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
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Outline

1 Introduction

2 Deriving stellar parameters
   - Method
   - Line list

3 Surface gravity determination
   - Transits
   - Asteroseismology
   - Correction formulae
   - Compare with IRFM

4 Conclusions
Precise, homogeneous, and accurate stellar parameters crucial in astronomy

Introduction

(Torres et al. 2012)

Annelies Mortier (St Andrews)

Accurate loggs for FGK dwarfs
Spectral synthesis
Individual spectral line analysis
FGK stars - Method overview

- **FGK stars - Method overview**
  - Accurate loggs for FGK dwarfs
  - Annelies Mortier (St Andrews)

Diagram:
- **FGK stars**
  - Model Grid - Kurucz
  - Linelist - Fel and Fell (~300 lines)
  - ARES Input Parameters (depend on S/N)
  - Spectrum 1D (normalization not necessary)
  - ARES Automatic EWs
  - EWs measurements
  - MOOG
  - Minimization Code based on Downhill Simplex Method
  - Spectroscopic Parameters: Teff, logg, [Fe/H], vtur
  - Interpolation Code
  - Atomic data
    - log gf computed using solar spectrum
**FGK stars - Method overview**

**Masses and radii**

- **Dwarfs**: corrected Torres et al. (2010) calibration
- **(Sub)giants**: Padova stellar evolutionary models

**Stages of the method**:

1. **Model Grid - Kurucz**
2. **Linelist - FeI and FeII (∼300 lines)**
3. **ARES**
   - Input Parameters (depend on S/N)
4. **Spectrum 1D**
   - (normalization not necessary)
5. **ARES Automatic EWs**
6. **Minimization Code based on Downhill Simplex Method**
7. **Spectroscopic Parameters**
   - Teff, logg, [Fe/H], vtur

**Interpolation Code**

**MOOG**

**Accurate loggs for FGK dwarfs**
Carefully chosen stable line list set

[Temperature plots with data points and error bars.]

\[ \langle \Delta T_{\text{eff}} \rangle = -31 \text{ K} \]
\[ \sigma = 53 \text{ K} \]

Sousa et al. (2008) for stars with \( T_{\text{eff}} > 5200 \text{ K} \)

Tsantaki et al. (2013) for stars with \( T_{\text{eff}} \leq 5200 \text{ K} \)
### SWEET-Cat: a catalog of stellar parameters for stars with planets

(Santos et al. 2013)

**Catalogue of homogeneously derived parameters for planet hosts**

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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 $\nu_{\text{max}}$, effective temperature $T_{\text{eff}}$, metallicity $[\text{Fe/H}]$, 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

\[ y = (-4.57 \pm 0.25) \cdot 10^{-4} \cdot x + (2.59 \pm 0.15) \]

\[ y = (-3.89 \pm 0.23) \cdot 10^{-4} \cdot x + (2.10 \pm 0.14) \]

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 $1.3 - 2\%$ and $1 - 1.5\%$.
- **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**.
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 $1.3 - 2\%$ and $1 - 1.5\%$.

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Thank you!