Metallicity determination for M dwarfs from high-resolution IR spectra

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Towards Other Earths II – The Star-Planet Connection
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Collaborators

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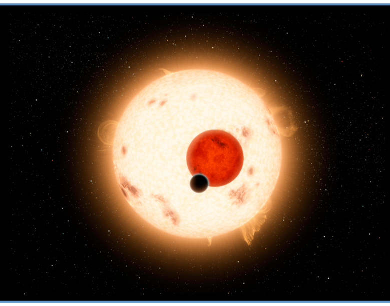
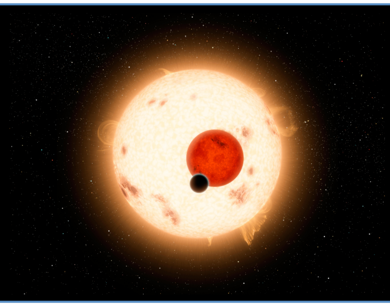


Outline

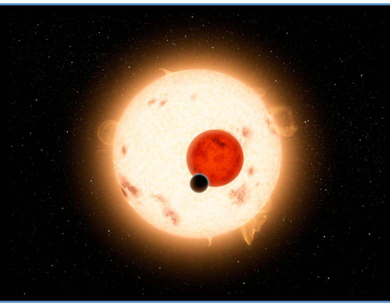
- Why work with M dwarfs? And what are the challenges?
- Idea of the project
- Observational data and analysis
- Determined metallicities for the sample



Why M dwarfs?

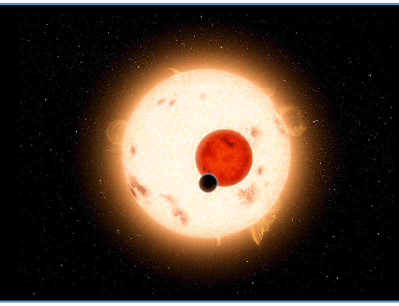
M dwarfs are of interest for several reasons

- Stellar and galactic evolution
- Low-mass end of the initial/present-day mass function
- Finding Earth-sized planets, and planets in the habitable zone
- Determine a possible planet – metallicity connection. Give constrain for planet formation theory



Exoplanet characterization

We cannot know the properties of an exoplanet atmosphere with better precision than we know the properties of the host star itself.



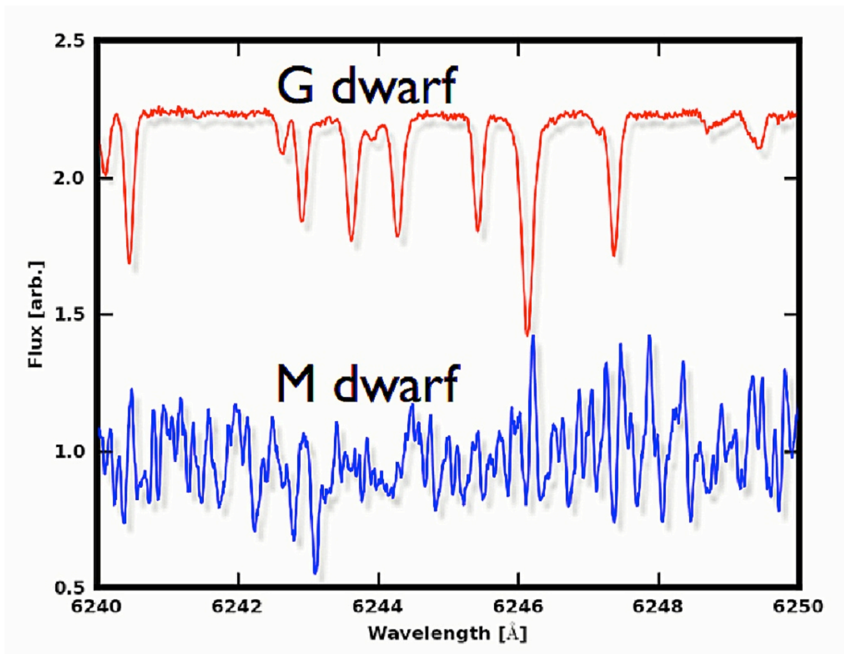
M dwarfs - a spectroscopic challenge

The continuum

FGK dwarfs: Dominated by H^-

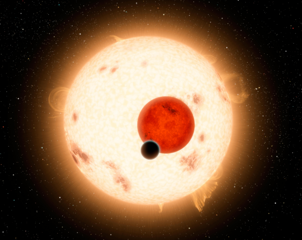
M dwarfs: TiO, VO, FeH, H_2O and CO

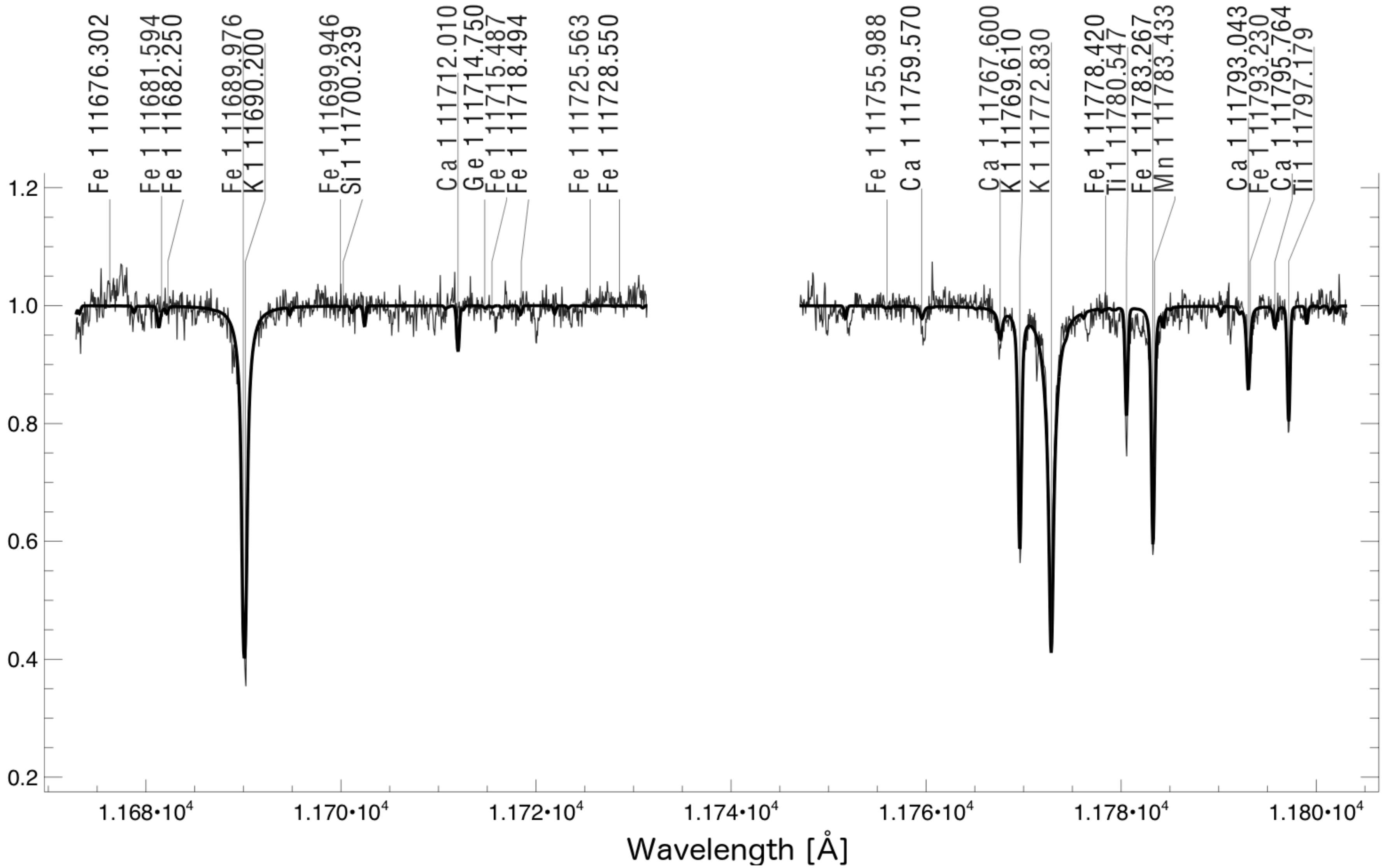
- *Optical* - Impossible to reliably place the continuum level, i.e. the reference for spectroscopy
- *Infrared* – Situation is highly improved. A good continuum placement possible

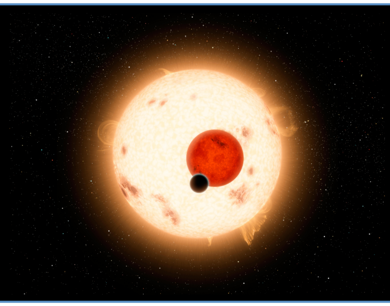


Bonfils (2012)

M dwarfs - a spectroscopic challenge







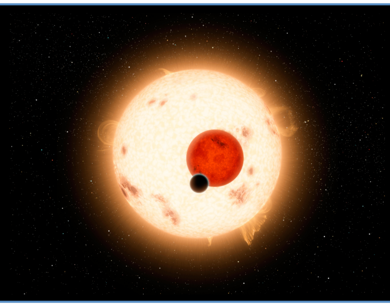
Method

Önehag et al. (2012) analyzed 11 M dwarfs observed in the J band (1100-1400 nm) with promising results

Verify the reliability of the derived metallicity using M dwarfs in binary systems with a warmer companion

- Önehag et al. (2012) worked with K dwarf companions
- In this work G and F dwarf companions

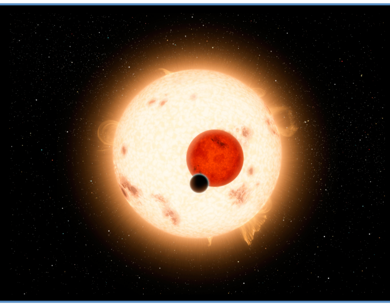
Sample of 5 binary systems and 8 single M dwarfs observed with the CRIRES spectrograph, VLT. Resolution ~ 50000



Analysis

Analysis was done with Spectroscopy Made Easy, using synthetic spectral fitting though χ^2 minimization.

- MARCS model atmospheres
- Line list from VALD3 with some atomic data from Meléndez & Barbuy (1999) and a line list of FeH calculated by Bertrand Plez



Stellar parameters

Solar-like dwarfs

T_{eff} and log *g*: Average of literature values

M dwarfs

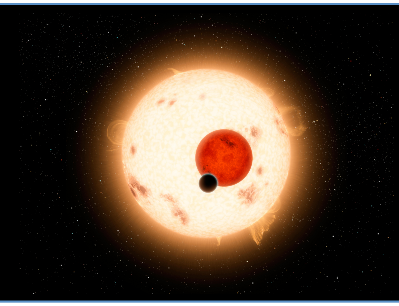
T_{eff} :

- Photometric colors and relation from Casagrande et al. (2008)
- Adjusted with FeH line strength

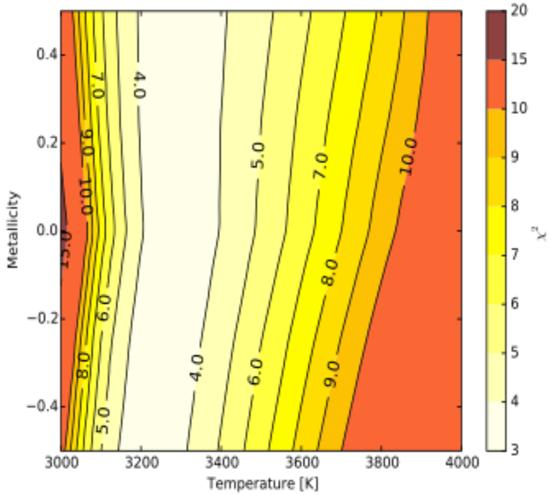
log *g* :

- Derived from the log *g* – M_* relation by Bean et al. (2006)

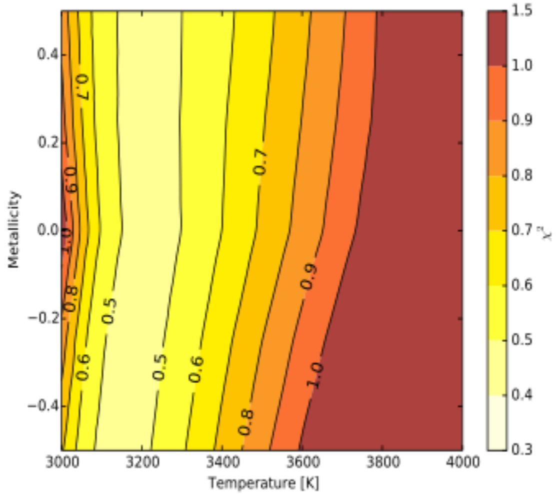
Spectral types: M0-M4.5 $3250 < T_{eff} < 3900$ $4.46 < \log g < 4.96$



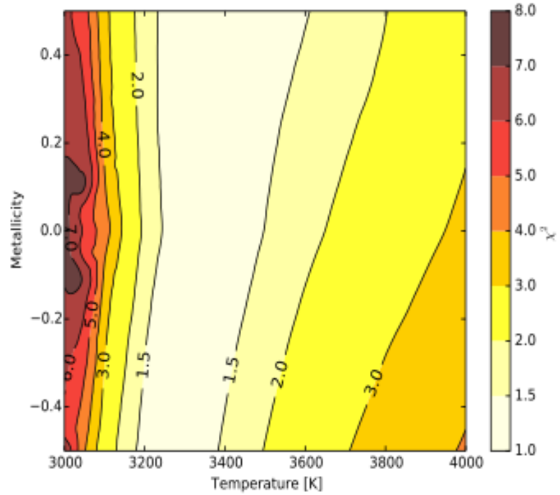
Temperature adjustments with FeH line strength



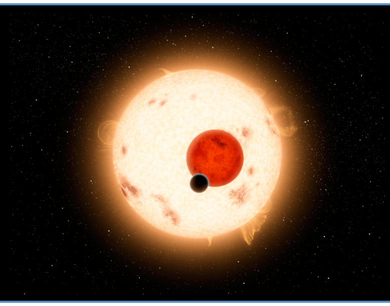
GJ105 B



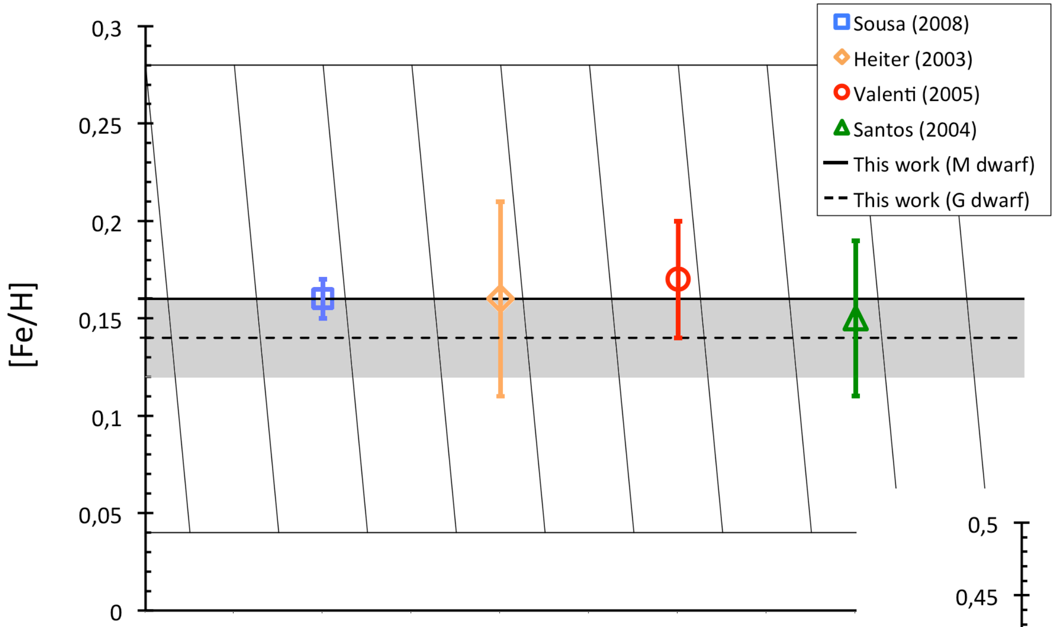
HIP12048 B



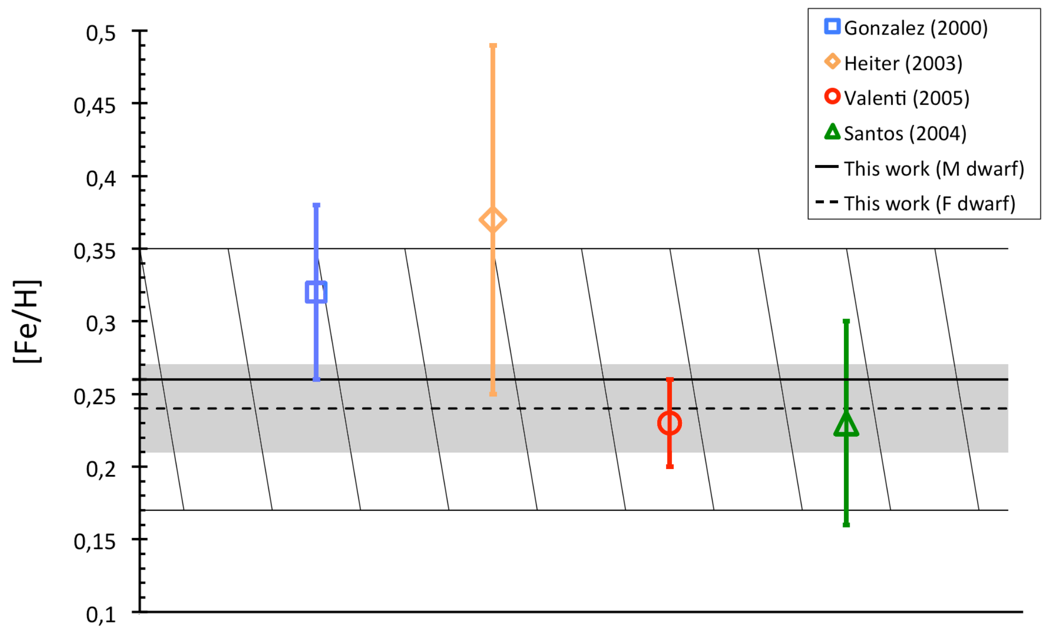
GJ527 B



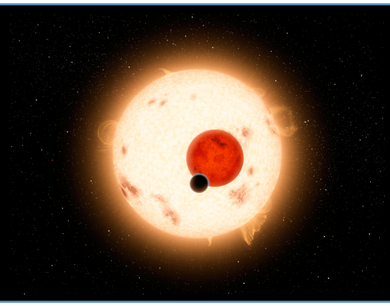
Result



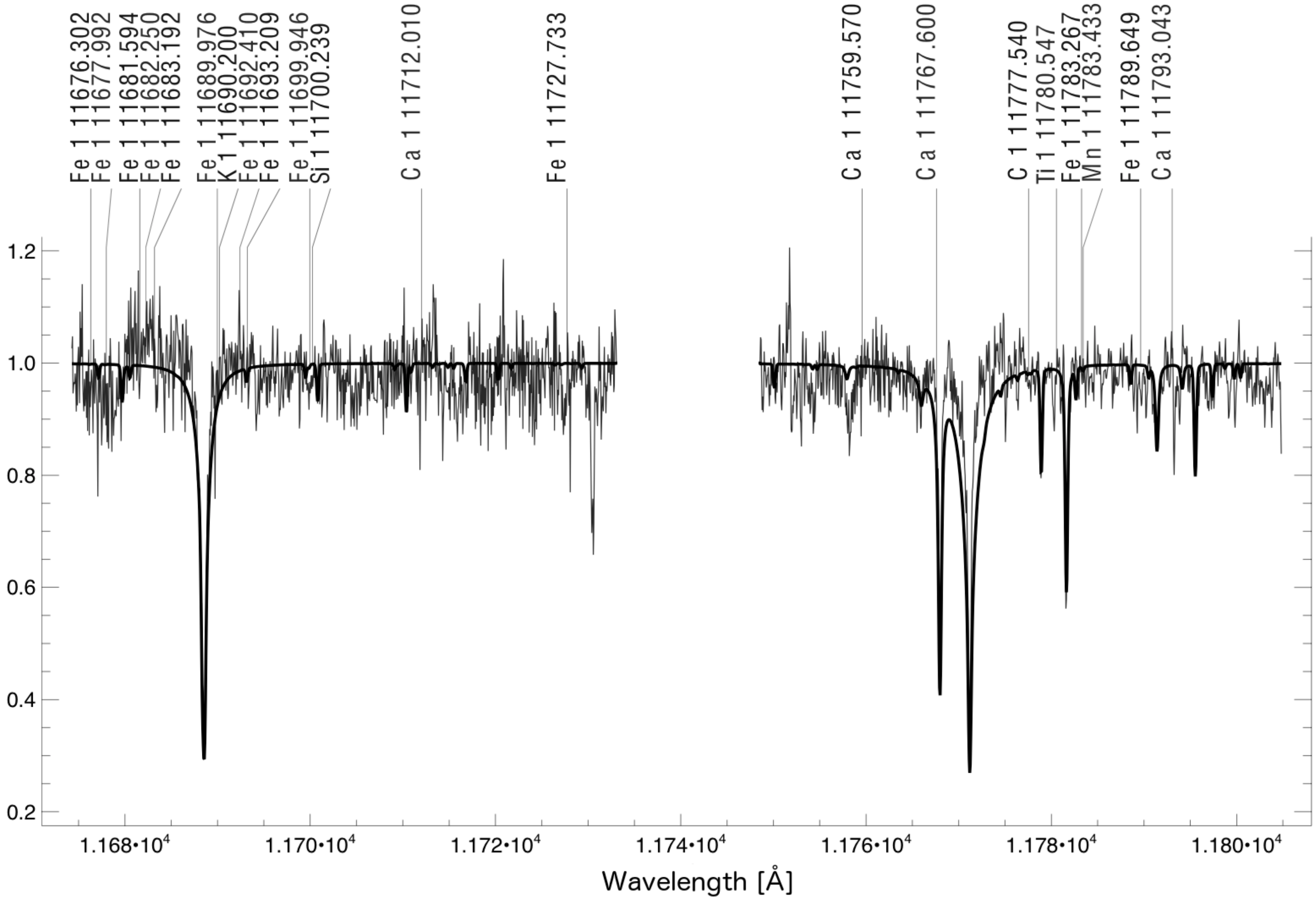
[Fe/H]
0,3
0,25
0,2
0,15
0,1
0,05
0
Sousa (2008)
Heiter (2003)
Valenti (2005)
Santos (2004)
This work (M dwarf)
This work (G dwarf)

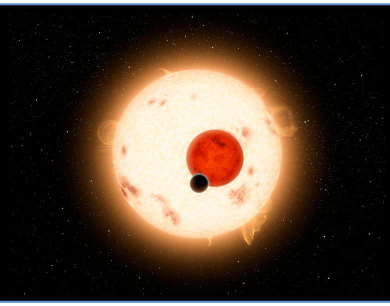


[Fe/H]
0,5
0,45
0,4
0,35
0,3
0,25
0,2
0,15
0,1
Gonzalez (2000)
Heiter (2003)
Valenti (2005)
Santos (2004)
This work (M dwarf)
This work (F dwarf)



Result

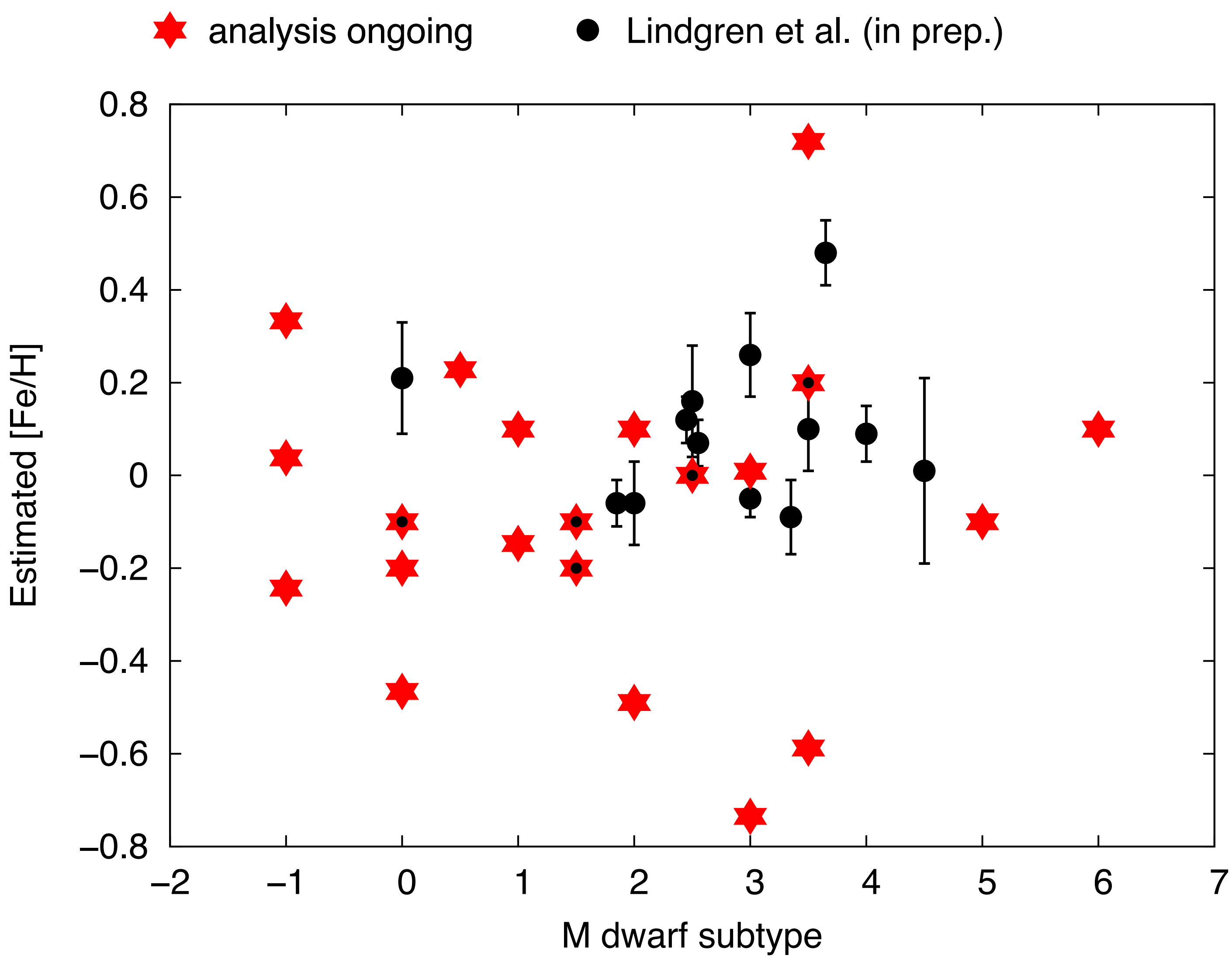

Fe 1 11676.302
Fe 1 11677.992
Fe 1 11681.594
Fe 1 11682.250
Fe 1 11683.192
Fe 1 11689.976
K 1 11690.200
Fe 1 11692.410
Fe 1 11693.209
Fe 1 11699.946
Si 1 11700.239
Ca 1 11712.010
Fe 1 11727.733
Ca 1 11759.570
Ca 1 11767.600
C 1 11777.540
Ti 1 11780.547
Fe 1 11783.267
Mn 1 11783.433
Fe 1 11789.649
Ca 1 11793.043
1.2
1.0
0.8
0.6
0.4
0.2
1.168•10^4
1.170•10^4
1.172•10^4
1.174•10^4
1.176•10^4
1.178•10^4
1.180•10^4
Wavelength [Å]

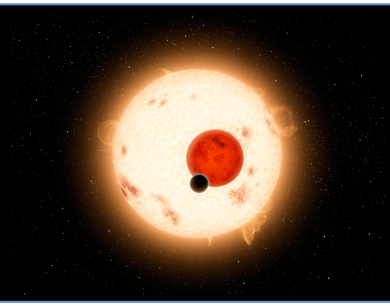


Derived metallicities of binaries

Target	Metallicity [dex]	Estimated error	Ave. lit. (σ)
HIP12048 A	0.14	0.03	0.13 (0.05)
HIP12048 B	0.16	0.12	
GJ527 A	0.24	0.03	0.29 (0.07)
GJ527 B	0.26	0.09	
GJ105 A	0.02	0.05	–0.12 (0.05)
GJ105 B	0.01	0.20	
GJ250 A	–0.03	0.04	0.01 (0.11)
GJ250 B	–0.06	0.05	
HIP57172 A	0.25	0.04	0.17 (0.07)
HIP57172 B	0.21	0.12	
GJ176	–0.06	0.09	
GJ317	–0.09	0.08	
GJ436	0.12	0.05	
GJ581	–0.05	0.04	
GJ628	0.10	0.09	
GJ674	0.07	0.05	
GJ849	0.48	0.07	
GJ876	0.09	0.06	

Outlook


analysis ongoing
Lindgren et al. (in prep.)
Estimated [Fe/H]
M dwarf subtype
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−2
−1
0
1
2
3
4
5
6
7



Conclusions

This work show that spectroscopic analysis of high-resolution spectra from the J band gives reliable metallicities for M dwarfs

Reliability confirmed based on comparison with:

- Warmer binary companions
- Literature values

Our current result covers subtypes M0-M4.5 and
-0.1 < [Fe/H] < 0.3