Estimating the mass of solar type stars

Fernando J.G. Pinheiro
Centro de Geofísica da Universidade de Coimbra, Observatório Astronómico da U.C

XXIII ENAA, 18-19 July 2013, FCUL (Portugal)

Estimating the mass of solar type stars

In collaboration with:

J. M. Fernandes[123], M. Cunha[4], M. J. Monteiro[4], N. Santos[4], S. Sousa[4], J.P. Marques[5], J. Fang[6] and J. Sousa

[1]Centro de Geofísica da Universidade de Coimbra, [2]Observatório Astronómico da U.C., [3]Departamento de Matemática da F.C.T.U.C., [4]Centro de Astrofisica da Universidade do Porto, [5]University of Göttingen [6]Universidade de Coimbra

Additional thanks:

O. Creevey (Institut d'Astrophysique Spatiale), A. Mortier[4]

Support:

/PTDC/CTE-AST/66181/2006
/SFRH/BPD/37491/2007

Mass inference methods[1]

1) Surface gravity:

$$\log(g) = 4.4377506 + \log\left((M/M_o)/(R/R_o)^2 \right)$$

$$R/R_o = F(L, T_{eff})$$

2) Torres et al. (2010, A&A Rev.,18, 67)

$$\log(M/M_o) = 1.5689 + 1.3787X + 0.4243X^2 + 1.139X^3 - 0.1425(\log g)^2 + 0.01969(\log g)^3 + 0.1010[Fe/X]$$

$$X = \log(Teff) - 4.1$$

3) Henry & McCarthy (1993, AJ, 106, 77)

$$\log(M/M_o) = 0.002456\ Mv - 0.09711\ Mv + 0.4365$$

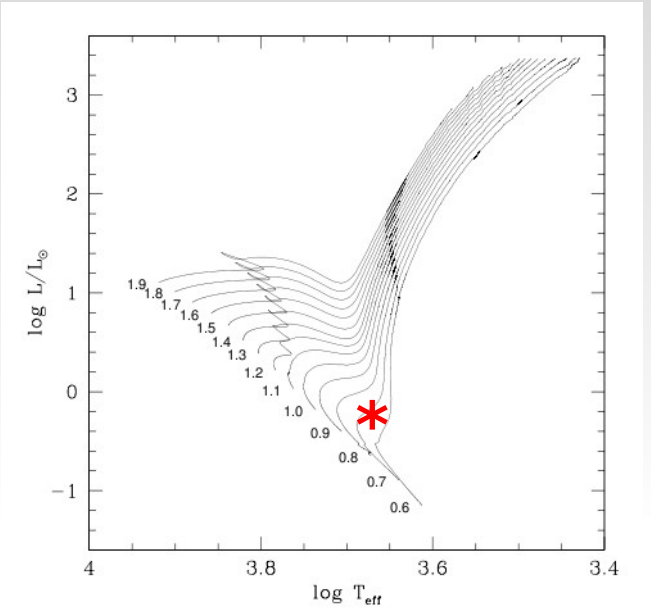
$Mv = F(L, T_{eff})$ from Torres(2010, AJ, 140, 1158)

Mass inference methods²

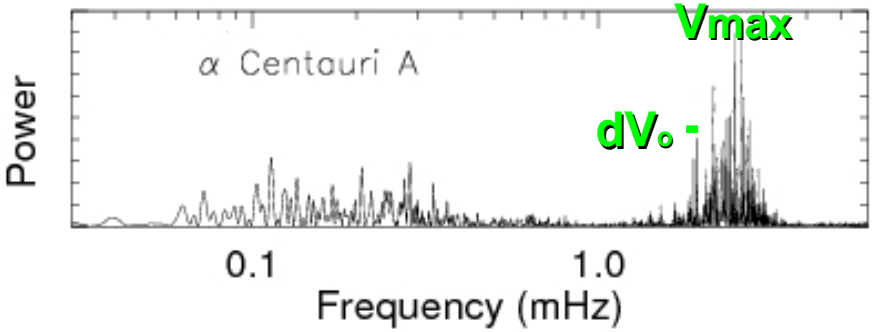
4) Padova Models

(Girardi et al., 2000, A&AS, 141, 371)

$$min \sum_{X = T_{eff}, L/L_o, \log(g), [Fe/X]} \frac{X_{star} - X_{model}}{errX_{star}}$$



Asteroseismology:

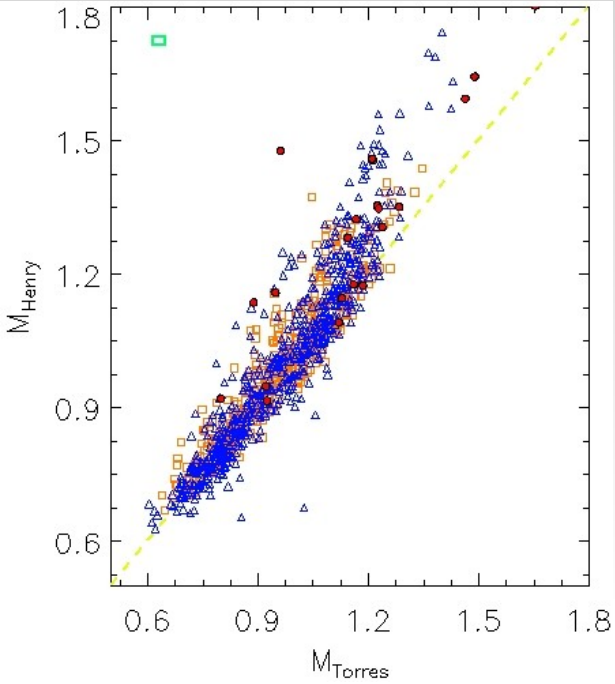


$$dVo = \sqrt{(M/Mo)/(R/Ro)^3} \times 0.1349\text{mHz}$$

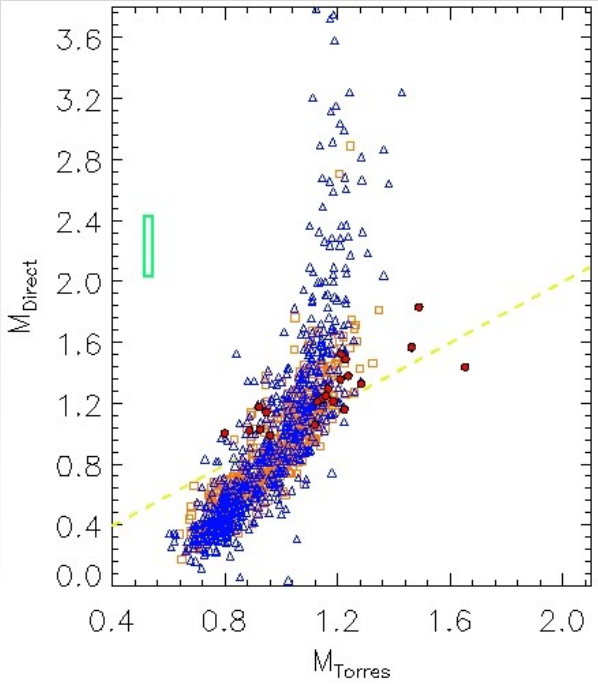
$$Vmax = \frac{M/Mo}{(R/Ro)^2 \sqrt{Teff/5777}} \times 3.05\text{mHz}$$

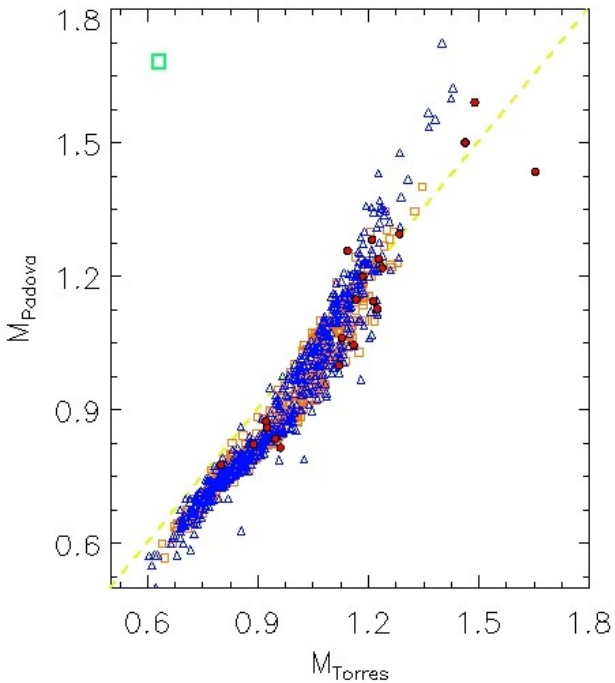
(Kjeldsen & Bedding,1995, A&A, 293, 87)

Comparison between estimates

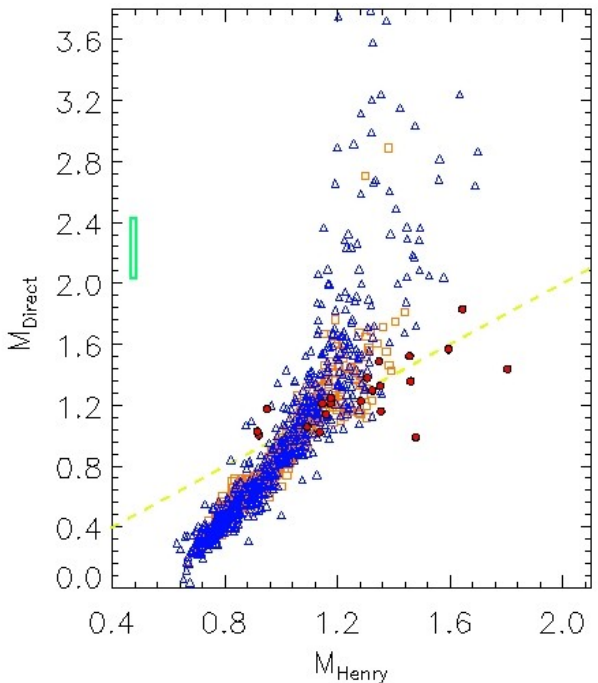


$M_H = 1.17\ M_T - 0.13$ $M_{Sp} = 3.24\ M_T - 2.12$





$M_P = 1.17\ M_T - 0.21$ $M_{Sp} = 2.81\ M_H - 1.82$



Sousa et al. 2008
541*s; spectroscopic log(g)
Sousa et al. 2011
582*s; spectroscopic log(g)
Bruntt et al. 2010
22 *s; asteroseismic log(g)

(known: L, Teff, log(g), [Fe/X], π)

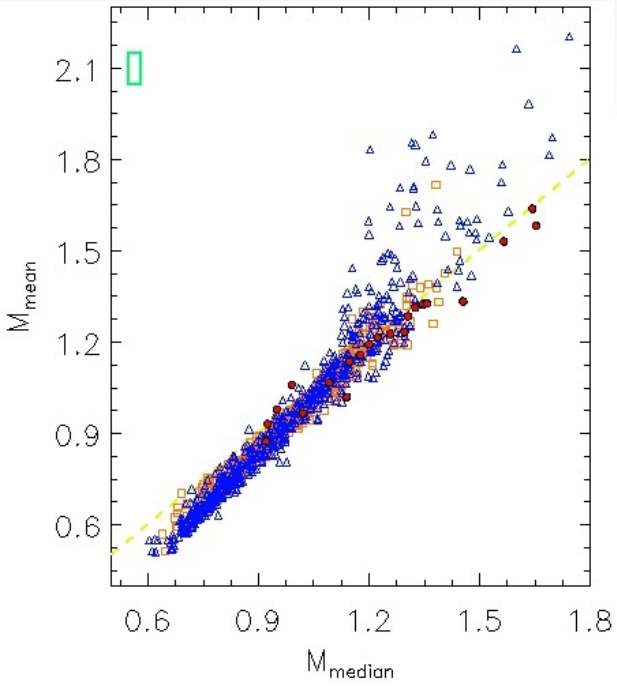
Combining mass estimates

$$\frac{\sum_{i=1,4} M_i w_i}{\sum_{i=1,4} w_i}$$

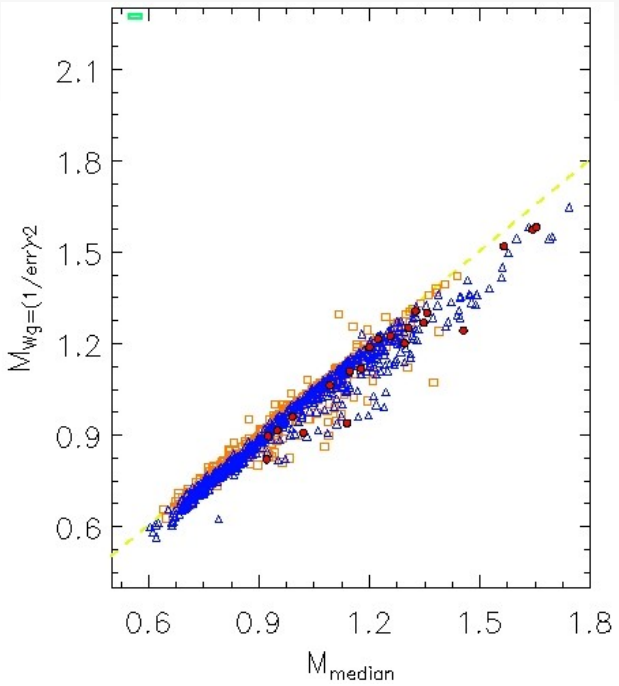
W_i:	
1	mean
$1/(err)^2$	weighted mean
$Q_i/(err)^2$	, Q_i = quality factor
...	

Mu < Mv < Mw < Mx

Median

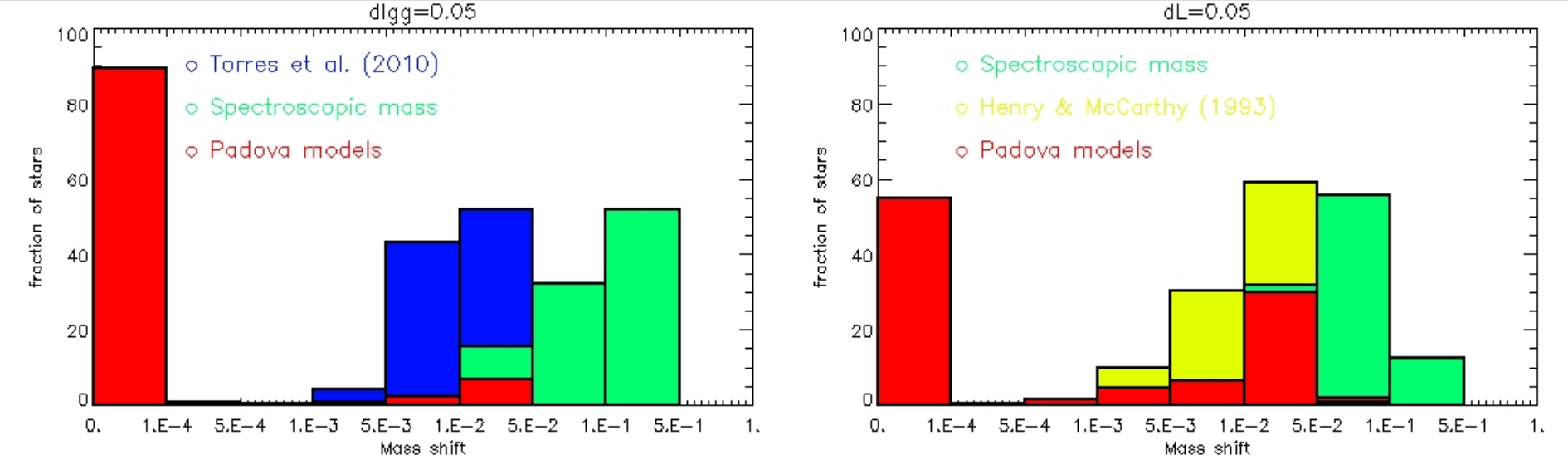


Mean: more sensitive to outliers (duh!)



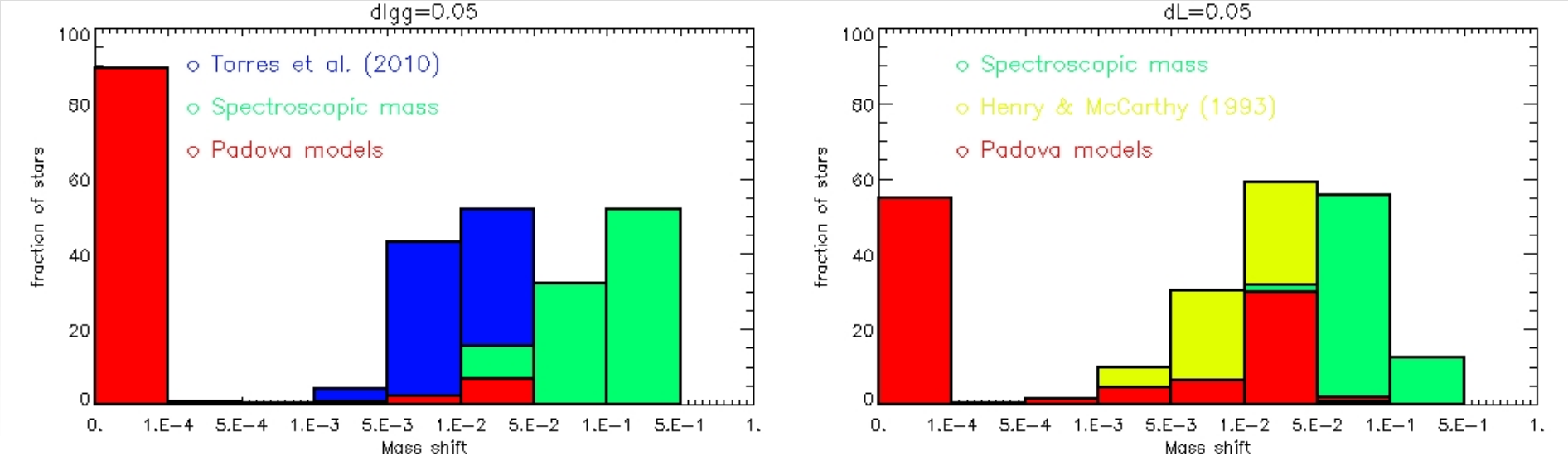
Good agreement between median and weighted mean

Understanding the differences[1]

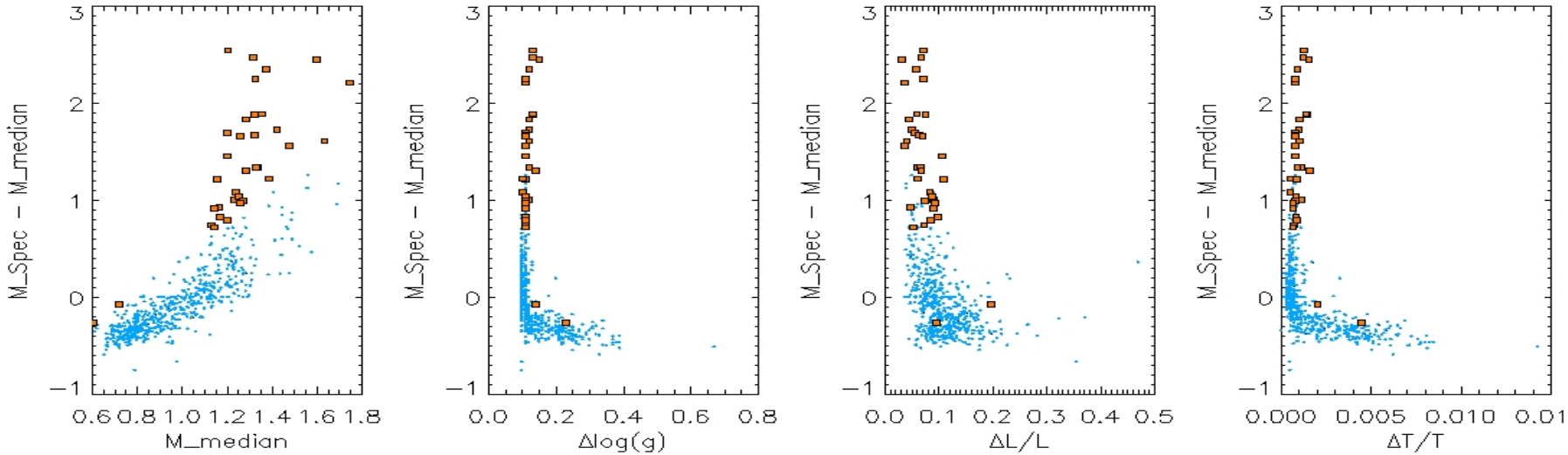


”Direct” method seems more sensitive to errors in L & log(g)

Understanding the differences[1]

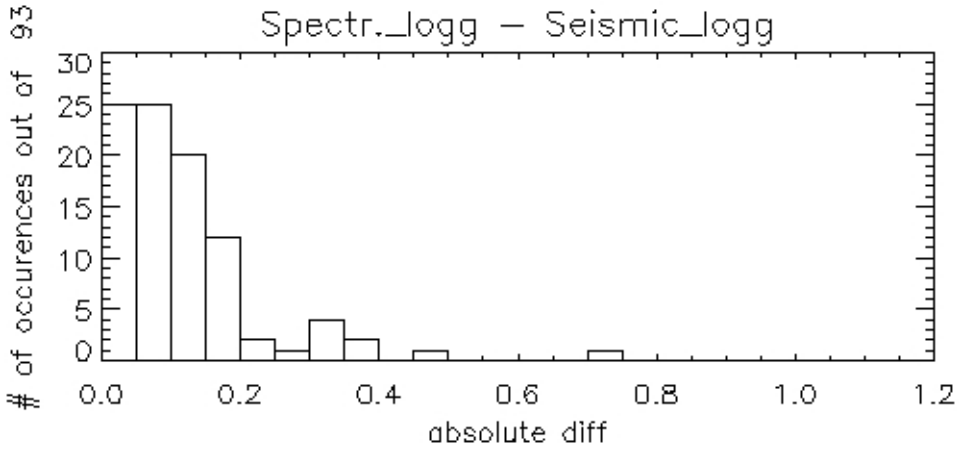


"Direct" method seems more sensitive to errors in L & log(g)



Found no errors in input parameters that justify such differences

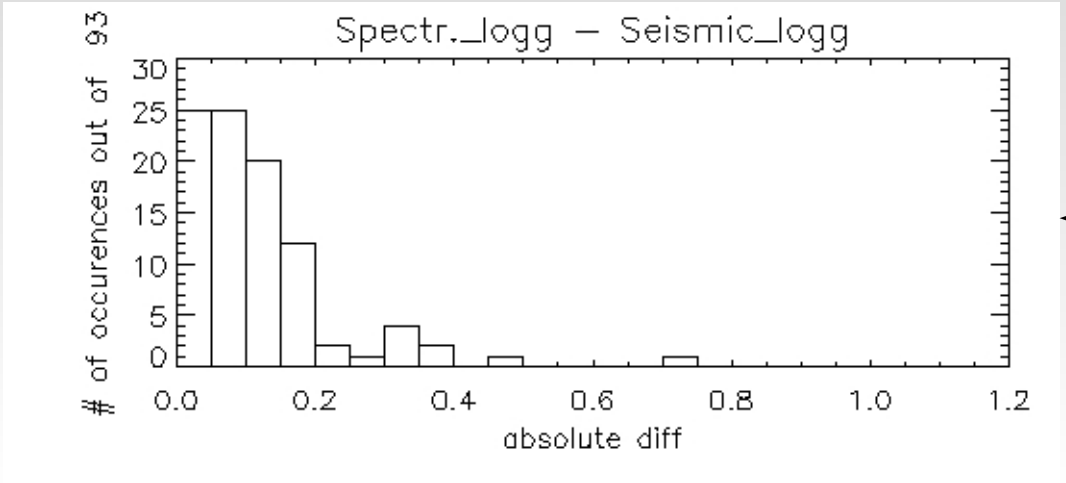
Understanding the differences²



Bruntt et al., 2012, MNRAS, 423, 122
(KEPLER's data)

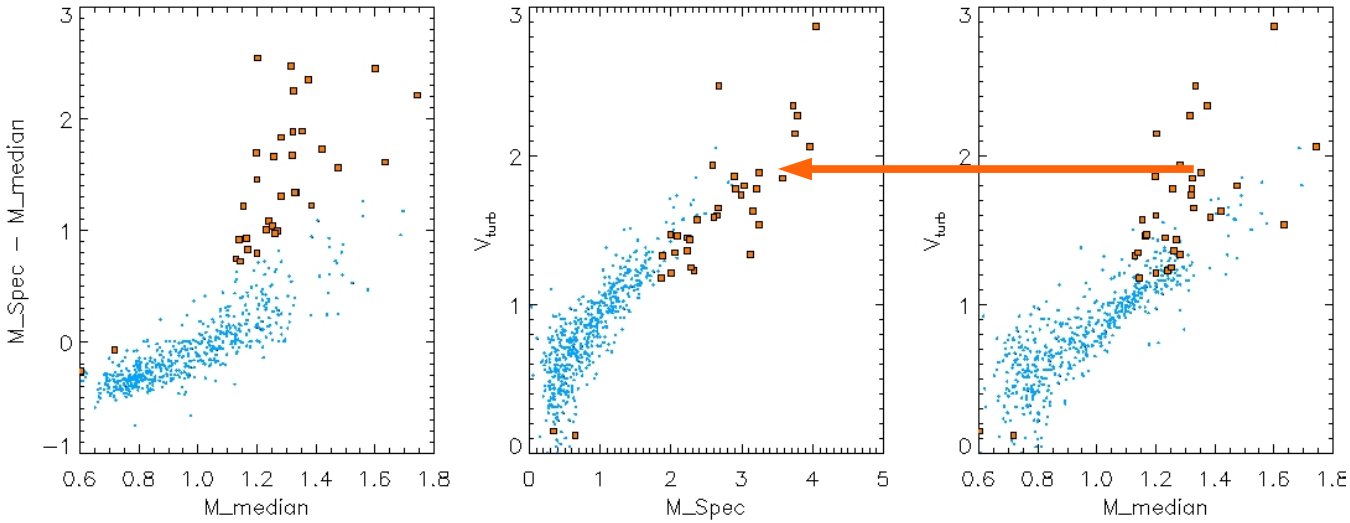
Is there a problem with spectroscopic log(g)?

Understanding the differences[2]



Bruntt et al., 2012, MNRAS, 423, 122
(KEPLER's data)

Is there a problem with spectroscopic log(g)?



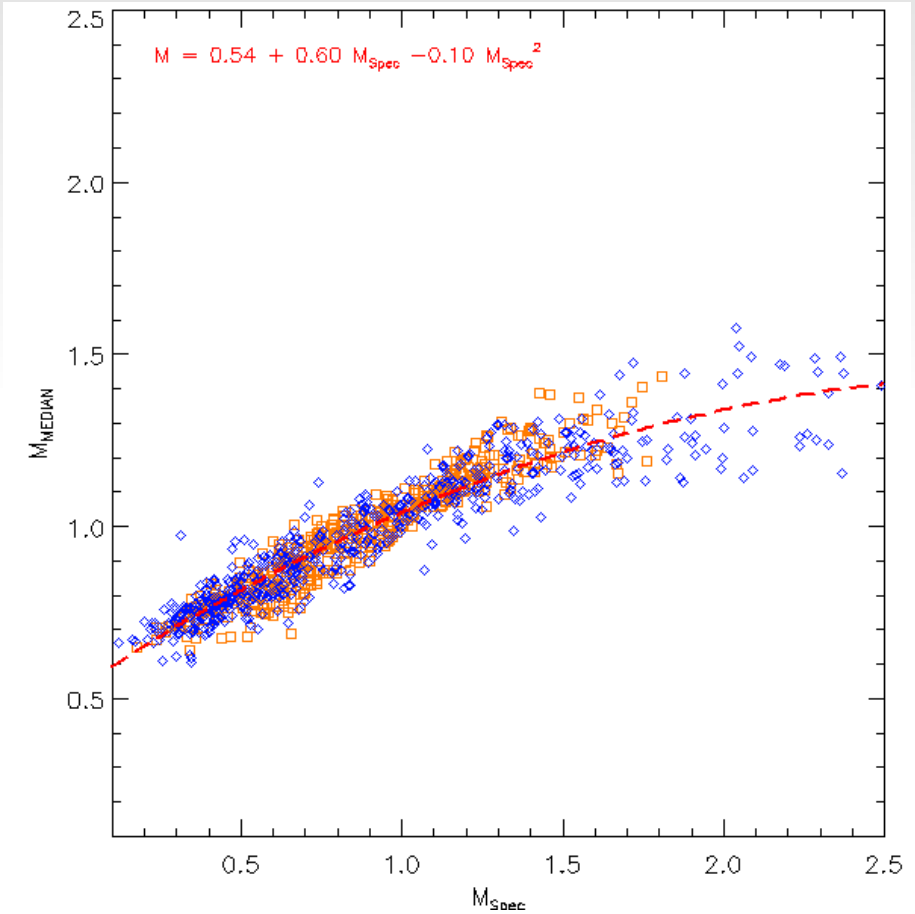
Problem wth V_{turb}?

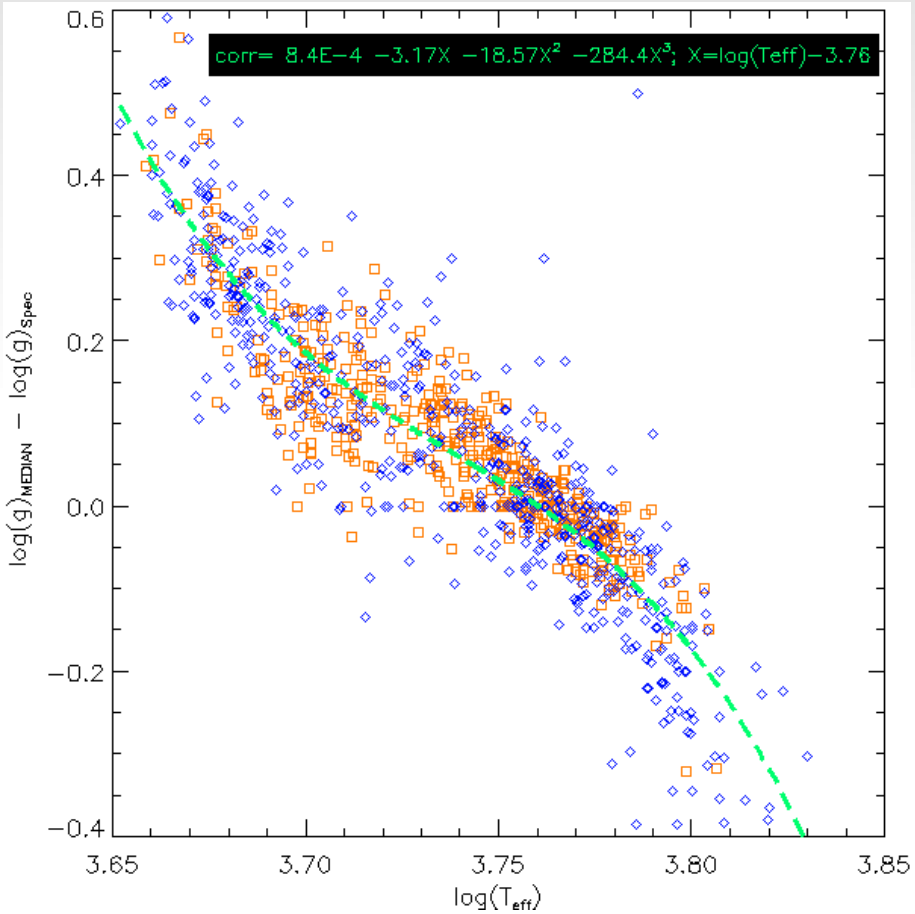
Beware:

V_{turb}-T_{eff} correl.

M-L-T_{eff} correl. @MS

Empirically ”adjusting” the spectroscopic predictions





Conclusions

- Good agreement between Torres, Henry & Padua's predictions
- A bit less for the spectroscopic masses.
- Median & weighted mean good ways of combining masses

- Observed sistematic difference (non-random) between the spectroscopic predictions and those of the remaining methods

- Physical reason for this difference?
  (perhaps V_{turb} or 3D vs 1D atmosferic models?)
- That difference can be empiricaly corrected

Thank you!