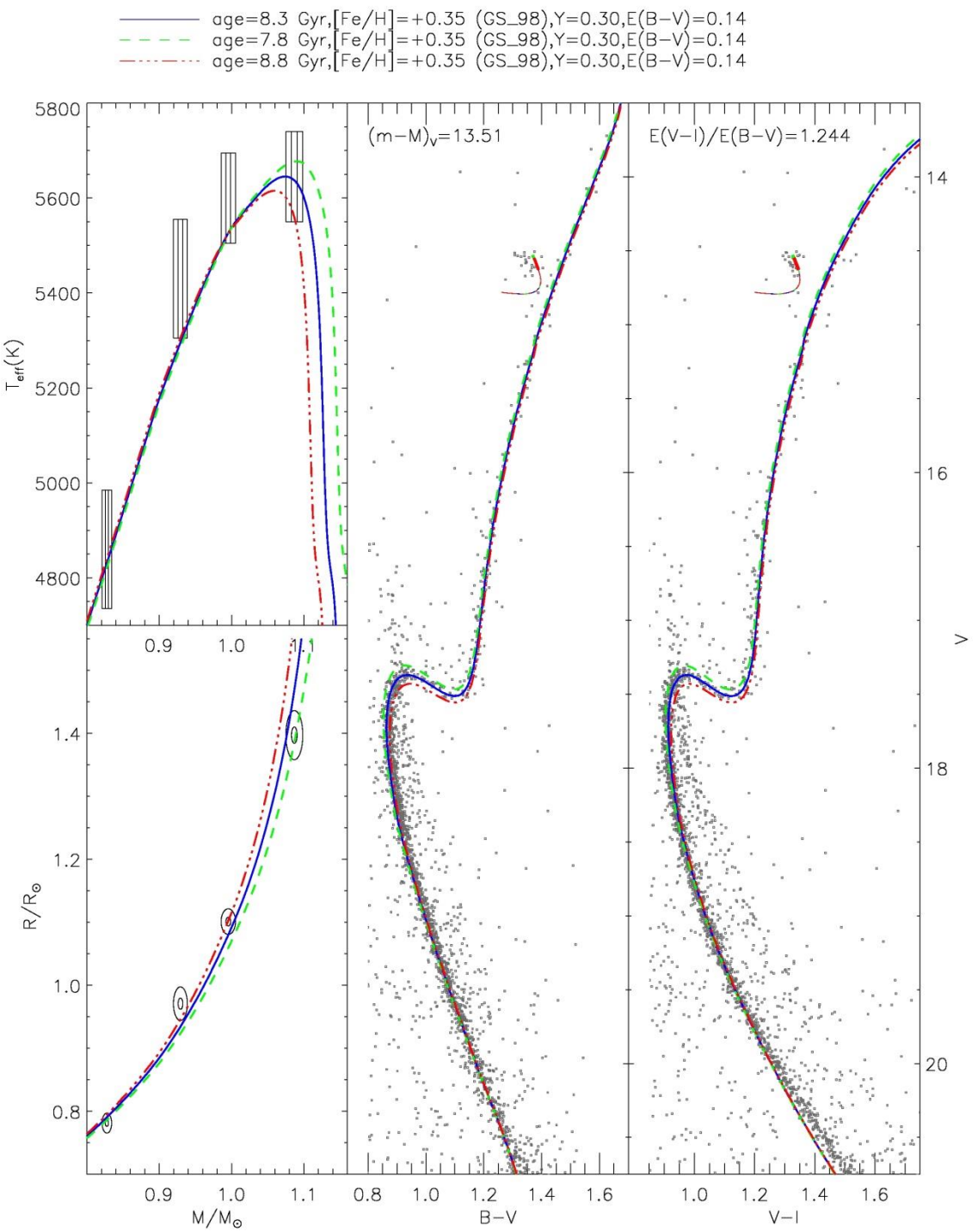
(m-V)_V=13.51±0.06

Y=0.30±0.01

Age=8.3±0.7

M_RGB=1.15±0.02

(Brogaard et al. 2012)



NGC6791

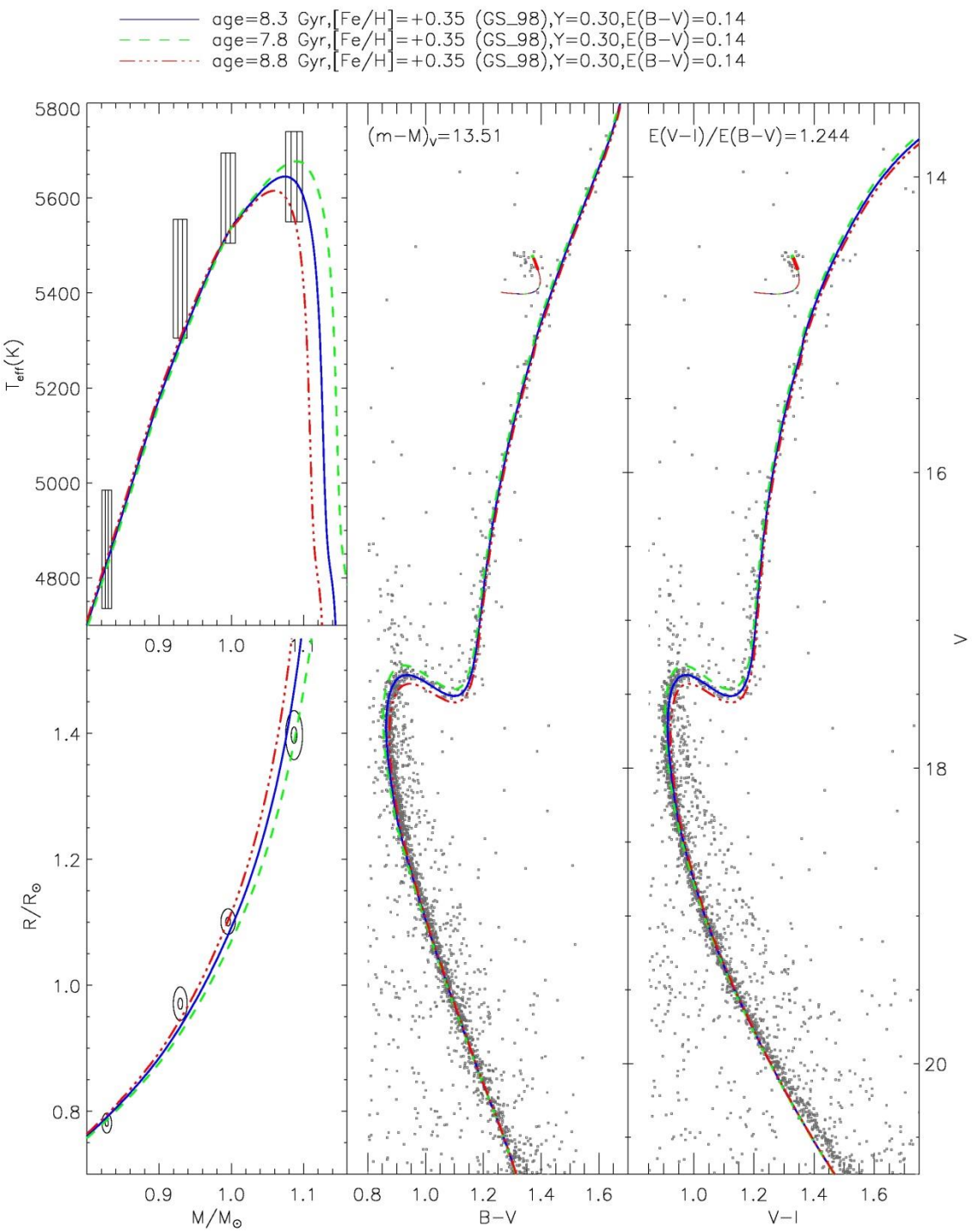
dEBs + CMDs:

M_RGB=1.15±0.02

Asteroseismology:

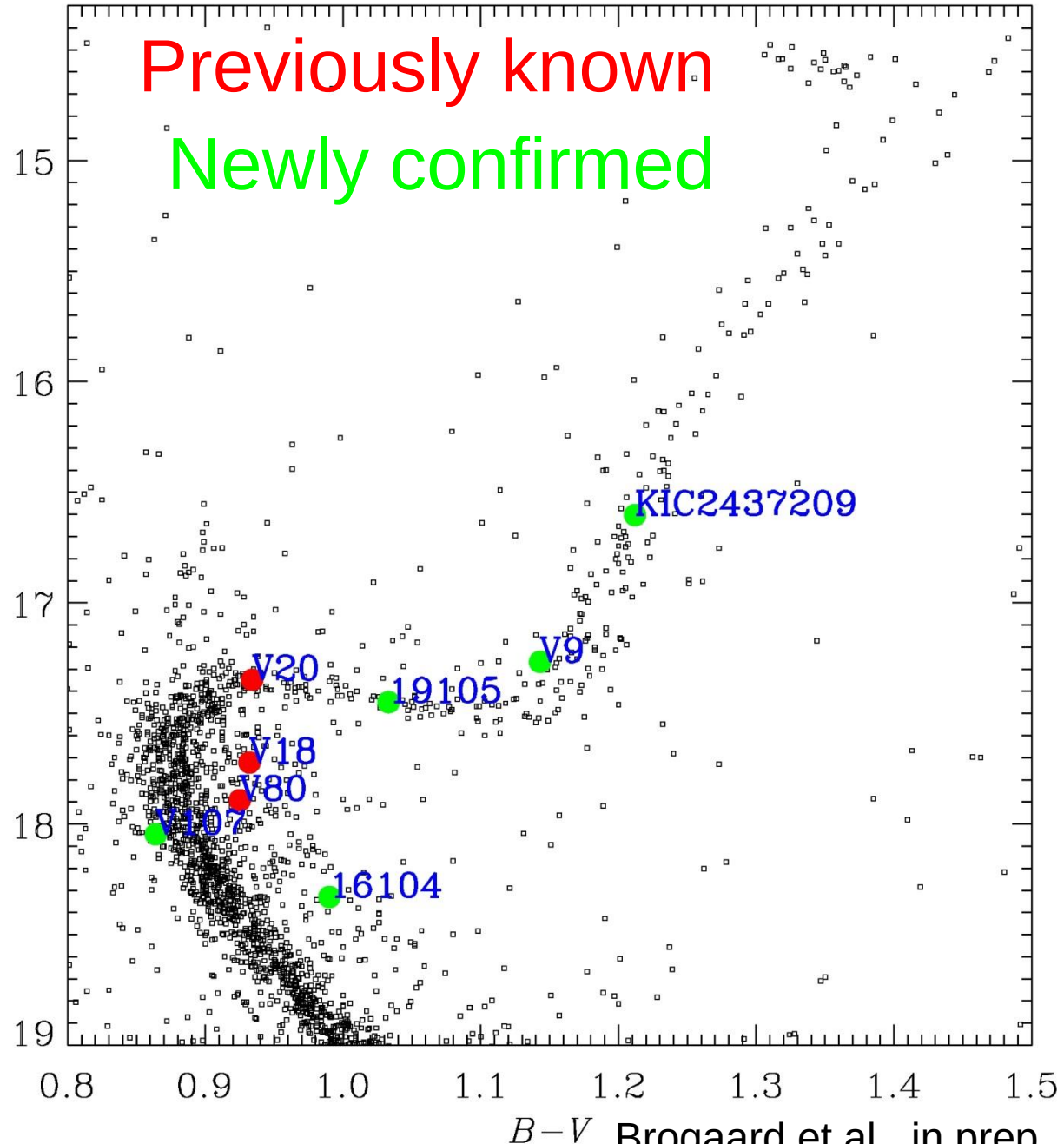
M_RGB=1.20±0.01
(Basu et al. 2011)

M_RGB=1.22±0.02
(Miglio et al. 2012)
Significantly higher!



NGC6791 eclipsing members from *Kepler* + VLT

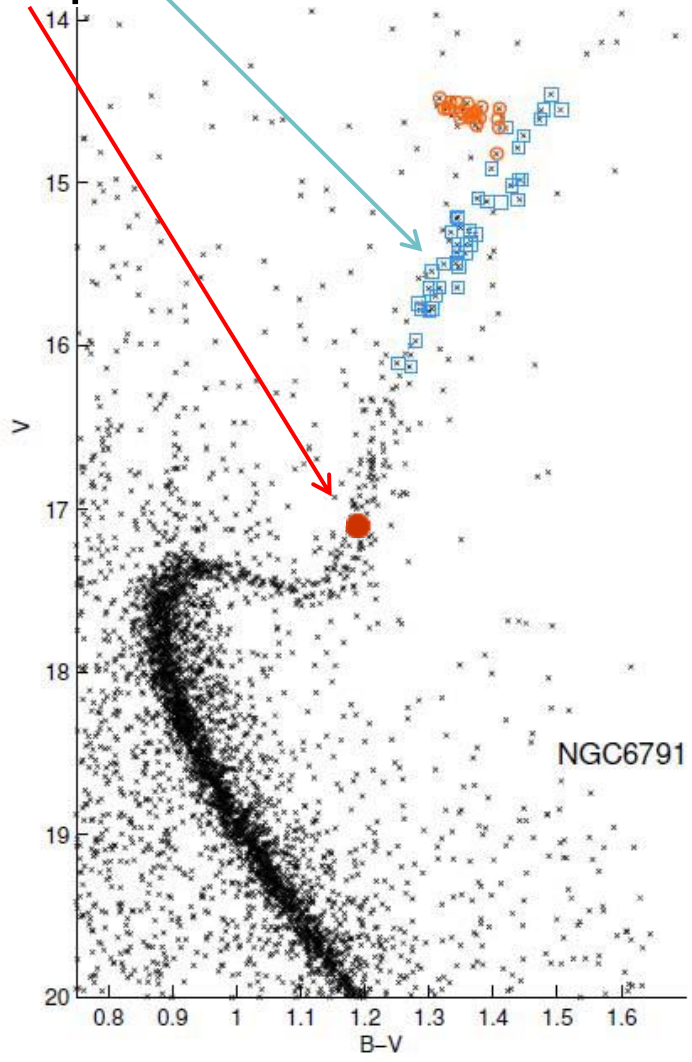
Orbital periods of new systems: 281.33, 3.187095, 80.75, 3.3157, 34.86 days

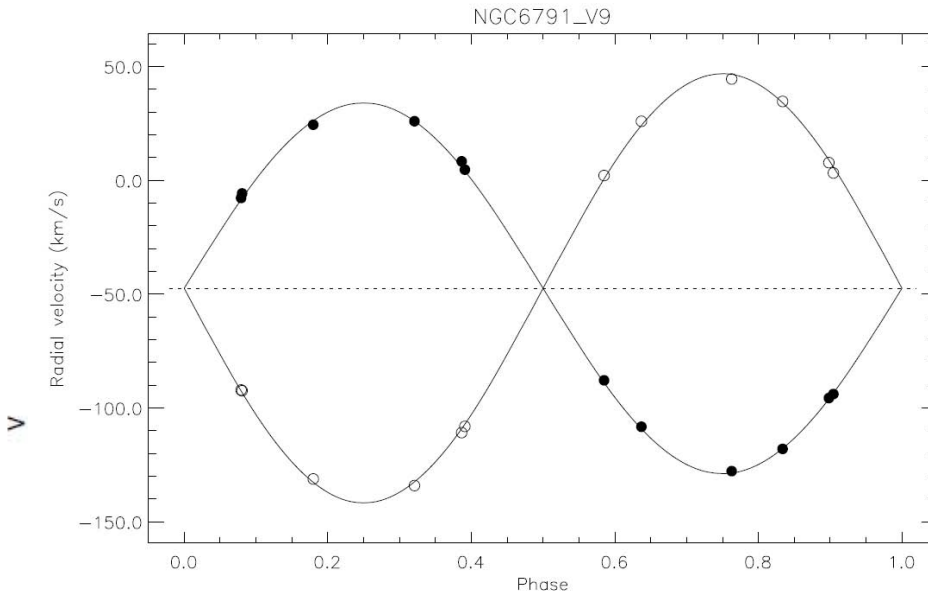


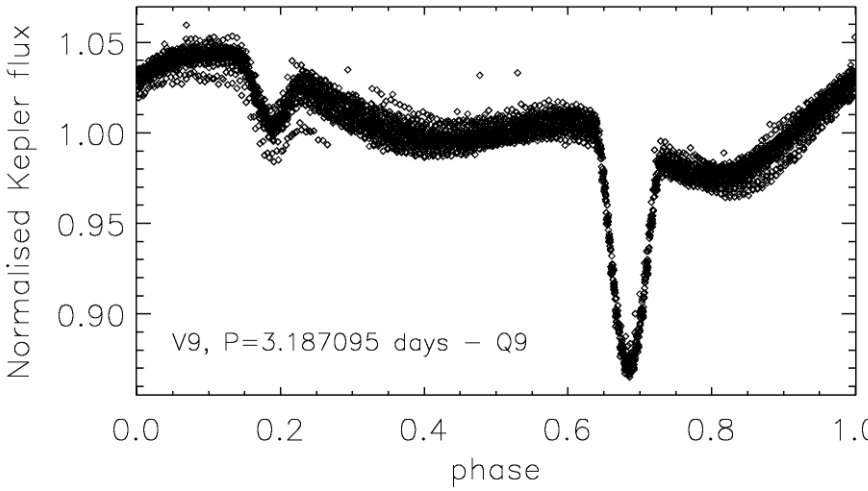
Brogaard et al., in prep.

$<M_{RGB,seismic}>=1.20 \pm 0.01\ M_{\odot}$

$M_{V9p} = 1.14 \pm 0.02\ M_{\odot}$ (preliminary)







NGC 6819

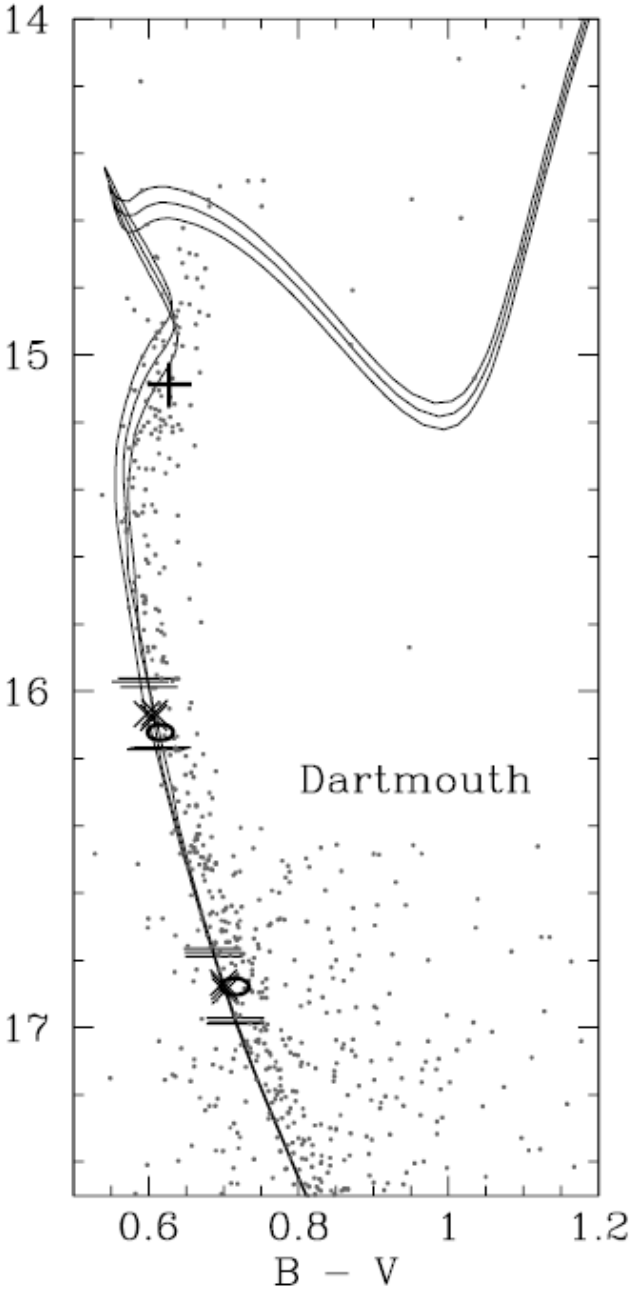
M_RGB = 1.55 ± 0.06
(m-M)_v = 12.40±0.06

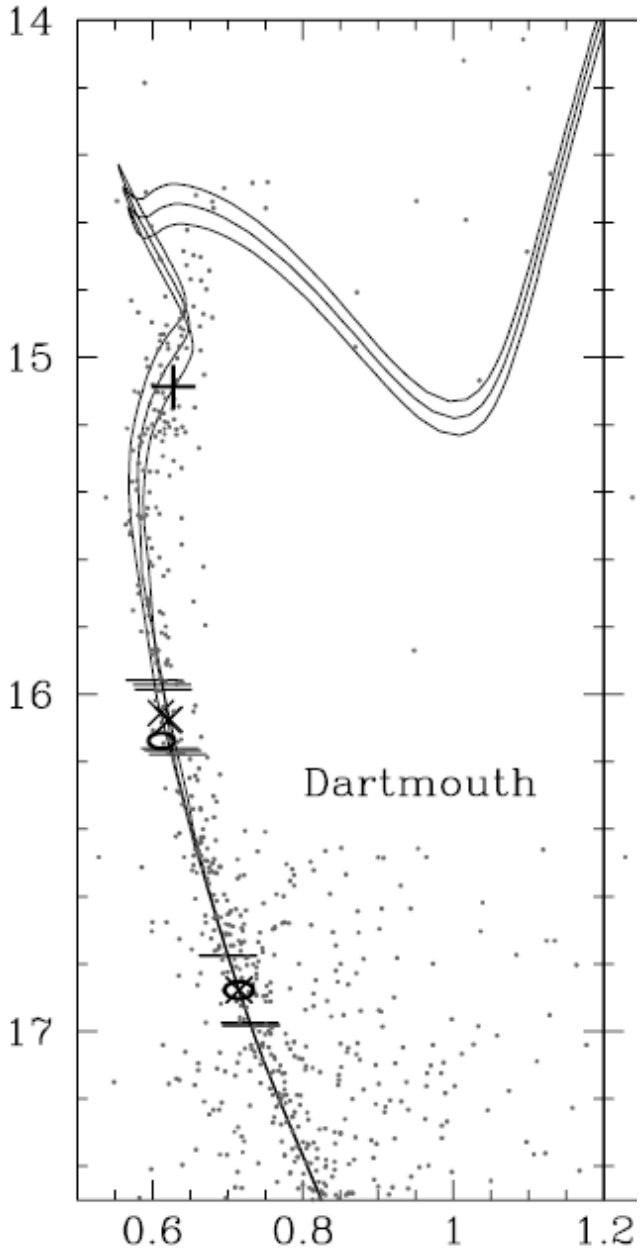
vs

M_RGB_seis = 1.61±0.04
(Miglio et al. 2012)
(m-M)_v = 12.22±0.02

and

M_RGB_seis = 1.68±0.03
(Basu et al. 2012)
(m-M)_v = 12.30±0.05

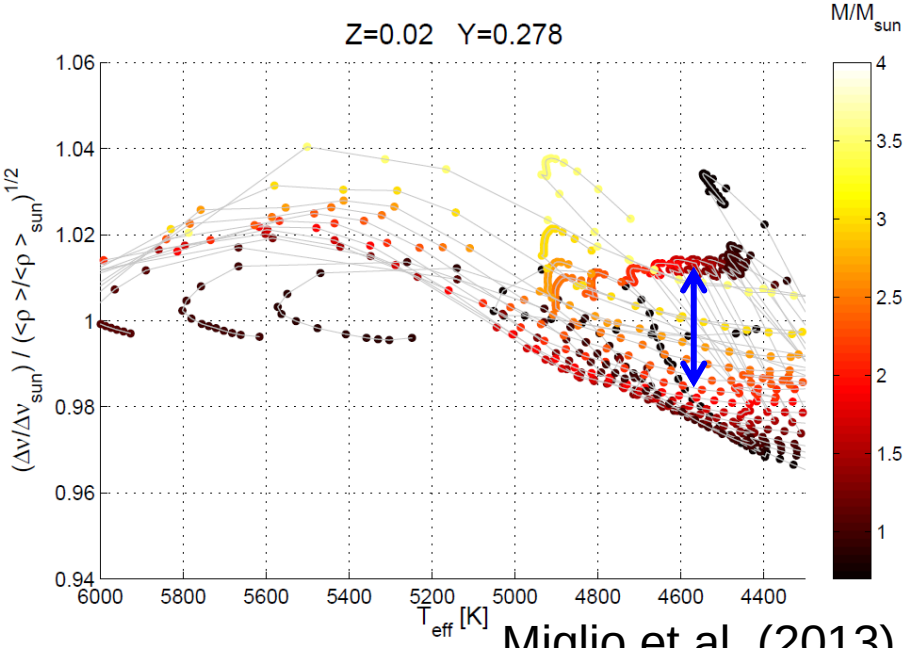




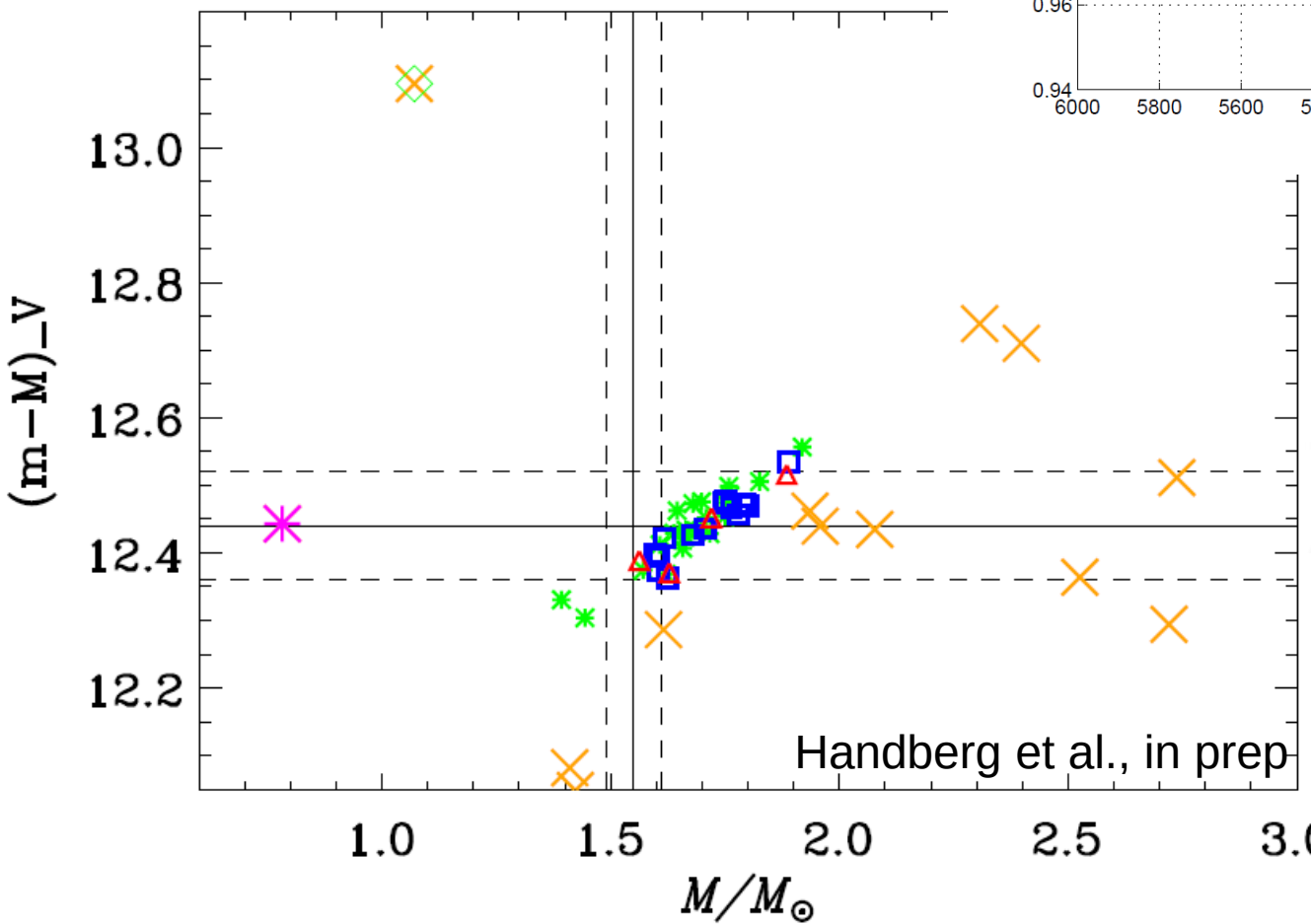
Jeffries et al. (2013) + Sandquist et al. (2013)

NGC 6819

Spec. Teff-scale!



Miglio et al. (2013)

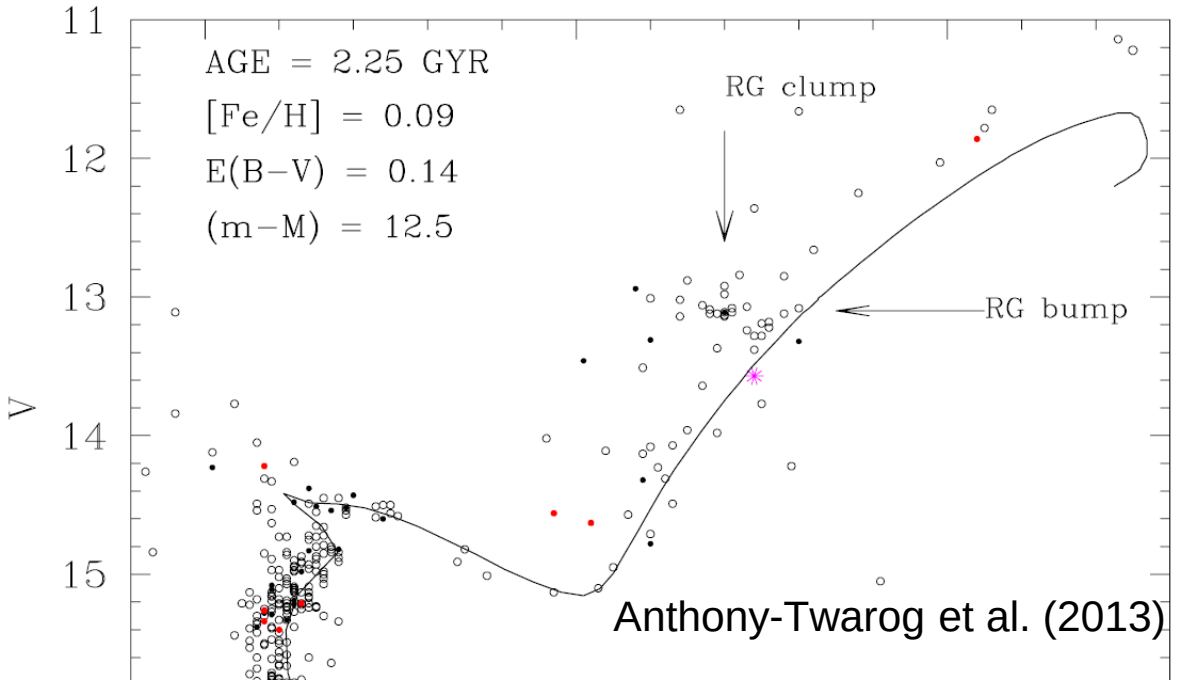


$$\frac{M}{M_\odot} \approx \left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right)^{3} \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-4} \left(\frac{T_{\rm eff}}{T_{\rm eff,\odot}}\right)^{3/2}$$

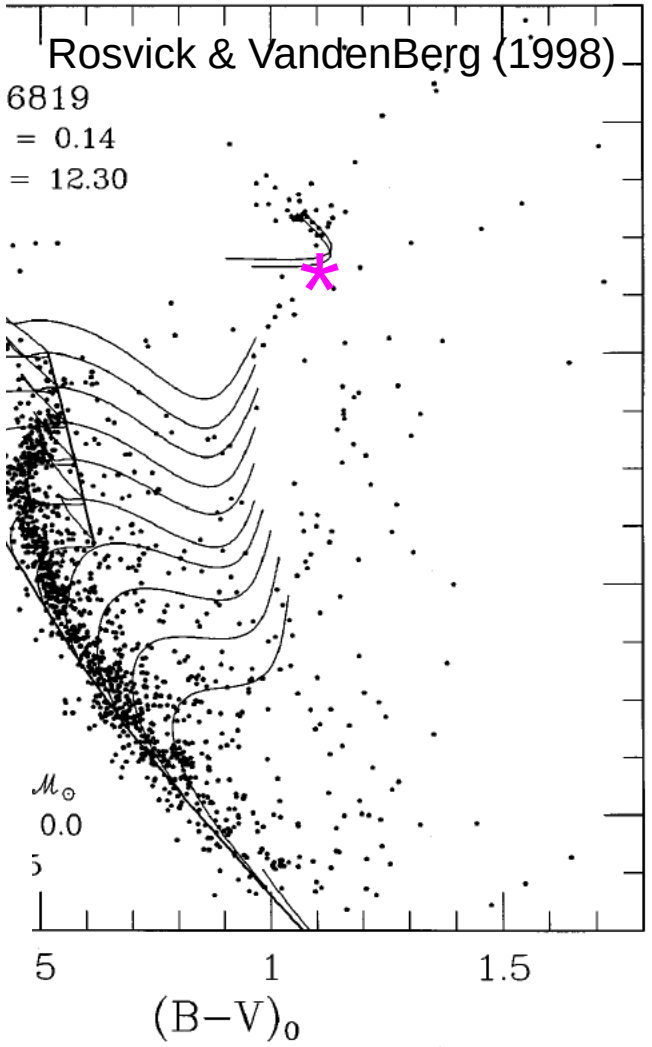
$$\frac{M}{M_\odot} \approx \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{2} \left(\frac{L}{L_\odot}\right)^{3/2} \left(\frac{T_{\rm eff}}{T_{\rm eff,\odot}}\right)^{-6}$$

$$\frac{M}{M_\odot} \approx \left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right) \left(\frac{L}{L_\odot}\right) \left(\frac{T_{\rm eff}}{T_{\rm eff,\odot}}\right)^{-7/2}$$

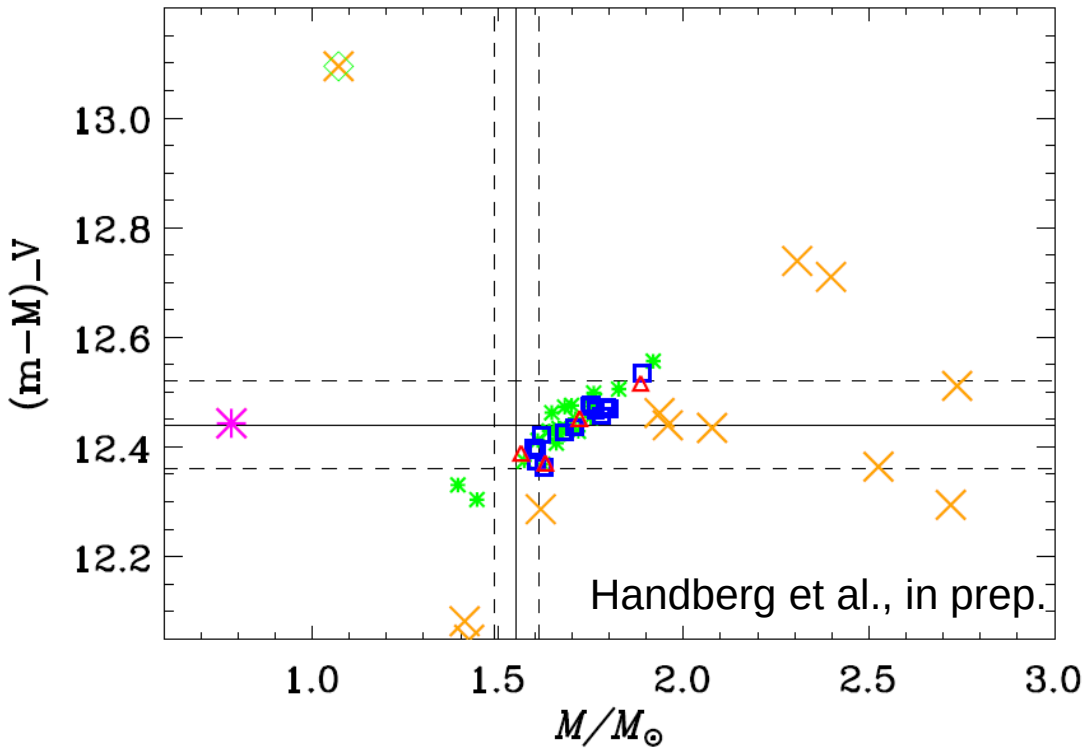
$$\frac{M}{M_\odot} \approx \left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right)^{12/5} \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-14/5} \left(\frac{L}{L_\odot}\right)^{3/10}$$



Anthony-Twarog et al. (2013)

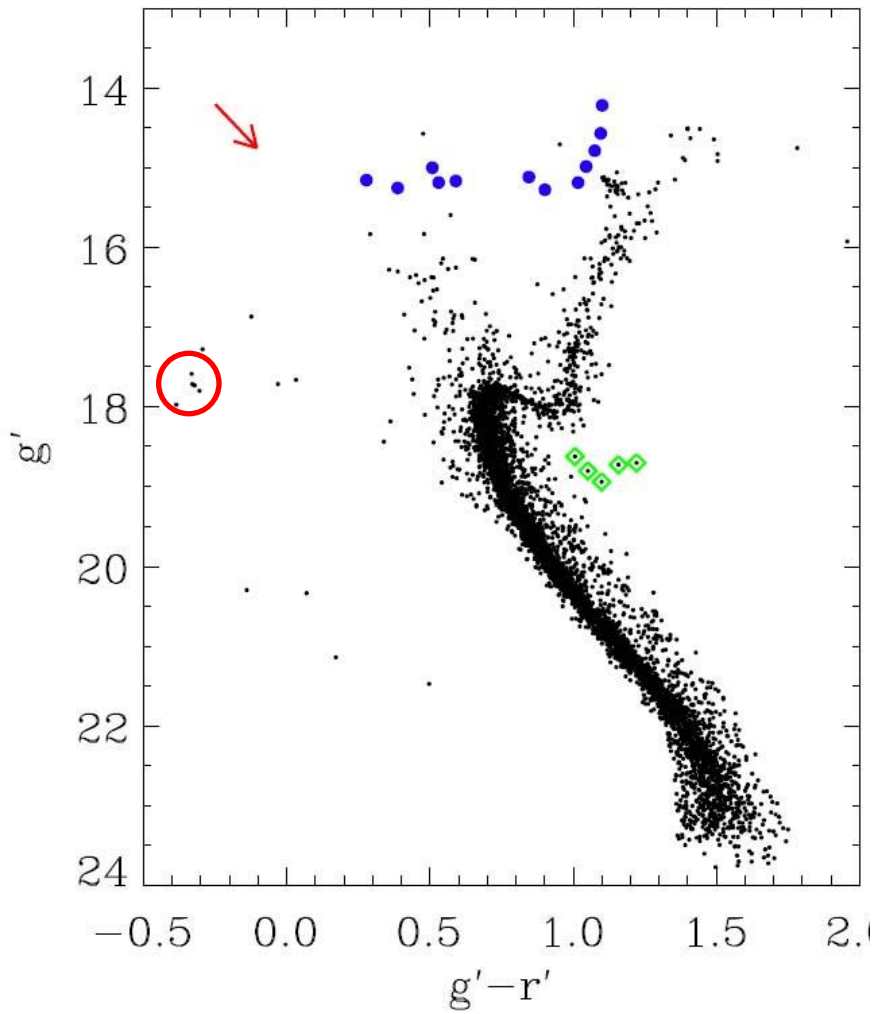


Rosvick & VandenBerg (1998)

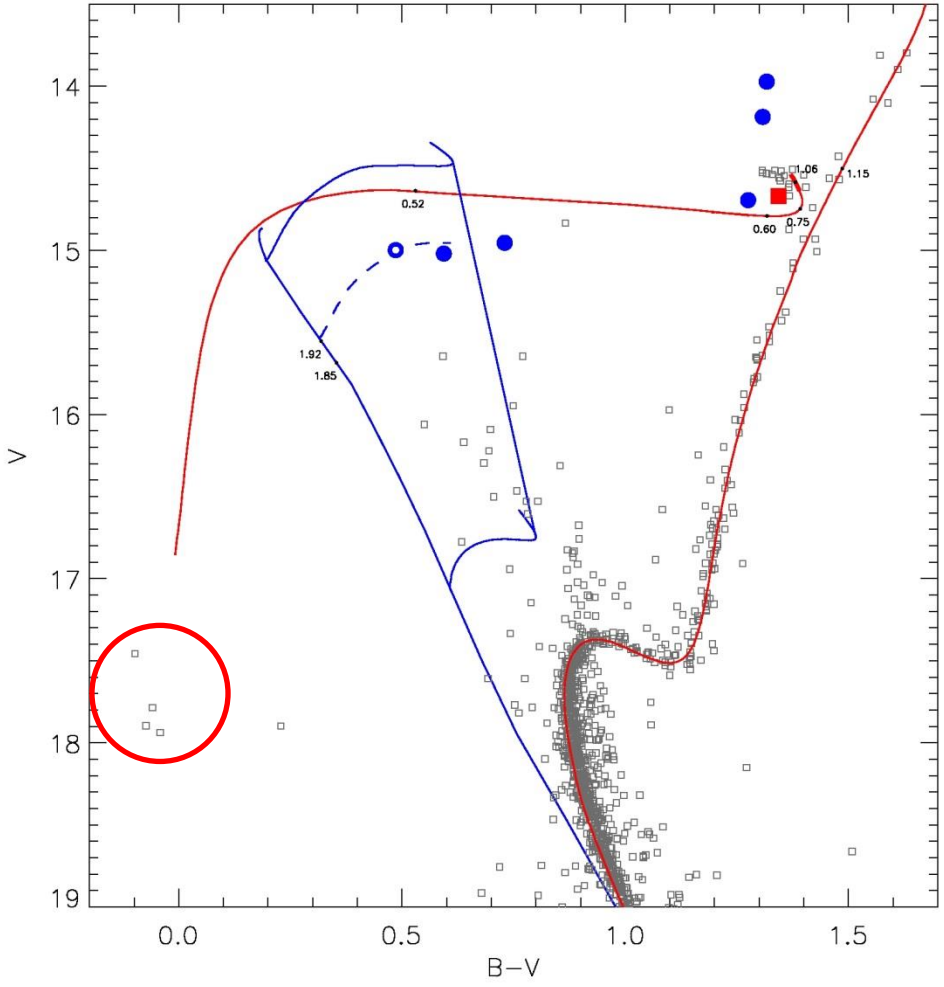


Handberg et al., in prep.

BHB stars in NGC6791?



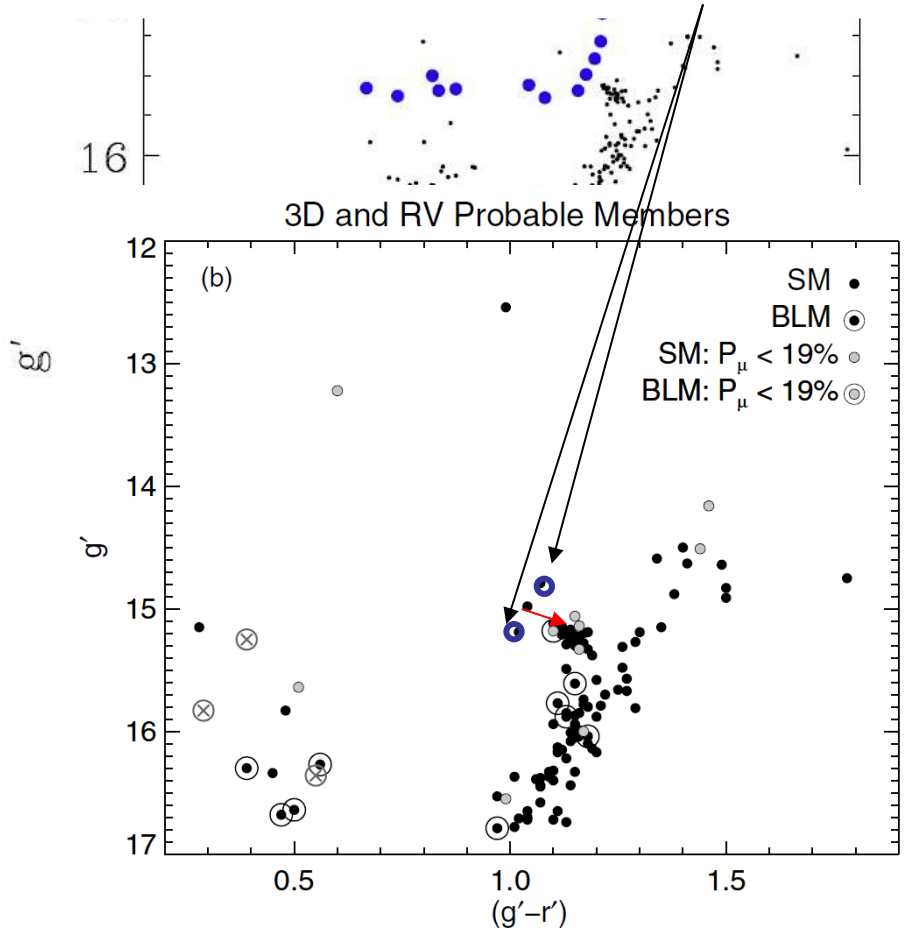
Platais et al. (2011)



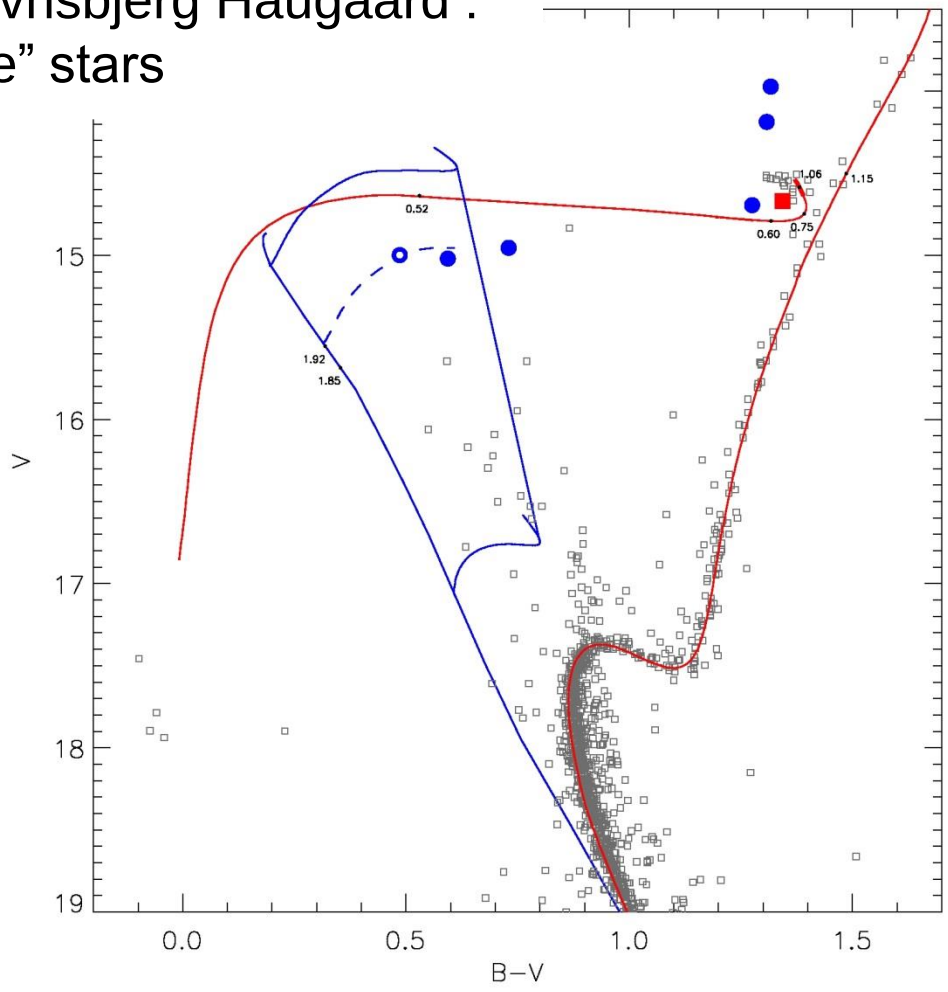
Brogaard et al. (2012)

BHB stars in NGC6791?

Project during ‘observational tools’ course at AU by Kenneth Lund Kjærgaard & Nicolai Avnsbjerg Haugaard : These are “overmassive” stars



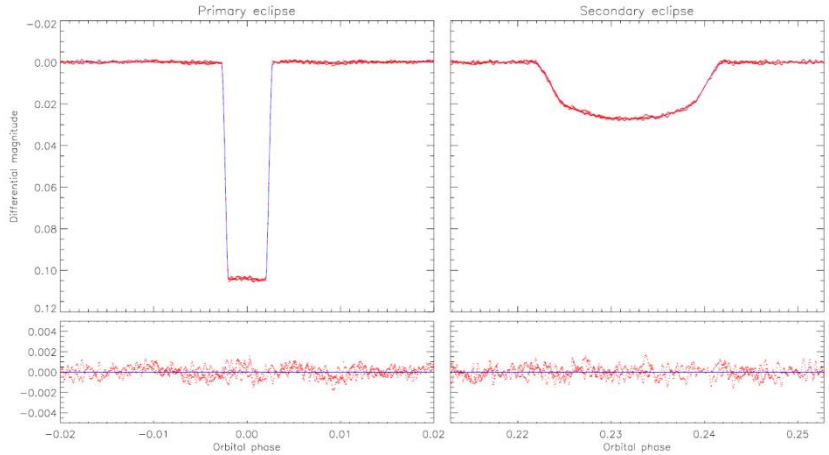
Tofflemire et al. (2014)



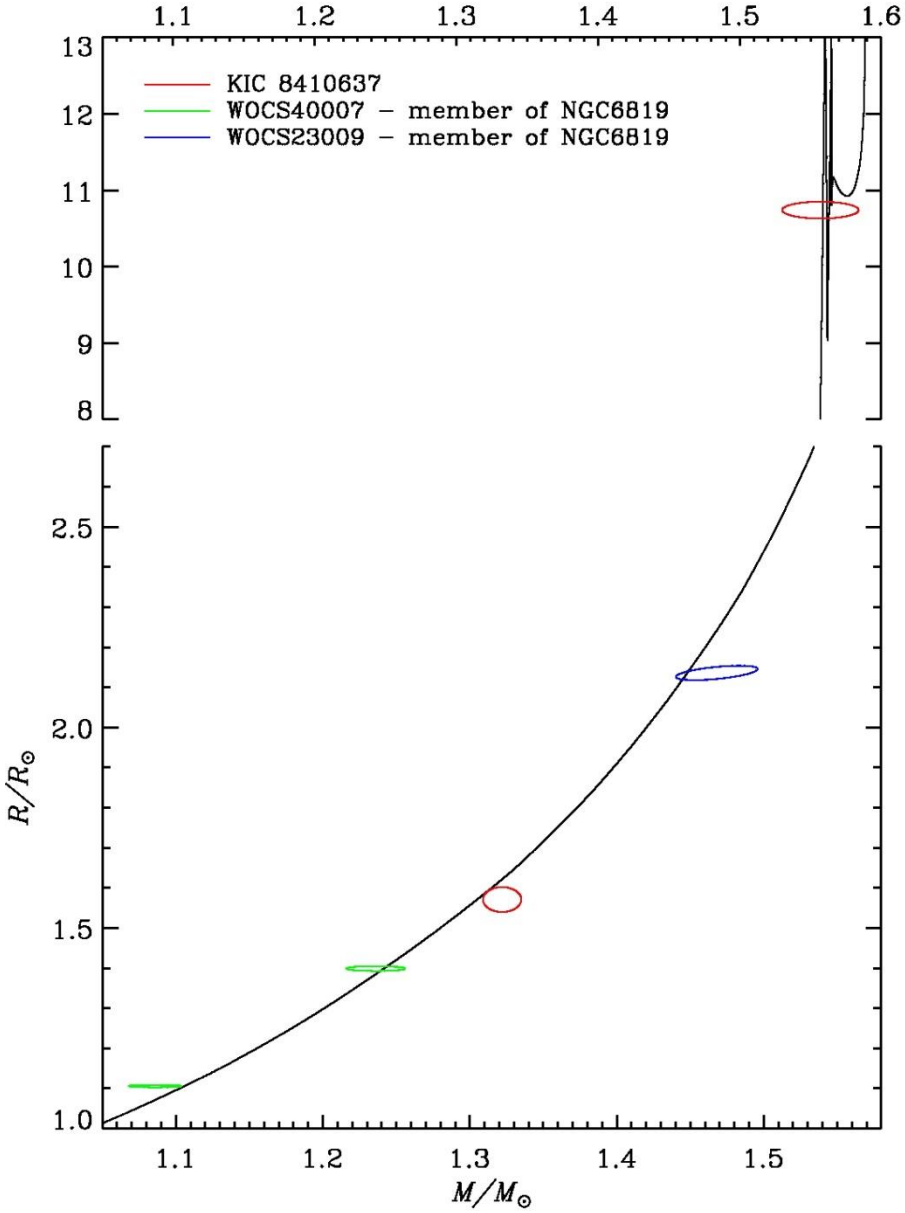
Brogaard et al. (2012)

Metallicity effect?

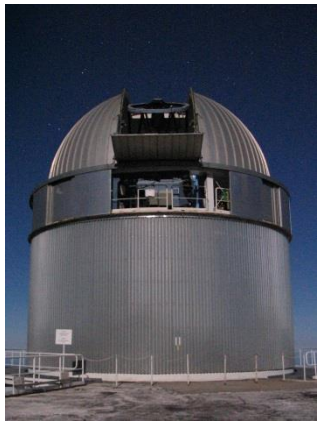
No metal-poor clusters, but eclipsing systems with an oscillating giant component: KIC8410637

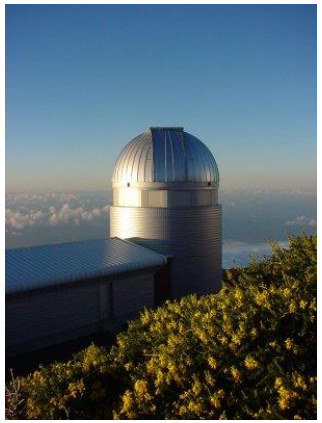


+ more such systems with a giant, 3 of which have [Fe/H]~ -0.4 (KIC)



Frandsen et al. (2013)





KIC9540226

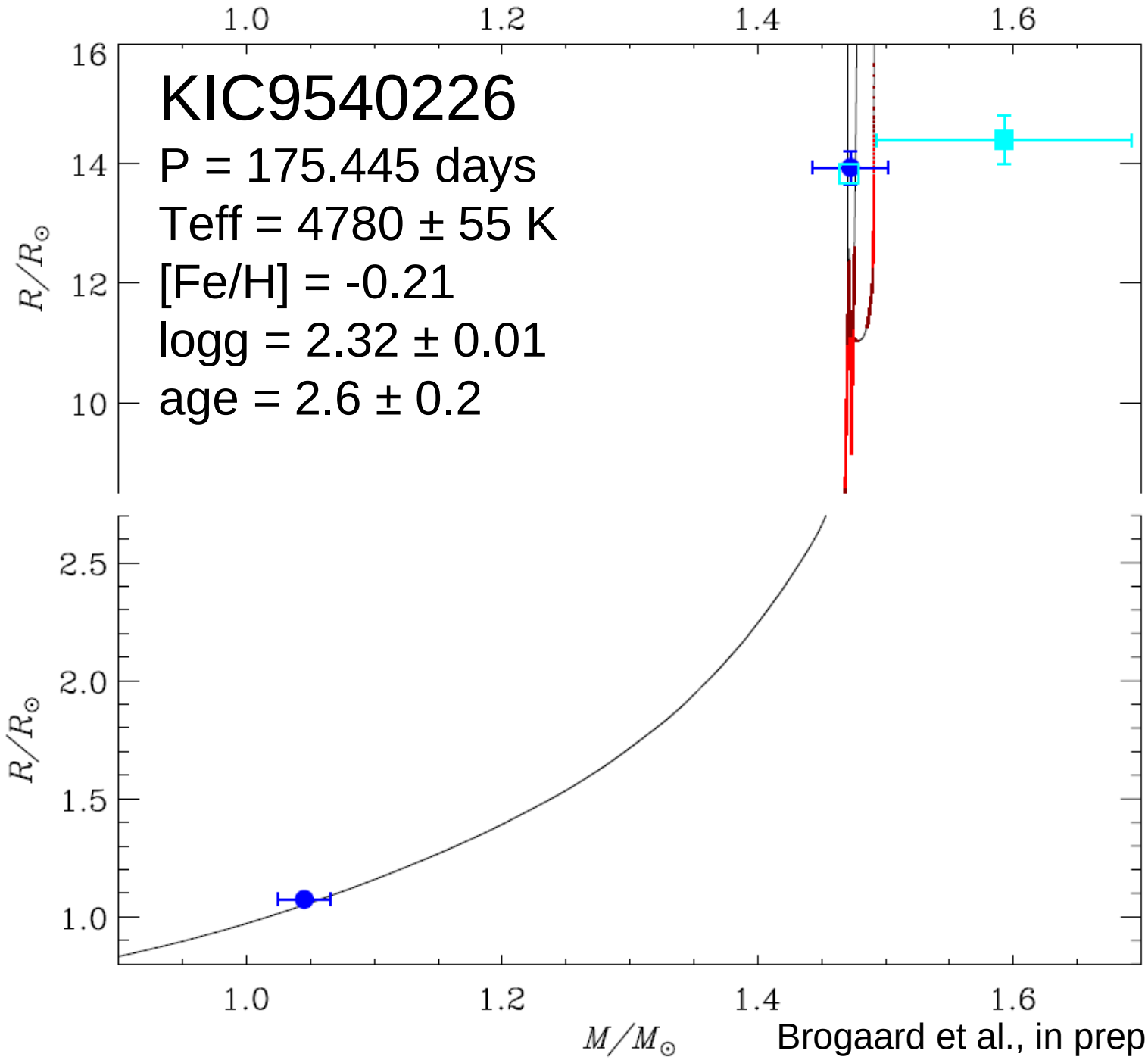
P = 175.445 days

Teff = 4780 ± 55 K

[Fe/H] = -0.21

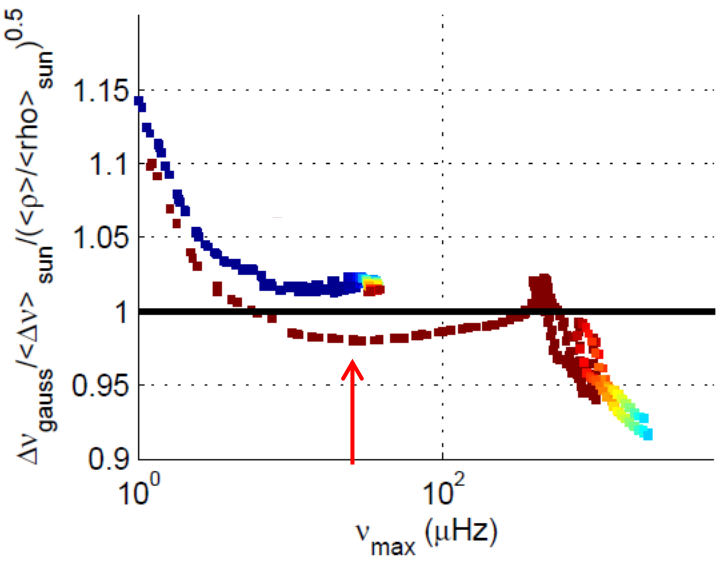
logg = 2.32 ± 0.01

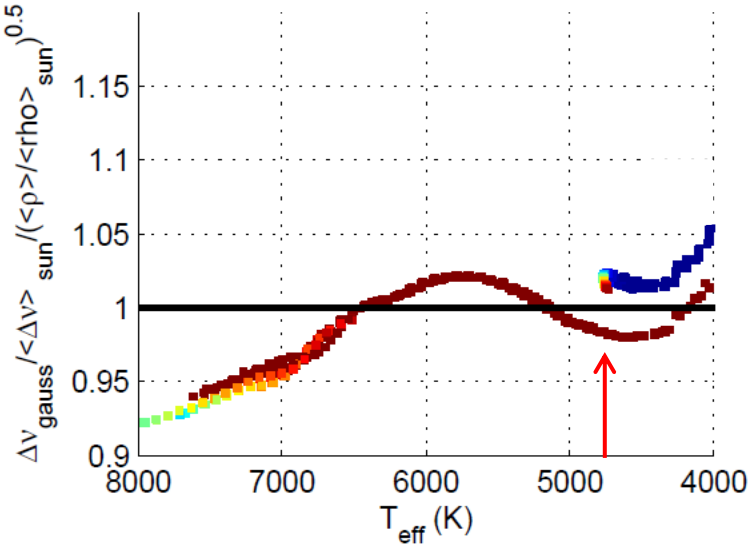
age = 2.6 ± 0.2



Brogaard et al., in prep.

KIC9540226





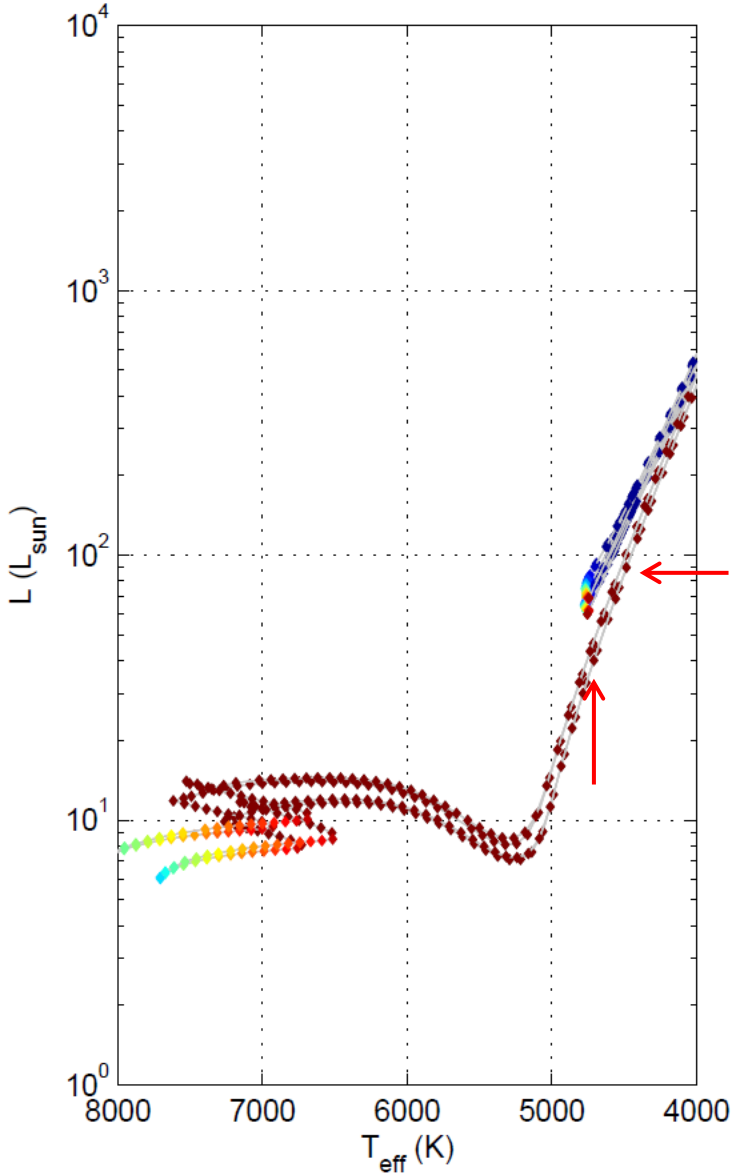
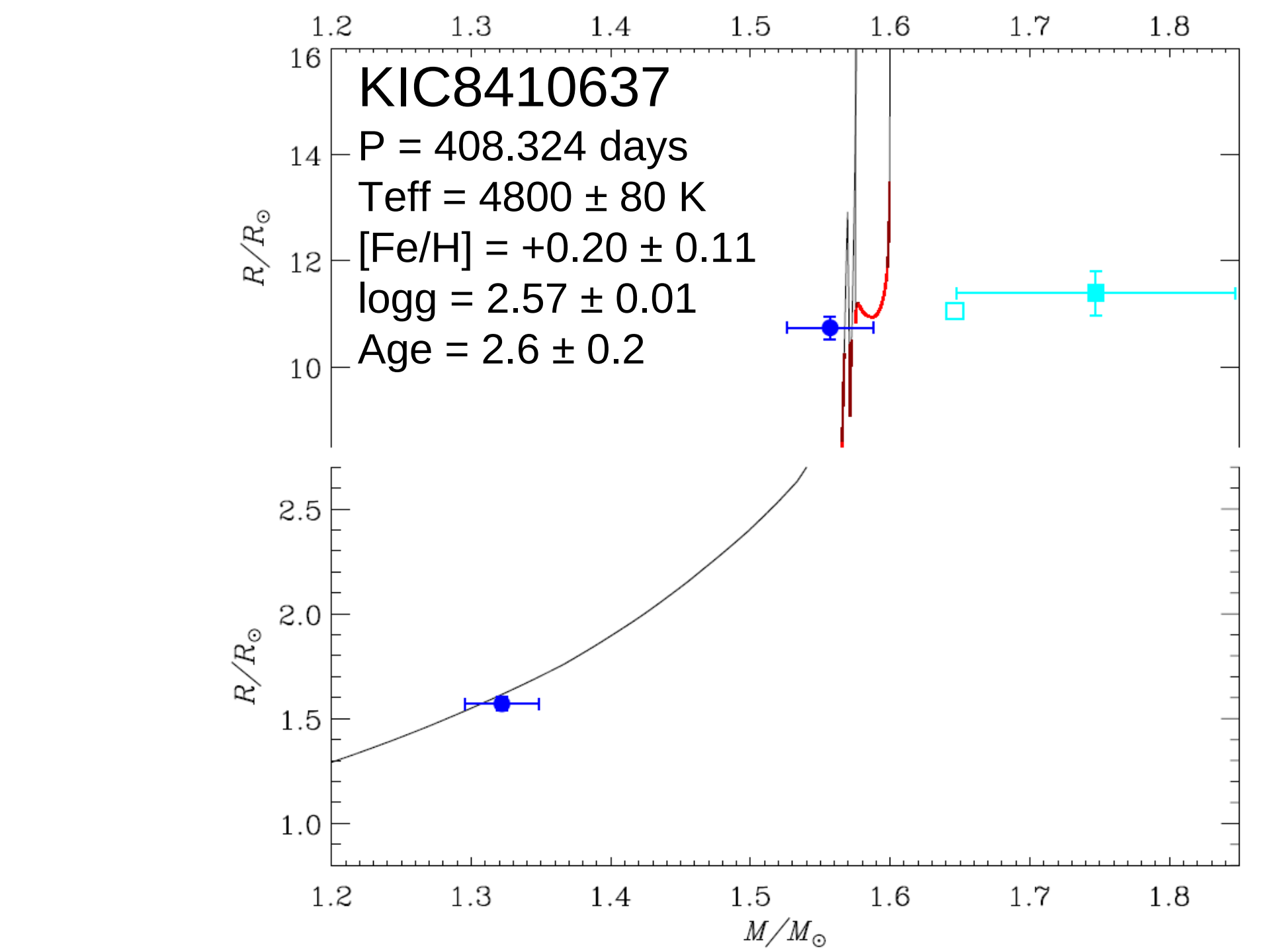


Figure by A. Miglio & D. Bossini


KIC8410637
P = 408.324 days
Teff = 4800 ± 80 K
[Fe/H] = +0.20 ± 0.11
logg = 2.57 ± 0.01
Age = 2.6 ± 0.2
$R/R_\odot$
$M/M_\odot$

Conclusions

- The ‘raw’ scaling relations are not accurate, but the ‘correction’ form is still uncertain – work in progress

- logg seems accurate to ~0.01 dex,
  mass almost to 1-sigma,
  Teff remains an issue to be aware of!

- Asteroseismology is excellent for identifying cluster stars with non-standard evolution – in the field such stars would mimic stars of different ages!