

High-Resolution Spectroscopy of Hot Subdwarfs with VUES: Benchmarking Gaia XP and LAMOST Classifications

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Introduction

The Objects: Compact, extreme horizontal branch stars (He-core burning). They are primary drivers of galactic UV excess and critical laboratories for late-stage binary interactions (e.g., common-envelope ejection).

The Observational Bottleneck: Theoretical models predict high binary fractions, but massive automated surveys rely on low-resolution spectra. This blends critical absorption features, creating degeneracies that mask companions and skew atmospheric parameters.

Case Study (TYC 1398-532-1): We present a multi-resolution comparison of this anomalous target to investigate the conflicting automated classifications using targeted high-resolution verification (VUES).

Population Context

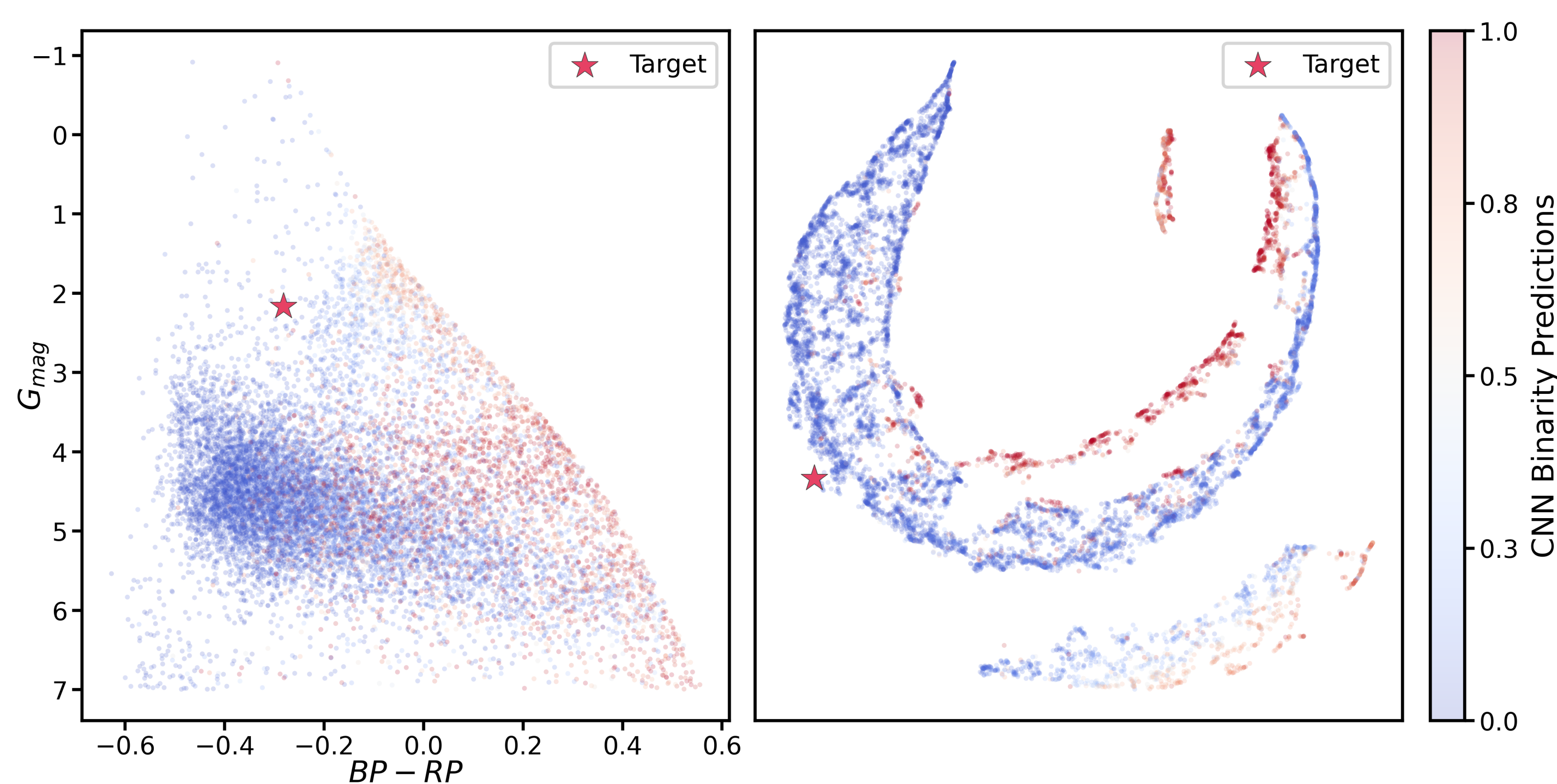


Figure 1. Population context of TYC 1398-532-1 among $\sim 20\,000$ hot subdwarf candidates (Culpan et al., 2022). Gaia DR3 HR diagram (left) and Gaia XP UMAP projection (right) color-coded by CNN binarity probability (Ambrosch et al., 2026).

Physical Space: Target resides strictly on the extreme horizontal branch within the Gaia HR diagram.

Feature Space: UMAP projection of Gaia XP spectra places the target firmly within the high-probability single-star regime.

Astrometric & Photometric Diagnostics

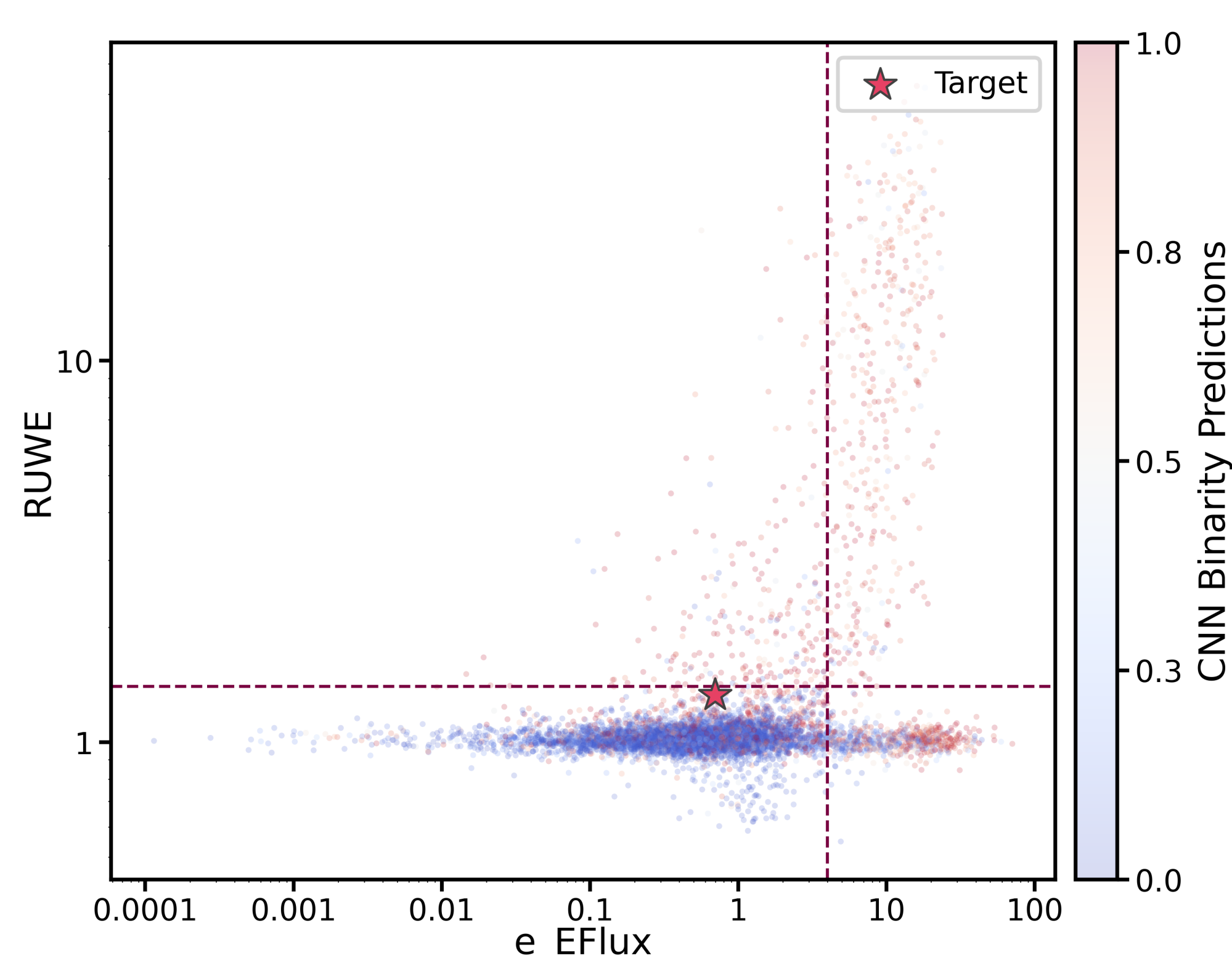


Figure 2. Gaia astrometric (RUWE) and photometric (e_EFlux) variability indicators for the $\sim 20\,000$ star sample.

Astrometric Stability: The renormalised unit weight error of 1.33 approaches the 1.4 threshold, preserving the possibility of a wide-binary wobble.

Photometric Purity: The excess flux error of 0.70 remains well below the 4.0 limit, ruling out flux blending from a close companion.

The Classification Discrepancy

Table 1. Conflicting automated classifications for TYC 1398-532-1.

Method/Survey	Binarity	Spectral Subclass	T_{eff} [K]
VOSA	Binary	–	–
CNN/SOM	Single ($P_{\text{binary}} \approx 0.10$)	sdB ($P_{\text{sdB}} \approx 0.89$)	–
LAMOST DR10	–	B6	Failed
Gaia DR3	–	–	34 393

Photometric Excess: Automated SED fitting via VOSA (Solano et al., 2022) flags a binary, driven by an uncharacterized infrared flux excess.

Spectroscopic Contradiction: Machine learning models applied to Gaia XP spectra (Viscasillas Vázquez et al., 2024; Ambrosch et al., 2026) predict a single-star configuration.

Pipeline Degeneracy: Standard LAMOST template matching classifies the target as a main-sequence B6 star, failing to resolve the extreme atmospheric parameters.

Instrumental Parameters

Table 2. Instrumental specifications for the multi-resolution spectroscopic datasets.

Instrument	Resolution (R)	Wavelength Range [nm]	Aperture [m]
Gaia BP/RP	50	330 – 1050	1.20
LAMOST LRS	1 800	370 – 900	4.00
MAO VUES	30 000 / 45 000 / 60 000	400 – 880	1.65

Resolution Comparison

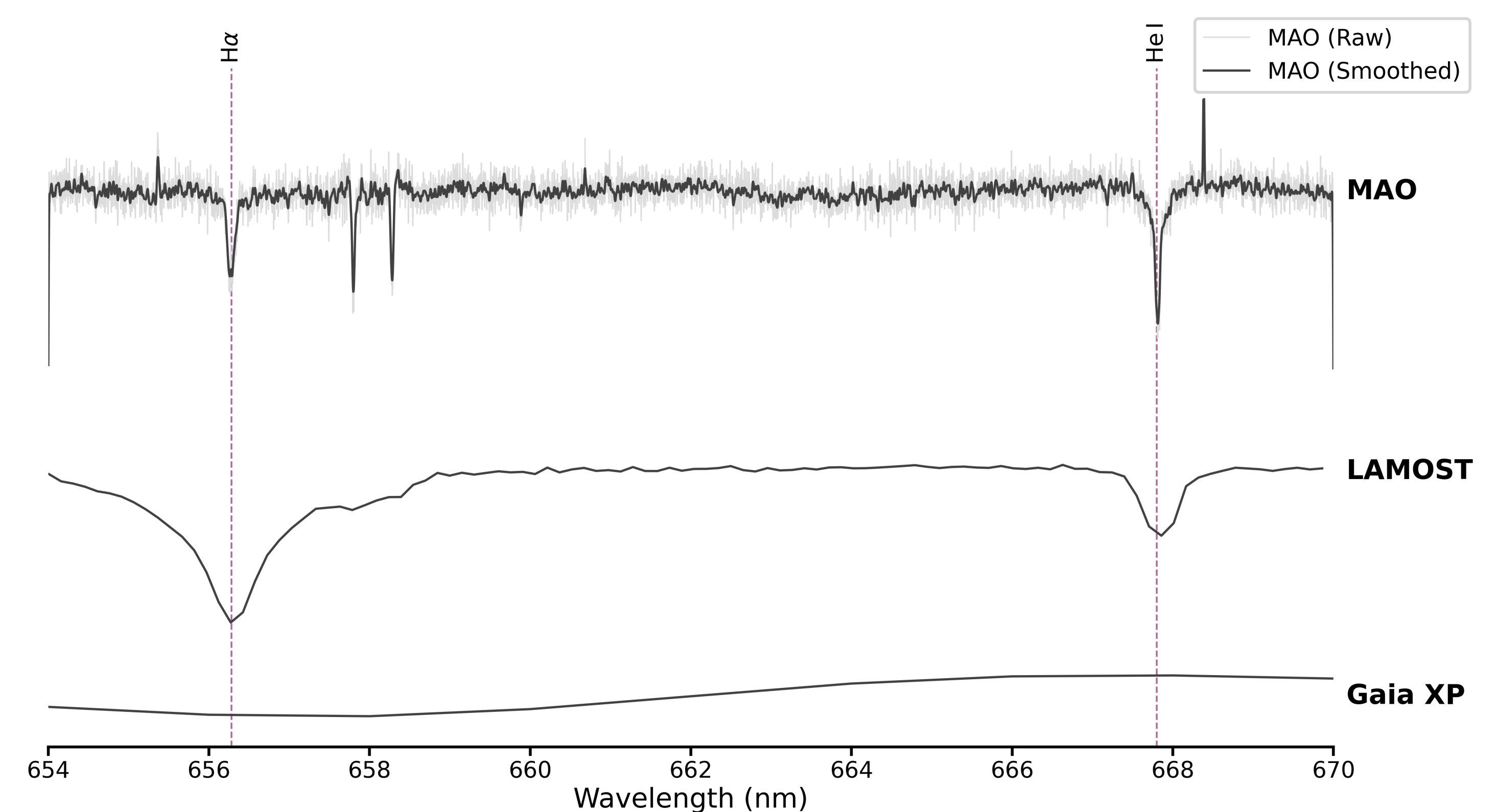


Figure 3. Multi-instrument comparison of the $H\alpha$ and He I region.

Low-Resolution Blending: Gaia XP and LAMOST capture the macroscopic flux distribution but severely blend adjacent lines into broad absorption troughs.

High-Resolution Precision: VUES captures the true, un-smearred depth of the line cores and extended Stark-broadened wings required for accurate surface gravity determinations.

Future Directions

Quantitative Spectrometry: Perform comprehensive NLTE atmospheric fitting utilizing the TMAP framework on both the LAMOST and MAO spectra to derive precise physical parameters (T_{eff} , $\log g$, $\log Y$).

Photometric Re-evaluation: Conduct targeted VOSA SED modeling for LAMOST and MAO spectra to definitively reassess the source of the reported infrared flux excess.

Survey Expansion: Extend this multi-resolution benchmarking pipeline to a larger, statistically significant subset of anomalous hot subdwarfs identified by our neural network framework.

References & Acknowledgements



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