A Survey of L/T-transition and Peculiar Brown Dwarfs from an SDSS/2MASS/WISE Cross-match

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Abstract

We are studying a broad sample of brown dwarfs that are either in the process of sedimenting dust from their atmospheres, or have peculiar atmospheric characteristics, such as low surface gravities, metallicities, or unusual cloud properties. Our study has uncovered 25 candidate peculiar early L- to early T- dwarfs which are mostly completely new objects with only a few having been previously discovered but with no published spectra. With spectroscopic observations, we confirmed that 12 from our prioritized sample and one from our complete sample, are moderately peculiar or are potentially L/T binaries, including one which, with a J-K_s color of 2.62, is the reddest field dwarf currently known. These new discoveries come from the SDSS, 2MASS and WISE surveys which have already been subject to considerable scrutiny, demonstrating that our exploration of these surveys is not yet complete. The ultimate goal of this program is to produce a flux-complete estimate of the fraction of peculiar ultra-cool dwarfs in large-area surveys and improve our ability to classify these objects on a more finely gradated classification scheme.

Motivation

The ensemble of factors that governs the evolution of clouds and dust in substellar atmospheres necessitates samples of hundreds of objects for an empirical separation of the various phenomena. To address the limitations of our understanding of the breadth of the physical conditions in substellar atmospheres, we have undertaken a targeted study of peculiar ultra-cool dwarfs.

Our aims are: (1) to increase their sample by finding them in large-area surveys through tailored photometric search techniques, and (2) to establish a flux-limited sample of peculiar objects for their statistical and evolutionary analysis.

Method

- Our selection criteria are based on positional matches and photometric magnitudes and colors:
  - SDSS/2MASS (16.5") and SDSS/WISE (6") positional match
  - i-z > 3.0 mag or i > 21.3 mag
  - z-J > 2.0 mag
  - z-J > -0.75*(J-K_s) + 4 mag to prioritize selection of the reddest peculiar ultra-cool objects
  - H-W2 > 1.2 mag
- Follow-up observations were taken with SpeX/IRTF and FIRE/Magellan

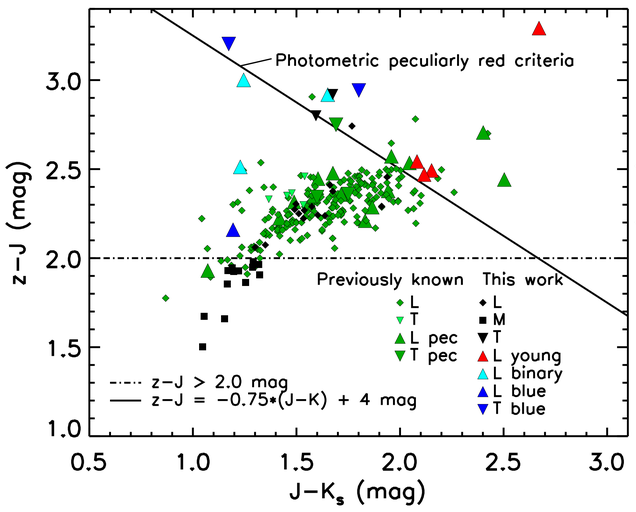

Figure 1. Spectroscopic colors of objects from the SpeX prism library[8] (green symbols) and of objects observed as part of our follow-up (other symbols). Large symbols are those confirmed to be peculiar objects, namely young, old, binary or blue objects.

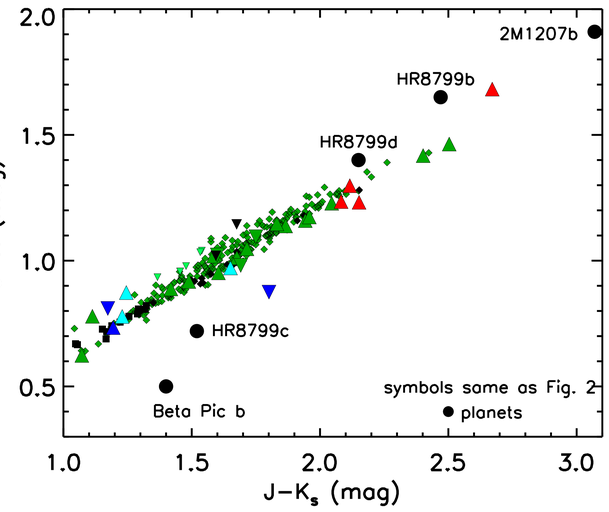

Figure 2. 2MASS photometric colors of several directly imaged planets as a comparison to the spectroscopic colors of the peculiar objects. We find that one of our blue T dwarfs and four of the red L dwarfs reside in similar locations to the planets, suggesting similar photospheric properties.

Results

- We have identified 4 young L dwarfs, 5 L/T-transition objects, 3 potential binaries and 15 M dwarfs, along with 17 "normal" L dwarfs
- We have discovered a peculiarly blue L9 or T0 object (Fig. 4) and the reddest known field L dwarf (Fig. 5) which is photometrically similar to several exoplanets
- Interestingly, we are uncovering a large proportion of normal L/T-transition objects as well
- Because the majority of our candidate ultra-cool dwarfs are low-SNR detections, they are subject to flux over-estimation bias[6], especially in the 2MASS J band. This led to the identification of an unexpectedly high number of M dwarfs which had erroneously posed as redder objects (Fig. 1).

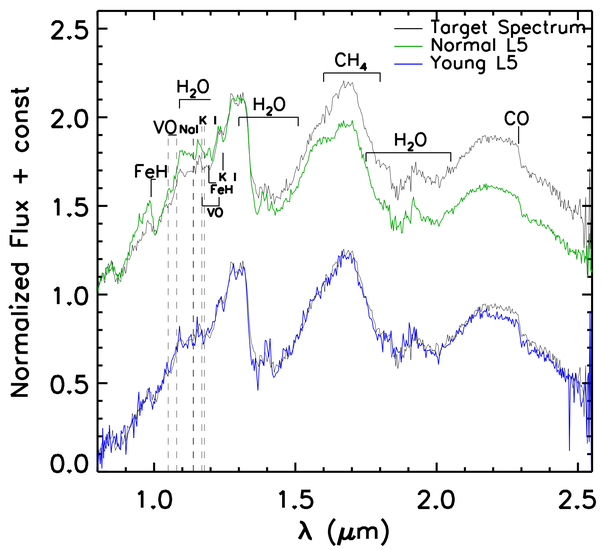

Figure 3. Red L5 with SpeX spectra of a "normal" L5 field dwarf (2M 0155+0950[5]) (top/green) and a young L5 dwarf (2M 2249+0049[4]) (bottom/blue). Low-gravity (young) features include redness in the H- and K- bands, a peaked H-band, and increased absorption of FeH , VO and potentially water.

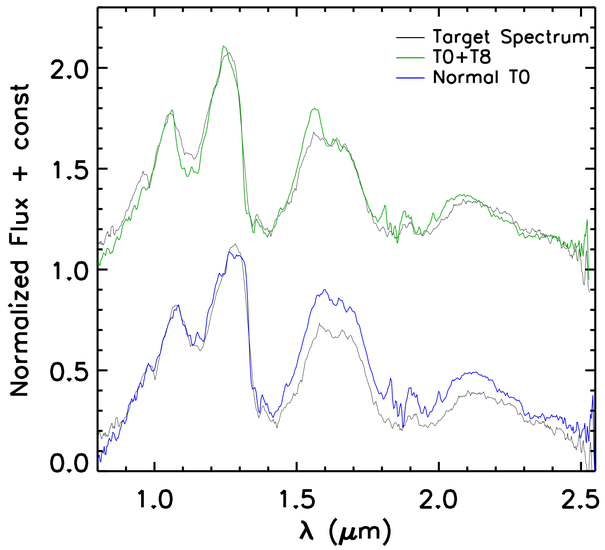

Figure 4. Blue T0 or L9 with SpeX spectra of the best fit binary consisting of a T0 (2M 1207-0244[7]) and a T8 (2M 0415-0935[1]) and a normal T0 field dwarf (2M 1207-0244[7]). This object was best fit by a T-dwarf binary but it is clearly a poor fit. This is most likely a blue L9 or T0 object. With a J-H of 0.88, this object is the blue outlier in Fig. 2.

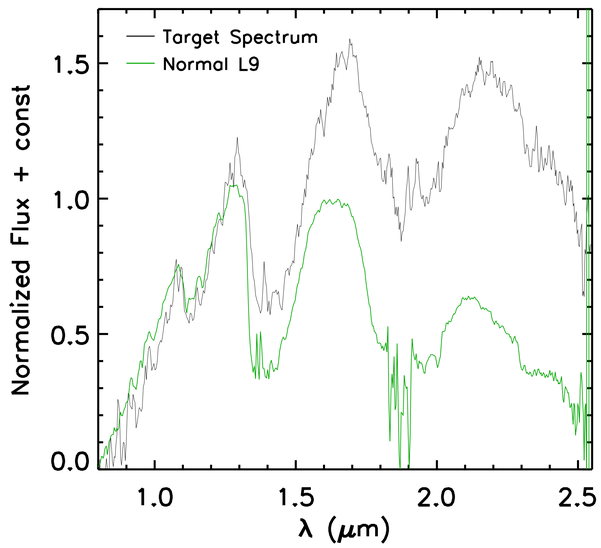

Figure 5. Red L9 with SpeX spectrum of a "normal" L9 field dwarf (DENIS-P J0255-4700[2]). This is the reddest known field object with a J-K_s of 2.62. The only ultra-cool/planetary object that has a redder color is the planet 2MASS 1207-3932 b with a J-K_s of 3.07. This object lies in the upper right corner of Fig. 2 near several planetary objects.

References:

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[3]Burgasser et al. (2007) ApJ, 659, 655
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[8](http://pono.ucsd.edu/~adam/browndwarfs/spexprism)

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