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# Kinematics of ultracool dwarfs: Membership in moving groups and associations

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**Abstract.** We present the preliminary results of a detailed study of the kinematics (Galactic space motions *UVW*) of a sample of very low-mass ultracool dwarfs (spectral type later than M6) with radial velocities and proper motions determined in the literature. For the dwarfs with *U* and *V* velocity components inside or near the boundaries that determine the young disk population as defined by Eggen, we have analyzed their possible membership in the classical moving groups with ages between 100 and 650 Myr (i.e., Castor, Ursa Major, IC 2391, Hyades) and the nearby loose associations with ages younger than the Pleiades that are associated to the Local Association (i.e., TW Hya, $\beta$ Pic, Tuc-Hor, AB Dor). For the candidate members in young stellar kinematic groups, we have compiled the information available in the literature to constraint their membership by applying other age-dating methods (lithium, low-gravity).

## 1. Introduction

Can the lithium test be applied to the youngest brown dwarfs with the latest spectral types? How do the least massive components in star-forming regions evaporate and evolve in moving groups, first, and the Galactic thin disk, next? If the estimation that around 8 % of the field L dwarfs are younger than the Pleiades is correct (e.g., Kirkpatrick et al. 2008), why there is an overabundance of such young L dwarfs with respect to young solar-like stars? Is it due to an observational bias (i.e., young L dwarfs are overluminous and, hence, less difficult to detect than old dwarfs of the same mass)?

To answer these questions and others, we need a comprehensive analysis of the kinematics of late-M, L and T dwarfs in the solar neighborhood. In the last years, some general kinematic studies have focused on the determination of mean kinematic ages of ultracool dwarfs as a single population (Faherty et al. 2009; Reiners & Basri 2009; Seifahrt et al. 2010; Schmidt et al. 2010). However, only a few studies have addressed the detailed membership in stellar kinematic groups (Zapatero Osorio et al. 2007; Bannister & Jameson 2007; Clarke et al. 2010; Gálvez-Ortiz et al. 2010). In this proceeding, we present the preliminary results of a membership study of ultracool dwarfs in young moving groups and associations.

## 2. Sample

The sample analyzed in this study comprises very low-mass ultracool dwarfs of spectral types later than M6 (including L and T) with radial velocities and proper motions determined in the literature. The main sources of radial velocity, which is the parameter that is most difficult to measure, are the following works and references therein:

- L and T dwarfs within 20 pc of the Sun (Zapatero Osorio et al. 2007, 2010).
- Volume-complete ($d < 20$ pc) sample of M7–9.5 dwarfs (Reiners & Basri 2009).
- Nearby L dwarfs (Seifahrt et al. 2010).
- Low-mass objects with spectral types in the range M7–L1 (Gálvez-Ortiz et al. 2010).
- NIRSPEC Ultracool Dwarf Radial Velocity Survey (Blake et al. 2010).
- Ultracool dwarf members of resolved close binaries and wide binaries (e.g., Caballero 2007a,b; Faherty et al. 2010). The radial velocities (and proper motions) are those of the primaries.

We have not included the sample of L dwarfs from the SDSS (Sloan Digital Sky Survey) analysed by Schmidt et al. (2010), due to the large radial velocity uncertainties (20 km s$^{-1}$) reported by these authors.

## 3. Methods

We have computed Galactic-space velocity components $UVW$ as explained in Montes et al. (2001) from the dwarf coordinates, radial velocities (taken from the references cited in Section 2), proper motions, and parallactic distances. When parallactic distances are not available, we have estimated spectro-photometric distances from the absolute magnitude–spectral type relations given by Cruz et al. (2003) for M7–L4.5 dwarfs and Burgasser (2007) for L5–T8 dwarfs (see Faherty et al. 2009).

To date, we have collected $UVW$ velocities for 186 ultracool dwarfs. The $UVW$ improvement for dwarfs without accurate measurements is on-going (Montes & Caballero, in preparation). We plot the compiled $UVW$ velocities onto $UV$ and $WV$ planes in Figs. 1 and 2.

Membership of the ultracool dwarfs in each moving group has been done taking a dispersion of $\sim$10 km s$^{-1}$ around the core velocity of each group. The Local Association region in the $UV$ and $WV$ also comprises nearby loose associations such as TW Hydrae, $\beta$ Pictoris, Tucana-Horologium, Columba, and Carina (Torres et al. 2006, 2008; Zuckerman & Song 2004; Montes 2010)[1].

Our sample includes some previously known members of moving groups and associations. Most of them are faint companions to brighter stars previously reported as being young (e.g., G 196-3 or HN Peg in the Local Association), but there are also young single late-M dwarfs (e.g., LP 944–20 in Castor or the TWA series in the TW Hydrae Association):

[1]see `http://www.ucm.es/info/Astrof/invest/actividad/skg/skg.html`

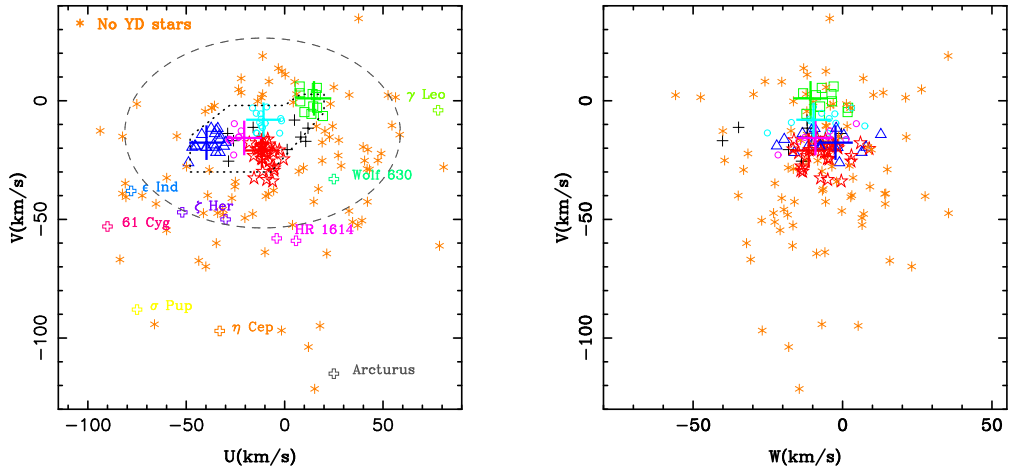


Figure 1. *UV* and *WV* planes (Böttlinger diagrams) for the complete sample of analyzed ultracool dwarfs. See Fig. 2 for the color symbol description. The central region marked with dotted lines delineates the boundaries that determine the Eggen's young disk population. The dashed line is the velocity ellipsoid determined by Francis & Anderson (2009) to identify high velocity stars. The location of the Eggen's main "old" classical moving groups are also marked in the *UV* diagram (see Montes et al. 2001; Montes 2010, and references therein).

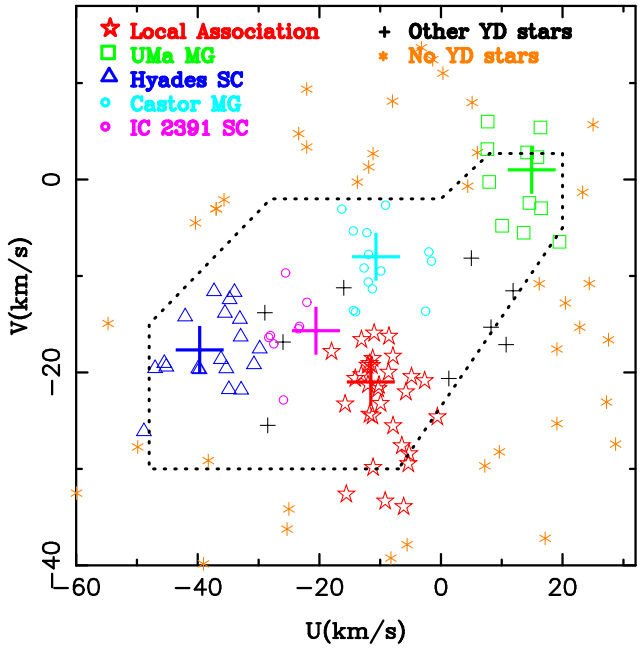


Figure 2. Zoom of the *UV* plane in the region of the young disk population (see Fig. 1), where the youngest ($\tau \leqslant 650$ Myr) and best documented moving groups in the solar vicinity are located: Hyades Supercluster, Ursa Major, Local Association, IC 2391 and Castor (see Montes et al. 2001, and references therein).

- **Local Association**: G 196-3 B, GJ 417 B, HN Peg B (in the Hercules-Lyra Association), GQ Lup B (in the Lupus association).
- **Hyades Supercluster**: DT Vir C (*aka* Ross 458 C).
- **Castor**: LP 944–20.
- **Ursa Major**: CE Boo BC (*aka* GJ 569 Ba,b).
- **IC 2391**: V457 Vul B (*aka* HD 203030 B), GJ 900 C.
- **TW Hydrae**: TWA 5B, TWA 26, TWA 27 A,b (*aka* 2M1207–39), TWA 28.[2]
- $\beta$ **Pictoris**: PZ Tel B.
- **Tucana-Horologium**: AB Pic B, CD–52 381 B (*aka* GSC 08047–00232), 2MASS J01415823–4633574.
- **AB Doradus**: HD 89744 B.

Our sample also includes some objects previously assigned to some young moving groups, such as the Hyades Supercluster and Ursa Major, based only on photometric and astrometric selection techniques, such as the convergent point method (Bannister & Jameson 2007; Clarke et al. 2010). They can be confirmed o rejected with our kinematic information (*UVW* velocities).

## 4. Preliminary results

Of the 186 ultracool dwarfs for which we have computed their Galactic velocity components *UVW*, around 50 % are inside or near the boundaries that determine the young disk population as defined by Eggen in Fig. 1. We summarize their possible membership in young moving groups in Table 1.

Table 1. Number of ultracool moving group member *candidates* in our sample.

| Moving group | *N* |
|---|---|
| Local Association[a] | 31 |
| Ursa Major | 11 |
| Hyades Supercluster | 19 |
| Castor | 14 |
| IC 2391 | 8 |
| Other Young Disk | 10 |

[a] The Local Association includes ultracool member candidates in TW Hydrae, $\beta$ Pictoris, Tucana-Horologium and AB Doradus.

Taking into account our previous results of contamination by old field stars (López-Santiago et al. 2009, 2010; Maldonado et al. 2010), about 50–70 % of the 93 ultracool

[2]TWA 29 is another M9.5 member in the TW Hydrae Association, but there is no radial velocity available.

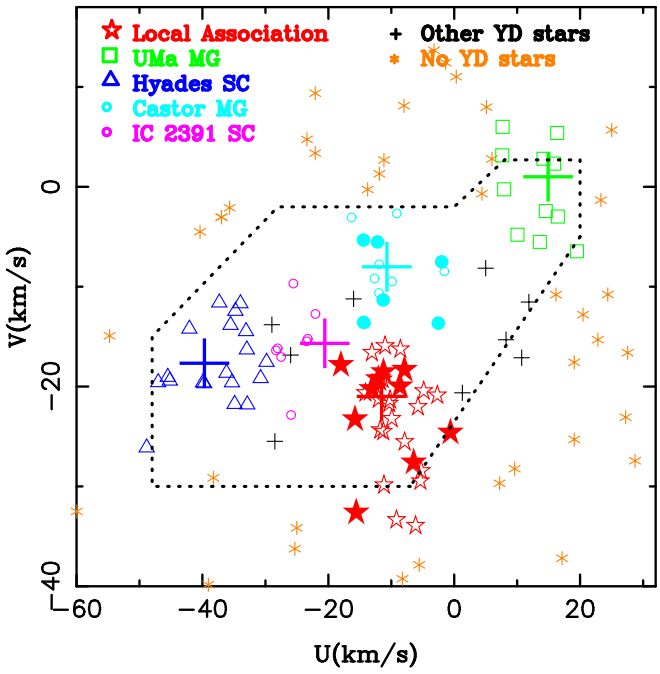


Figure 3. Same as Fig. 2 but indicating the detection of the Li ı 6708 Å line in their spectra with filled symbols.

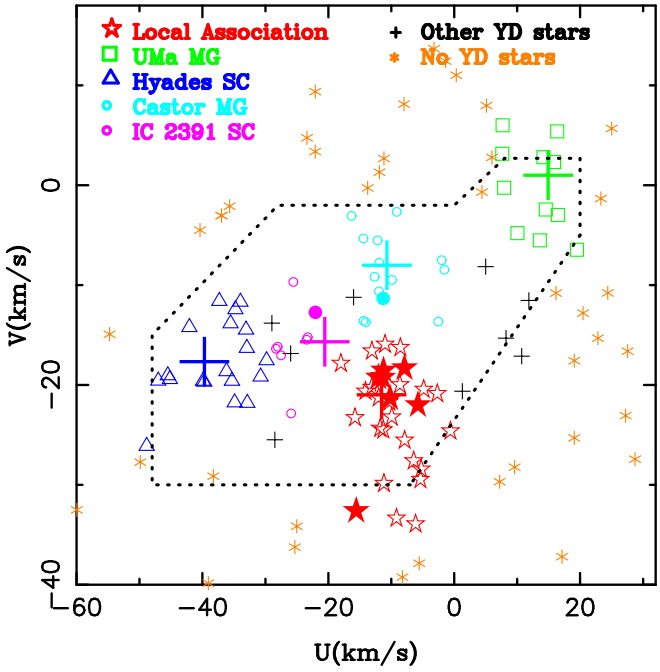


Figure 4. Same as Fig. 2 but indicating the detection of signatures of low gravity in their spectra with filled symbols (Kirkpatrick et al. 2008; Cruz et al. 2009).

dwarfs in Table 1 could be actually young. To constraint their membership in young moving groups, other age-dating methods apart from kinematics need to be applied.

In particular, we have compiled information on the strength of the lithium line and of low-gravity signatures[3] in the spectra of the 93 ultracool dwarfs with available information (see Figs. 3 and 4). The positive detection of lithium in absorption and low-gravity features in the spectra of some dwarf member candidates in IC 2391, Castor, and, especially, the Local Association, supports our classification.

We continue our analysis to ascertain the moving group membership of an enlarged sample of ultracool dwarfs with improved radial velocity, proper motion, distance, and age determinations.

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[3]We have not included here other low-gravity ultracool dwarfs due to the lack of accurate radial velocity or astrometry (Kirkpatrick et al. 2010).

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