MODELING STELLAR PARAMETERS FOR HIGH RESOLUTION LATE-M AND EARLY-L DWARF SDSS/APOGEE SPECTRA

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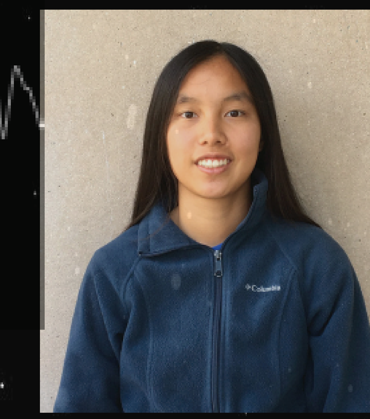


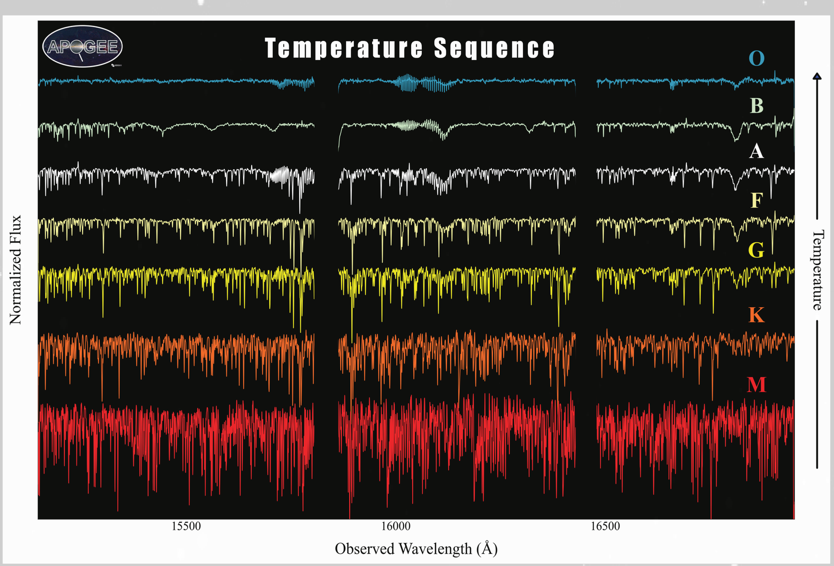
Abstract

The Apache Point Observatory Galactic Evolution Experiment (**APOGEE**) of the Sloan Digital Sky Survey IV has measured high resolution (**R~22,500**), near-infrared (**1.51-1.70 µm**) spectra for nearly 100,000 stars within the Milky Way Galxy [1]. While the APOGEE experiment was originally designed to research Galactic structure by targeting bright stellar populations in the disk, we have focused attention on the lesser-studied subset of faint and low-temperature **late-M and early-L dwarfs**, with the objective of characterizing their chemical abundances. Using spectral sythesis routines from the **Starfish package** [2], we report preliminary determinations of Teff, logg, and [Fe/H] for a small sample of spectra using PHOENIX models [3]. We also compare these PHOENIX fits to low-resolution data from the SpeX Prism Library [4] fitted by BT-Settl models.

Background

SOURCES - our sample is comprised of the coldest stars observed by APOGEE; **25 M5 - L3** spectral type dwarf targets were chosen by cross-matching with four very low mass star catalogs (see poster by Aganze et. al.).

CHALLENGE - many overlapping features for spectra of this low temperature and high resolution make it difficult to derive chemical abundances, so spectral synthesis is preferable over equivalent width measurment [5].



[6]

STELLAR PARAMETERS

Teff - Effective Temperature
Logg - Surface Gravity
[Fe/H] - Iron abundance

Spectral Synthesis with Starfish

MODELING TOOLS - Models were generated using the **Starfish package**; a routine which uses Principal Component Analysis and forward modeling to synthesize best fitting parameters from a library of pre-computed model grids. [2]

PHOENIX MODELS - We used a library of PHOENIX grid models [3] ranging over
Teff: [2300, 3000]
logg: [4.5, 5.5]
[Fe/H]: [-1.5, 0.0].

FITTING - Markov Chain Monte Carlo (MCMC) optimization was run for **10,000 samples** on six separate bands; also optimized radial (**vz**) & rotational velocity (**vsini**).

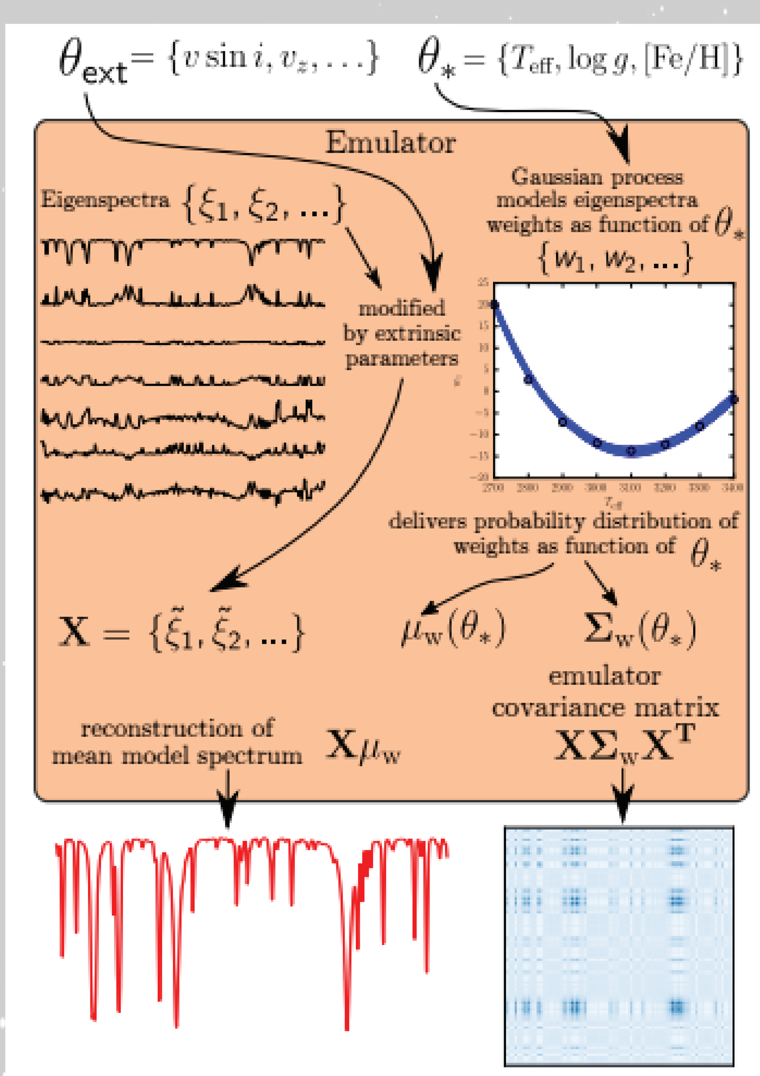
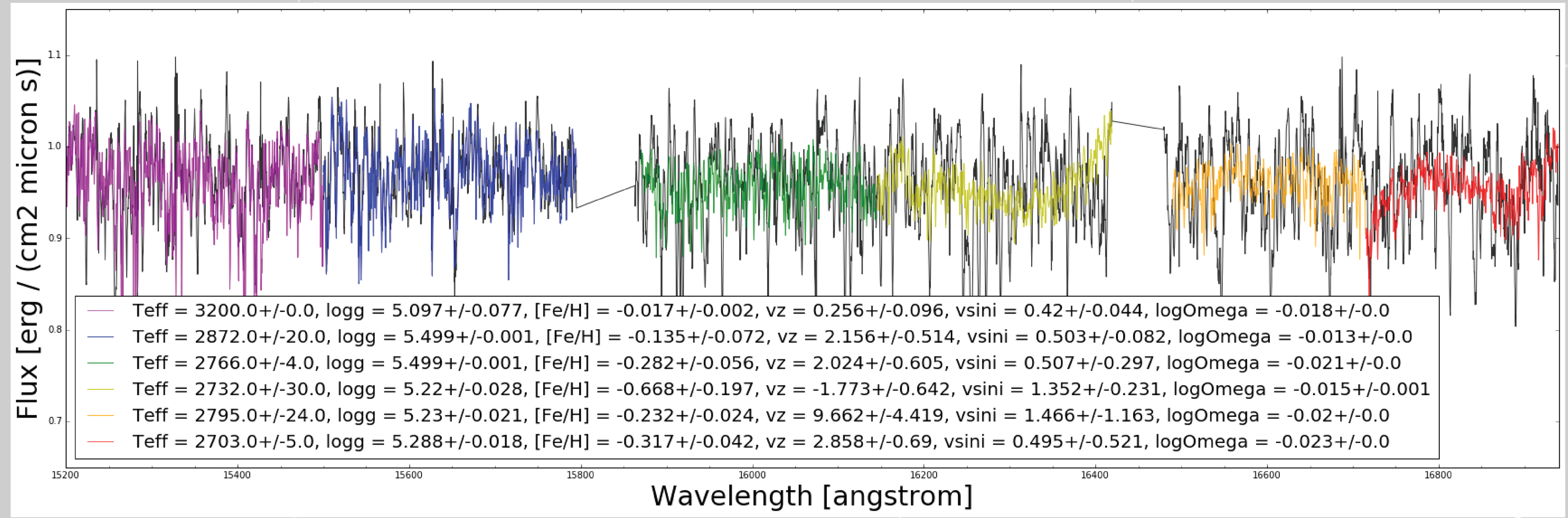


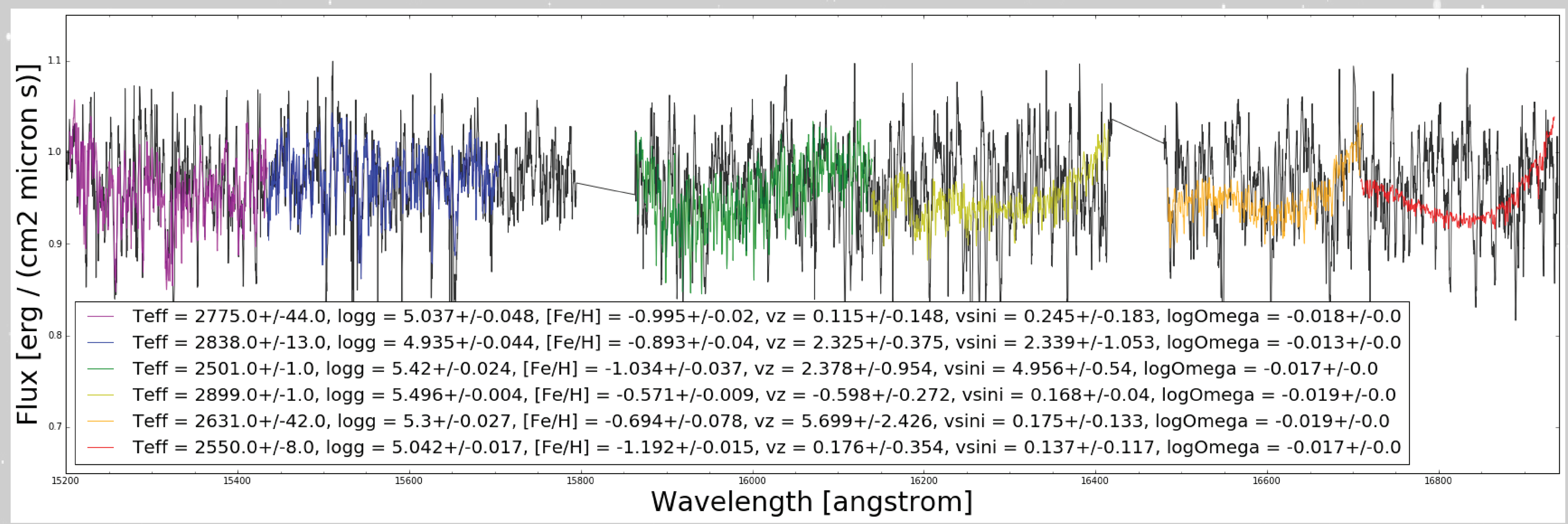
Figure from Czekala et al. (2014)

Model Fits and Derived Parameters

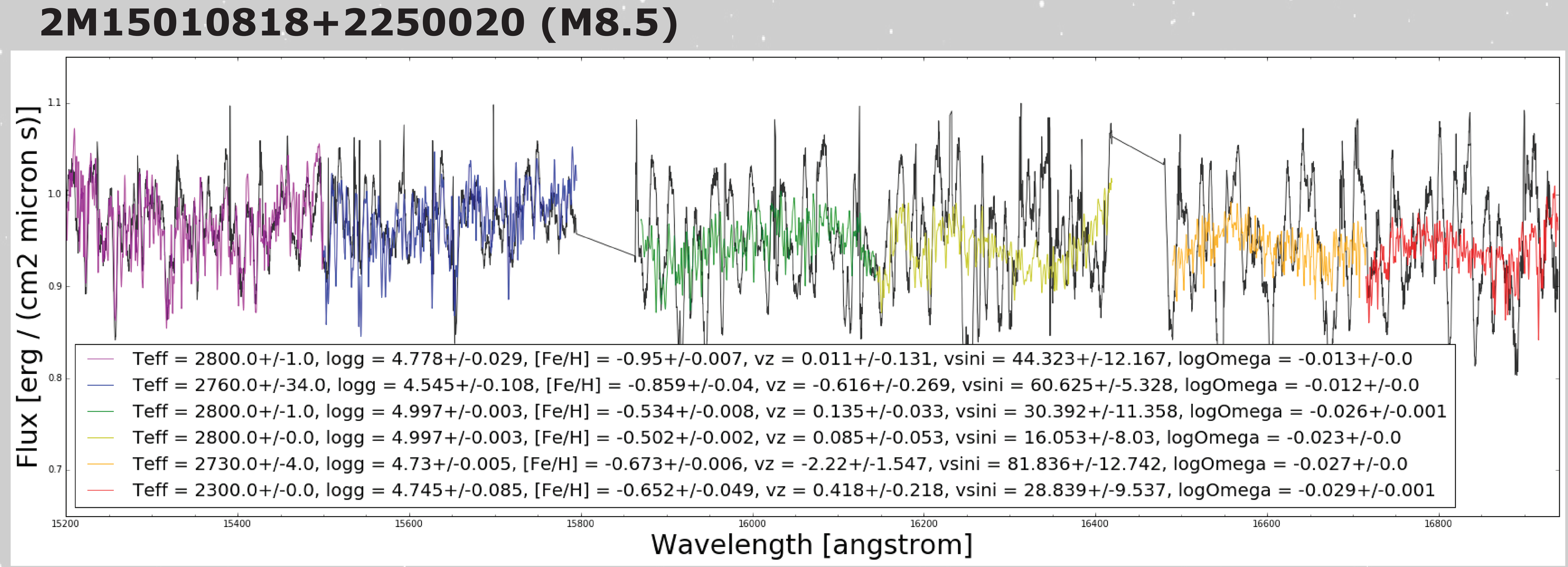
2M19535443+4424541 (M5.5)



2M03122509+0021585 (M7)

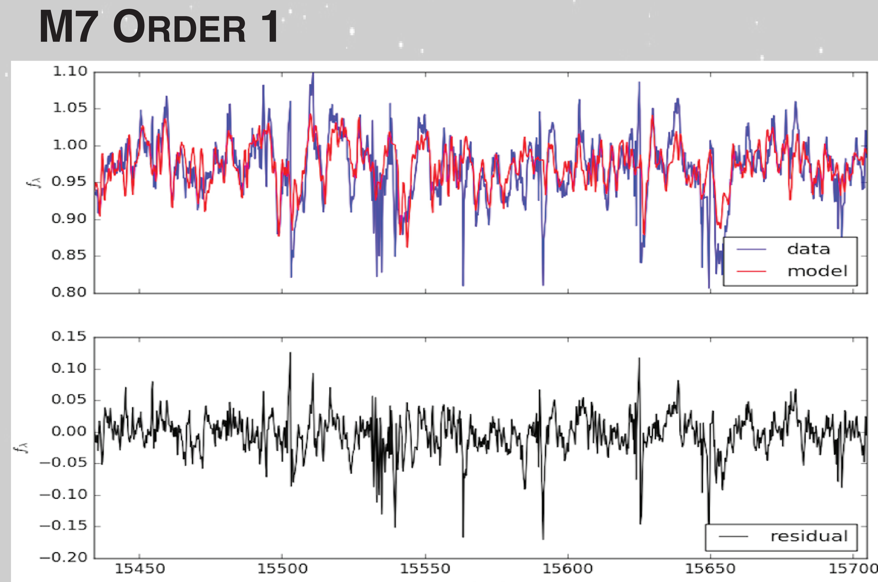


2M15010818+2250020 (M8.5)



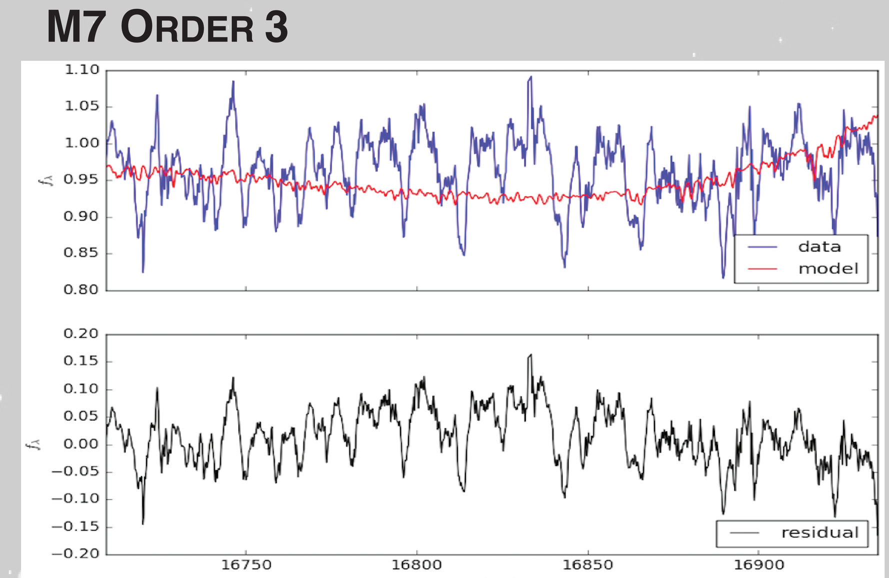
Good Fit

M7 Order 1



Bad Fit

M7 Order 3

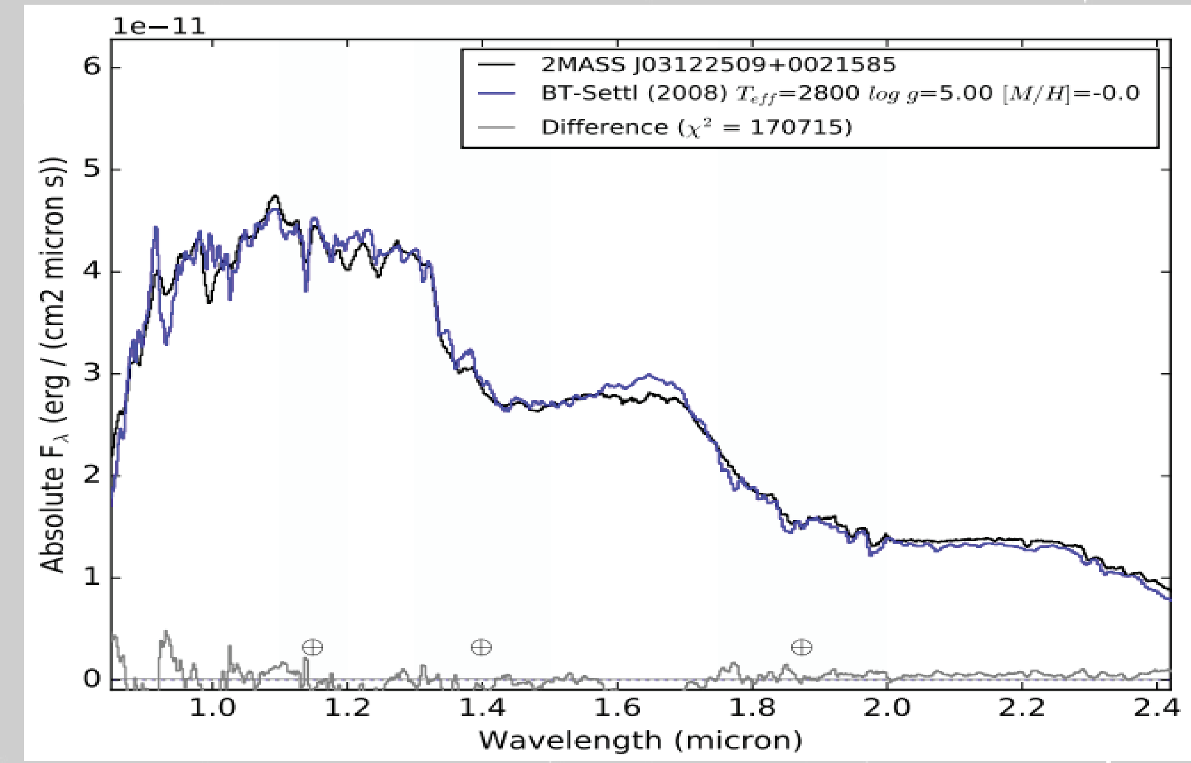


Parameter Summary

APOGEE ID	SPT	DIST (pc)	TEFF (K)	LOGG (cgs)	[Fe/H]	VZ (km/s)	VSINI (km/s)	Low-res [Teff, logg, [M/H]]
2M19535443+4424541	M5.5	~4 [8]	2872 +/- 20	~ 5.5	-0.1 +/- 0.1	2.9 +/- 0.5	0.5 +/- 0.1	N/A
2M03122509+0021585	M7	~24.9 [9]	2838 +/- 13	~ 4.9	~ -0.9	50.3 +/- 0.4	2.3 +/- 1.1	[2800, 5.0, 0.0]
2M15010818+2250020	M8.5	~19.9 [9]	2760 +/- 34	4.5 +/- 0.1	~ -0.9	-5.6 +/- 0.3	60.6 +/- 5.3	[2200, 4.5, 0.0]

Low Resolution SpeX Model Fits

2M03122509+0021585 (M7)



- We compared PHOENIX derived parameters from APOGEE to low resolution **BT-Settl** [7] derived parameters from **SpeX Prism library** spectra [4].

Discussion

- Fits are good for first order of each spectra (1.52 - 1.58 μm), however worsen at higher wavelengths; perhaps due to missing line opacities.
- High & low res: temperatures are coming out much higher than expected for spectral type; ex: M8 fits are deriving Teff ~ 2800K, however previous analysis indicates Teff = 2398±36 [10].
- Fits are consistently converging to low metallicities not indicated by broad-band spectrum.
- Spectra required radial velocity shift of -80 km/s

Future Work

OPTIMIZATION
- Improve optimization, particularly for continuum fitting.

RADIAL VELOCITY
- Cross correlate spectra with models to accurately determine radial velocities

BT-SETTL MODELS [7]
- Use BT-Settl models with APOGEE, particularly for our colder (T < 2,300K) L dwarf targets.

LONG TERM GOALS
- Derive empirical relations between stellar parameters for very low mass stars
- Target larger sample of late-M and early-L dwarfs

References:

[1] Majewski et. al. 2015, AJ, arXiv:1509.05420
[2] Czekala et. al. 2014, ApJ, 812, 128
[3] Husser et. al. 2013, A&A, 553, 6
[4] Burgasser et. al. 2014, ASICS, 10, 1-10
[5] Souto et. al. 2016, ApJ, arXiv:1612.01598
[6] https://www.sdss3.org/dr10/irspec/spectro_basics.php
[7] Allard et. al. 2010, ASP Conference, arXiv:1011.5405
[8] Newton et. al. 2014, AJ, 147, 1
[9] West et. al. 2011, AJ, 141, 97
[10] Dieterich et. al. 2013, AJ, 147, 94

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