Identifying Young and Active Stars Among the Nearest 1600 K Dwarfs within 40 pc with the CHIRON Spectrograph

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1. Characterizing the nearby K dwarfs by RECONS

Introduction

Chromospheric activity levels can reveal young, mature, active, and inactive stars. The RKSTAR (RECONS K Stars) Survey is surveying the chromospheric activity and youth of the nearest K dwarfs. Here we investigated the four spectral features in three spectral lines found in K dwarf spectra: Hα (6562.8 Å) and Ca II IRT (second line at 8542 Å) for activity, and Li I (6707.8 Å) to find young and active K dwarfs in the Solar Neighborhood.
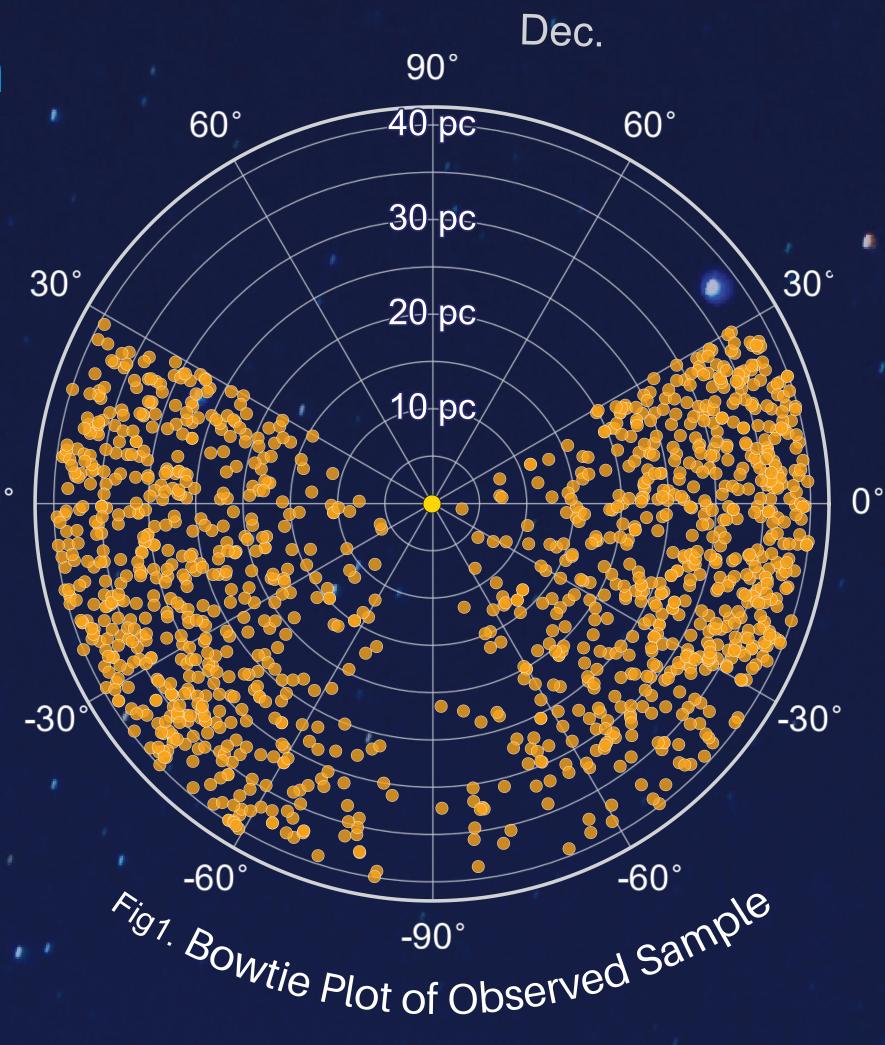
2. Nearest RKSTARs within 40 Parsecs

Sample

- 1294 out of 1597 K dwarfs within 40 pc, with declinations southern that 30°, from RKSTAR Catalog (Johns et al. in prep).

- Spectra taken with the CHIRON spectrograph at the CTIO/SMARTS 1.5m telescope, with R=80,000 in slicer mode (Tokovinin et al. 2013).

Fig 1. Bowtie Plot of Observed Sample

3. Spectral Assembly, SNR and Equivalent Widths

Methodology

1. Select the best RKSTAR spectra
2. Deblaze spectra
3. Barycenter and Radial Velocity Corrections
4. SNR calculation per order
5. Equivalent Width (EW) and error measurements by numeric integration over spectral window*
   the EW Fe I (6707.4 Å)
   (Hubbar-James, PhD thesis 2023)
6. Analysis

Hα (6562.8 Å) | Li I (6707.8 Å) | Ca II IRT (8542 Å) / core emission

HIP 52462 - K1V — RKS1043-2903: young / MG = 5.82 / d = 21.51 pc
HIP 118008 - K3V — RKS1750-6729: mature / MG = 6.09 / d = 38.19 pc
HIP 118008 - K3V — RKS2356-3903: young / MG = 6.23 / d = 21.95 pc
V* AO Men - K4V — RKS0618-7202: young_active / MG = 6.31 / d = 39.11 pc
CD-40 4615 - K8V — RKS0847-4047: active / MG = 7.59 / d = 36.77 pc

Fig 2. Compilation of five K dwarf spectra showing the output of the spectral assembly that will be used for stars in the RKSTAR Survey (Henry et al. 2021) .Features from left to right: Hα , Li I , Ca II IRT$_{8542}$. Shaded regions are the windows used to calculate EWs. Common known names are shown in orange. Spectra are sorted by absolute G magnitudes (MG) as proxy of spectral type (K0V-M0V: 5.5 < MG < 8.1).
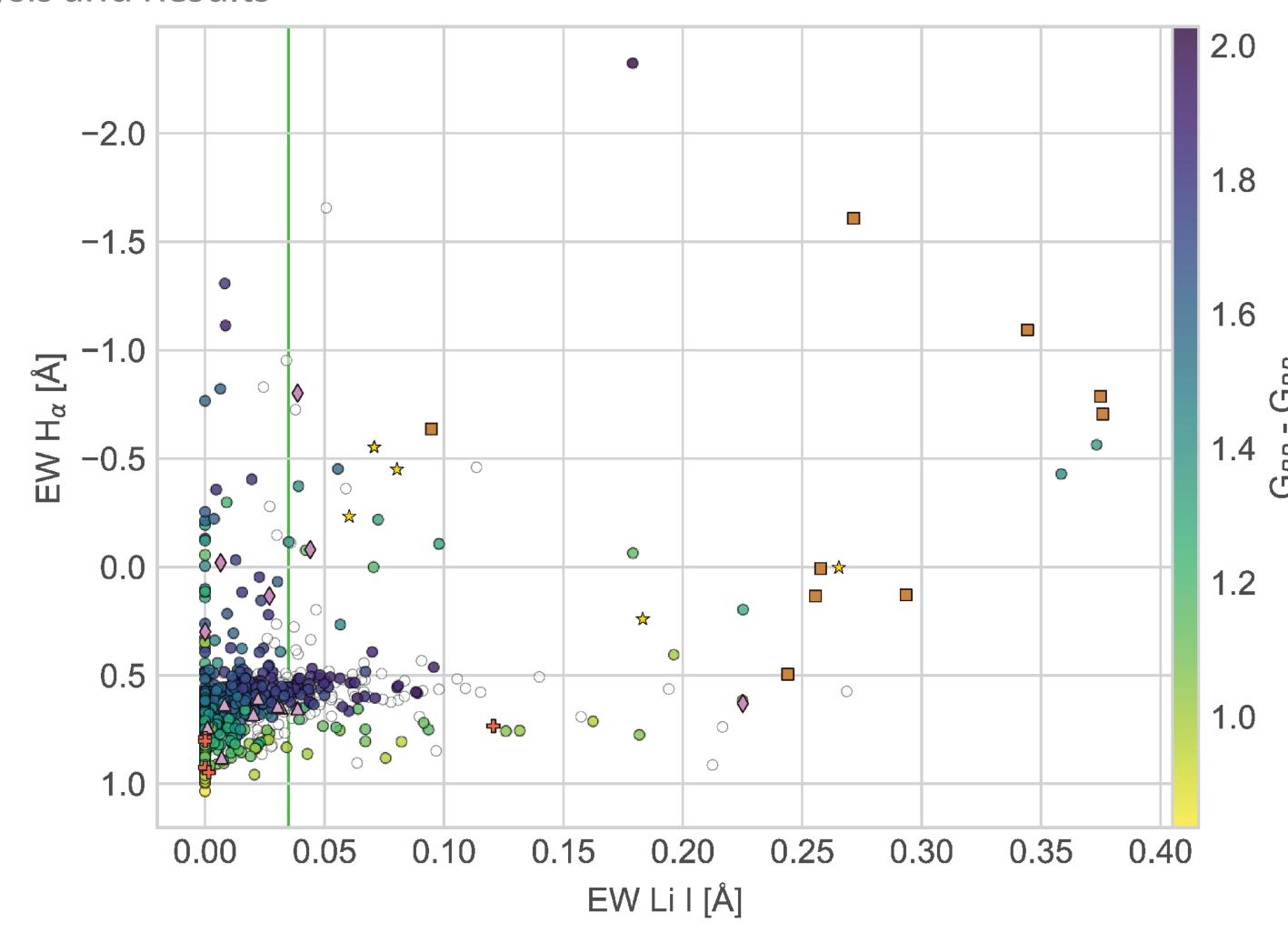
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- Henry, T., Casetti-Dinescu, D., Horch, E., et al. (2022). Bulletin of the AAS, 54(6)
- Hubbard-James, H.-S., Lesley, D. X., Henry, T. J., et al. 2022, AJ, 164, 174.
- Paredes, L. A., Henry, T. J., Quinn, S. N., et al. 2021, AJ, 162, 176.
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Background: CTIO/NOIRLab/NSF/AURA/P. Marenfeld

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4. EWs and Active/Young Status Criteria

Analysis and Results

- RKSTAR
- β Pic: 24 ± 3 Myr
- Tuc Hor: 45 ± 4 Myr
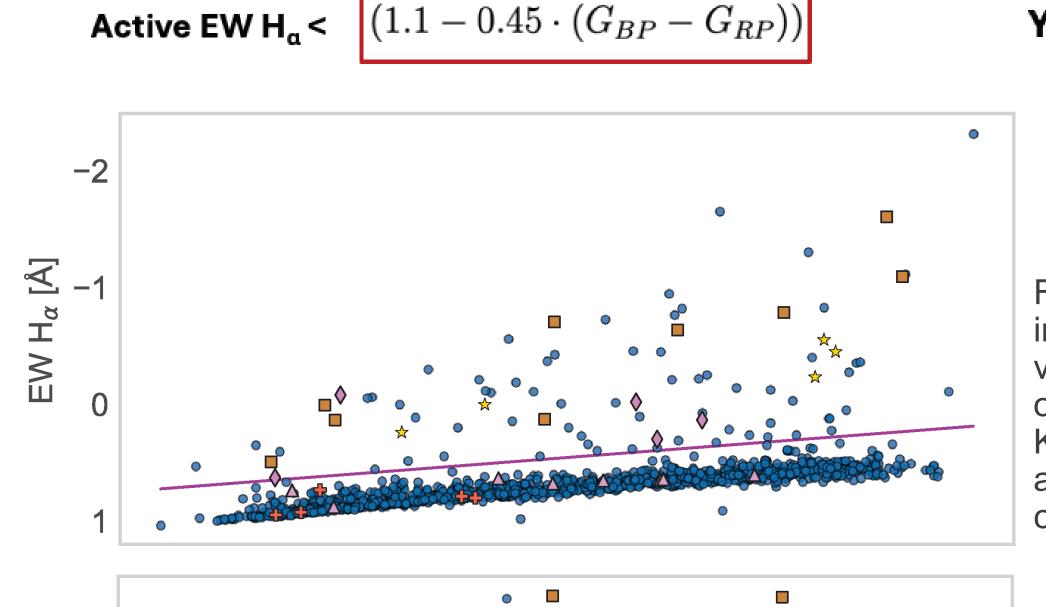- AB Dor: 145 ± $^{50}_{19}$ Myr
- Hyades: 750 ± 100 Myr
- Field K dwarf: 0.3–5.7 Gyr
- SNR at Li < 30

Fig 3. Compilation of the measured EWs for the Hα and Li I lines in our sample and benchmark K dwarfs with known ages (Hubbard-James et al. 2022). Circles in white represent EW measurements with SNR at Li < 30. Stars with known ages are shown in markers other than circles. The vertical green line represents the proposed limit of EW Li I for a K dwarf to be classified as young (see below).

Chromospheric Activity by Hα and Ca II IRT$_{8542}$ and Youth by Li I Depletion

We report a Hα "quiescent" activity level for K dwarfs determinations via Hα along, with the support of Ca II IRT core emission, to make the final call on chromospheric activity, and a lower EW Li I limit in which a K dwarf show signals of youth:

Active EW Hα < $(1.1 - 0.45 \cdot (G_{BP} - G_{RP}))$

Youth EW Li I > 35 mÅ (0.035 Å)

Fig 4. Hα Quiecent Activity Level. EW Hα in emission is given with negative values. The magenta line represents our proposed quiescent activity level for K dwarfs. Benchmark star with known ages represented by markers other than circles.
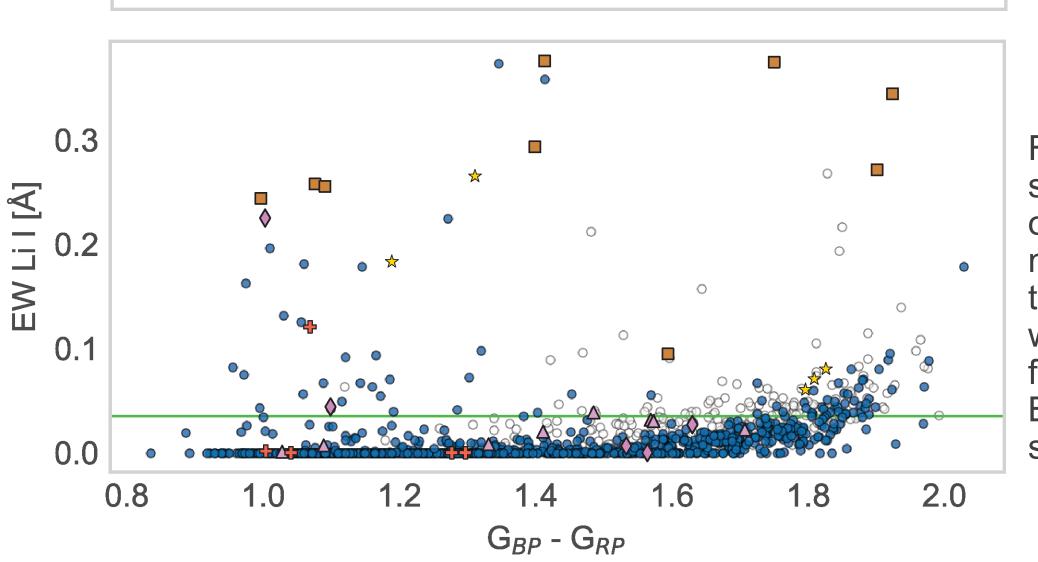
Fig 5. EW Li I of studied sample and strenght signal of Youth. A SNR at Li I order > 30 is required to have a reliable measure of EW LI I.We visually explored the spectra close to the region with stars with known ages to get a cutoff to definine a K dwarf as young (green line). Benchmark star with known ages represented by markers other than circles.

Conditions for classification:

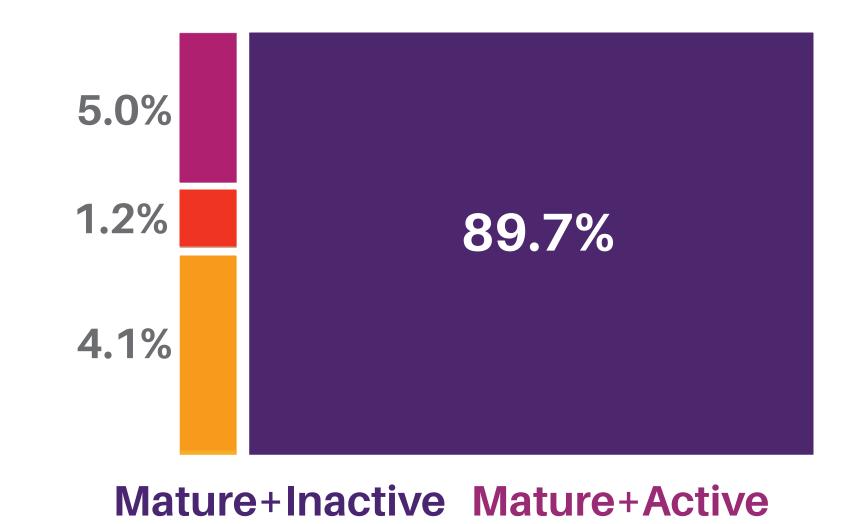| Status	SNR Li I < 30		SNR Li I > 30	
	A. Hα	Y. Li I	A. Hα	Y. Li I
Young + Calm	✖	✖	✖	🟢
Mature + Active	🟢	✖	🟢	✖
Young + Active	🟢	◯	🟢	🟢
Mature + Calm	✖	✖	✖	✖

◯ : Visual Inspection Required

5. Young, Active, Mature, and Inactive K dwarfs

Conclusions

With a 79.2% observed volume-complete sample:

- 10.3% of nearest K dwarf to the Sun are either young or chromospherically active, which are probably good targets to search for young planets.

- 89.7% of K dwarfs are both mature and chromospherically calm which could offer more stable environments for life than the young/active stars.
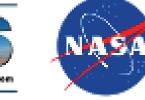

5.0%
1.2%
4.1%
89.7%

Mature+Inactive   Mature+Active
Young+Active   Young+Inactive

RECONS Research Consortium on Nearby Stars | Georgia State University | SMARTS Small and Moderate Aperture Research Telescope System | NASA | NOIRLab | CERRO TOLOLO Inter-American Observatory