Massive Stars Across Redshifts in the Era of JWST and Large Surveys
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A Census of B/A Galactic Supergiants: Refinement of the Fundamental Parameters

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Abstract. This study is aimed at investigating B5–A5 Galactic supergiants and developing a method for accurately determining their fundamental parameters from photometric and spectroscopic data. These luminous stars can serve as standard candles for extragalactic distance measurements, but their properties remain poorly constrained. Despite spectral advances, temperature and luminosity estimates still vary, and only small samples have been analyzed. We analyzed mostly medium-resolution ($R = 12{,}000$-$18{,}000$) spectra of ~ 200 supergiants down to $V \sim 10$ mag. Measuring numerous absorption lines revealed correlations between their strengths and stellar parameters, while using recent Gaia distances and SEDs improved accuracy of the parameters. The results form a basis for a forthcoming catalog of observed features and fundamental parameters of these stars.

Keywords. BA supergiants, spectral energy distribution, EW, stellar parameters.

1. Introduction

Mid-B to mid-A supergiants are luminous (7-15 M$\odot$) optical emitters, among the brightest galactic stars, observable up to tens of Mpc and usable as standard candles when $T_{\rm eff}$ and L are well determined. Previous studies (Verdugo et al. 1999a,b; Firnstein & Przybilla 2012; Weßmayer et al. 2022) analyzed only in small groups of 20-40 objects, though hundreds within a few kpc are accessible with even small telescopes. We have obtained several spectra for ∼200 B5–A5 supergiants down to $V \sim 10$ mag (Sec. 2). Although some projects focus on high-resolution data (e.g., de Burgos et al. 2023), medium-resolution spectroscopy combined with SED analysis provides independent validation of model-derived parameters and enables purely observational selection criteria.

2. Observations

Spectroscopic observations of the BA supergiant sample have been obtained with échelle spectrographs and are summarized in Table 1. Initial results of this project were

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Table 1. Spectroscopic Observations of the Supergiant Sample.

Observatory	Dates	Telescope/Spectrograph	R	Range (Å)	stars	sp
TCO	2011–2025	0.81 m, eShel	12,000	3800–7800	135	1075
OAN SPM	2013–2019	2 m, REOSC	18,000	3700–7800	46	50

Notes: R – resolving power; sp – total spectra
SPM – Observatorio Astronómico Nacional San Pedro Mártir, Baja California, Mexico; TCO – Three College Observatory, North Carolina, USA. *References:* Miroshnichenko et al. (2023) for TCO data reduction and eShel information; Contarini & Gratton (1992) for the REOSC information.

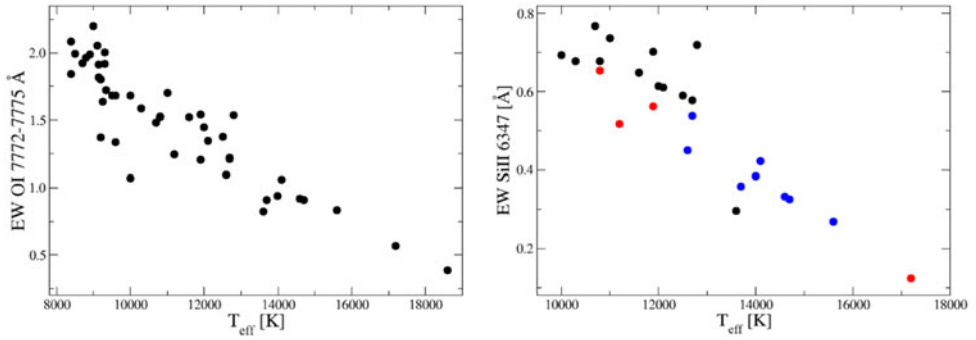


Figure 1. Correlations of line EW with T_{eff}. **Left:** O I 7772–7775 Å. **Right:** Si II 6347 Å. Symbols indicate stars of different luminosity classes: Black – Ia, red – Iab, blue – Ib.

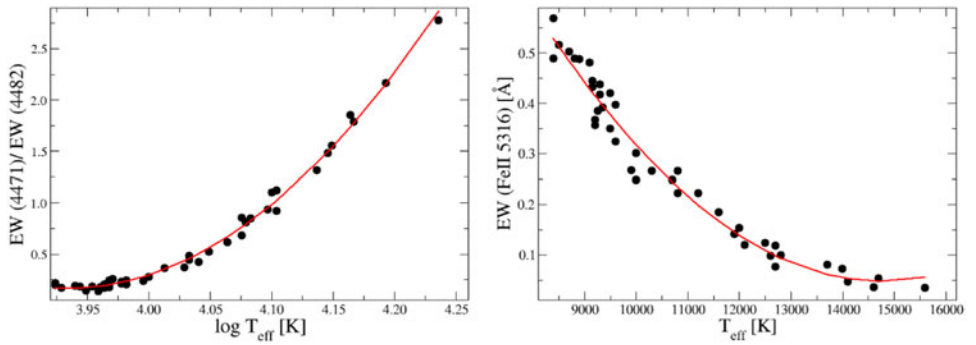


Figure 2. Correlations between EW and T_{eff}. **Left:** EW(He I 4471/4482) vs log T_{eff}; **Right:** EW(Fe II 5316) vs T_{eff}. Red lines show the best quadratic fits.

reported in Miroshnichenko et al. (2013). Higher-resolution ($R = 40{,}000$–$65{,}000$) spectra of other ∼30 stars from the Southern Hemisphere were retrieved from the ESO and CFHT archives.

3. Results

Calibration relationships between T_{eff} and equivalent widths (EW) of the Fe II 5316, C II 6578, Si II 6347 Å lines, O I 7772–7775 Å triplet, and the EW ratio of the He I 4471 to Mg II 4482 Å lines were established using data of ∼50 stars mainly from Firnstein & Przybilla (2012) and Weßmayer et al. (2022) and are shown in Figures 1–2. The points scatter in these plots is suggestive of an additional luminosity dependence. We found that combined EWs of the O I 7772–7775 Å triplet correlates well with T_{eff} from 8,000 K to 19,000 K (Fig. 1), while previous studies of cooler supergiants ($T_{eff} \leq 8,000$ K) showed that it correlates well with absolute visual magnitudes (e.g., Arellano Ferro et al. 2003).

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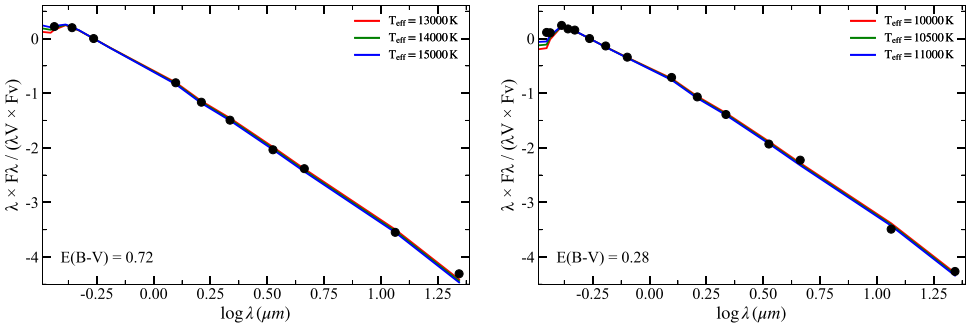


Figure 3. SEDs of HD 25914 (B6 Ia, left) and HD 35600 (B9 Ib, right). Black dots represent photometric data corrected for the interstellar extinction, while solid lines show model atmospheres with different T_{eff} normalized to the V–band flux that provide a good fit to the observational data.

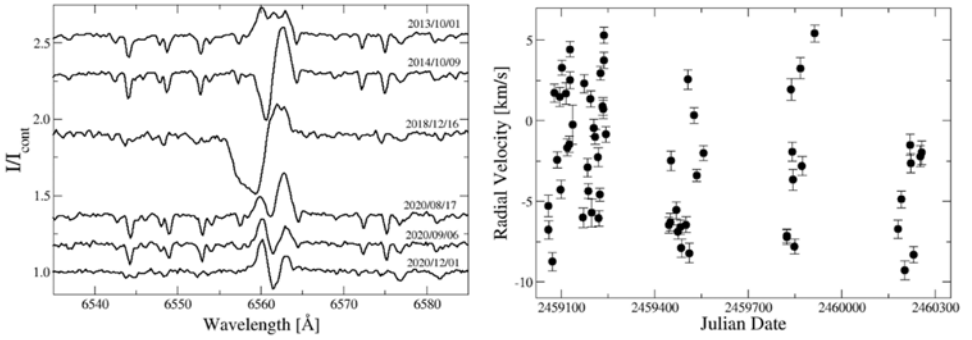


Figure 4. Variability of the Hα line profile (telluric lines not removed) and radial velocity of absorption lines derived by cross-correlation in the TCO spectra ($R \sim 12{,}000$) of the emission-line supergiant HD 223960 (A0 Ia+).

SED modeling showes good agreement with T_{eff} determined from the calibration relationships for most of the sample stars (Fig. 3), although it is weakly sensitive to the surface gravity. Some stars with Hα in emission show strong line profile variations from a P Cyg-type to a double-peaked with a variable violet-to-red peak intensity (Fig. 4).

4. Discussion and Conclusions

Analysis of ∼200 Galactic B5–A5 supergiants shows that medium-resolution spectroscopy along with photometric and SED data provides reliable stellar parameters. Empirical relations between the EWs of key lines versus T_{eff} and/or L allow determination of the stars fundamental parameters as an alternative method to modeling of high-resolution spectra. SED fits agree with spectroscopy, while variable Hα emission indicates circumstellar and wind variability. The growing sample and improved calibrations will yield a uniform catalog of Galactic B/A supergiants for stellar evolution and distance-scale studies.

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