Fundamental stellar parameters for 222 B-type stars for the X-shooter Spectral Library

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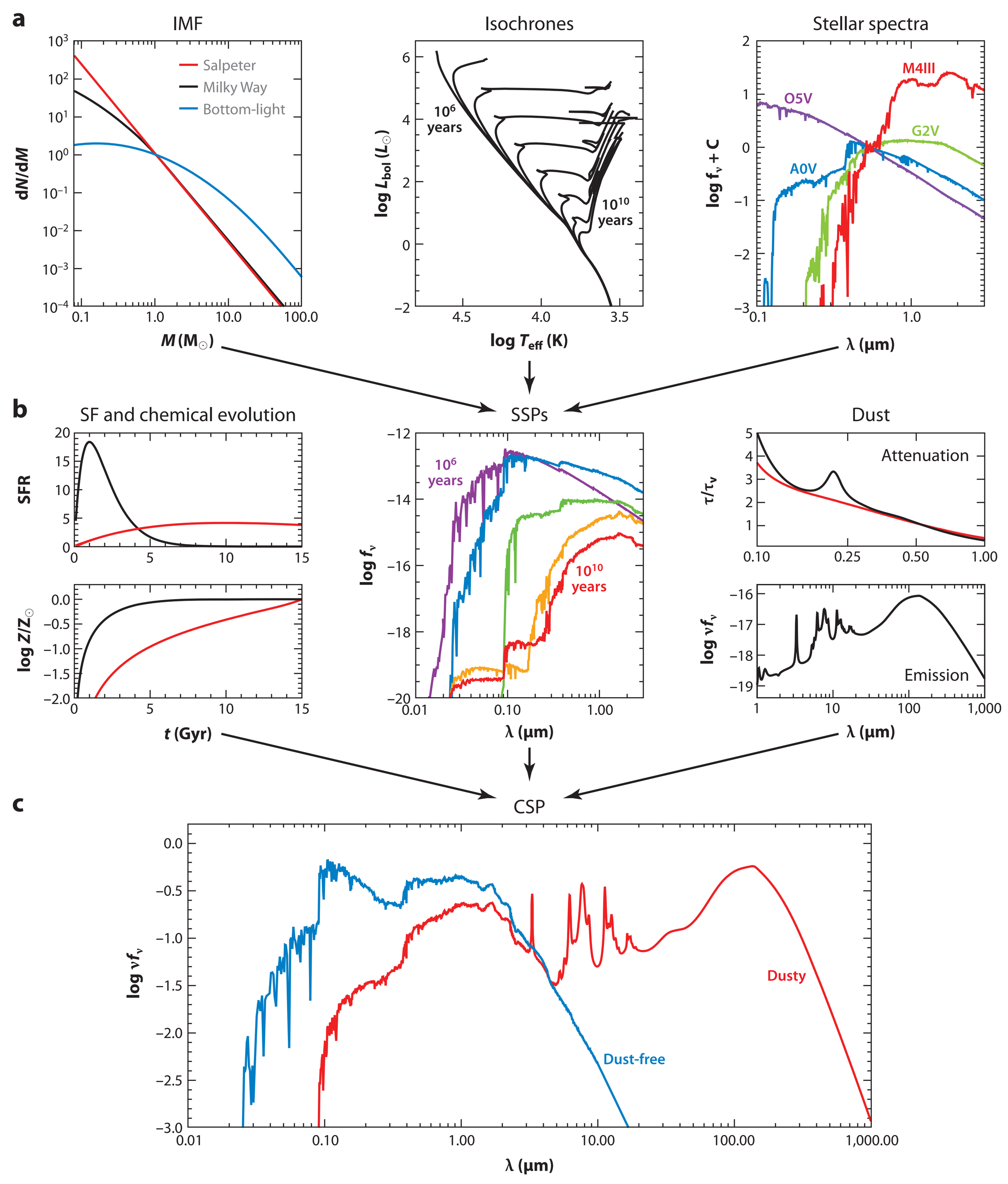
Abstract

Stellar population models are building blocks for furthering our understanding of galaxies. With short lifetimes and high bolometric luminosities, B-type stars dominate the first few to tens of Myr of a stellar population, and strongly influence the chemical evolution of their environment via nucleosynthesis of metals and supernovae explosions. Currently, empirical spectral libraries such as the X-shooter Spectral Library (XSL) have a paucity of these stars compared to cooler stars, making it difficult to probe younger populations. We use the MIDE3700 code to find effective temperatures $T_{\rm eff}$ and surface gravities $\log g$ via the BCD method for 222 B-type stars in the XSL calibration archive in preparation for their inclusion as an extension to the XSL itself. We find agreement to within $\sim 0.1\sigma \log T_{\rm eff}$ and $\sim 0.25\sigma \log g$ between our results and a sample of literature stars. We populate a previously bare region of the XSL Hertzsprung-Russell diagram in the ranges $9000\mathrm{K} \leq T_{\rm eff} \leq 23000\mathrm{K}$ and $2.8 \leq \log g \leq 4.0$, and extend the lower age limit for XSL stellar population models by up to a factor ~ 10 for [Fe/H] = -1.2, and a factor ~ 2 for Solar metallicity.

Stellar Population Modelling



Stellar Population Synthesis overview. (a) Simple Stellar Population (SSP) components include an Initial Mass Function (IMF), an isochrone grid, and a library of stellar spectra. (b) SSPs are combined with models of dust and star formation (SF) and chemical evolution to create a Composite Stellar Population model, shown in (c). From Conroy (2013).

Stellar population synthesis requires a library of stellar spectra as an input. The lower age limit for stellar populations that can be synthesised depends on the earliest spectral types in the spectral library.

BCD Method

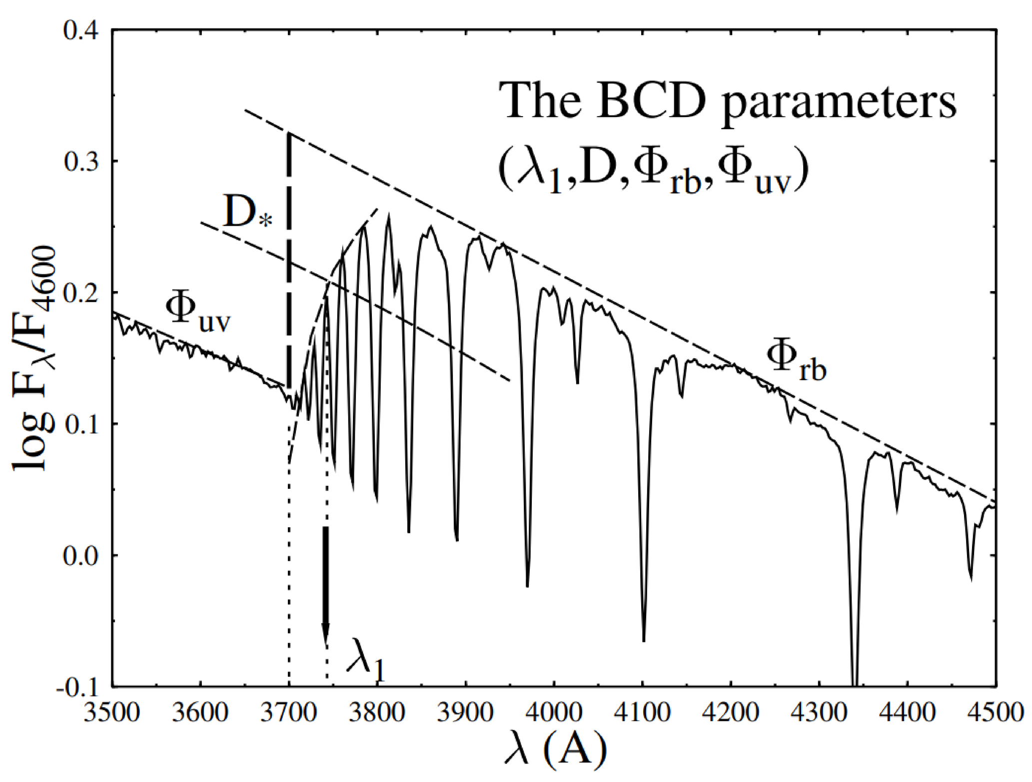
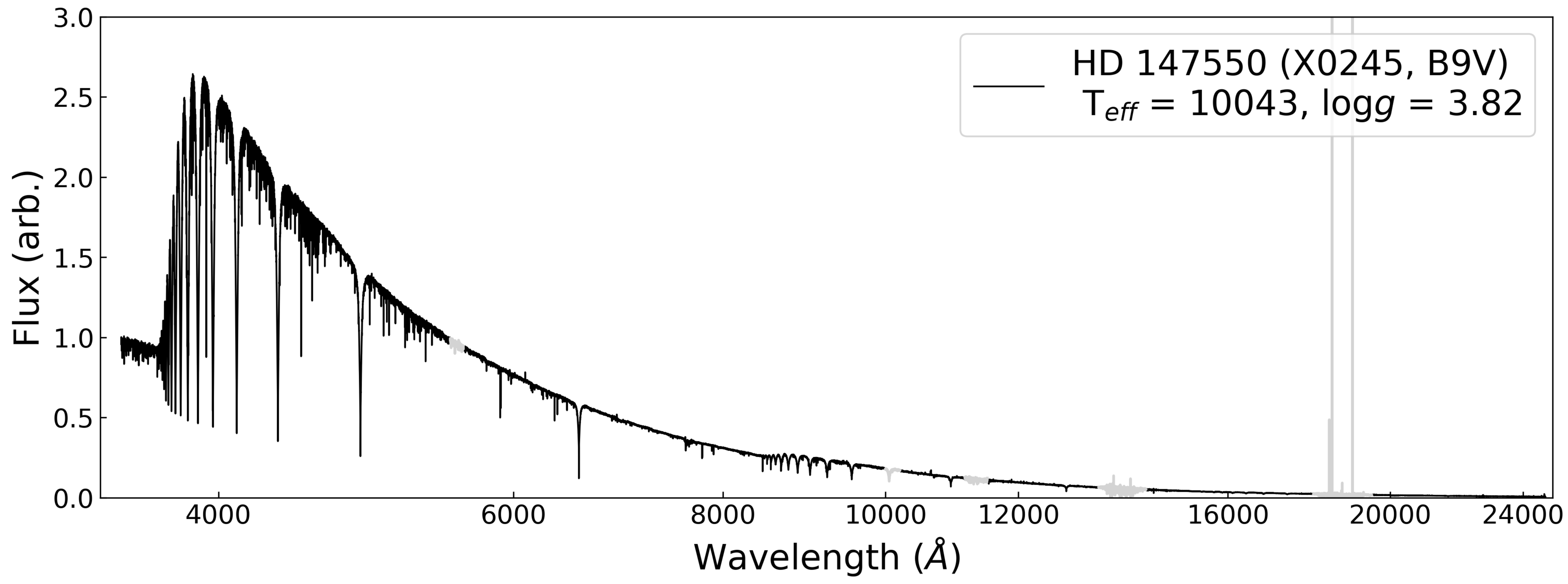


Diagram of BCD parameters on a stellar spectrum. From Zorec et al. (2009).

- BCD method uses the position λ_1 and size D of Balmer jump to find $\log g$ and $T_{\rm eff}$
- $\lambda_1 \propto \log g$ $\rightarrow$ Balmer jump approaches theoretical limit of 3648 Å as atmosphere density decreases
- $D \propto T_{\rm eff}$ $\rightarrow$ Measures amount of continuum absorbed by Balmer lines

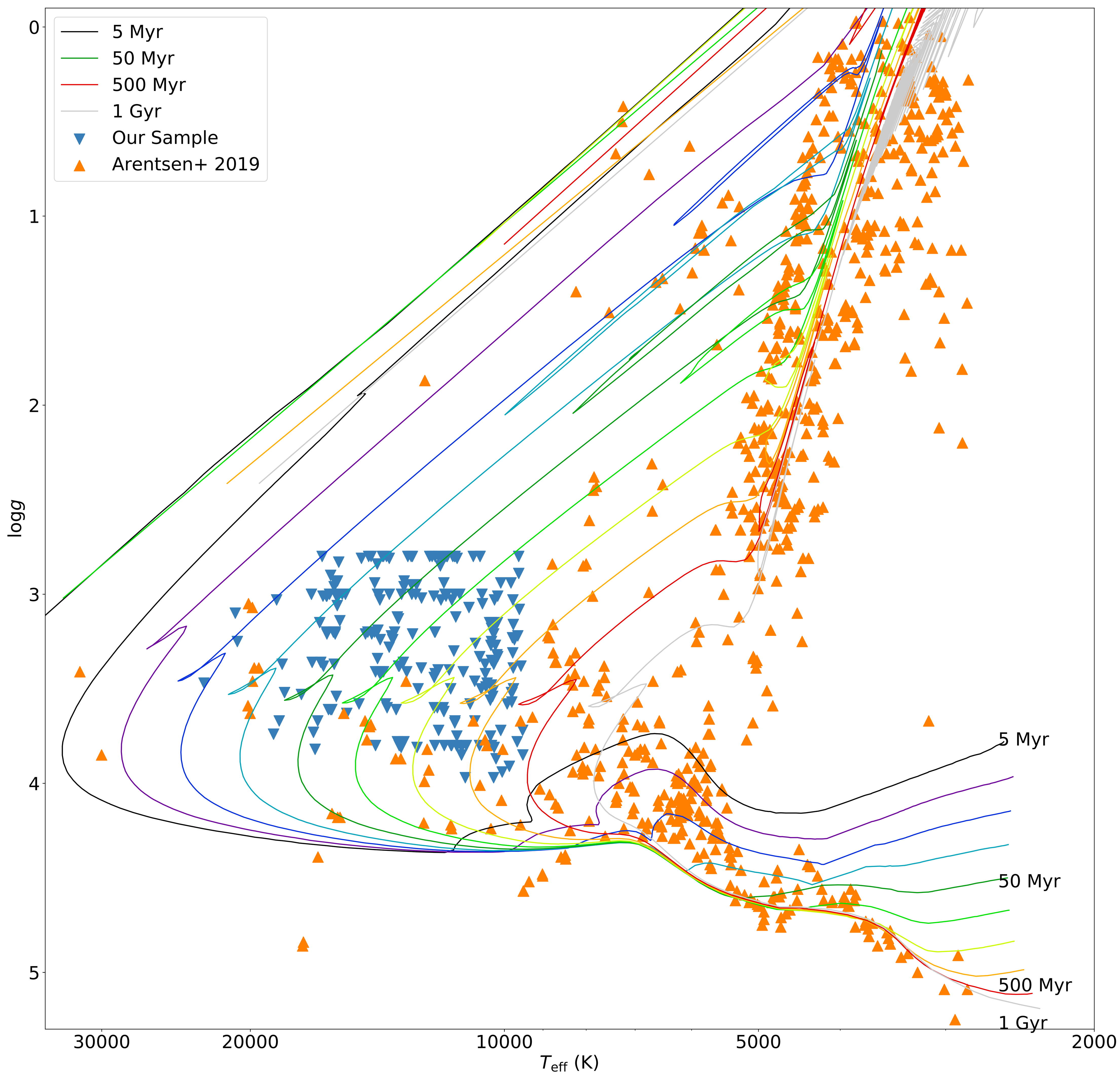
X-shooter Spectral Library



Example spectrum of a late-type B star from the XSL.

- The X-shooter Spectral Library (XSL) has moderate-to-high resolution ($R \sim 10000$), NUV-NIR wavelength coverage ($3000\mathrm{Å} - 24500\mathrm{Å}$) and good spectral type coverage up to OB stars (Gonneau et al. 2020, Verro et al. 2022a)
- XSL currently able to model SSPs at ~ 100 Myr for [Fe/H] = 0 (Verro et al. 2022b)
- We are **extending XSL** from 830 spectra of 683 stars to **1537 spectra of 905 stars!**

Results



Hertzsprung-Russell Diagram in $T_{\rm eff}$ and $\log g$ of our sample (blue) and Arentsen et al. (2019) (orange), with PARSEC/COLIBRI isochrones at Solar metallicity. The isochrones are color-coded by age, all spaced by 0.25 dex in years except for the 1 Gyr isochrone.

- Factor ~ 10 increase in XSL B star census (previously ~ 20 stars)
- Pushes SSP model lower age limits to 50 Myr $\rightarrow$ factor 2 lower at [Fe/H] = 0, factor 10 lower at [Fe/H] = -1.2
- Good agreement to available literature values in Huang et al. (2010) $\rightarrow \sim 0.1\sigma \log T_{\rm eff}$, $\sim 0.25\sigma \log g$

References

[1] Conroy, C. 2013, ARA&A, 51, 393 [2] Zorec, J., Cidale, L., Arias, M. L., et al. 2009, A&A, 501, 297 [3] Gonneau, A., Lyubenova, M., Lançon, A., et al. 2020, A&A, 634, A133 [4] Verro, K., Trager, S. C., Peletier, R. F. et al. 2022a, A&A 660, A34 [5] Verro, K., Trager, S. C., Peletier, R. F. et al. 2022, A&A 661, A50 [6] Arentsen, A., Prugniel, P., Gonneau, A., et al. 2019, A&A, 627, A138 [7] Huang, W., Gies, D. R., & McSwain, M. V. 2010, ApJ, 722, 605

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