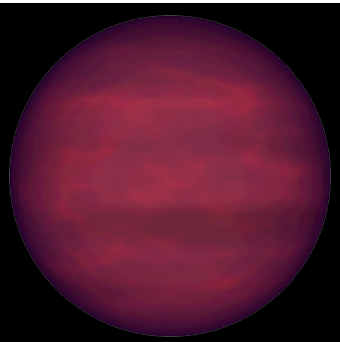
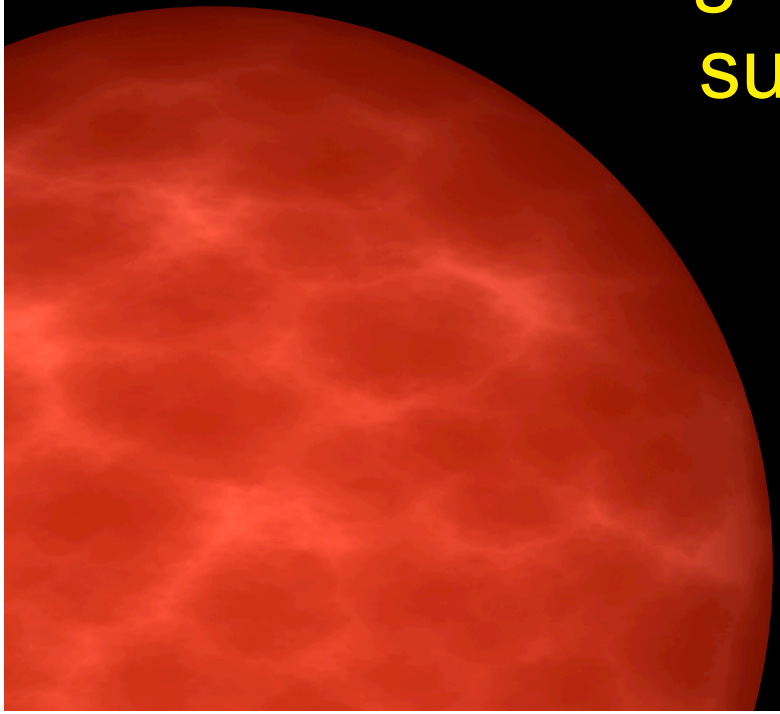
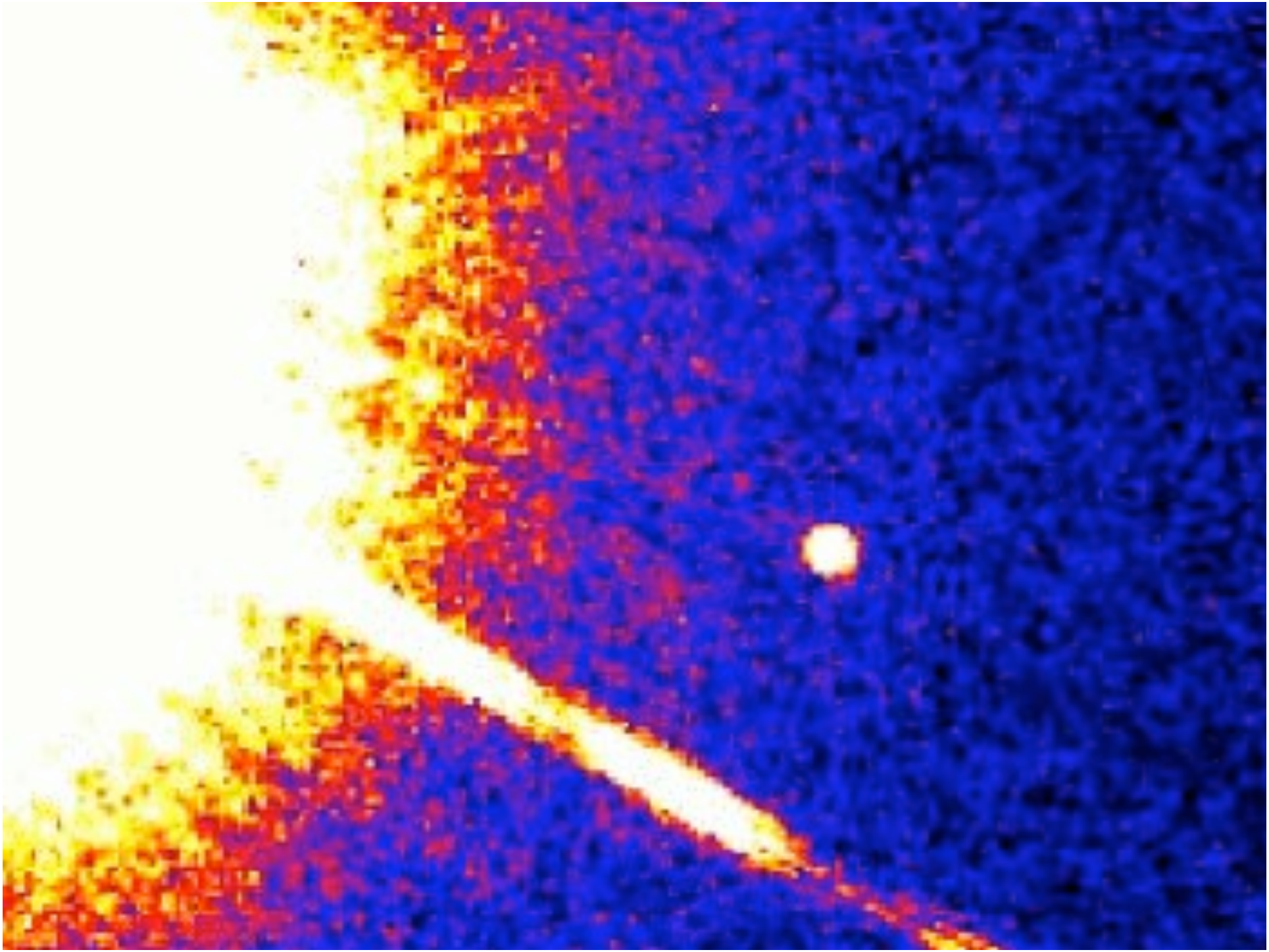


deconstructing brown:

unraveling the physical properties of substellar objects



Adam J. Burgasser (MIT)



“The discovery of a new dish does more for human happiness than the discovery of a new star.”

Anthelme Brillat-Savarin (1825)

“The most exciting phrase to hear in science, the one that heralds new discoveries, is not 'Eureka!' (I found it!) but 'That's funny ...’ ”

Isaac Asimov

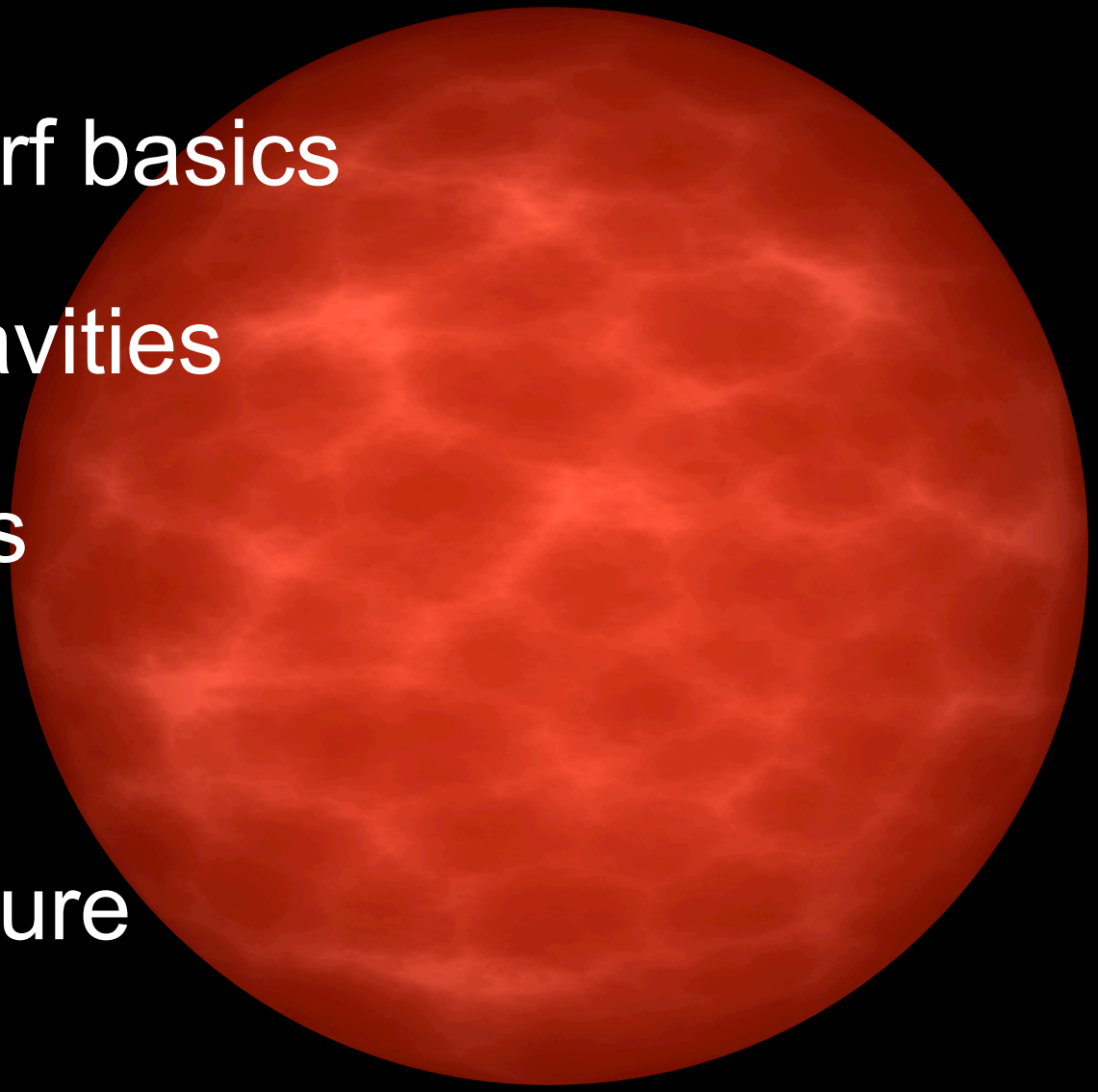
brown dwarf basics

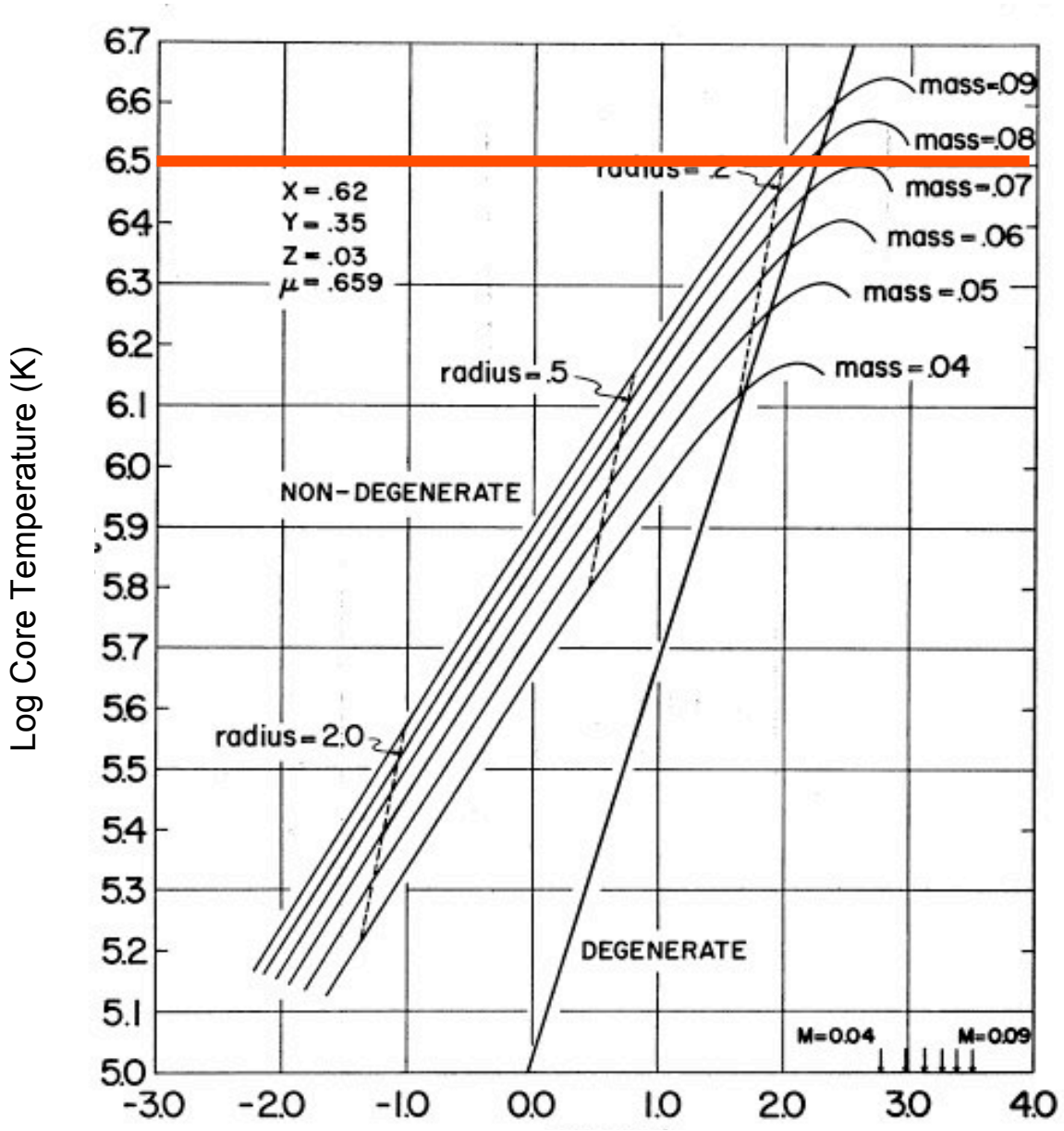
surface gravities

metallicities

clouds

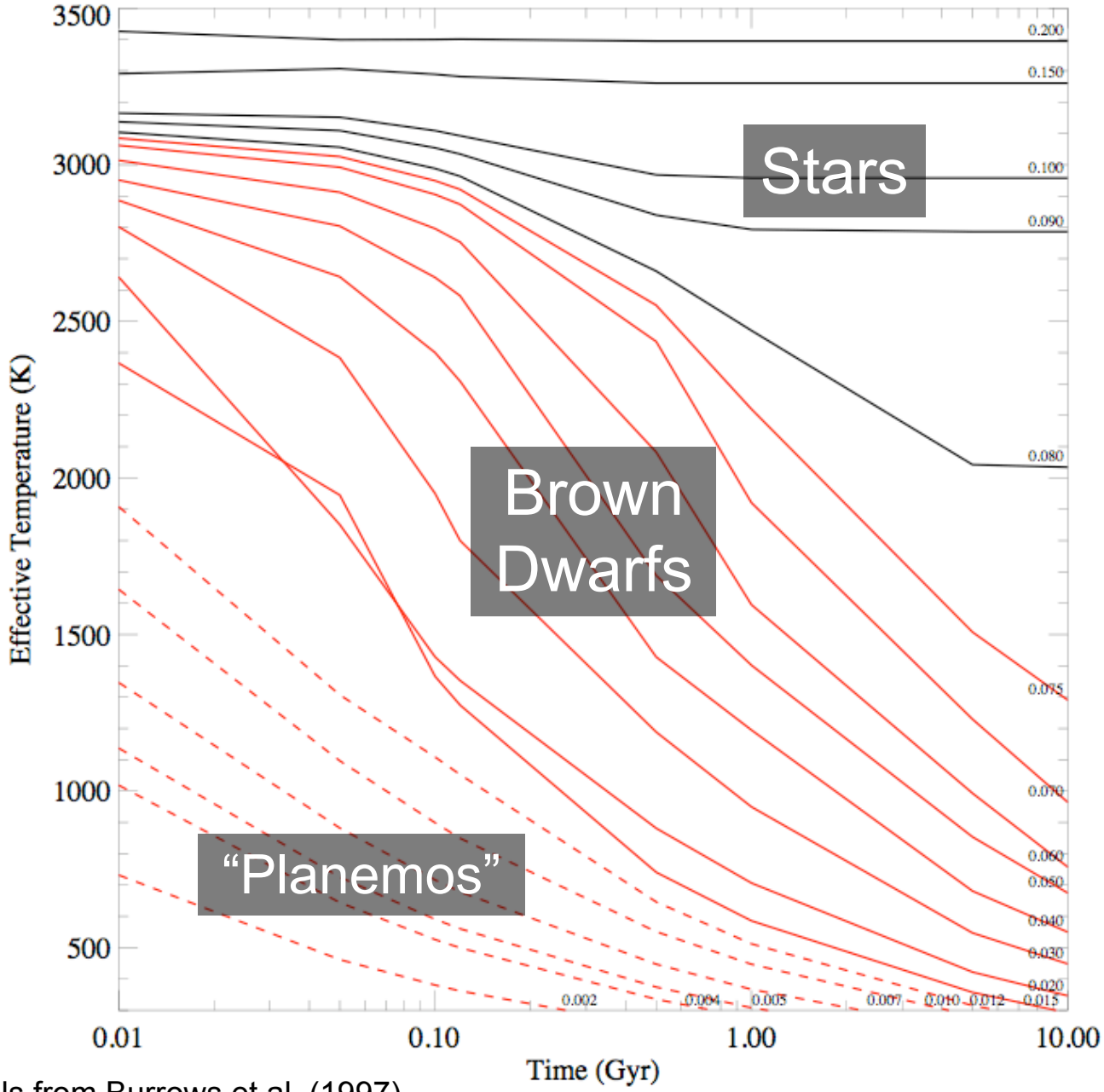
the big picture





H-burning threshold

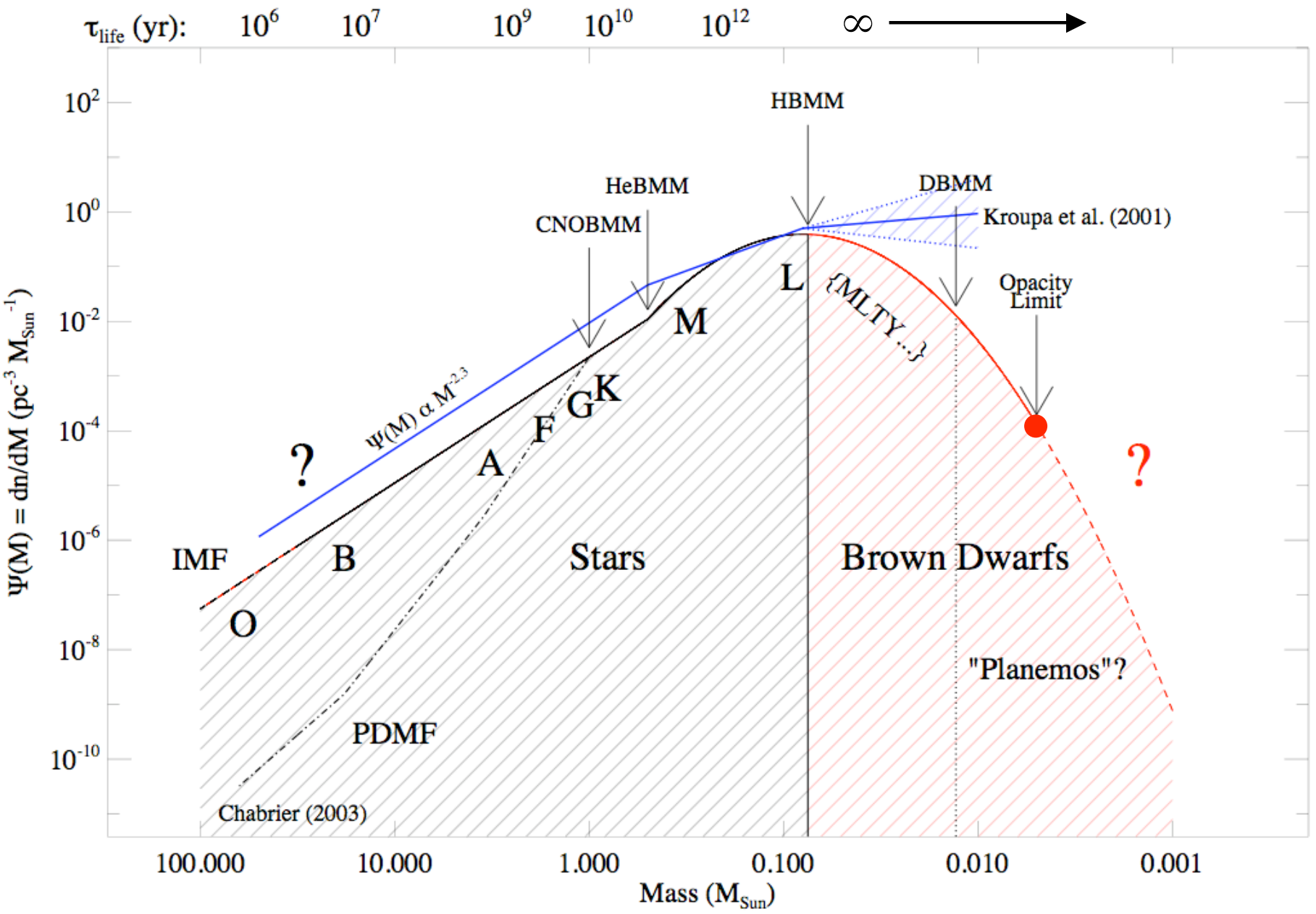
Kumar (1962, 1963)
see also Hayashi & Nakano (1963)

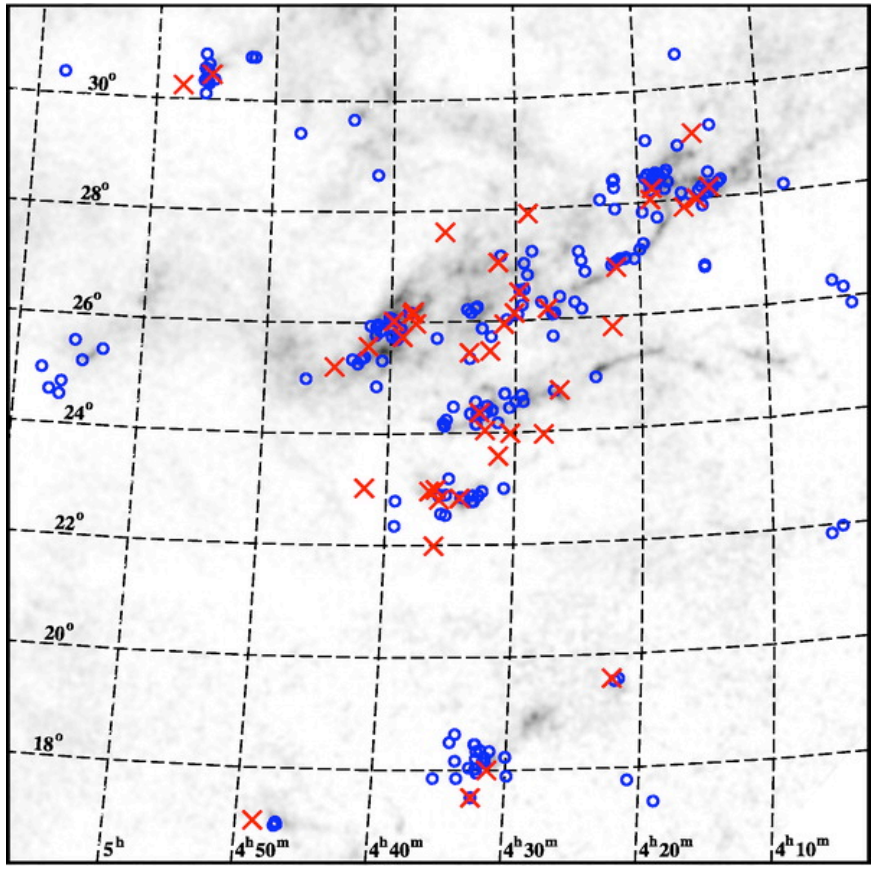


sustained H-burning

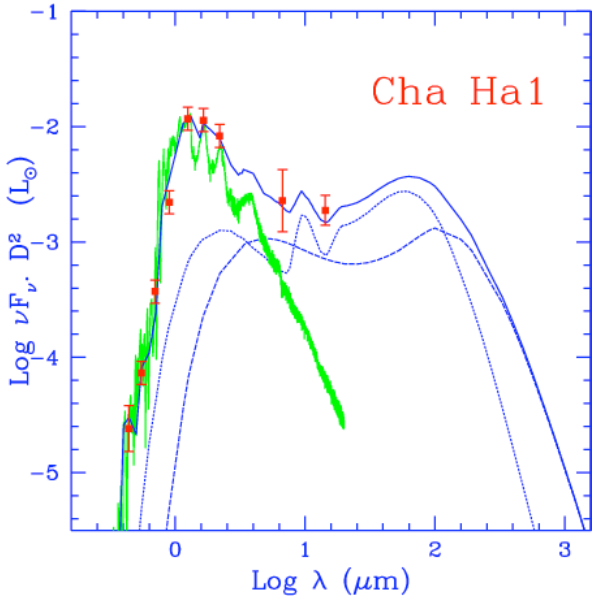
insufficient H-burning

models from Burrows et al. (1997)



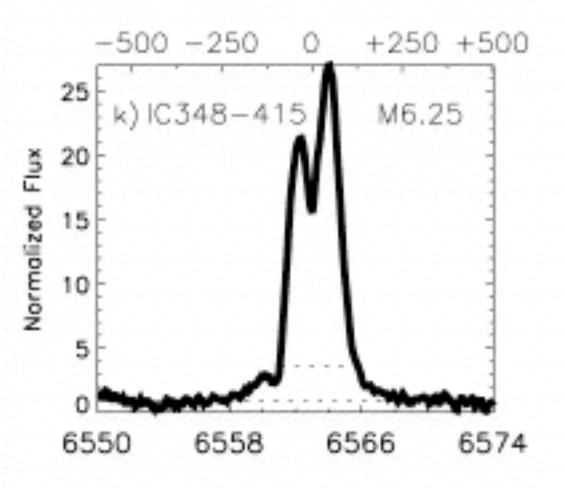


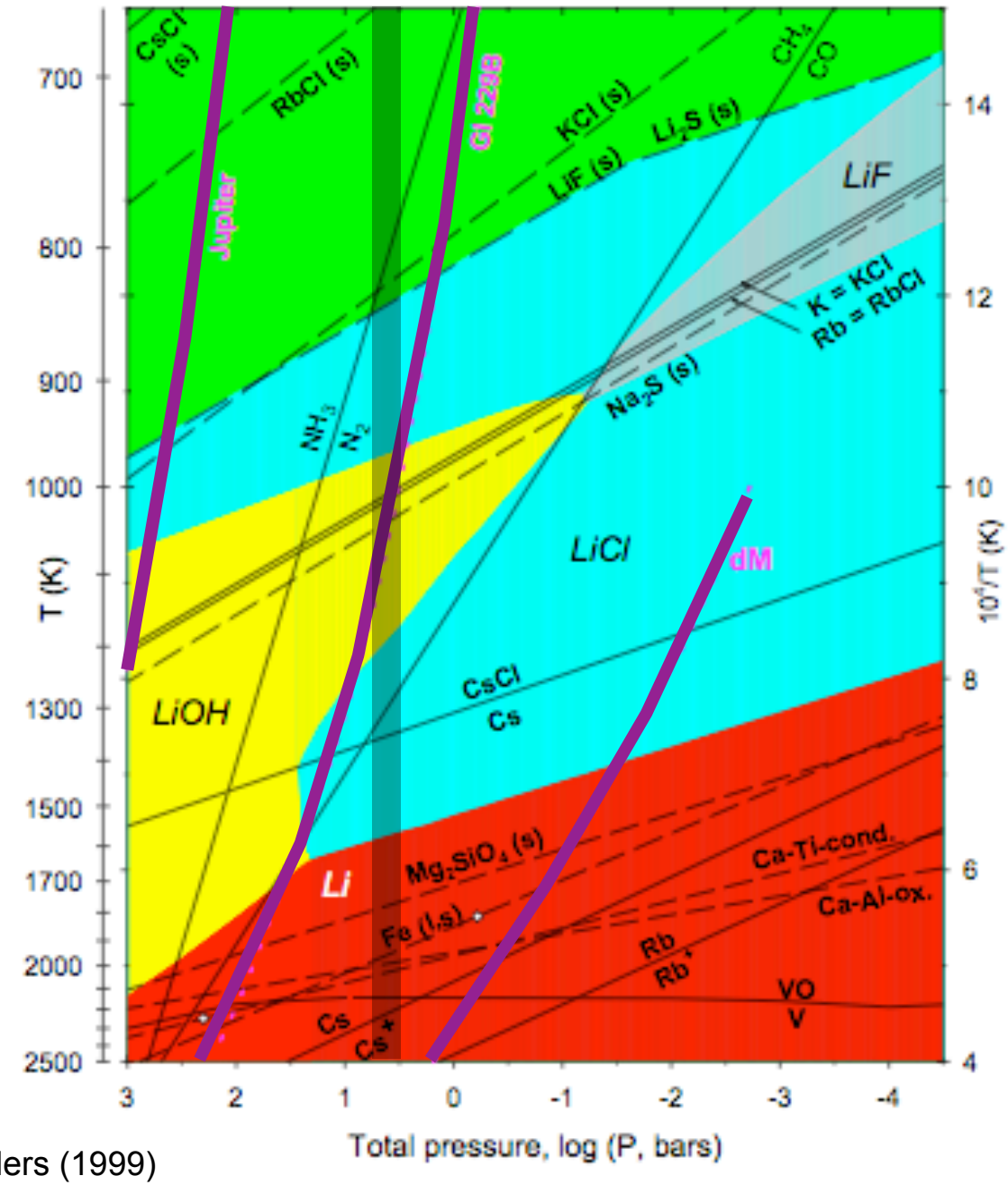
stellar and substellar distribution in Taurus
Luhman (2006)
see also Briceno et al. (2002); Guieu et al. 2006



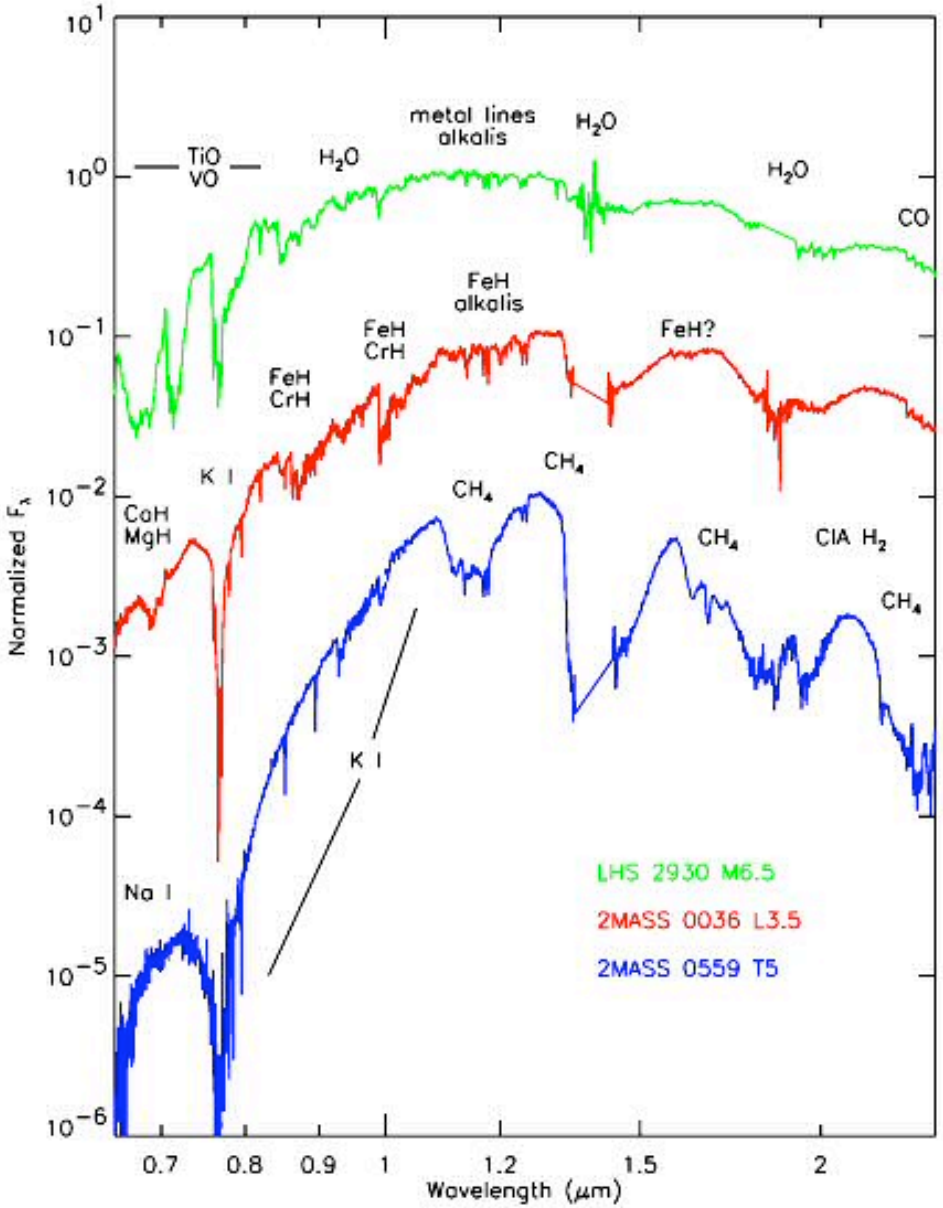
young brown dwarf with disk excess
Natta & Testi (2001)
see also Comeron et al. (1998,1999)

disk accretion in a young brown dwarf
Jayawardhana et al. (2003)
see also White & Basri (2003); Muzerolle et al. (2003,2005)





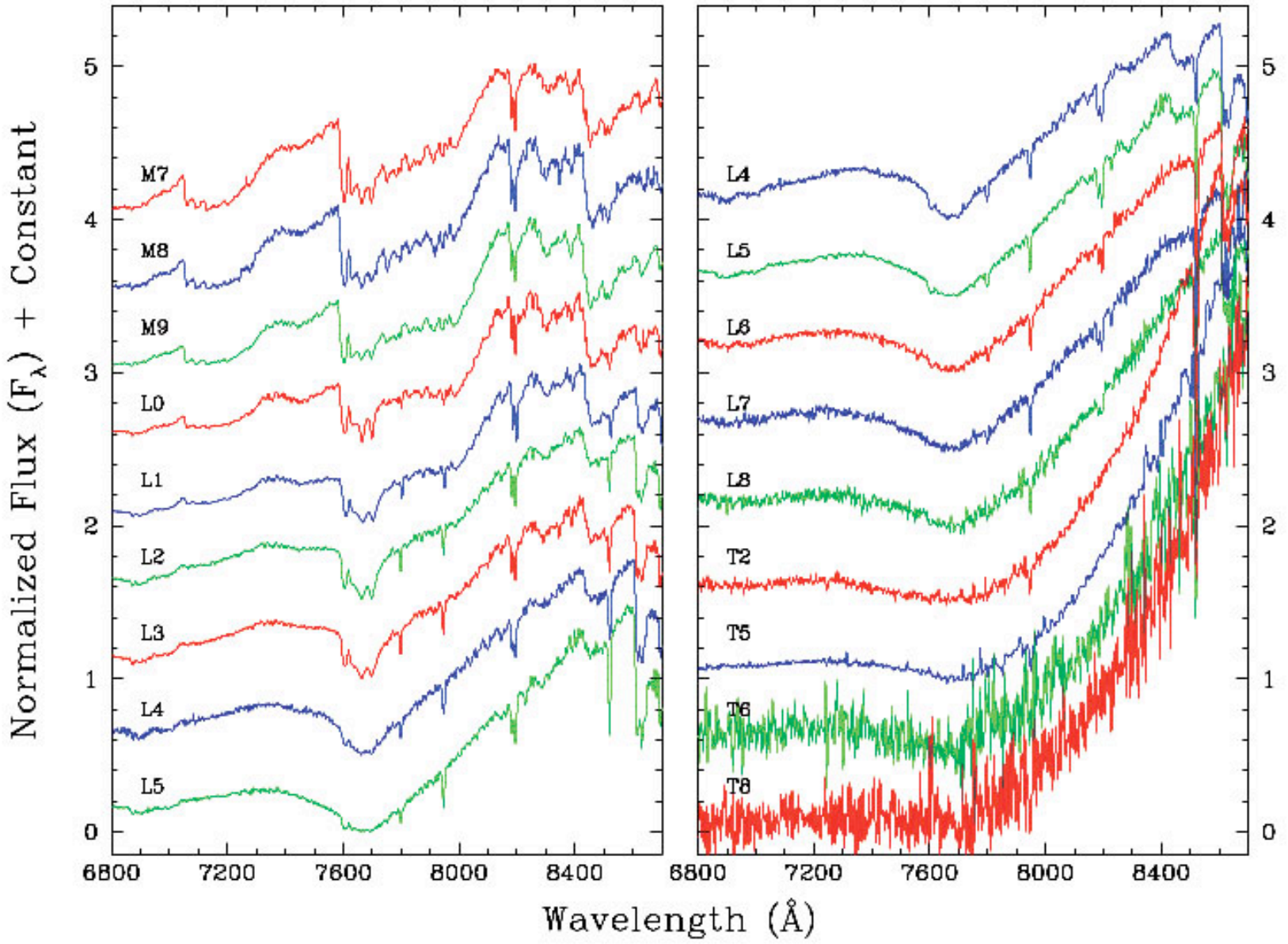
Lodders (1999)



M dwarfs are dominated by TiO, VO, H_2O, CO absorption plus metal/alkali lines.

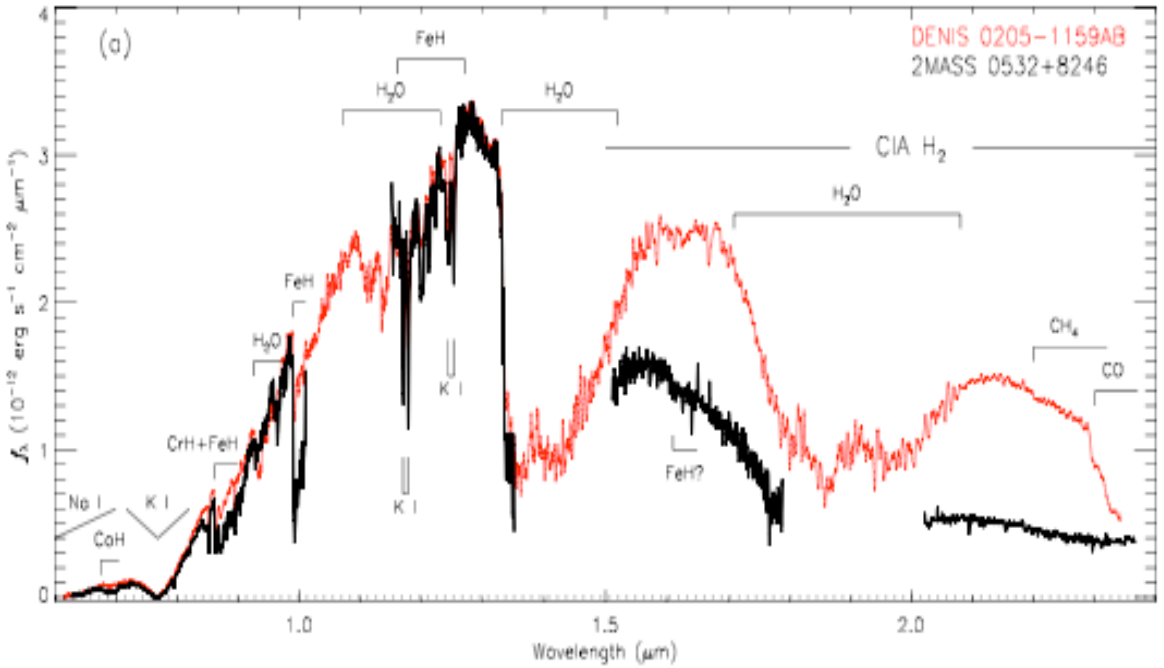
L dwarfs replace oxides with hydrides (FeH, CrH, MgH, CaH), alkalis are prominent, condensate clouds.

T dwarfs exhibit strong CH_4 and H_2O and extremely broadened Na I and K I.

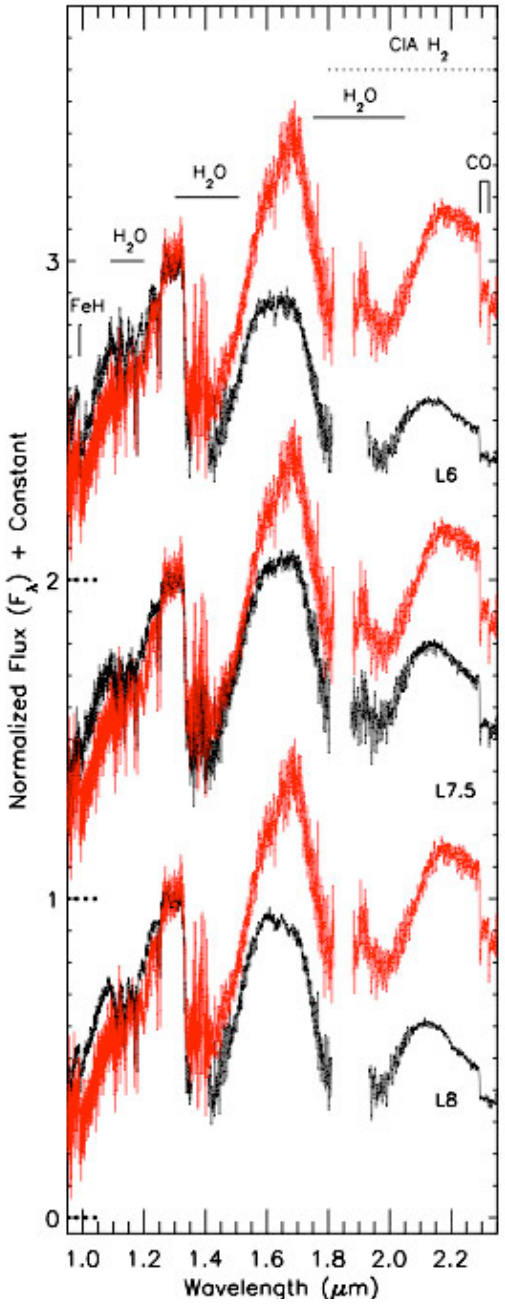


Kirkpatrick (2005)

peculiar sources

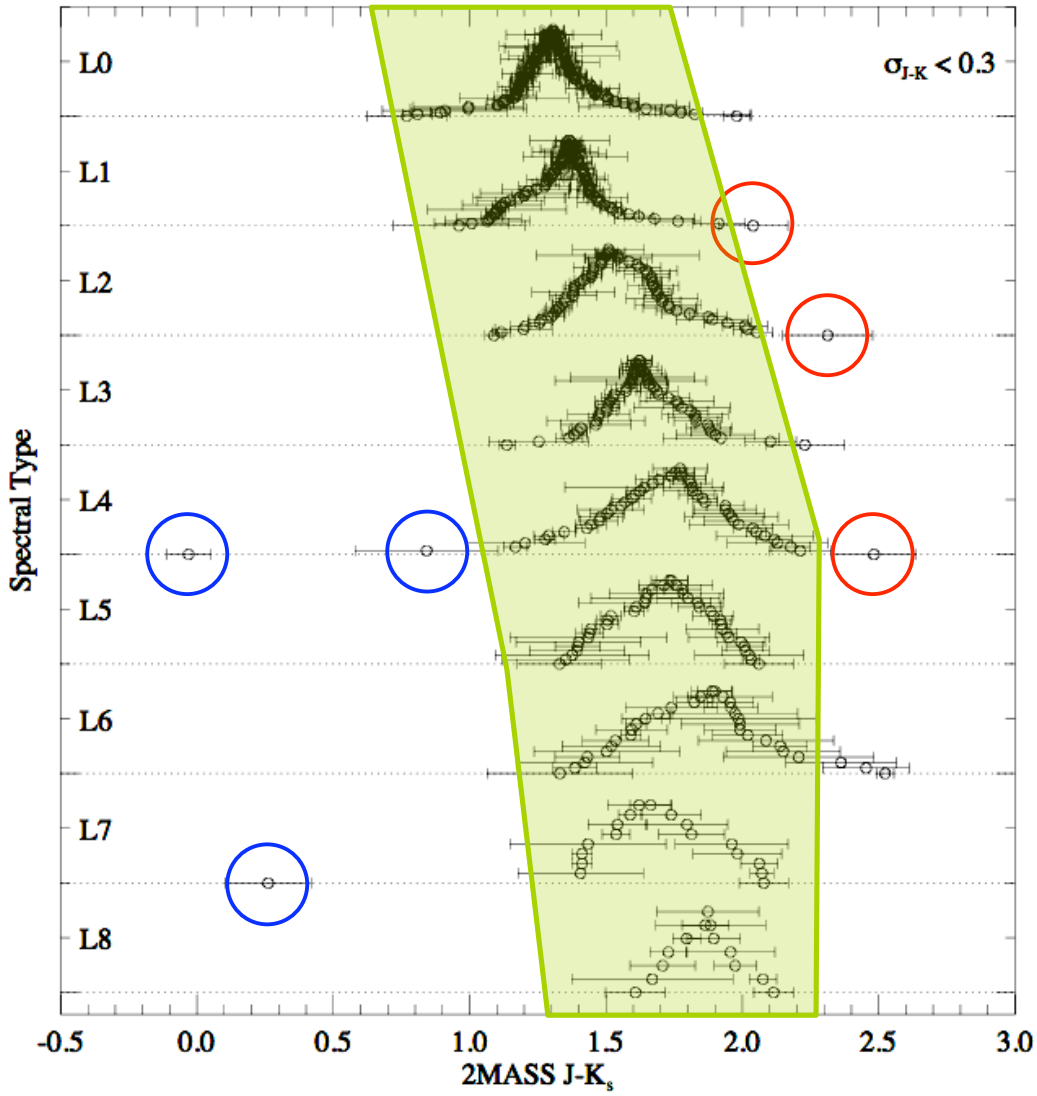


Burgasser et al. (2003)

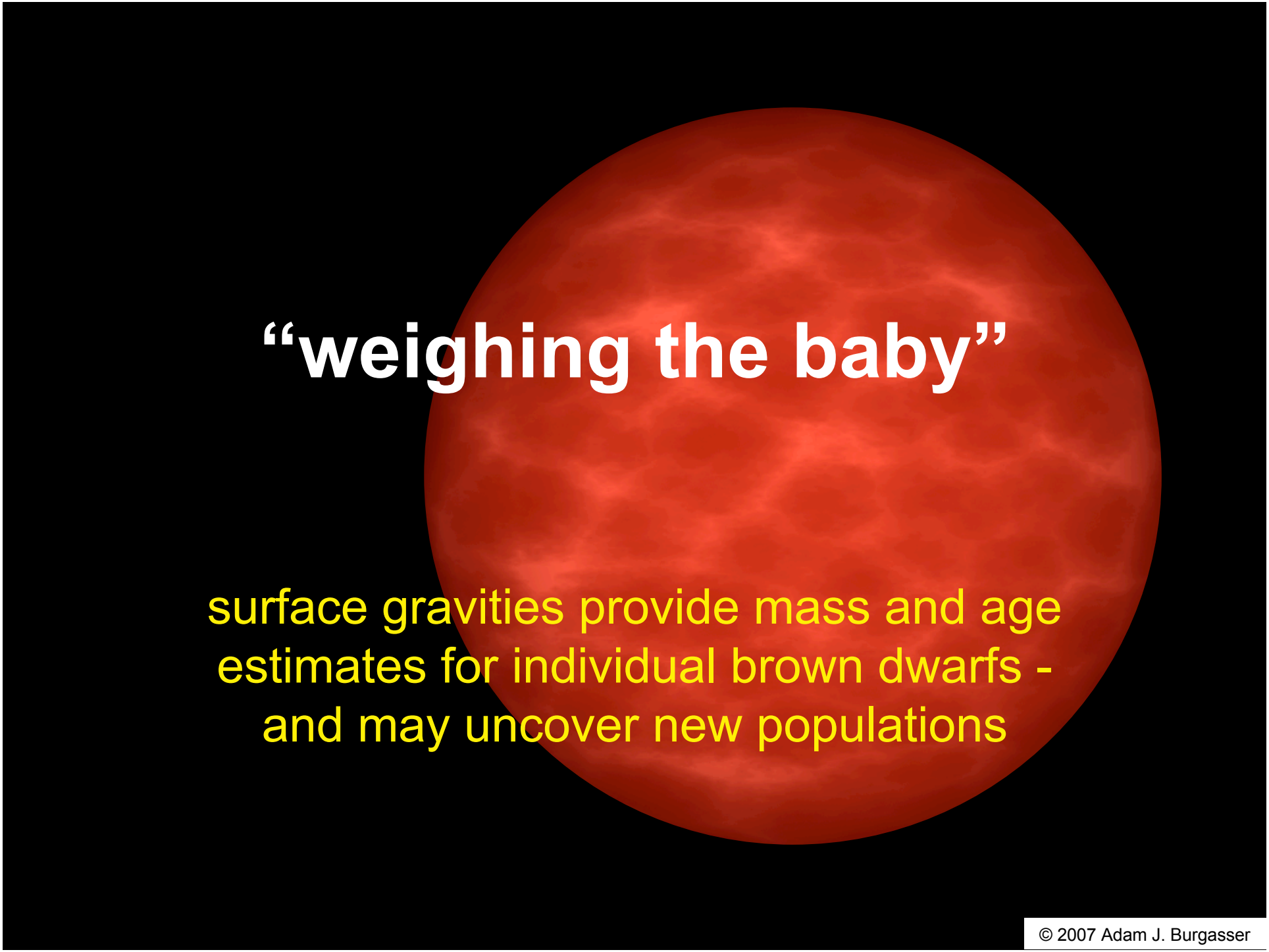


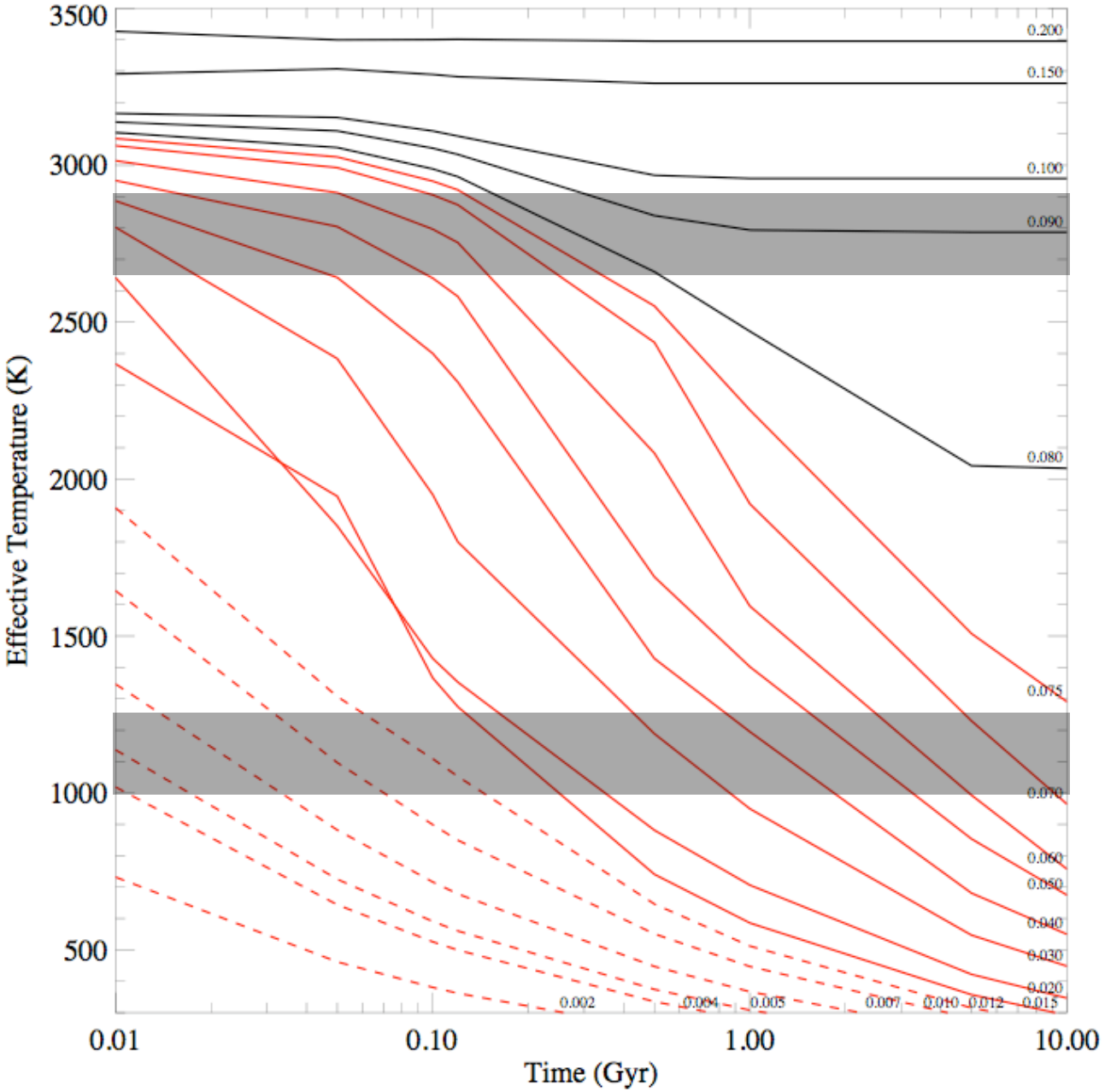
Looper et al. (in prep.)

the “shrimp plot”



Kirkpatrick et al. (in prep.)

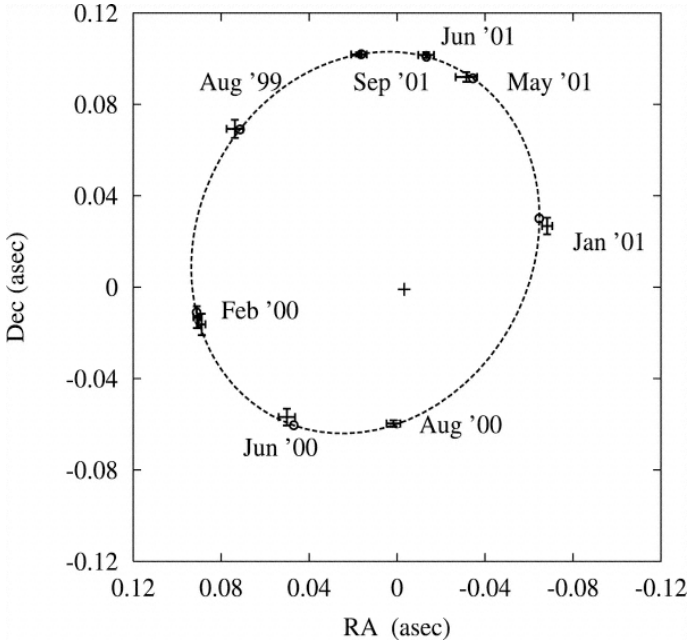




star or
brown dwarf?

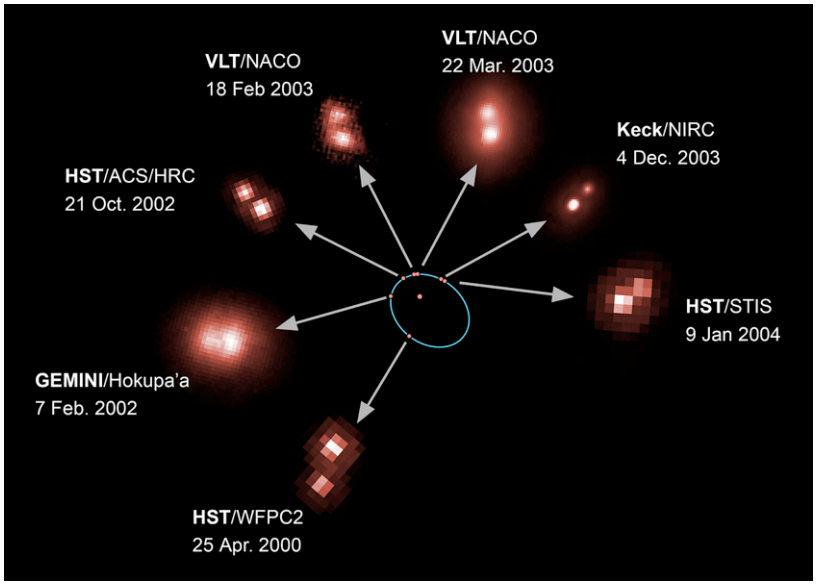
brown dwarf
or planemo?

Direct Mass Determinations



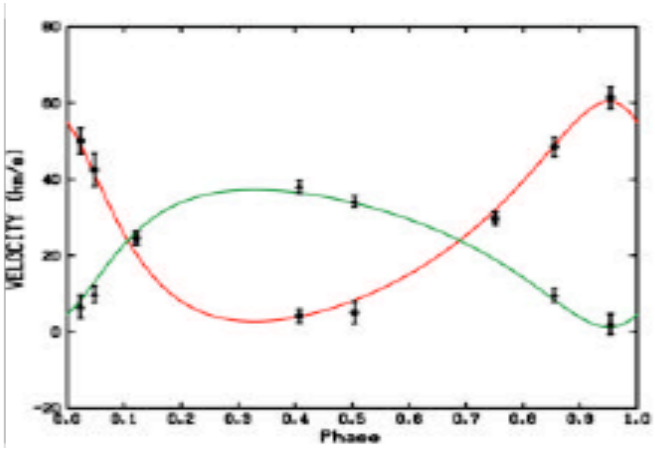
GJ 569Bab

Lane et al. (2001); Zapatero Osorio et al. (2004)



2MASS 0746+2000

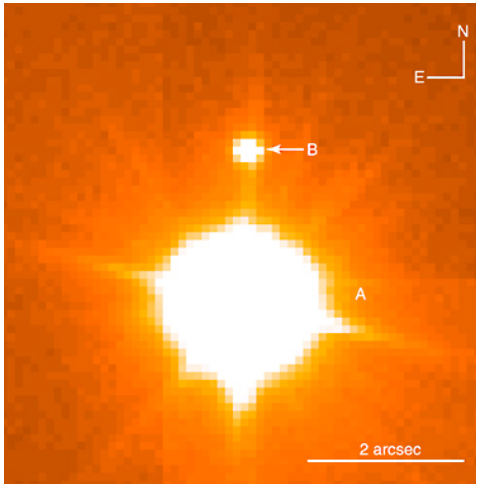
Bouy et al. (2004)



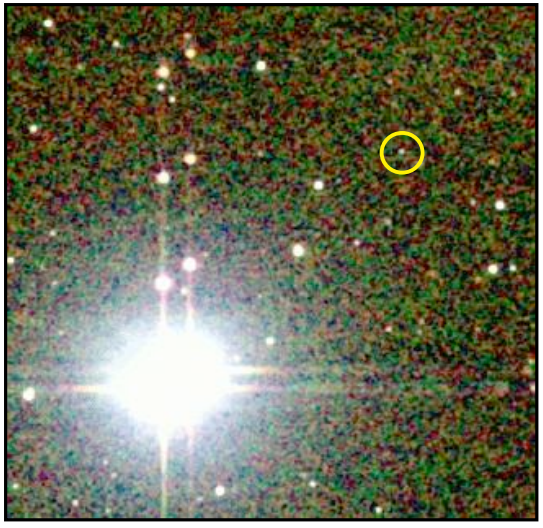
2MASS 0535-0546AB

Stassun et al. (2006)

Direct Age Determinations

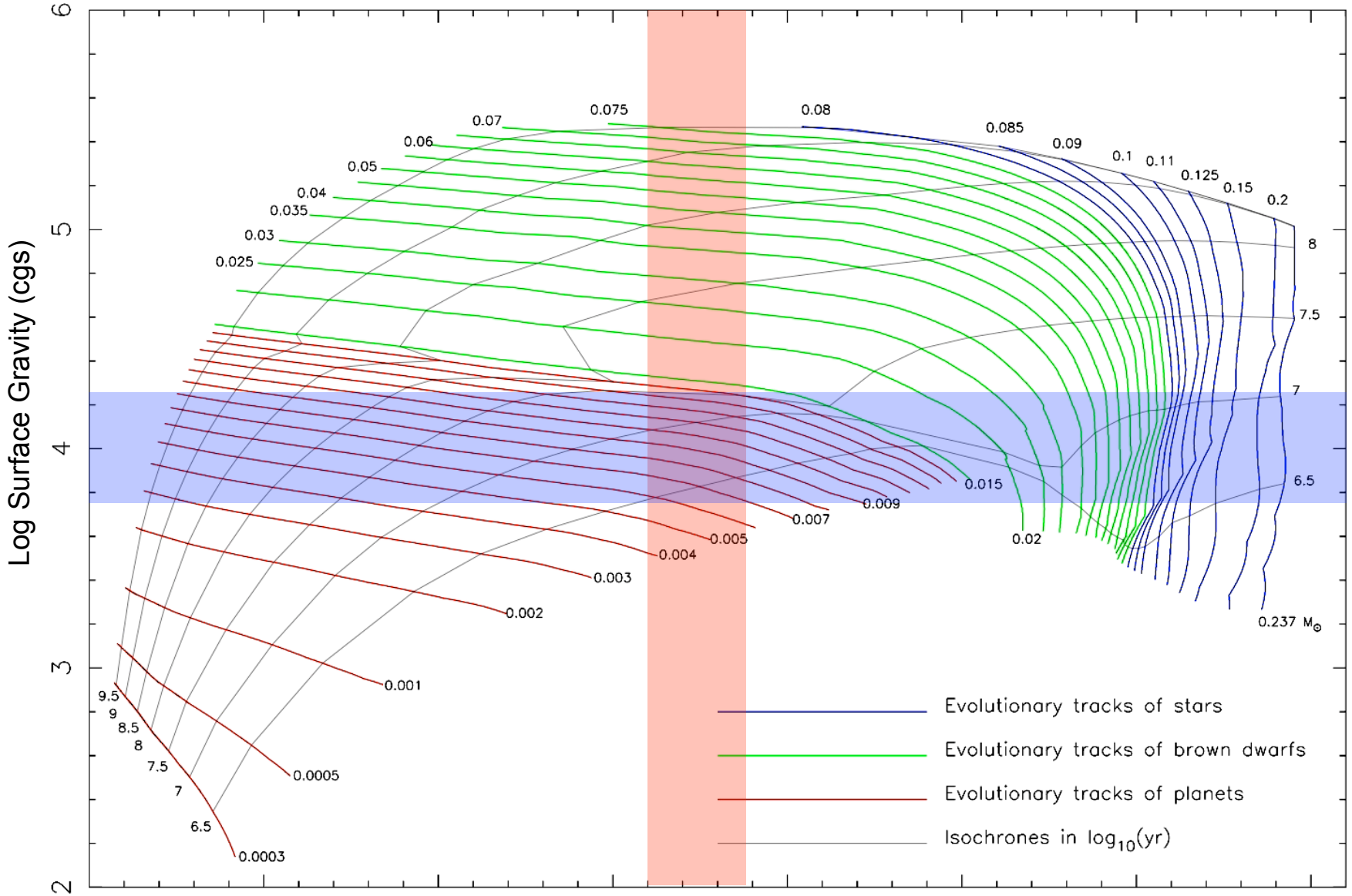


TWA 5B, ~12 Myr
Lowrance et al. (1999); Neuhäuser et al. (2000)

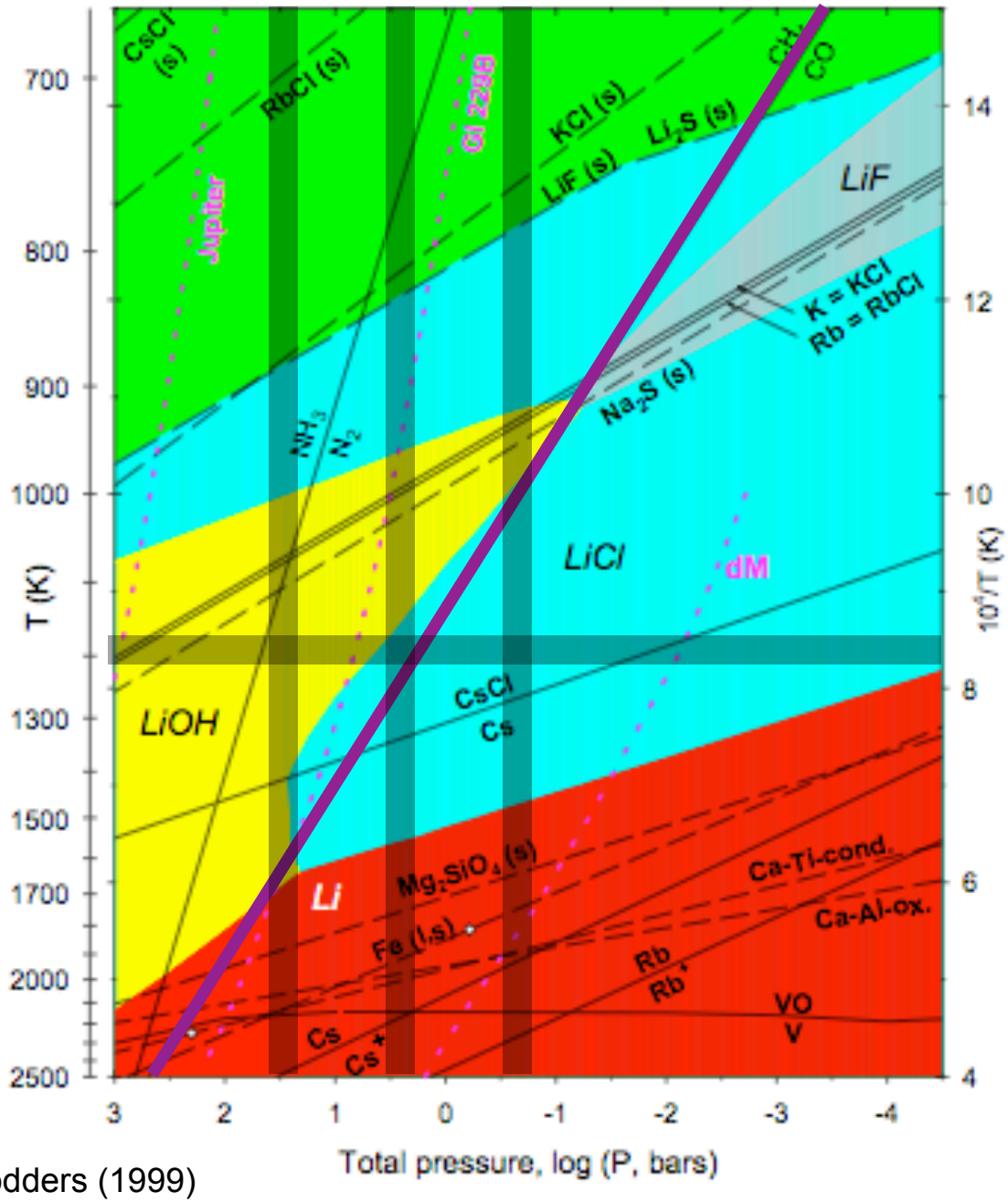


Gliese 570D, 2-5 Gyr
Burgasser et al. (2000)

Orion Nebula Cluster ~ 1 Myr

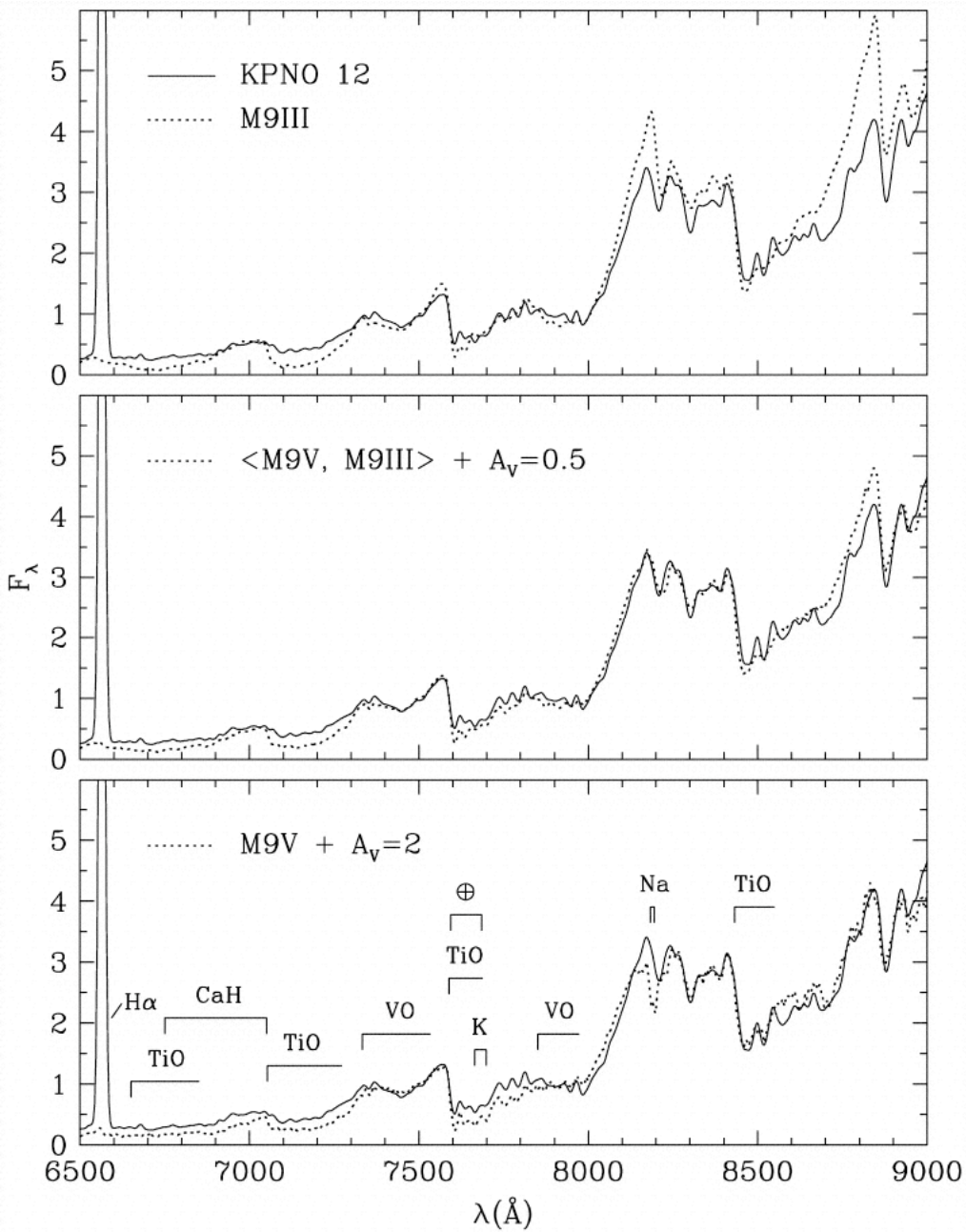


Burrows et al. (1997)



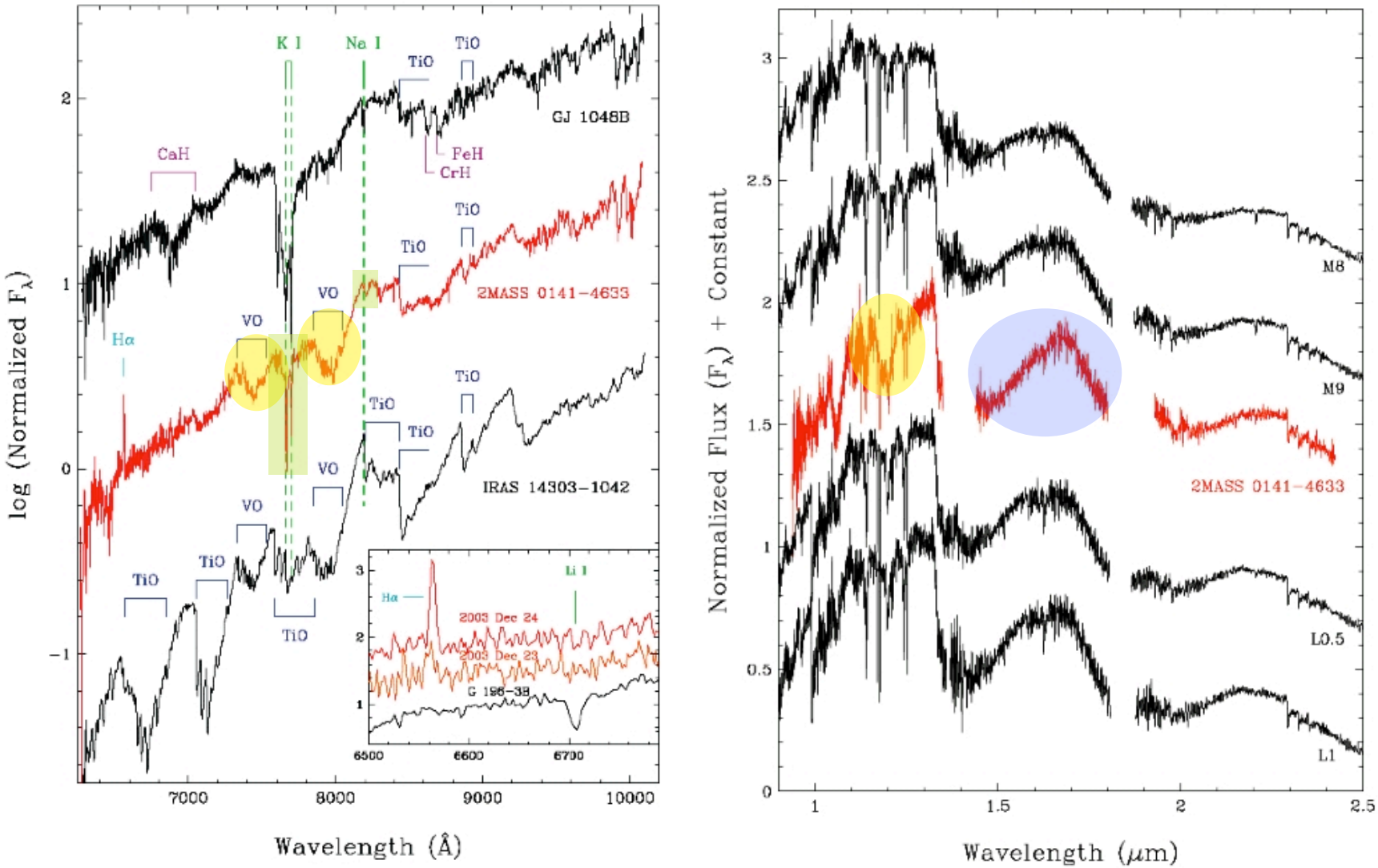
Lodders (1999)

$$P_{ph} \propto g/\kappa_R$$



Luhman et al. (2003)

2MASS 0141-4633: ~10 Myr and nearby

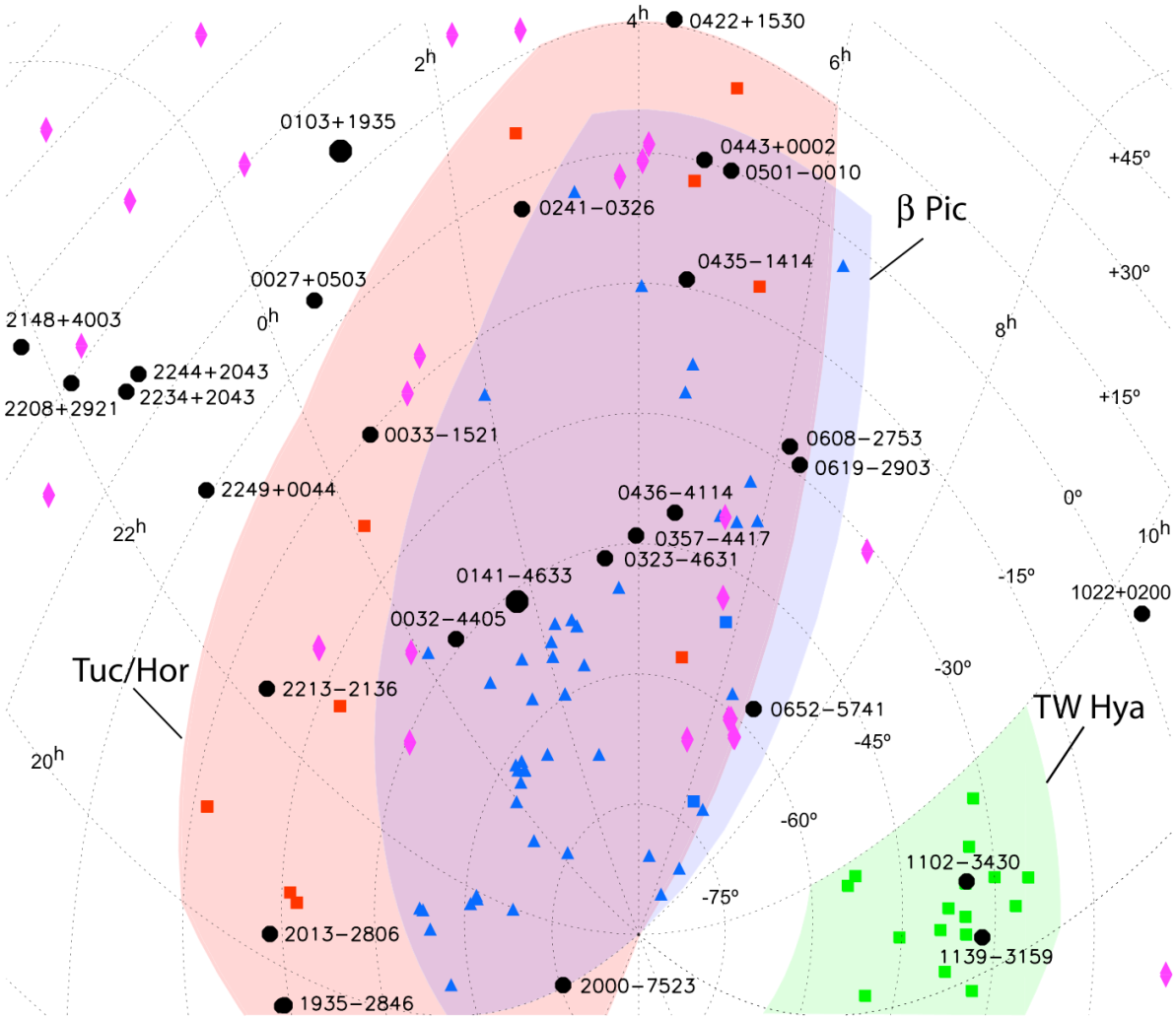


Kirkpatrick et al. (2006)

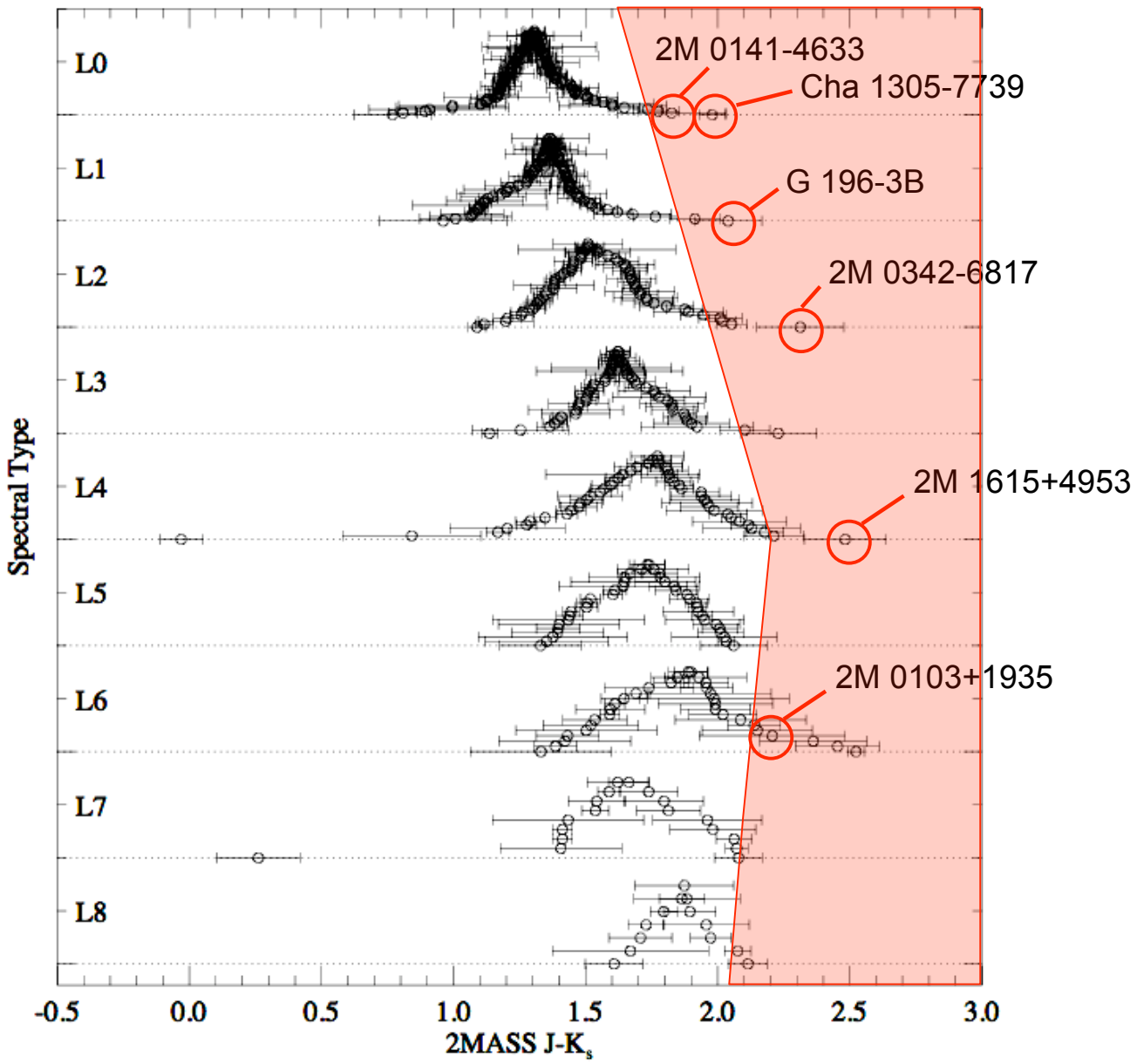
indicators of low surface gravity/youth:

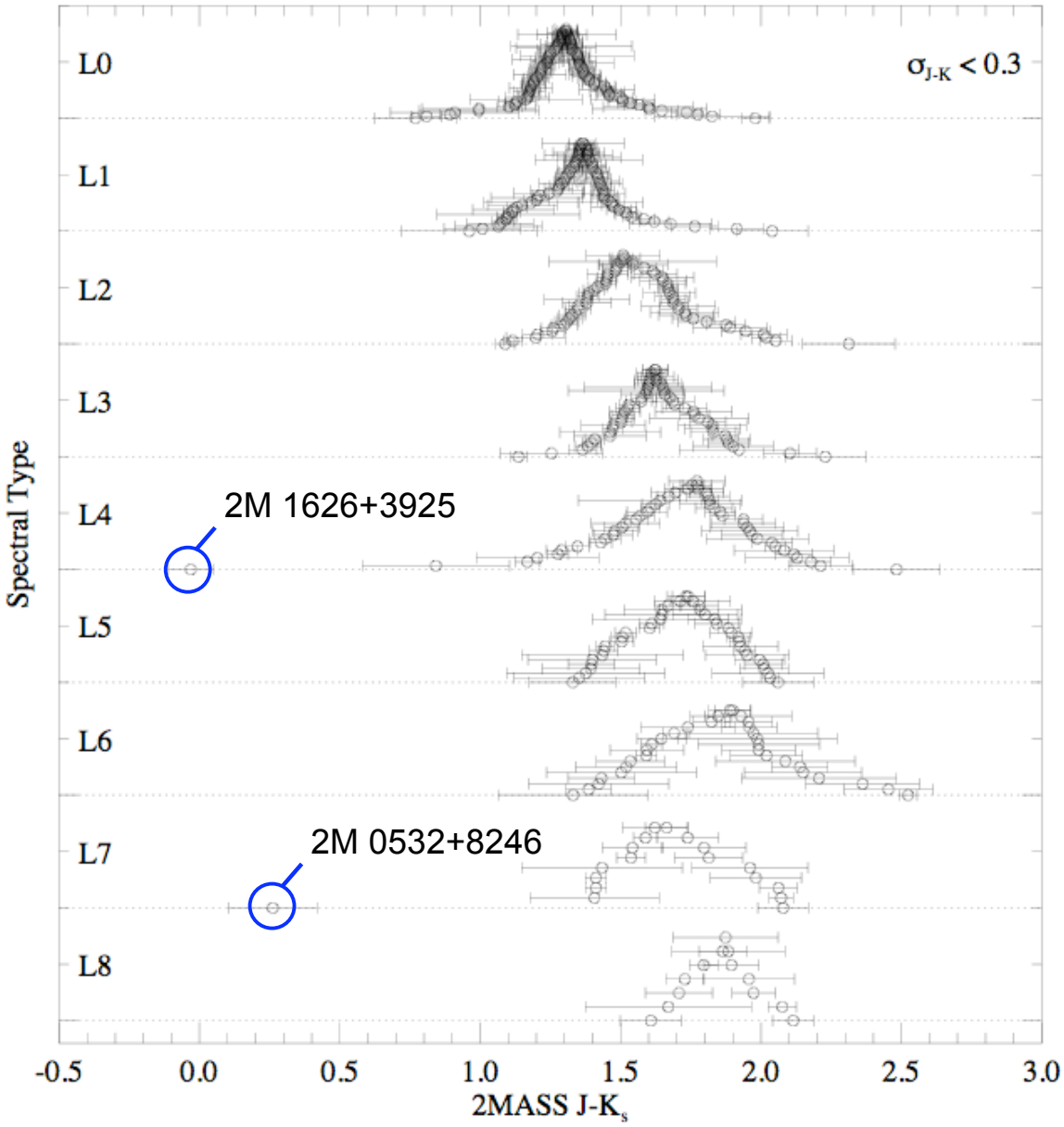
1. weak optical alkali lines (Na I, K I, Li I?)
2. enhanced metal oxide bands (VO, H_2O, CO)
3. a “peaky” H-band peak
4. reddened near-infrared SEDs

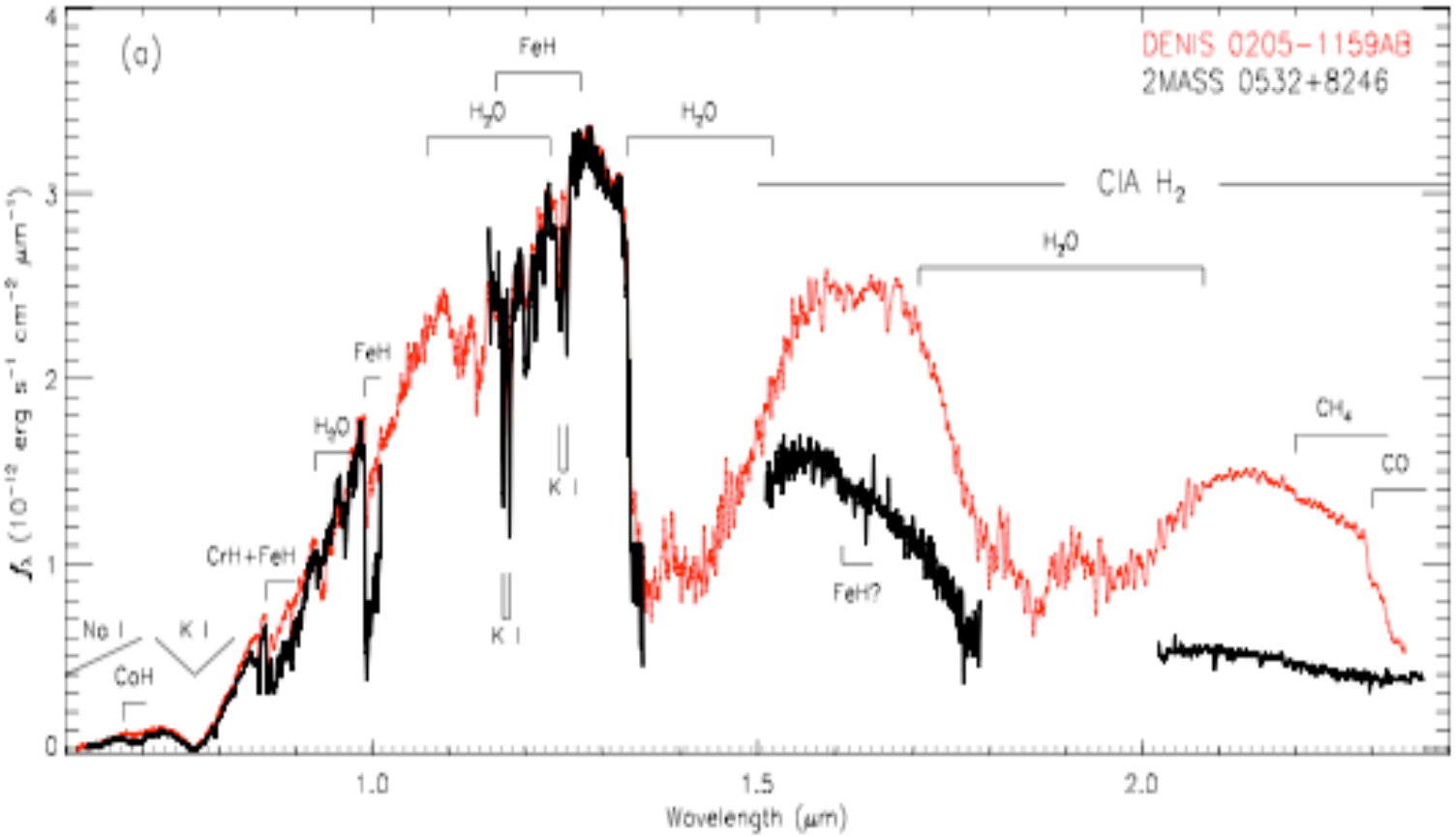
10-50 Myr brown dwarfs in the vicinity of the Sun



Cruz et al. (2006)

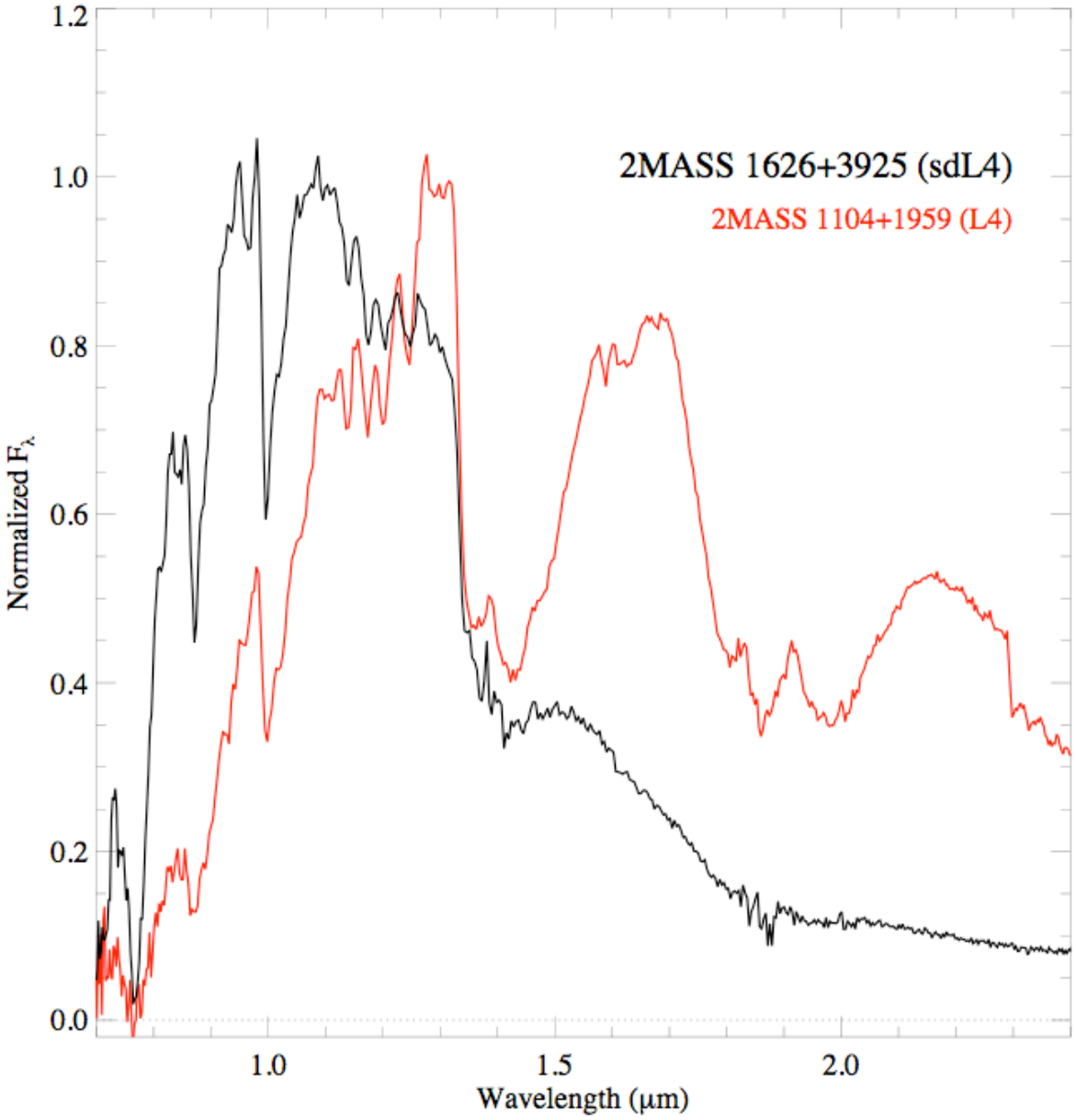






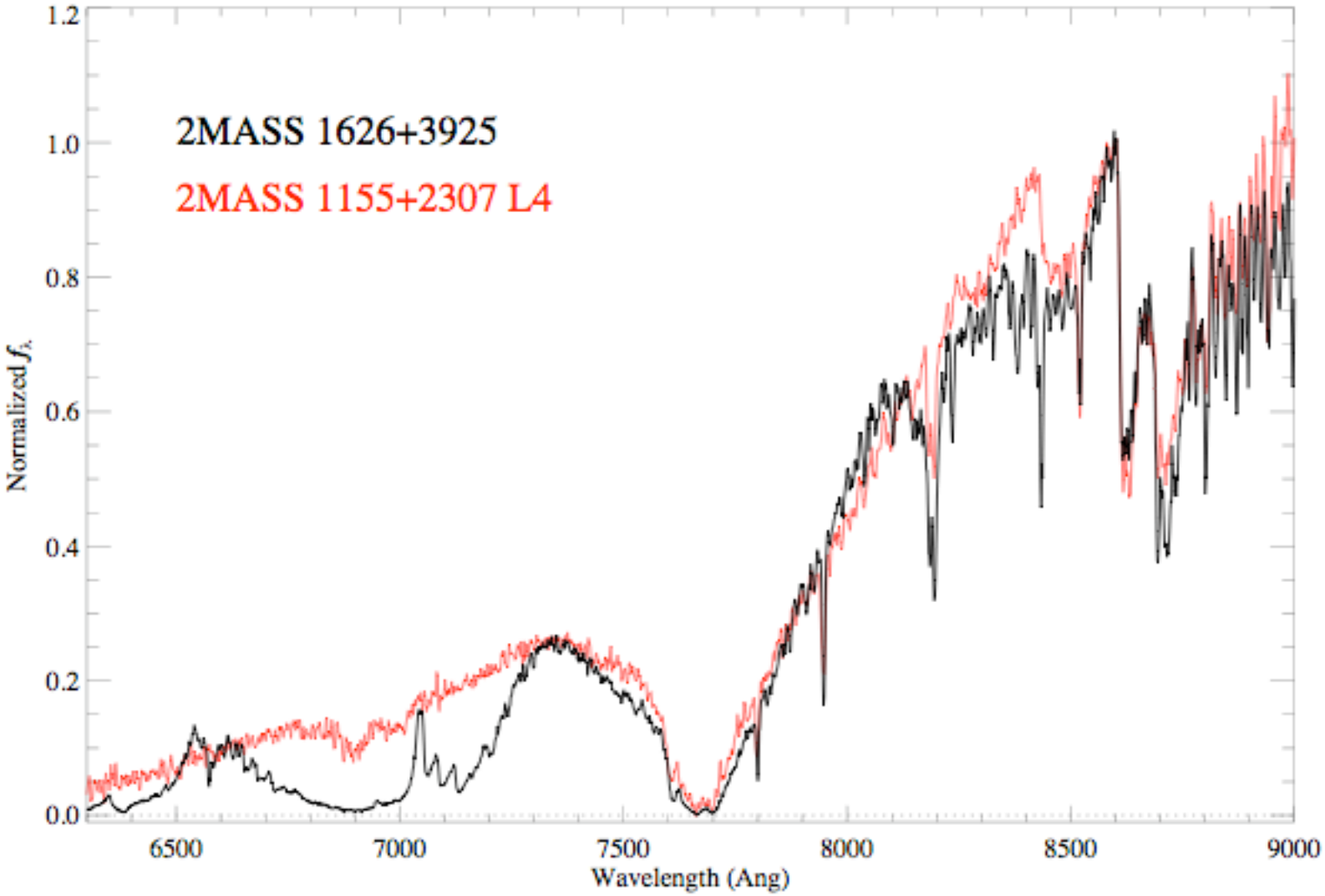
2MASS 0532+8246

Burgasser et al. (2003)

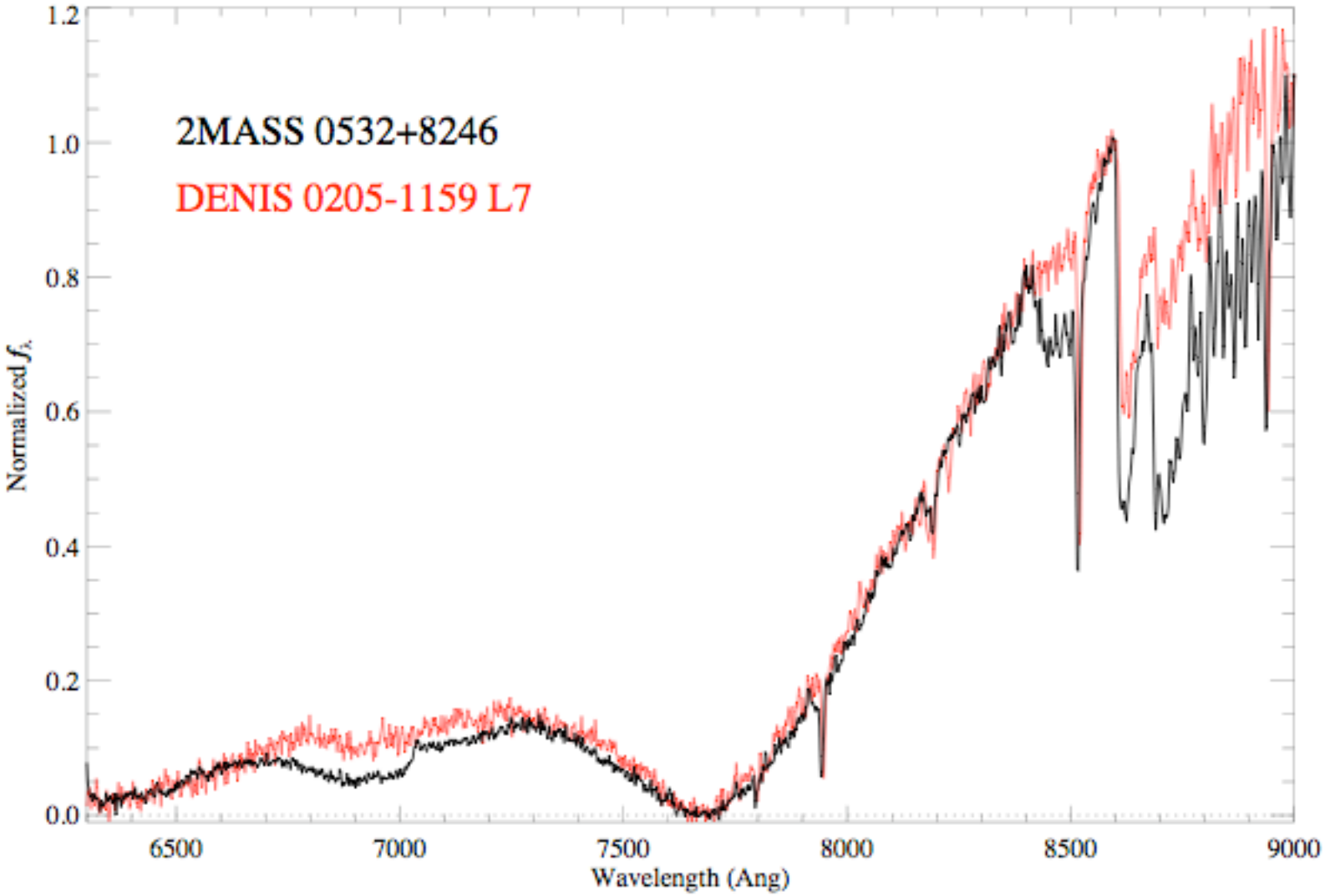


2MASS 1626+3925

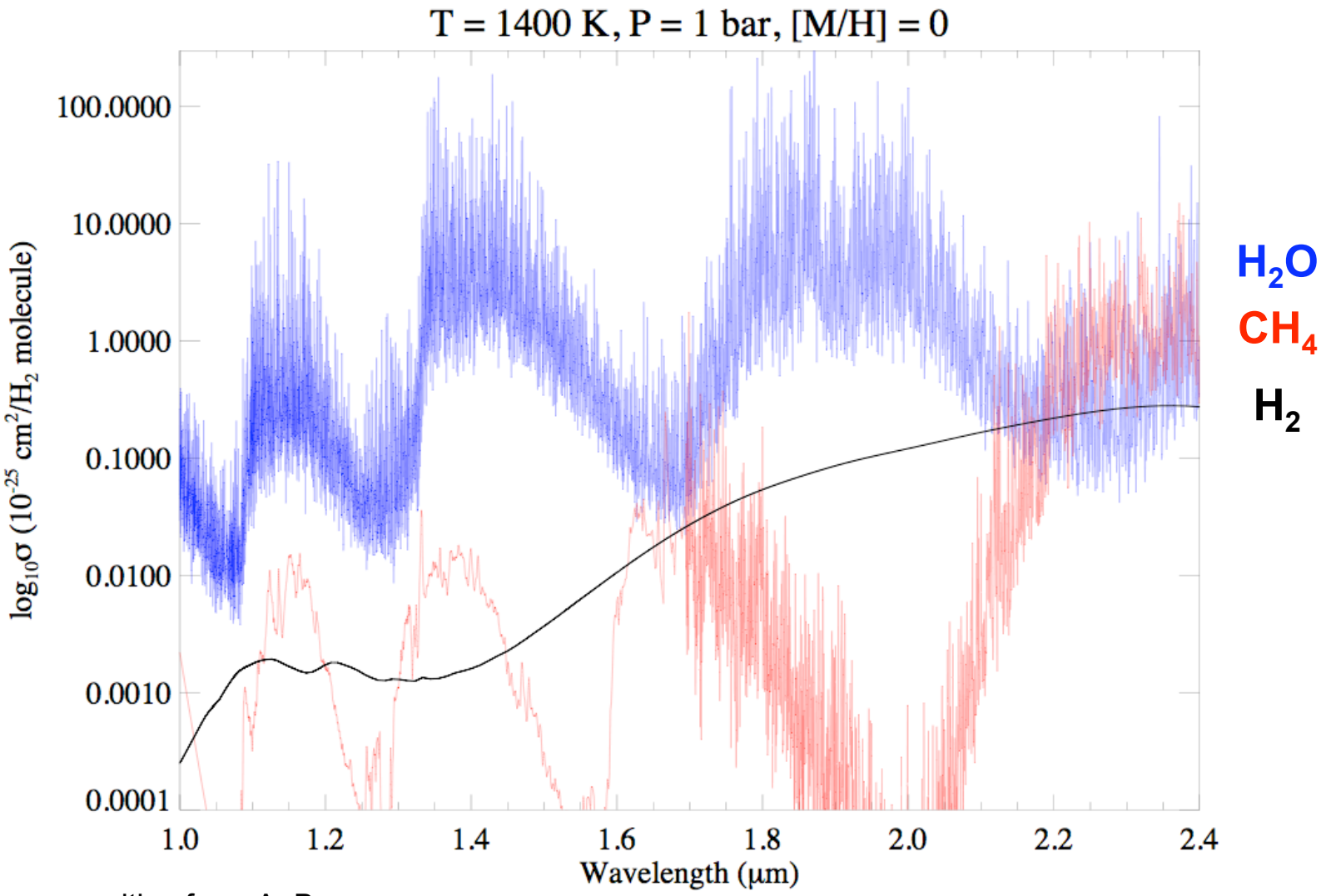
Burgasser (2004)



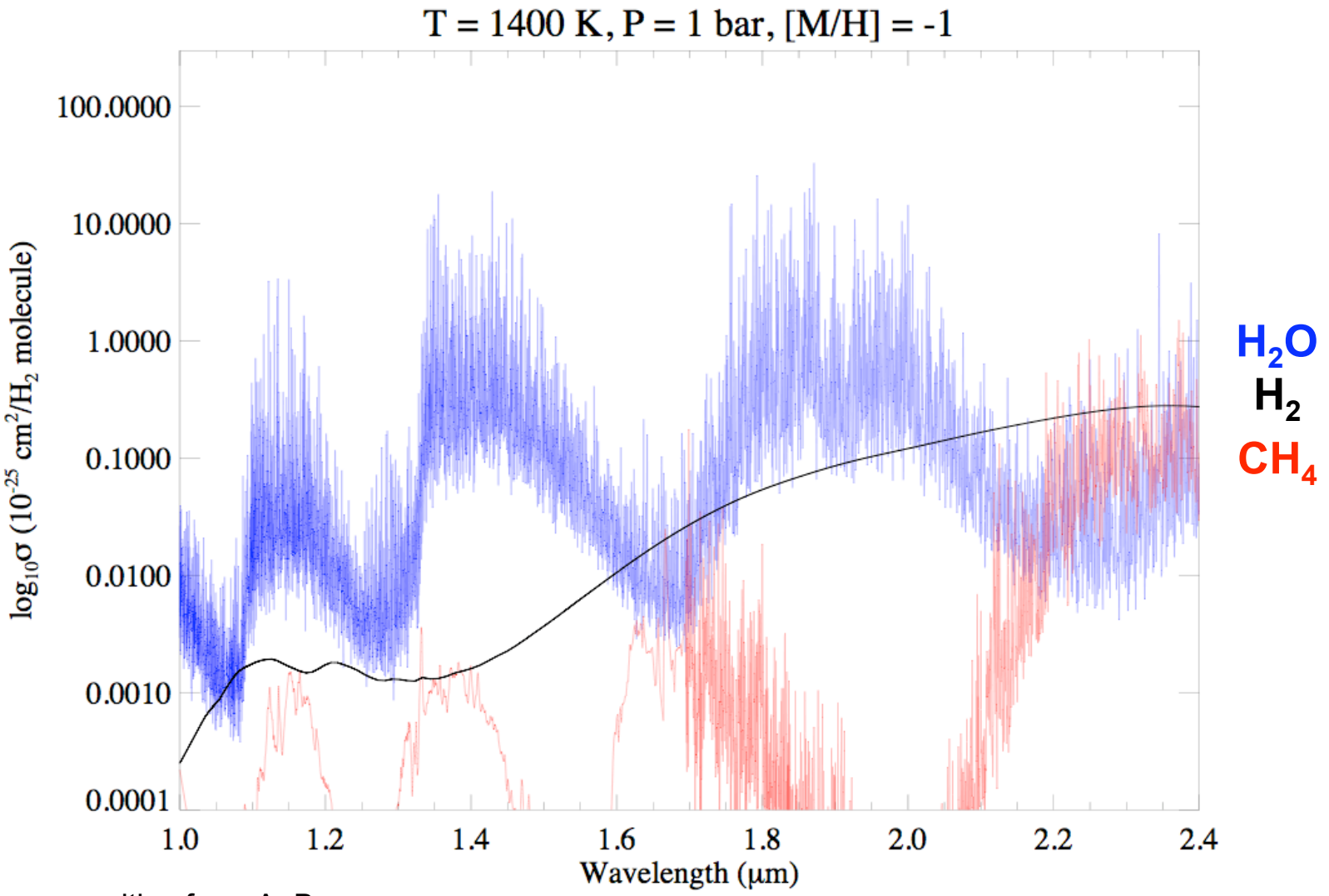
Burgasser, Kirkpatrick & Cruz (2006)



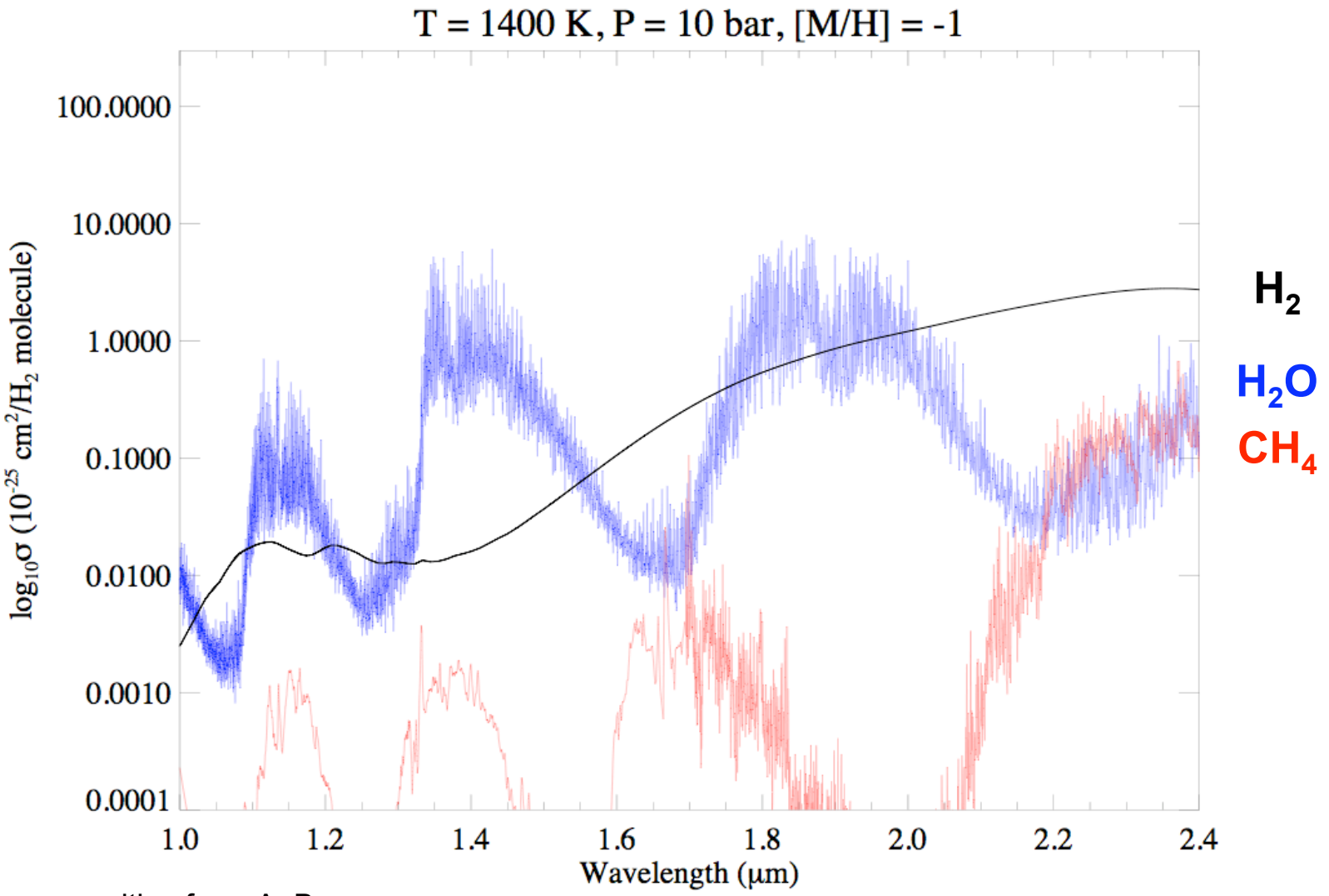
Burgasser, Kirkpatrick & Cruz (2006)



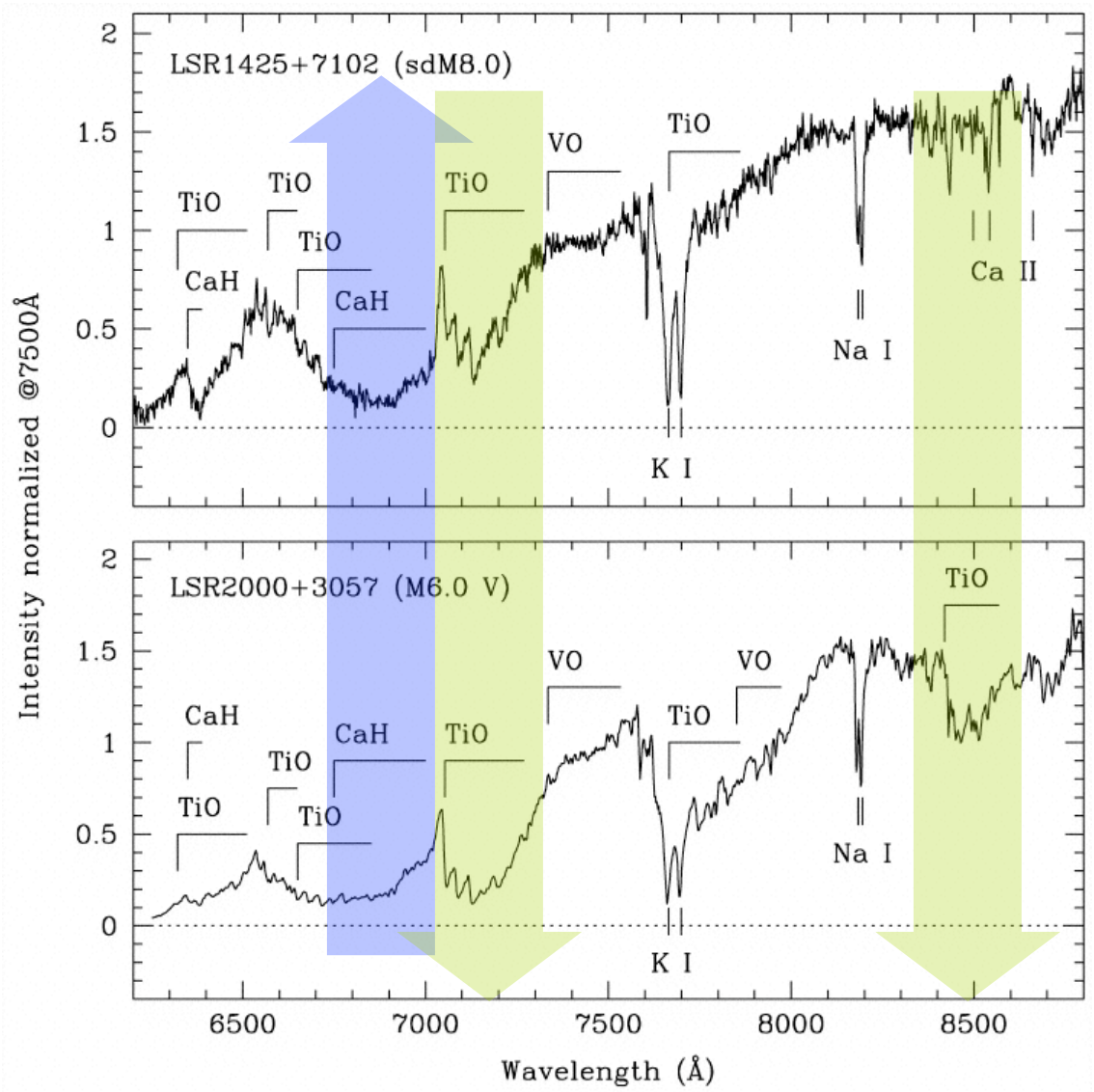
opacities from A. Burrows



opacities from A. Burrows



opacities from A. Burrows



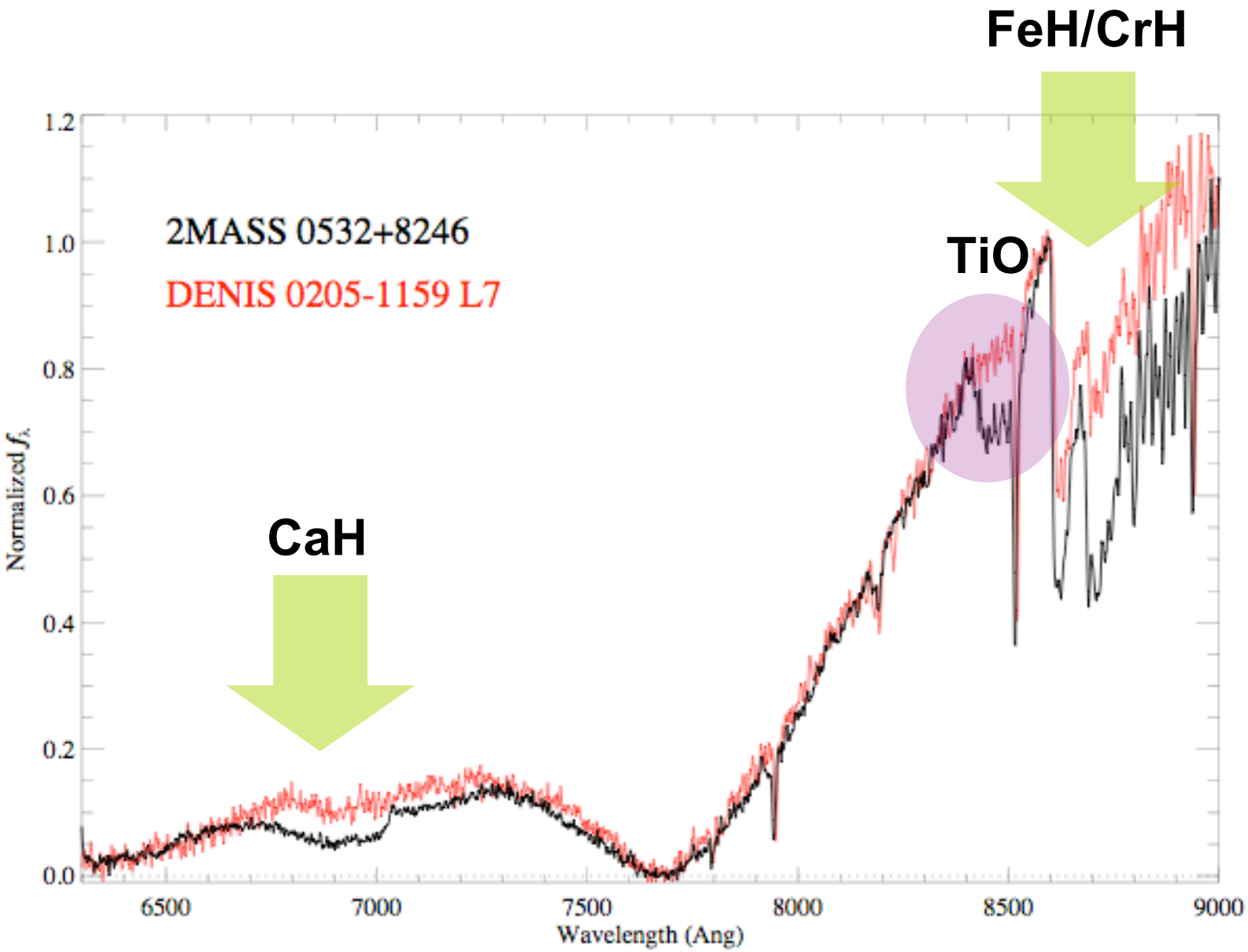
Lepine et al. (2003)
see also Gizis (1997); Lepine et al. (2004); Burgasser et al. (2006)

M subdwarfs

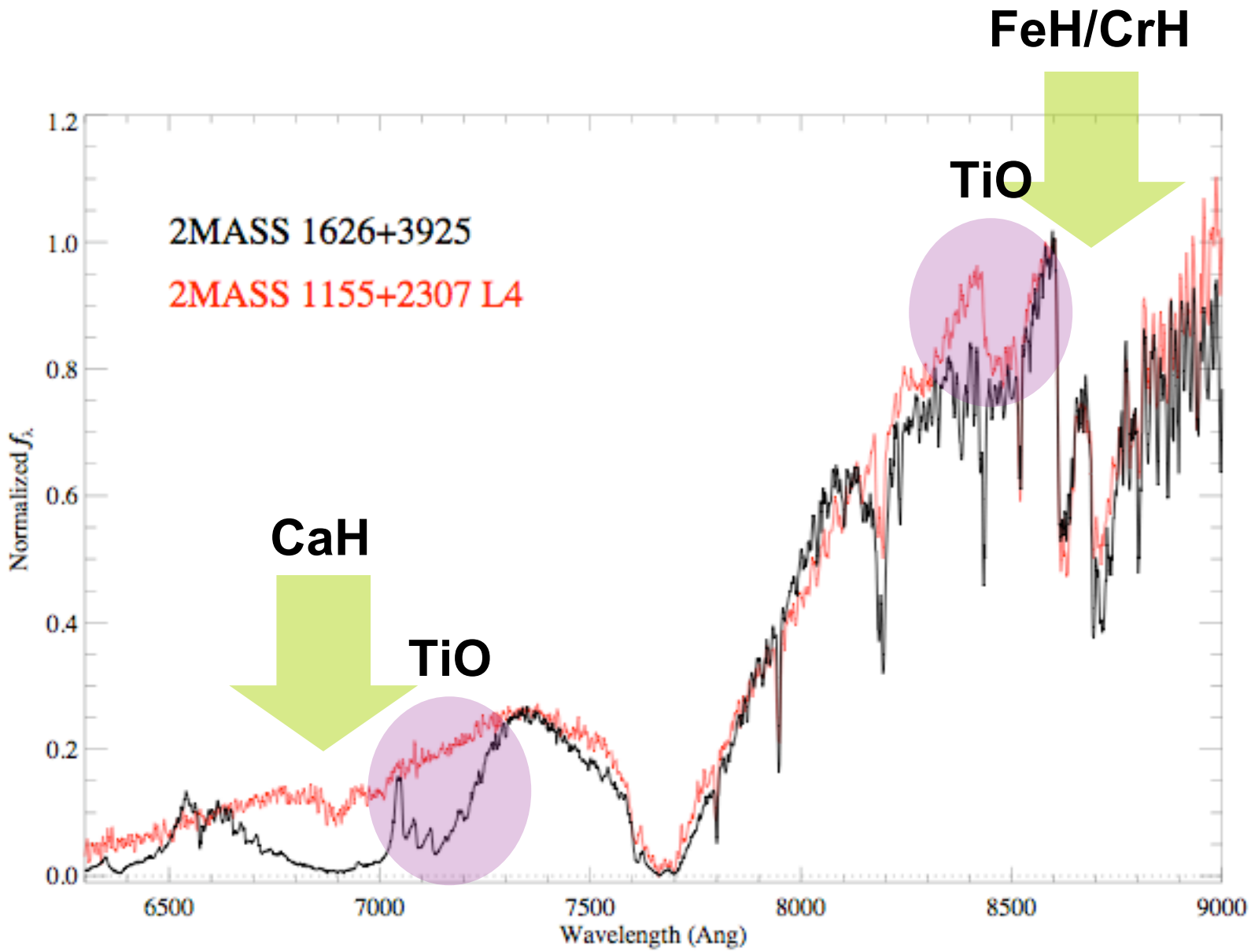
strong metal hydrides
weak metal oxides

sdMs: [M/H] ~ -1.2
esdMs: [M/H] ~ -2.0

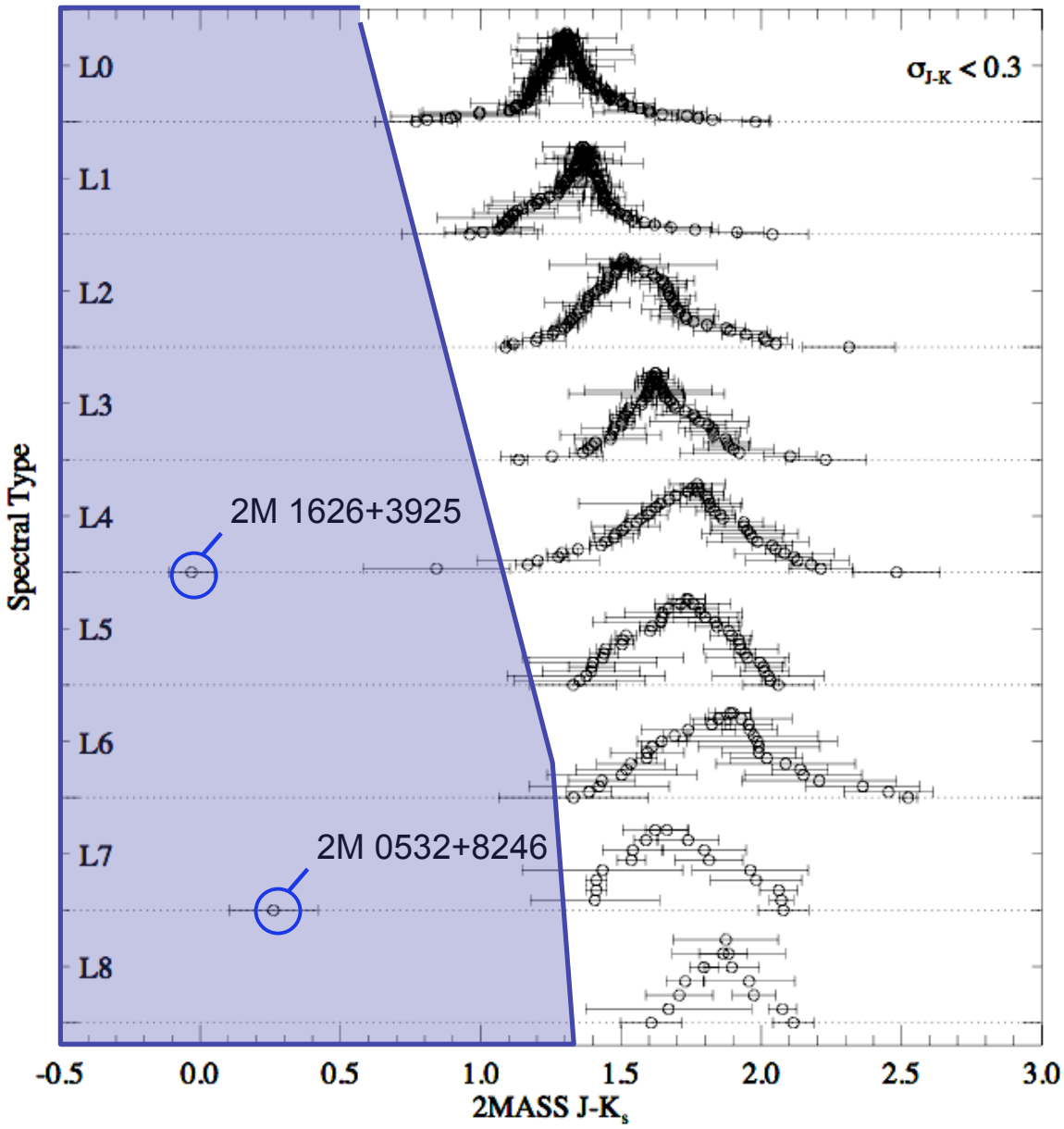
V_{LSR} ~ -200 km/s

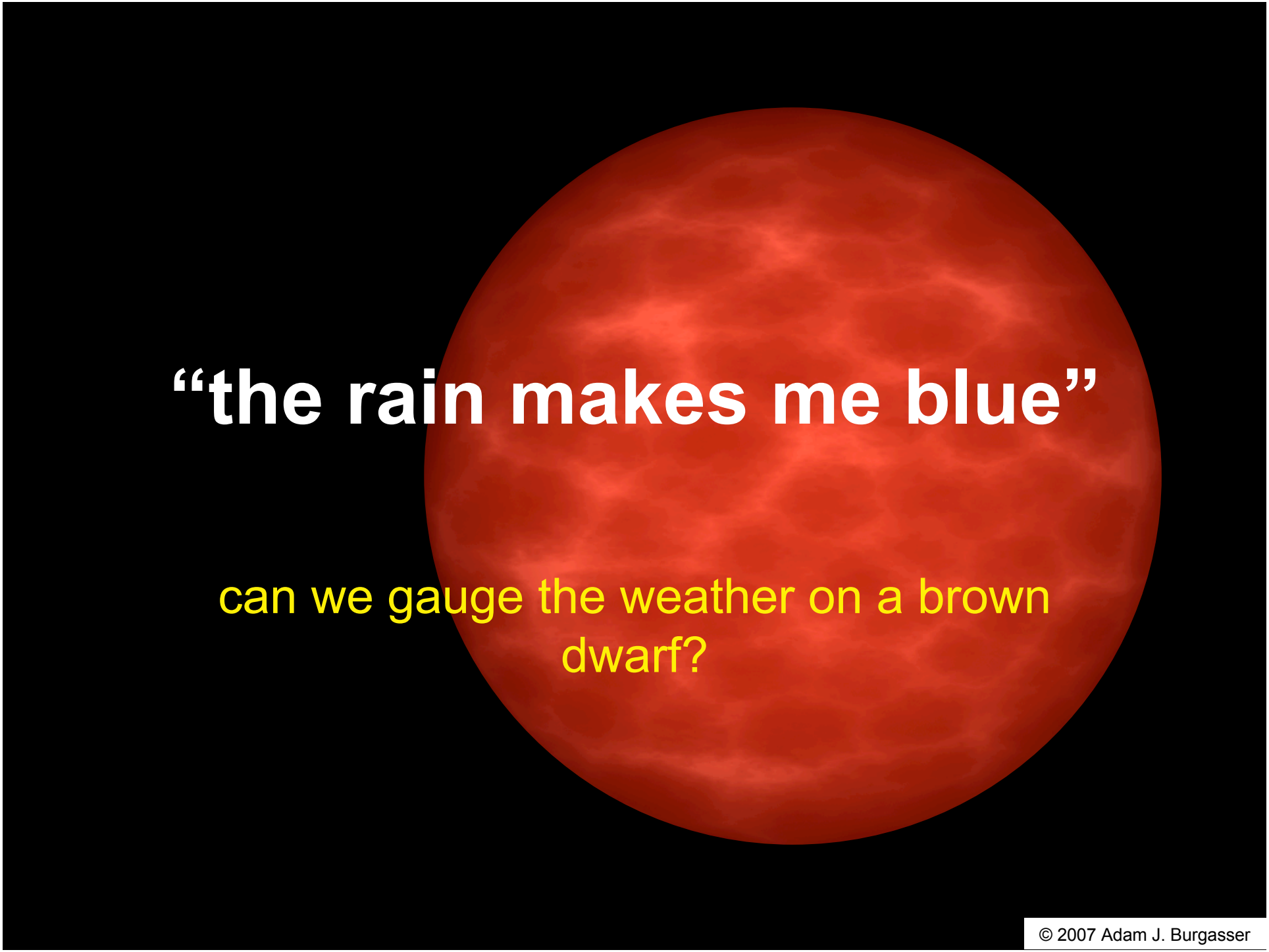


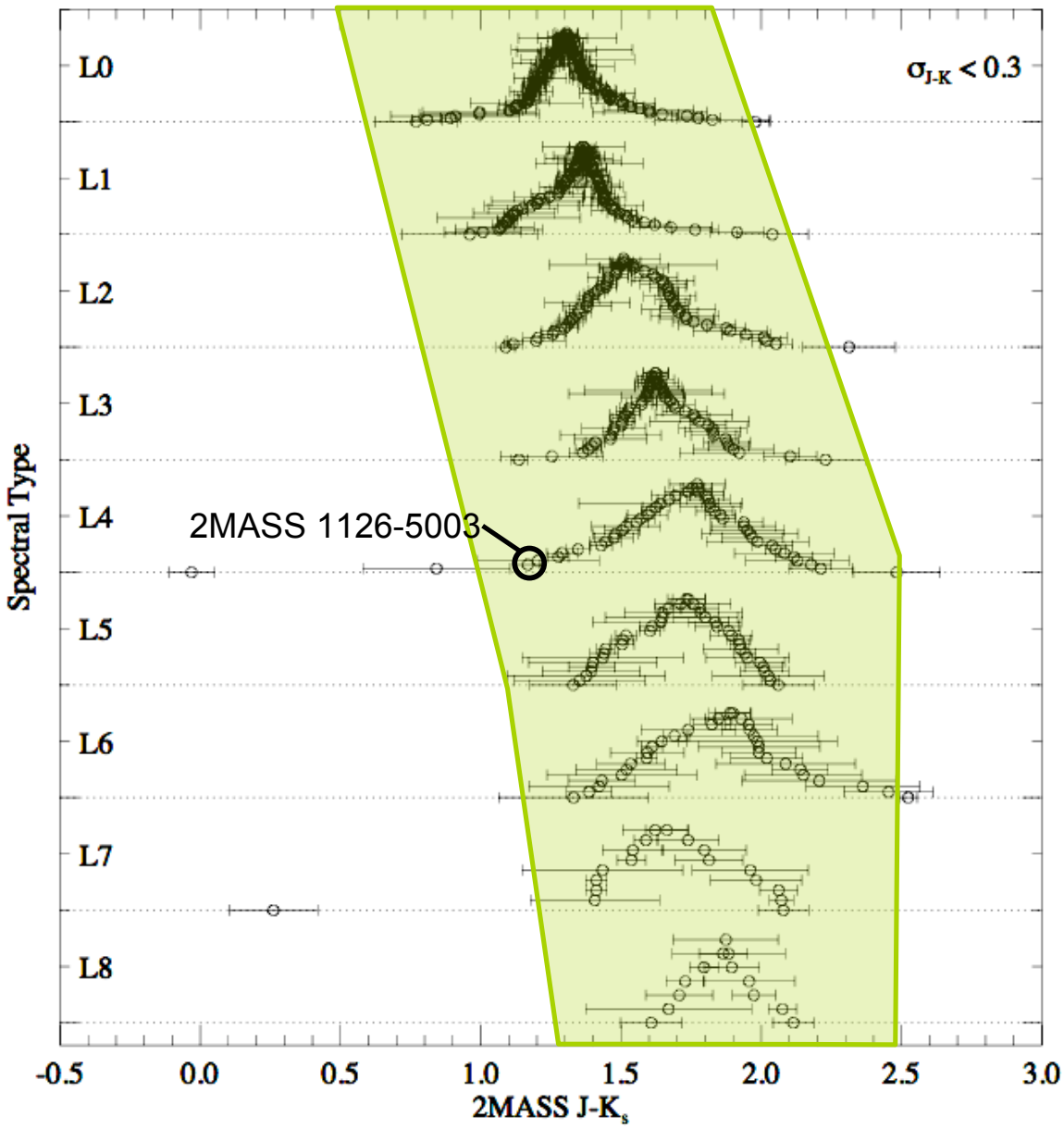
Burgasser, Kirkpatrick & Cruz (2006)

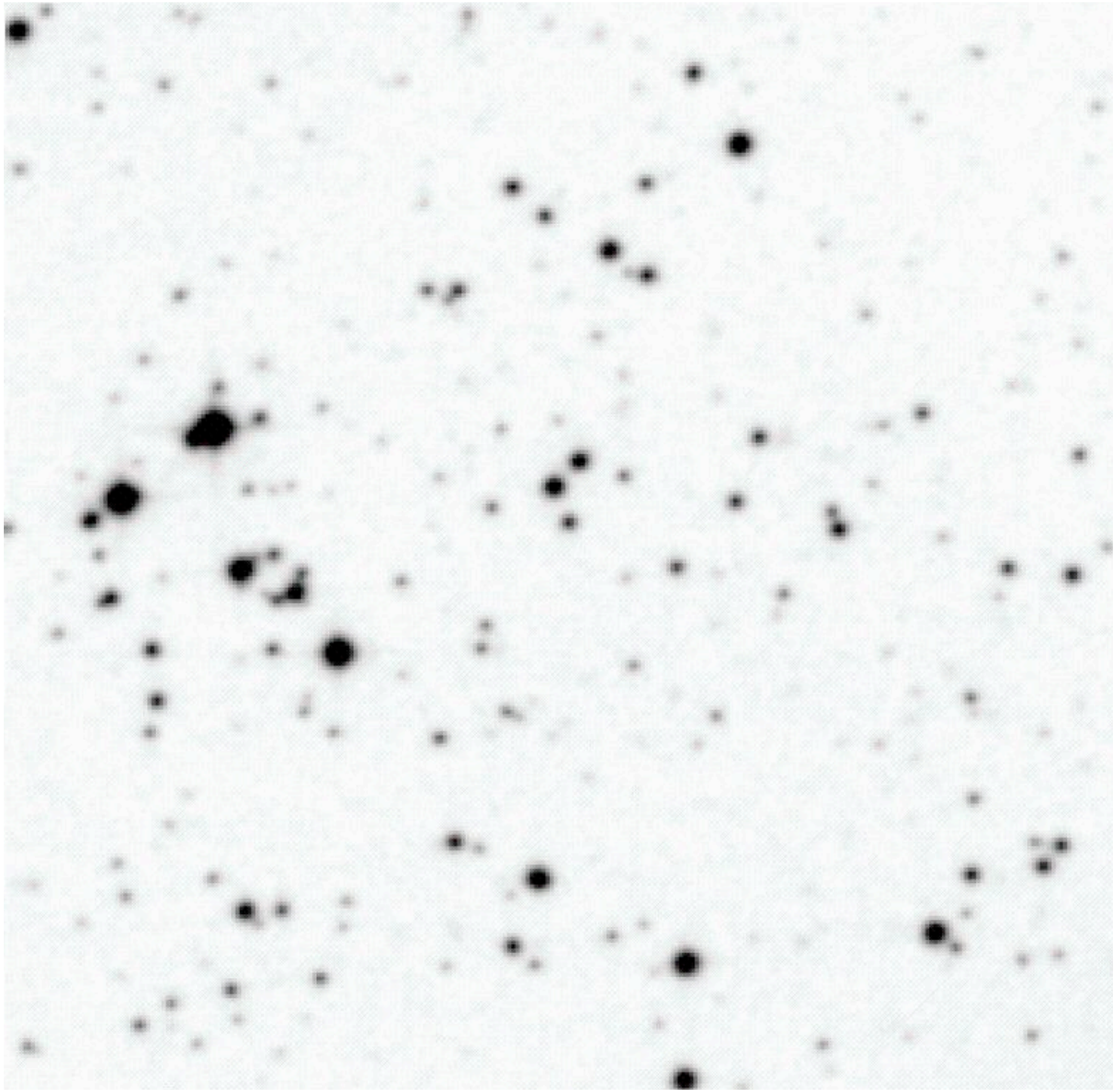


Burgasser, Kirkpatrick & Cruz (2006)

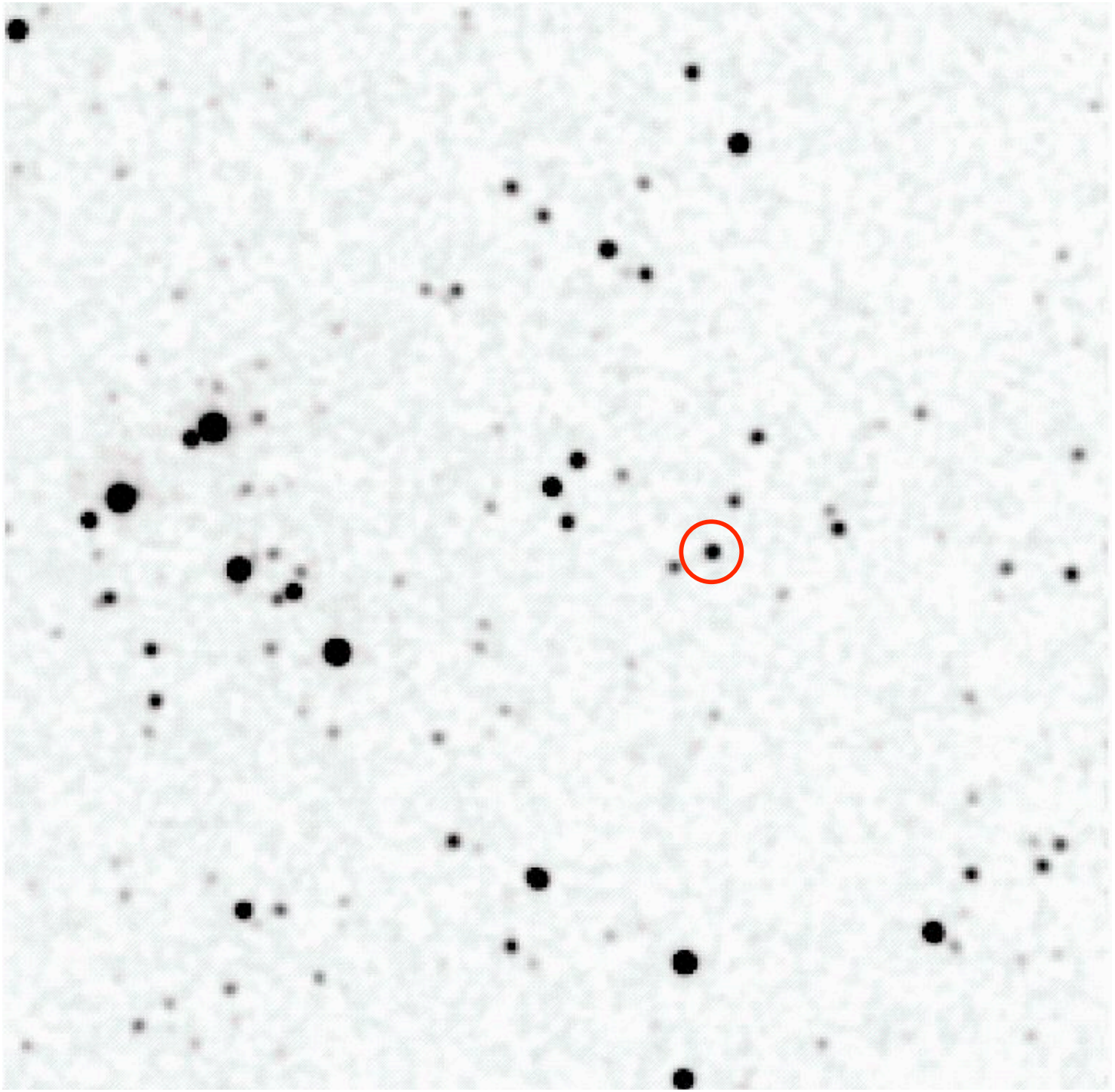




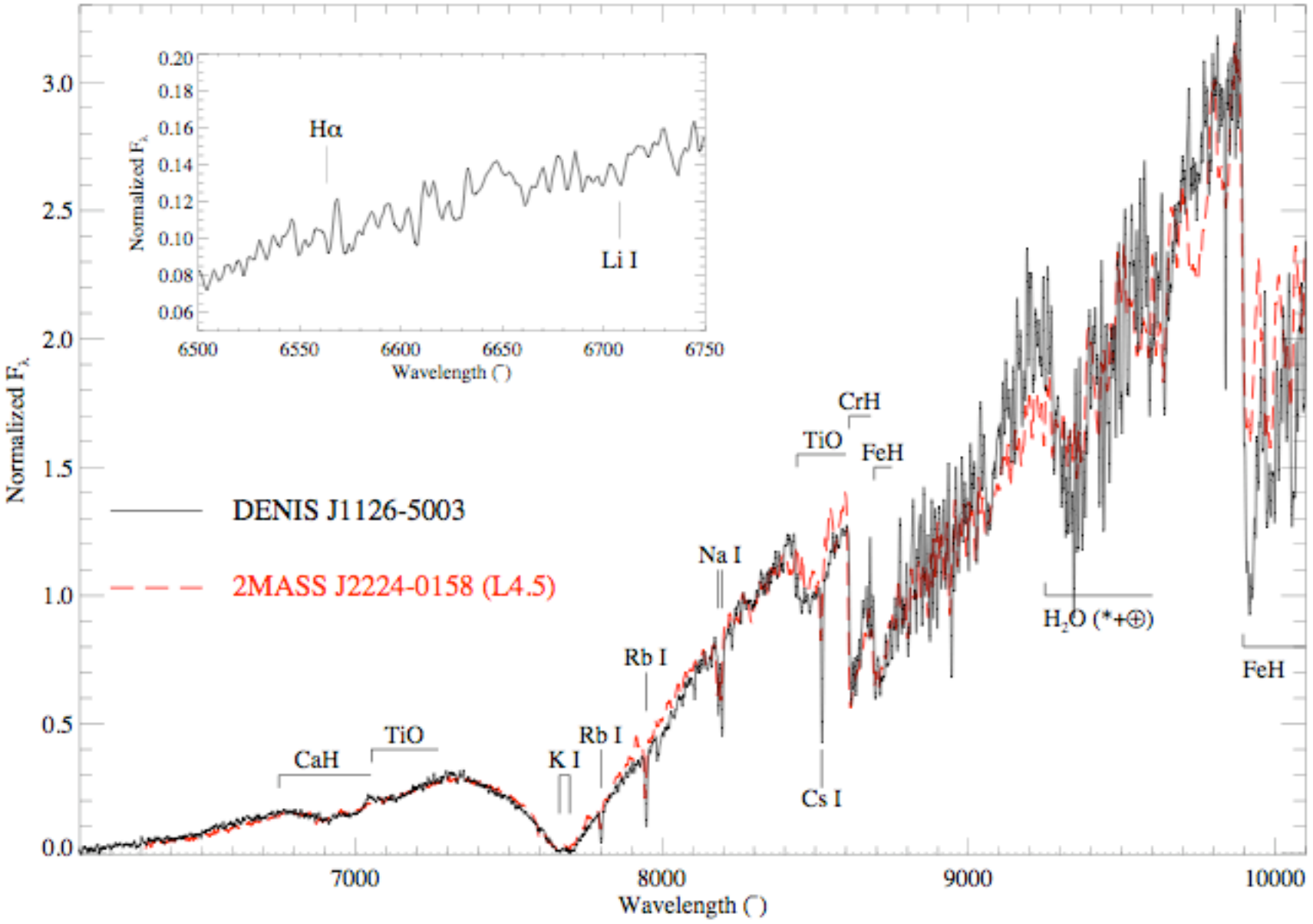




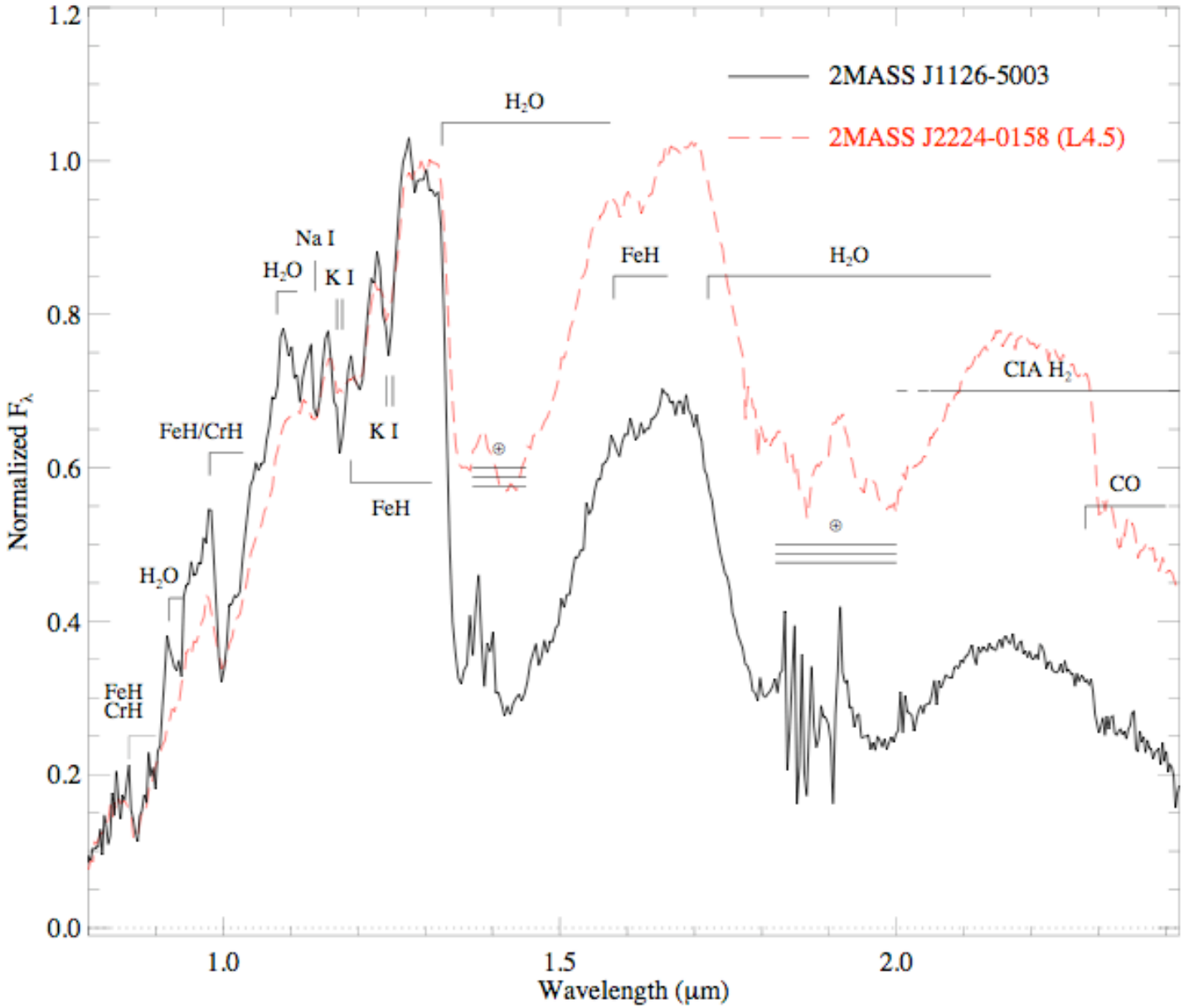
1985
SERC I_N



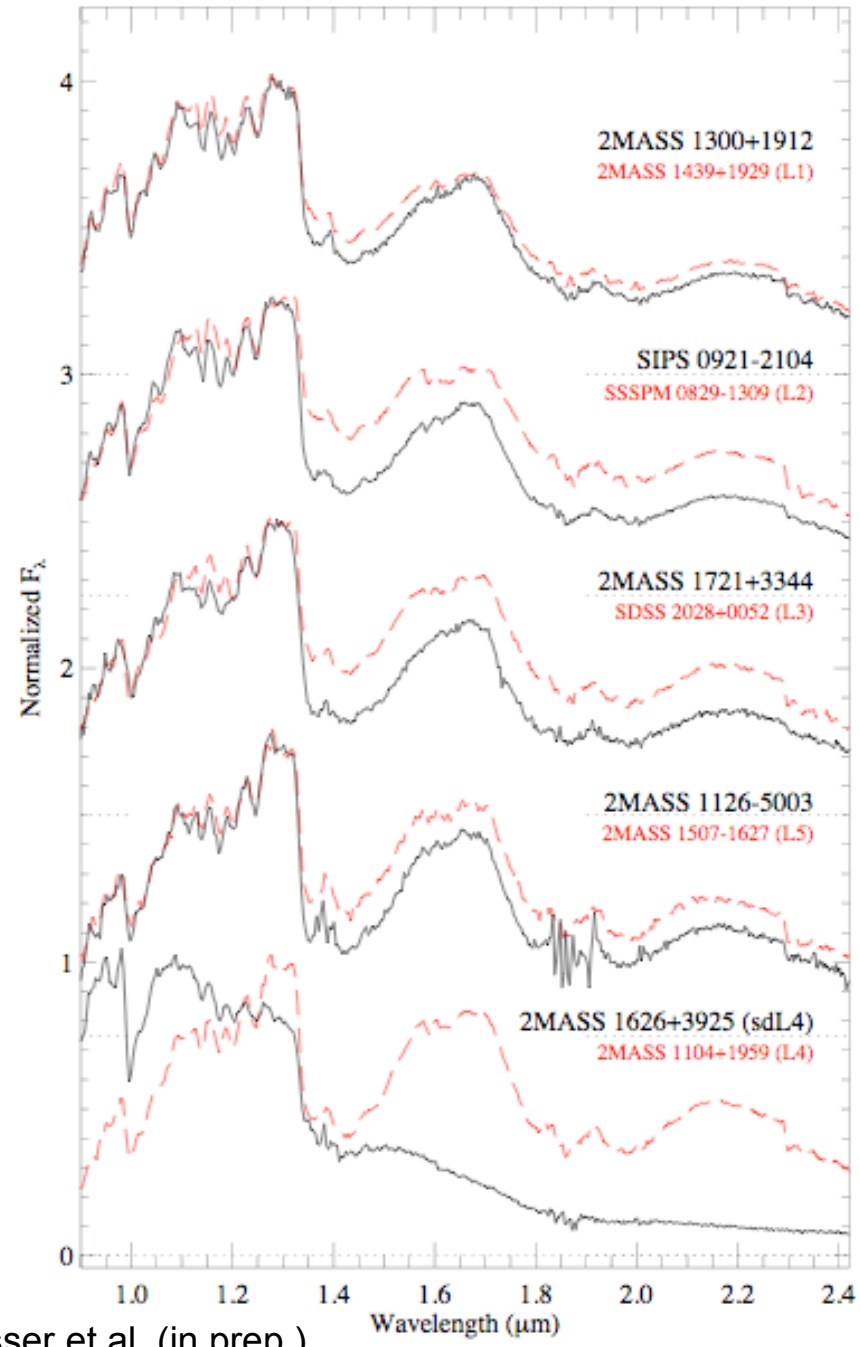
1999
2MASS J



Burgasser et al. (in prep.)



Burgasser et al. (in prep.)



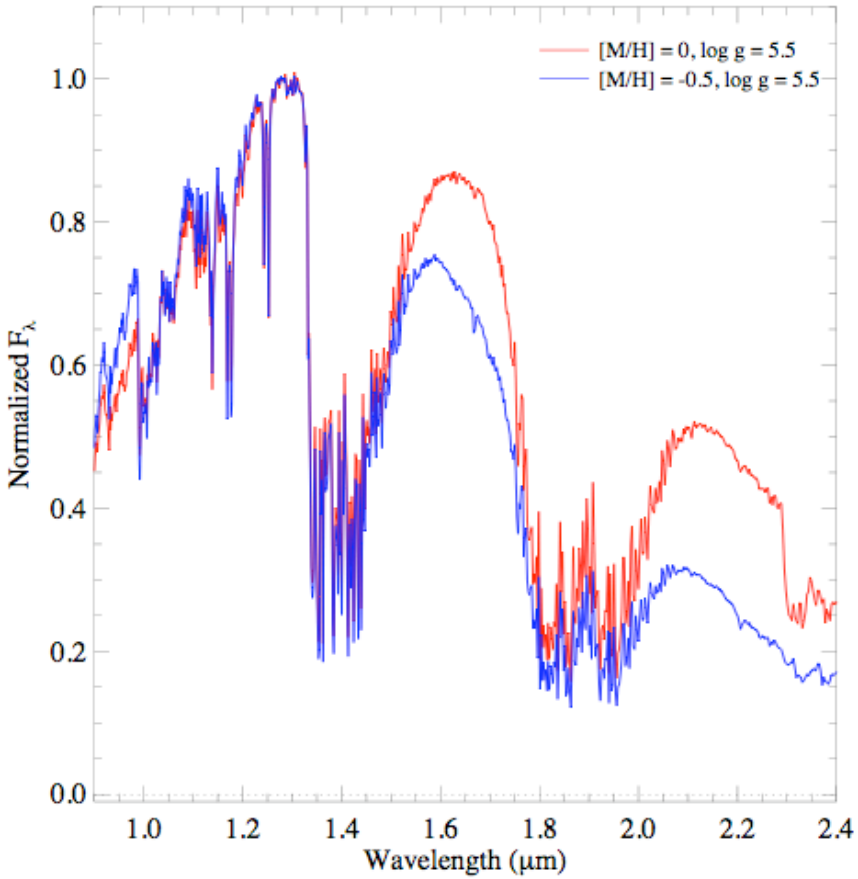
Burgasser et al. (in prep.)

blue L dwarfs

Cruz et al. (2003, 2006); Burgasser et al. (2004); Knapp et al. (2004); Chiu et al. (2006); Schmidt et al. (2007)

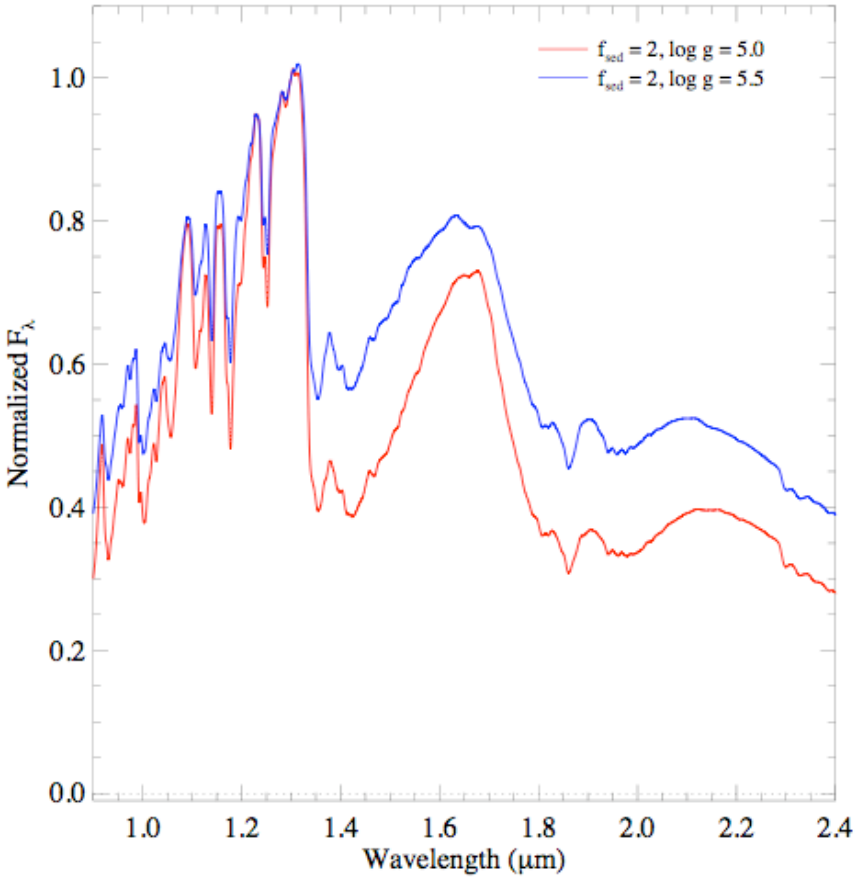
- J-K ~ 0.3 mag too blue
- normal optical spectra
- deep H_2O absorption
- large proper motions

Lower metallicity?

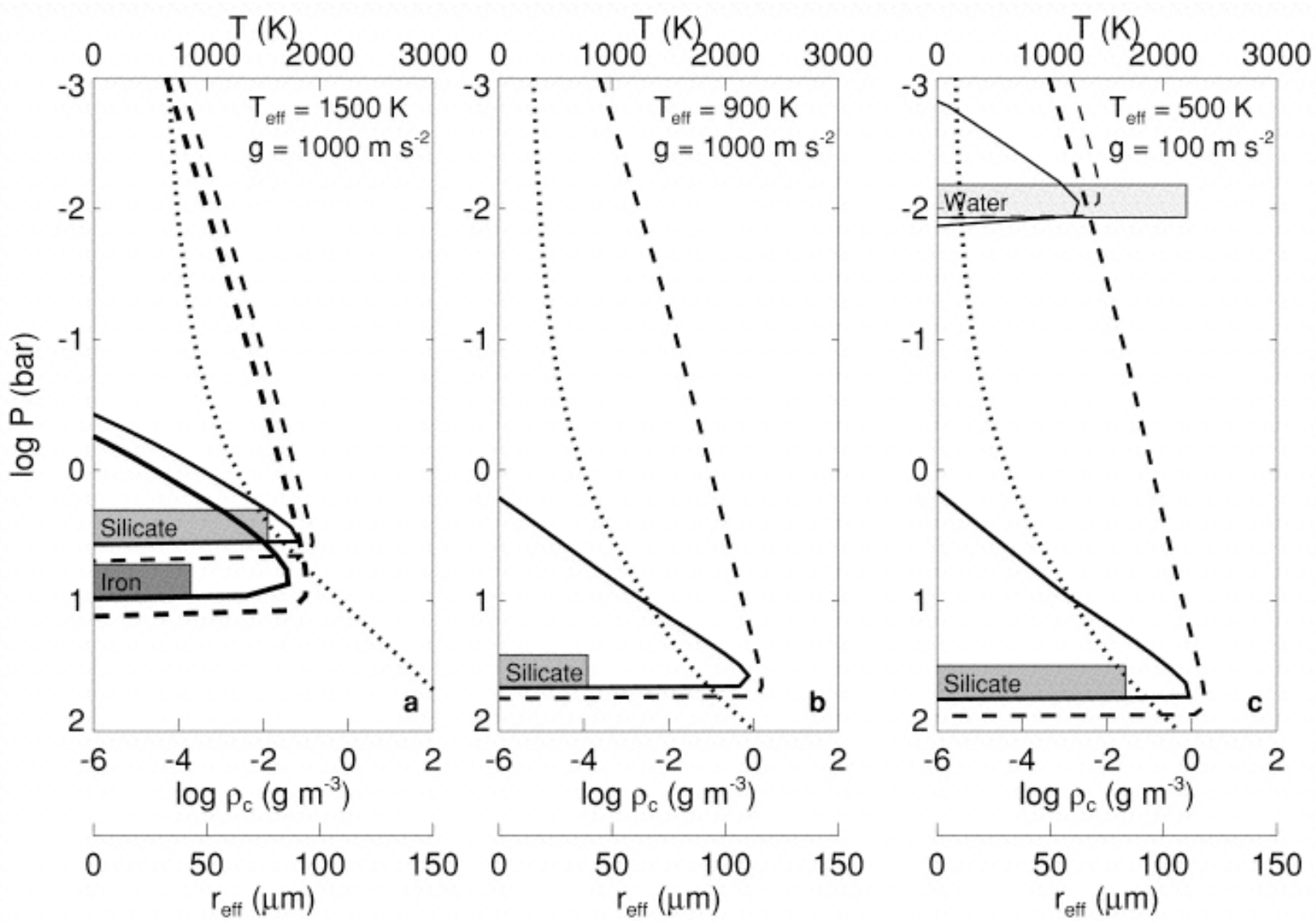


models from Burrows et al. (2006)

Higher surface gravity?

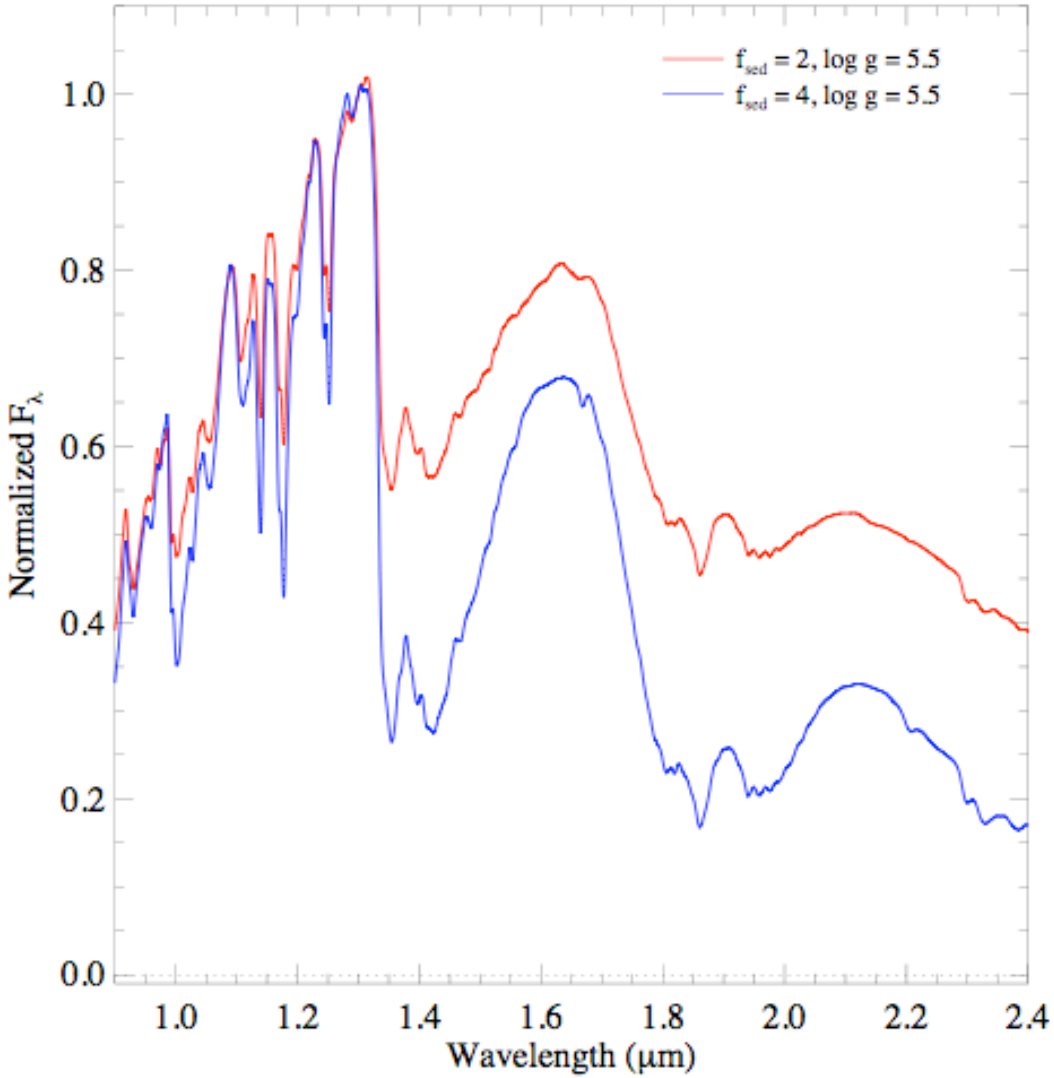


models from D. Saumon & M. Marley



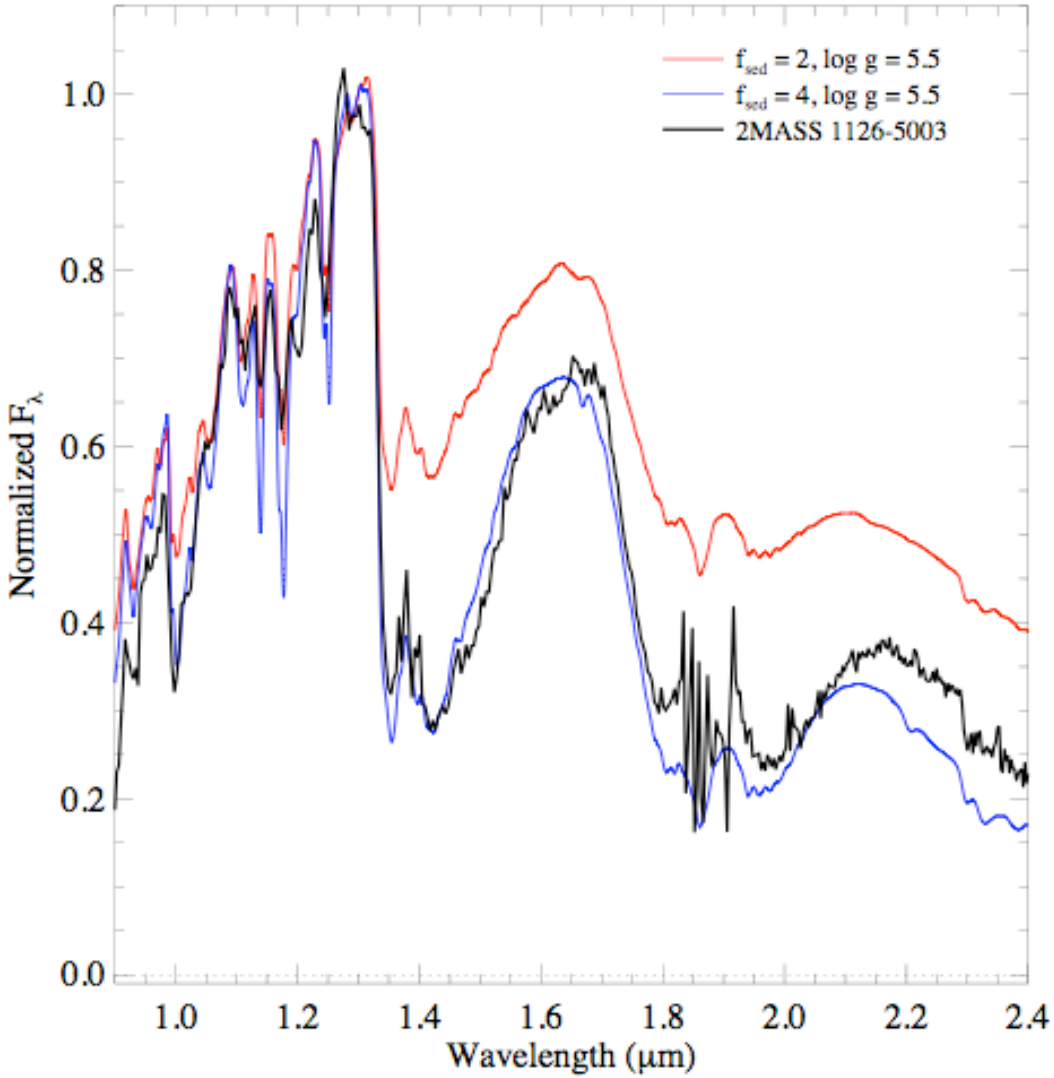
Ackerman & Marley (2001)

Thinner clouds?

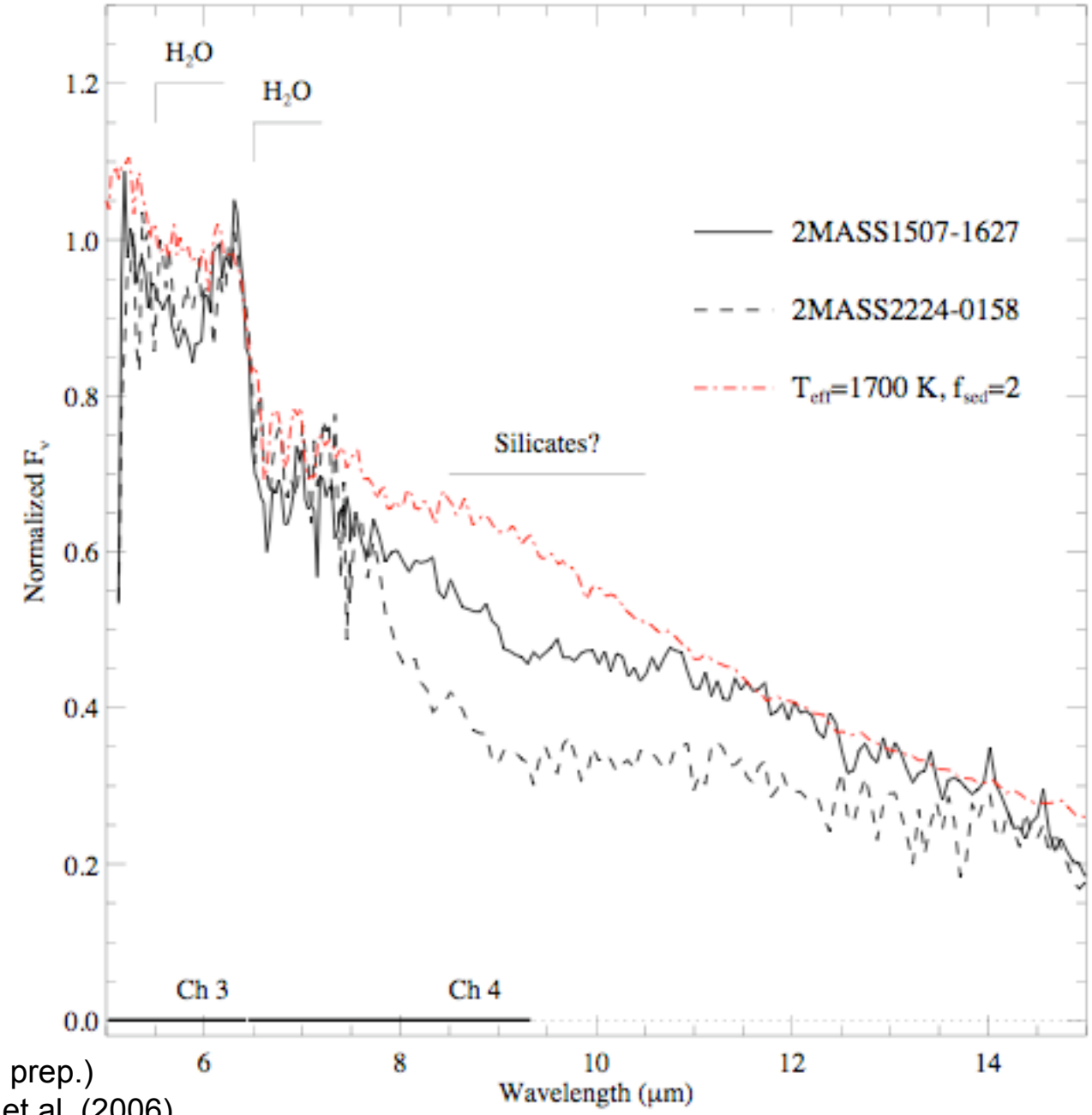


models from D. Saumon & M. Marley

Thinner clouds?

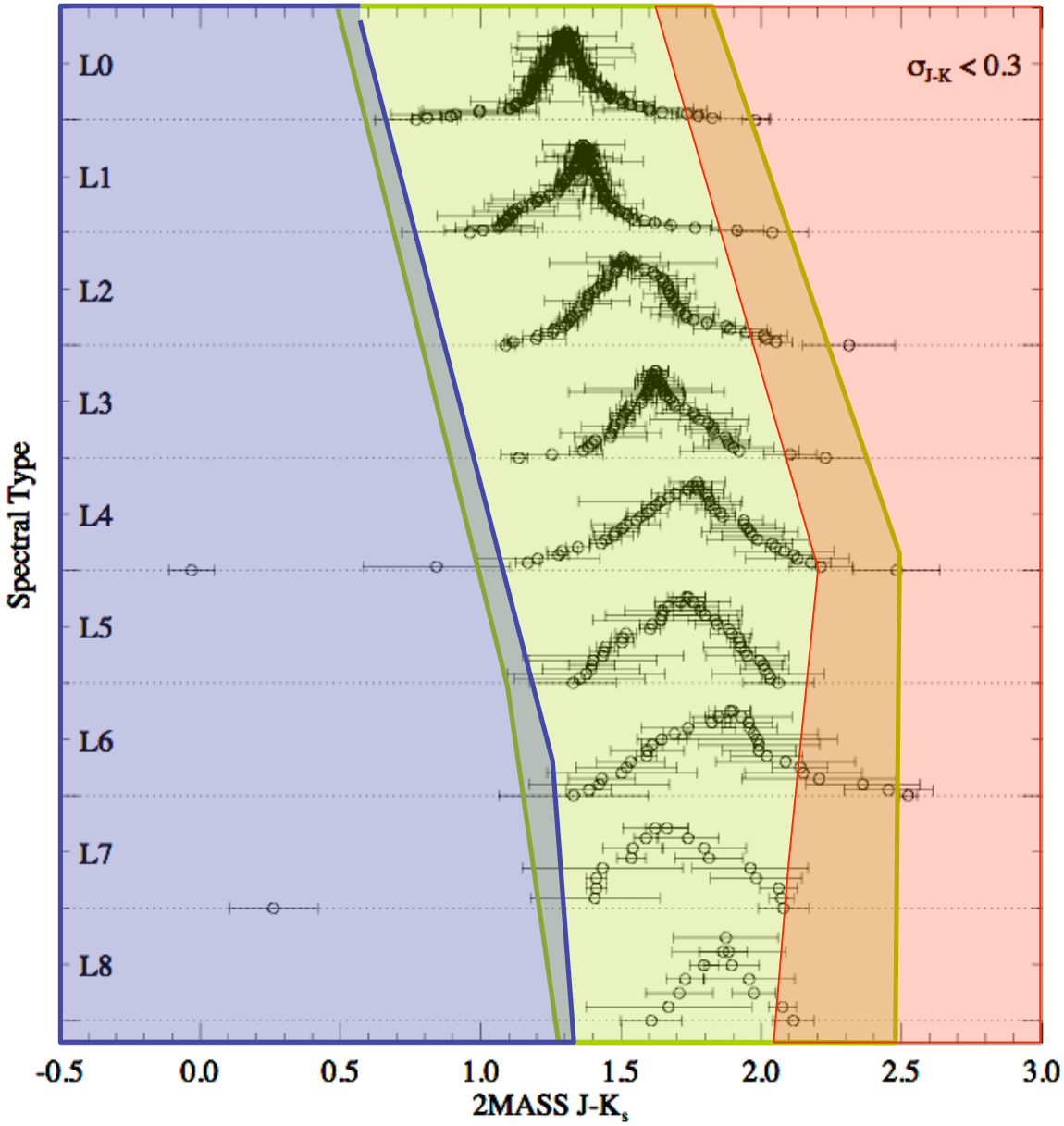


Burgasser et al. (in prep.)
see also Knapp et al. (2004)



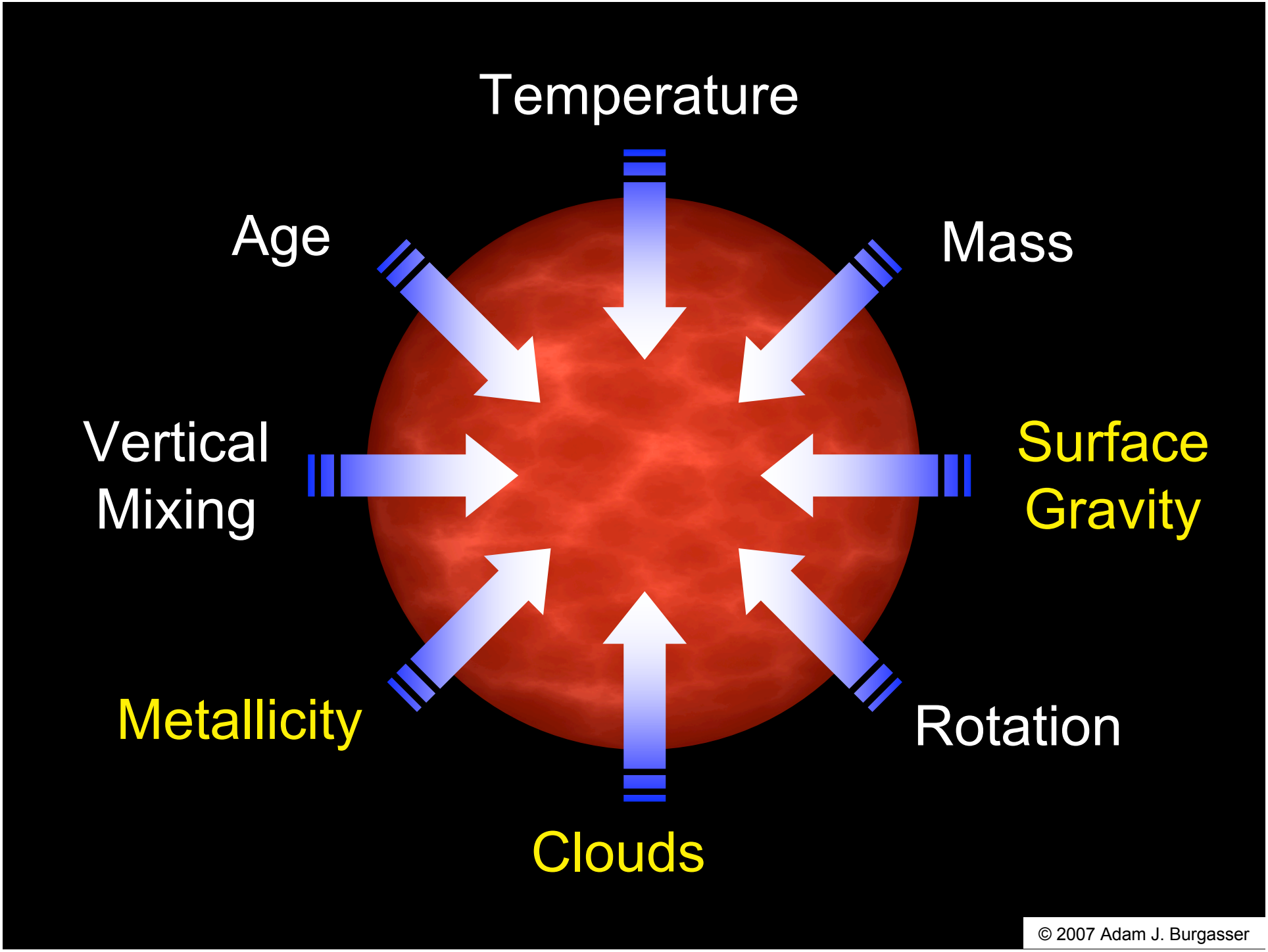
Burgasser et al. (in prep.)
data from Cushing et al. (2006)

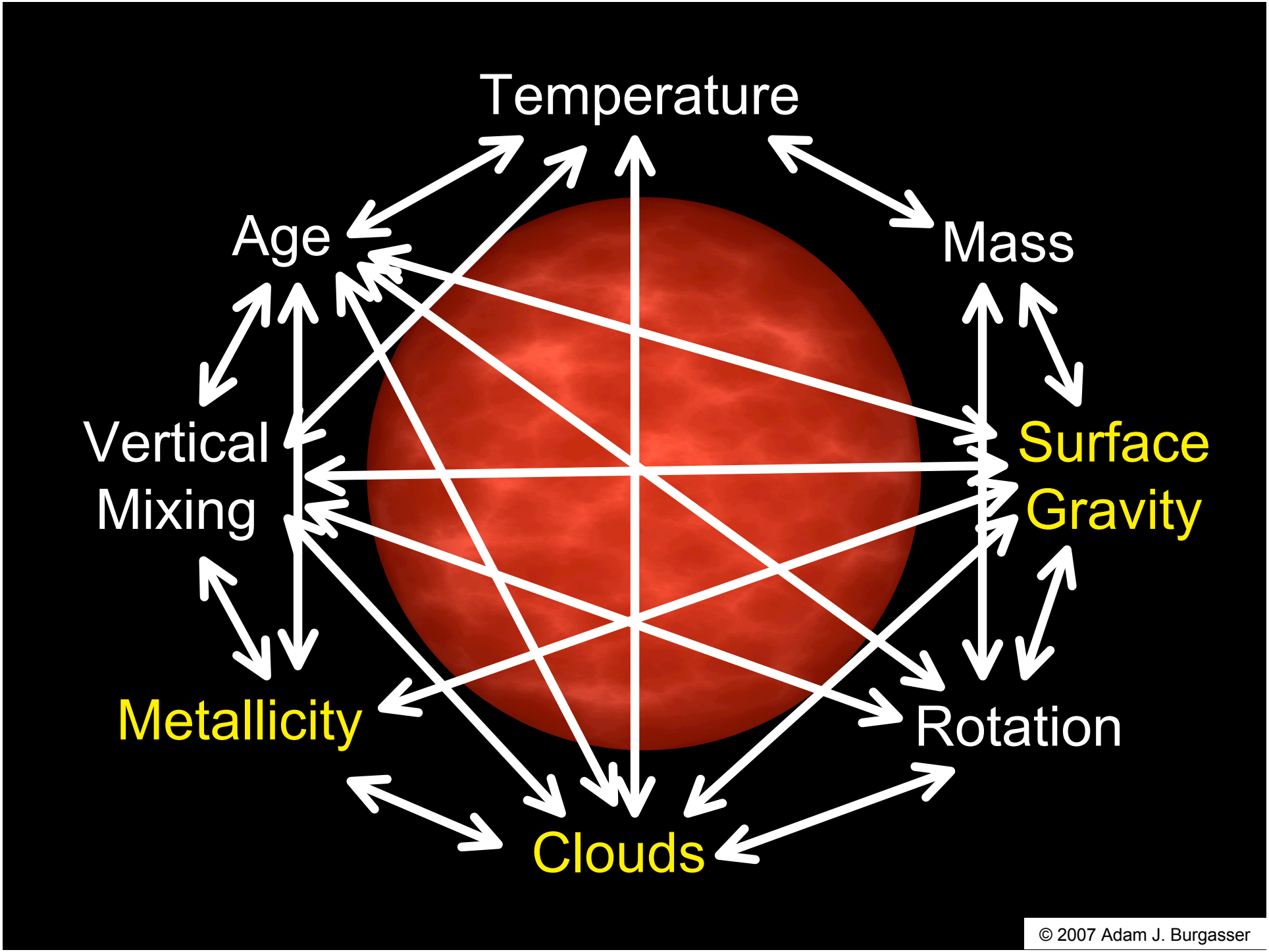
clouds & gravity

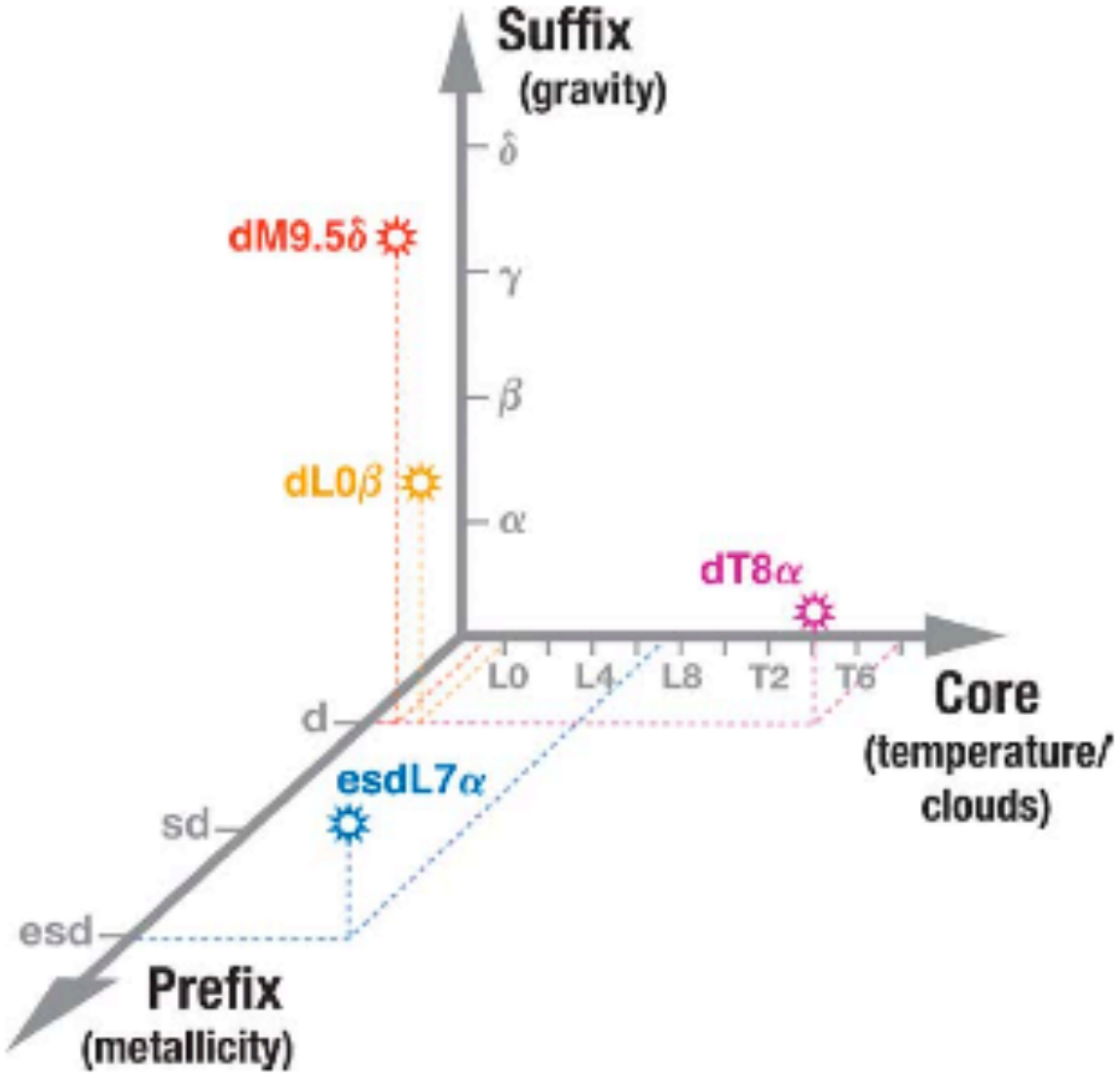


metallicity effects

youth







Kirkpatrick (2005)