JHKW1W2 Colors and their Utility on Finding M/L+T Spectral Binaries

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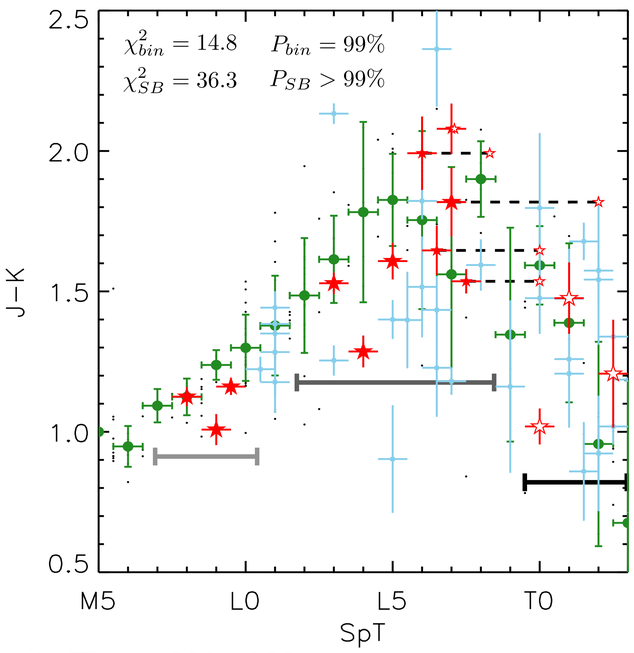
The SEDs of late-M and early-L dwarfs peak in the NIR and have a negative slope in the MIR at W1 and W2 bands, while T dwarfs show more molecular features and peak at W2. An unresolved spectral binary (SB) of late-M/early-L plus T-dwarf components should have different colors than a single dwarf of the same spectral type (SpT) as the primary. In this experiment, we explore whether colors combining NIR and MIR bands can identify binaries. We find that color/SpT plots are more effective than color/color plots at separating confirmed spectral binaries (★) from the average color at each SpT (•). J-K color increases with later SpTs and turns over at the L/T transition, while W1-W2 color increases steadily with later SpTs.

Sample Selection and Analysis

We used the sample of 2MASS *JHK* and WISE *W1W2* photometry of 350 known MLT dwarfs from Kirkpatrick et al. 2011 and combined it with the *JHKW1W2* photometry of 51 spectral binaries (Bardalez Gagliuffi et al. 2014). We then calculated all combinations of colors and averages and standard deviations of the colors per spectral type for single sources. We used optical and NIR SpTs.



SpT vs. J-K

M dwarfs: SBs are bluer compared to their averages per SpT because the T dwarf companion adds more flux in *J* than in *K*.

L dwarfs: Early-L dwarfs behave like late-M dwarfs. SBs are redder than the averages because the *J* flux from the L decreases. The candidates look bluer. At the L/T transition, the cloud properties of these objects make their colors unreliable.

T dwarfs: Systems of late-L+T yield combined T SpTs. SBs are bluer than the averages because the T dwarf adds more flux in the *J* band, where both L and T components are comparably bright. The combined SpT in NIR is a later type than in the optical.

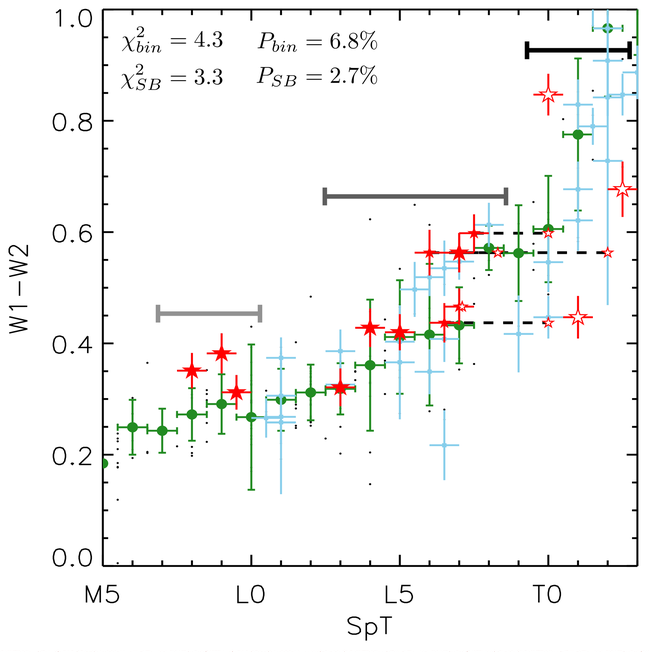
★ Confirmed SBs
★ Binaries (Opt SpT)
☆ Binaries (NIR SpT)
• Average color
SB candidates

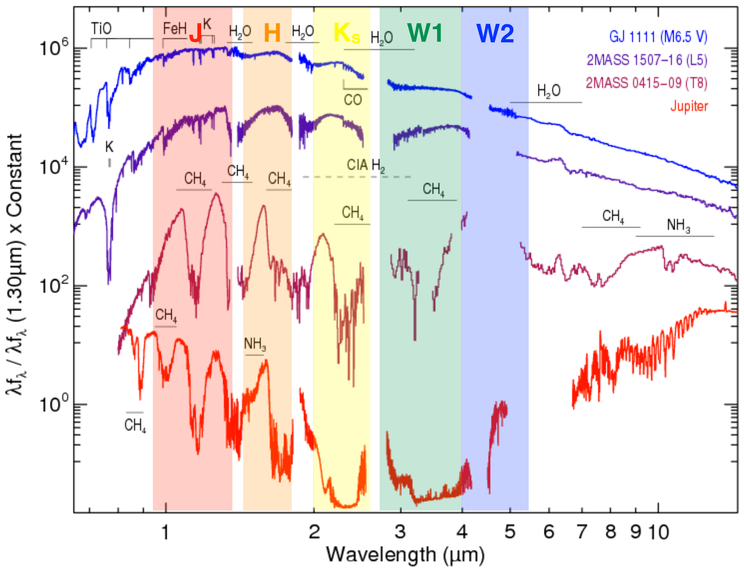
SpT vs. W1-W2

M dwarfs: SBs are redder than the averages because T dwarf adds more flux at W2 than M dwarf.

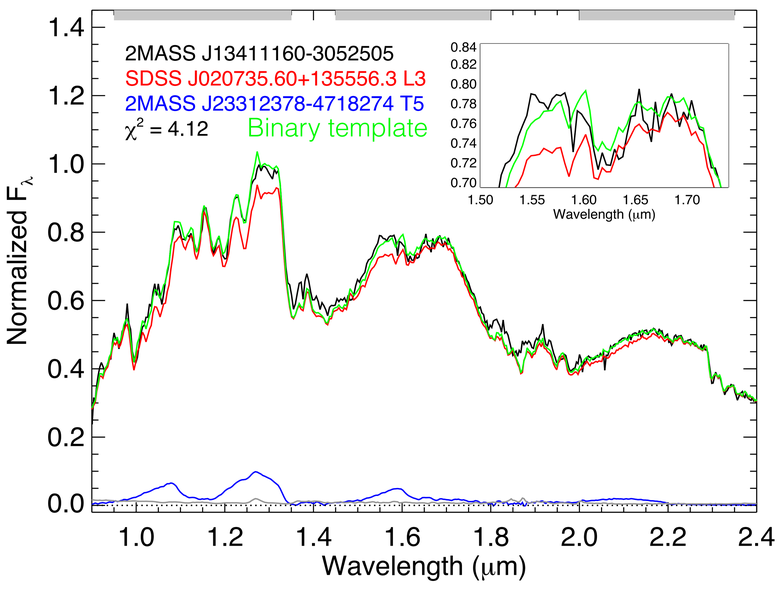
L dwarfs: SBs are slightly redder and close to the averages because while the T dwarf adds flux on W2, the late-L dwarf has a CH_4 absorption band in W1 that strengthens in later SpTs.

T dwarfs: SBs are bluer than averages at the combined optical type because the T dwarf is comparably bright as the L dwarf at W2, but the T dwarf has a deep CH_4 absorption band in W1, so adding the L onto the T dwarf leads to bluer colors. However, when compared to the NIR SpT, the SBs appear redder.





Near- to mid-infrared spectra of examples of MLT dwarfs and Jupiter from Cushing et al. 2006 with superimposed approximate *JHK* and *W1W2* bands.



SpeX spectrum of 2MASS 1341-3052, an example of an early-L plus T spectral binary recently resolved with AO, (Bardalez Gagliuffi et al., 2014; in prep.) covering *JHK* bands.

Conclusions

Our hypothesis was that spectral binaries composed of late-M/early-L (M7-L5) and T dwarfs would have bluer J-K and redder W1-W2 colors than the "model", i.e. the average colors of normal, single brown dwarfs, due to the physical processes in the atmospheres of these objects. From the chi-squared values in J-K, we cannot rule out the null hypothesis. For the case of W1-W2, we *can* rule out the null hypothesis, so this color could be useful to separate spectral binaries from single brown dwarfs.

References
Bardalez Gagliuffi et al. (2014), ApJ, 794, 143.
Cushing et al. (2006), ApJ, 648, 614.
Kirkpatrick et al. (2011), ApJS, 197, 19.
Noll et al. (2000), ApJ, 541, L75.