XII Jornadas de Introducción a la Investigación 2024

LA METALICIDAD DE LAS ESTRELLAS M MÁS ALLÁ DE LA ESPECTROSCOPÍA DE ALTA RESOLUCIÓN



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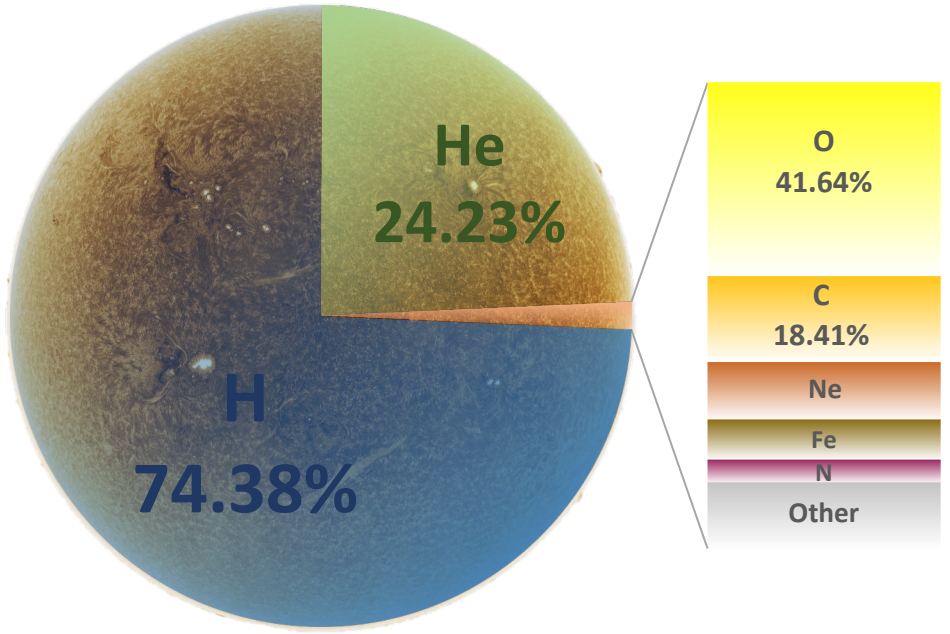
IPARCOS

carmenes

What stars are made of

According to current data (Asplund et al. 2021), the mass fractions in the solar photosphere are:

$$X = 0.7438$$
$$Y = 0.2423$$
$$Z = 0.0139$$

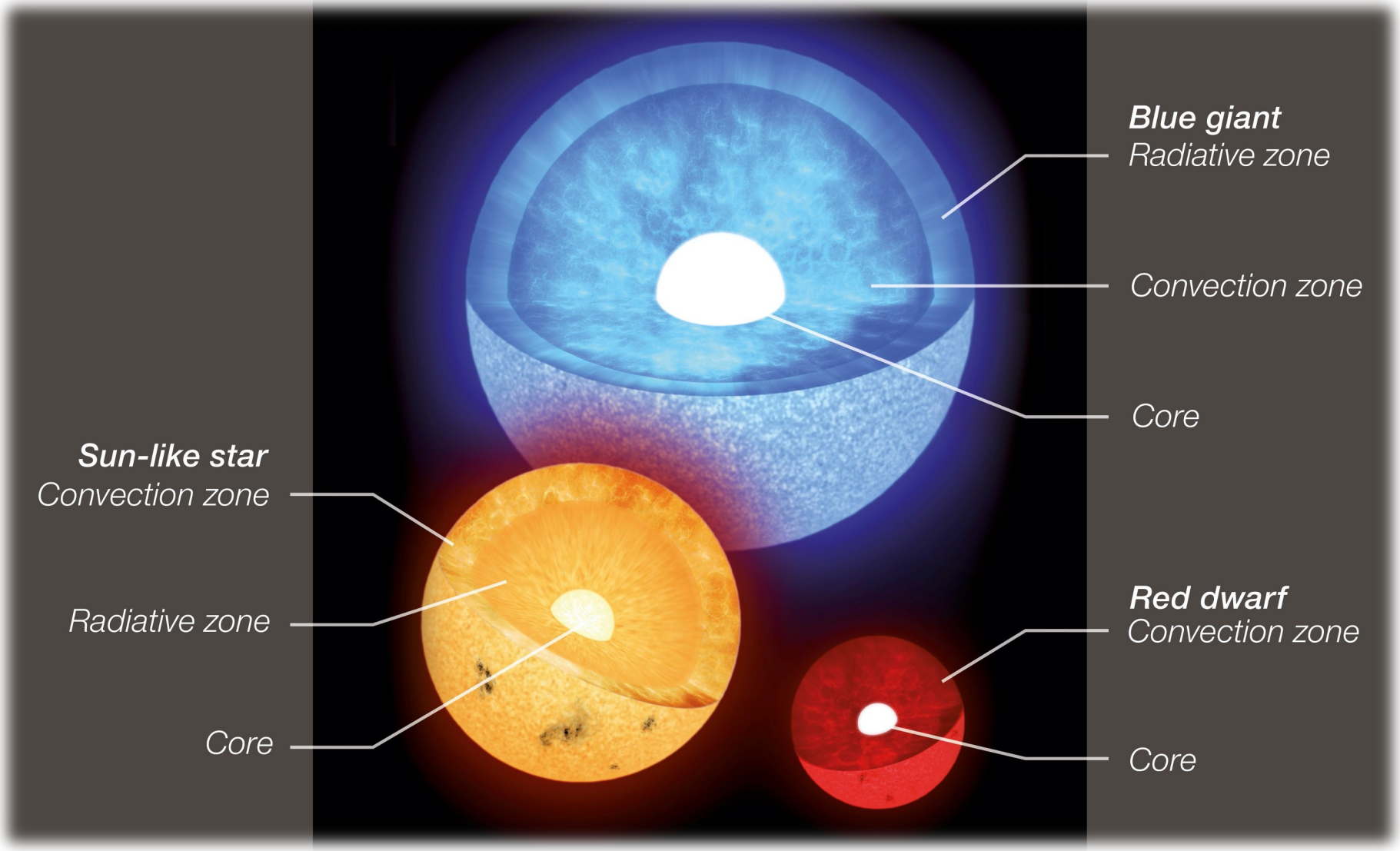


Henry Norris Russell, in 1914:

"If the Earth's crust should be raised to the temperature of the Sun's atmosphere, it would give a very similar absorption spectrum. The spectra of the Sun and other stars were similar, so it appeared that the relative abundance of elements in the universe was like that in Earth's crust."

It was Cecilia Payne-Gaposchkin who proposed in 1925 in her doctoral tesis that stars were composed primarly of hydrogen and helium.

What stars are made of

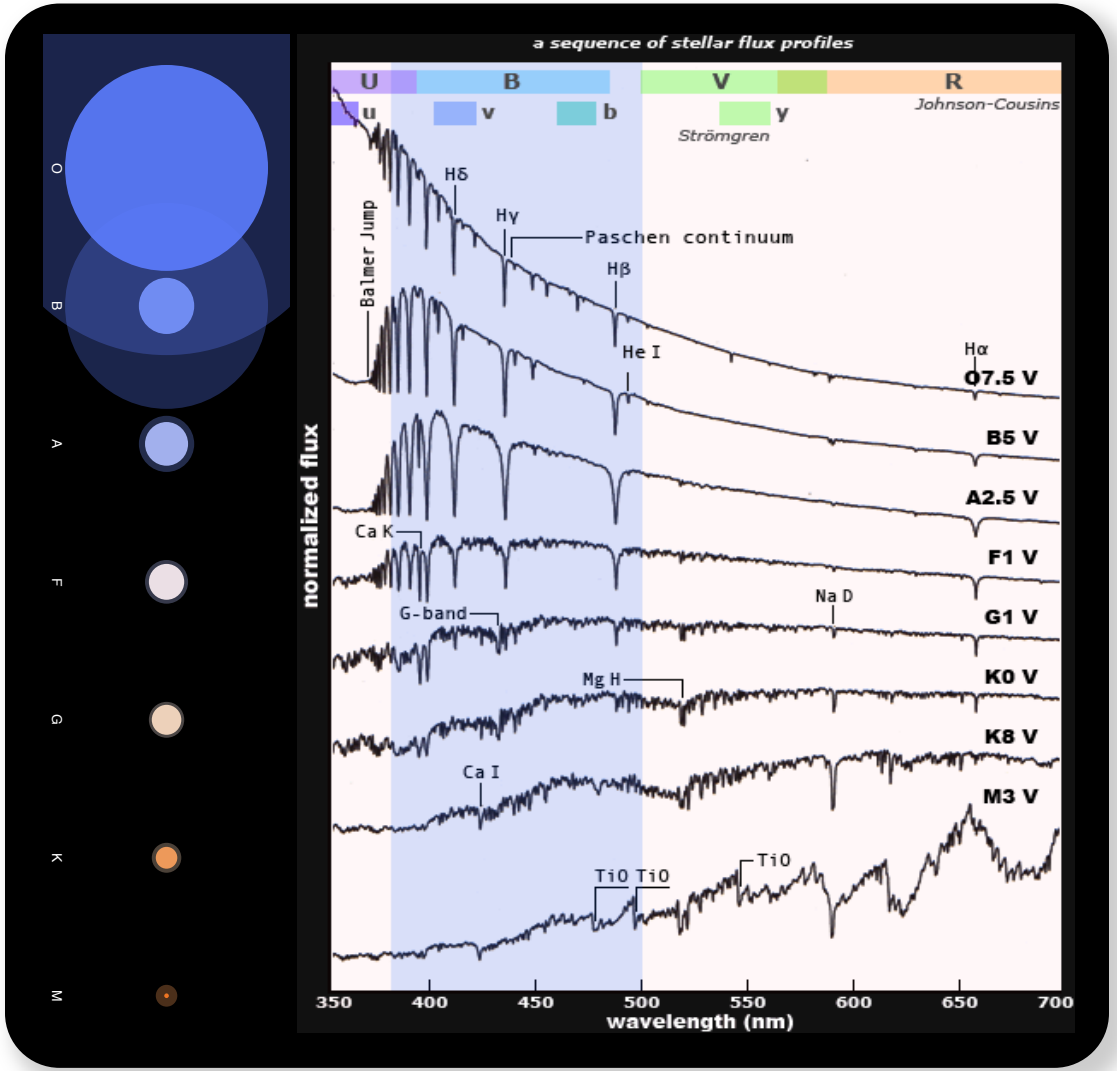


Why M dwarfs?

M dwarfs stand as excellent probes to study the chemical and dynamical evolution of the Galaxy, and the two most successful techniques for detecting exoplanets (RV and transits) are favored in M dwarfs.

However, the determination of their metallicity is a challenging task, and measurements of abundances of these cool stars have been limited due to difficulties in the analysis of their spectra:

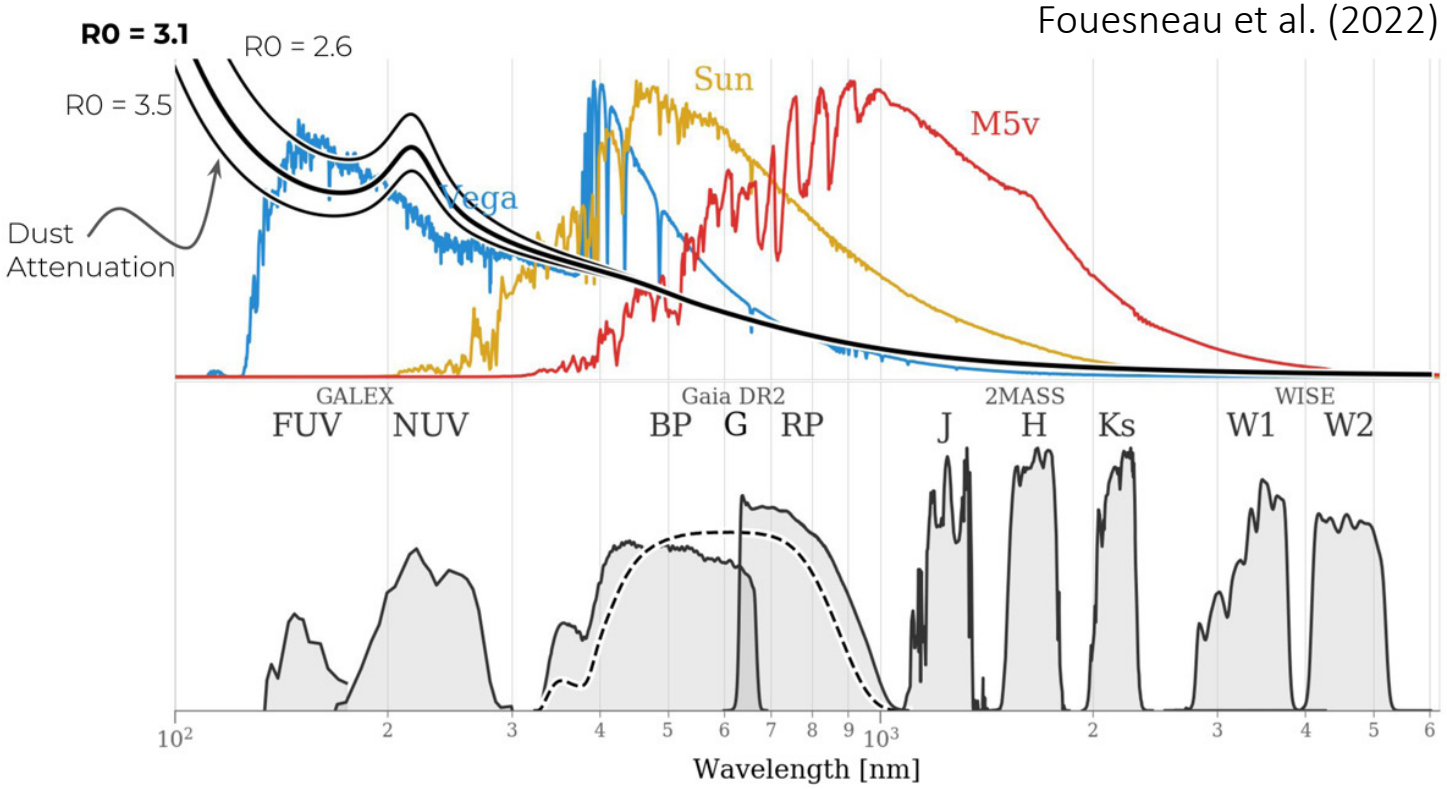
- Spectra much more complex than those of solar-type or hot stars due to their low atmospheric temperatures.
- Forests of lines caused by several molecular species (TiO, VO, ZrO, FeH, CaH in the optical regime; H2O, CO in the near-infrared).



Photometric metallicity of M dwarfs

The position of a star in a color-color or a color-magnitude diagram is determined mainly by its initial mass, chemical composition and age.

Fouesneau et al. (2022)



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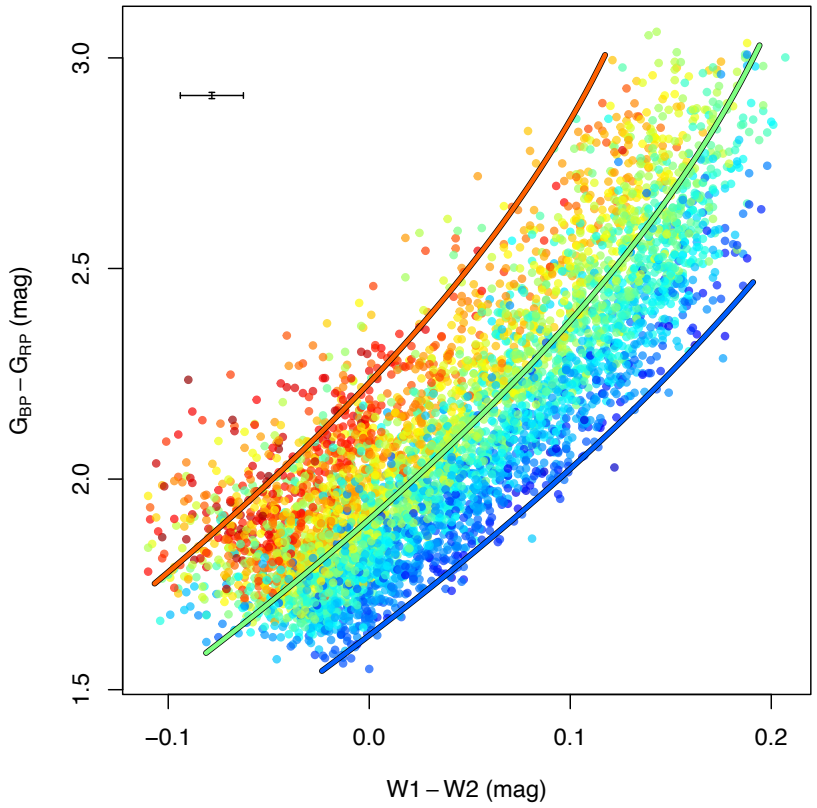
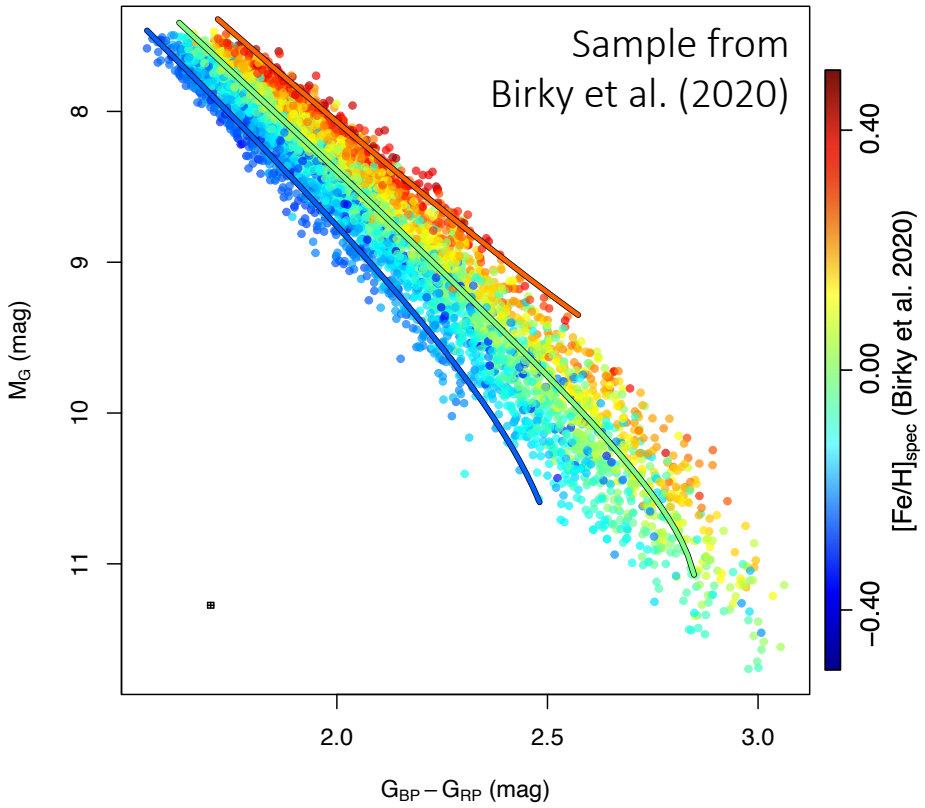
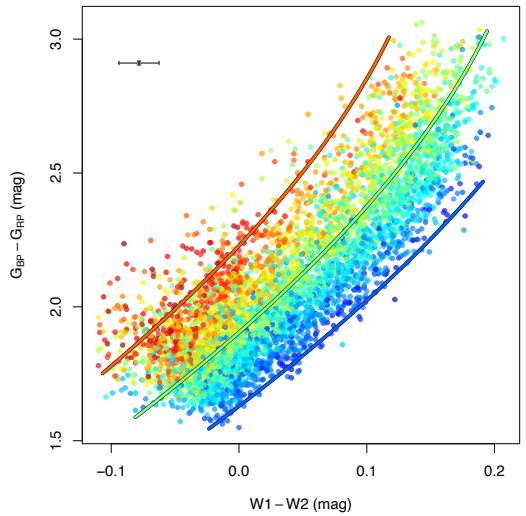


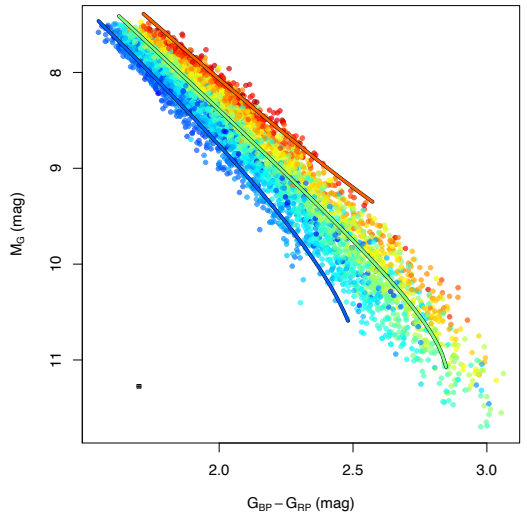


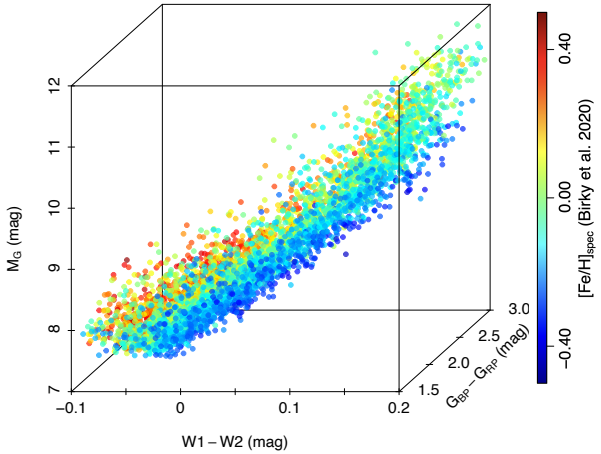
↑ metallicity ⟹ ↑ opacity ⟹ ↓ temperature and luminosity

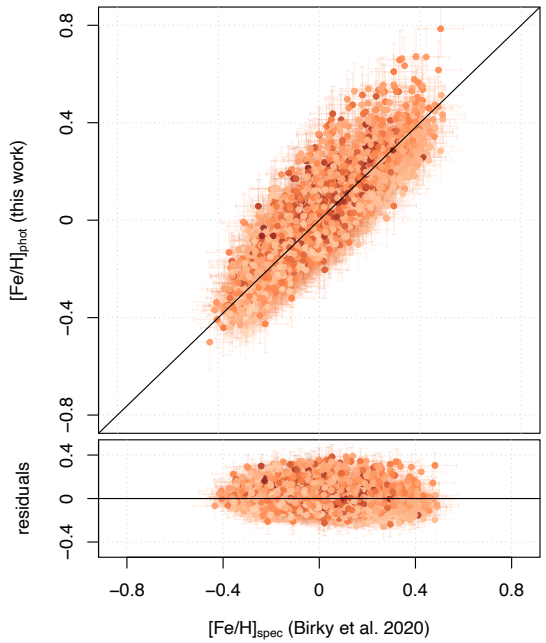
↘ e^- → H^- ↗

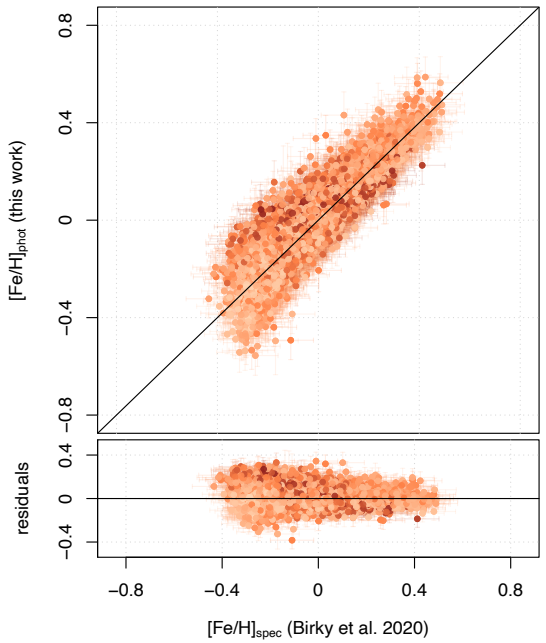
Photometric metallicity of M dwarfs

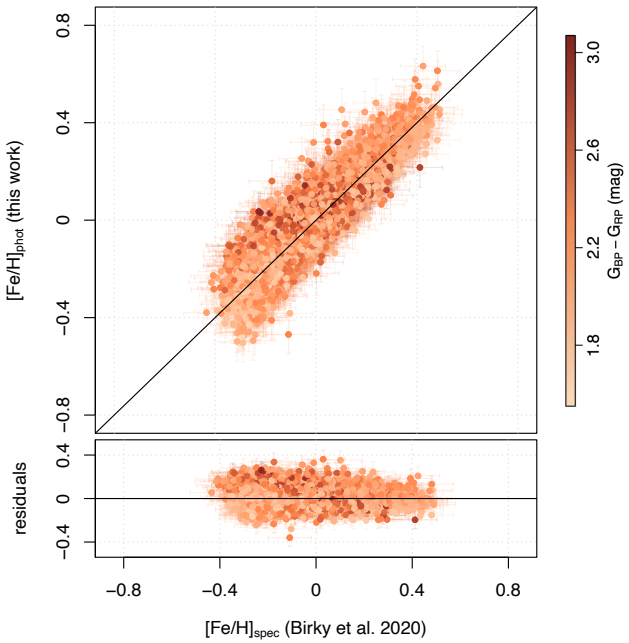










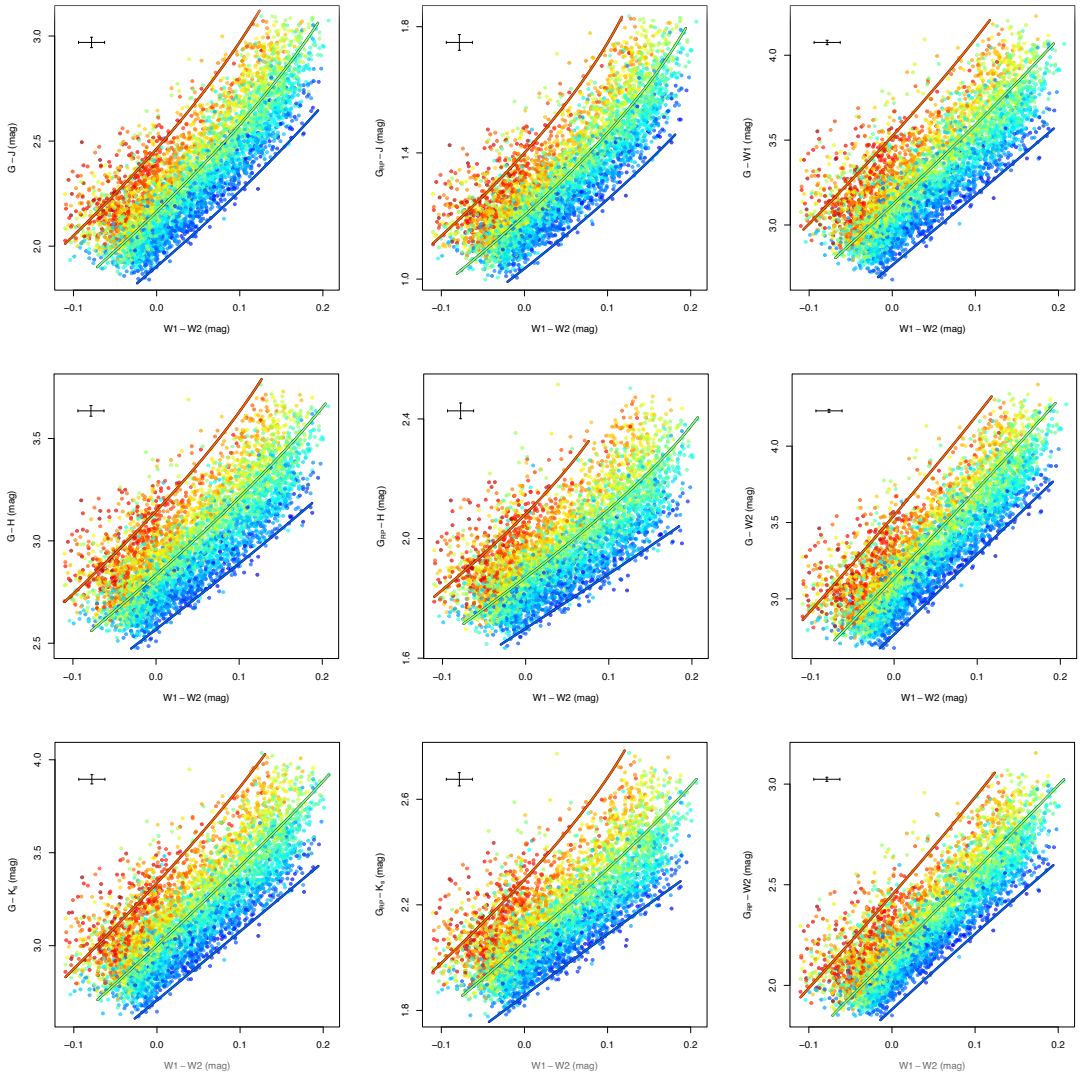


Generalized linear models

Bayesian approach to error measurement

Uncertainties:
0.10 dex

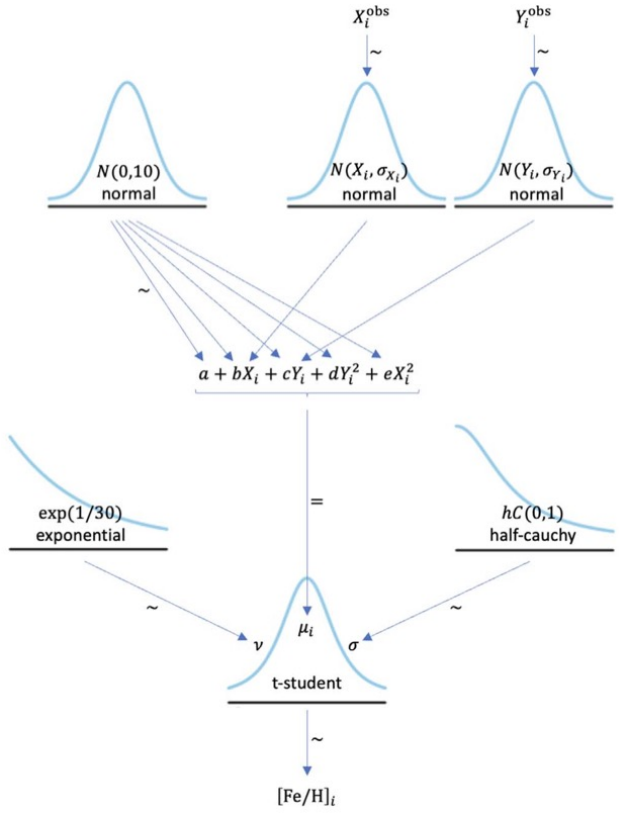
Photometric metallicity of M dwarfs



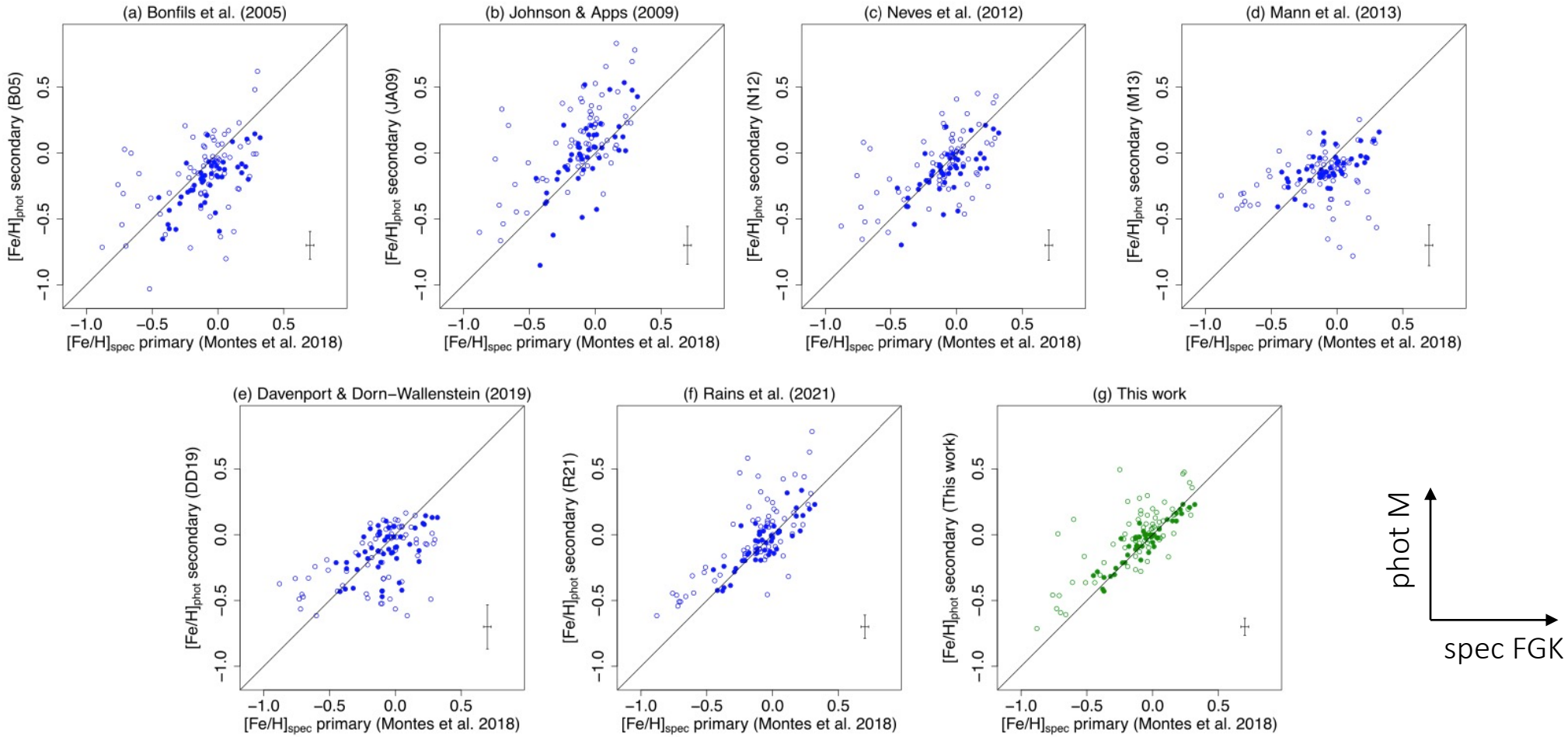
We derived different calibrations based on several diagrams, and compared their performance with the Leave-One-Out Cross-Validation criterion

$$\mathrm{elppd}_{\mathrm{LOO}} = \sum_{i=1}^{N} \log(P(x_i|\boldsymbol{x}_{-i}))$$

The W1–W2 color index constitutes an important metallicity indicator (Schmidt et al. 2016).



Photometric metallicity of M dwarfs



Comparison between the spectroscopic and photometric metallicities estimated by several authors (in blue) and by us (in green). Filled circles represent stars with good photometric and astrometric data.

Photometric metallicity of M dwarfs

Photometric Calibrations of M-dwarf Metallicity with Markov Chain Monte Carlo and Bayesian Inference

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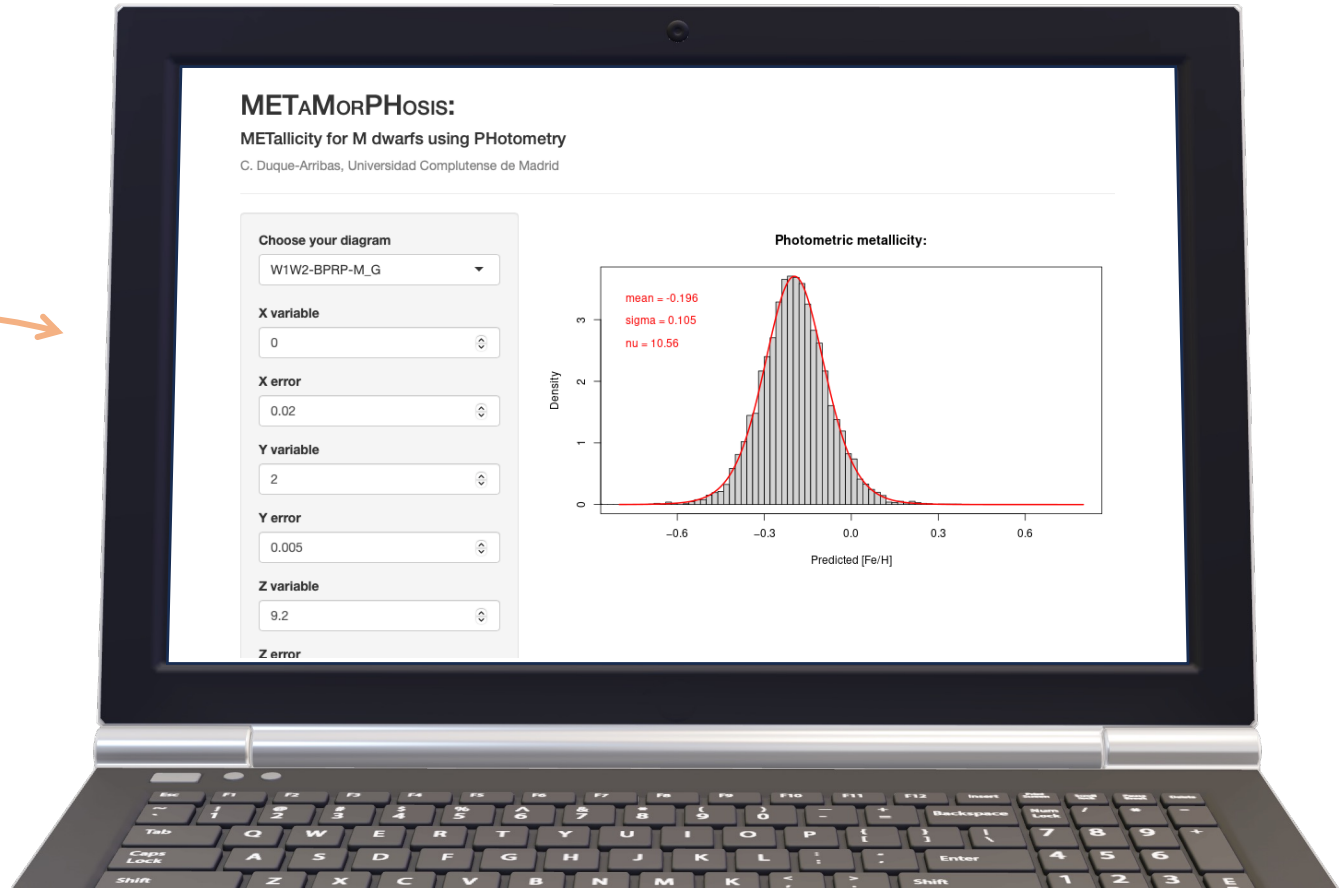
Paper already published at ApJ:
https://ui.adsabs.harvard.edu/abs/2023ApJ...944..106D

METaMorPHosis

Github and interactive web app
github.com/chrduque

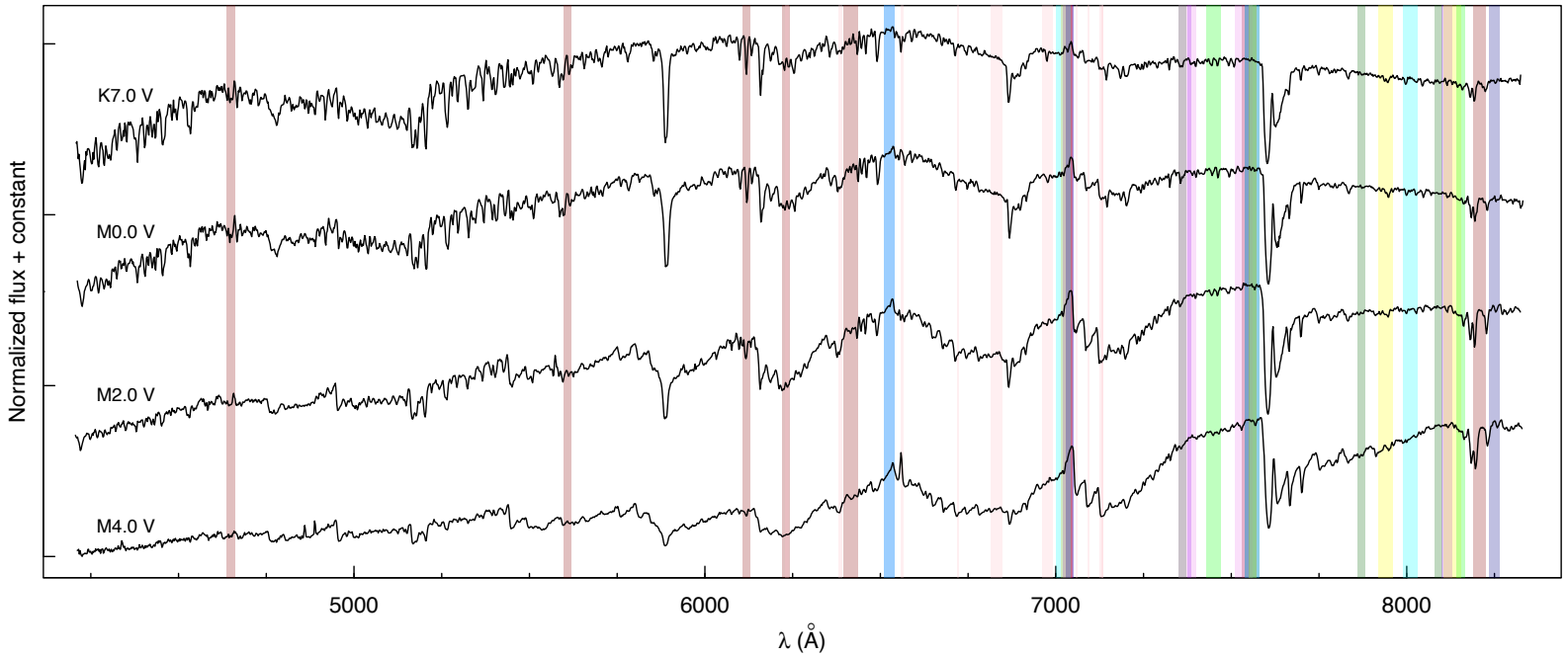


Low-res abundances of M dwarfs

WORK IN PROGRESS

CAFOS: **C**alar **A**lto **F**aint **O**bject **S**pectrograph

At the 2.2m telescope at Calar Alto, provides a spectral coverage between 4200 and 8300 Å with a R = 1500.



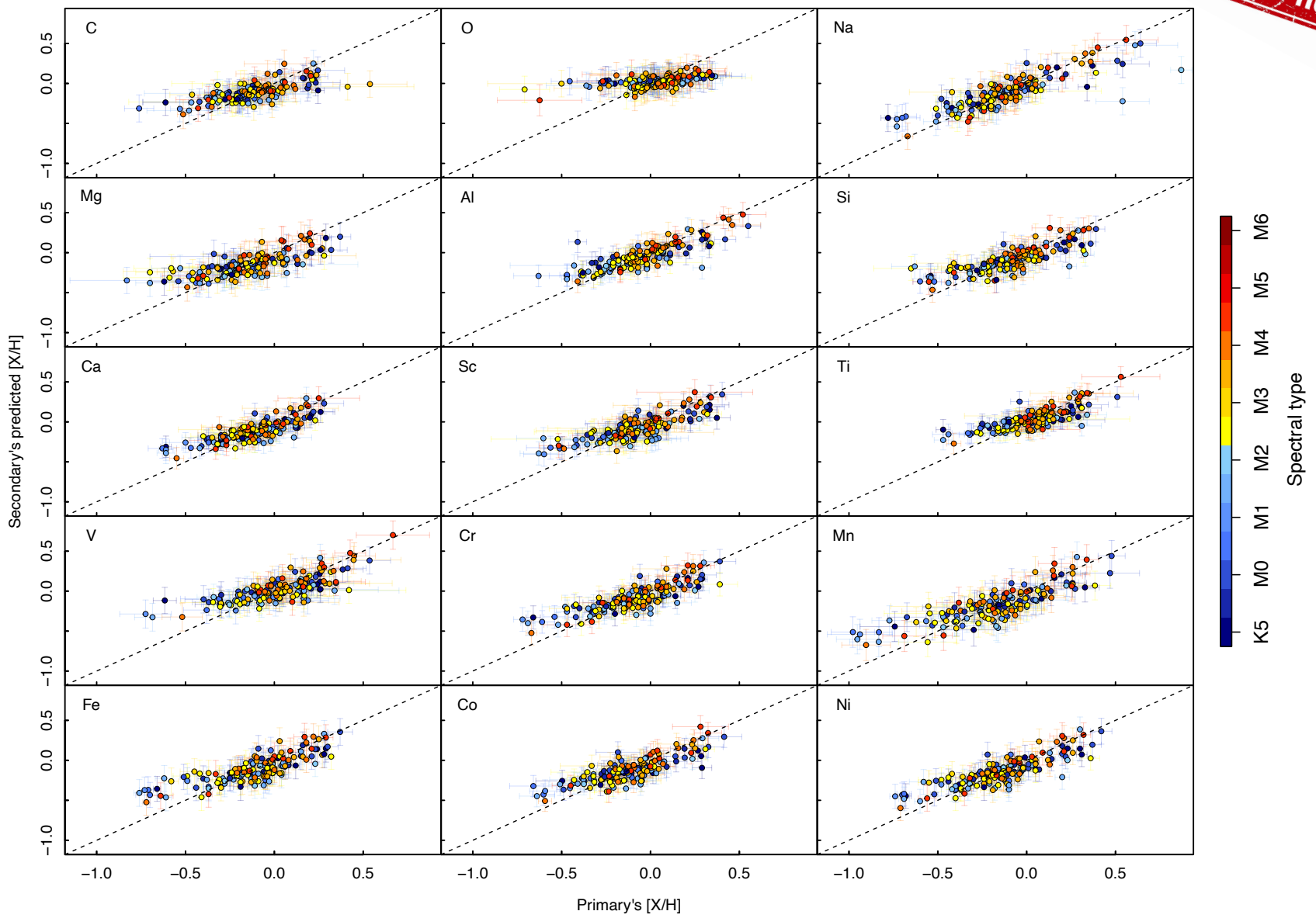
CAFOS spectra of four solar-metallicity stars and different spectral types, highlighting the metal-sensitive features and spectral indices compiled.

A spectral index is defined as the flux ratio at certain wavelength intervals in low-res spectra.

Spectral typing (Alonso-Floriano et al. 2015)

Use these 38 indices to estimate the abundances of the M-dwarf companions.

Low-res abundances of M dwarfs



Low-res abundances of M dwarfs

