THE PECULIAR L DWARF ULAS J2227-0045

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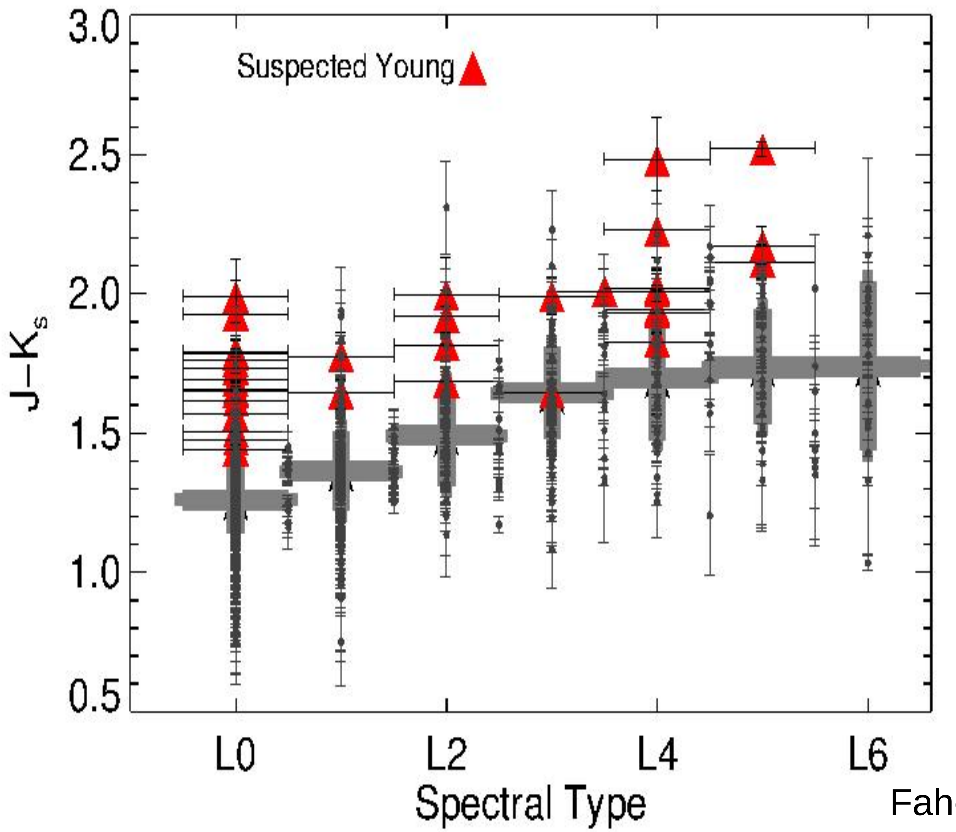
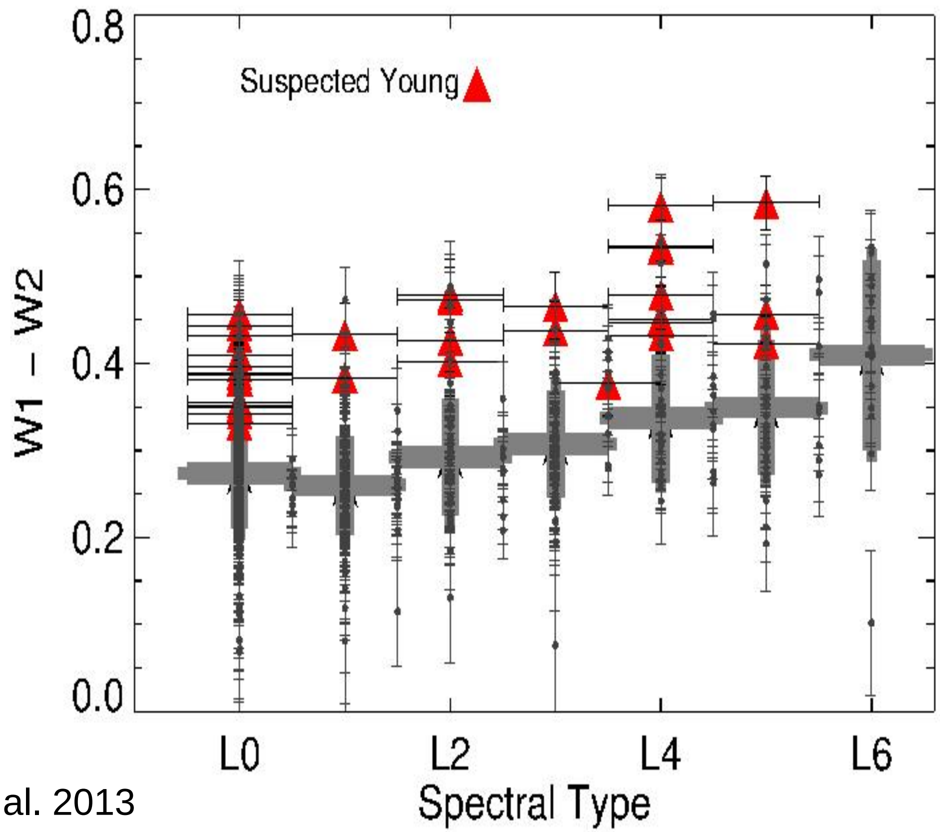
Introduction

Brown dwarfs do not form a “Main Sequence”.

Because of the mass-age-luminosity degeneracy objects of similar spectral type can have very different physical properties (e.g. age, mass, metallicity, surface gravity)

The wide range of parameters covered is reflected by the NIR colours.





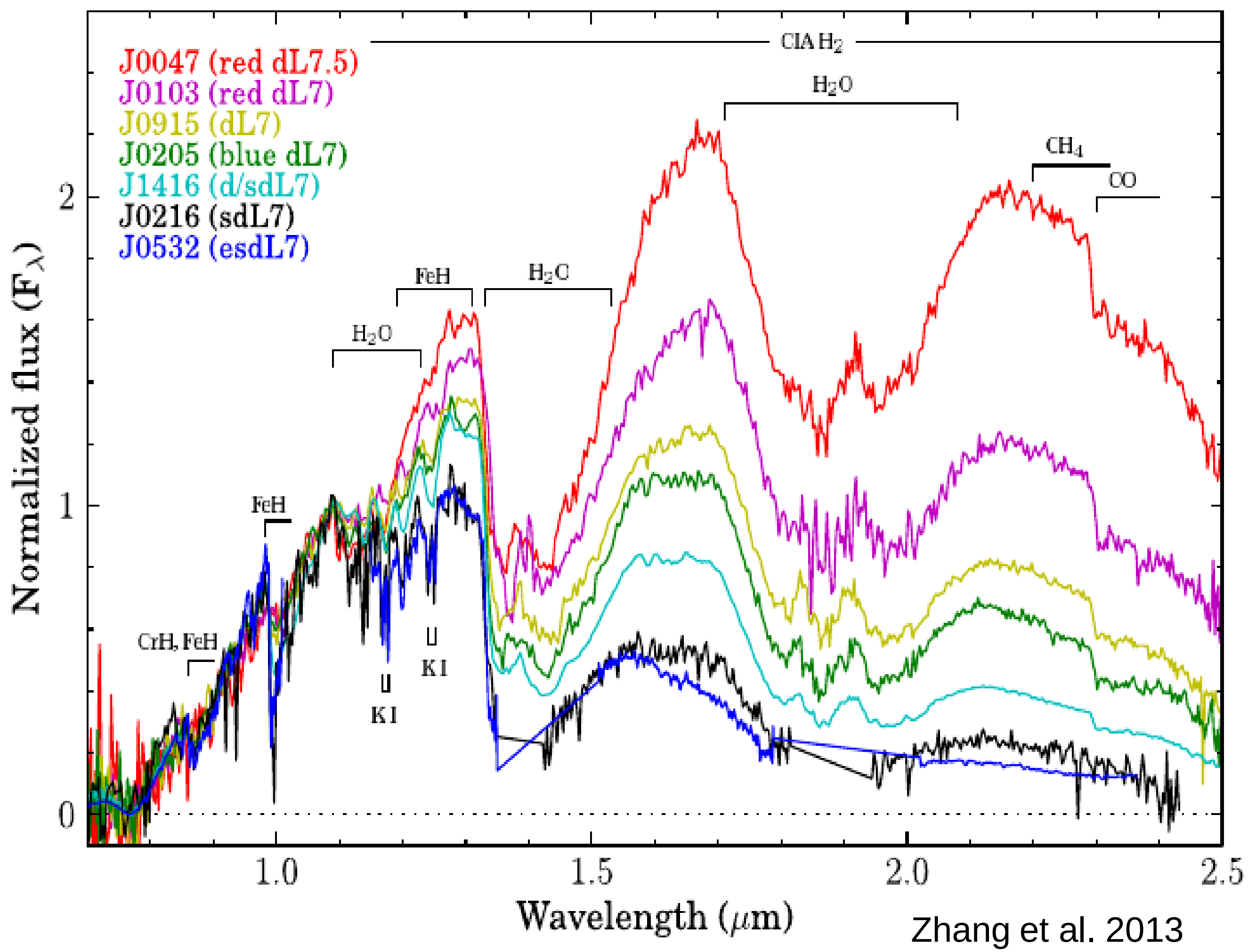
Faherty et al. 2013

Introduction

The same effect can be seen in the spectra.

The huge differences in the NIR spectra of these late Ls are due to the large spread in metallicities (i.e. ages) sampled, from the very blue, very metal poor esdL7 to the very red dL7.5.

However, age is not always the answer...



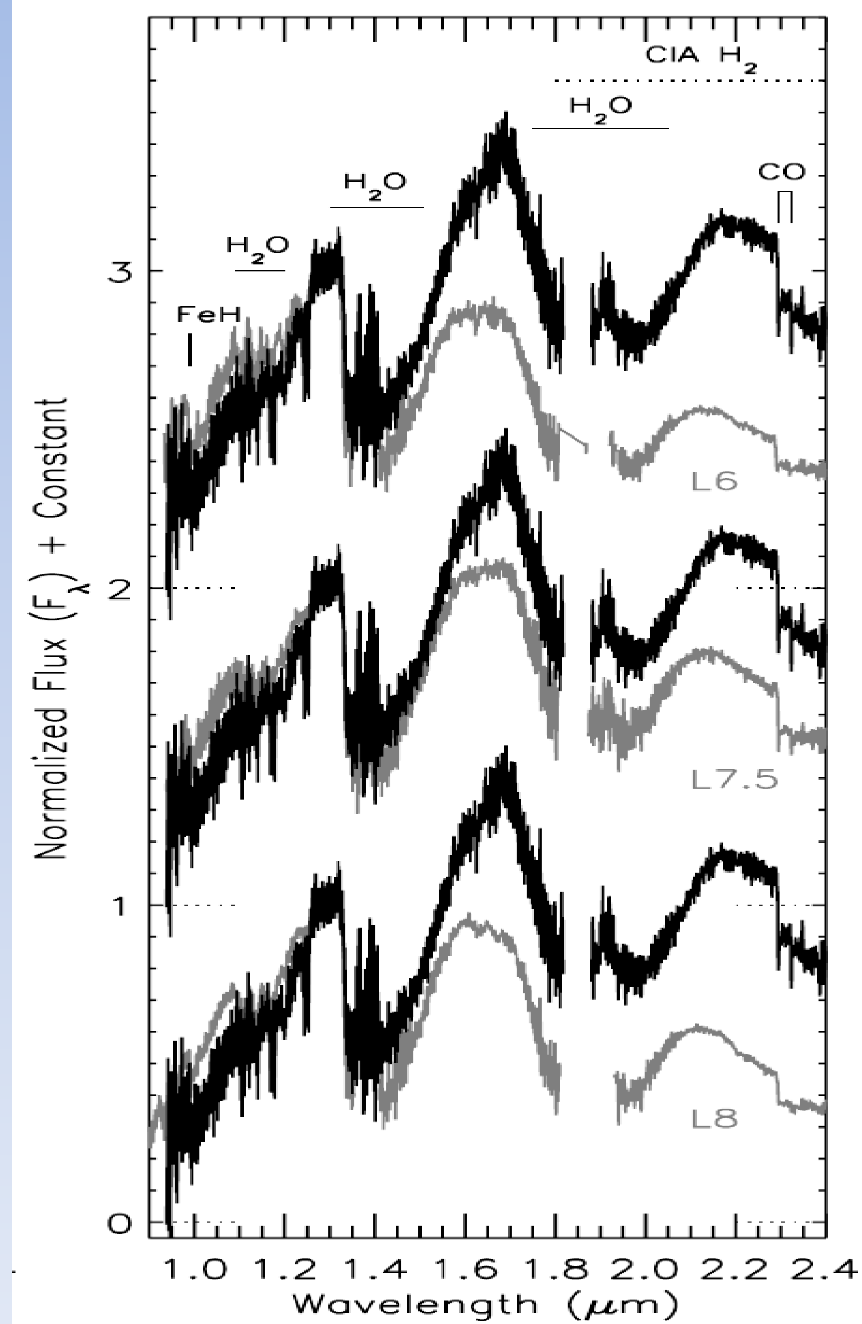
Zhang et al. 2013

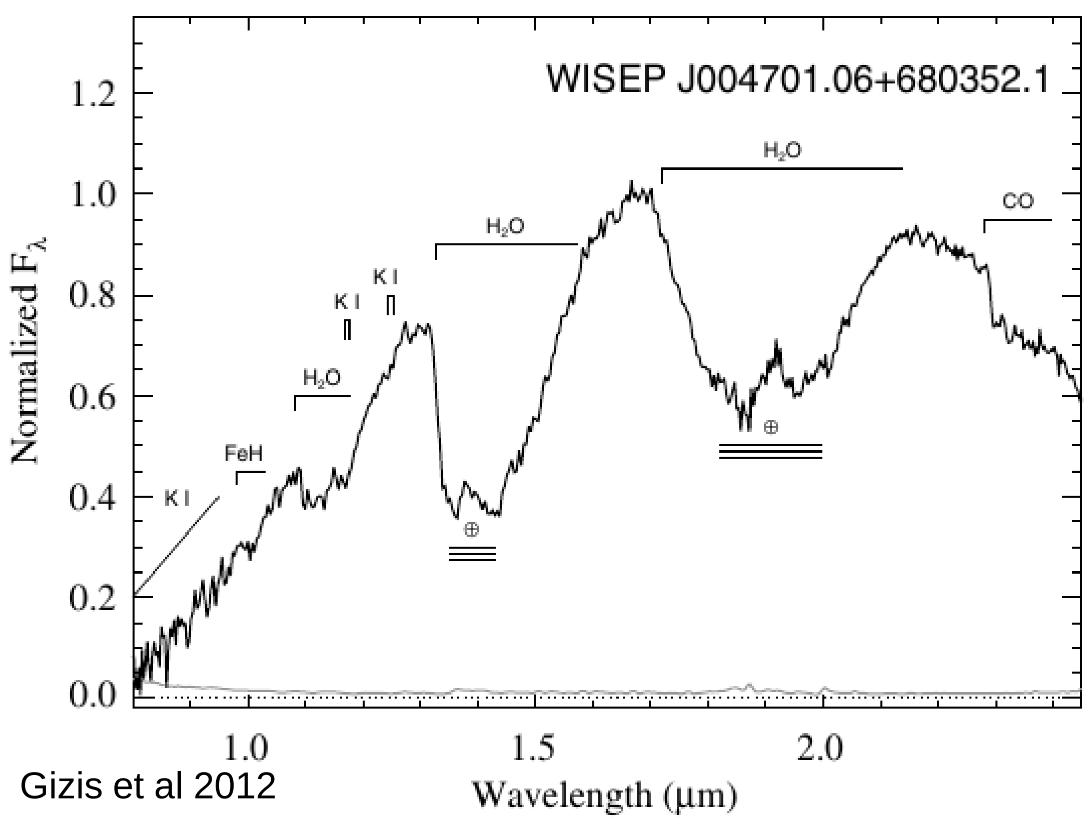
Unusually red L dwarfs

There is infact a category of L dwarfs with very red NIR colours and spectra, that do not appear to be particularly young (e.g. Kirkpatrick et al. 2010).

Low gravity is not sufficient to explain their peculiar colours (e.g. Allers & Liu 2013).

Looper et al 2008

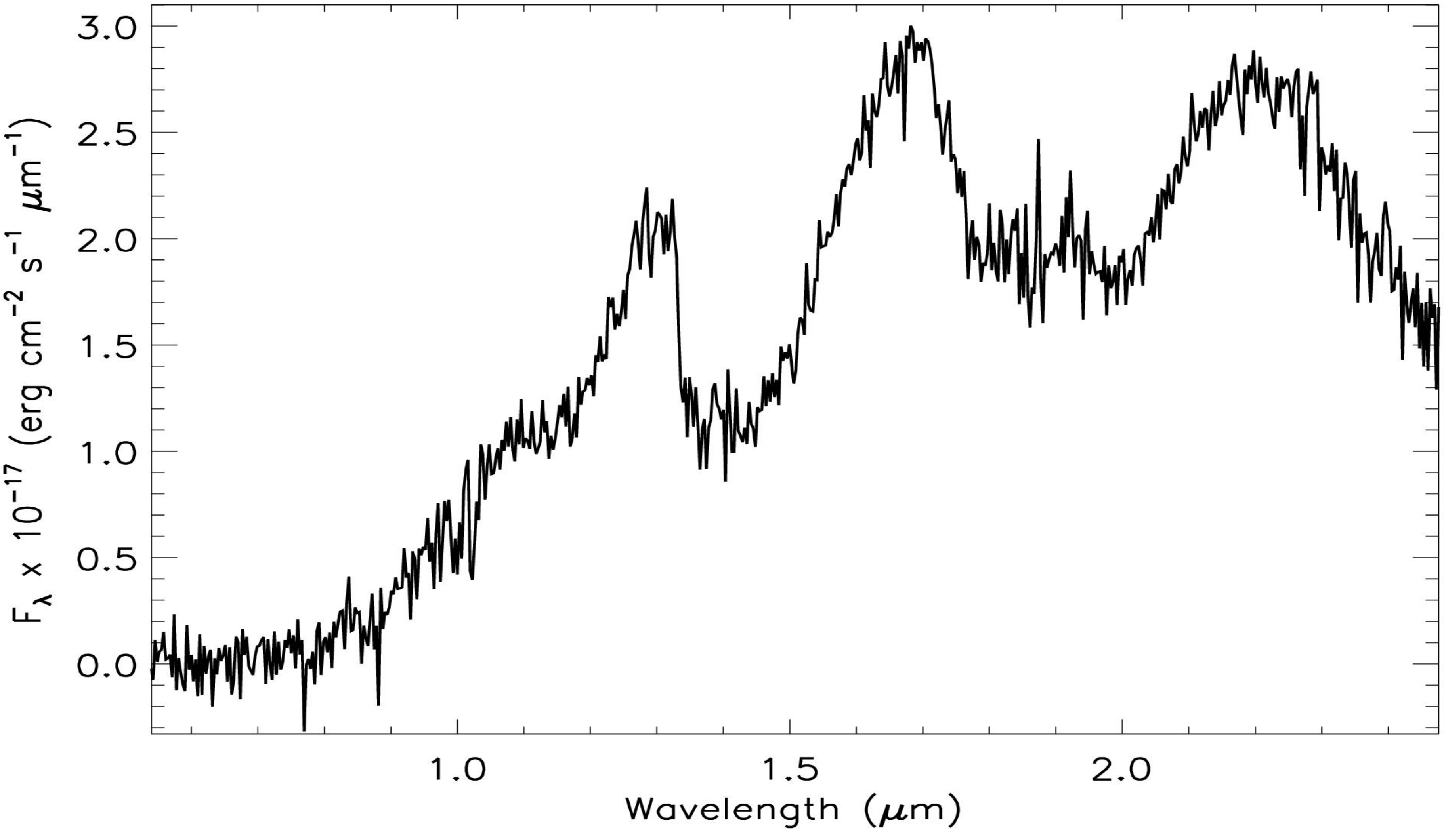




Gizis et al 2012

ULAS J2227-0045

We present here the discovery of ULAS J2227-0045, another example of URLs, with MKO J-K= 2.79.



Candidates Selection

ULAS 2227-0045 comes out of a Large sample of L and T dwarf candidates, selected from the UKIDSS LAS DR7 (Day-Jones et al. 2013).

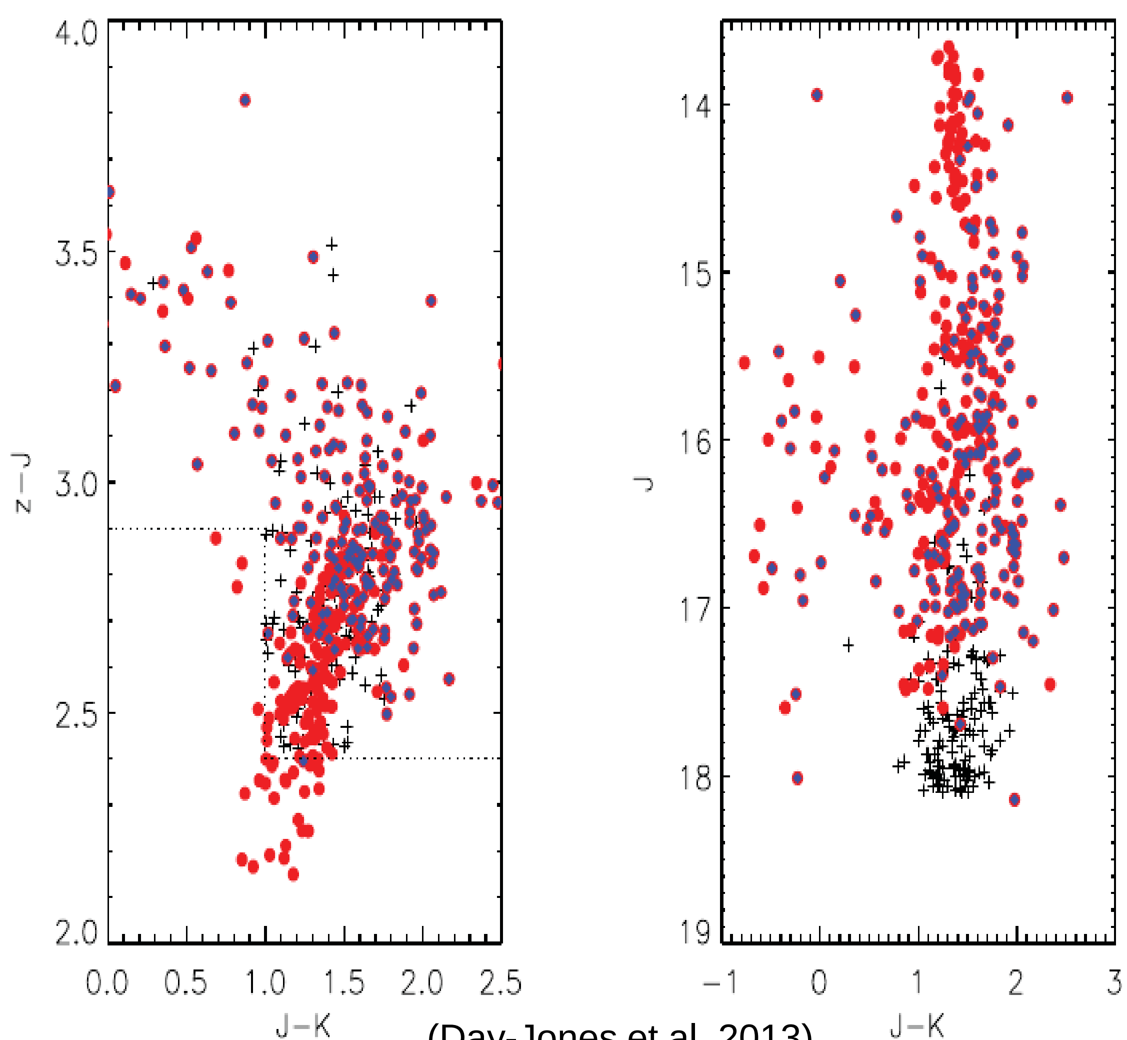
Criteria:

- J <= 18.1
- Y-J >= 0.8
- z-J >= 2.4 and J-K >= 1.0

  OR

  z-J >= 2.9 and J-K < 1.0
- i-z > 2.0
- i-J > 4.7
- z-K > 3.5 and J-K < 1.0

Final candidates list: 263 objects, to be followed-up with Xshooter



(Day-Jones et al. 2013)

Spectroscopic follow-up

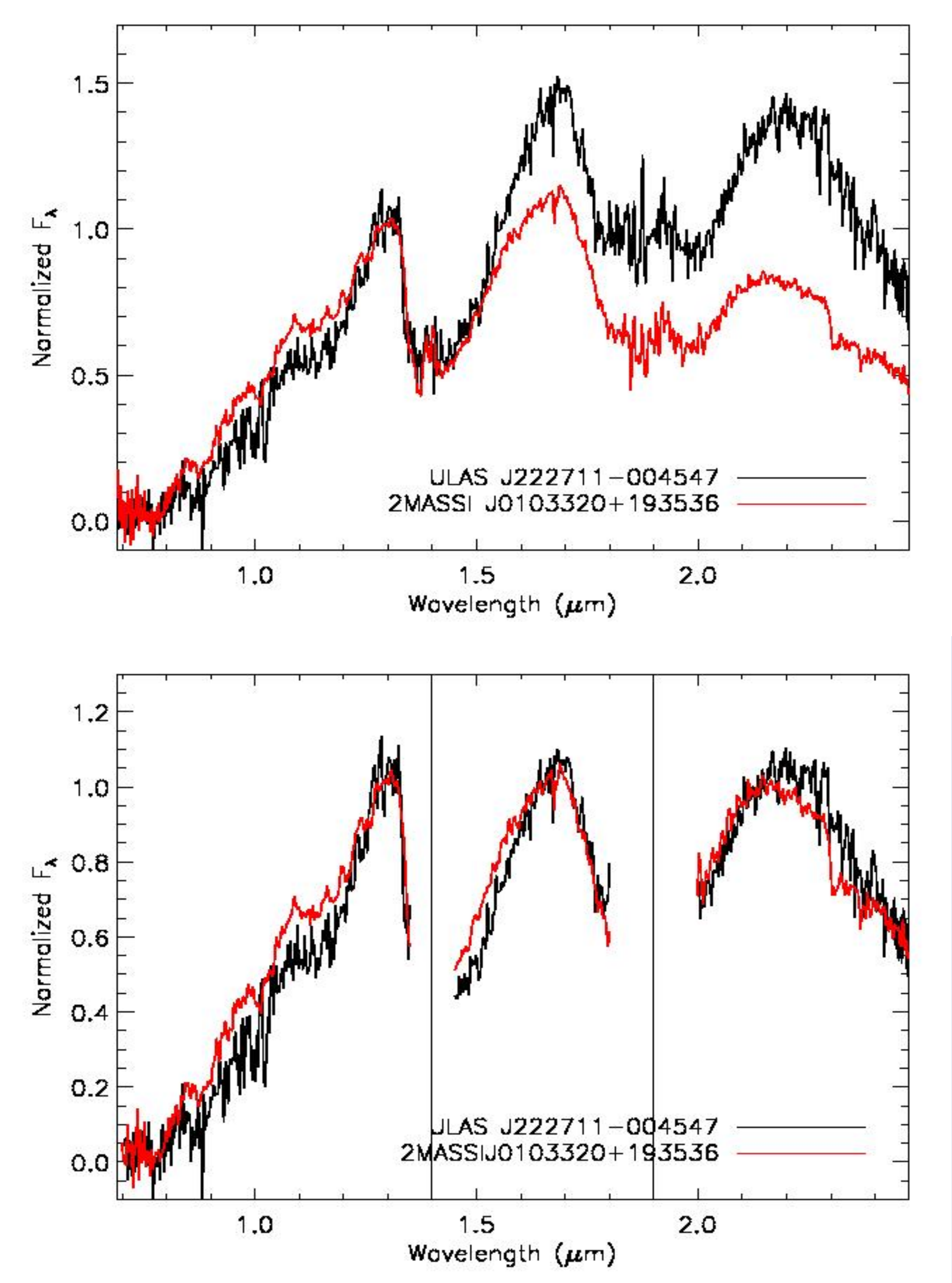
We obtained a optical+NIR spectrum using VLT/Xshooter.

Very red spectrum, peaks in the H band.

We classify this object L7 via spectral fitting.

We split the spectrum in three parts (optical+J, H and K band) and separately normalize them to remove the “red excess”, then we fit it to the spectroscopic standards (Burgasser et al. 2006; Kirkpatrick et al. 2010).

When compared directly to the standard, ULAS 2227-0045 show a massive H and K band “excess”



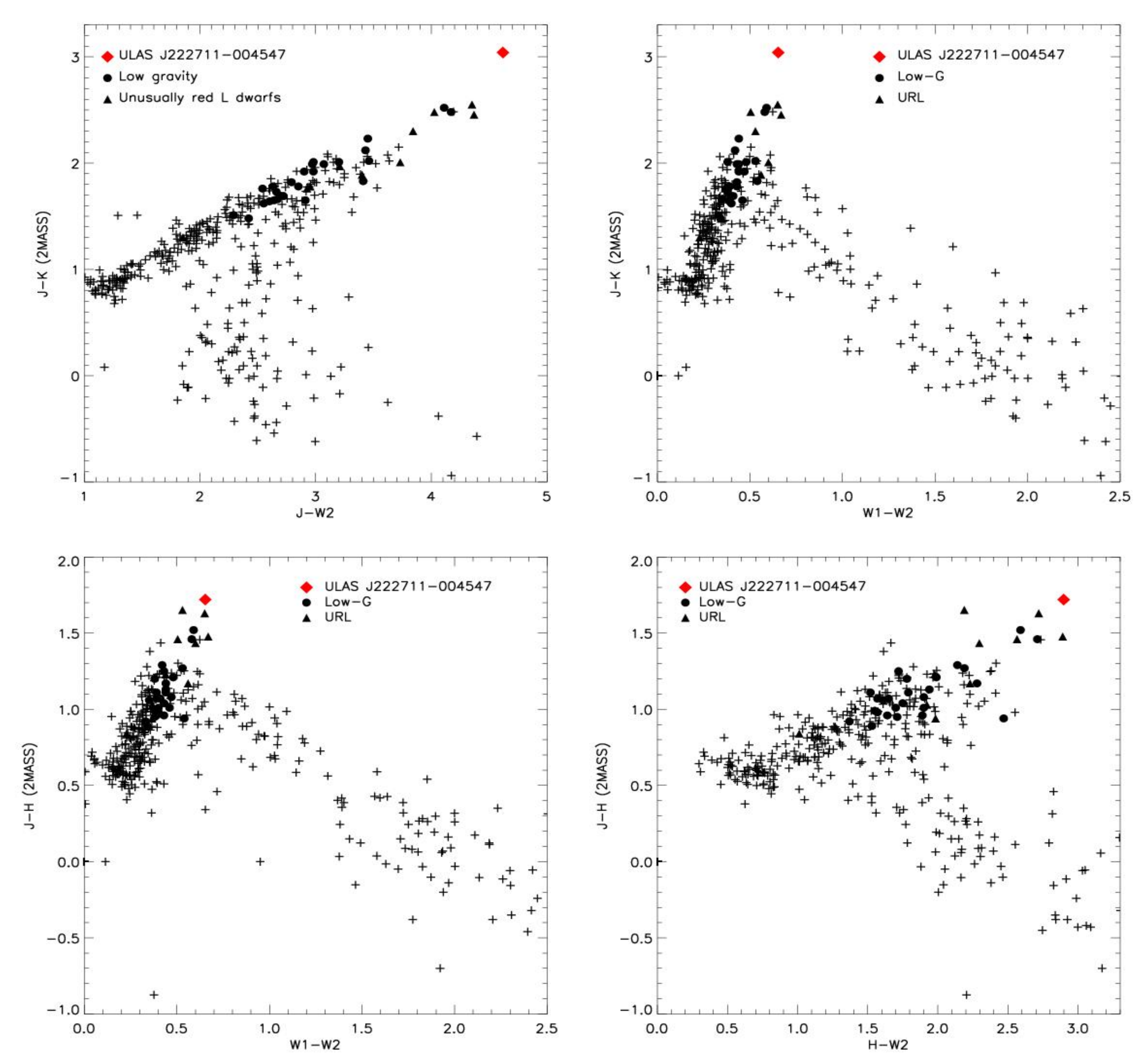
Photometry

ULAS 2227-0045 is detected in UKIDSS, WISE and 2MASS (H and K band only):

MKO J = 18.11
MKO J-K= 2.79
2MASS J-K= 3.04
J-W2= 4.47
W1-W2= 0.653

The object marks an extreme in the L-T sequence.

The peculiarity is more prominent in the NIR than in MIR.

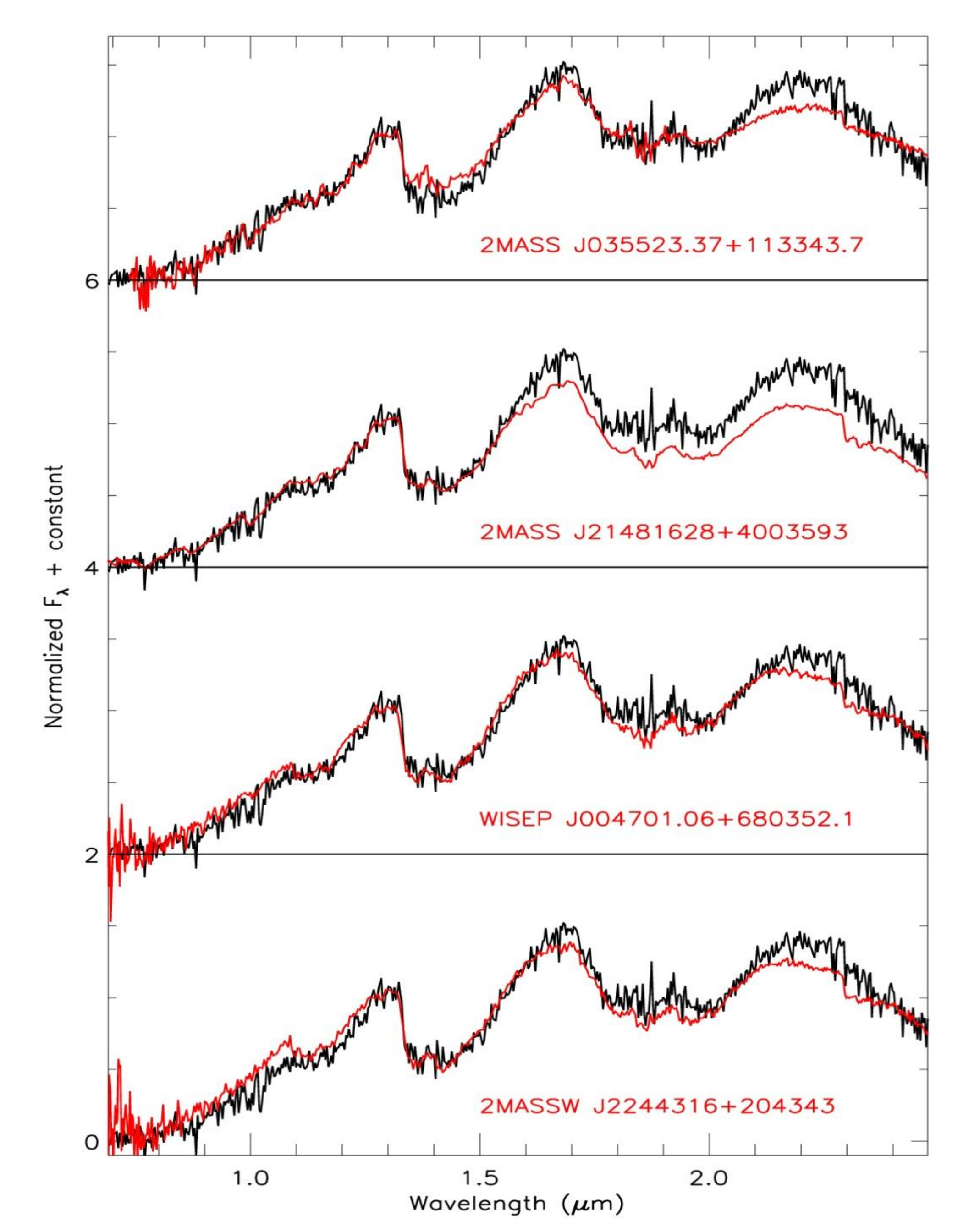


Spectroscopic follow-up

The spectrum looks very similar to other low-gravity dwarfs and URLs.

They all show smooth optical spectra and very red SEDs, peaking in the H band.

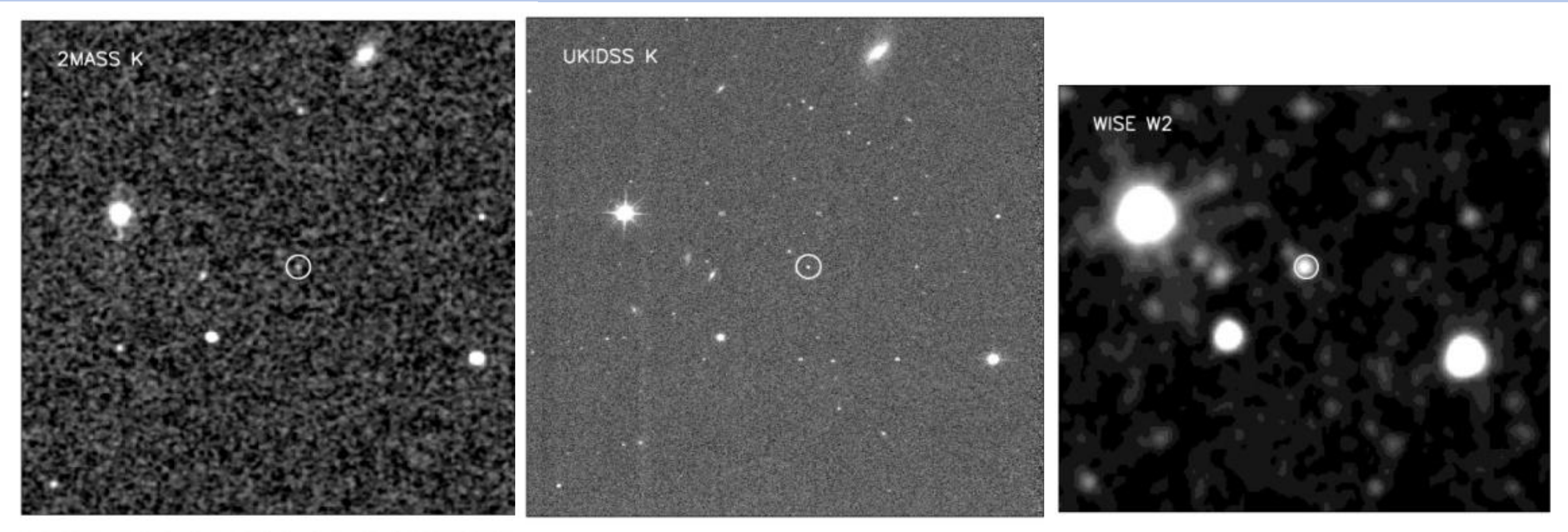
The spectral indices defined in Allers & Liu 2013 do not point towards low gravity for ULAS 2227-0045.



Astrometry

We have estimated the proper motion using 2MASS, UKIDSS and WISE

$\mu_{\alpha}\cos\delta = 100 \pm 16$ mas/yr $\mu_{\delta} = -30 \pm 16$ mas/yr



Not a member of any young moving group. So what causes the H and K band excess? Dust?

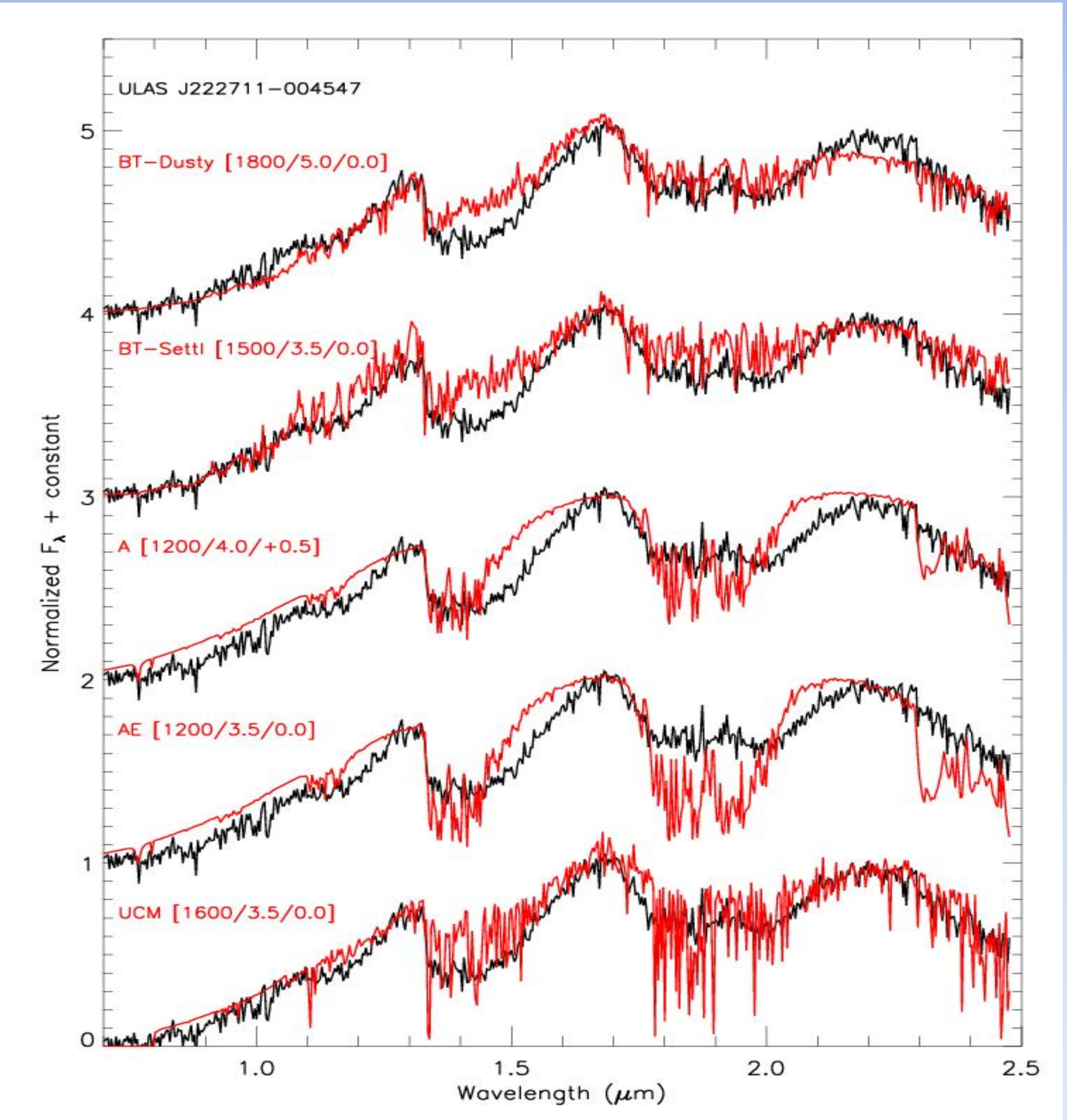
Model fitting

Models do not reproduce the spectrum properly.

H_2O and CO absorption bands, and the shape of the H band peak are the major issues.

NB: models do not include higher-than-solar metallicity

Ref:
Allard et al. 2011 (BT-Dusty & BT-Settl)
Madhusudhan et al. 2011 (A & AE)
Tsuji 2005 (UCM)



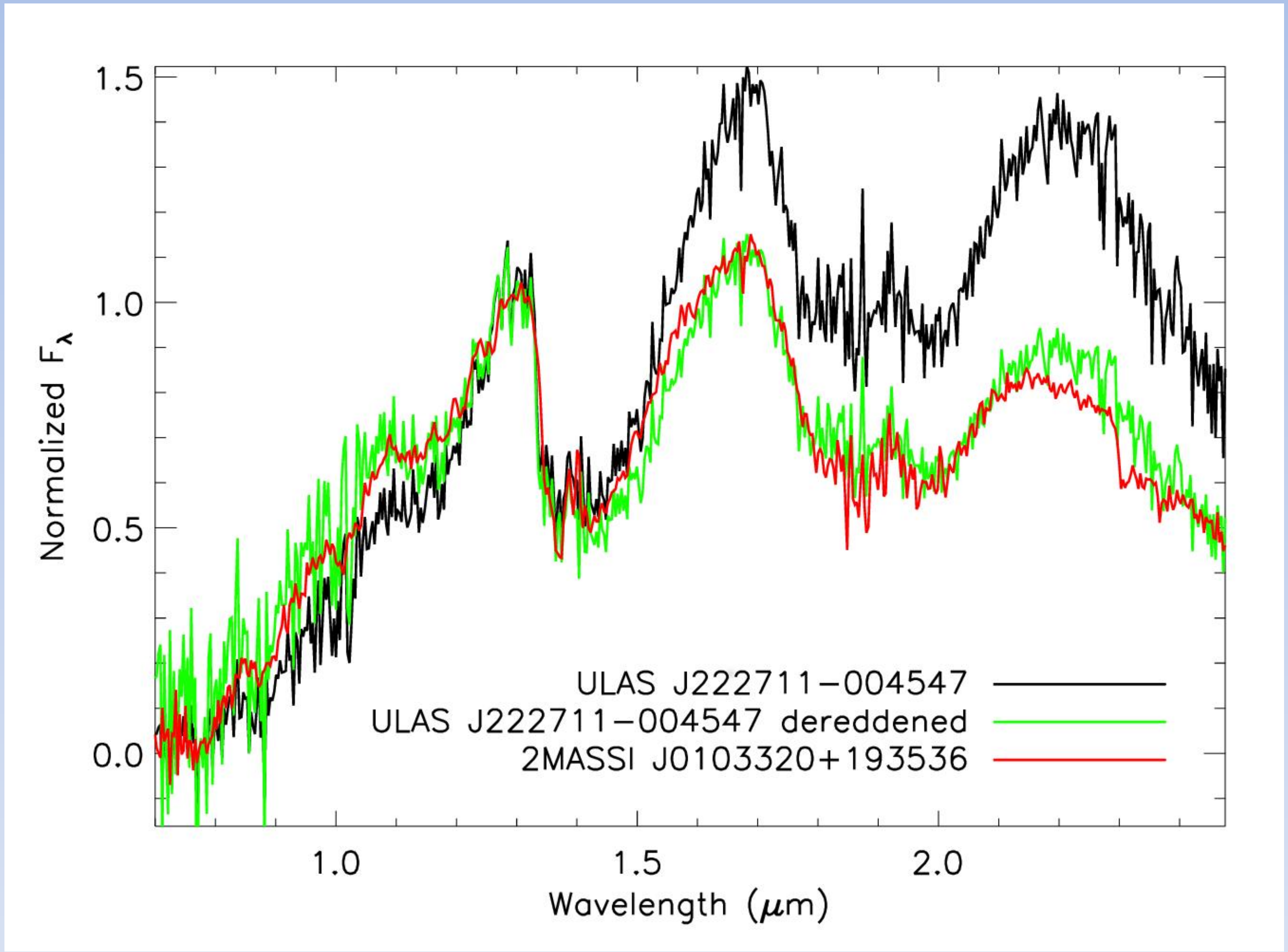
De-reddening

We have de-reddened the spectrum of ULAS 2227-045 using the Fitzpatrick 1999 extinction curve.

The spectrum fits quite well the L7 standard with an E(B-V) = 1.1.

The asymptotic reddening of the field is 0.07, i.e. The reddening of the spectrum is intrinsic.

There still remain differences (H and K band especially).



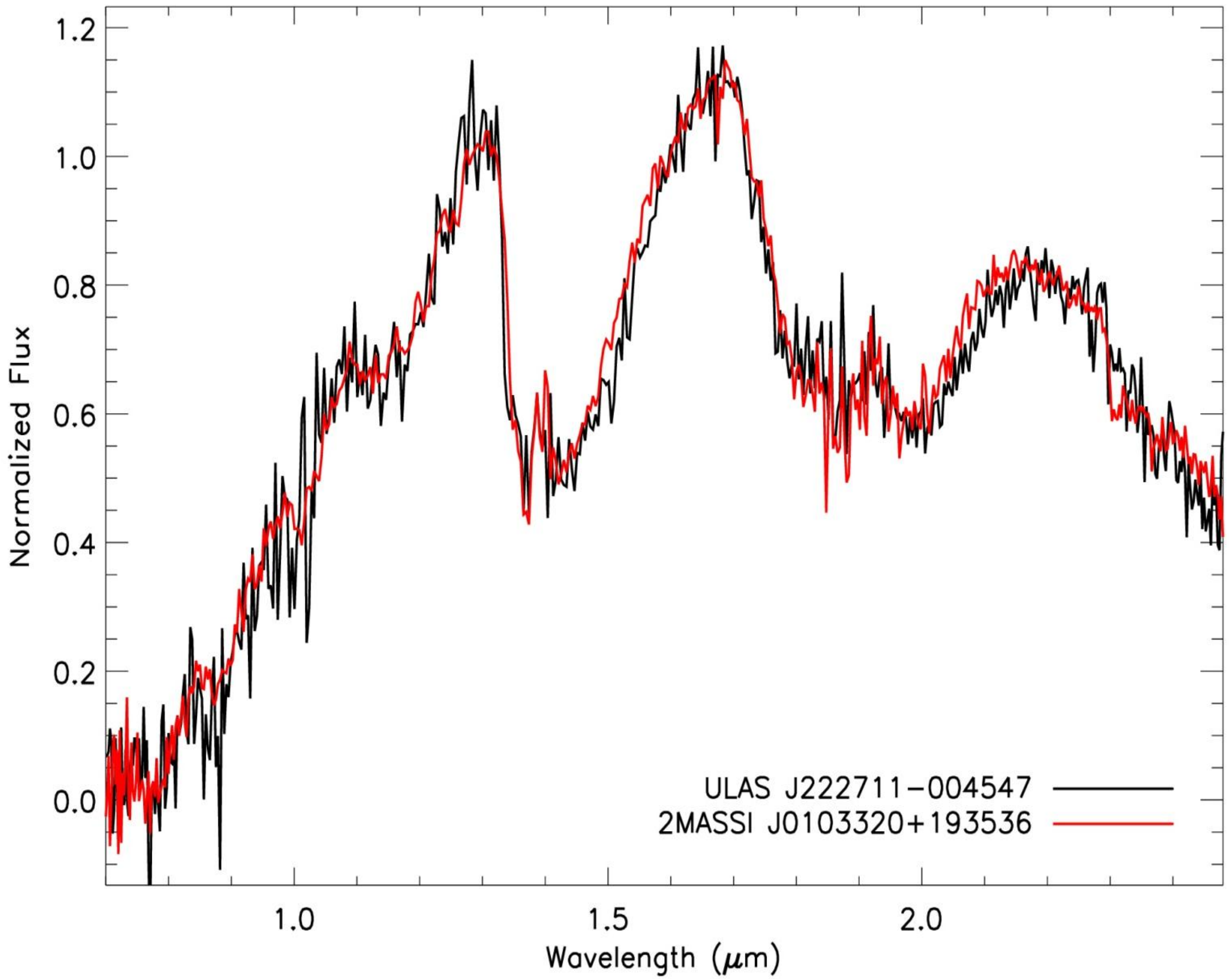
De-reddening

The main dust species in L dwarfs are thought to be corundum (Al_2O_3), enstatite ($MgSiO_3$) and iron (e.g. Morley et al. 2012).

We derived extinction curves for these 3 species for a range of grain sizes (r = 0.05 to 1.00 µm) and applied them to the spectrum of ULAS 2227-0045.

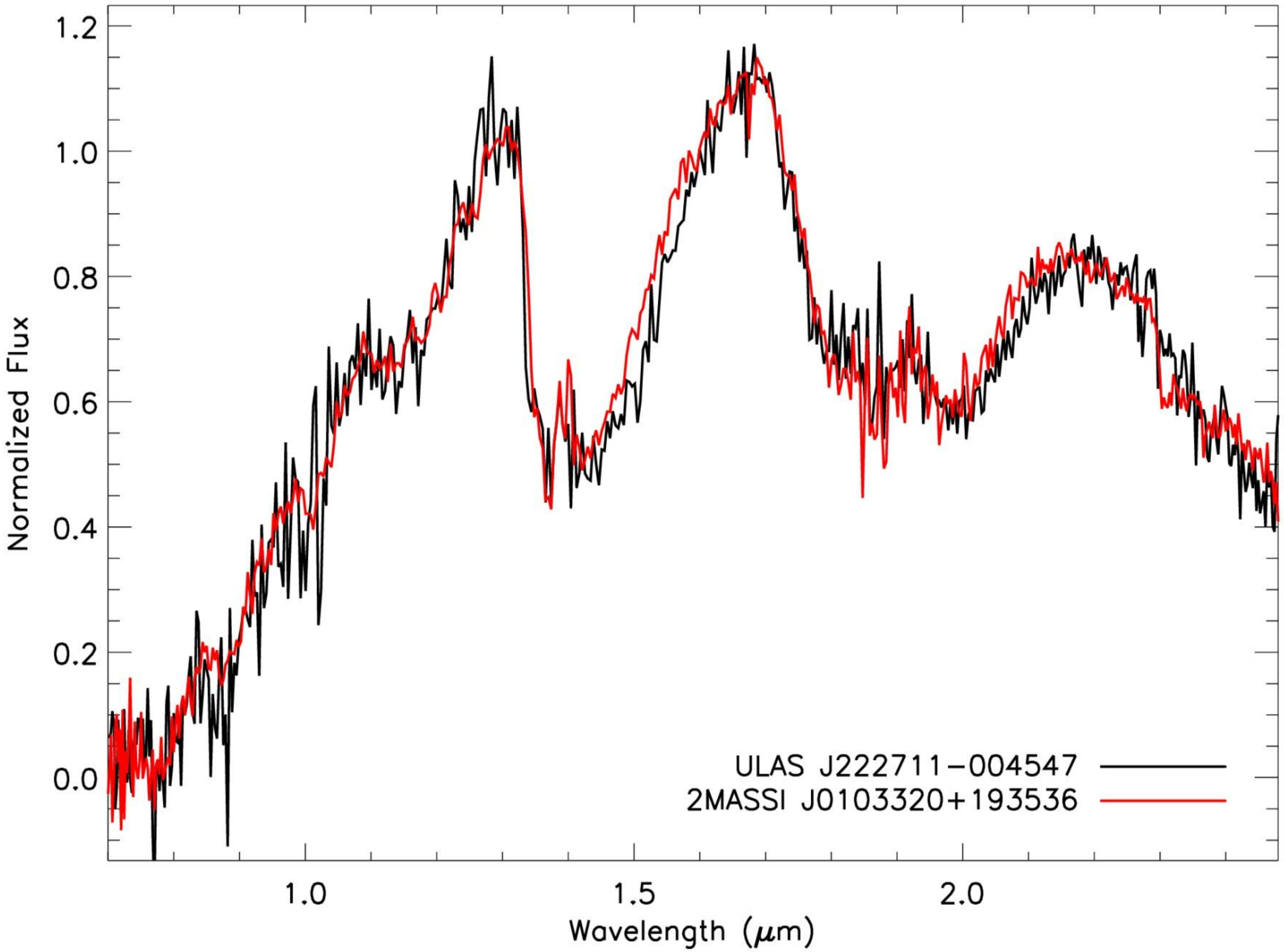
Corundum and enstatite give good fit for grain size of 0.40-0.55 µm.

ULAS 2227-0045 dereddened with **corundum**: r= 0.45 µm



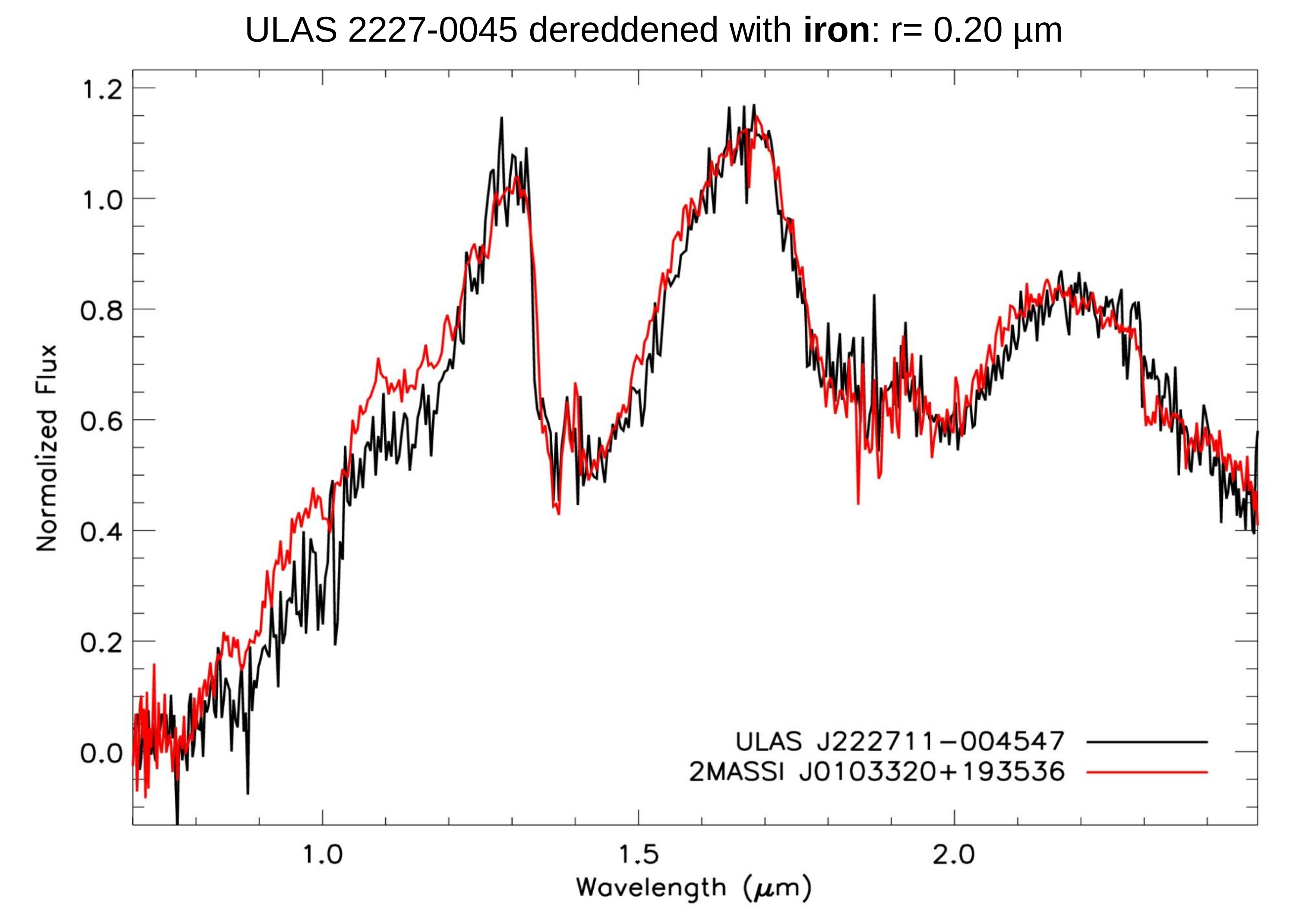
De-reddening

ULAS 2227-0045 dereddened with **enstatite**: r= 0.50 µm



De-reddening

Iron requires smaller grains but does not give good results in the optical part of the spectrum.



Summary & Conclusions

ULAS 2227-0045 is one of the reddest L-dwarfs known to date, and it fits into the category of URLs.

Spectral indices and kinematic show that its extreme colours are not caused by low gravity.

An alternative explanation can be an excess of dust in the photosphere, maybe caused by unusual metallicity.

De-reddening the spectrum using extinction curves for different dust species gives surprisingly good results.

URLs can be used to constrain grain sizes and dust species abundances!

Thank you!