Spectroscopic parameters of the B-type stars in the modern grid of standards for spectral classification

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ABSTRACT: As a follow-up to the work made by Holgado et al. (2018) – who focused in O-type stars – we present here preliminary results from the **quantitative spectroscopic analysis** of several dozen stars comprising the recently **revised grid of B-type standards for spectral classification** (see Negueruela et al. 2024). In particular, we present their location in the spectroscopic HR diagram and the resulting SpT-Teff and SpT-logg calibrations. Results have been obtained using spectra compiled in the framework of the **IACOB project**, the state-of-the-art atmosphere code **FASTWIND** (Puls et al. 2005), and a **brand-new battery of analysis tools** (based on traditional methods) implemented in python.

INTRODUCTION

The **IACOB project** (Simón-Díaz, 2011, 2020) is a long-term observational project driven by the compilation and scientific exploitation of a large database of high-resolution multi-epoch spectra of Galactic OB stars. At present, the IACOB spectroscopic database comprises more than 15000 high-resolution (R=25000-85000) spectra of about 2800 Galactic OB stars obrighter than V~10.

As part of the observed sample, we have obtained at least 3 spectra for those stars included in the **modern grids of O and B-type stars for spectral classification** (see Maíz-Apellaniz et al. 2015, and Negueruela et al. 2024, respectively). Among other things, we use those stars as **benchmark for our subsequent quantitative spectroscopic analyses of the full IACOB sample** (see, e.g. Holgado et al. 2018 and this poster for the case of O- and B-type stars, respectively).

SAMPLE SELECTION

The recently revised **grid of B-type standards for spectral classification** comprises about 160 stars (see Negueruela et al. 2024). For the purposes of this work we have concentrated in those stars in the initial sample fulfilling the following criteria:

- vsini < 100 km/s
- Clear identification of the following lines (to allow a reliable measurement of their equivalent width): the Si III λ4552, 4567, 4574 Å triplet and at least one of the following lines: Si IV λ4116 Å and Si II λ6347 Å.

Final sample (see Fig. 1): 71 stars from O9 to B7 and spectral types covering luminosity classes from V to I.

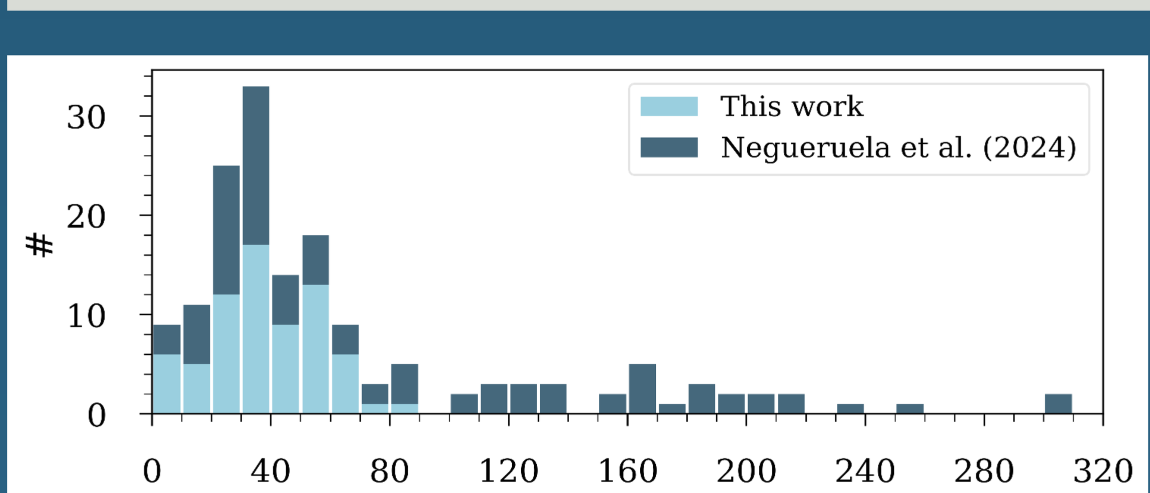

Fig. 1: vsini distribution of the complete list of B-type standards defined in Negueruela et al. (2024), highlighting the 71 stars considered for this study (see sample selection)

METHODOLOGY

- Line-broadening parameters (**vsini** and **vmac**) computed with **IACOB-broad** (Herrero & Simón-Díaz, 2014)
- Identification of potential **SB1** and **SB2** systems using all available multi-epoch spectra in the IACOB database.
- Spectroscopic parameters (**$T_{\rm eff}$, log g** and **log Q**), as well as Si abundances **ε (Si)** and microturbulences **ξ_t** obtained using traditional techniques implemented in a brand-new module of the python package pyiacob (de Burgos et al. 2023) called **pyiacob-abun** (Casasbuenas et al., in prep).
  - Computation of two **HHeSi grids of models** with the stellar atmosphere code **FASTWIND** (see Tab. 1) for the comparison with the observed spectra.
  - **Iterative** determination of the spectroscopic parameters, ε (Si) and ξ_t using the following diagnostic lines:
    - i. **Si III λ4552 Å, Si IV λ4116 Å** and **Si II λ6347 Å** for the $T_{\rm eff}$ estimation.
    - ii. The Balmer lines **H_β, H_γ, H_δ** for the gravity determination, as well as **H_α** for the wind strength estimation.
    - iii. **Si III λ4552, 4567, 4574 Å, Si IV λ4116 Å** and **Si II λ6347 Å** for the ε (Si) and ξ_t determination.

Grid	$T_{\rm eff}$ [10^3K]	log g [dex]	log $\mathcal{L}/\mathcal{L}_\odot$	ξ_t [km/s]	Y (He) [dex]	ϵ (Si) [dex]	-log Q [dex]	β
1	14 - 40	2.0 - 4.3	1.6 - 4.0	1 - 30	0.1	7.35 - 7.65	14 - 13.0	1
2	14 - 40	1.6 - 4.3	3.4 - 4.5	1 - 30	0.1	7.35 - 7.65	14 - 12.7	1 - 3

Tab. 1: Parameter coverage of the pre-computed grids of FASTWIND models incorporated to the pyiacob-abun module. Grid 1 is optimized for the analysis of B-type stars with luminosity classes (LCs) V, IV and III,, while Grid 2 can be used for the analysis of B-type stars with LCs I and II (see Fig 2). Note the existence of some overlap between the 2 grids.

RESULTS

We have been able to determine spectroscopic parameters (including $T_{\rm eff}$, log g, ξ_t, and log Q) and ε (Si) for **62 (out of 71) stars**.

- 2 Bsgs with a bad fitting to H_α (HD216411, HD169454)
- 7 late-type B stars with Teff outside the boundaries of the computed grids (see Tab. 1): HD15497, HD191243, HD199478, HD208501, HD36371, HD58350, HD7902.

Using these results, in this poster we present:

- i. The location of the analyzed stars in the **Spectroscopic HR Diagram** (SHRD) (see Fig. 2).
- ii. The obtained distributions of **Si abundances and microturbulences** (see Fig. 3).
- iii. A set of modern **SpT-$T_{\rm eff}$ and SpT-log g calibrations** (see Fig. 4), which allows to extend the work previously done by Holgado et al. (2018) to the B star domain.

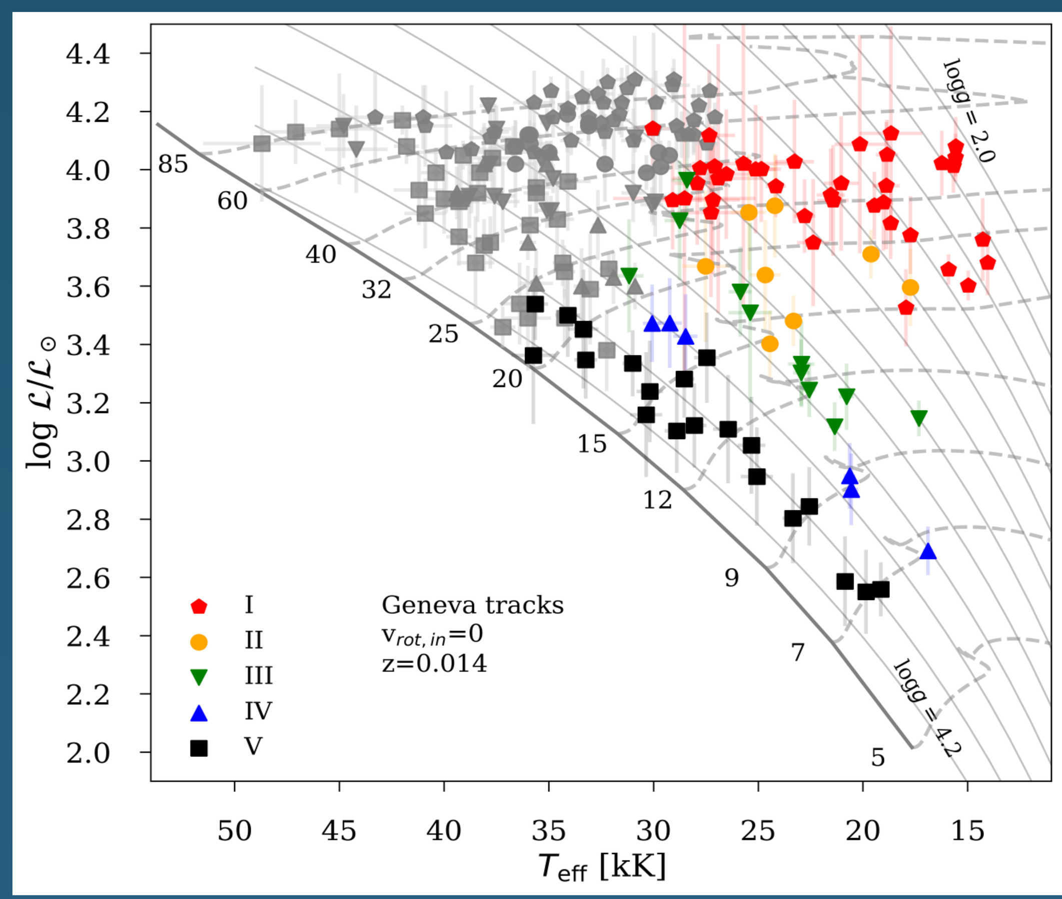

Fig. 2: Location of the analyzed sample of 62 B-type stars in the SHRD. Different colors and symbols are used to separate stars into luminosity classes, with the grey color used to indicate the location of the O-type stars analyzed by Holgado et al. (2018). Non-rotationg evolutionary tacks from Ekström et al. (2012) used for reference.

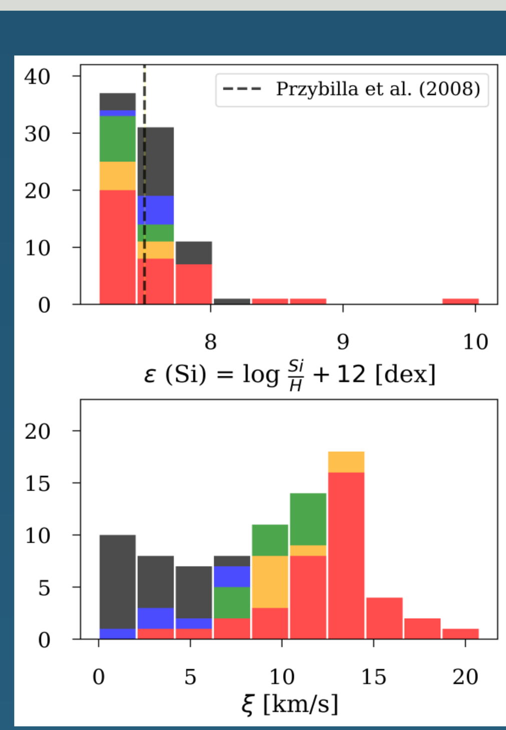

Fig. 3: Distribution of Silicon abundances (top panel) and microturbulence in the analysed sample (the color scheme follows Fig. 3)

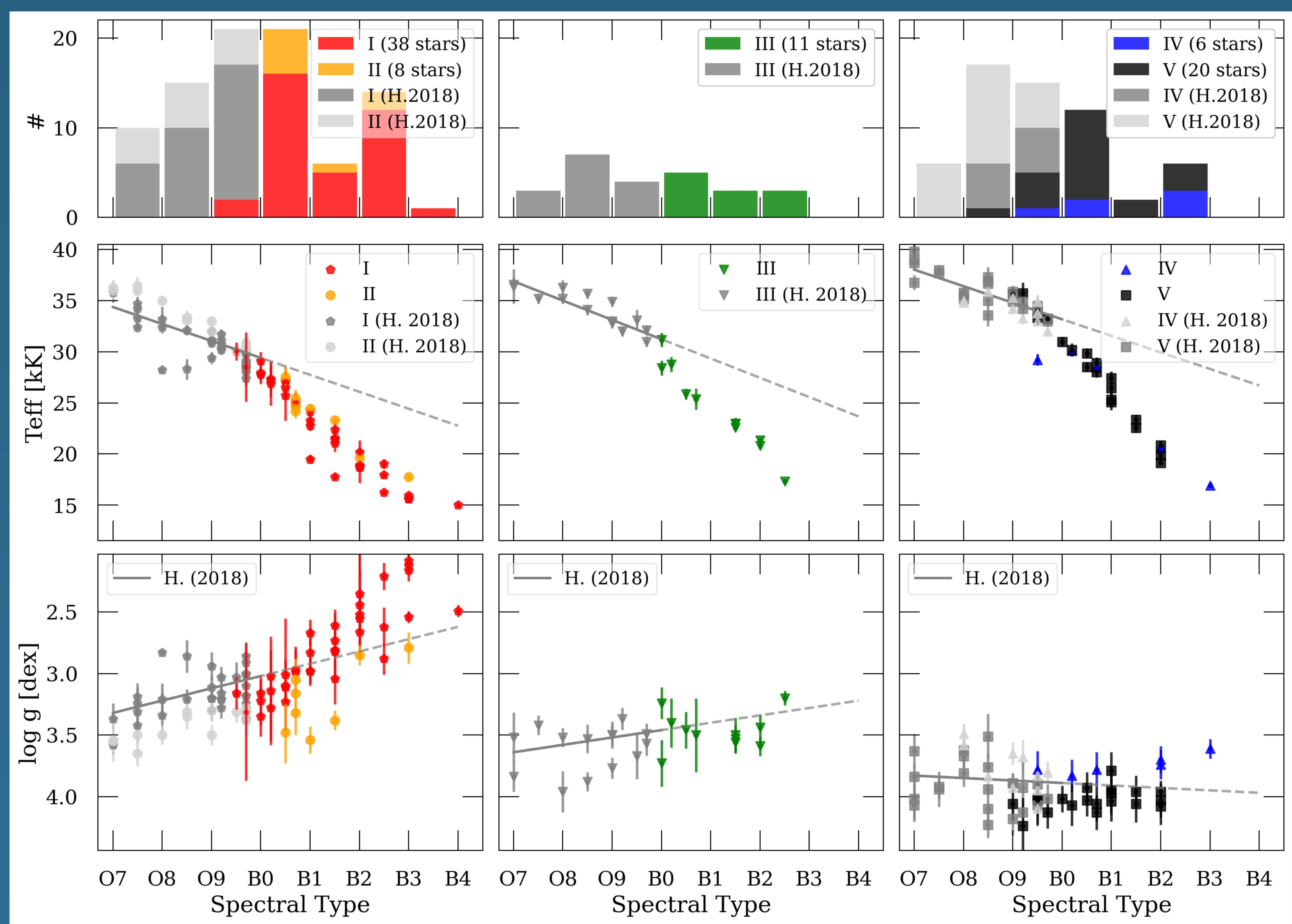

Fig. 4: SpT–$T_{\rm eff}$ (middle panels) and SpT–log g (bottom panels) calibrations. The global sample is divided by luminosity class groups in columns. We show in grey the results from the analysis of O-type standard stars from Holgado et al. 2018 together with the associated calibration (extrapolated to the B-star domain) as a dashed line.

CONCLUSIONS AND FUTURE PROSPECTS

This is the first step towards the **full empirical characterization** of the recently revised **grid of B-type standards of spectral classification**.

- Here, we present the **methodology and preliminary results**, for a subsample of the complete list of B-type standards presented in Negueruela et al. (2024)
- We have obtained robust results for **B dwarfs** and giants. The preliminary analysis performed for the B-type supergiants (LC I) are pending some fine-tuning to better account for the impact of stellar wind on the parameter determination.

Next steps:

- Extend the available grids to **lower temperatures** to be able to analyse the missing stars.
- Review and improve the solution for the **B Supergiants** where the effect of the wind is more relevant.

We plan to use this spectroscopic dataset to test and improve the model atoms (Si, C, N, O, Mg) presently available for FASTWIND computations.

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