Modeling exoplanet hosts :
characterizing the optical and nIR spectra of low-mass PMS and MS stars for the SPIRou Legacy Survey

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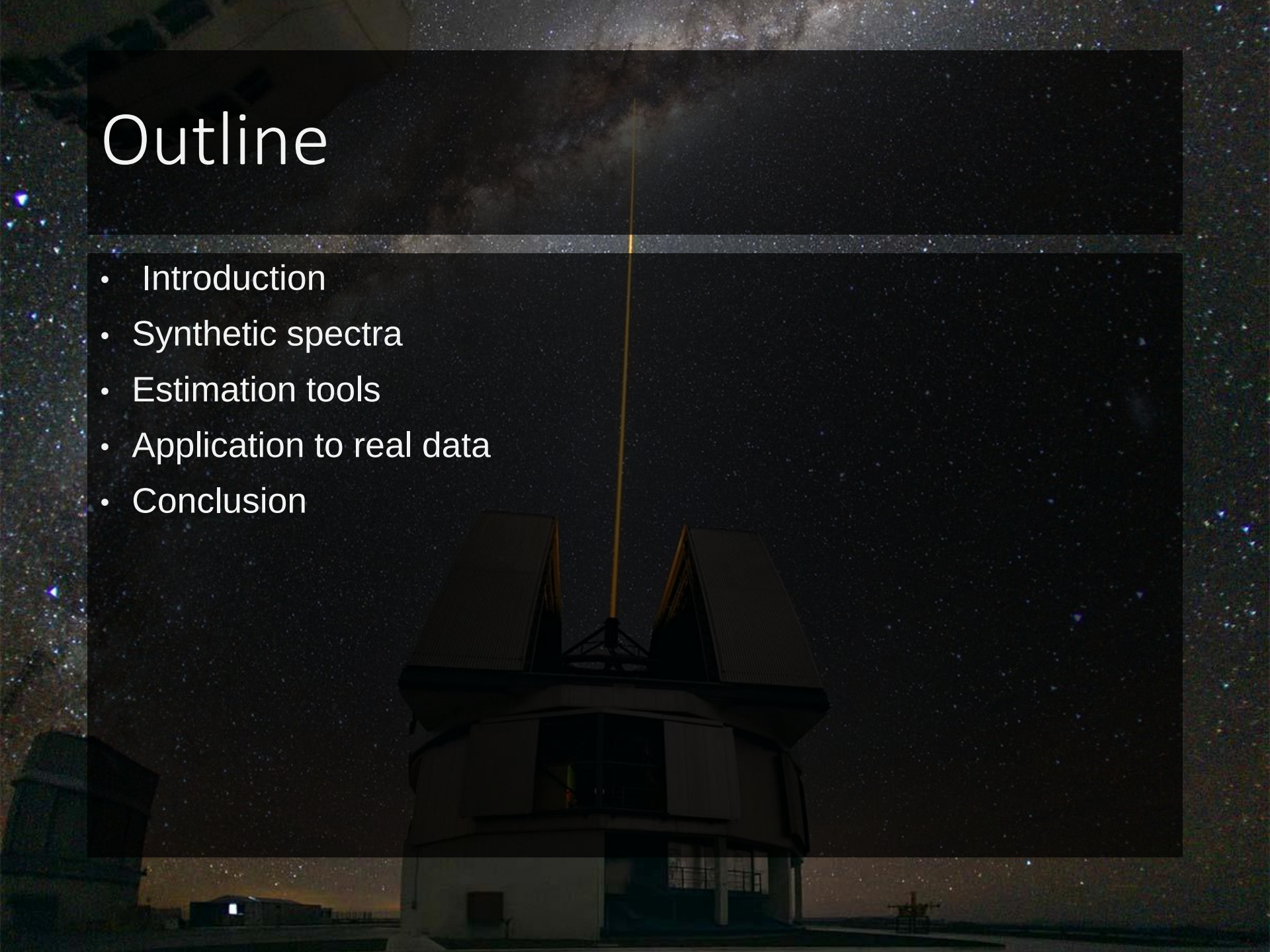
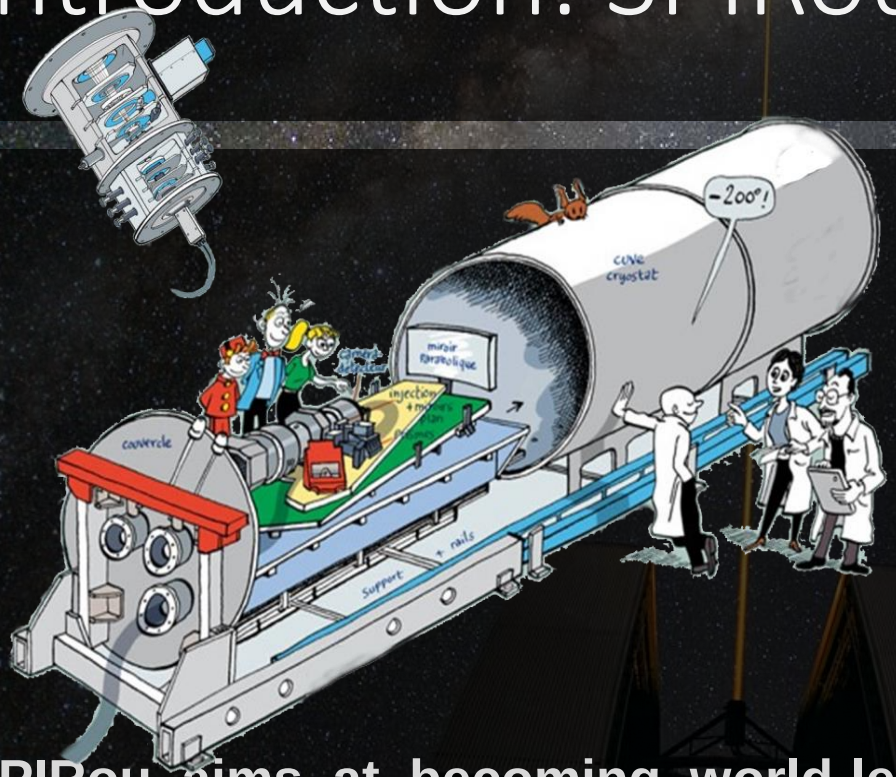
cnrs dépasser les frontières

Outline

- Introduction
- Synthetic spectra
- Estimation tools
- Application to real data
- Conclusion



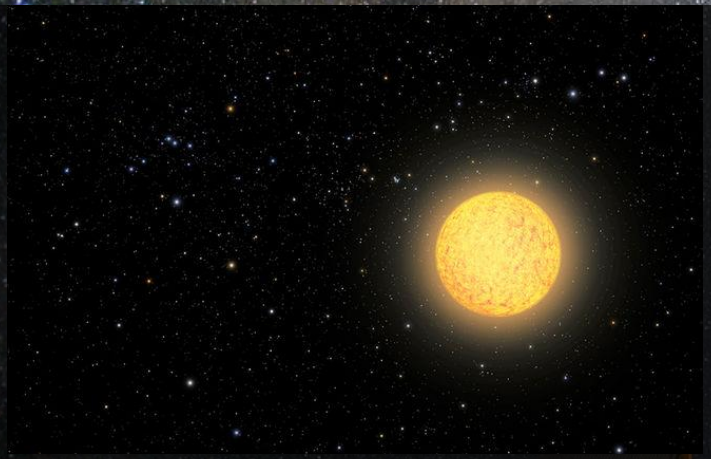
Introduction: SPIRou



- SPIRou is a new generation near-infrared (nIR) spectropolarimeter / velocimeter currently in construction

SPIRou aims at becoming world-leader on two major science topics, (i) the quest for Earth-like planets in the habitable zones of very-low-mass stars, and (ii) the study of low-mass star & planet formation in the presence of magnetic fields

Introduction: Characterizing the star



How?

- Radiative transfer
- Stellar model atmospheres
- High-resolution spectra

yields fundamental measurements of stellar temperature, gravity, rotation, and composition

Difficulties: compensating for the different effects affecting the spectrum

- Rotation of the star
- Radial velocity
- Instrumental errors

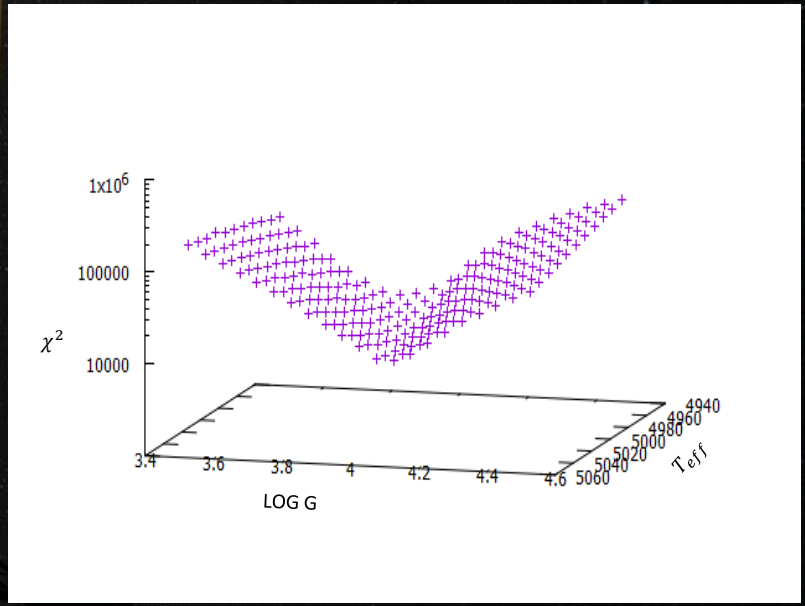
Introduction: X^2 minimisation

With nonlinear least- squares Marquardt fitting algorithm, it is possible to directly estimate :

- Teff
- log g
- metallicity

of a spectrum by matching it to the library and by minimizing the corresponding chi square.

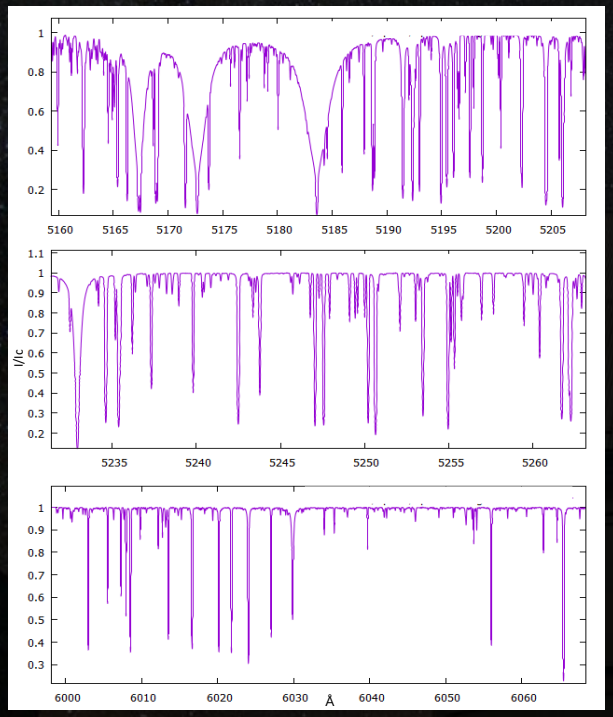
➔ We require a large library of synthetic spectra

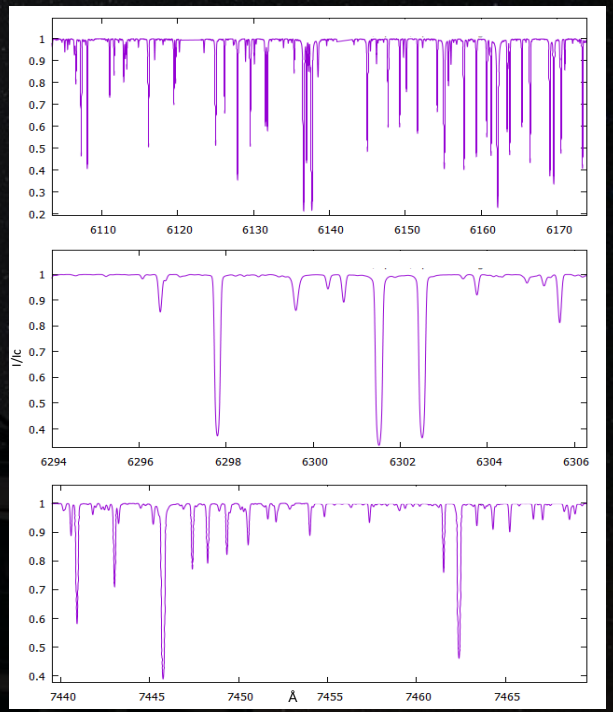


Synthetic spectra

Kurucz

We used version 2.76f of the software package spectrum to generate synthetic spectra to fit. V&F(2014) proposed 20 spectral windows to better characterize the variability of the spectrum with Teff, log g and [M/H].





Synthetic spectra

Phoenix

As we are trying to characterize stellar parameters for M dwarfs we need to be able to model both atomic and molecular lines accurately

Kurucz ➔ ✗
Phoenix ➔ ✓

This necessity for a state of the art stellar atmosphere model resulted in a fruitful collaboration with France Allard (ENS Lyon).

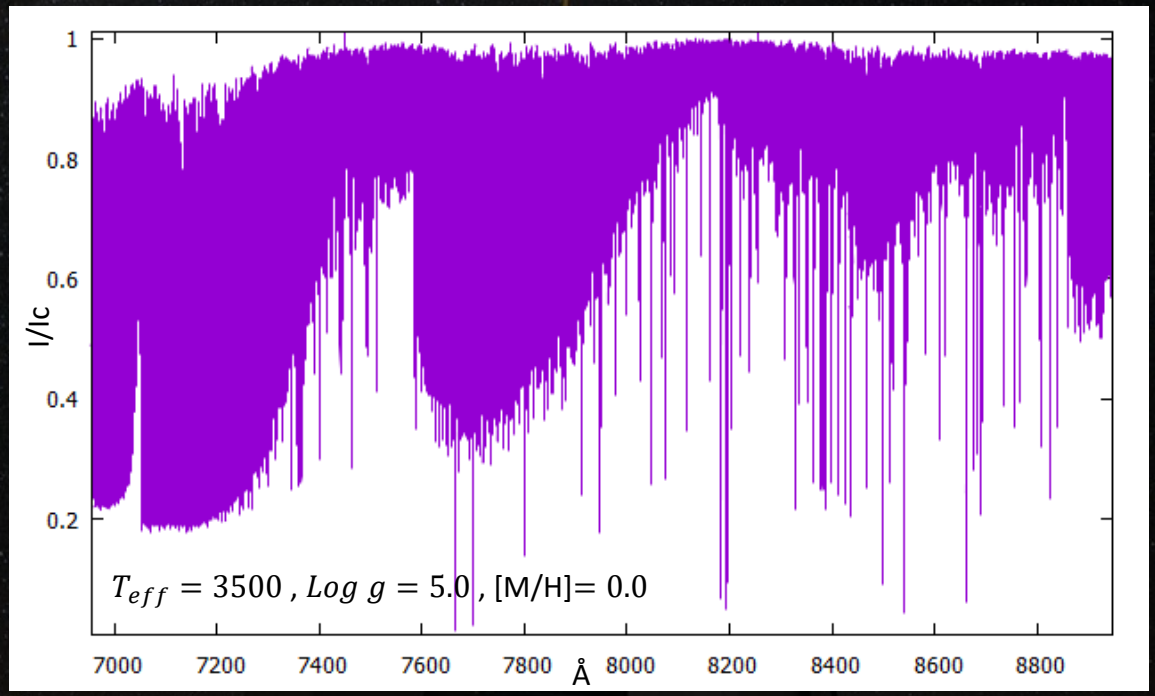
With her help I managed to setup on a local supercomputer (CALMIP, eos) since the code is fully MPI.

It took weeks/months recompile the code and make it work properly, without any major/avoidable errors.

Synthetic spectra

Phoenix

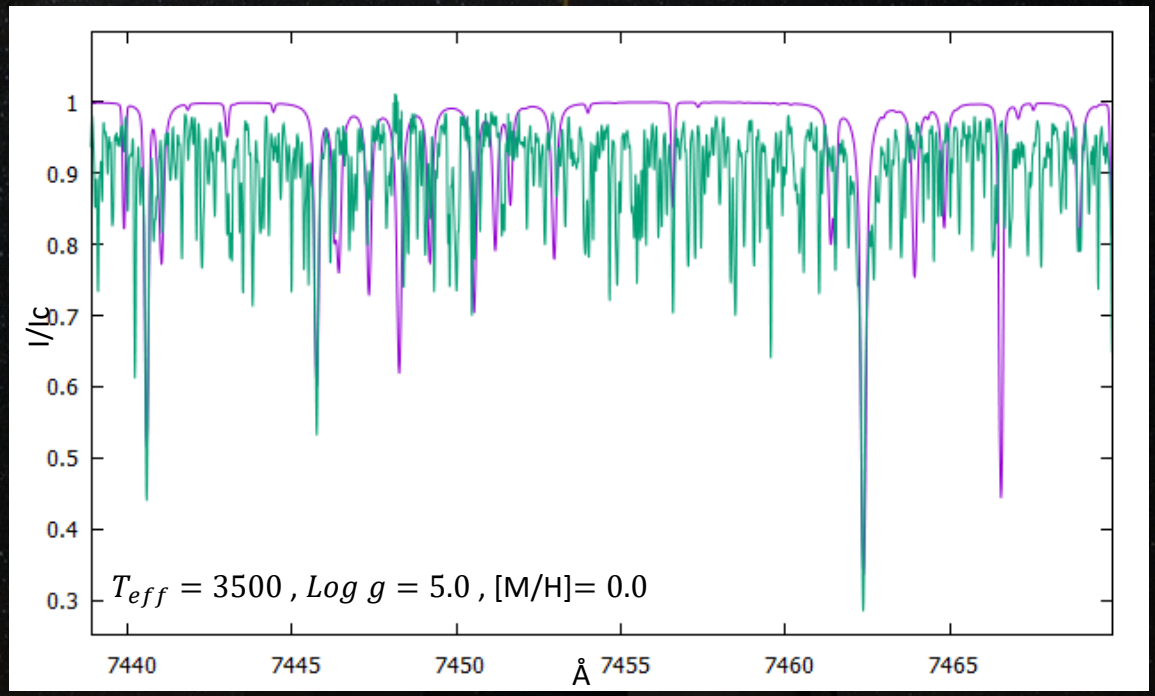
As we are trying to characterize stellar parameters for M dwarfs we need to be able to model both atomic and molecular lines accurately



Synthetic spectra

Phoenix vs Kurucz

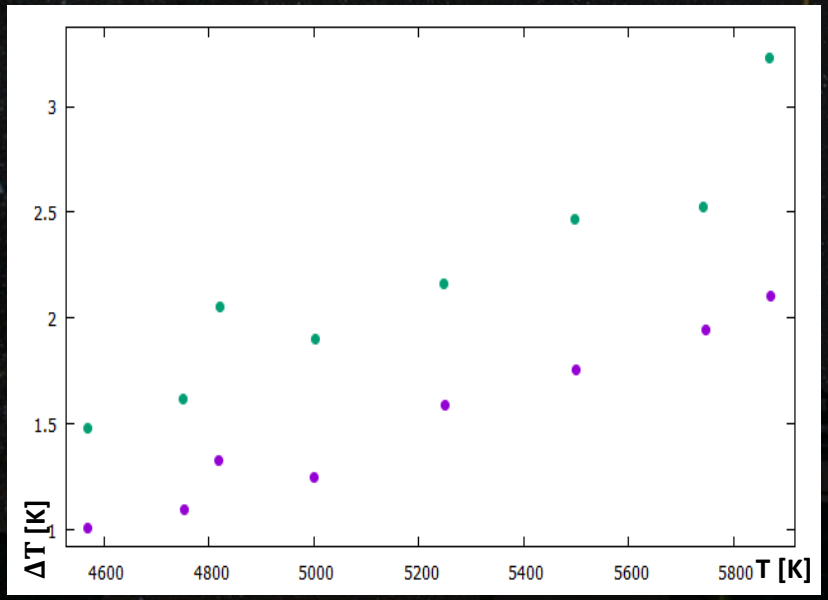
As we are trying to characterize stellar parameters for M dwarfs we need to be able to model both atomic and molecular lines accurately

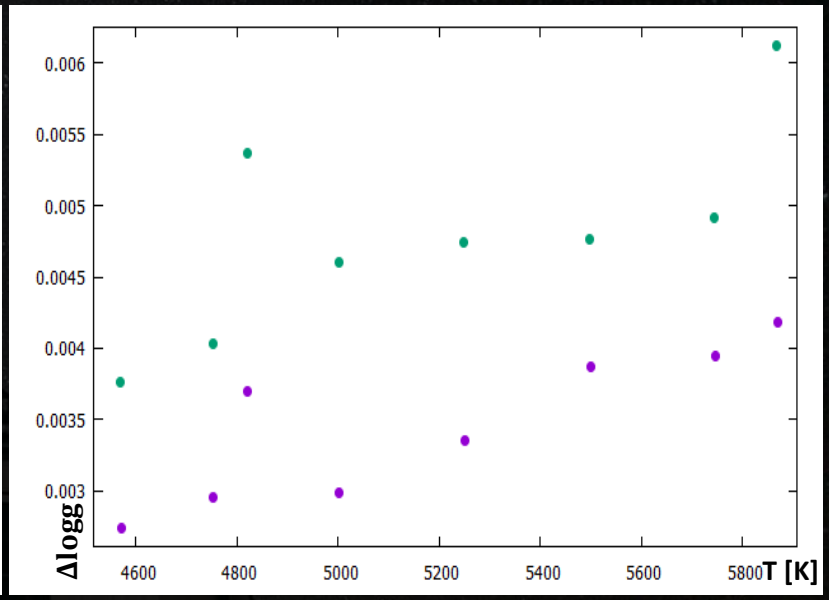


Estimation tools

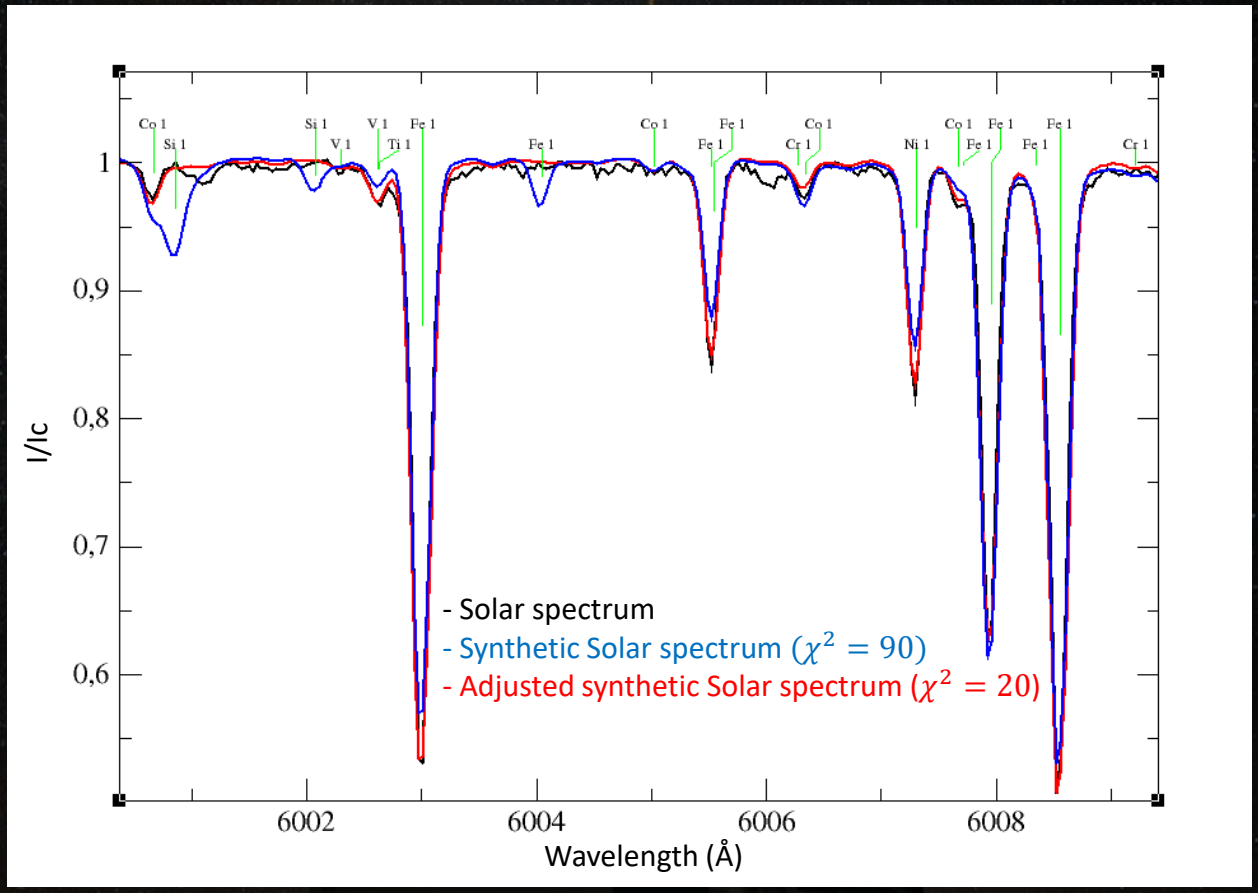
Ordinary least square (OLS)

Applying OLS to artificially noised synthetic Kurucz spectra to recover the wanted parameters. Comparison between data with 8 (V&F 2005) vs 20 (V&F 2014) windows and the impact on the errors.





Application on real data
Sun



Application on real data
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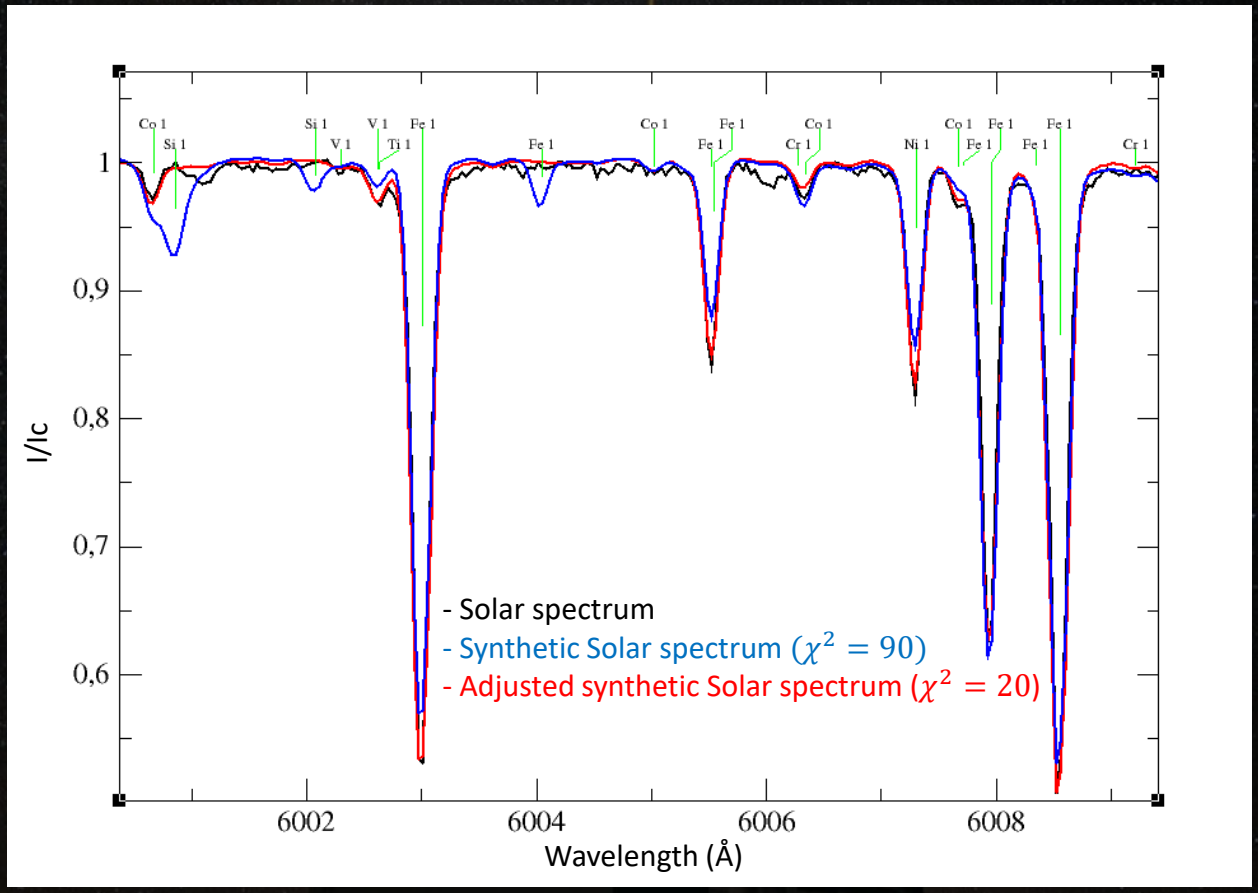

Conclusion
Coming steps

- Testing phoenix library against actual FGK stars in the optical range using spectral windows provided by V&F (2005, 2014). Many spectra were already collected with two spectropolarimeters and are and many of them are already available.
  - ESPaDOnS at CFHT
  - HARPS-Pol at ESO

- Find new windows in the nIR range that are also sensitive to changes in Teff, log g and [M/H] so that we use the same techniques with nIR data. Some data for M dwarfs are also already available
  - Archival CRIRES
  - CARMENES

- And hopefully SPIRou's high resolution data will also be available before the end of the PhD.