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THE THIRD VERSION OF THE GAIA FGK BENCHMARK STARS

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Abstract. The Gaia FGK Benchmark Stars (GBS) are reference stars carefully selected for the calibration and the validation of atmospheric parameters massively determined from large-scale spectroscopic surveys. Their Teff and logg are determined independently of spectroscopy, through the fundamental relations based on angular diameters, bolometric fluxes, parallaxes and masses. An initial version of the GBS comprising 34 stars was presented by Heiter et al. (2015). We now introduce the third version, GBS V3, which comprises ∼200 stars.

Keywords: stars: late-type, stars: fundamental parameters, stars: atmospheres, standards, surveys

1 Introduction

Gaia needs to anchor its stellar astrophysical parameters on a set of well-characterised stars spanning the HR diagram and the full metallicity range. Similarly, spectroscopic surveys that massively derive atmospheric parameters and abundances (e.g. RAVE, GALAH, Gaia ESO, WEAVE,..) need reference stars to assess and calibrate their results. We expect atmospheric parameters and abundances from these different origins to be consistent. The GBS were defined to address these needs. They also contribute to improve stellar models from observational constraints.

2 Method

We start with a sample of 201 stars with a known angular diameter. Teff and logg are deduced from the Stefan-Boltzmann law and Newton's law of gravitation:

$$T_{\rm eff} = \left(\frac{F_{\rm bol}}{\sigma}\right)^{0.25} (0.5\,\theta_{\rm LD})^{-0.5} \tag{2.1}$$

$$g = \frac{GM}{(0.5\,\theta_{\rm LD}/\pi)^2} \tag{2.2}$$

Interferometric angular diameters $\theta_{\rm LD}$ are taken from the JMDC catalogue (Duvert 2016) and Salsi et al. (2020). Bolometric fluxes $F_{\rm bol}$ are determined using fluxes compiled from VOSA (Bayo et al. 2008), extinction values from the 3D map of Vergely et al. (2022) and the SED fitting method developed by Creevey et al. (2015). Parallaxes π are mostly from Gaia DR3, or Hipparcos for the brightest stars. Masses are computed with the SPInS code (Lebreton & Reese 2020) operated with both sets of stellar evolution tracks BaSTI and STAREVOL.

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Teff and luminosities determined from $F_{\rm bol}$, $\theta_{\rm LD}$ and π are used as input for SPInS, with [Fe/H] from high-resolution spectroscopy. Our validation tests showed that the determination of masses from evolutionary tracks can be rather uncertain for some giants.

The resulting Teff and logg were assessed by comparing them to other determinations of similar quality. We identify a subset of 165 GBS of the best quality, with uncertainties on Teff and logg better than 2% and 0.1 dex respectively. Their Kiel diagram is shown on Fig. 1. We have used this subsample to assess Teff and logg obtained by high-resolution and high signal-to-noise spectroscopy (PASTEL catalogue), by medium-resolution spectroscopy (APOGEE, GALAH and Gaia-ESO surveys), and by Gaia photometry and spectroscopy. This has revealed some issues in spectroscopic values that need to be investigated.

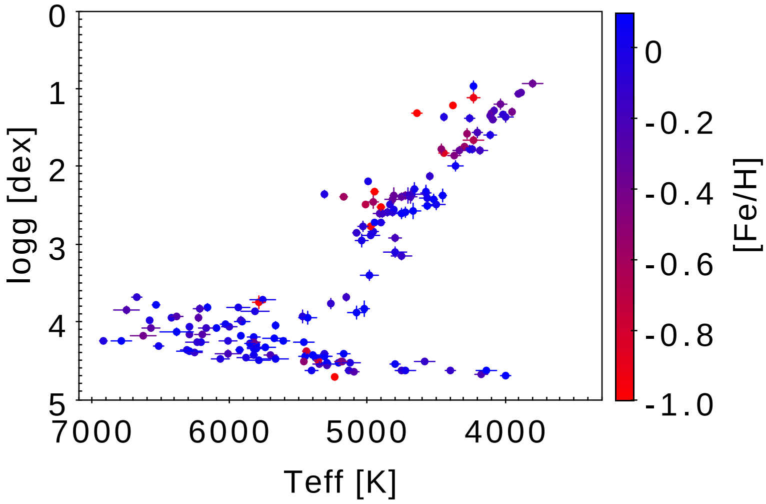

Fig. 1. Kiel diagram with fundamental Teff and logg of the 165 GBS with uncertainties better than 2% and 0.1 dex respectively. The colour scale is related to spectroscopic metallicities from the literature.

3 Conclusions

GBS V3 show significant improvements with respect to previous versions due to: (1) the larger number of stars, ∼200 instead of ∼40, resulting from our systematic search of high quality angular diameters based on interferometric measurements, (2) more accurate Teff and logg, resulting from better parallaxes which now mostly come from Gaia DR3, (3) more precise and homogeneous Fbol values, owing to the methodology of SED fitting applied to a combination of photometric and spectrophotometric data, including measurements made on XP spectra from Gaia DR3, with extinctions deduced from a state-of-the-art 3D map of the solar neighbourhood. This new set of well-characterised stars is a powerful tool for the calibration of parametrisation methods. We are now determining the chemical abundances of these stars from a large set of high quality spectra.

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