DETERMINATION OF FUNDAMENTAL PROPERTIES OF M-DWARFS FROM NEW MODEL ATMOSPHERES AND SPECTRA

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Why M-dwarfs and Challenges Modeling them

- M-dwarfs have cooler temperatures (between 4000 - 2500 K) relative to sun-like stars, **facilitating molecule formation throughout their atmospheres** [1, 2], forming continuum opacities which are difficult to model using **standard stellar methods traditionally designed for FGK stars** [3].
- **Generational differences in line list databases cause inconsistencies** in model spectra [4].
- **Possible unknown physics** in modeling M-dwarf stellar atmospheres.

STRENGTHS OF OUR MODEL PIPELINE:

1) We produce a **self-consistent Radiative-Convective thermochemical equilibrium grid of models which permit physical plausibility + a Bayesian retrieval framework which will permit arbitrary species abundance determinations** of **M-dwarf atmospheres**, thereby stress-testing model assumptions.
2) Our model has the **most up-to-date opacities computed with the correlated-K method**, and are flexible to modify our model spectral resolutions for a variety of datasets.
3) We **leverage the broadband molecular absorption features** occurring in M-dwarf spectra over a wide wavelength range seamlessly to infer molecular abundances over the **near-infrared** bandpass—contrary to classical stellar abundance methods which focus on narrow spectral lines at higher resolutions.
4) We primarily **focus within the low-spectral resolution (R~120) regime**, with an advantage for neglecting non-LTE effects and microturbulence.
5) Our grid model retrieval component will incorporate an open source Bayesian Inference tool with an **error covariance matrix via a Gaussian Process scheme [9]**, giving us **better control over model and data systematics and associated interpolation errors**, thereby **maximizing risk mitigation**.
6) **Our grid model pipeline will be open source** (on platforms like *Zenodo*) and allow for flexibility to include additional parameters of choice such as α/M, N/C ratio etc, in addition to providing a straightforward way of including opacity data by the user allowing for easy upgrades.

Future Work

- Benchmark our stellar model grid for M+G binaries [10, 11] with robust metallicity measurements.
- Incorporate Gaussian Process Scheme interpolator, accounting for the error covariance matrix for our fits.
- Perform Bayesian retrieval fits to estimate stellar properties and investigate model deficiencies.
- Incorporate cloud parameterizations and extend model grid to cover low-gravity cloudy M-dwarfs.

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Comparison with latest PHOENIX-ACES Models

We find that our models are not only consistent with PHOENIX-ACES [5], we also show improved fits using our grid-models owing to the latest opacity calculations. **Our approach leverages broadband molecular features (unlike traditional stellar abundance analysis approaches) to derive bulk stellar chemical properties.**

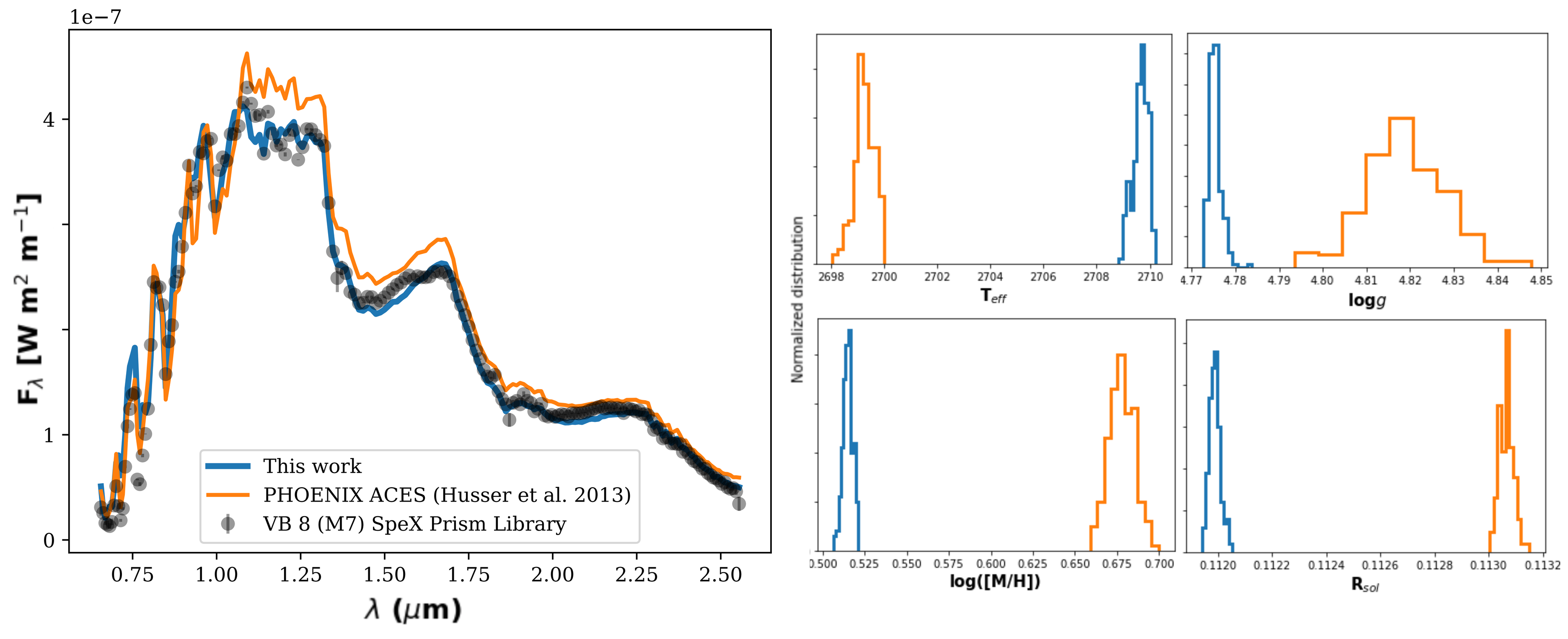

Figure 1: Comparison of fits and constraints between OUR GRID and PHOENIX-ACES [5] model grid. Here we use *Pymultinest* [6] along with a linear interpolation over an irregular grid to fit a low-resolution (R~120) SpeX Prism Library Spectrum [7] of an M7 dwarf VB-8 to **retrieve Teff (K), logg, log([M/H]), and Radius (sol),** scaling with a radius-to-distance factor $(R/D)^2$ with distances acquired from GAIA [8].

Grid Model Fits to SpeX Prism Library Data

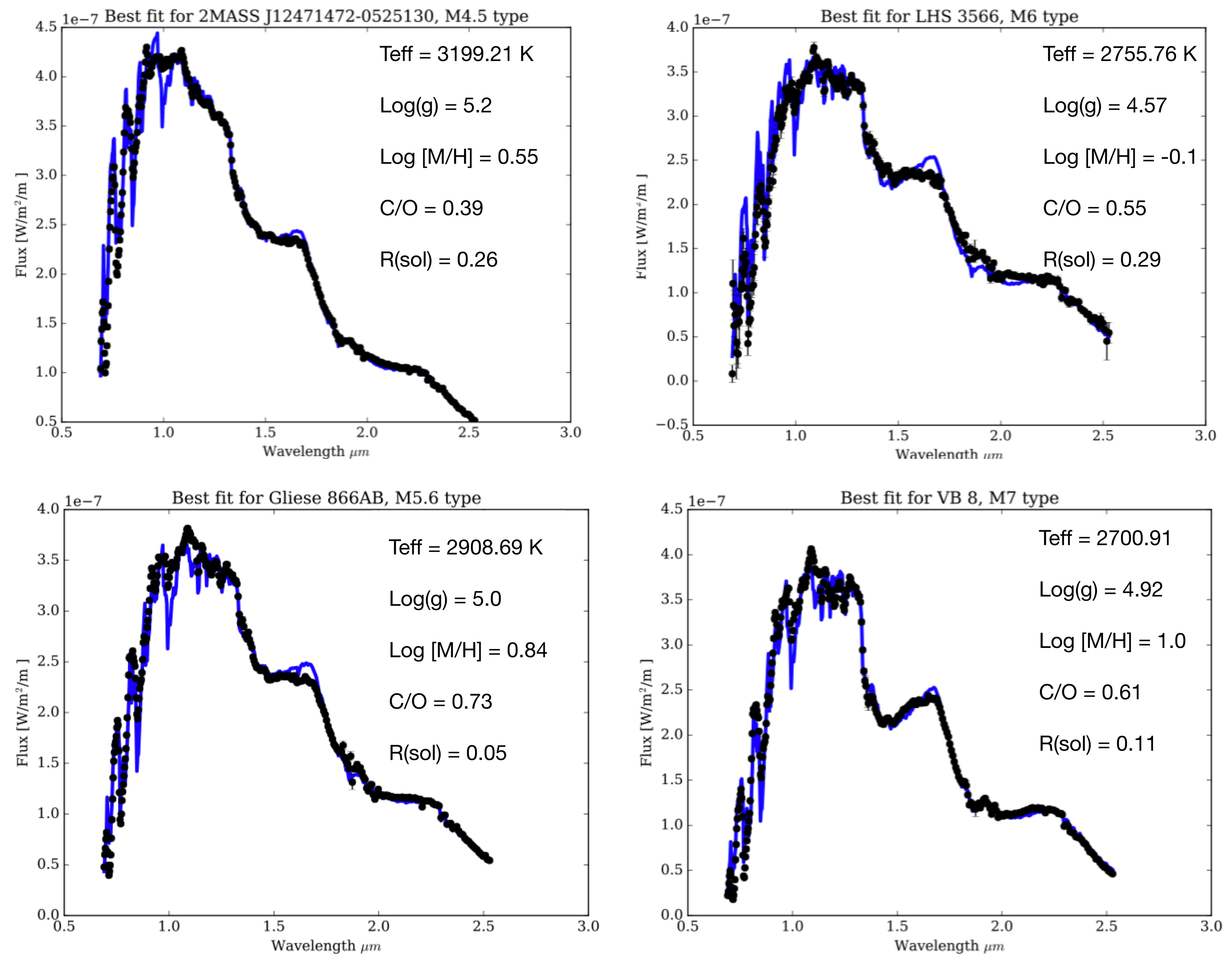

Figure 2: Preliminary Grid-model fits of M-dwarfs varying in class from M4.5—M7 from the SpeX Prism Library Database[7]. Using updated line-list opacities and with the self-consistent approach of modeling radiative-convective thermochemical equilibrium through our model grid, we are able to reasonably estimate the stellar parameters for these targets.

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