Data Driven Optical Cool Dwarf Chemistry & the Giant Planet–[Fe/H] Correlation

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Detailed chemical studies of Solar-type stars have long been routine in stellar astrophysics, making possible studies in Galactic chemodynamics and exoplanet demographics. However, a similar understanding of the chemistry of M and late-K dwarfs—the most common stars in the Galaxy and most likely to host planets—has been greatly hampered by the complex molecular chemistry of their cool atmospheres. Here we present a new implementation of the Cannon, a data-driven model widely used in stellar spectroscopy, developed here for optical cool dwarf spectra. Our novel fourparameter model in T_{eff} , log g, [Fe/H], and [Ti/H] handles both label uncertainties and missing labels, and is trained on 121 cool dwarf benchmarks—21 of which have literature [Ti/H] measured from a warmer binary companion. Under leave-one-out cross-validation we recover T_{eff} , [Fe/H], and [Ti/H] with precisions of 2%, ±0.12 dex, and ±0.09 dex respectively, allowing insight into the giant planet–[Fe/H] correlation for our sample of 61 TESS candidate planet hosts.



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V ABAD of ABAD	Gl 908, <i>T_{eff}</i> = 3600 K, [Fe/H] = -0.49, (<i>BP</i> – <i>RP</i>) = 2.10		
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V	Gl 173, <i>T_{eff}</i> = 3578 K, [Fe/H] = +0.06, (<i>BP</i> – <i>RP</i>) = 2.25		
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V	LP 837-53, <i>T_{eff}</i> = 3524 K, [Fe/H] = +0.38, (<i>BP</i> – <i>RP</i>) = 2.40		
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V	GI 581, <i>T_{eff}</i> = 3360 K, [Fe/H] = -0.14, (<i>BP</i> – <i>RP</i>) = 2.57		
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V	Gl 876, <i>T_{eff}</i> = 3318 K, [Fe/H] = +0.23, (<i>BP</i> – <i>RP</i>) = 2.82		
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· · · · · · · · · · · · · · · · · · ·	GI 699, $T_{eff} = 3200 \text{ K}$, $[Fe/H] = -0.44$, $(BP - RP) = 2.84$		
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V.	GI 166 C. $T_{eff} = 3106$ K. [Fe/H] = -0.29. (BP - RP) = 2.99	Υ	



Cannon performance for combined ANU 2.3 m Telescope/WiFeS blue (4000 < λ< 5400 Å, R~3000) and red (5400 < λ< 7000 Å, R~7000) arm spectra showing superior flux recovery at blue wavelengths compared to current generation grids of synthetic spectra (see Rains+2021, MNRAS, 504, 5788). Vertical red bars correspond to telluric features, stellar emission, or detector artefacts not included in the model.



Cross validation performance for label recovery in T_{eff} , [Fe/H], and [Ti/H] for our 121 stellar benchmarks consisting of stars with interferometric or fundamentally calibrated T_{eff} , abundance measurements from a wide binary companion of spectral type F/G/K, or [Fe/H] determined from empirical relations based on low-resolution NIR spectra. The precision of our [Ti/H] recovery hints at optical spectra of cool stars being a powerful and as-yet-untapped resource for studying the chemistry of our Galaxy and the demographics of planets. Histogram of stellar [Fe/H] for confirmed and candidate exoplanet hosts for stars both with and without large ($R_P > 2.5 R_{\oplus}$) planets detected by TESS. Each bin has Poisson uncertainties overplotted.











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