Characterizing Extra-Solar Planets with Low Resolution Spectroscopy

Missions.20

Emily L. Rice
erice@amnh.org
American Museum of Natural History
Ben R. Oppenheimer, Neil Zimmerman, Lewis Roberts, Sasha Hinkley
Project 1640: AMNH, Cambridge IofA, JPL, Caltech

In the next few years, several high contrast imaging instruments equipped with integral field spectrographs will allow the direct spectral characterization of a variety of companions, from low-mass stars to Jupiter-mass extra-solar planets, at Solar System-like separations (4–40 AU). The spectra obtained by these instruments will be low resolution (R~30–60), making detailed thermo-chemical analysis difficult. Therefore, we have developed a technique that quantitatively compares observed low-resolution spectra with a set of synthetic spectra in order to obtain physical parameters, such as temperature and surface gravity, quickly and robustly. The technique requires no assumptions about age, mass, radius or metallicity of the companion or the primary. I will describe this technique and demonstrate its effectiveness with simulated and observed spectra from Project 1640, the high contrast imager and integral field spectrograph on Palomar. The technique can also be used ! to optimize observing efficiency by determining the ideal wavelength range (for multi-filter instruments such as the Gemini Planet Imager) and signal to noise ratio for a desired precision and accuracy of inferred parameters. The current analysis uses the PHOENIX models as a basis for comparison, but the technique can be applied to any set of models and even used to quantify the differences between models created by different groups. This tool provides a necessary, fast, and comprehensive method of characterizing faint companions of stars, whether they be stellar, sub-stellar or planetary in nature.

Simulated Spectra

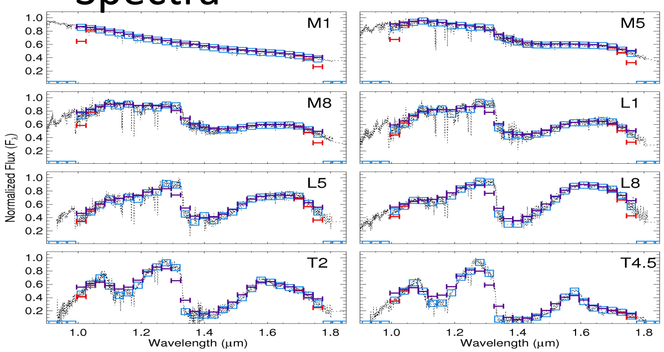

Figure 1 – IRTF/SpeX spectra from Rayner et al. 2009 (black dotted lines) binned and trimmed to match the wavelength coverage and resolution of Project 1640 (blue squares), then filtered (red bars) and corrected for edge effects (purple bars). The last two steps mimic the spectral extraction described in Zimmerman et al. 2011, astro-ph/1104.5233.

Synthetic Spectra

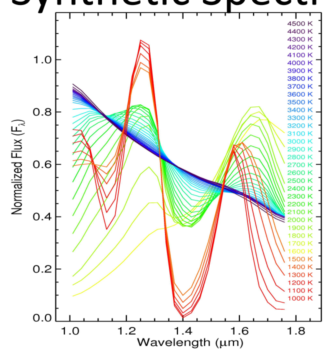

Figure 2 – Model spectra calculated with the PHOENIX code (Hauschildt et al. 1999) for a range of effective temperatures and gravities (log[g]=3.0 to 6.0) at solar metallicity.

Best Fit Spectra

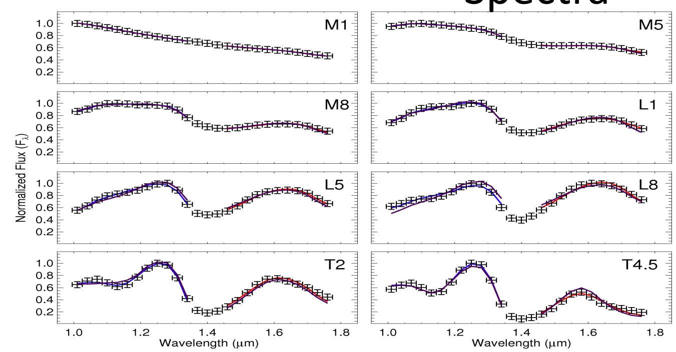

Figure 3 – Best fit spectra for three variations of each simulated spectrum: J band (blue), H band (red), and JH without the H_2O band at 1.4 μm (purple). The fits are excellent for M and early L dwarfs, but less consistent for the coolest objects. The values of the best fit parameters are shown in the figures below.

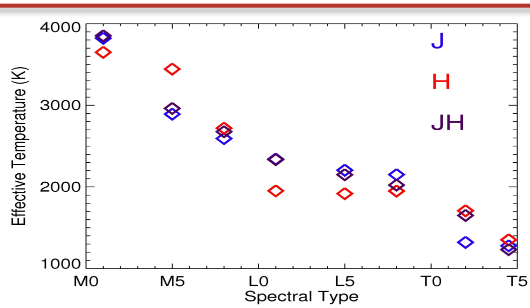

Figure 4 – Best fit effective temperatures versus spectral type for the simulated spectra as shown in Figure 3. Generally J and JH produce similar values.

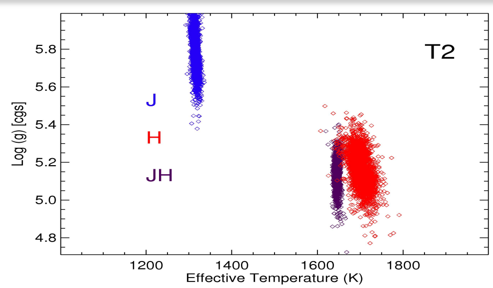

Figure 5 – Range of best fit effective temperatures & surface gravities for the T2 simulated spectrum determined via Monte Carlo methods. For this object, H & JH spectra result in similar values, and for all three spectra temperature is better constrained than gravity.

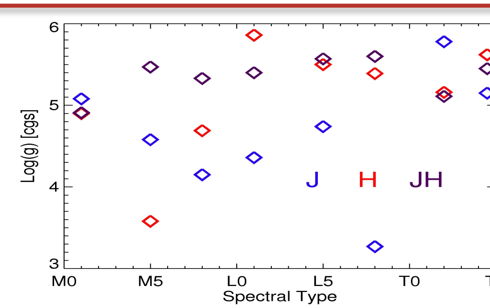

Figure 6 – Best fit surface gravity versus spectral type for the simulated spectra as shown in Figure 3. Gravity results are much less consistent than temperature.