Deriving accurate surface gravity values for planet host stars

Annelies Mortier

Nuno C. Santos, S.G. Sousa, V.Zh. Adibekyan, I.M. Brandão

Towards Other Earths II

The Star-Planet Connection

17 September 2014, Porto

Centro de Astrofísica da Universidade do Porto

SEVENTH FRAMEWORK PROGRAMME

erc

University of St Andrews

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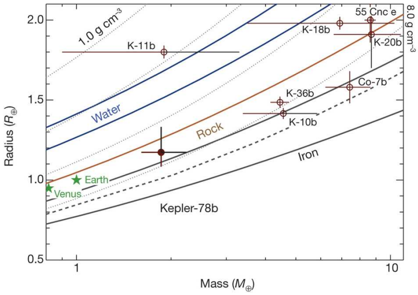
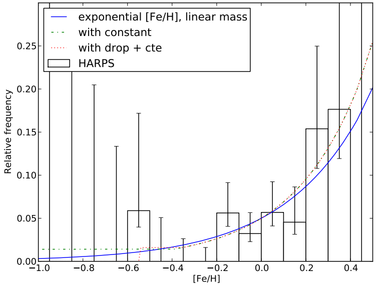
Outline

Introduction

Precise, homogeneous, and accurate stellar parameters crucial in astronomy



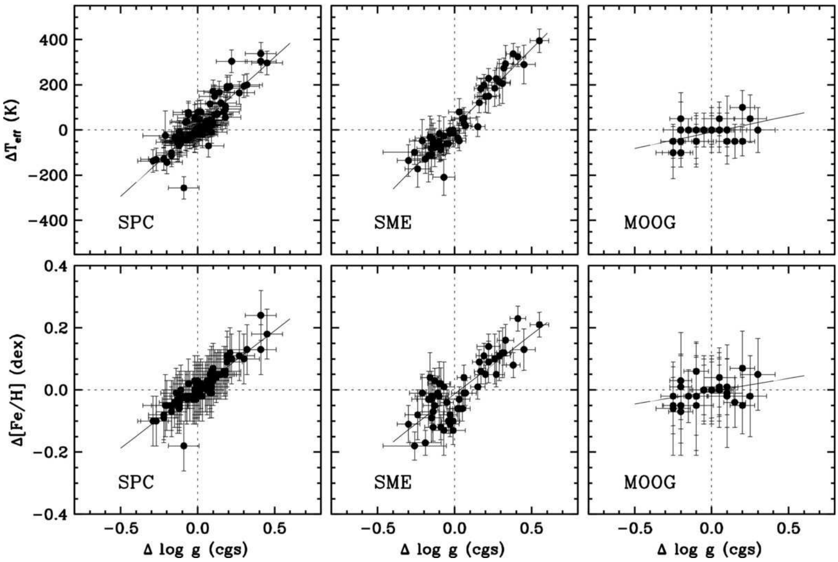
(Pepe et al. 2013)



(Mortier et al. 2013)

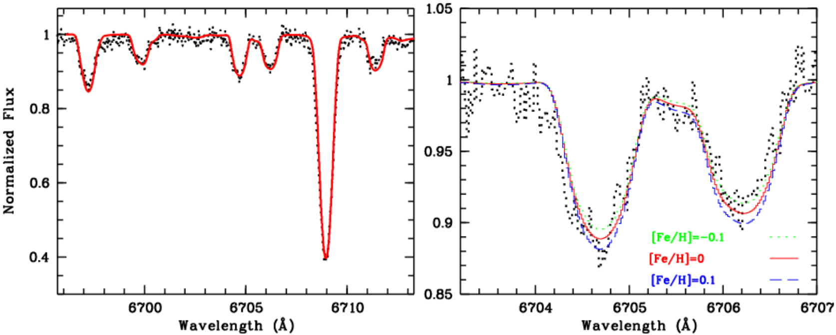
Stellar and planetary characterization – Star-planet connection – Galactic evolution – ...

Introduction



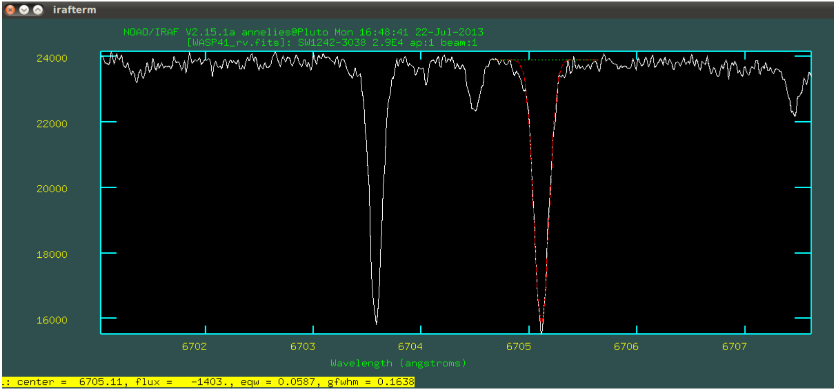
(Torres et al. 2012)

Spectroscopic analysis: high-resolution spectroscopy



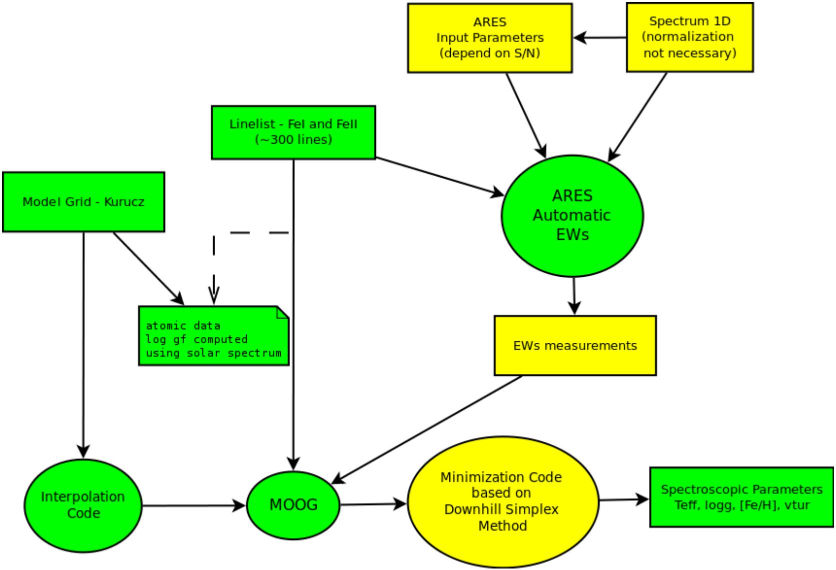
Spectral synthesis

Spectroscopic analysis: high-resolution spectroscopy

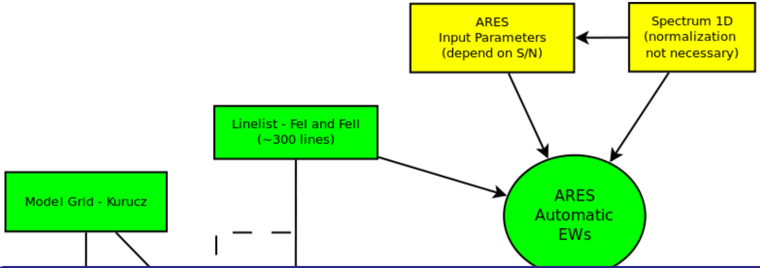


Individual spectral line analysis

FGK stars - Method overview



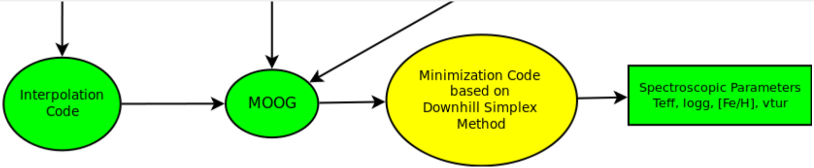
FGK stars - Method overview



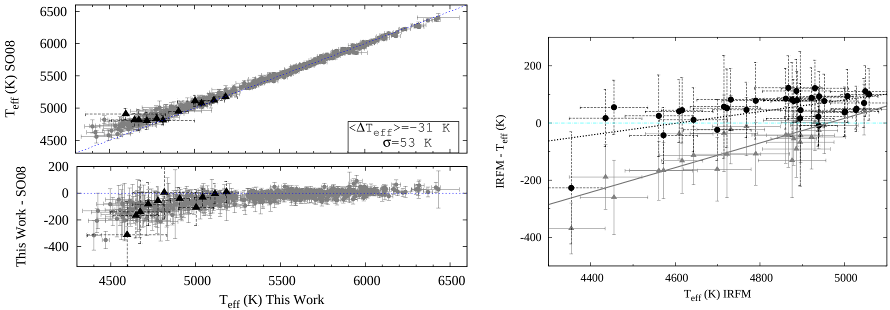
Masses and radii

Dwarfs: corrected Torres et al. (2010) calibration

(Sub)giants: Padova stellar evolutionary models



Carefully chosen stable line list set



(Tsantaki et al. 2013)

- Sousa et al. (2008) for stars with $T_{eff} > 5200\,K$
- Tsantaki et al. (2013) for stars with $T_{eff} \leq 5200\,K$

SWEET-Cat: a catalog of stellar parameters for stars with planets

Centro de Astrofísica
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Download Data

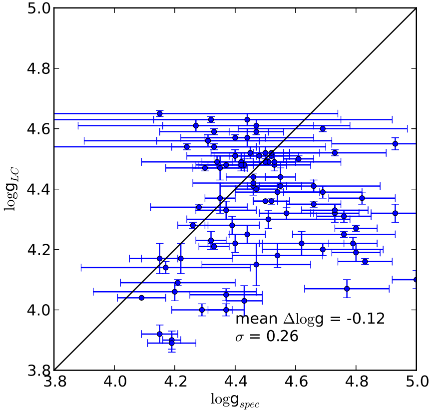
Name	HD number	RA	Dec	Vmag	σ(Vmag)	π	σ(π)	Source of π	Teff	σ(Teff)	logg	σ(logg)	LC logg	σ(LC logg)	Vt	σ(Vt)	[Fe/H]	σ([Fe/H])	Mass	σ(
11 Com	107383	12 20 43.02	+17 47 34.33	4.74	0.02	11.25	0.22	Simbad	4830	79	2.61	0.13	-	-	1.70	0.10	-0.34	0.06	2.00	0.2
11 UMi	136726	15 17 05.88	+71 49 26.04	5.02	-	8.19	0.19	Simbad	4340	70	1.60	0.15	-	-	1.60	0.80	0.04	0.04	1.80	0.2
14 And	221345	23 31 17.41	+39 14 10.30	5.22	-	12.63	0.27	Simbad	4773	100	2.53	0.10	-	-	1.64	0.30	-0.26	0.11	1.45	-
14 Her	145675	16 10 24.31	+43 49 03.52	6.67	-	56.91	0.34	Simbad	5311	87	4.42	0.18	-	-	0.92	0.10	0.43	0.08	0.95	0.0
16 Cyg B	186427	19 41 51.97	+50 31 03.08	6.20	-	47.14	0.27	Simbad	5772	25	4.40	0.07	-	-	1.07	0.04	0.08	0.04	1.00	0.0
18 Del	199665	20 58 25.93	+10 50 21.42	5.52	-	13.28	0.31	Simbad	5076	38	3.08	0.10	-	-	1.32	0.04	0.00	0.03	2.33	0.0
24 Sex	90043	10 23 28.37	-00 54 08.09	6.44	0.01	12.91	0.38	Simbad	5069	62	3.40	0.13	-	-	1.27	0.07	-0.01	0.05	1.81	0.0
30 Ari B	16232	02 36 57.74	+24 38 53.02	7.09	-	24.52	0.68	Simbad	6377	170	4.49	0.05	-	-	-	-	0.14	0.18	1.16	0.0
4 Uma	73108	08 40 12.81	+64 19 40.57	4.60	-	12.74	0.26	Simbad	4564	100	2.28	0.10	-	-	1.69	0.30	-0.16	0.13	1.48	-
42 Dra	170693	18 25 59.13	+65 33 48.52	4.83	-	10.36	0.20	Simbad	4513	100	2.24	0.10	-	-	1.59	0.30	-0.39	0.12	1.74	-
47 Uma	95128	10 59 27.97	+40 25 48.92	5.04	0.05	71.11	0.25	Simbad	5954	25	4.44	0.10	-	-	1.30	0.04	0.06	0.03	1.04	0.0
51 Peg	217014	22 57 27.98	+20 46 07.79	5.46	0.05	64.07	0.38	Simbad	5804	36	4.42	0.07	-	-	1.20	0.05	0.20	0.05	1.04	0.0
55 Cnc	75732	08 52 35.81	+28 19 50.95	5.95	0.05	81.03	0.75	Simbad	5279	62	4.37	0.18	-	-	0.98	0.07	0.33	0.07	0.93	0.0
6 Lyn	45410	06 30 47.10	+58 09 45.48	5.88	-	17.92	0.47	Simbad	4978	18	3.16	0.05	-	-	1.10	0.07	-0.13	0.02	1.70	0.2

(Santos et al. 2013)

Catalogue of homogeneously derived parameters for planet hosts

Surface gravity from photometric transit

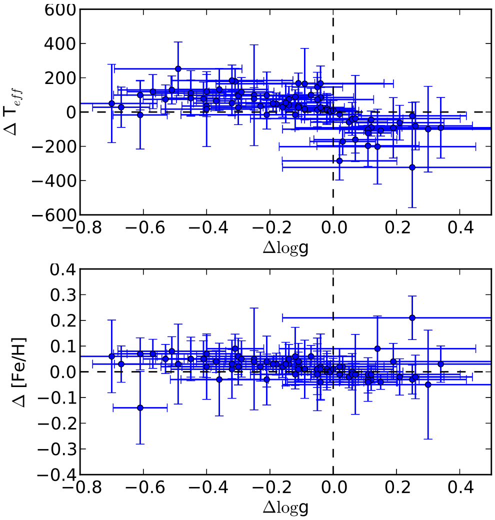
90 transit hosts analysed



$$\rho_* + k^3 \rho_p = \frac{3\pi}{GP^2} \left(\frac{a}{R_*} \right)^3$$

Spectroscopic surface gravity not well constrained. Transit light curve surface gravity more precise and accurate

Marginal effect on temperature and metallicity



Mean differences

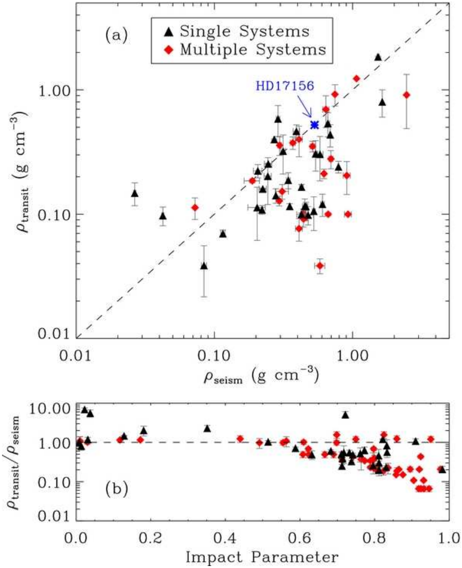
19 K and 0.02 dex

Mean absolute deviation

66.5 K and 0.03 dex

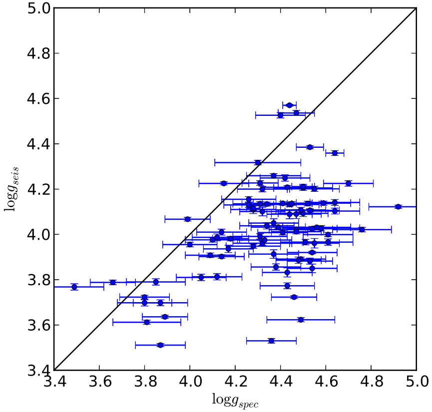
Systematic, but small trends, even for very large logg differences

Transit logg may also be inaccurate (Huber et al. 2013)



Surface gravity from asteroseismology

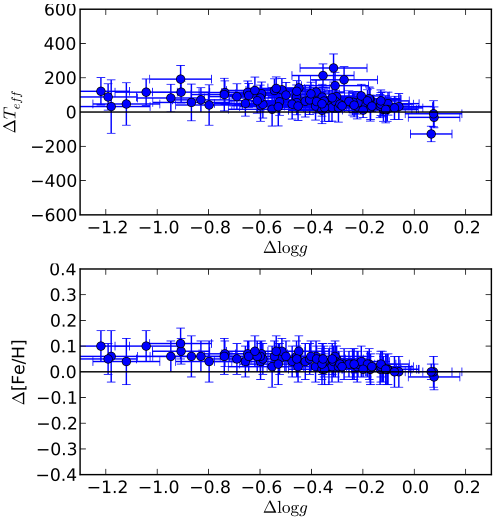
86 FGK stars analysed



Use large separation $\Delta\nu$, maximum frequency ν_{max}, effective temperature T_{eff}, metallicity [Fe/H], and PARSEC isochrones

Asteroseismic surface gravity more precise and accurate

Marginal effect on temperature and metallicity



Mean differences

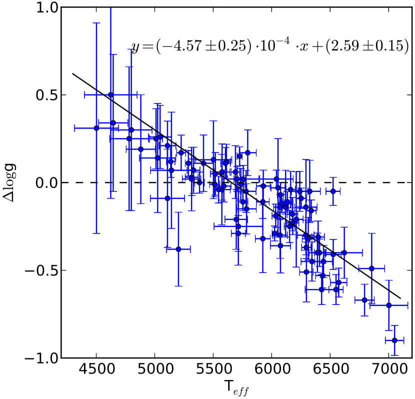
68 K and 0.04 dex

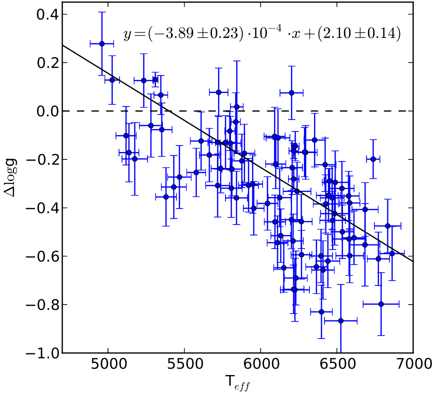
Mean absolute deviation

28.5 K and 0.02 dex

Same systematic, but small trends as with the transit sample

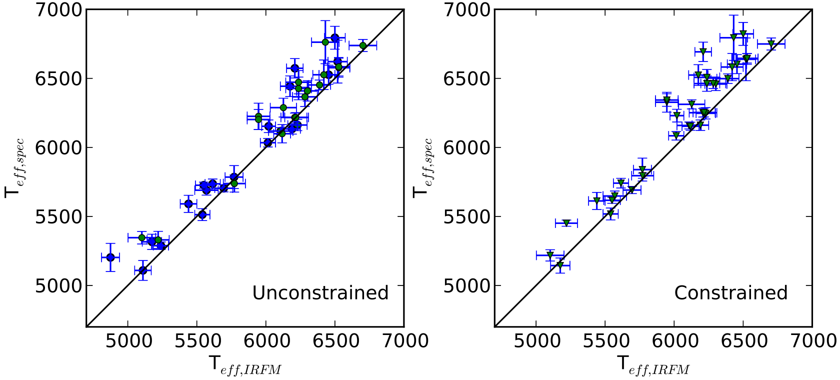
Linear correction formula





Correcting for the spectroscopic logg will not make it more precise, but it will make it more accurate!

Comparison with accurate IRFM



Our unconstrained spectroscopic results can be trusted!

Conclusions

- Precise, homogeneous, and accurate stellar parameters are crucial
- Our long-standing spectroscopic method to analyse **FGK stars** provides precise, accurate, and homogeneous results
- Surface gravity is not well constrained by spectroscopy but by using the **ARES+MOOG method** combined with **SO08+TS13 line list set**, there is only a **marginal effect** on the other atmospheric parameters
- Planetary mass and radius differ only by $\mathbf{1.3-2\%}$ and $\mathbf{1-1.5\%}$
- **Temperatures, metallicities, and microturbulences** developed by our method+linelist have been proven to be **consistent** with various methods
- Our spectroscopic surface gravity can be **easily corrected with a linear formula**

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Thank you!