The HArps-n red Dwarf Exoplanet Survey (HADES)
Flux-flux and activity-rotation relationships in early-M dwarfs

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While most of the planets discovered so far have been found orbiting around solar-type stars, low-mass stars have been recognised as a "shortcut" to glance into an exo-life laboratory. Currently, stellar activity is one of the most limiting factors for achieving the precision required to detect Earth-twins via the radial velocity method. Understanding the chromospheres of M dwarfs is crucial to solve this problem. In this contribution we present a study of the activity-rotation-stellar parameters and flux-flux relationships among a large sample of early-M dwarfs which are currently being monitored in the framework of the HADES (HArps-n red Dwarf Exoplanet Survey) radial velocity survey (see also the posters by Affer et al., and Scandariato et al.).

Stellar sample and analysis

Our stellar sample is composed of 71 late-K/early-M dwarfs monitored within the HArps-n red Dwarf Exoplanet Survey (HADES, see poster by Affer et al.) The stars were selected from the the Palomar-Michigan State University (PMSU) catalogue, Lèpine & Gaidos (2011), and targets observed by the APACHE transit survey (Sozzetti et al. 2013). High-resolution échelle spectra of the stars were obtained at La Palma observatory (Canary Islands, Spain) using the HARPS-N instrument at the Telescopio Nazionale Galileo (TNG). Our analysis includes:

- The calculation of projected rotational velocities, vsini, by using the cross-correlation technique.
- The determination of emission excess in different chromospheric indicators (Ca II H, K; Balmer lines) by using the spectral subtraction technique.
- The computation of the Galactic spatial-velocity components (U,V,W) and identification of possible young stars.
- The identification of X-ray counterparts.

For an analysis of the short-term chromospheric variability of the sample see the poster by Scandariato et al.

Rotation-activity-stellar parameters

Activity vs. effective temperature (Fig. 1)

Besides a large scatter, we find the strength of the emission excess to be roughly constant for the stars in the temperature range studied here (3400-3980 K, spectral types K7.5-M3). This result holds for all the considered activity indicators although in the Ca K the coolest stars might show slightly lower levels of flux.

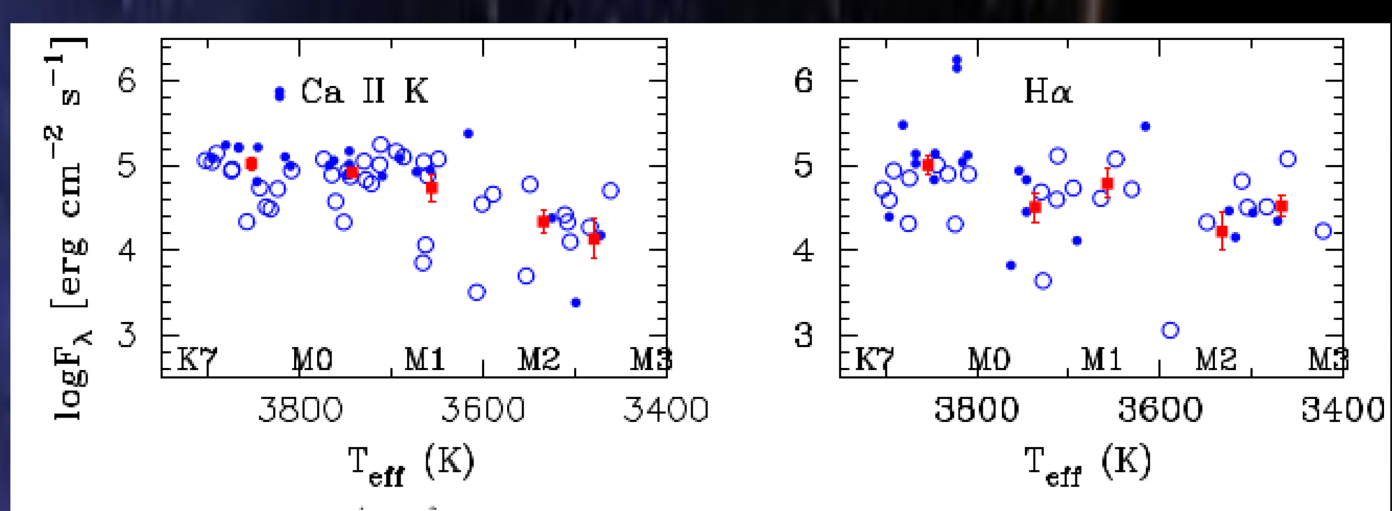
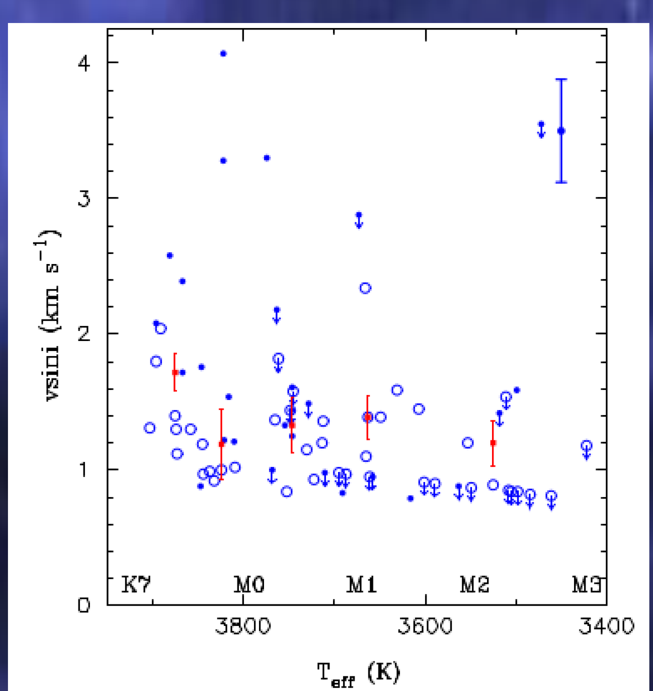


Fig. 1. Emission excess flux as a function of the stellar effective temperature.

Rotation vs. effective temperature (Fig. 2)



Our analysis reveals the very low rotation levels of our sample. We also find a tendency of lower rotational levels (and higher errors on vsini) towards cooler stars.

Fig. 2. vsini as a function of the effective temperature.

Rotation vs. activity (Fig. 3)

Our data suggests a moderate but statistically significant tendency of higher vsini values with increasing activity strength.

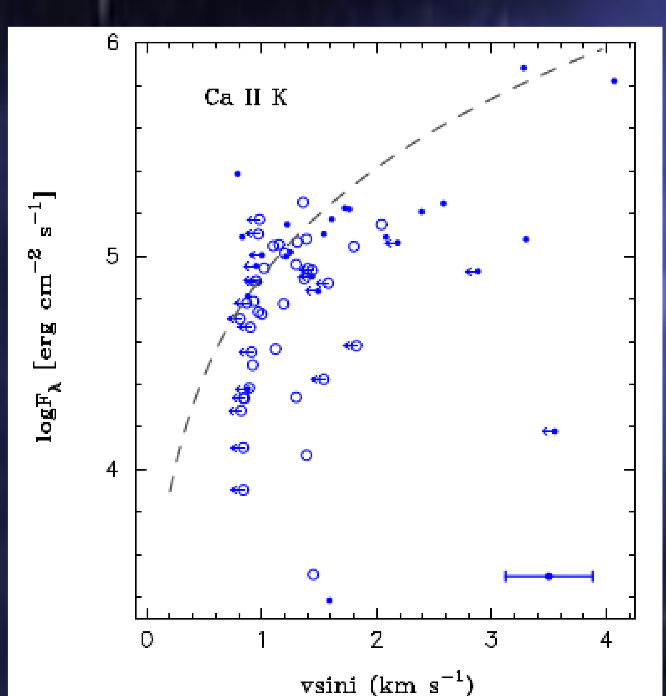


Fig. 3. CaII K emission excess as a function of vsini.

Age effects (Fig. 4)

We find a tendency of possible young stars to show higher levels of activity in the Ca lines when compared with old disc stars.

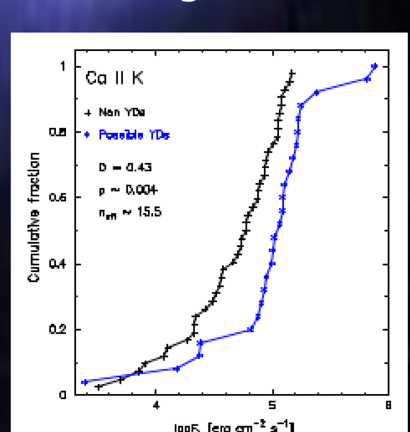
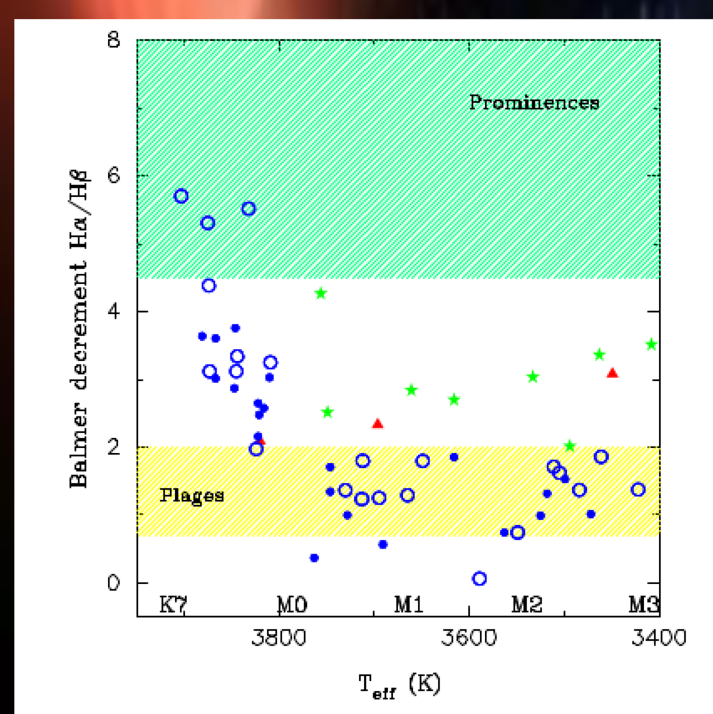


Fig. 4. Cumulative distribution function of the Ca II K emission excess for possible young (blue) and old (black) stars.

Comparison of activity indicators



Balmer decrements (Fig. 5)

The analysis of the Balmer decrement shows a trend of decreasing values, from values compatible with solar prominences for stars with $T_{eff} \sim 3900$ K to values similar to those of the solar plages for $T_{eff} \sim 3850$ K. Then, the Balmer decrement remains roughly constant in the range 3750 – 3400K. We also note the low values of the Balmer decrement for our stars when compared with other literature samples.

Fig. 5. Balmer decrement F(Hα)/F(Hβ). Green stars denote pre-MS M stars (Stelzer et al. 2013), red triangles correspond to active M dwarfs templates (Bochanski et al. 2007).

Flux-flux relationships (Fig. 6)

Our M dwarf sample is complementary in terms of chromospheric fluxes with those of the literature, but with lower chromospheric fluxes, extending the analysis of the flux-flux relationships to the very low activity domain.
In the corona-chromospere relationships, our sample of M dwarfs shows similar X-ray luminosities as the solar-type FGK stars but lower chromospheric flux.

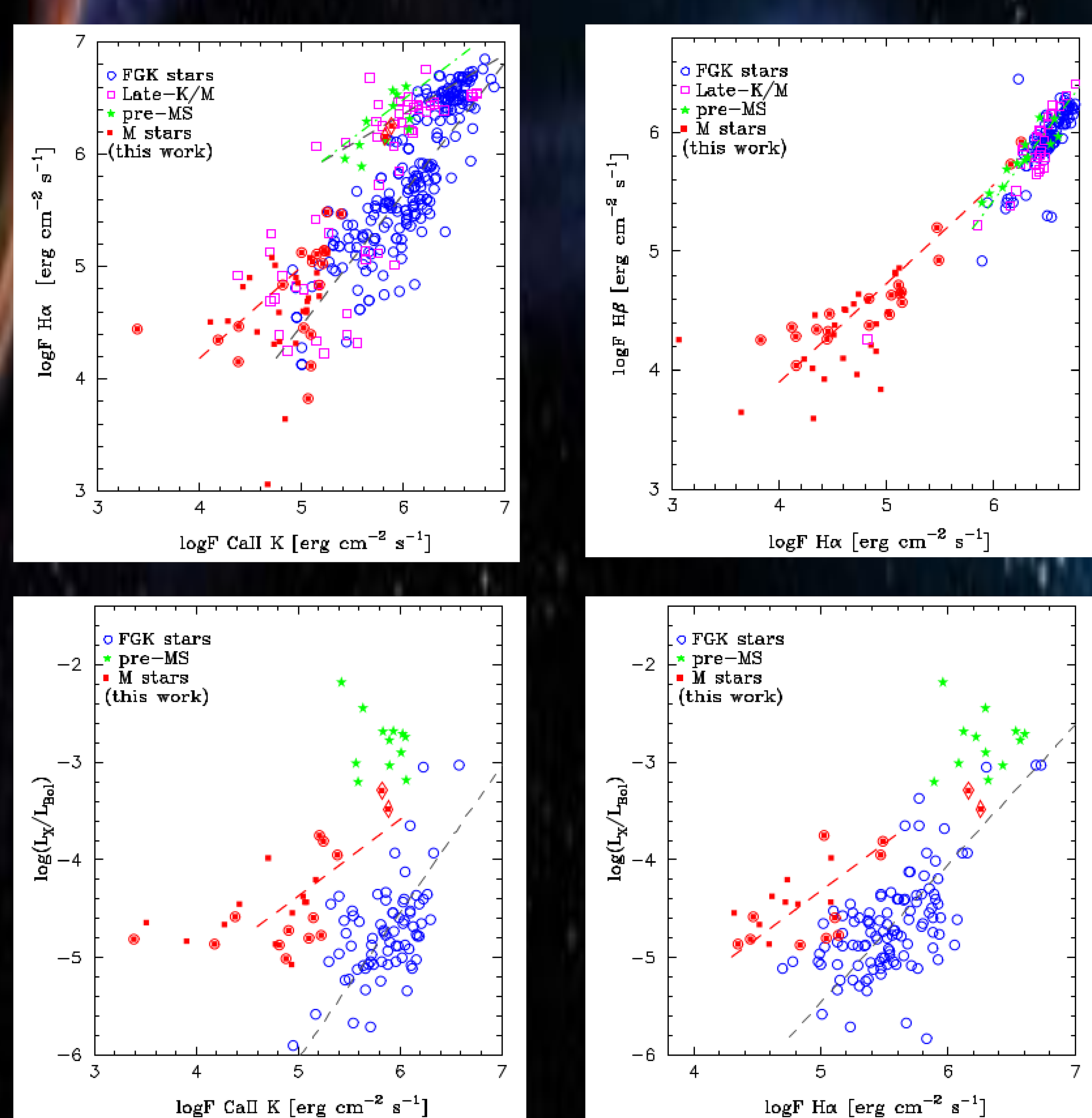


Fig. 6. Flux-flux relationships. Hα vs. Ca II K (top left); Hβ vs. Hα (top right); X-ray vs. Ca II K (bottom left) ; and X-ray vs. Hα (bottom right). M dwarfs from this work are shown with red filled squares, FGK stars with open blue circles, M dwarfs from the literature in purple open squares, and pre-MS M stars in green.

Background image: An artist's conception of an M dwarf with a habitable planet and moons. Credit: David A. Aguilar (CfA)