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SPECTRAL CHARACTERISATION OF THE CARMENES INPUT CATALOGUE

A. Klutsch[1], F. J. Alonso-Floriano[1], J. A. Caballero[2], D. Montes[1], M. Cortés-Contreras[1], J. López-Santiago[1], J. C. Morales[3], A. Quirrenbach[4], P. J. Amado[5], I. Ribas[3], A. Reiners[6], R. Mundt[7] and the CARMENES Consortium

Abstract. CARMENES (Calar Alto high-Resolution search for M dwarfs with Exoearths with Near-infrared and optical Échelle Spectrographs) is the future exoplanet hunter for the 3.5-m Calar Alto telescope. Its first light is expected to be in early 2014. For a sample of 312 M-type stars, we performed their spectral-type classification by comparing their low-resolution spectra with those of spectral-type standard stars acquired during the same observing runs, and using spectral indices well-calibrated for M dwarfs, such as, TiO5, CaH2 and CaH3. We also derived chromospheric activity indicators and relative metallicities. All these data were included in our "input catalogue", CARMENCITA (CARMENES Cool star Information and daTa Archive), which will be the most comprehensive catalogue on M dwarfs ever built. This database currently comprises the over 1300 brightest, latest M dwarfs northern of δ = -23 deg. Among them, we will select carefully the 300 most promising candidates that will be surveyed for low-mass planet companions by means of the analysis of high accuracy radial velocity measurements. Our URL: `http://carmenes.caha.es/`

Keywords: stars: low-mass, stars: planetary systems, instrumentation: spectrographs, stars: fundamental parameters

1 Introduction

M dwarfs are the most common stellar population in the solar neighborhood. As their habitable zones are closer than those of F, G, and K stars, the radial-velocity signature of an Earth-like planet located in the habitable zone and the probability of showing transits are much larger. But, because of their faintness in the optical, few searches for exoplanets around M dwarfs with the radial-velocity method have been performed in comparison to Solar-like main-sequence stars. For these reasons, our consortium is building a near-infrared spectrograph with a radial velocity accuracy on the m s^{-1} level for the Calar Alto Astronomical Observatory. Such an instrument would be more efficient to detect terrestrial planets around low-mass stars. Before that, we must have chosen carefully the sample of 300 M dwarfs to which CARMENES will look for low-mass exoplanets under guaranteed time. This task implies a deep understanding of their stellar parameters.

2 Sample selection and observations

All our sources were taken from the CARMENCITA (CARMENES Cool star Information and daTa Archive) database, which results from the compilation of previous and on-going M-dwarf catalogues and surveys (e.g., Ross, Luyten, Gliese, Palomar/Michigan State University –PMSU–, Lépine & Gaidos). Caballero et al. (2012) gave an exhaustive list of information already collected for all the selected sources.

[1] Universidad Complutense de Madrid, Departamento de Astrofísica, Facultad de Ciencias Físicas, E-28040 Madrid, Spain
[2] Centro de Astrobiologia (CSIC-INTA), PO Box 78, E-28691 Villanueva de la Cañada, Madrid, Spain
[3] Institut de Ciències de l'Espai (CSIC-IEEC), Campus UAB, Facultat de Ciències, Torre C5 parell, E-08193 Bellaterra, Spain
[4] Landessternwarte Königstuhl (ZAH), Königstuhl 12, D-69117 Heidelberg, Germany
[5] Instituto de Astrofísica de Andalucía (CSIC), PO Box 3004, E-18080 Granada, Spain
[6] Institut für Astrophysik Göttingen, Physik Fakultät, Friedrich-Hund-Platz 1, D-37077 Göttingen, Germany
[7] Max Planck Institute für Astronomy, D-69117 Heidelberg, Germany

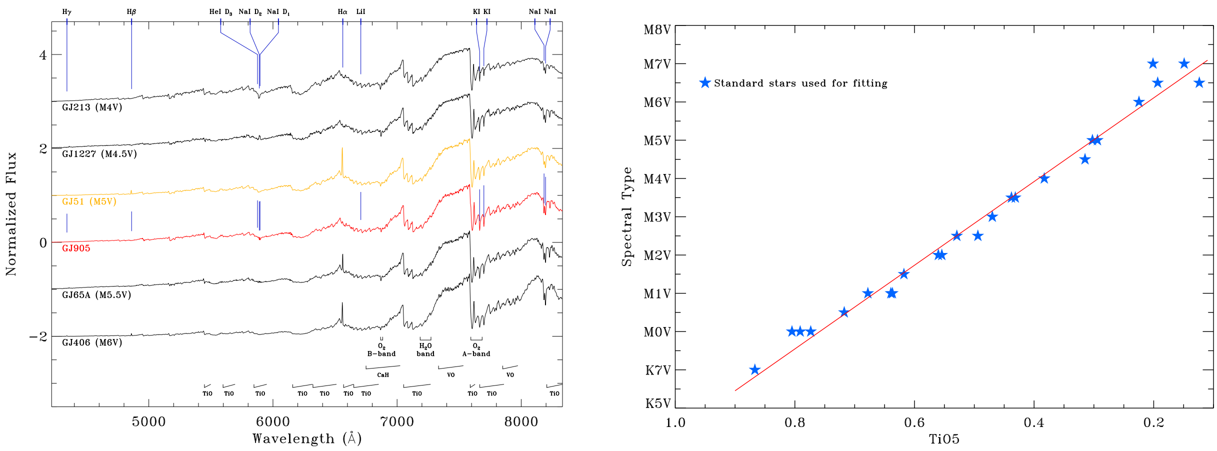


Fig. 1. Spectral type determination of our sources. **Left:** Example of least-square minimisation of an M5.0V star (GJ 905). In red, target spectrum; in orange, the best match; in black, other standard spectra. We also display the locus of molecular and telluric bands listed by Kirkpatrick et al. (1991). **Right:** Calibration of the spectral type from the TiO5 index.

From November 2011 to March 2012, we conducted an observing programme on a first sample of 312 sources. Their long-slit low-resolution spectra (spectral resolution R $\sim$ 1500) were taken with the Calar Alto Faint Object Spectrograph (CAFOS) mounted on the 2.2 m telescope of the German-Spanish Calar Alto Observatory (`http://www.caha.es/`, Almería, Spain). Another sets of sources will be observed in forthcoming CAFOS runs.

3 Spectral typing

During these observations, we also included about 50 standard stars with spectral types from K5 to M7 for both dwarf and giant classes. By comparing with the archive of M-type star spectra from the PMSU survey (Reid et al. 1995; Hawley et al. 1996), we only retained those whose spectra were the most representative of one given spectral type in order to build our own library of standard stars.

Our spectral characterisation of every target relied on the comparative analysis of the full spectral range of its normalised spectrum and of our standards. For this work, we discarded the wavelength ranges contaminated by strong telluric lines or by any activity indicators (e.g., the Balmer lines). By means of a least-square minimisation technique, we looked for best matches (see the left panel of Fig. 1)

Alonso-Floriano et al. (2012) used calibrations with the spectral indices to derive the spectral type of our stars by interpolating the relation between one given spectral index and the spectral type (e.g., the TiO5 index, see the right panel of Fig. 1). So far, we were studied the TiO1–5, CaH1–3, CaOH and Hα indices as defined by Reid et al. (1995). However more indices will come later (e.g., from Lépine et al. 2003).

Our results show that these two independent methods of classification are fairly consistent. The spectral types of the 312 targets mainly range from M2.5V to M5.0V (Fig. 2). The spectral typing of all our targets was performed with an accuracy of about ± 0.5 subtypes.

We also compared our results with those derived from both photometric and/or spectroscopic data. Most of the standard stars, which are both in PMSU catalogue and in our sample, have the same spectral type, with an accuracy of ± 0.5 subtypes. However, we found that the spectral types estimated from optical to near-infrared colours by Lépine & Gaidos (2011) are mainly 1–2 subtypes later than those derived from our spectroscopic data and over 5 subtypes for some M dwarfs (Fig. 2).

4 Chromospheric activity and metallicity

Some spectral indices are more sensitive to activity, metallicity or gravity. Alonso-Floriano et al. (2012) focused on the chromospheric activity and relative metallicity of all the observed stars.

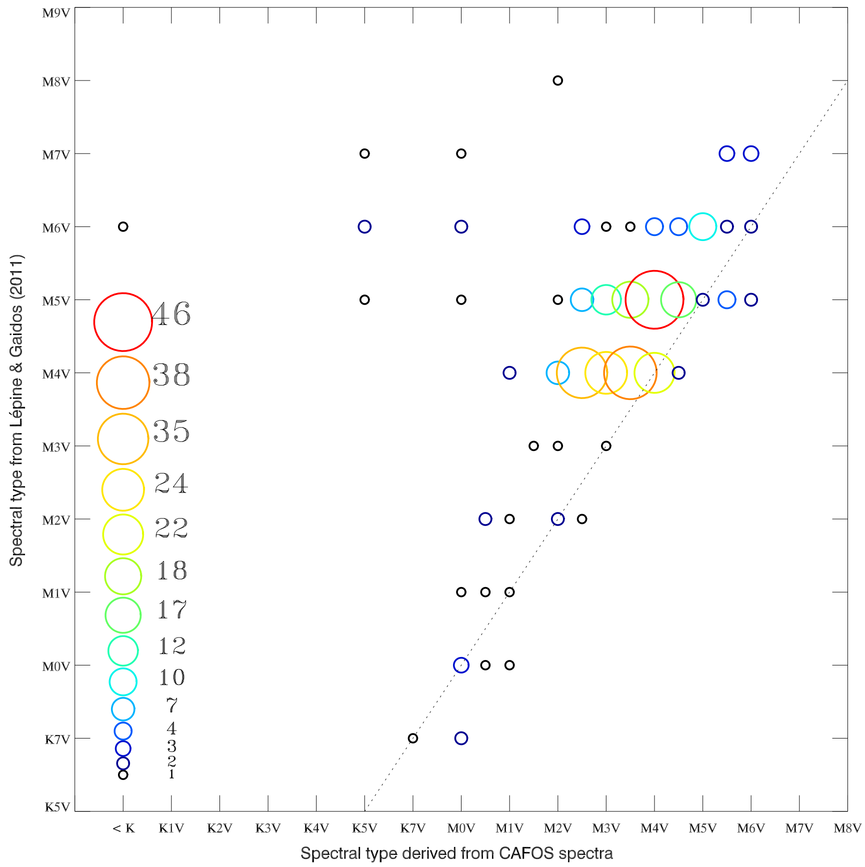


Fig. 2. Comparison between spectral types estimated by Lépine & Gaidos (2011) from photometric data and from our spectroscopic observations of stars in common. The size and colour of symbols indicate the number of sources in each bin. The dotted line shows the one-to-one relation.

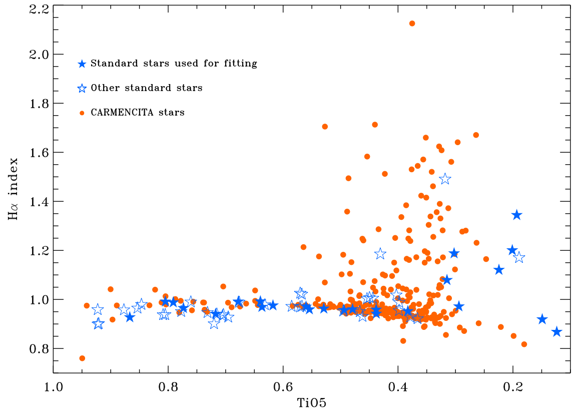
By determining the Hα index, we enabled to make a preliminary identification of chromospherically active stars in our sample. The most active stars have a spectral type between M3.0V and M5.0V (Fig. 3, left panel). A more detailed analysis of the Hα and Hβ behaviours will give us a better characterisation of their activity.

We determined relative metallicity index ζ = [1-TiO5]/[1-TiO5$_\odot$] following the method described by Lépine et al. (2007). Our fit of TiO5 index as a function of the sum of CaH2 and CaH3 indices (Fig. 3, right panel) is rather consistent with that presented recently by Lépine et al. (2012). We found a difference between these two calibrations for the latest M dwarfs only. None of our targets are classified as subdwarfs.

Montes et al. (2012) investigated some M dwarfs in wide-binary systems with FGK primaries to which we already performed abundance analysis from our high-resolution spectra using the code StePar (Tabernero et al. 2012). We showed that the relation between the TiO5 and CaH2+CaH3 indices could be calibrated using the [Fe/H] abundances of the FGK companions.

5 Conclusions

We performed the spectral-type classification of 312 M-type dwarfs by means of a least-square minimisation technique applied on the full spectral range of normalised spectra, and using spectral indices well-calibrated for M dwarfs, such as, TiO5, CaH2 and CaH3. These two methods provide the same classification with an accuracy of about ±0.5 subtypes. We also derived chromospheric activity indicators and relative metallicities. We included all these parameters, derived from our data, in the CARMENCITA database. This catalogue will be the centrepiece for choosing the 300 most promising planet candidates that will be surveyed during a five-year survey with the CARMENES spectrograph under guaranteed time (Quirrenbach et al. 2010, 2012). We expect to detect super-Earths of 5 M$_\odot$ or less, some of which may be in the habitable zone or transiting.



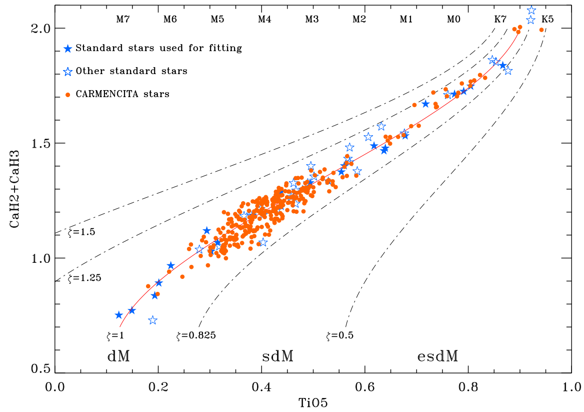


Fig. 3. Distribution of the Hα (**left panel**) and CaH2+CaH3 (**right panel**) index values as a function of the TiO5 one. On the right panel, we display the iso-ζ contours (1.5, 1.25, 1.0, 0.825, and 0.5 from top to bottom). The two last values correspond to the separators between the metallicity classes of M-type stars as defined by Lépine et al. (2007): dwarf (dM), subdwarf (sdM), and extreme subdwarf (esdM).

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