SPLAT: Using Spectral Indices to Identify and Characterize Ultracool Stars, Brown Dwarfs and Exoplanets in Deep Surveys and as Companions to Nearby Stars

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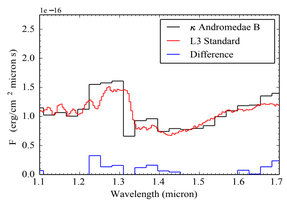
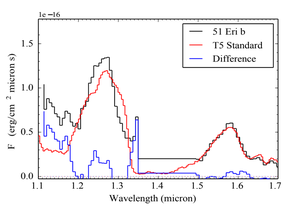
Abstract

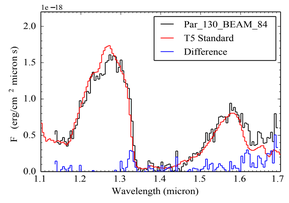
The majority of ultracool dwarf stars and brown dwarfs currently known were identified in wide-field red optical and infrared surveys, enabling measures of the local, typically isolated, population in a relatively shallow (<100 pc radius) volume. Constraining the properties of the wider Galactic population (scale height, radial distribution, Population II sources), and close brown dwarf and exoplanet companions to nearby stars, requires specialized instrumentation, such as high-contrast, coronagraphic spectrometers (e.g., Gemini/GPI, VLT/Sphere, Project 1640); and deep spectral surveys (e.g., HST/WFC3 parallel fields, Euclid). We present a set of quantitative methodologies to identify and robustly characterize ultracool dwarfs using templates and tools developed in the SpeX Prism Library Analysis Toolkit including source identification and classification using indices and template sources. We apply these techniques to HST/WFC3 parallel fields data in the WISPS and 3D-HST programs which allow us to identify late M, L and T dwarfs to distances out to ~3 kpc.

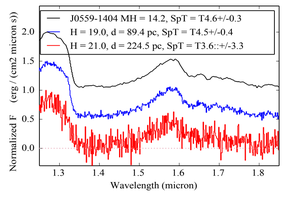
Using SPLAT tools to Analyze Exoplanet and Distant Ultracool Dwarf Spectra





- Right: GPI spectrum of 51 Eri b (Macintosh et al 2015) compared to a T5 Standard (Kirkpatrick et al. 2010)
- Left: Project 1640 Spectrum of κ Andromedae B (Hinkley et al. 2013) matched to L3 standard (Kirkpatrick et al 2010)





- Left: WFC3 Spectrum of Par_130_BEAM_84 compared to a **T5** standard (Kirkpatrick et al. 2010) discovered in the WISPS survey (Masters et al. 2012)
- Right: Generating Euclid spectra from **2MASS J0559-1404** SpeX spectrum at different apparent magnitudes and distances using the resolution and wavelength coverage defined from the Euclid Red Book (Laureijs et al. 2011)

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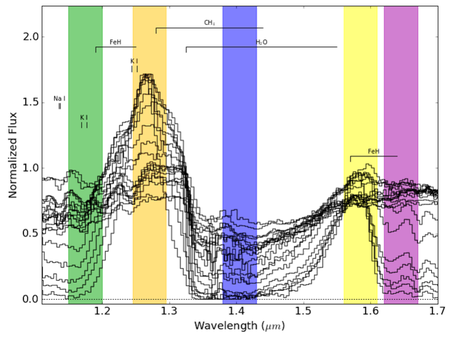
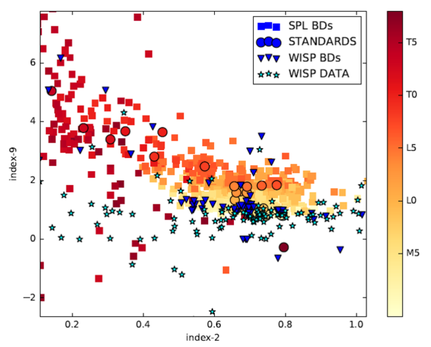
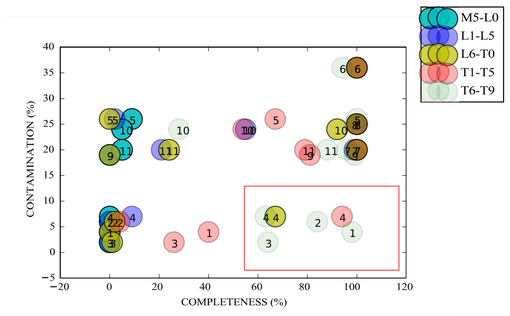
Using Spectral Indices to Find Brown Dwarfs in the WFC3 Fields from WISP and 3D-HST Surveys



- Left: Plot showing spectral bands used to define 10 NIR indices, highlighting main CH4 and H20 features in brown dwarfs, data: SPL
- Right: Plot of **Index-2 vs Index-9** showing sources from SPL, WISP brown dwarfs and all WISP spectra from field 58



Plot showing **contamination and completeness** factors for 11 selection criteria (selected from 45 index vs index plots). Colors help differentiate different spectral ranges. The best criteria are boxed in red



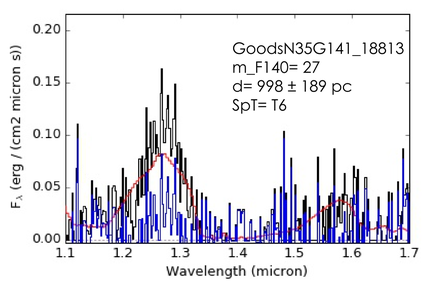
We defined 10 NIR spectral indices between 1.1-1.7 μm to sample H_2O and CH_4 features

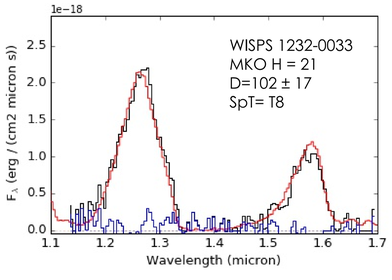
- We plot pre-indentified WISP brown dwarfs and SpeX spectral templates from SpeX Prism Library (SPL) (Burgasser 2014) on **45 index vs index plots** and use different shapes as selection criteria.
- We find **11 selection criteria** for which we compute completeness and contamination factors defined as

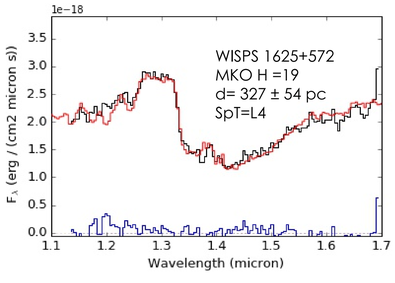
$$Contamination = \frac{[\#WFC3\ selected\ spectra] - [\#WFC3\ selected\ spectra\ that\ are\ MLT\ dwarfs]}{[\#WFC3\ spectra\ total\ in\ all\ fields]} * 100$$

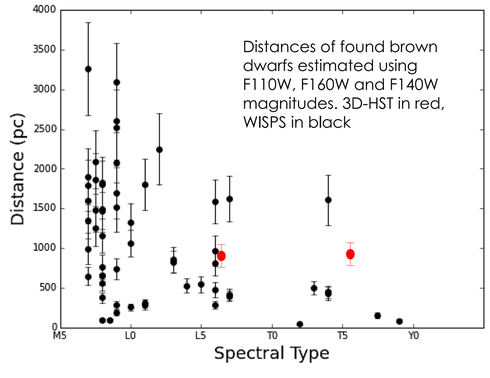
$$completeness = \frac{\#SPL\ templates\ selected}{\#of\ SPL\ templates} * 100$$

Results and Future Work









- We found **~50 brown dwarfs** by searching ~300 fields in the WISP Survey , and ~2 brown dwarfs in the 3D-HST fields after searching ~20 northern fields
- Future work includes
  - Quantifying selection effects: **overlapping spectra, determine robust detection limits**
  - Expanding analysis to **include G102 spectral data**
  - Identifying subdwarfs using **subdwarf standards**
  - **MCMC fit of Galaxy disk and halo models** to the number of brown dwarfs found, spectral types and distances