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Kinematics of ultracool dwarfs: Membership in moving groups and associations



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Abstract

We present a detailed study of the kinematics (Galactic space motions U, V, W) of a sample of very low-mass ultracool dwarfs (spectral type later than M7) with radial velocities and proper motions determined in the literature. Spectrophotometric distances have been estimated when parallaxic distance is not available. For the stars with U and V velocity components inside or near the boundaries that determine the young disk population as defined by Eggen, we have analyzed the possible membership in the classical moving groups with ages between 10 and 600 Myr (i.e. Local Association, Castor, Ursa Majoris, IC 2391, Hyades) and the recently identified young nearby loose associations with ages younger than the Pleiades (e.g. TW Hya, β Pic, Tuc-Hor). For the candidate members in young stellar kinematic groups, we have compiled the information available in the literature in order to constraints their membership by applying other age-dating methods. We have compiled also well known ultracool dwarf members of wide binaries in order to use the well known properties of the primary to better constrain their kinematic and age.

Sample selection

The sample analyzed in this study comprises very low-mass ultracool dwarfs (UCD hereafter) (spectral type later than M7, L and T) with radial velocities and proper motions determined in the literature. The main sources from radial velocities are the following works and references therein:

- L and T dwarfs within 20 pc of the Sun (Zapatero Osorio et al., 2007, ApJ, 666, 1205; 2010, ApJ, 715, 1408)
- Volume-complete ($d < 20$ pc) sample of M7–M9.5 dwarfs (Reiners & Basri, 2010, ApJ, 705, 1416)
- Nearby L dwarfs (Seifahrt, et al., 2010, A&A, 512, A37)
- Low-mass objects with spectral types in the range M4.5–L1 (Galvez-Ortiz, et al. 2010, arXiv:1007.3128)
- NIRSPEC Ultracool Dwarf Radial Velocity Survey (Blake et al., 2010, arXiv:1008.3874)

Some additional UCD members of resolved close binaries and wide binaries have been included taken the parameters from the well known primaries (see Faherty et al., 2010, AJ, 139, 176).

Methods

We have computed **Galactocentric space velocities UVW** derived from star coordinates, radial velocities (from the references cited in the sample selection section), proper motions, and parallaxic distances (when available). For the stars with not parallax spectrophotometric distances have been estimated using the absolute magnitude / spectral type relation given by Cruz et al. (2003, AJ, 126, 2421) for M7–L4.5 dwarfs and Burgasser (2007, ApJ, 659, 655) for L5–T8 dwarfs (see also Faherty et al., 2009, AJ, 137, 1).

To date, we have collected **UVW velocities for 186 UCD**. The UVW derivation for additional UCD with not accurate parameters available in the literature is on-going. We plot the compiled UVW velocities onto **UV and WV planes** [Böttlinger diagrams in Fig. 1 and a zoom of UV plane in Fig. 2].

Galactic velocity components U, V, W

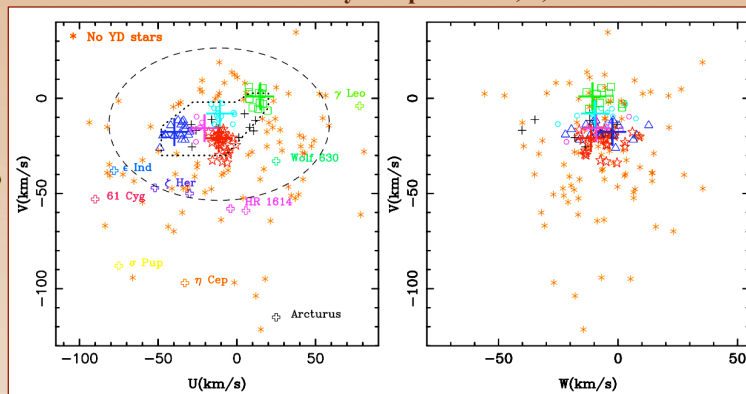
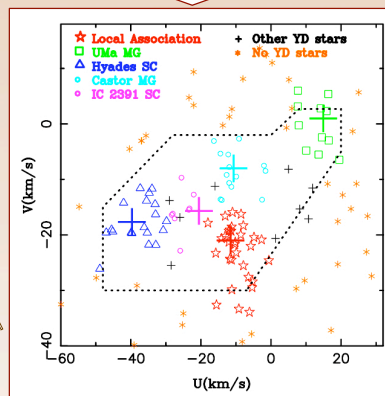


Fig. 1: UV and WV planes (Böttlinger diagrams) for the complete sample of UCD analyzed. The central region marked with dotted line delimit the boundaries that determine the young disk population as defined by Eggen (see Montes et al. 2001, MNRAS, 328, 45 and Fig. 2). The dashed line is the velocity ellipsoid determined by Francis & Anderson 2009, NewA, 14, 615 to eliminated high velocity stars. The location of the main old classical moving groups defined by Eggen are also marked in the UV diagram.

The sample include some previously known members of some moving groups and associations:

- LA: HN Peg B, Gl 417 B, G196-3 B
- Hyades SC: Ross 458C (ULAS J1300+12)
- Castor: LP 944-20
- UMa: Gl 569A BaBb (CE Boo)
- IC 2391: HD 203030 B, GJ 900 C
- TW Hya association: TWA 26 (2MASS J1139-31), TWA 27 A&B (2MASS J1207-39), TWA 28 (SSSPM J1102-34), TWA 5B (2MASS J1131-34), TWA 29 (DENIS J1245-44) is another UCD member but not included here because it has not radial velocity available
- β Pic: PZ Tel
- Tuc-Hor: AB Pic, GSC08047-00, 2MASS J0141-46.
- AB Dor: HD 89744B

Fig. 2: Zoom of the UV plane in the region of the young disk population (see Fig. 1) where the youngest (age < 800 Myr) and best documented moving groups (MG) in the solar vicinity are located: Hyades SC, Ursa Major (UMa), Local Association (LA), IC 2391 and Castor (see Montes et al. 2001, MNRAS, 328, 45 and references therein). The membership of the UCD in each MG has been done taking a dispersion of ≈ 10 km/s around the core velocity of each group. The region of the LA comprises also the nearby loose associations (TW Hya, β Pic, Tuc-Hor, Col. Car, Torres et al., 2008 hsf2.book.757; Zuckerman & Song 2004, ARA&A, Vol. 42, 685).



The sample include also some object previously assigned to some moving groups like the Hyades and Ursa Major moving groups based only photometric and astrometric selection techniques. (convergent point method) Bannister & Jameson (2007, MNRAS, 378, L24) Clarke et al. (2010, MNRAS, 402, 575) that can be confirmed or reject with kinematic (UVW velocities) information.

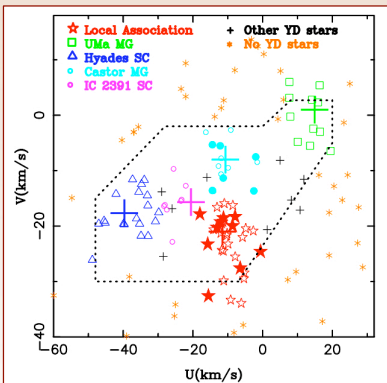


Fig. 3: Objects with the LiII 6708 Å line detected in their spectra (indicative of young brown dwarfs) are marked with filled symbols. Note their UV location are in the region of the LA and the Castor MGs.

Preliminary results

We have computed Galactic velocity components U, V, W for a sample of **186 ultracool dwarfs**. Around 50% of the stars are classified as young disk (inside the boundaries that determine the young disk population as defined by Eggen, see Fig. 1). For these objects we have obtain the following membership in the youngest moving groups:

- Local Association: 31
- Ursa Major: 11
- Hyades SC: 19
- Castor: 14
- IC 2391: 8

In order to constraints their membership other age-dating methods need to be applied, but taken into account our previous results of contamination by old filed stars (Lopez-Santiago et al. 2009, A&A, 499, 129) around a 50-70% could be true members. In addition, indicators of age like the lithium and low gravity signatures in the spectra are compatible with membership of the young moving groups (see Figs. 3 & 4).

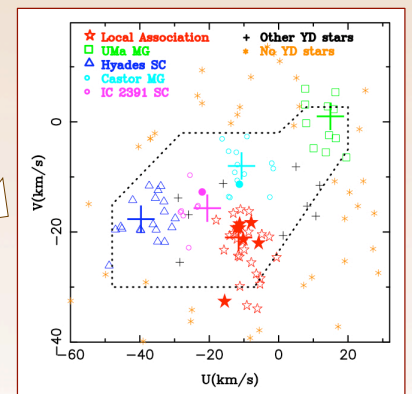


Fig. 4: Objects with spectroscopic signatures of low gravity (youth) in their spectra are marked with filled symbols (Kirkpatrick et al. 2008, ApJ, 689, 1295; Cruz et al. 2009, AJ, 137, 3345). Other low gravity object are not included here due to le lack of accurate radial velocity or astrometry (see Kirkpatrick et al. 2010, arXiv:1008.3591).



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