Quantifying Optical Cool Dwarf Model Systematics and a New Photometric [Fe/H] Relation

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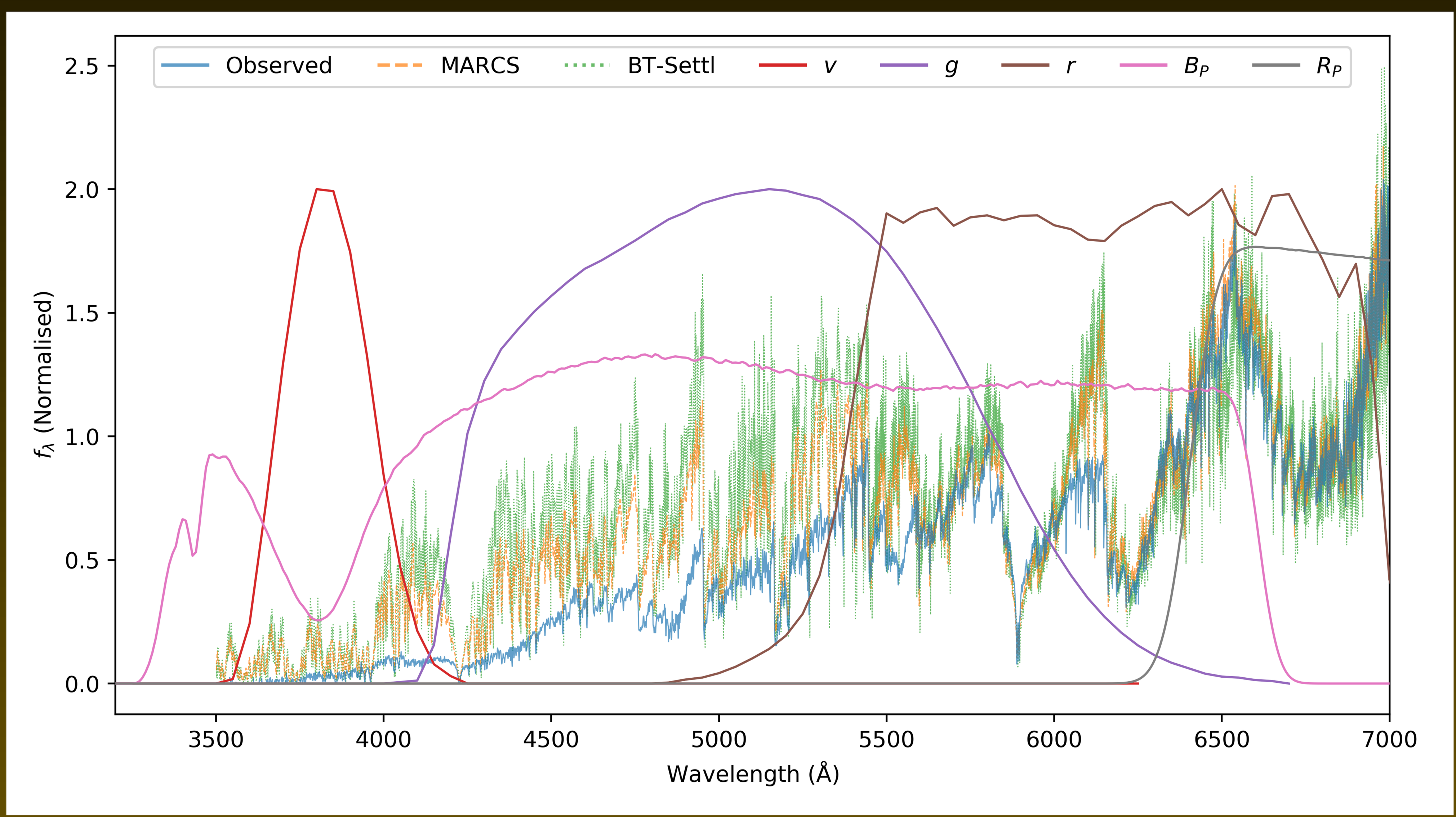
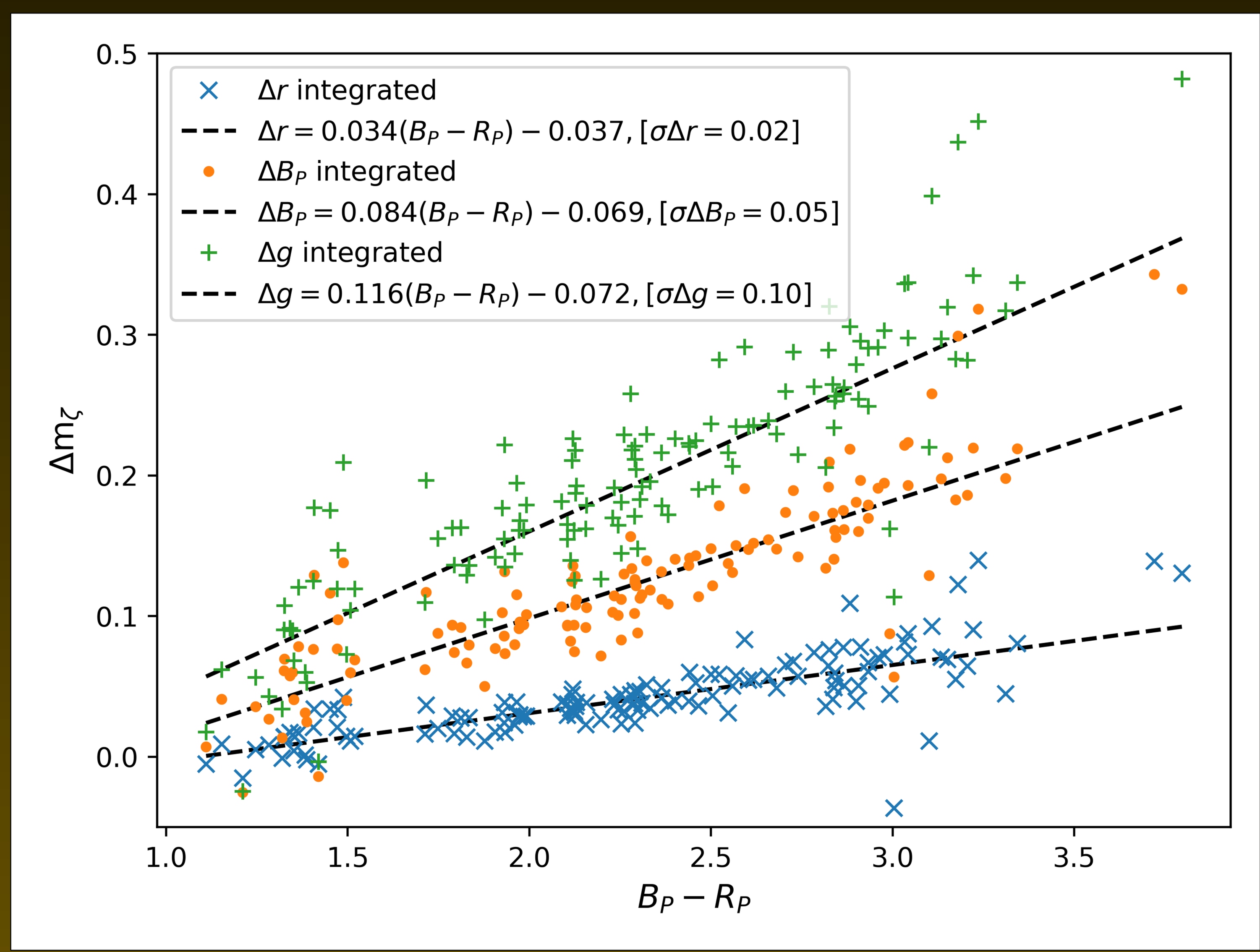
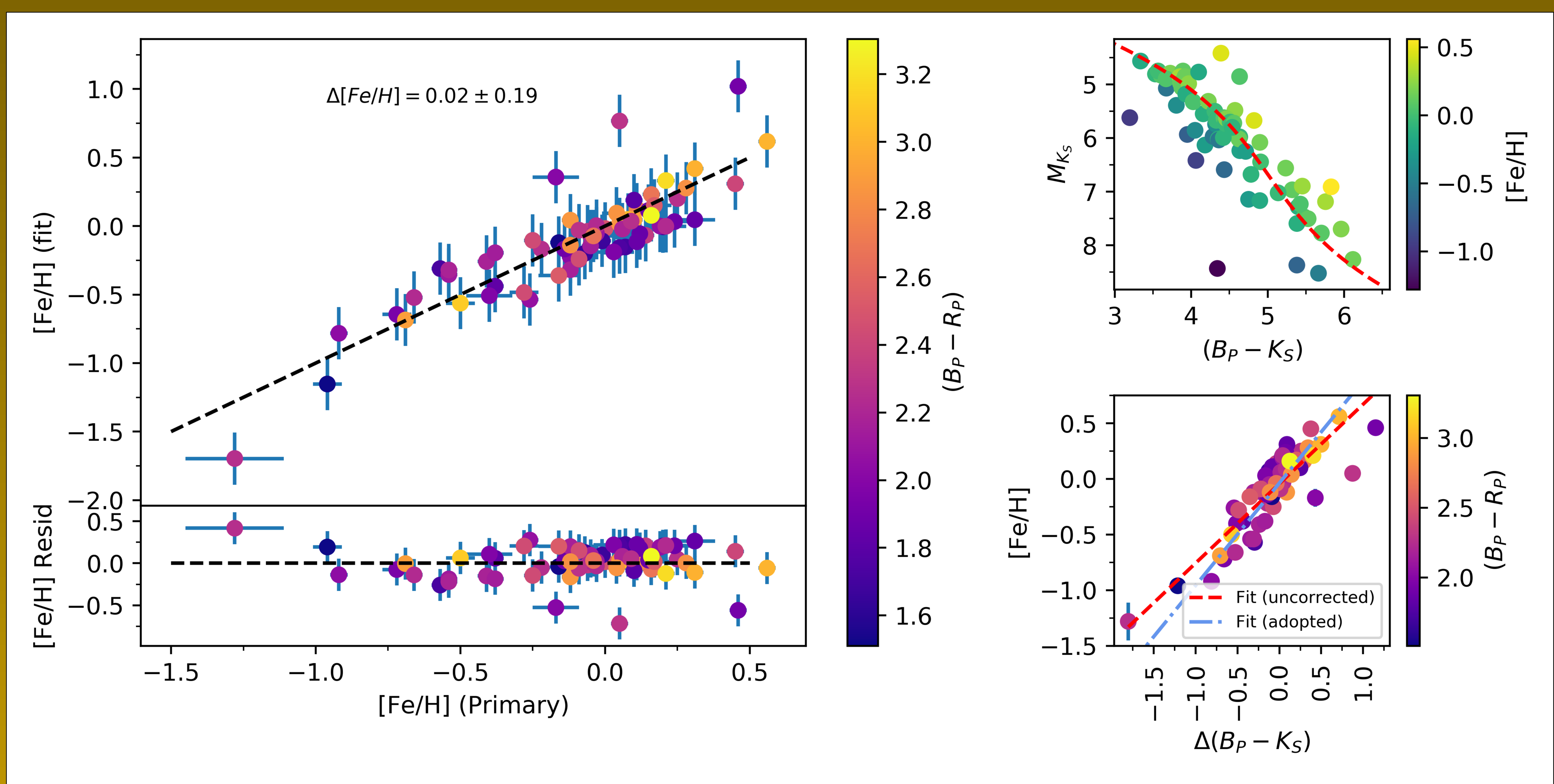
In Rains et al. 2021 (arXiv:2102.08133) we conducted a medium resolution optical (3,500 < λ < 7,000 Å) spectroscopic survey of 92 cool (3,000 ≲ T_{eff} ≲ 4,500 K) southern TESS candidate exoplanet hosts and 136 cool dwarf standards using WiFeS on the ANU 2.3 m Telescope. As part of our model-based fitting methodology, we conducted an investigation into MARCS model atmospheres and found they systematically overestimate flux the cooler the star and bluer the wavelength. In addition, we developed an updated photometric [Fe/H] calibration with Gaia+2MASS photometry for isolated main sequence stars precise to ±0.19 dex. This was built upon a calibration sample of 69 cool dwarfs in binary systems with a hotter FGK companion, valid from super-solar to metal poor, and over 1.51 < Gaia B_P–R_P < 3.3.



Flux calibrated WiFeS spectra for GJ 447, along with a MARCS synthetic spectrum interpolated to the parameters from Mann et al. 2015 (T_{eff}=3192 K, log g=5.04, [Fe/H]=-0.02), and a PHOENIX/BT-Settl spectrum at the closest grid point available (T_{eff}=3200 K, log g=5.0, [Fe/H]=0.0). SkyMapper *v*, *g*, *r*, and Gaia B_P and R_P filters are overplotted for reference. Note the severe model disagreement below ~5,500 Å.



Standard star offsets in B_P, *g*, and *r* for integrated WiFeS vs MARCS spectra at literature parameters, plotted as a function of observed Gaia B_P–R_P. Redder stars have systematically more synthetic flux at blue wavelengths, with the best fit linear magnitude offset plotted for each filter, and the standard deviation in magnitude noted.



Left: [Fe/H] calculated from our calibration vs [Fe/H] from the primary star, colour coded by Gaia B_P–R_P. The standard deviation of the residuals, and our adopted uncertainty for the relation, is ±0.19 dex. **Top Right:** M_{K_S}–(B_P–K_S) colour magnitude diagram for our sample of cool dwarf secondaries colour coded by host star [Fe/H]. The dashed red line is a third order polynomial representing the main sequence, fitted to the Mann et al. 2015 sample of cool dwarfs. **Bottom Right:** Fitted [Fe/H] as a function Δ(B_P–K_S) offset from the mean main sequence polynomial.

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