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CARMENES science preparation: low–resolution spectroscopy of M dwarfs

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Abstract

CARMENES is the new optical/near-infrared spectrograph at Calar Alto observatory. 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, using the CAFOS spectrograph of the 2.2 m telescope at Calar Alto observatory. We derived spectral types with 0.5 subtypes accuracy combining the spectral indices technique and the best-fit & χ^2 matches. We also studied metallicity and surface gravity through spectral indices, and activity from the pseudo-equivalent width of the Hα line. We identified high-activity, low-metallicity and low-gravity stars, which should be discarded for exoplanet searches. Here we present preliminary results.

1 Istrument overview

CARMENES[1] (Calar Alto high-Resolution for M dwarfs with Exoearths with Nea-infrarred and optical Échelle Spectrographs) is a next-generation instrument being built for the 3.5 m telescope at the Calar Alto observatory by a consortium of German and Spanish institutions. It consists of two separated spectrographs covering the wavelength ranges from 0.5 to 1.0 μm and from 1.0 to 1.7 μm with spectral resolutions R = 82,000, each of which shall perform high-accuracy radial-velocity measurements ($\sim$1 m s^{-1}) with long-term stability. The fundamental science objective of CARMENES is to carry out a survey of $\sim$300 late-type main-sequence stars with the goal of detecting low-mass planets in their habitable zones. We aim at being able to detect 2 $M_\oplus$ planets in the habitable zone of M5 V stars. The CARMENES first light is expected to occur in Summer 2015 (Quirrenbach et al. 2014 [22])

2 The CARMENES Input Catalogue

CARMENCITA (CARMENES Cool dwarf Information and daTa Archive) is the Input Catalogue of CARMENES (Caballero et al. 2014 [5]). It contains over 2 200 M dwarfs from a number of references (Reid et al. 1995, 2002 [23, 24]; Hawley et al. 1996 [11]; Gizis et al. 2002 [10]; Bochanski et al. 2005 [3]; Caballero 2007 [4]; Gatewood & Coban 2009 [9]; Lépine et al. 2009 [17]; Lépine & Gaidos 2011 [18]; Johnson et al. 2010 [13]; Irwin et al. 2011 [12]; Avenhaus et al. 2012 [1]; Deacon et al. 2012 [7]; Newton et al. 2014 [21]). Our catalogue includes information on spectral type, photometry, multiplicity, $v \sin i$, activity, X-ray, etc., and helps us to select the 300 brightest, latest, least 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 (Reid et al. 1995 [23]; Gizis et al. 2002 [10]; Lépine et al. 2013 [19]; Gaidos et al. 2014 [8]). The second step is to take high-resolution imaging (Cortés-Contreras et al. 2014 [6]) and high-resolution spectroscopy in order to discard binaries, fast rotators with high $v \sin i$, and very active M dwarfs.

3 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(Hα), studied gravity sensitive features and calculated the metallicity-sensitive index ζ proposed by Lépine et al. (2007) [16].

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

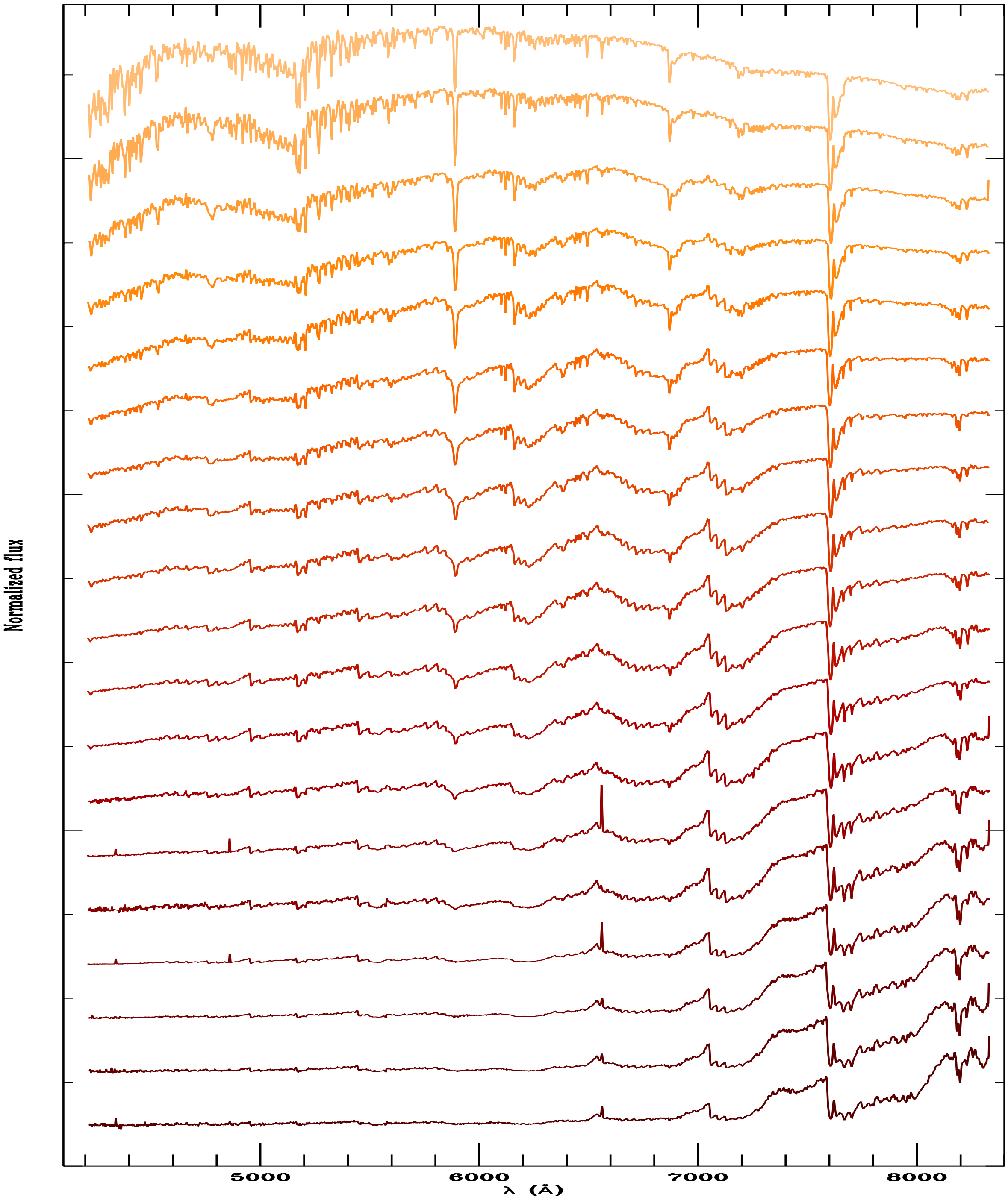

Figure 1: CAFOS spectra of our prototype stars. From top to bottom: HD 50281 (K3 V), 61 Cyg A (K5 V), η Cas B (K7 V), HD 79210 (M0.0 V), BD+45 2743 (M0.5 V), GX And (M1.0 V), HD 36395 (M1.5 V), GJ 2066 (M2.0 V), Ross 905 (M2.5 V), HD 173739 (M3.0 V), Luyten's star (M3.5 V), V1352 Ori (M4.0 V), GJ 1256 (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 vB 10 (M8.0 V).

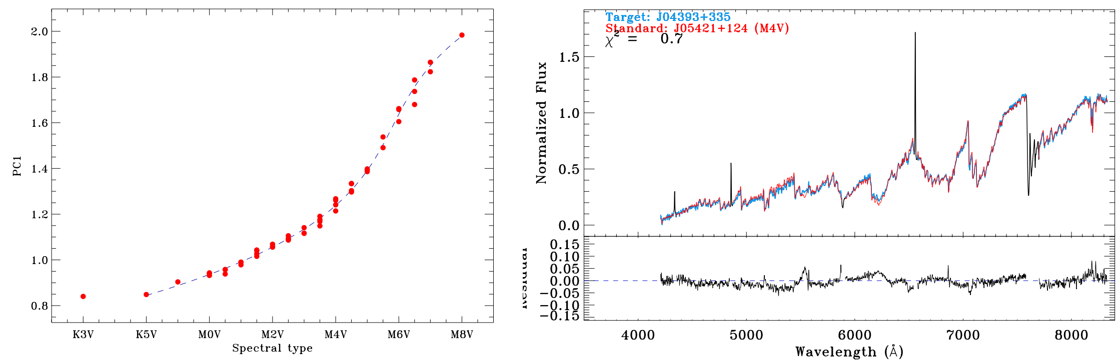

Figure 2: *Left panel:* PC1 index vs spectral type. The red dots are the standard stars and the blue-dashed line is the fitt to the PC1 index (Martín et al. 1996 [20]). *Right panel:* target J04393+335 best match obtained by means of a least-square minimization technique.

4 Spectral typing

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 [14], Reid et al. 1995 [23], Martín et al. 1996 [20]) and from best-fit and χ^2 matches (Klutsch et al. 2012 [15]).

The indices method uses the known spectral types of the standard stars fitting them to ratios of spectra features sensitives to temperature. Therefore, we obtained the target spectral type, replacing the target index measurement on the adequate adjustment. The best-fit and χ^2 method use the whole standard stars spectra as templates to compare with the target star spectra (Fig. 2). Combining these two methodologies we obtained uncertainties of only 0.5 subtypes according with comparisons with Lépine et al. (2013) [19] and PMSU (Reid et al. 1995 [23]).

5 Activity, gravity and metallicity research

We used the $pEW(\mathrm{H}\alpha)$ measurements to quantify the cromospheric activity of each object, study the influence of activity on the spectral types indices and to identify possibly accreting stars (White & Basri 2003 [26]; Barrado y Navascués & Martín [2]). We picked up unidentified giant stars with the Ratio C (Na I $\lambda\lambda$8183,8195 Å; Kirkpatrick et al. 1991 [14]; Fig. 3) and subdwarf candidates with the ζ index (Lépine et al. 2007 [16], Fig. 4). 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.).

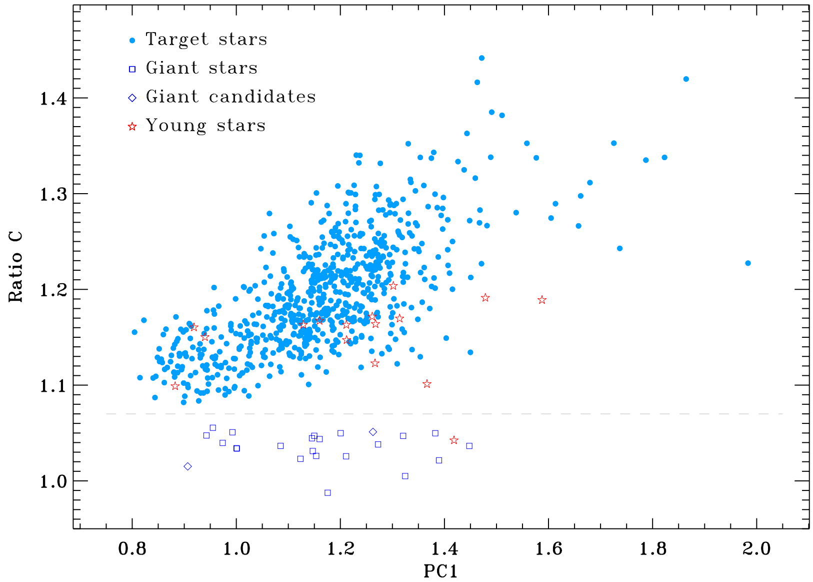

Figure 3: Ratio C vs. PC1 diagram. The PC1 index is a spectral type proxy. A T Tauri star (open red star) and all objects below the dashed line (open squares and diamonds) have very low surface gravities typical of giant stars (Ratio C < 1.07).

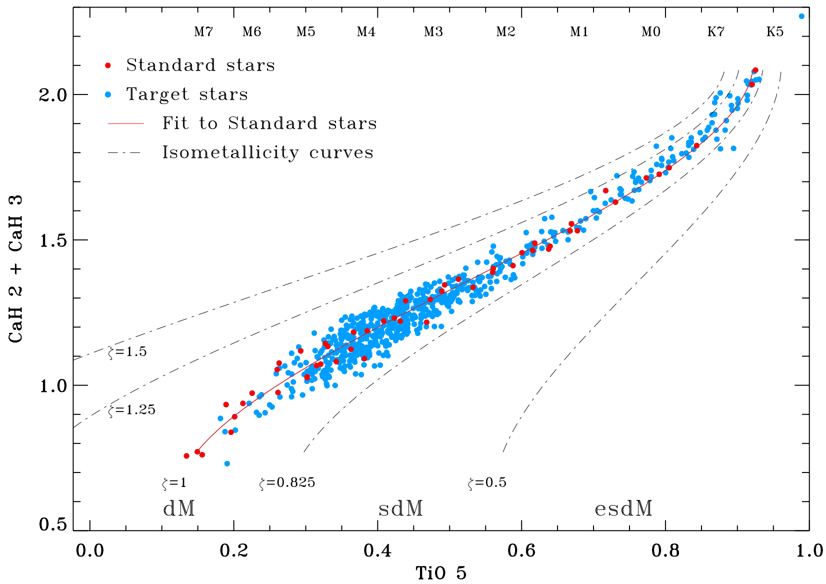

Figure 4: CaH bands vs. TiO 5 diagram. The two stars under the "isometallicity curve" ζ=0.825 are low-metallicity candidates.

Acknowledgments

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