Brown Dwarf Kinematics Project (BDKP)

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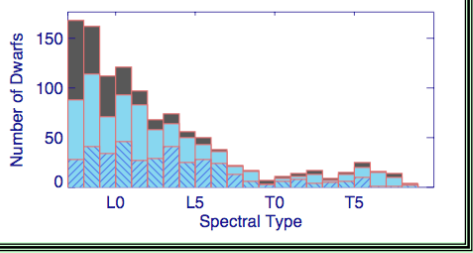
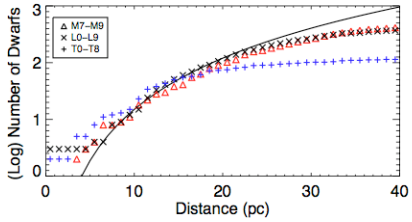
ABSTRACT: We report proper motion measurements for 427 late-type M, L and T dwarfs, 332 of which have been measured for the first time. Combining these new proper motions with previously published measurements yields a sample of 841 M7-T8 dwarfs. We combined parallax measurements or calculated spectrophotometric distances and computed tangential velocities for the entire sample. We find that kinematics for the full and volume-limited 20 pc samples are consistent with those expected for the Galactic thin disk, with no significant differences between late-type M, L, and T dwarfs. Applying an age-velocity relation we conclude that the average kinematic age of the 20 pc sample of ultracool dwarfs (UCDs) is older than recent kinematic estimates and more consistent with age results calculated with population synthesis models. There is a statistically distinct population of high tangential velocity sources V_{tan} > 100 km/s whose kinematics suggest an even older population of ultracool dwarfs belonging to either the Galactic thick disk or halo. We isolate subsets of the entire sample, including low surface-gravity dwarfs, unusually blue L dwarfs, and photometric outliers in J-K_s color and investigate their kinematics. We find that the spectroscopically distinct class of unusually blue L dwarfs has kinematics clearly consistent with old age, implying that high surface-gravity and/or low metallicity may be relevant to their spectral properties. The low surface-gravity dwarfs are kinematically younger than the overall population, and the kinematics of the red and blue ultracool dwarfs suggest ages that are younger and older than the full sample, respectively. We also present a reduced proper motion diagram at 2MASS K_s for the entire population and find that a limit of H_{Ks} > 18 excludes M dwarfs from the L and T dwarf population regardless of near-infrared color, potentially enabling the identification of the coldest brown dwarfs in the absence of color information.

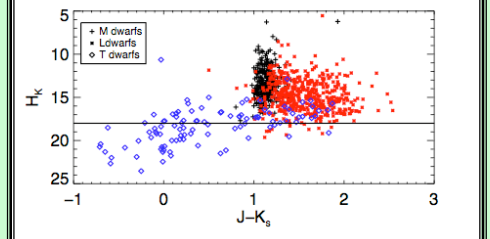
KINEMATIC CHARACTERISTICS OF THE ULTRACOOL DWARFS



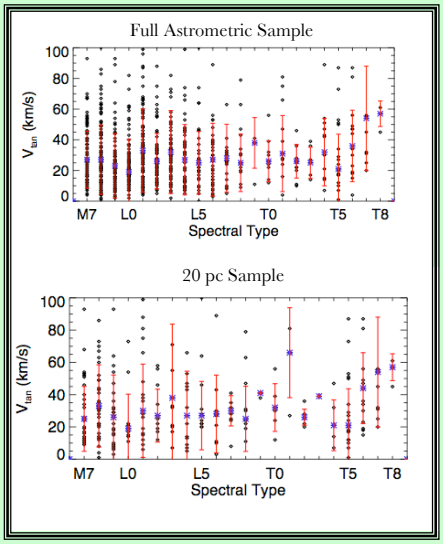
The overall histogram is the distribution of all UCDs in our sample. The blue shaded histogram shows UCDs with proper motion measurements. The diagonally shaded histogram shows the distribution of UCDs whose proper motion we measured.

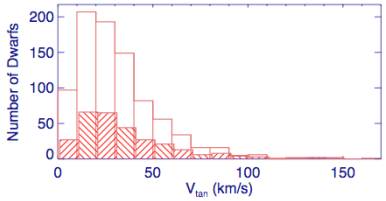


Cumulative distance distribution of all UCDs in our database. Triangles refer to the M7-M9 dwarfs, the 'X' symbols refer to all L0-L9 dwarfs and the plus symbols refer to all T0-T8 dwarfs. The solid line corresponds to a constant density distribution (N ~ d^3). The L and M dwarfs deviate from this distribution around 20 pc but the T dwarfs fall off closer to 15 pc.



Reduced proper motion diagram using the 2MASS J and K_s magnitudes. Late-type M dwarfs are marked with a black plus sign, L dwarfs are marked as a red 5 point star and T dwarfs are marked as blue diamonds. The line at H_{Ks} of 18 marks where M dwarfs are segregated from the L and T dwarfs regardless of near-IR color. This cut-off will also include subdwarfs and cool white dwarfs but these objects will be rare.





V_{tan} DISTRIBUTION

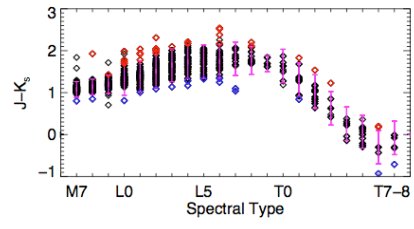
Far Left: The two plots represent the Vtan distribution for the full astrometric sample and the 20 pc sample. The asterisks mark the median Vtan values and the red vertical bars mark the dispersions. We find no significant difference between spectral types or between samples.

Left: The distribution of Vtan for all UCDs (large histogram full sample, shaded histogram 20 pc sample). There are 14 objects with Vtan > 100 km/s that may comprise a different population.

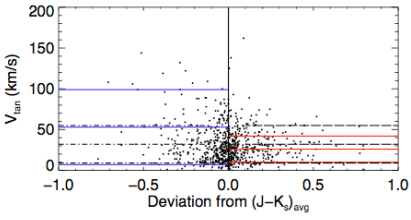
SpT	N	N High V_{tan}	median V_{tan} (km/s)	median V_{tan} with high V_{tan} (km/s)	σ_{tan} (km/s)	σ_{tan} with high V_{tan} (km/s)	Age (Gyr)	Age with high V_{tan} (Gyr)
M7-M9	93	2	29	29	21	24	$3.0^{+1.0}_{-0.8}$	$5.0^{+1.7}_{-1.4}$
L0-L9	114	5	27	27	21	26	$3.2^{-0.8}_{+1.1}$	$6.6^{+2.2}_{-1.8}$
T0-T9	70	1	30	31	20	24	$2.8^{+1.0}_{-0.8}$	$4.6^{+1.6}_{-1.3}$

Left: Table of Kinematic data for the 20 pc sample. The ages are consistent with ages generated from population synthesis models (3-6 Gyr) and the kinematics are consistent with those of objects in the Galactic thin disk.

OUTLIER SUBGROUPS



SpT	N	Median V_{tan} km s^{-1}	σ_{tan} km s^{-1}	Age Range Gyr
(1)	(2)	(3)	(4)	(5)
M7-T9/BLUE	16	53	47	$37.9^{+12.6}_{-10.3}$
M7-T9/RED	29	26	16	$1.2^{+0.3}_{-0.4}$
M7-L9/BLUE	13	56	50	$46.0^{+15.2}_{-12.4}$
M7-L9/RED	24	26	15	$1.0^{+0.4}_{-0.3}$
UBLs	10	99	47	$37.9^{+12.6}_{-10.3}$
Low Gravity	37	18	15	$1.0^{+0.4}_{-0.3}$



We compute the average values for each spectral type (binned by 1 subtype) from the 2MASS photometry of a select sample of UCDs and then flag objects as photometric outliers when they are either twice the standard deviation of J -K_s or 0.4 magnitude redder or bluer than the average value. Red diamonds mark red outliers and blue diamonds mark blue outliers.

A scatter plot showing V_{tan} as a function of the deviation in J-K_s color from the average at a given spectral type. The blue outliers appear to move faster on average than the red outliers. To demonstrate this we have over-plotted the average V_{tan} with dispersion for the blue and red photometric outliers as well as for the full astrometric sample (dashed lines).