Kinematic Characterization of Nearby K Dwarfs

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ABSTRACT

We report systemic and UVW space velocities for 287 K dwarf systems for which we have acquired spectra (R=80,000) using the CHIRON high-resolution echelle spectrometer on the SMARTS 1.5m telescope at CTIO. These stars are compared to our benchmark set of 35 systems in known moving groups by using their measured gamma velocity (GV) and Gaia astrometry to determine UVW space motions through the Galaxy. The observed stars are part of a large RECONS (REsearch Consortium On Nearby Stars, http://www.recons.org) effort to explore over 1,200 of the nearest K dwarfs, all within 50 pc.

The sample described here consists of systems within 25 pc of the Sun that lie in the equatorial region of the celestial sphere, between declinations +30 and -30 degrees. Our GVs ranged from −133 km/s to +176 km/s. Ultimately, our study aims to use diagnostics of age, activity, and kinematics, along with spectroscopically-derived stellar properties to identify the best K dwarfs for habitable planetary companions.

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INTRODUCTION
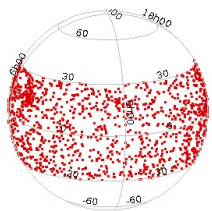
Our sample pictured above (left) is volume-complete and comprised of 287 systems in which K dwarfs are the primary component. These stars are within a distance of 25 pc and have -30 to +30 DEC, the latter allowing us to observe from all major observatories in both hemispheres.

We obtain spectra using the CHIRON spectrograph at the CTIO/SMARTS 1.5m shown above (right).

In comparison to the Sun, K dwarfs are slightly less luminous and massive. Additionally, they typically exhibit low variation in intensity and makeup ~12% of the Milky Way's stellar population, making them the second most abundant type after M dwarfs. It follows that K dwarfs are the ideal candidates for having habitable planetary companions and would be excellent for systematic exoplanet surveys.

An effort as in-depth as this has yet to be completed and as part of our mission statement, we seek to provide key statistics on the rate of formation of the different types of companions that may be present.

SPECTROSCOPY
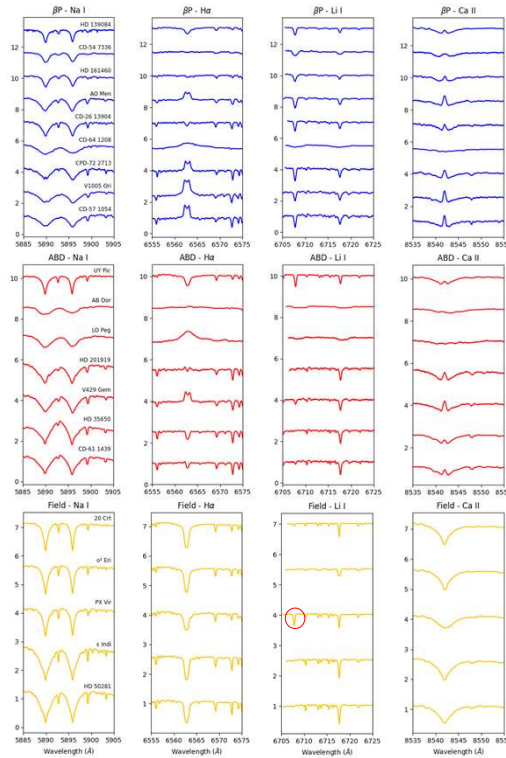
Above are spectra of 21 stars chosen from our benchmark sample[1] of 42 K dwarfs in the Beta Pictoris (βP, blue) moving group, Tucana-Horologium association, AB Doradus (ABD, red) moving group, and Hyades cluster, as well as a group of five field stars (Field, yellow) and seven stars with variable GVs.

For our program, we select spectral features produced by the following Na I at 5890/5896 Å, H-alpha at 6563 Å, Li I at 6708 Å, Ca II at 8542 Å

Much can be revealed from a system's spectral signatures:
- Rapid rotation indicates youth --- CD-54 7336 (βP) and CD-64 1208 (βP)
- H-alpha emission indicates high activity --- V1005 Ori (βP) and V429 Gem (ABD)
- Lithium indicates youth --- AO Men (βP), UY Pic (ABD) and PX Vir (Field)

We use these diagnostic lines to evaluate stellar age and activity. Because there is a connection between the two parameters, understanding them is key to investigating habitability. Younger stars tend to be more active, creating a hostile environment.

DYNAMICS: SYSTEMIC & GALACTIC MOTIONS
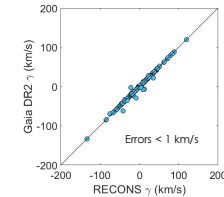
From the spectrum we determine the GV, the radial velocity of the system. The GV gives information on youth and/or multiplicity. The above figure is a 1-to-1 plot showing the GVs of the sample, where Gaia DR2 values are used as a reference.
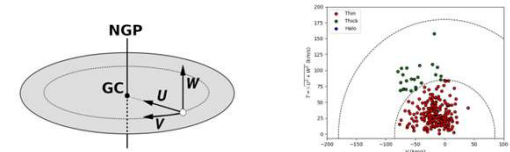
Galactic space velocities (UVW) (left) may be computed from astrometric information and the GV. Stars formed together are expected to move together through space. However, as they age, they can separate from their associations due to both internal and external interactions. Thus, analyzing the UVWs of a given star might indicate whether that star is tied to a known moving group.

We assign each system to a region in the Galaxy using a Toomre diagram (right), allowing us to determine population membership. The dotted curves show the approximate regional transitions[2]. There are 24 systems (green) defined to be located in the thick disk and the remaining stars (red) reside in the thin disk. We find mean metallicities of -0.089 dex and -0.233 dex for members of the thin and thick disk, respectively.

CONCLUSIONS & FUTURE WORK

SAMPLE	# ★	OBS	GV	UVW
25 pc	287	✓	✓	✓
33 pc	687	✓	Nearly Done	Nearly Done
40 pc	1217	✓		
50 pc	2474			

- 287 K dwarfs within 25 pc in an equatorial sample observed with high-resolution spectrograph CHIRON
- Systemic radial velocities and UVW Galactic space motions computed
- 92% of K dwarfs have UVW consistent with membership in the thin disk of the Milky Way; 8% are likely members of the thick disk
- In the solar neighborhood, thin disk K dwarfs are more metal rich than those in the thick disk
- Observations have been secured for another 931 stars within 40 pc, increasing the sample by more than a factor of three

RECONS will provide a list of the nearest, oldest, most habitable K dwarfs.

REFERENCES & ACKNOWLEDGMENT

[1] Hodari-Sadiki Hubbard-James et al 2022 AJ 164 174
[2] Fuhrmann K., 2000, unpublished
Background: https://images.nasa.gov/details-NHQ202108100009