Modular Spectral Inference Framework Applied to Young Stars and Brown Dwarfs

Michael A. Gully-Santiago
Kepler/K2 Guest Observer Office at NASA Ames Research Center

Perfect Synthetic Spectral Models

If synthetic spectral models were perfect, we could use forward modeling and statistical inference to derive accurate stellar parameters for a given observed spectrum.

- data spectrum $D$
- model spectrum $M$
- stellar parameters $\theta$

The model spectrum might be hard to compute, and so you could emulate a grid of precomputed spectra, and track uncertainty.

Imperfect Synthetic Spectral Models

In practice, synthetic spectral models are imperfect, causing inaccurate estimates of stellar parameters. Czekala and collaborators (2015) recently introduced the spectral inference framework Starfish robust against some common model imperfections.

- spectrograph resolution $\theta_{\text{obs}}$
- wavelength dependent slit losses $\phi_{\text{slit}}$
- intrinsic stellar parameters $\{T_{\text{eff}}, \log g, [\text{Fe/H}]\}$
- extrinsic stellar parameters $\{\sin i, v_{\text{rot}}\}$

Emulator delivers reconstruction of model spectrum

- flexible polynomials multiply model to adjust flux calibration
- global and local kernels identify and downweight residuals in noise matrix

Starfish-derived posterior PDF

- composite draws fill a region with T and log g
- posterior fit the IGRINS data to within the uncertainties

Marley and collaborators have been producing synthetic spectral models of brown dwarfs for over 20 years (Marley et al. 1996, Morley et al. 2014). The newest grid of models, known as the Starfish grid, (Marley et al. in prep.), spans a massive multi-dimensional grid.

The combination of inference with the new Marley et al. models applied to IGRINS spectra will be transformative to accurate fundamental parameter estimation and improvement of atmospheric models for JWST.

Figure: Spectral line or bandhead outlier rejection can be built into the Starfish covariance matrix. IGRINS data will provide exceptional feedback to models.

Immiscion Grating Infrared Spectrograph (IGRINS)

IGRINS provides R=45,000 spectral resolution across the entire H- and K- near IR windows in a single shot. Its high spectral grasp and high efficiency stem from a custom Silicon Immersion Grating (Gully-Santiago et al. 2012) and VPH cross dispersers. The instrument is currently on the Discovery Channel Telescope, but will move to Gemini South starting in April 2018.

Figure: This 12.5 brown dwarf (courtesy M. Cushing) has an effective temperature less than 1300 K, approaching surface temperatures of young exoplanets. The green line on the inset shows the IGRINS data fit with a single draw from the family of Starfish-derived posteriors. This particular draw has $T_{\text{eff}} = 1275$ K and $\log g = 5.34$. IGRINS is providing the highest fidelity test of models to date.

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What’s new at K2 GO office

Guest Observer (GO) Cycle 6 proposals are due by October 12.

- New: Tutorials for data mining K2 metadata
- Fine Guidance Star (FGS) data on MAST
- Updated: PyKE is now pyraf-free; python, CLI, and API
- Experimental: Supernova lightcurves from difference imaging
- Infer color changes from PSF chromaticity
- Tools for PSF photometry adapted from FFIs
- Coming soon: Podcasts and screencasts