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Spectroscopy of Companions with Project 1640

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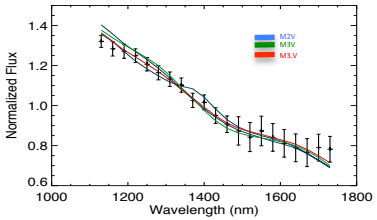
HD 129333

- A young solar analog
- RV binary from Duquenoy & Mayor (1991)
- 45 yr Orbit (Konig et al. 2005)



The data points are our measured spectrum of HD 129333B. Stars of various spectral types that fit the data well are overplotted.

Based on JK spectra, Metchev & Hillenbrand (2004) derived a spectral type of M2V±1. We derive a spectral type of M2V-M3.5V.

Abstract

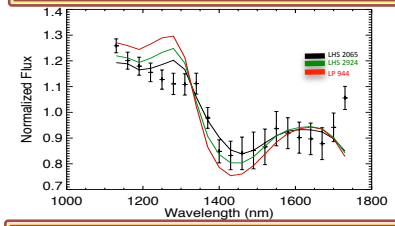
The Project 1640 instrument is designed to find and characterize young relatively luminous exoplanets and brown dwarfs. We present our spectral calibration methodology and the near-IR spectra of the late type stellar companions to three stars. These have been used to determine spectral classifications of these stars. Furthermore, we show examples of what brown dwarf spectra are expected to look like when observed with Project 1640.

Project 1640 Instrument

- Designed to find and characterize warm exoplanets and brown dwarfs.
- Mounted on the Hale 5m telescope at Palomar Observatory.
- Couples an integral field unit (IFU) spectrograph, a diffraction limited apodized Lyot coronagraph with the Palm-3000 high order adaptive optics system.
- The resulting spectra have a resolution of ~50 over a passband from 1.1 to 1.78 μm.
- Operating since 2009 with the current lower order Palomar Adaptive Optics system, will see first light with Palm 3000 in a few months.

HD 91782

- A young nearby G0V primary star
- Very little published about system



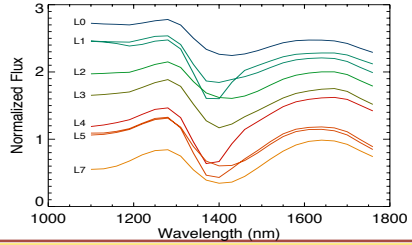
The data points are the measured spectrum of HD 91782B. Overplotted are three M9V spectra. LP 944 is a young M9V.

Data Analysis Process

- The Project 1640 IFU produces data cubes with images at 23 wavelengths from 1.1 to 1.7 μm.
- To extract a spectrum, we perform aperture photometry on each image.
- Extracted spectra are a combination of the object and the spectral response function (SRF) of the instrument and the atmosphere.
- The SRF is estimated by dividing the spectrum of the primary in the unocculted image by a template spectra of the correct spectral type from the IRTF Spectral Library.
- The object spectra is then divided by the SRF, producing the final spectra.
- This is then compared to the templates in the IRTF Spectral Library. The spectra with minimum value of sum of the squares of the residual,

$$SSE = \sum_{\lambda} w_{\lambda} (S_{\lambda} - R_{\lambda})^2$$

where, w_{λ} , is the weight (set equal to the inverse of the error bar)
S_{λ} is the spectrum at a given wavelength and R_{λ} is the reference spectrum at a given wavelength.

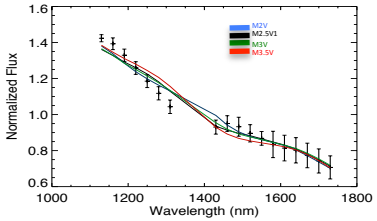


Simulated spectra for L-type brown dwarves as observed by Project 1640. IRTF spectra of L-type brown dwarves were binned and smoothed to simulate the spectra as observed by Project 1640. The spectra are offset from one another to show the details.

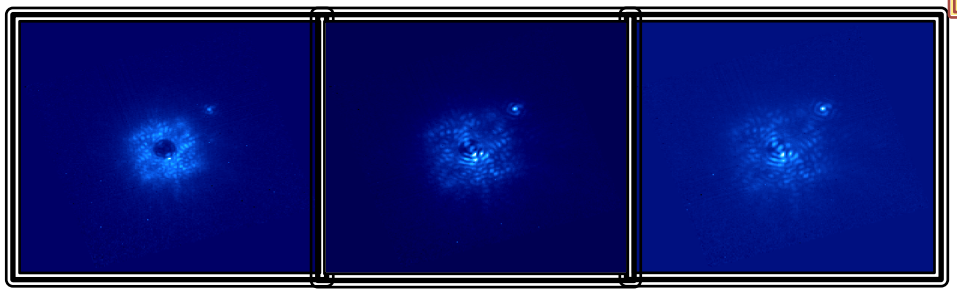
This shows that Project 1640 will be able to determine the spectral class of brown dwarfs from their spectra.

HD 112196

- A young nearby F8V primary
- Known companion (Metchev & Hillenbrand 2009)



The data points are our measured spectrum of HD 112196 B. Stars of various spectral types that fit the data well are overplotted.



Three images from an occulted HD 91782 data cube at a constant image stretch. From right to left the wavelengths are 1190nm, 1550 nm, 1700 nm. As the wavelength increases, the image quality improves, but the resolution decreases. The primary is covered by the occulting spot and only the speckles in the halo are visible.

Conclusion

Our results illustrate the power of the combination of an IFU with a coronagraph.

The agreement between our results and published results validate our data reduction process.

We have shown that Project 1640 will be able :

- Successfully spectral type late type companions
- Determine the type of brown dwarfs