A new tool to determine parameters of FGK dwarfs and giants

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Introduction

The derivation of accurate and precise stellar parameters is becoming an ever increasing fundamental aspect of astrophysical studies. Fundamental parameters such as stellar mass, radius and age are of absolute importance but, very difficult or impossible to measure by direct methods. As these fundamental parameters depend on the stellar atmospheric parameters, in particular on the values of effective temperature, T_{eff}, surface gravity, log*g*, and metallicity, [Fe/H], which can be obtained mainly by spectroscopic or photometric methods.

TMCalc is a code capable of computing the T_{eff} and [Fe/H] of solar type stars (Sousa et al. 2012), requiring only the equivalent widths, EW, of the spectra, a file with the T_{eff} calibration and another with the [Fe/H] calibration.
The new calibration will be presented in an upcoming paper (Teixeira et al. 2014).

Sample

Calibration sample: We used a joint sample made of two distinct stellar samples: the well-studied 451 FGK-dwarf sample of Sousa et al. (2008), with the updated parameters from Tsantaki et al. (2013), and a sample of 256 giant stars of Alves et al. (2014).

Independent sample: We used two different samples to test the new calibration: the sample of 56 GK-giant stars from Santos et al. (2009) and the **34 GAIA-ESO FGK** benchmark stars from Jofré et al. (2014) which contains a wide range of spectral types.

GeTCal

GeTCal, is a code capable of producing Teff and [Fe/H] calibrations based on any calibration sample in a timely fashion. The code and calibrations are available at http://astro.up.pt/~gteixeira/GeTCal/

Method

The EWs and parameters of the stars in the calibration sample, computed using, respectively **ARES** (Sousa et al. 2007) and the **ARES+MOOG** methods (Sousa 2014), and a line-list with 498 individual element lines (Sousa et al. 2010).

T_{eff} Calibration:
- Based on the relations between line-ratios r.
- Excitation potential > 3 eV.
- Lines used for the ratios at distance < 70 Å in wavelength.
- Discarded r>100 and r<0.01.
- Applied interquartile range method, IQR, for initial outlier removal.
- Fitted two functions to the distribution of r vs T_{eff}, 1/r vs T_{eff} and log(r) vs T_{eff}, a linear and a 3rd-degree polynomial function.
- Used 2-σ cut to remove outliers and re-fitted.
- Selected the fit based on lowest standard deviation, and kept the coefficients of the function for the calibration.

[Fe/H] Calibration:
- Selected only weak FeI lines.
- Discarded lines with EW>70mÅ and EW<20mÅ. } Reduces the dependence on V_{mic} and log*g*
- Solved the following equation:

$$EW=C_0 + C_1*[Fe/H]+C_2*T_{eff}+C_3*[Fe/H]^2+C_4*T_{eff}^2+C_5*[Fe/H]*T_{eff}$$

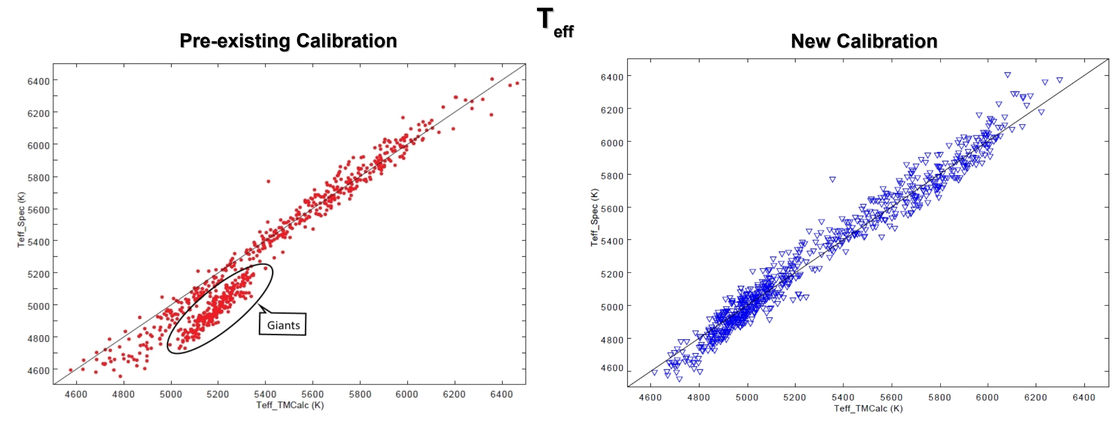
- Made a linear fit of the difference between computed and spectroscopic values
- Used 2-σ cut to remove outliers and re-fitted.
- Only selected lines with a slope of the fit within 3% of identity line.
- Only standard deviations inferior to 0.06 considered.
- Obtained coefficients of the function for the calibration.

TMCalc uses the new calibrations to get T_{eff} and [Fe/H].

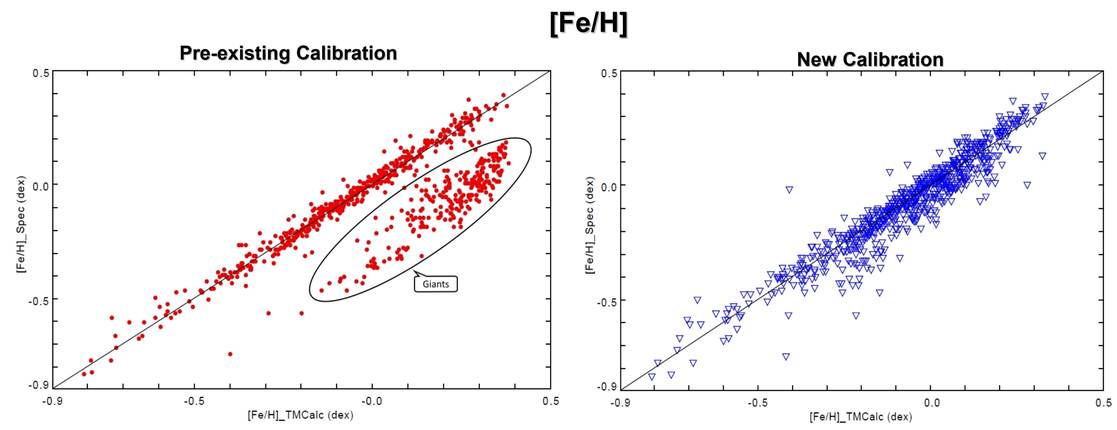
Applicability limits of the new calibration

T_{eff}(K)	log g (dex)	[Fe/H] (dex)
[4500, 6000]	[2.0, 4.9]	[-0.8, 0.5]

New calibration vs pre-existing calibration



Figs. 1-2: Comparison between the T_{eff} obtained by **TMCalc**(horizontal axis), and the T_{eff} from **ARES+MOOG** method. The black line is the identity line. The red circles are the values obtained using the pre-existing calibration, the open blue triangles are the values from the new calibration.



Figs. 3-4: Comparison between the [Fe/H] obtained by **TMCalc**(horizontal axis), and the [Fe/H] from **ARES+MOOG** method. The black line is the identity line. The red circles are the values obtained using the pre-existing calibration, the open blue triangles are the values from the new calibration.

Application to Independent samples

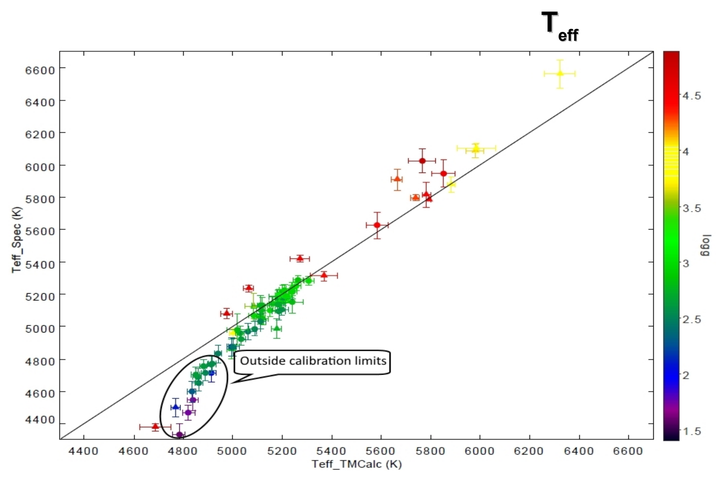


Fig. 3 – Comparison of theT_{eff} obtained by the new calibration, horizontal axis, and the values from the **ARES+MOOG** method, vertical axis. The black line is the identity line, the circles are 56 giants, and the triangles are the benchmark stars. Color coded are the log*g* values.
Extreme outliers are outside our applicability limits.

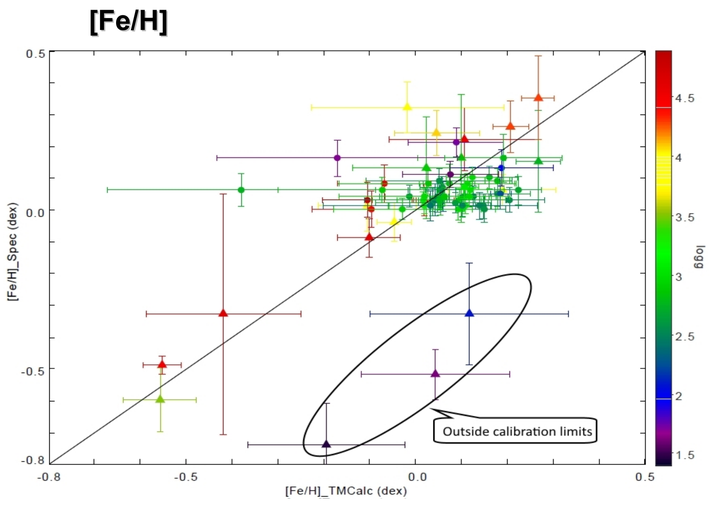


Fig. 4 – Comparison of the [Fe/H] obtained by the new calibration, horizontal axis, and the values from the **ARES+MOOG** method, vertical axis. The black line is the identity line, the circles are 56 giants, and the triangles are the benchmark stars. Color coded are the log*g* values.
Extreme outliers are clearly outside our applicability limits.

References

Alves, S. et al., 2014, submitted to A&A
Jofré, P., Heiter, U., Soubiran, C.,. et al. 2014, A&A, 564, A133
Santos, N. C., Lovis, C., Pace, G., Melendez, J. 2009, A&A, 493
Sousa, S. G., Santos, N. C., Israelian, G., et al. 2007, A&A, 469, 783
Sousa, S. G., Santos, N. C., Mayor, M., et al. 2008, A&A, 487, 373
Sousa, S. G., Alapini, A., Israelian, G., & Santos, N. C. 2010, A&A, 512, A13
Sousa, S. G., et al. 2012, A&A, 544, A122
Sousa, S., 2014, arXiv:1407.5817
Tsantaki, M., Sousa, S. G., Adibekyan, V. Z., et al. 2013, A&A, 555, A150
Teixeira, G. D. C. et al. 2014, in preparation

Acknowledgments

Teixeira acknowledges the support of the European Comission under the SPACEINN project(312844).