TITANS: the metal-poor reference stars

Riano E. Giribaldi[1]

André R. da Silva[1], Rodolfo Smiljanic[1], Deysi Cornejo Espinoza[2], and the SAGA team[1]

1. Nicolaus Copernicus Astronomical Center (CAMK), Polish Academy of Sciences
2. Center of Radio Astronomy and Astrophysics Mackenzie, Engineering School, Mackenzie Presbyterian University

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Context

Tracing the history of chemical evolution of the Milky Way requires the determination of chemical abundances in a large assortment of stars with accurate stellar parameters. Nonetheless, the accuracy achieved in the derived astrophysical parameters is still insufficient, mainly because of the paucity of adequate calibrators, particularly in the metal-poor regime ([Fe/H] < -1.0). At present, the prime stellar calibration sample is that of the Gaia benchmark stars (Jofre et al. 2014, Heiter et al. 2015). Most of these stars have effective temperature ($T_{\rm eff}$) constrained by measurements of their bolometric fluxes and angular diameters. However, only seven of them are metal-poor. To increase this number, we introduce the "Titans metal-poor reference stars": stars with accurate model-dependent parameters that are "descendants" of the Gaia benchmarks. Their distribution as compared with the Gaia benchmarks in the Kiel diagram is presented in Fig. 2. Their parameters and abundances, and further information regarding their membership to Galactic structures will be presented in Giribaldi et al. in prep. (**we are about to submit!**)

The need for calibrators

Large spectroscopic surveys observe stars with a broad range of parameters (e.g., from the pre-main sequence and/or main sequence to red giant stars; from metal-poor to metal-rich stars). Common challenges of all surveys include: understanding if their automatic pipelines have performed the analyses well, and properly quantifying systematic and random errors. The answers to such challenges are in the use of calibrating objects (e.g. Pancino et al. 2017). Calibrators are well studied objects with reliable reference parameters and abundances; see applications to MARVELS (Ghezzi et al. 2014), GALAH DR2 (Buder et al. 2019), and Gaia DR2 (Andrae et al. 2018). Calibration problems can produce large offsets between parameters provided by different surveys, decreasing the confidence in their use. See e.g., a comparison between $T_{\rm eff}$ values from the Gaia DR2 and GALAH DR2 in Fig. 1.

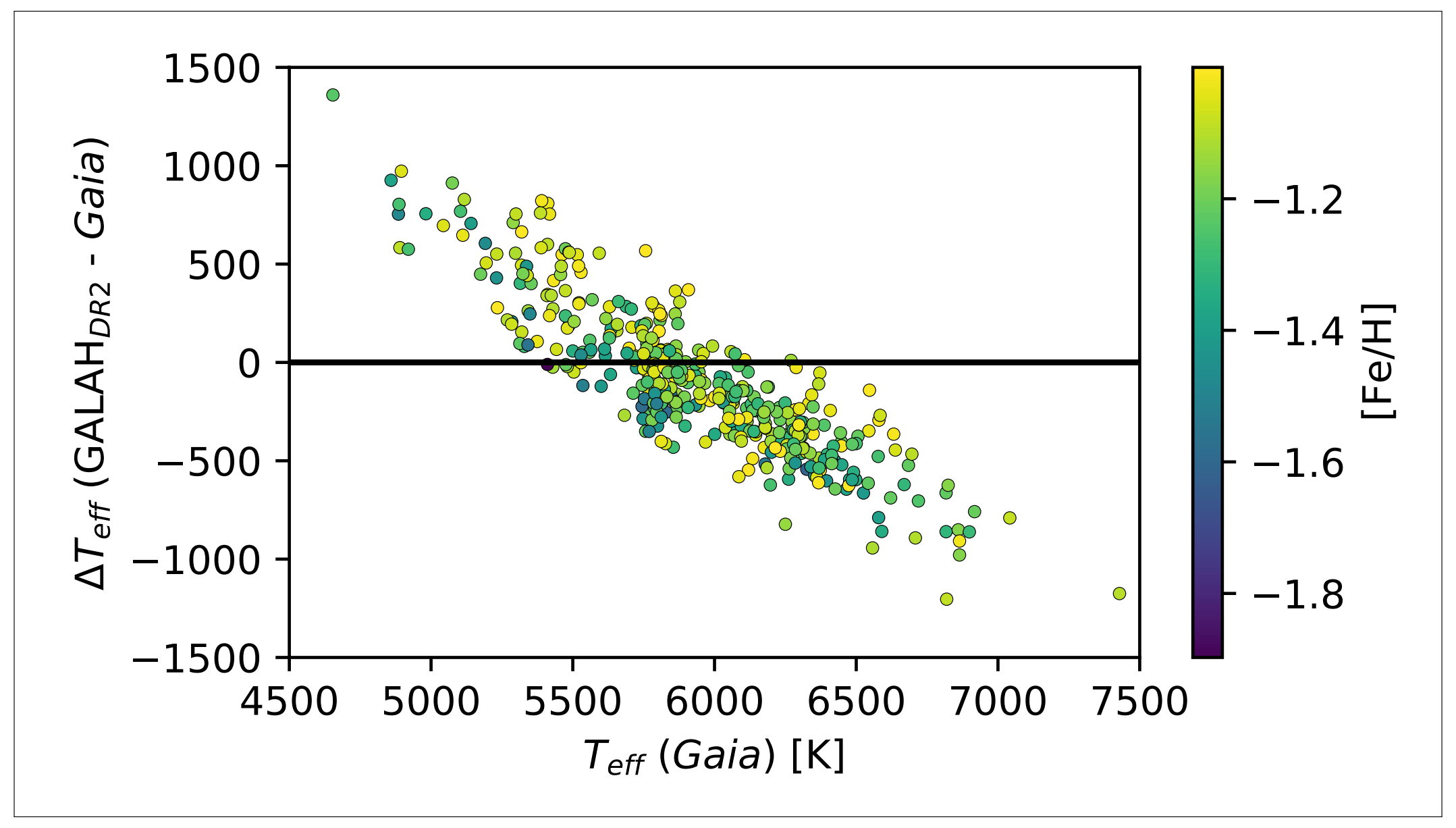

Figure 1: Comparison between $T_{\rm eff}$ in GALAH DR2 and Gaia surveys.

Titans in the Kiel diagram

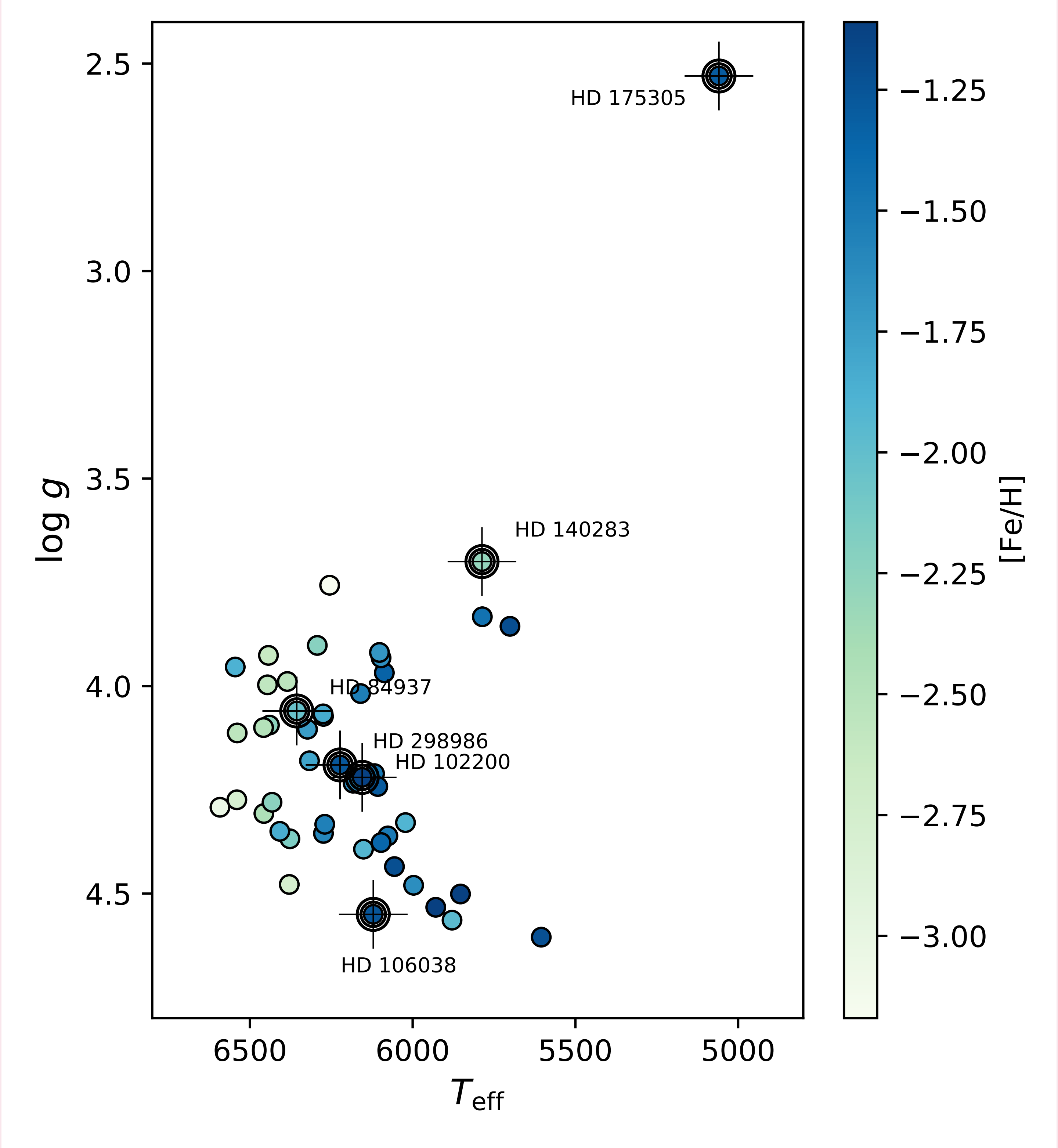

Figure 2: Distribution of the Titans in the Kiel diagram. Symbols with bold contours represent the Gaia Benchmark Stars.

Data

We selected a sample of metal-poor ([Fe/H] < −0.9 dex) dwarf and subgiant stars from the literature. This sample was crossmatched with the ESO phase 3 public archive choosing only UVES spectra with signal-to-noise ratio better than 150 that also encompass the Hα line. After clipping the spectra that presented distortions related to order merging defects, 189 spectra remained corresponding to a sample of 41 stars.

Contact Information

- Email: riano@camk.edu.pl

Accurate $T_{\rm eff}$ and log g values

$T_{\rm eff}$ was determined by Hα profile fitting using models synthesized under 3D non-LTE conditions (Amarsi et al. 2018) and the normalization-fitting procedure of Giribaldi et al. 2019. Surface gravity (log g) was derived by isochrone fitting running the q^2 software (Ramírez et al. 2014) using the Yale-Yonsei models and Gaia EDR3 parallaxes. $T_{\rm eff}$ and log g derivations were iterated in series of loops until the consistency between both parameters was reached. The accuracy of the parameter scale was validated by recovering the reference values of the Gaia Benchmark Stars (Heiter et al. 2015, Hawkins et al. 2016), when analyzing them with the same methods. The final uncertainties of the atmospheric parameters of the Titans are < 60 K ($\sim$ 1%) for $T_{\rm eff}$ and < 0.04 dex for log g. Fig. 3 shows the validation of the $T_{\rm eff}$ values.

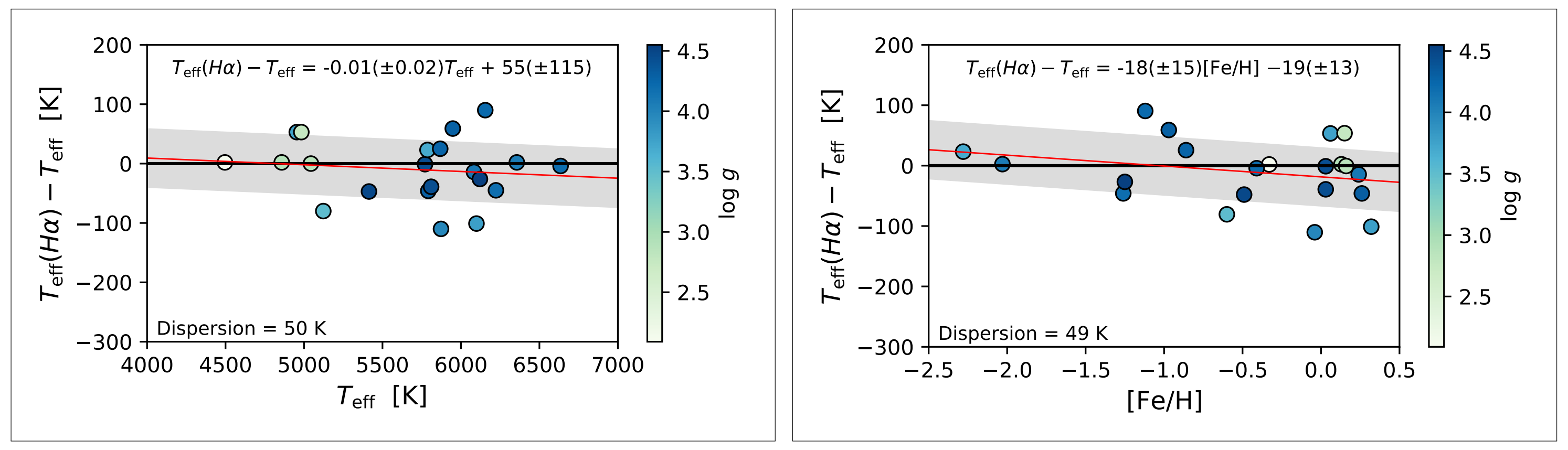

Figure 3:*

Difference between $T_{\rm eff}$ derived by Hα and standard $T_{\rm eff}$ (either interferometric or from infrared flux method) of the Gaia Benchmark stars as function of $T_{\rm eff}$ and [Fe/H].

Metallicity

[Fe/H] was derived by spectral synthesis using the program iSpec (Blanco-Cuaresma et al. 2014) and Fe II lines with $T_{\rm eff}$ and log g fixed. Two runs of spectrum synthesis analysis were performed for every star. The first run consisted on global fitting of several well shaped lines, and was used to constrain the values of micro and macroturbulence. The second run was used to derive the final [Fe/H] value, by a supervised line-by-line fitting, keeping the atmospheric and broadening parameters fixed.

References

Andrae et al. 2018, A&A, 616, A8; Amarsi et al. 2018, A&A, 615, A139; Blanco-Cuaresma et al. 2014, A&A, 569, A111; Buder et al. 2018, MNRAS, 478, 4513; Ghezzi et al. 2014, AJ, 148, 105; Giribaldi et al. 2019, A&A,624, A10; Hawkins et al. 2016, A&A, 592, A70; Heiter et al. 2015, A&A, 582, 49; Pancino et al. 2017, A&A 598, A5; Ramírez et al. 2014, A&A, 561, A7

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