Discovering New Stellar, Brown Dwarf, and Planetary Companions Orbiting 472 of the Nearest K Dwarfs

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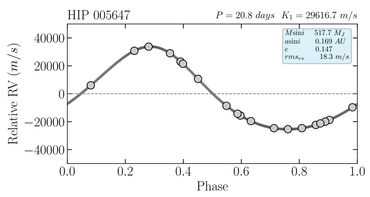
K-KIDS project is a comprehensive study of the multiplicity of a volume-complete sample of ~5000 K dwarfs within 50 pc. K-KIDS aims to search for stellar, substellar, and planetary companions using three observational techniques to cover separations from 10 000 AU to 0.1 AU. In this work, **we present the results of our companion search for 472 K dwarfs using the radial velocity (RV) technique**. Now in the third year of the survey using the CHIRON Spectrograph at the CTIO/SMARTS 1.5m, **we have achieved precisions down to 7 m/s** for K dwarfs with V magnitudes between 7.0-11.5. Of the 472 K dwarfs within 33 pc and between DEC +30° and -30°, a sample of **300 K dwarfs did not have high precision RV measurements before**, and are now the first portion of our volume-complete survey. Among the 300 stars **we have found 63 RV perturbations consistent with companions never detected before**, of which 28 are stellar nature, 7 are likely brown dwarfs, and 28 are likely planet candidates. Combining these results with known companions, we present here a detailed portrait of K dwarf systems and their orbital architectures. Ultimately, by using a careful defined sample, a multi-technique systematic search, and the combination of previous studies, the K-KIDS project will provide key insights for understanding star and planet formation processes for decades to come.

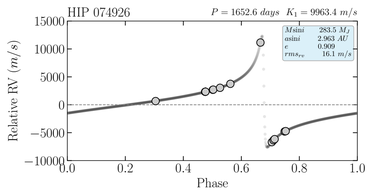
The Radial Velocity Survey

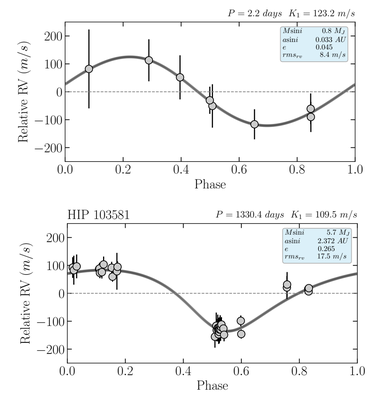
- 300 K dwarfs are monitored with multiple observations using CHIRON high resolution spectrograph
- The observing strategy is to complete at least 9 observations separated by few days, a month and a year
- **273 K dwarfs (91%) are fully covered to date**, and 27 (9%) need their one-year apart observations
- Follow-up observations are added when we detect changes on the RV of the star and solve for an orbit
- We have developed a custom pipeline to efficiently extract RVs from thousands of CHIRON spectra

New Orbits Found!

- Now after **2.5 years surveying 300 stars** we have solved **31 orbits** of stellar, sub-stellar and planetary companions.
  - Periods ranging from ~2 days up to ~10 years.
  - Minimum masses from 0.6 M_J to 0.8 M_S.
  - Semi-major axis from 0.03 to 8.2 AU.

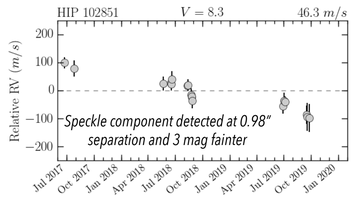






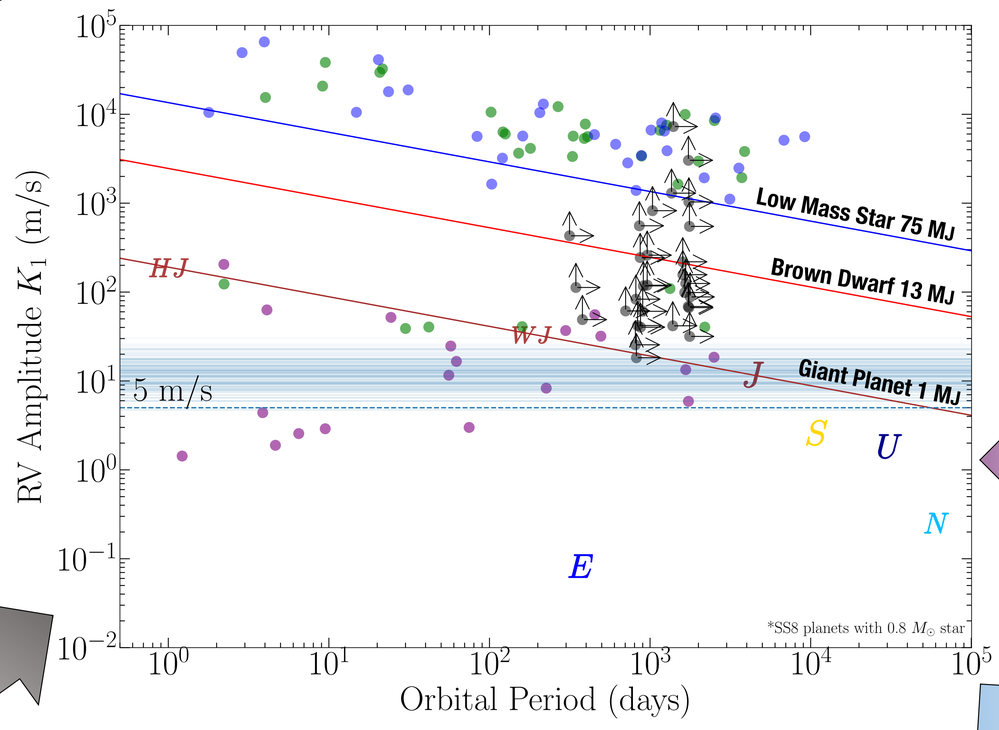
RV trends and Speckle

- On RV curves that only exhibit a steady constant change in velocity, Keplerian orbits are unlikely to fit. Therefore, we can only estimate a **minimum period and a minimum RV amplitude**.

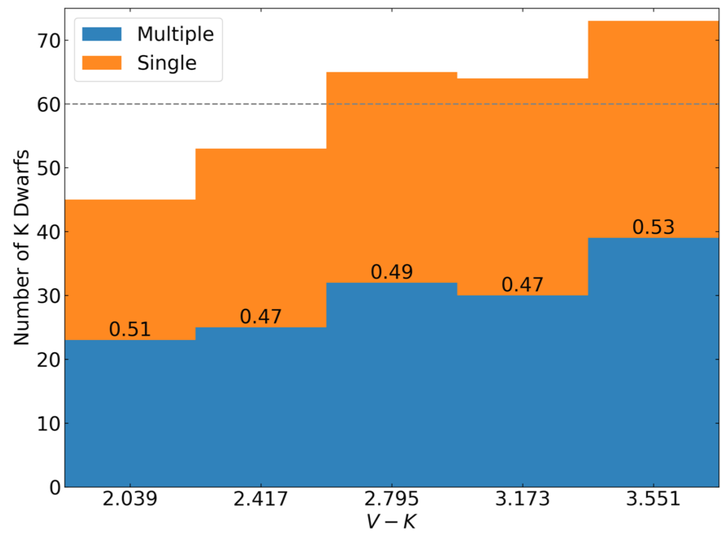


- Our **speckle imaging survey[3] done on all of these 472 K dwarfs** is providing detections of secondary components from **separations of ~10^{-3}" to ~3"**, to determine if the RV trend is due to a wider companion or to a lower mass closer companion.

Orbital Architectures of 472 K dwarfs



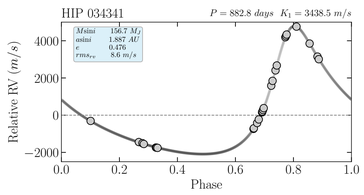
RESULTS



- In the context of previous studies, the multiplicity rate for **G dwarfs is ~50%** (Raghavan+ 2010) and for **M dwarfs is ~27%** (Winters+ 2019).
- Combining our RV-speckle-wide companion survey on 300 K dwarfs, we find that **~49% of the K dwarfs host at least one companion** detected with any of the three techniques.

Known Stellar/Sub-stellar Companions

- The main complement to our sample is the SB9 catalog of spectroscopic binary orbits[1], which provides reliable and published orbital solutions for a great number of multiple systems.



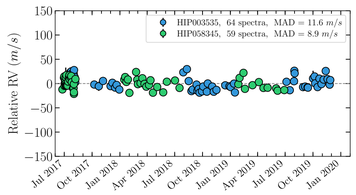
- We also observed known binary systems from SB9 to validate our companion detection methods by achieving nearly identical orbital solutions.

Known Planets

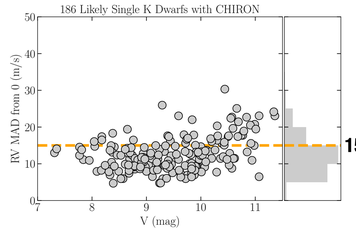
- Of the 472 K dwarfs, **172 were already covered intensively by HARPS and HIRES**, two of the most sensitive RV planet searchers spectrographs, with precisions below 5 m/s.
- 19 planets previously discovered were obtained from the NASA Exoplanet Database[2].

Single

- Horizontal blue lines show the radial velocity residuals on **186 K dwarfs where no companions were detected**, and they are an estimation of our limiting precision with the CHIRON Spectrograph at CTIO 1.5m.



- 75% have Mean Absolute Deviations (MAD) **less than 15 m/s, and down to 5 m/s**.



[1] SB9: The ninth catalogue of spectroscopic binary orbits, Pourbaix D., Tokovinin A. et al. 2004, Astronomy and Astrophysics, 424, 727-732

[2] NASA Exoplanet Archive, California Institute of Technology.

[3] Multiplicity Survey of 1048 K dwarfs at Solar System Scales. Nusdeo, D., Henry, T., Horch, E., Paredes, L. et al.2020, in preparation.

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Background photo: View from Cerro Tololo Inter-American Observatory to the west at sunrise – Leonardo Paredes