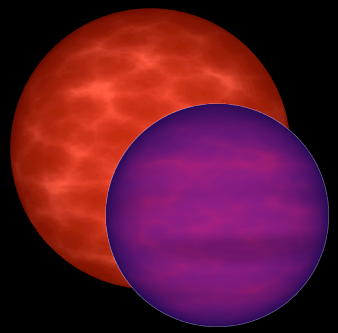
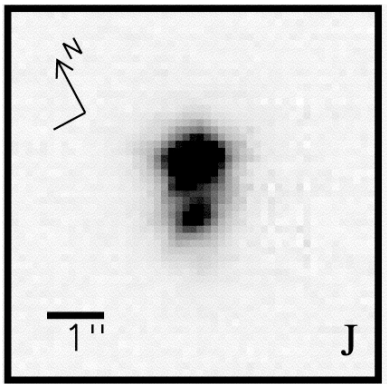

Secret Companions...
Identifying and characterizing unresolved, very low mass dwarf binaries
Adam J. Burgasser
Massachusetts Institute of Technology



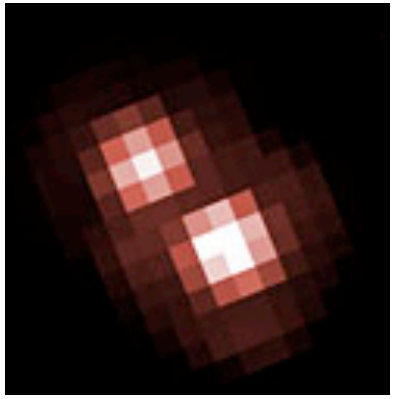
The punchline

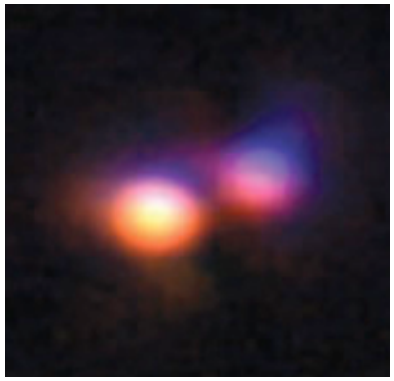
There appears to be a way to **identify and characterize very low-mass (VLM) stellar/brown dwarf binaries** without the need to resolve them using only low-resolution, near-infrared spectroscopy.

Burgasser (2008, AJ, in press); Burgasser et al. (2008, ApJ, submitted)



McElwain & Burgasser (2006)


Bouy et al. (2004)


Liu et al. (2006)

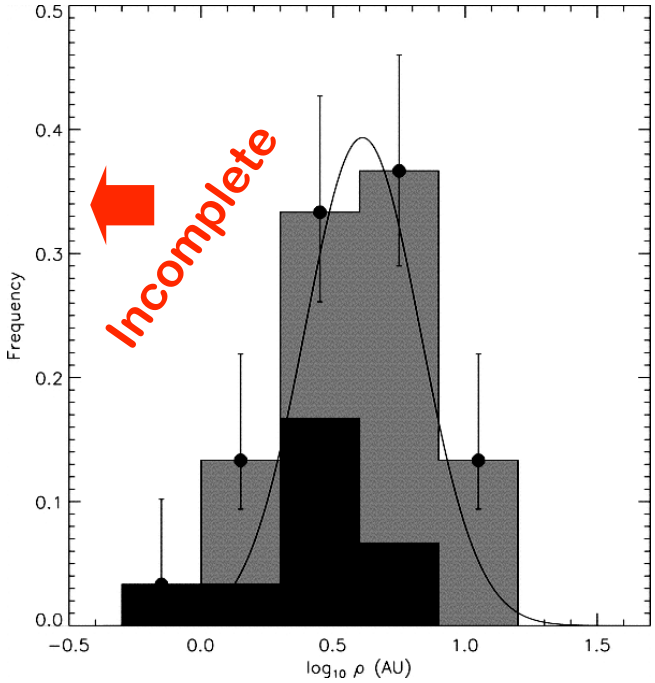
VLM Binary Science

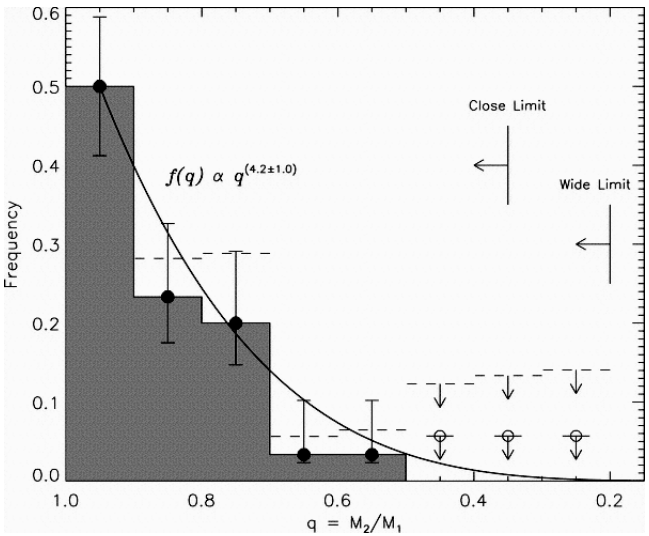
Binary statistics constrain formation mechanisms (e.g., Luhman et al. 2007)

Enable mass and radius measurements (e.g. Stassun et al. 2006)

Mini-laboratories for studying atmospheres, magnetic fields, and physical properties
(e.g., Mcelwain & Burgasser 2006)

Majority of work has been done by high resolution imaging





Burgasser et al. (2006)

VLM Binary Statistics

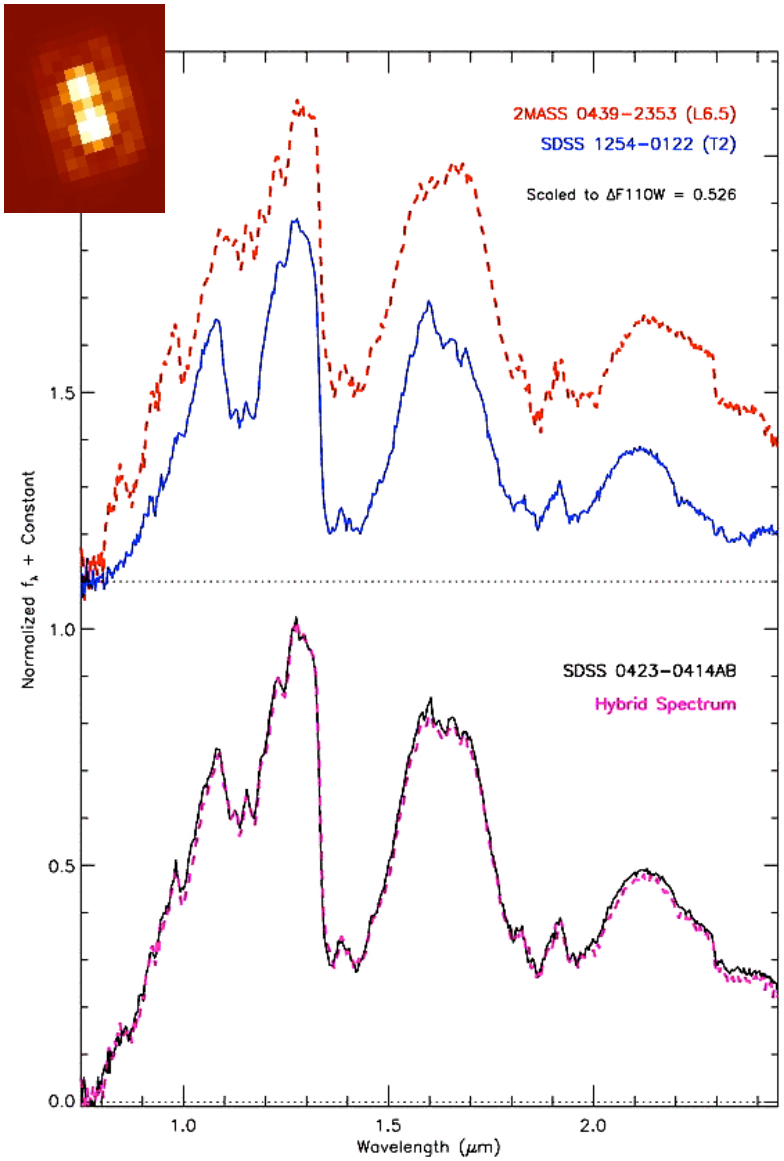
Resolved binary fraction ~ 10-20% - *true fraction may be 2x higher!*

Majority of VLM binaries are "tight"
(>90% have ρ < 20 AU)

Majority of VLM binaries are equal-mass
(<75% have q = M_2/M_1 > 0.8)

Bouy et al. (2003); Burgasser et al. (2003,2006); Close et al. (2003); Maxted & Jeffries (2005); Allen (2007)

VLM Binaries Archive: http://www.vlmbinaries.org/



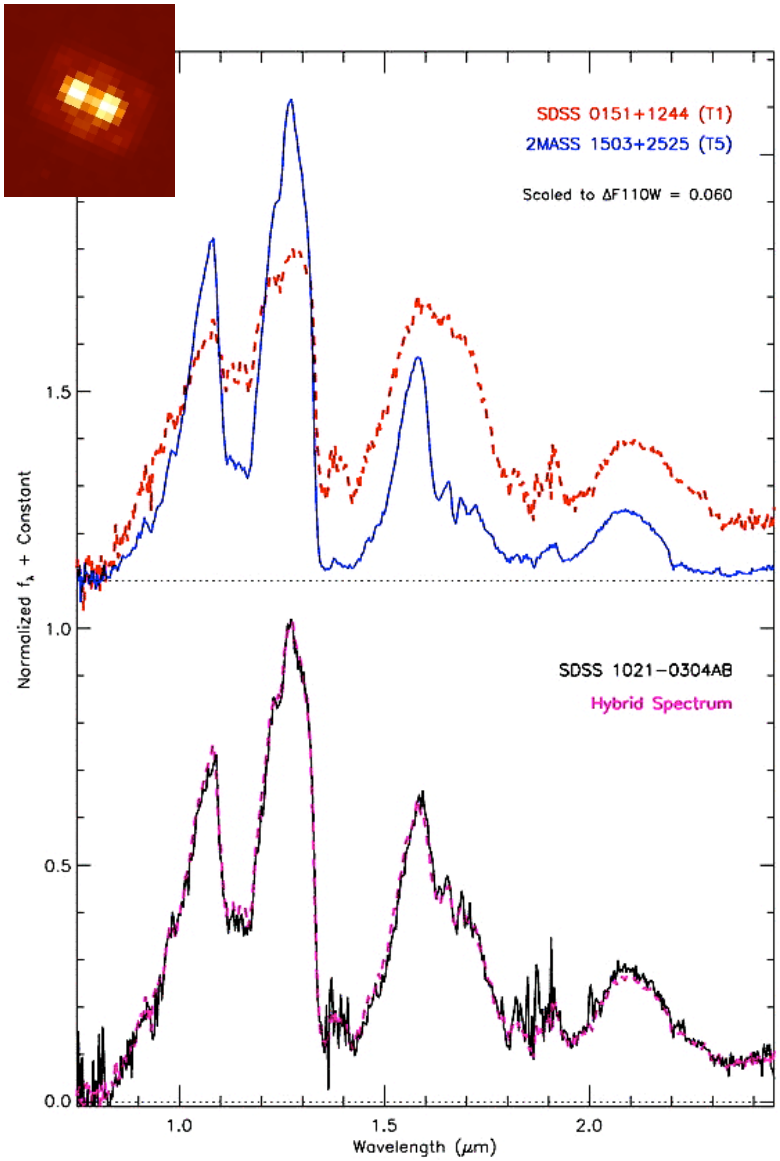
SDSS 0423-0414
(Burgasser et al. 2005,2006)

Spectral Decomposition

The complex spectra of low temperature dwarfs provide many physical diagnostics, **including multiplicity**.

We have developed a technique to characterize the components of a VLM binary based on their unresolved spectra and spectral templates.

Burgasser et al. (2006,2007); Reid et al. (2006); Siegler et al. (2007); Burgasser (2008a,2008b)



SDSS 1021-0304
(Burgasser et al. 2006)

Spectral Decomposition

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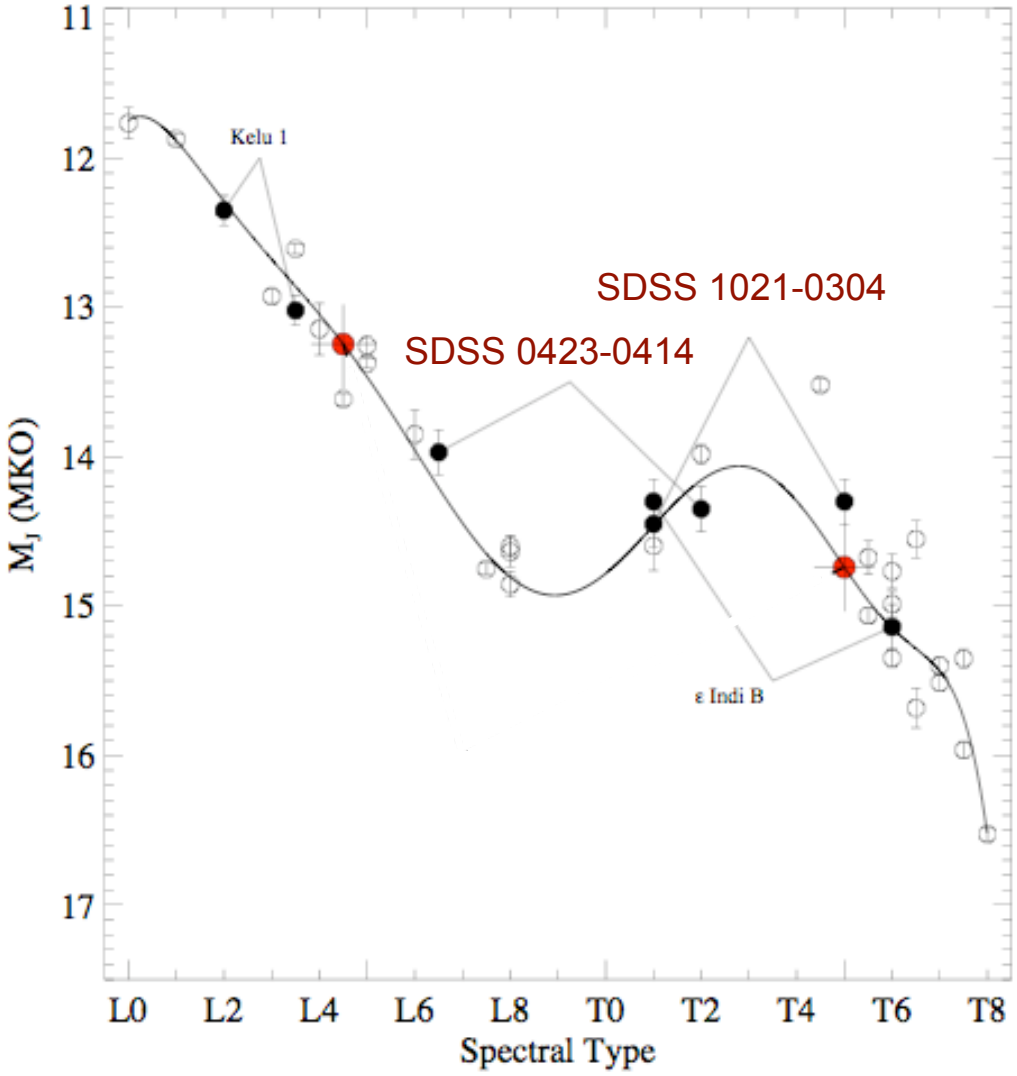
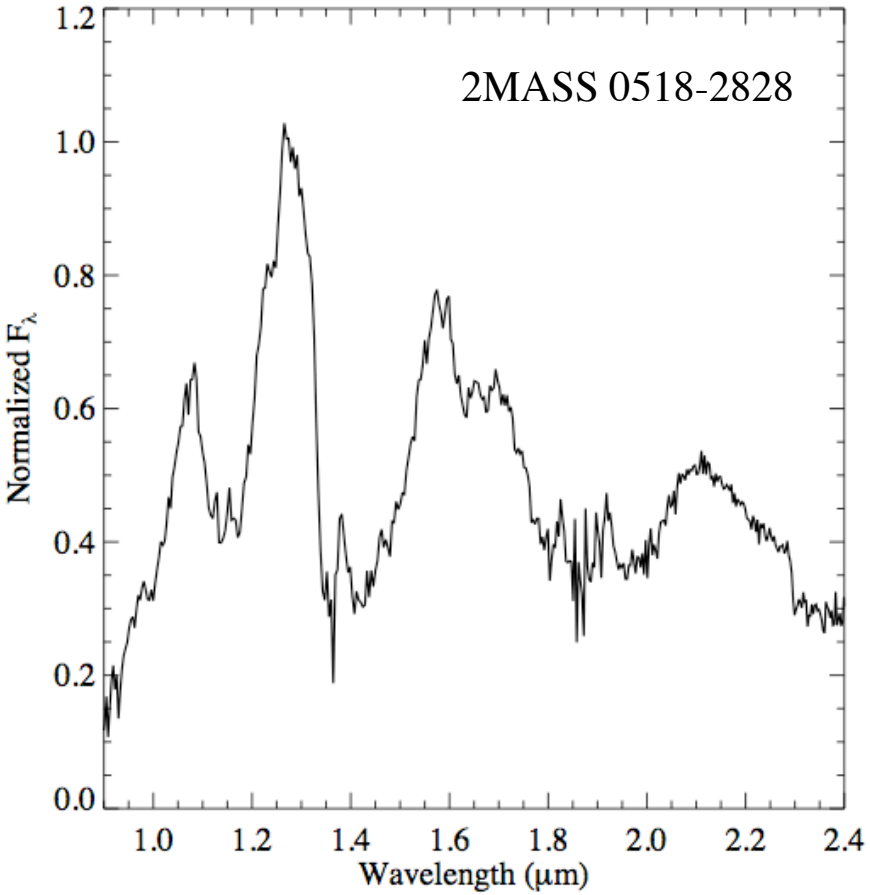


Burgasser (2008)

see also Dahn et al. (2002); Tinney et al. (2003); Vrba et al. (2004); Liu et al. (2006)

Q: Do we necessarily need to resolve a VLM binary to study it?

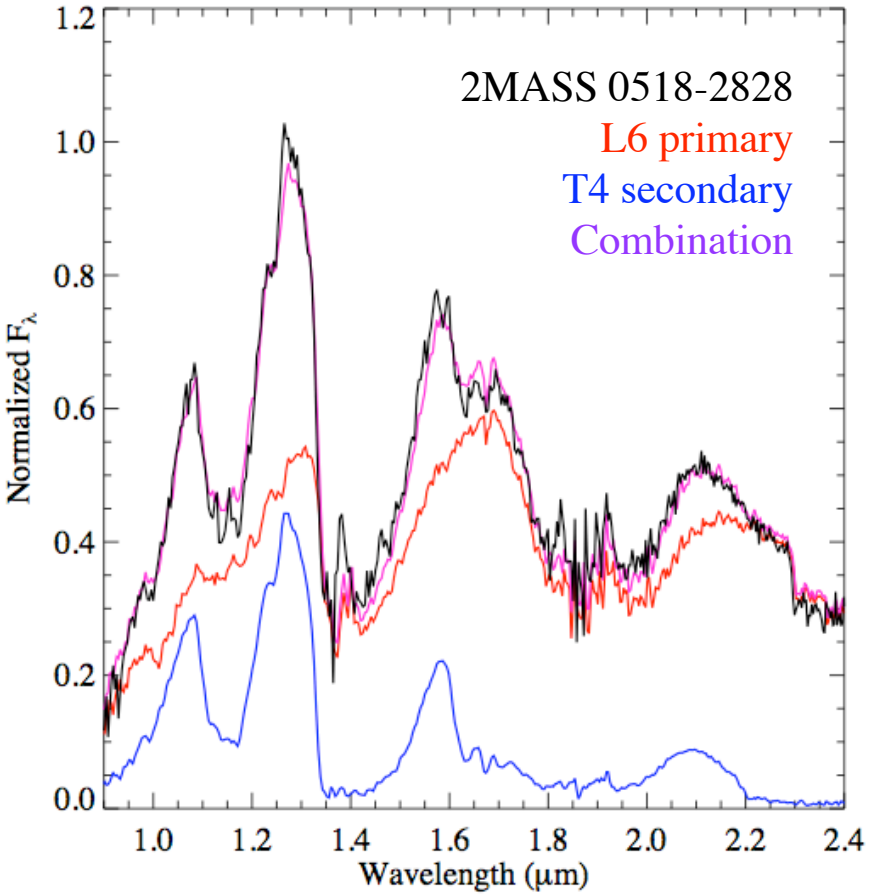


2MASS 0518-2828:

A breakthrough source

(Cruz et al. 2004)

A T dwarf with a very peculiar near-infrared spectrum.



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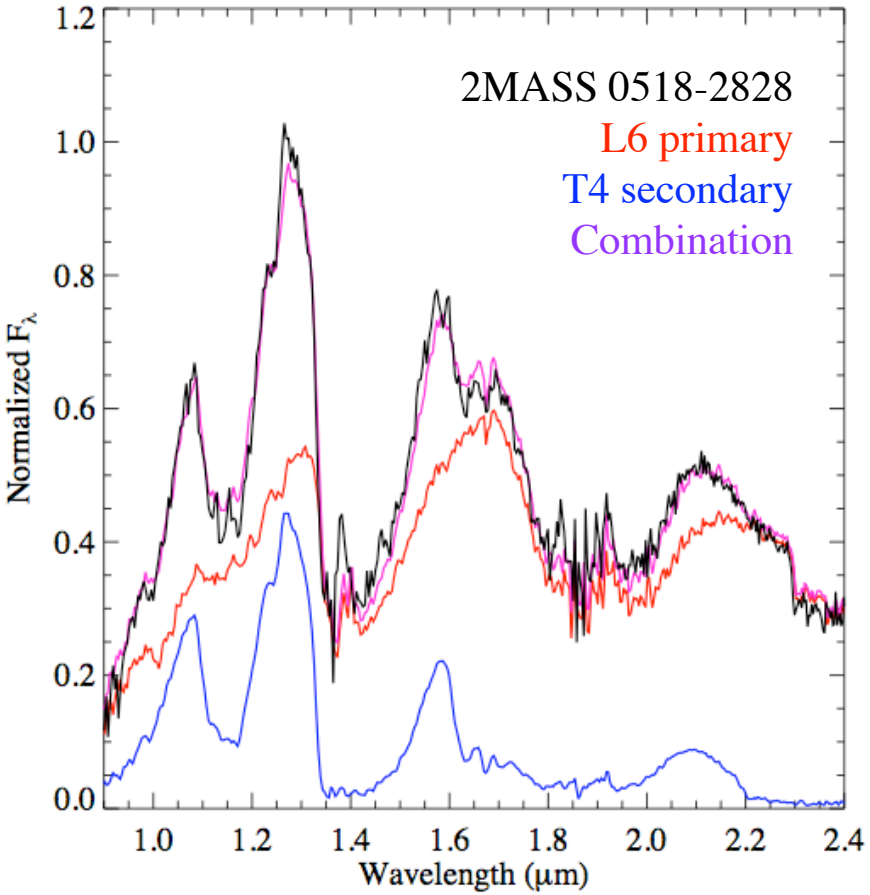

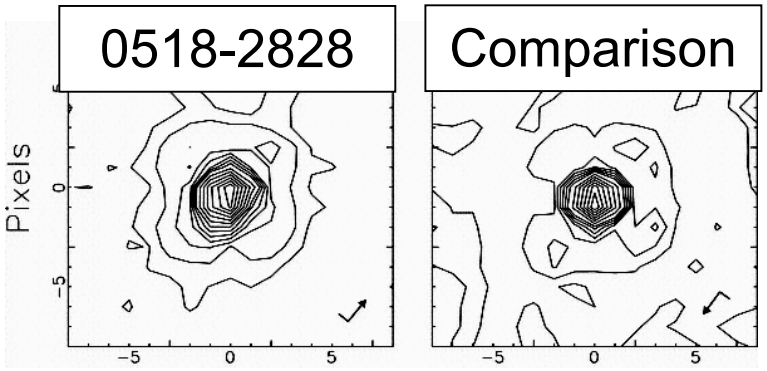

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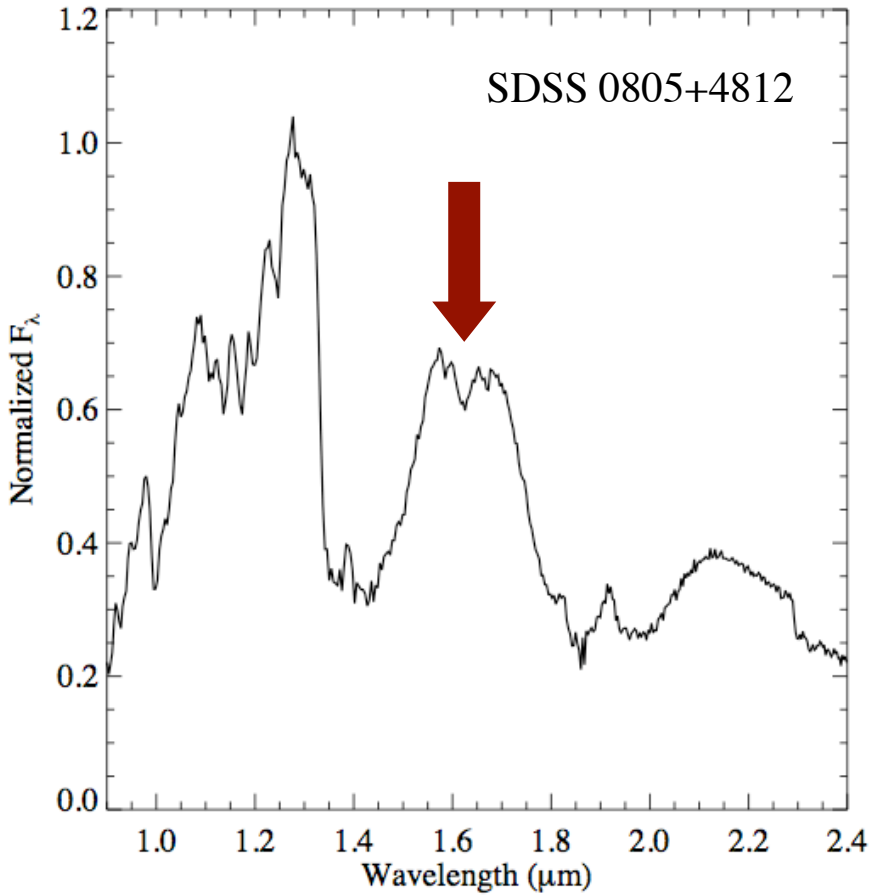
Spectrum can be reproduced by adding together L6 + T4 spectra **- an unresolved binary?**

HST observations verify as a resolved binary (ρ = 0”05 = 1.8±0.5 AU)

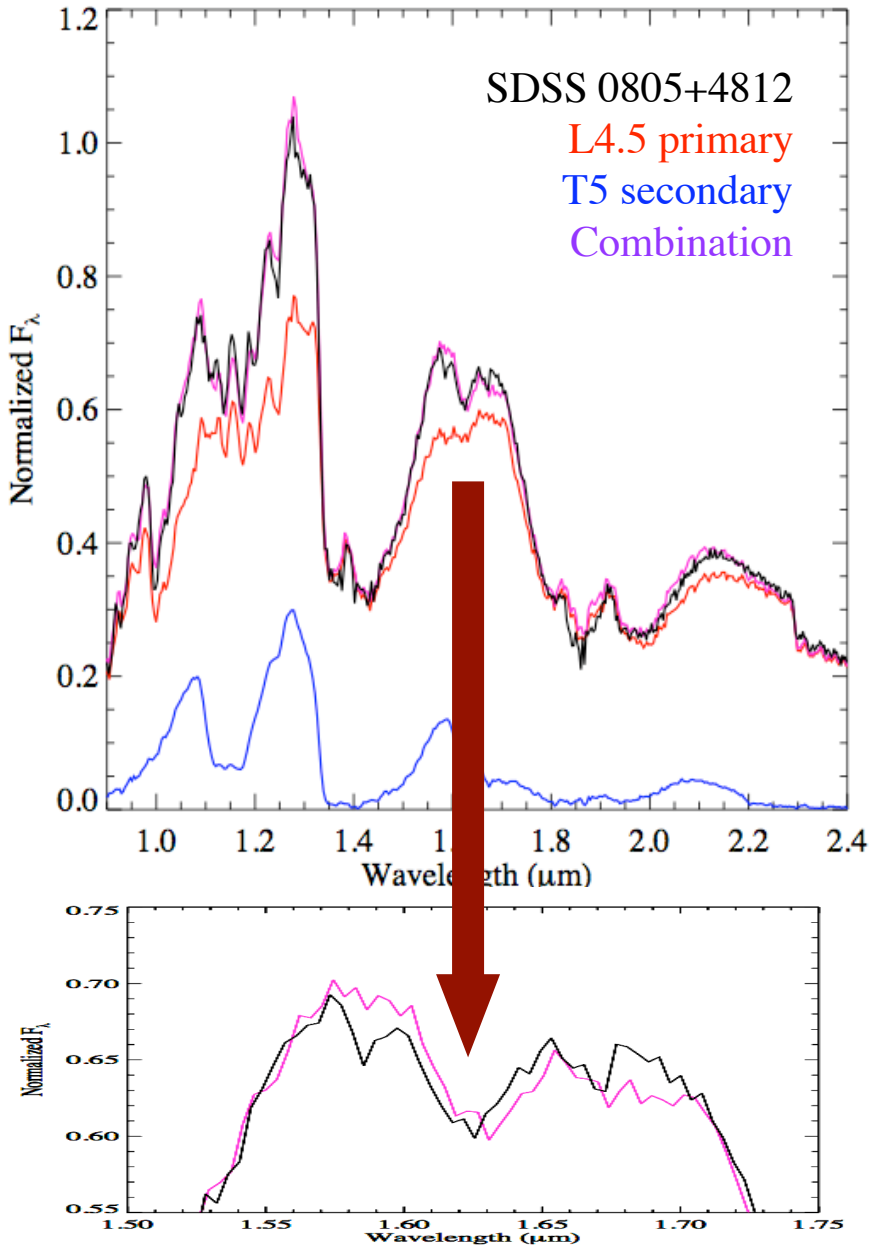


SDSS 0805+4812:

Another unresolved binary?

(Burgasser 2008)

An L dwarf with discrepant optical/near-infrared spectral types (L4/L9.5) and a peculiar little feature.



SDSS 0805+4812:

Another unresolved binary?

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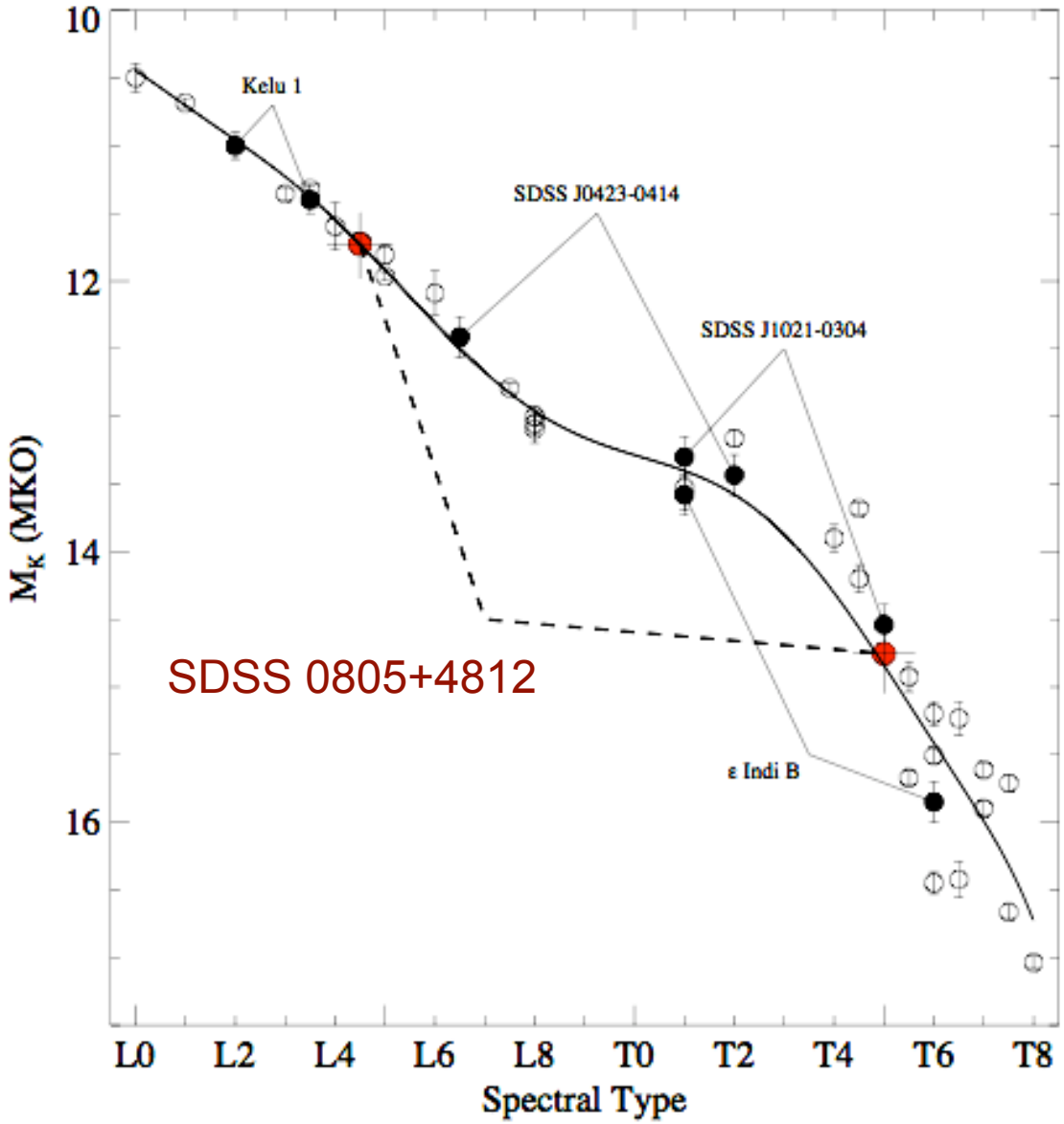
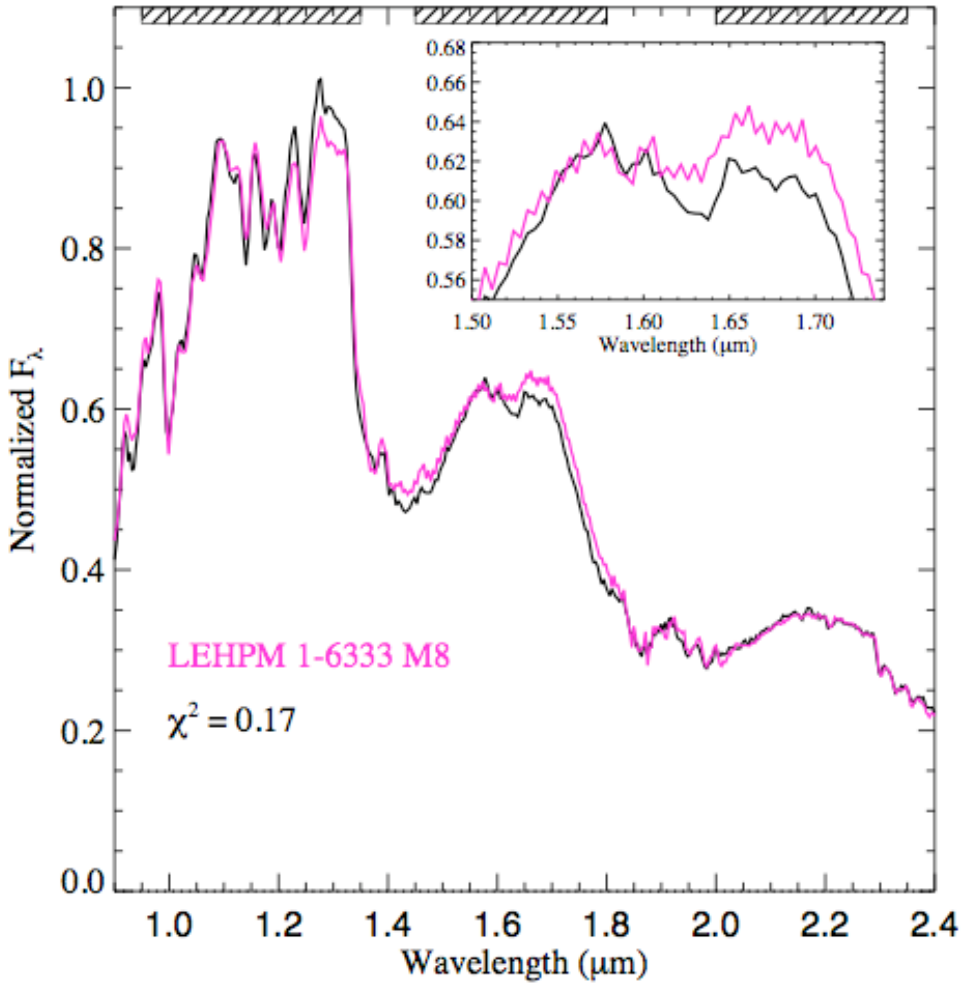
An L dwarf with discrepant optical/near-infrared spectral types (L4/L9.5) and a peculiar little feature.

Again, binary spectrum provides an excellent fit, including **detailed fit of 1.6 μm feature**



Burgasser (2008)

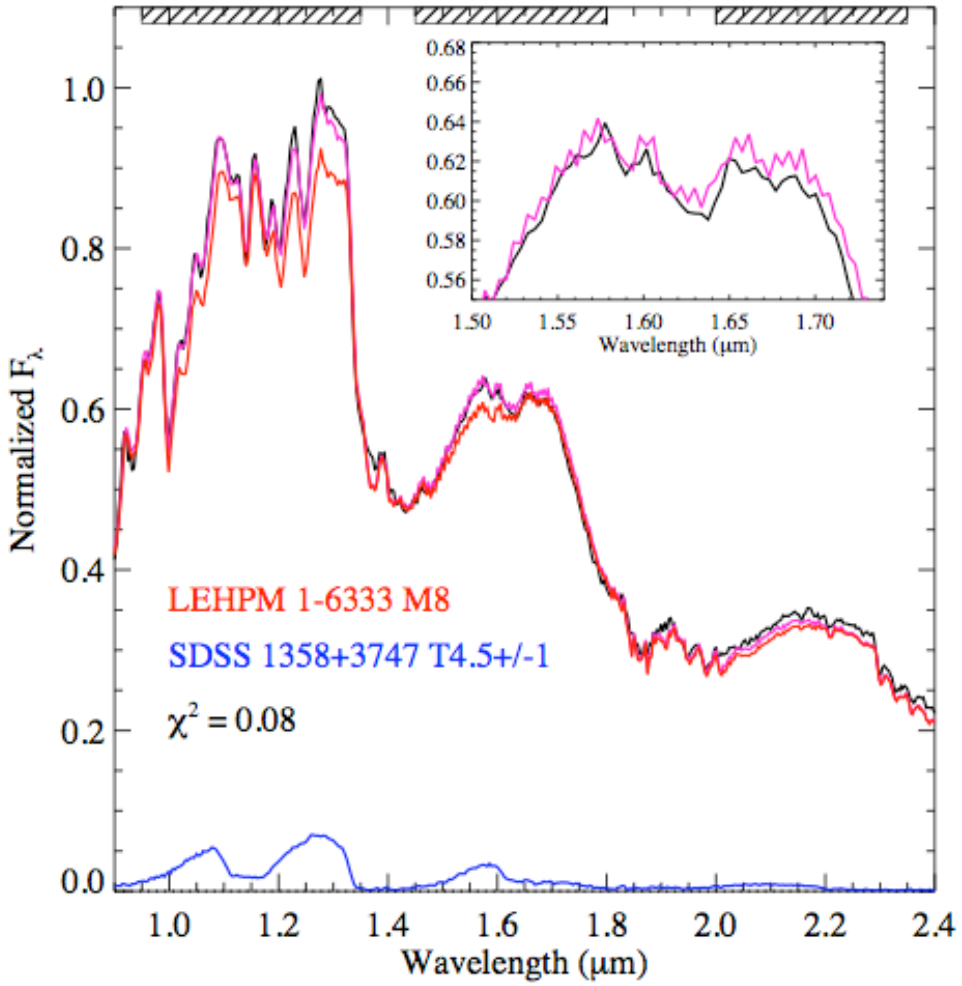


2MASS 0320-0446:

An extreme case

(Burgasser et al. submitted)

Spectrum overall looks like a normal late-type M dwarf, but with a weak 1.6 μm feature



2MASS 0320-0446:

An extreme case

(Burgasser et al. submitted)

Spectrum overall looks like a normal late-type M dwarf, but with a weak 1.6 μm feature.

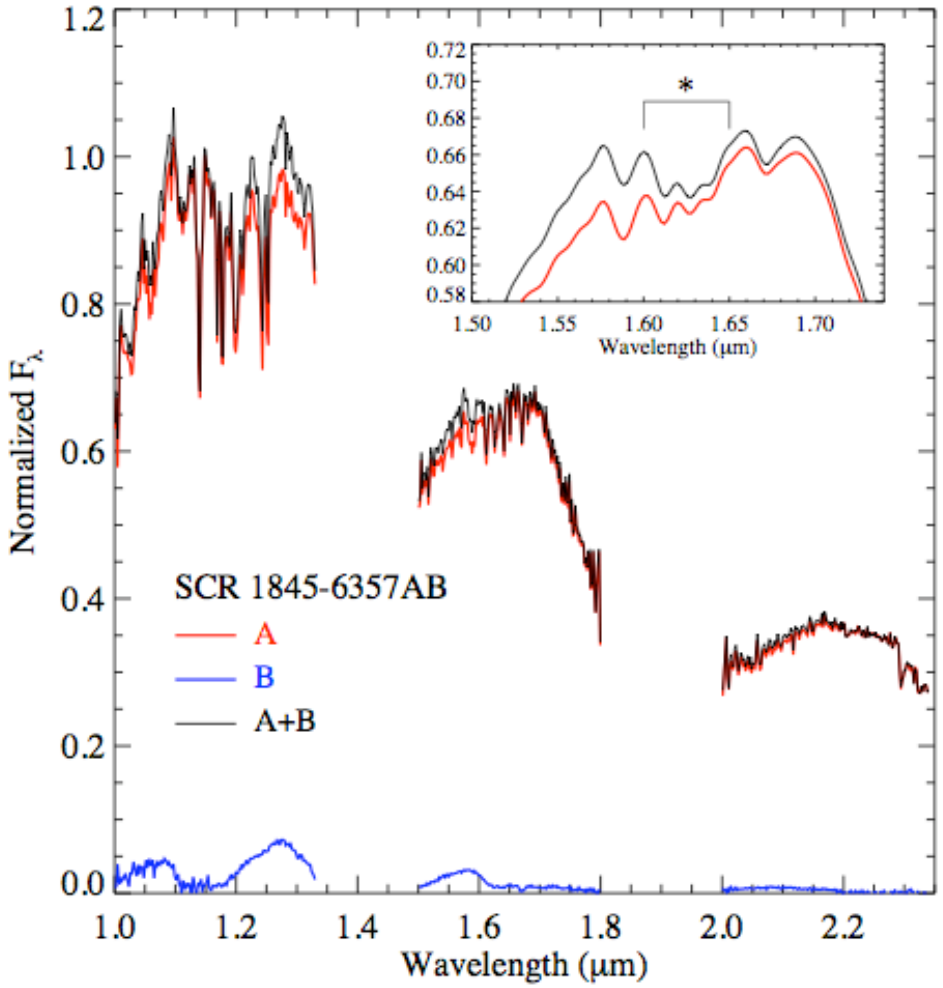
Yet the addition of a T dwarf companion considerably improves the fit.

Very faint companion:
$\Delta K \approx 4\text{-}5$ mag
(but q ~ 0.8 if > 5 Gyr)

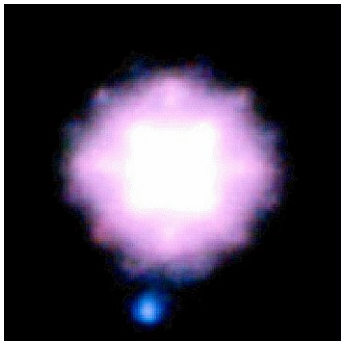
SCR 1845-6357AB:
A Confirmation?

1” M8.5+T6 binary with resolved spectroscopy.

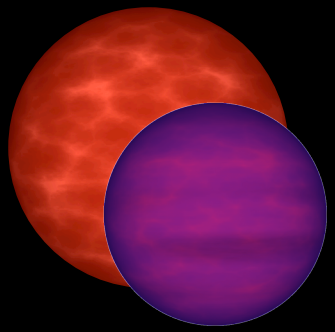
Adding component spectra yields produces similar 1.6 μm feature as seen in 2MASS 0320-0446.



Data from Kasper et al. (2007)

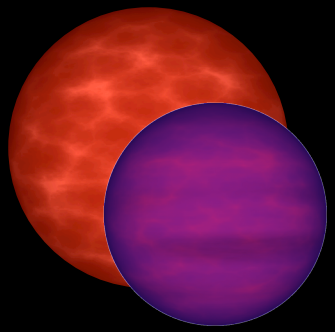


Biller et al. (2006)



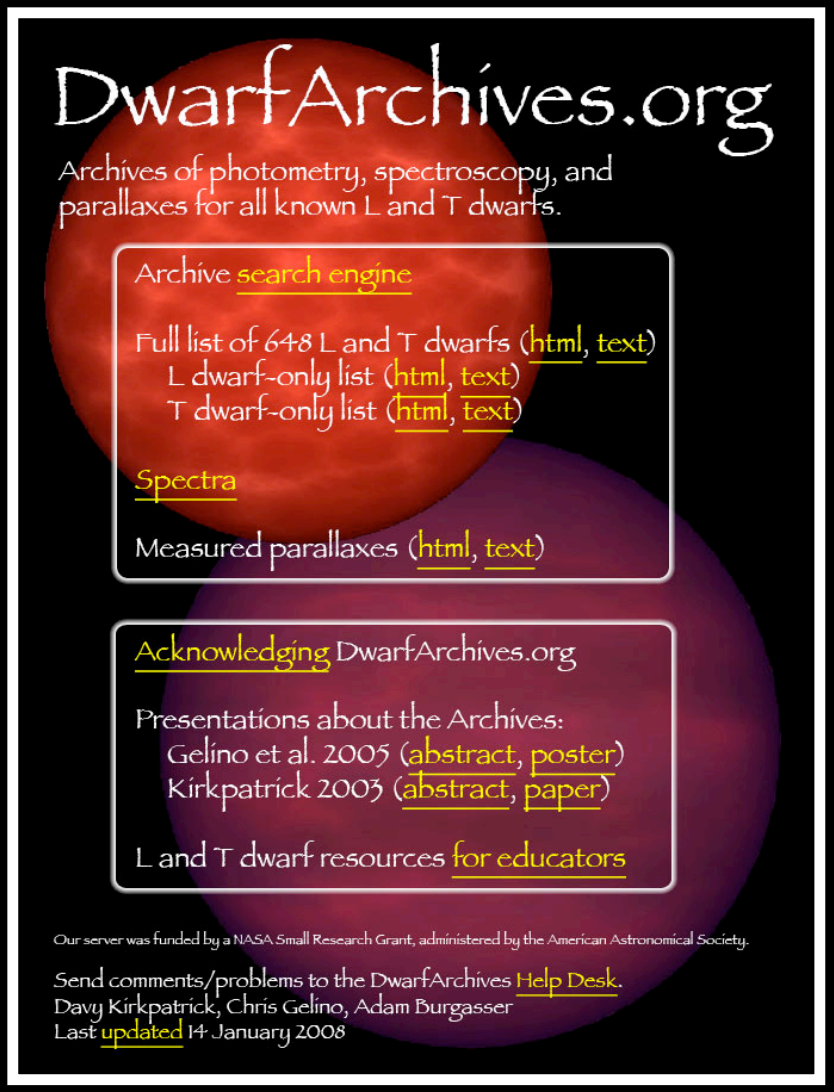
Benefits of the technique

- No projected/physical separation limitations
  - Better constraints on the tight binary population
  - Good way to identify eclipsing systems?
- Favorable for low-q systems
  - Better constraints on the low-q binary population
- Can be used to target faint and/or distant systems
  - More distant sources, larger volumes, larger samples, better statistics



Limitations of the technique

- Cannot identify companions with similar/extremely dissimilar spectral types
- No separation measurement - requires follow-up imaging or RV monitoring
- Only works for binaries with T dwarf companions?
- Necessary to distinguish binary-induced spectral peculiarities from other effects
  - Surface gravity, metallicity, clouds, etc



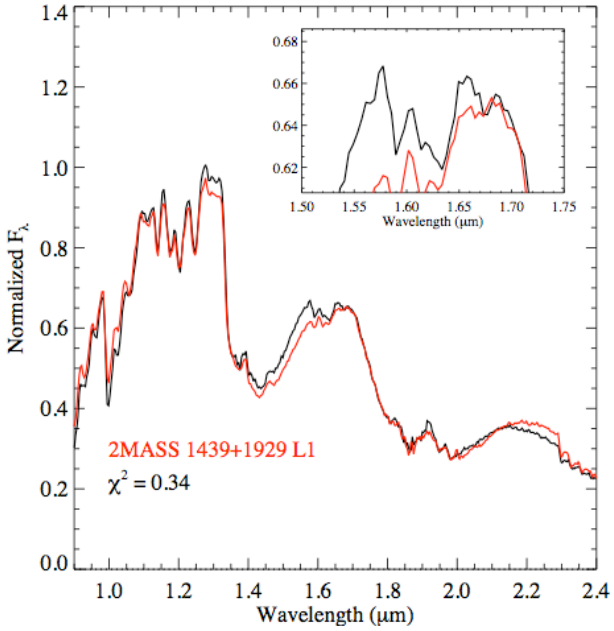
By the numbers:

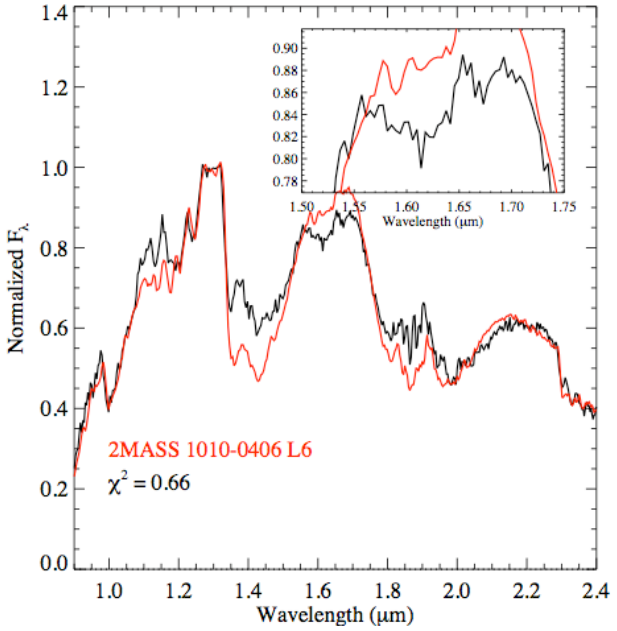
Population simulations (e.g. Burgasser 2007) indicate 15-25% of early-type L dwarf binaries have an early/mid-type T dwarf companion.

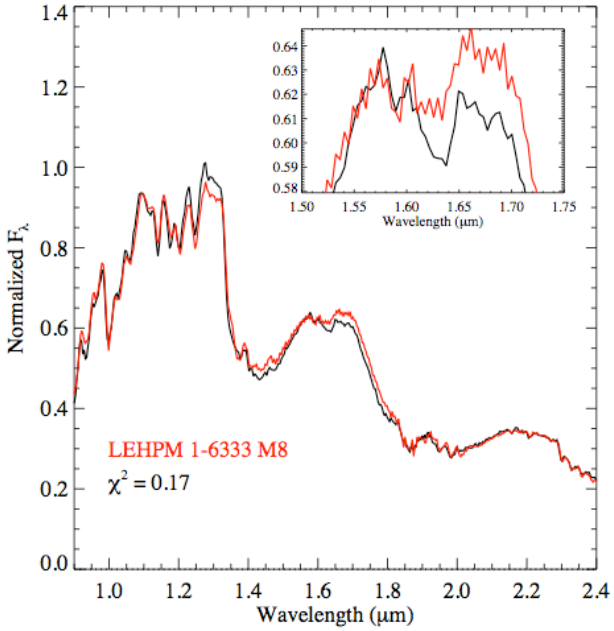
15-30% of L dwarfs are binary.

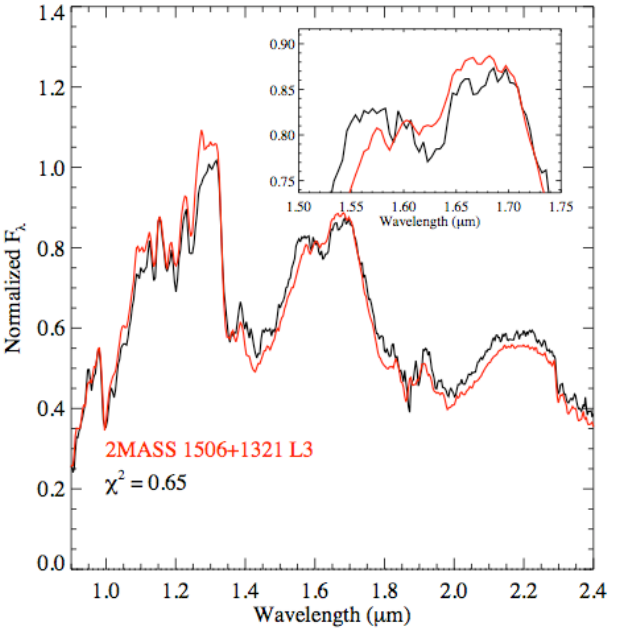
There are 400 early-type L dwarfs known (http://dwarfarchives.org)

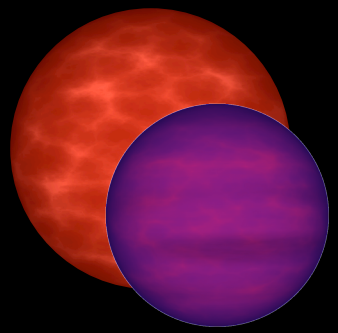
⇒ 10-30 known early-type L dwarfs should have early/mid-type T dwarf companions that can be discerned from NIR spectra











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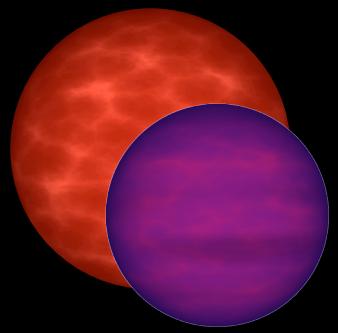


Acknowledgements

Collaborators:

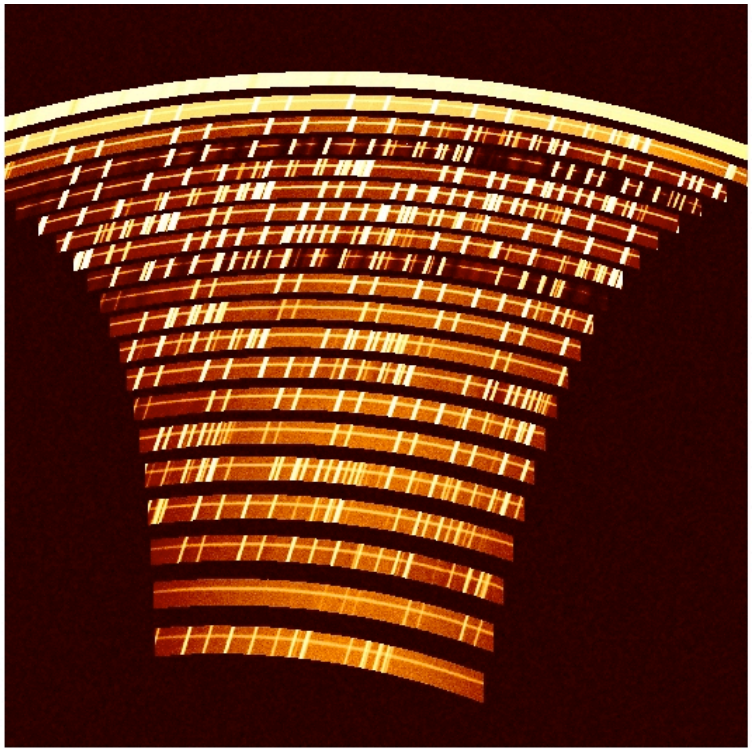
Kelle Cruz (Caltech)
Davy Kirkpatrick (Caltech/IPAC)
Dagny Looper (IfA)

Special thanks to the IRTF TOs, as well as John Rayner, Michael Cushing and everyone involved with the construction and maintainance of SpeX

The SpeX Prism Library (~240 published spectra):
http://www.browndwarfs.org/spexprism/

the FIRE spectrograph

Near-infrared Echellette for the Magellan Telescopes



MIT: Simcoe & Burgasser

~0.85-2.35 μm in one shot

R~6000 (50 km/s; 0”6 slit)

R~900-2500 high sensitivity

commissioning ~ 2008/9

http://www.firespectrograph.org