PPVI 5. Calibrating the metallicity of M dwarfs with wide physical binaries

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We summarise our on-going project aimed at calibrating the metallicity of M dwarfs. We have selected a large sample of physical binaries composed of an F-, G- or K-dwarf primary and an M-dwarf secondary. High-resolution spectra of the primary components are being analysed in order to determine, in a uniform way, accurate atmospheric parameters, metallicity and abundance of different elements. From low-resolution spectra of the secondary components we derived reliable spectral types and metallicity-dependent spectral indices. Using all this information, we are improving the current spectroscopic and photometric calibrations of M-dwarf metallicity, and testing some new ones. The resulting calibrations will be very useful in the characterisation of the input sample of exoplanet search programs around M dwarfs. In particular, we share some of our targets with CARMENES.

FGK primary

Using high-resolution spectroscopy (*HERMES*/Mercator La Palma, *R*=85000) of the **F-, G- or K-dwarf primary** component we have determined:

Stellar parameters:

T_{eff}, log*g*, ξ and **[Fe/H]**

and abundances of 20 elements:

Fe, Na, Mg, Al, Si, Ca, Sc, Ti, V, Cr, Mn, Co, Ni, Cu, Zn, Zr, Ba, Y, Ce and Nd

FGK

T_{eff}, log *g*, ξ and **[Fe/H]** and other elements

separated by at least 5″

M

spec indices

M secondary

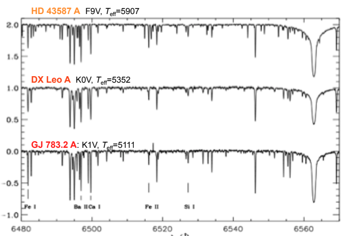
Using low-resolution spectroscopy (*CAFOS*/2.2m CAHA, *R*=1500) of the **M-dwarf secondary** component we have determined:

Spectral types,
Spectroscopic indices:
TiO1-5, **CaH**1-3, CaOH,
Activity: Hα,
Metallicity indicators:
$\zeta_{TiO5/CaH}$ = [1-TiO5]/[1-TiO5$_{\odot}$]

We selected more than 100 wide physical visual binaries composed of an **F-, G- or K-primary** component and an **M-dwarf secondary** from the Gliese & Jahreiss (1991) catalogue of nearby stars, the Poveda et al. (1994) catalogue of wide-binary and multiple systems of nearby stars, and the Gould & Chanamé (2004) list of physical *Hipparcos* binaries. We further required that the components are separated by at least 5″. Fast rotators, double-lined spectroscopic binaries (SB2) and close visual binaries have been disregarded. A total of **123** systems have been already observed including **45** analysed to date.

Stellar parameters and abundances

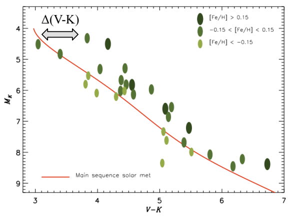
We are determining the stellar atmospheric parameters (T_{eff}, log *g*, ξ and **[Fe/H]**), using our code (***StePar***, Tabernero et al. 2012) that iterates until the slopes of χ *vs.* log(ϵ(Fe I)) and log(*EW*/λ) *vs.* log(ϵ(Fe I)) where zero and imposing ionization equilibrium: log(ϵ(Fe I)) = log(ϵ(Fe II)).

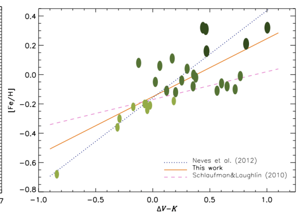


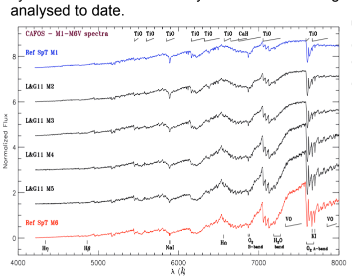
Absolute abundances of 20 chemical elements are being calculated using the equivalent width (*EW*) method in a line-by-line basis. We took the line lists from Neves et al. (2009), González Hernández et al. (2010) and Pompéia et al. (2011) and the *EW* measured with the *ARES* code (Sousa et al. 2007; 2008). Abundance analysis was carried out with the *MOOG* code (Sneden 1973) by means of our determined atmospheric parameters and a solar spectrum taken with the same instrumental configuration.

Photometric Metallicity Calibration

The bottom-left figure shows the color-magnitude diagram (***V-K***, M_K) for the M companions with [Fe/H] determined in this work. We have used the distance to the main sequence, Δ(***V-K***), as a metallicity diagnostic. The bottom-right figure shows our Δ(***V-K***) *vs.* [Fe/H] fit and the comparison with previous calibrations (Schlaufman & Laughlin 2010; Neves et al. 2012).





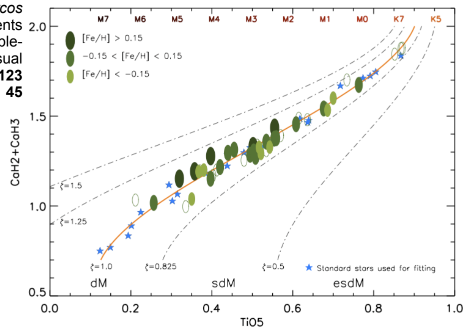


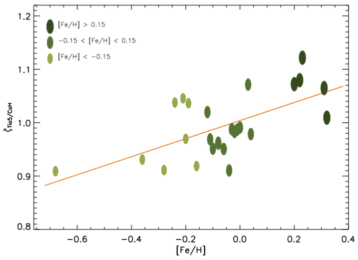
The spectral indices (TiO1-5 and CaH1-3, Reid et al. 1995) determined in our spectra of the M companions (see central figure, Alonso-Floriano et al. 2013 and poster CARMENES PPVI 3 by Mundt et al.) allowed us to analyse in detail the metallicity-dependent relation between **TiO5** and **CaH2+CaH3** (see middle right figure) by means of the parameter $\zeta_{TiO5/CaH}$ defined by Lépine et al. (2007):

$$\zeta_{TiO5/CaH} = [1\text{-TiO5}]/[1\text{-TiO5}_{\odot}]$$

Using the **[Fe/H]** abundance of the FGK companions derived by us with our high-resolution spectra is possible to calibrate this relation (see CaH2+CaH3 *vs* TiO5 figure). Note the dependence on [Fe/H] of the parameter $\zeta_{TiO5/CaH}$ (see bottom right figure).

Spectral Indices Metallicity Calibration





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Poster 2K022 @ PPVI