Preparation of the CARMENES Input Catalogue: Low- and High-resolution Spectroscopy of M dwarfs

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Abstract. The identification of the most promising targets for exoplanet hunting is a crucial first step to ensure an efficient use of the CARMENES guaranteed time. To achieve this, we obtained low-resolution (R $\sim$ 1500) spectra of 752 M (and late K) dwarfs mostly fainter than $J = 9$ mag with CAFOS. For all of them, we derived spectral types with 0.5 subtypes accuracy. We also studied metallicity and surface gravity through spectral indices, and activity from $pEW(\mathrm{H}\alpha)$. Next, we observed over 600 M dwarfs at higher resolution (R = 30 000–48 000) with FEROS, CAFE and HRS. We determined rotational velocities, $v \sin i$ ($\pm$0.2–0.5 km s^{-1}), and radial velocities, V_r ($\pm$0.1–0.2 km s^{-1}), of the observed stars. From our observations, we identified high-activity, low-metallicity and low-gravity stars, single- and double-lined spectroscopic binaries and, specially, fast rotators, which should be discarded from any target list for exoplanet searches. Here we present preliminary results.

1. The CARMENES Input Catalogue

CARMENES[1] is an exoplanet survey instrument being built by a collaboration of several Spanish and German institutions and the Calar Alto Observatory. Its main goal is to find exoearths around M dwarfs by the radial velocity technique (Quirrenbach et al. 2012).

CARMENCITA is the CARMENES Input Catalogue. It contains almost 2 200 M dwarfs from a number of references (Reid et al. 1995, 2002; Hawley et al. 1996; Gizis et al. 2002; Bochanski et al. 2005; Caballero 2007; Gatewood & Coban 2009; Lépine et al. 2009; Lépine & Gaidos 2011; Johnson et al. 2010; Irwin et al. 2011; Avenhaus et al. 2012; Deacon et al. 2012; Newton et al. 2014). This catalogue includes information on spectral type, photometry, multiplicity, $v \sin i$, activity, X-ray, etc., and helps us to select the 300 brightest, latest, less active, single M dwarfs observable from Calar Alto that will be monitored during CARMENES guaranteed time. Since many stars lack some of that information, we fill that gap by compiling it from the literature or by measuring it by ourselves. The first step of our preparatory observations was to take accurate low-resolution spectroscopy of M dwarf candidates with not well determined spectral types, as a complement to current spectroscopic surveys (Lépine et al. 2013; Gaidos et al. 2014). The second step was to take high-resolution imaging (Cortés-Contreras et al. 2014) and spectroscopy in order to discard binaries, fast rotators with high $v \sin i$ and very active M dwarfs.

2. Low-resolution spectroscopy

From November 2011 to April 2013, we used the CAFOS spectrograph at the 2.2 m Calar Alto telescope to observe 752 M (and late K) stars, including standard stars. With a spectral resolution R $\sim$ 1 500, a wavelength range of 4 300–8 300 Å and a signal-to-noise larger than 50 near Hα, we covered the whole main features of M dwarfs in the optical. The processing of the spectra, including instrumental response correction, was done with IRAF. We determined spectral types, measured $pEW(\mathrm{H}\alpha)$, studied gravity sensitive features and calculated the Lépine et al. (2007) metallicity-sensitive index ζ.

[1] http://carmenes.caha.es

For spectral typing, we defined a grid of 19 "prototype" and 52 "standard" stars from K3.0 V to M8.0 V (Fig. .1). We derived spectral types based on 31 spectral indices (e.g., Kirkpatrick et al. (1991); Reid et al. (1995); Martín et al. (1996)) and from best-fit and χ^2 matches (Klutsch et al. 2012). Uncertainties were of only 0.5 subtypes.

We used the $pEW(\mathrm{H}\alpha)$ measurements to study the influence of activity on the spectral types indices and identify possibly accreting stars (White & Basri 2003; Barrado y Navascués & Martín 2003). We picked up unidentified giant stars with the ratio C (Na I $\lambda\lambda$8183,8195 Å; Kirkpatrick et al. 1991; Fig. .2) and subdwarf candidates with the ζ index (Fig. .3) All the results outlined in this section, including the spectral typing for more than 700 M dwarfs, will be presented in a forthcoming paper (Alonso-Floriano et al. in prep.).

3. High-resolution spectroscopy

We are using FEROS at the MPG 2.2 m La Silla telescope (Fig. .4), CAFE at the 2.2 m Calar Alto telescope and HRS at the Hobby Eberly Telescope for obtaining high-resolution (R $\sim$ 30 000–48 000) spectra of M dwarfs. We are measuring rotational and radial velocities (Fig. .5), with accuracies of 0.2–0.5 and 0.1–0.2 km s^{-1}, respectively, and $pEW(\mathrm{H}\alpha)$s for over 600 M dwarfs. Some of them are new spectroscopic binaries, based on their double peaks in cross-correlation functions (CCFs; Fig. .6).

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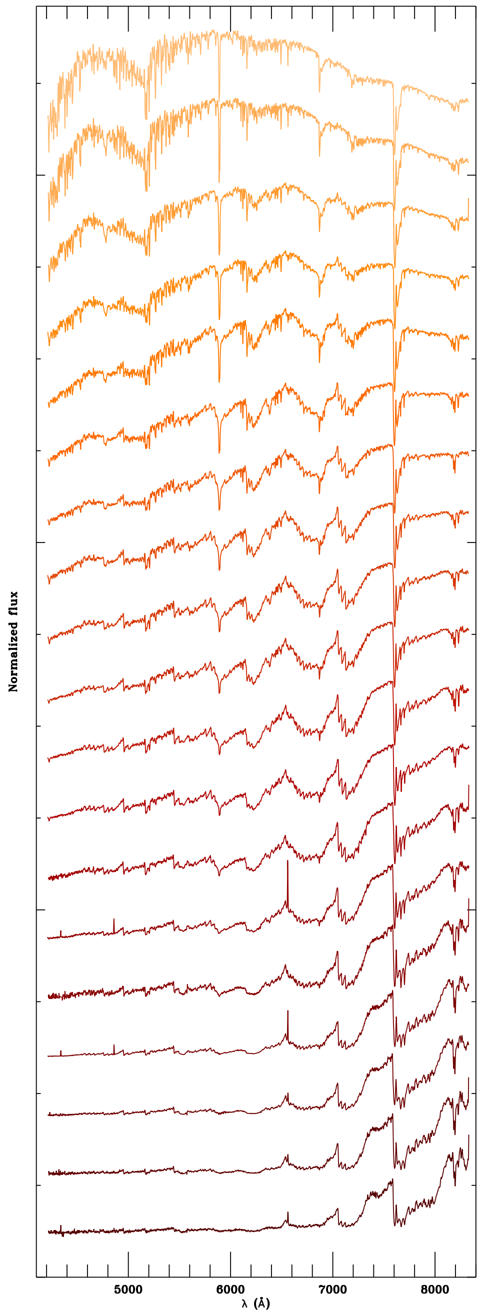

Figure .1: CAFOS spectra of our prototype stars. From top to bottom: HD 50281 (K3 V), 61 Cyg A (K5 V), η Cas B (K7 V), HD 79210 (M0.0 V), BD+45 2743 (M0.5 V), GX And (M1.0 V), HD 36395 (M1.5 V), GJ 2066 (M2.0 V), Ross 905 (M2.5 V), HD 173739 (M3.0 V), Luyten's star (M3.5 V), V1352 Ori (M4.0 V), GJ 1256 (M4.5 V), V388 Cas (M5.0 V), LP 469–067 (M5.5 V), CN Leo (M6.0 V), DX Cnc (M6.5 V), vB 8 (M7.0 V) and V1298 Aql (M8.0 V).

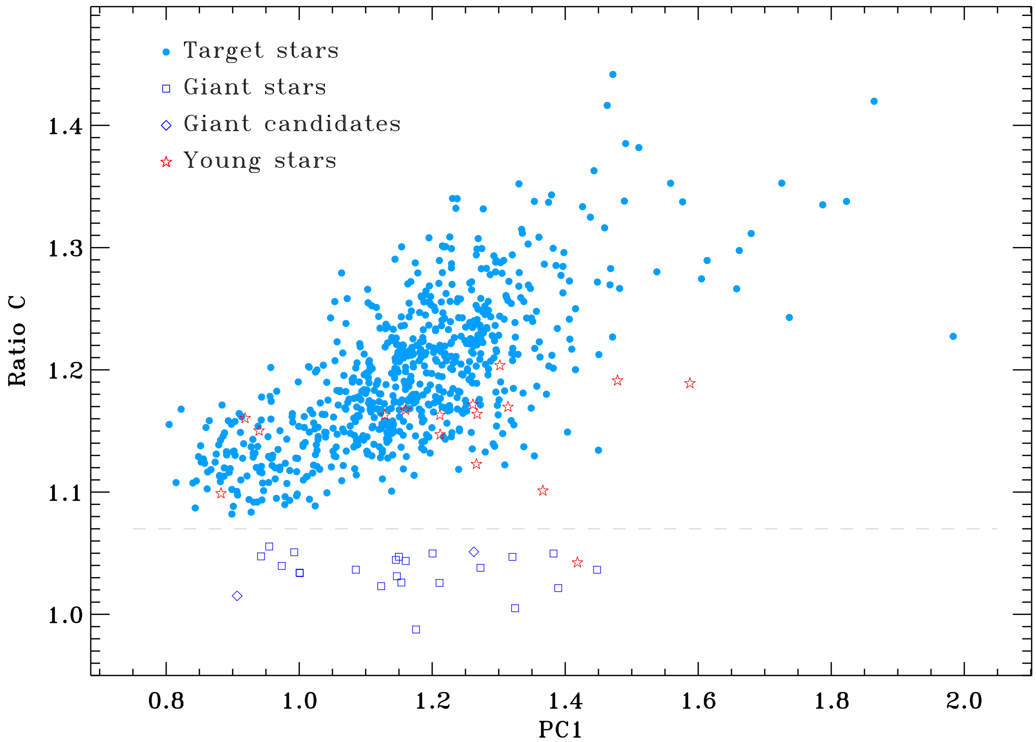

Figure .2: Ratio C vs. PC1 diagram. The PC1 index is a spectral type proxy. A T Tauri star (open red star) and all objects below the dashed line (open squares and rhombs) have very low surface gravities typical of giant stars.

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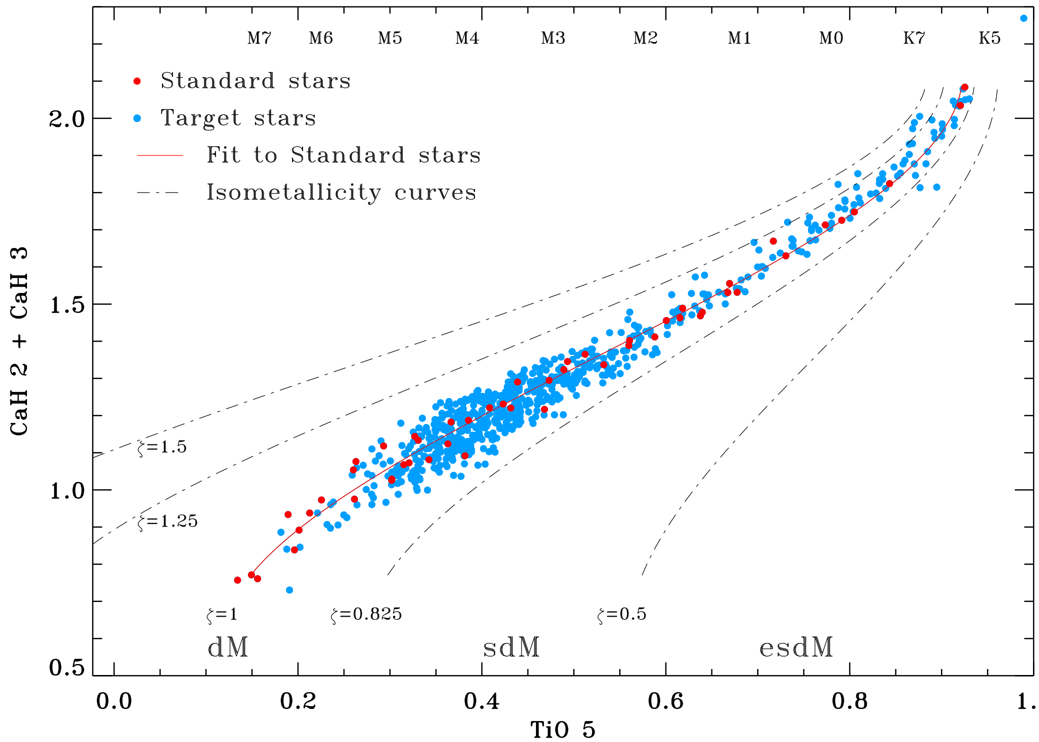

Figure .3: CaH bands vs. TiO 5 diagram. The stars under the "isometallicity curve" ζ=0.825 are low-metallicity candidates.

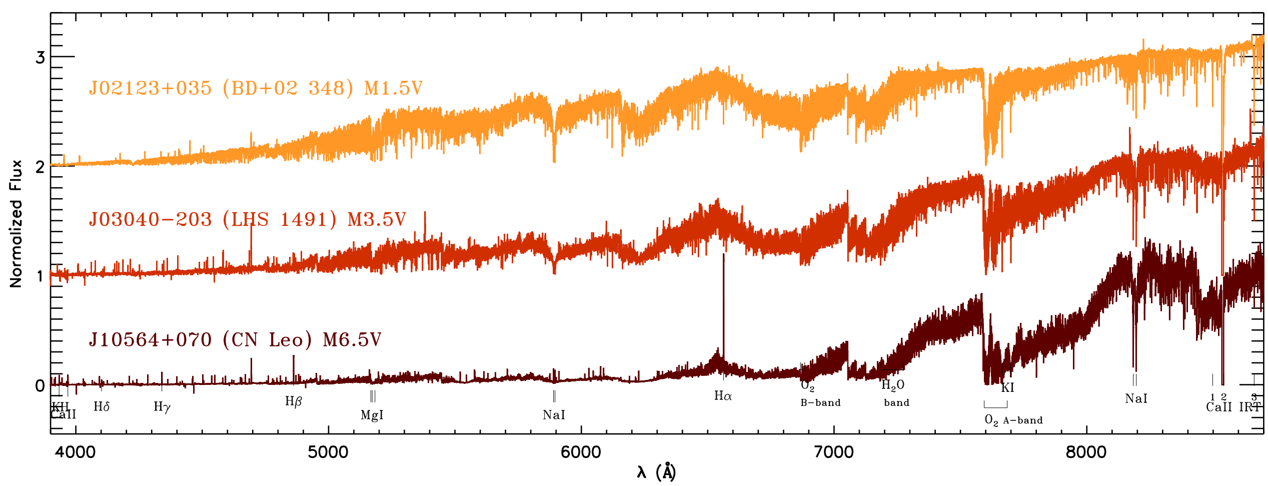

Figure .4: Three representative examples of spectra taken with FEROS. The main optical lines and telluric bands are indicated.

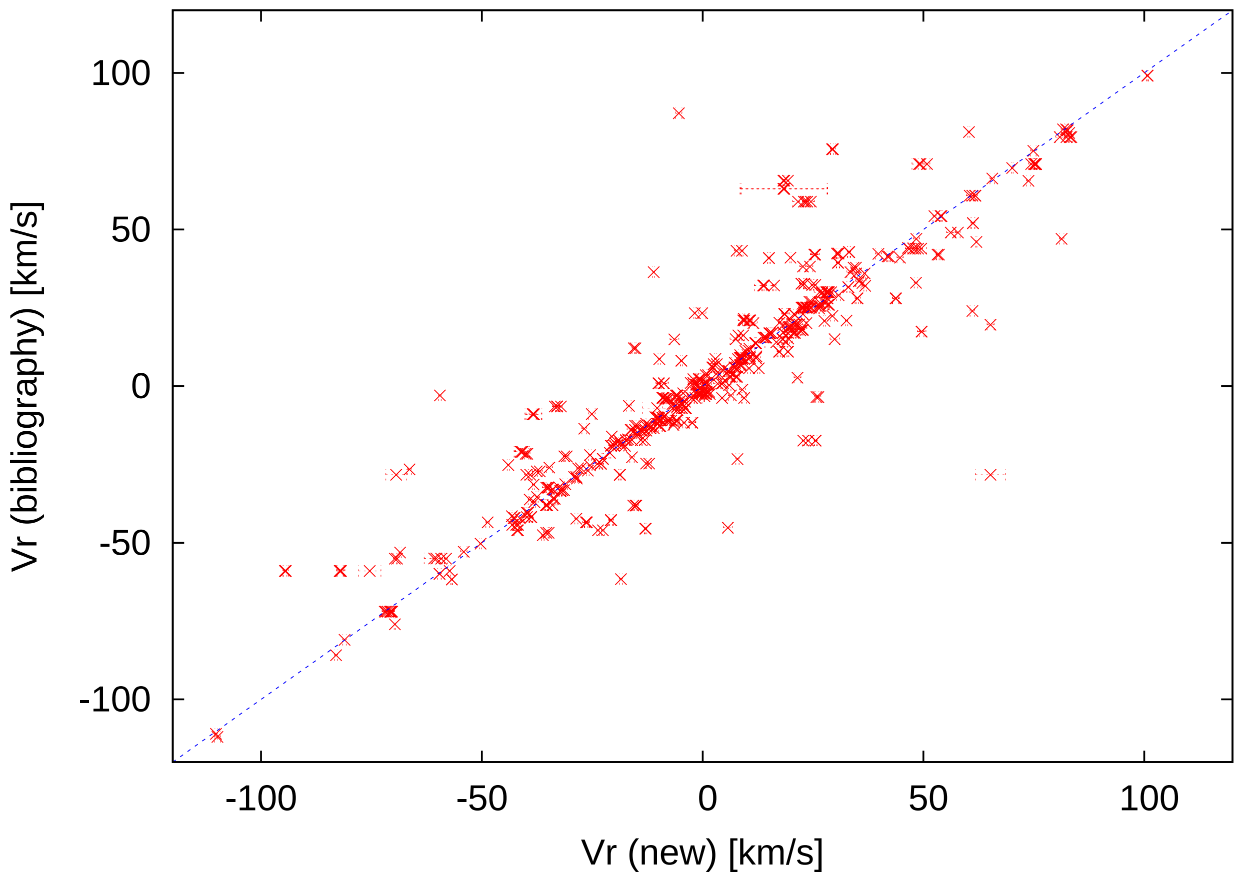

Figure .5: Radial velocity values from the bibliography compared with our radial velocity measurements. The blue dashed line is the one-to-one line. Error bars are showed

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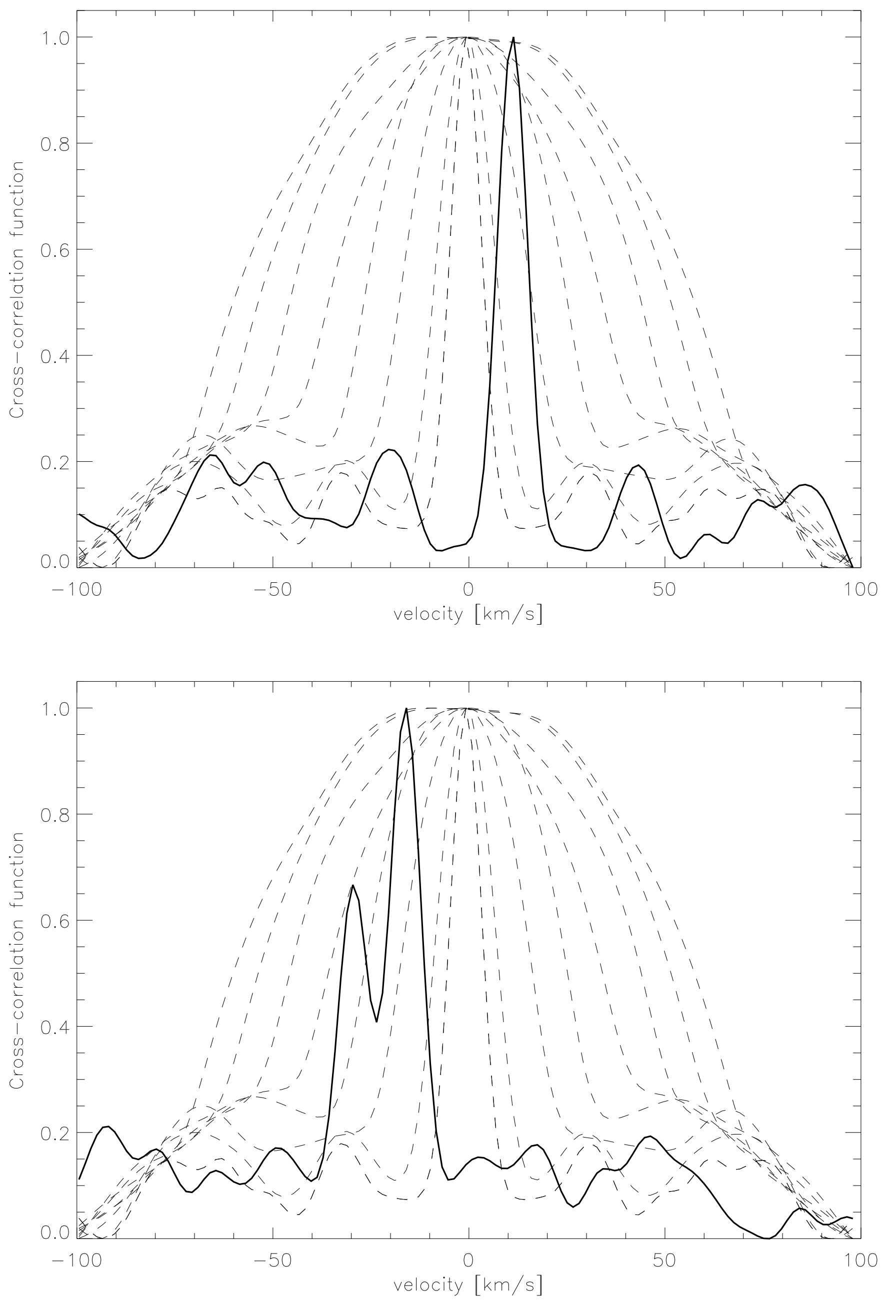

Figure .6: Cross-correlation functions. Top: Slow rotator star. Bottom: New double-lined spectroscopic binary. Dashed lines are CCFs for several $v \sin i$ values obtained from the artificially broadened of the template spectrum. The solid lines are the CCF of the target star, shifted by its own radial velocity.