The HArps-n red Dwarf Exoplanet Survey (HADES) Time resolved spectroscopic analysis of the steady chromosphere of low-activity early-M dwarfs

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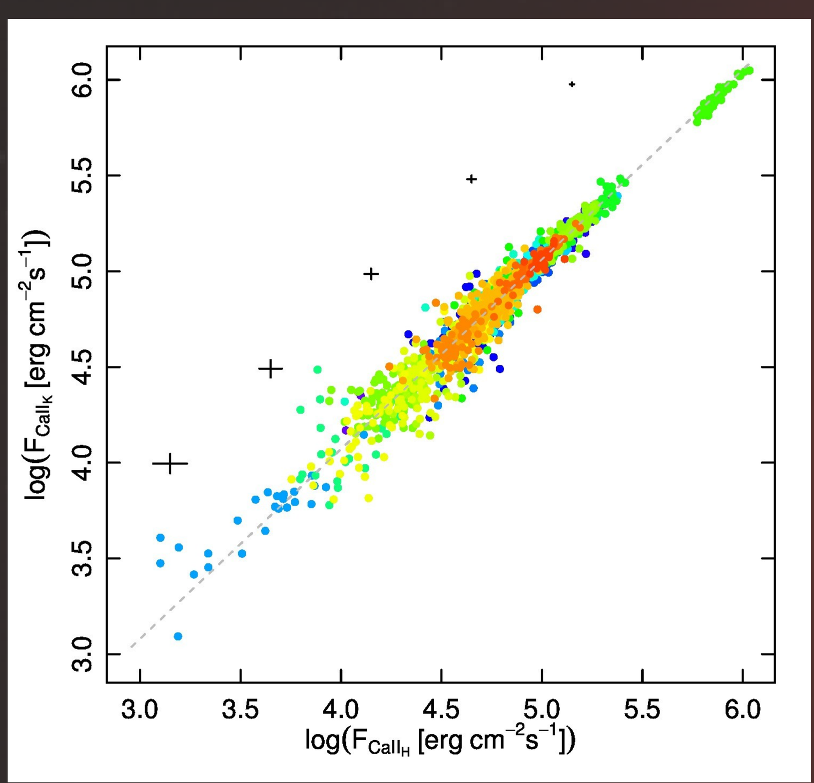
We analyze the spectra of the quiet early-M dwarfs that the HADES project monitored for 3.5 years. The wavelength range covered by the spectra allows us to analyze simultaneously the CaII H&K doublet and the Hα line, while the intensive follow up gives us a large number of spectra (up to ~100) for each targeted star. We show how the CaII H&K and Hα fluxes are correlated at low activity levels and we infer the evolution timescales of chromospheric active regions.

Stellar sample and analysis

Our stellar sample is composed by 71 late-K/early-M dwarfs monitored within the HArps-n red Dwarf Exoplanet Survey (HADES, see poster by Affer et al.). 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). In this work we measure the emission excess in units of flux at the stellar surface of the CaII H&K and Hα by using the spectral subtraction technique, and we analyze the time series of measurements to study the variability of the targeted stars.

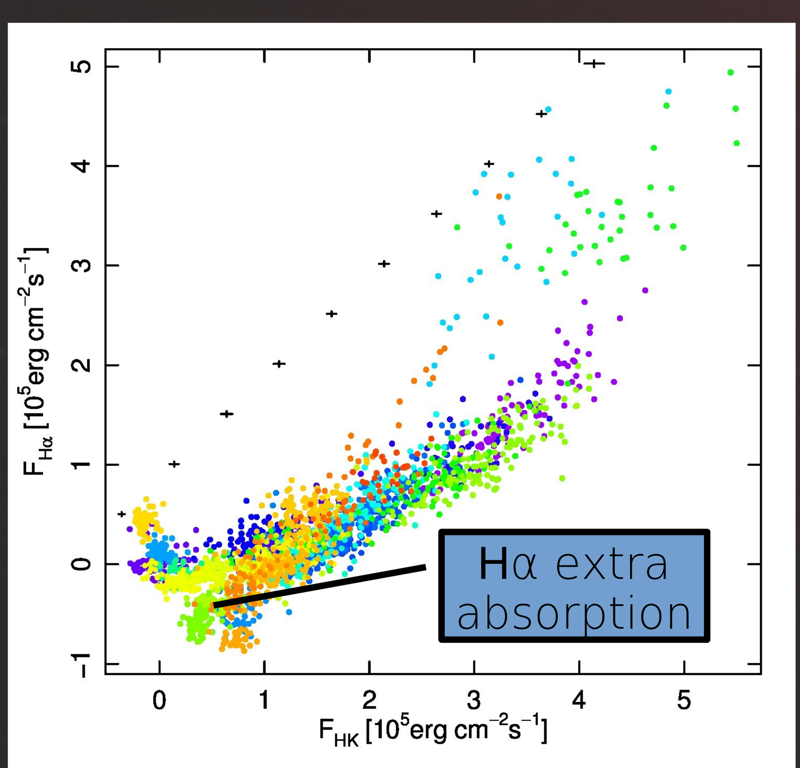
Flux-flux relationships

CaII H vs. CaII K



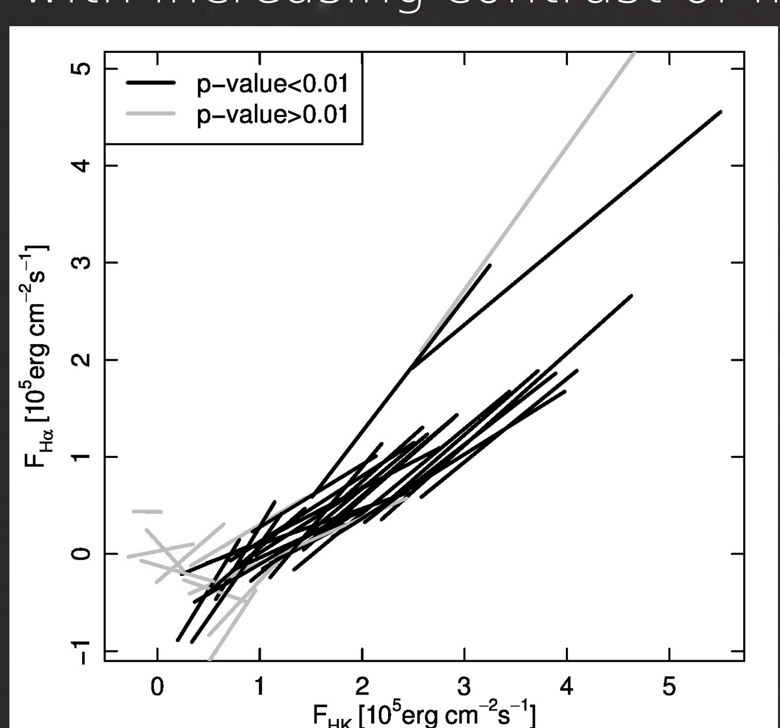
The excess fluxes in the CaII H and K lines are linearly correlated in the logarithmic scale, consistently to previous results (e.g. Martinez-Arnaiz et al. 2011, Stelzer et al. 2012). Crosses in the figure represent the typical uncertainties at the given excess flux, while different colors mark different stars.

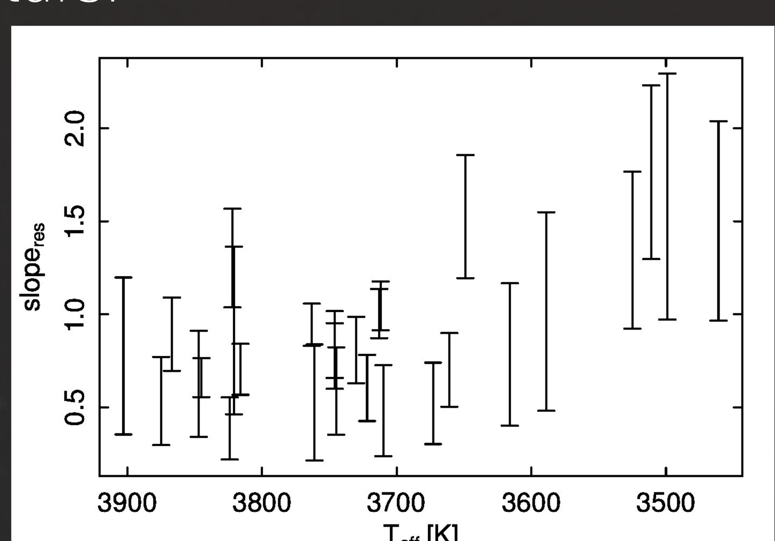
Hα vs. CaII H&K



The Hα emission flux is generally correlated to the H&K flux, except for the stars with the lowest activity. For these stars, the data suggest that the Hα goes into extra-absorption before going into emission. This trend is consistent with the theoretical models of, e.g., Cram & Giampapa 1987 and Houdebine & Stempels 1997.

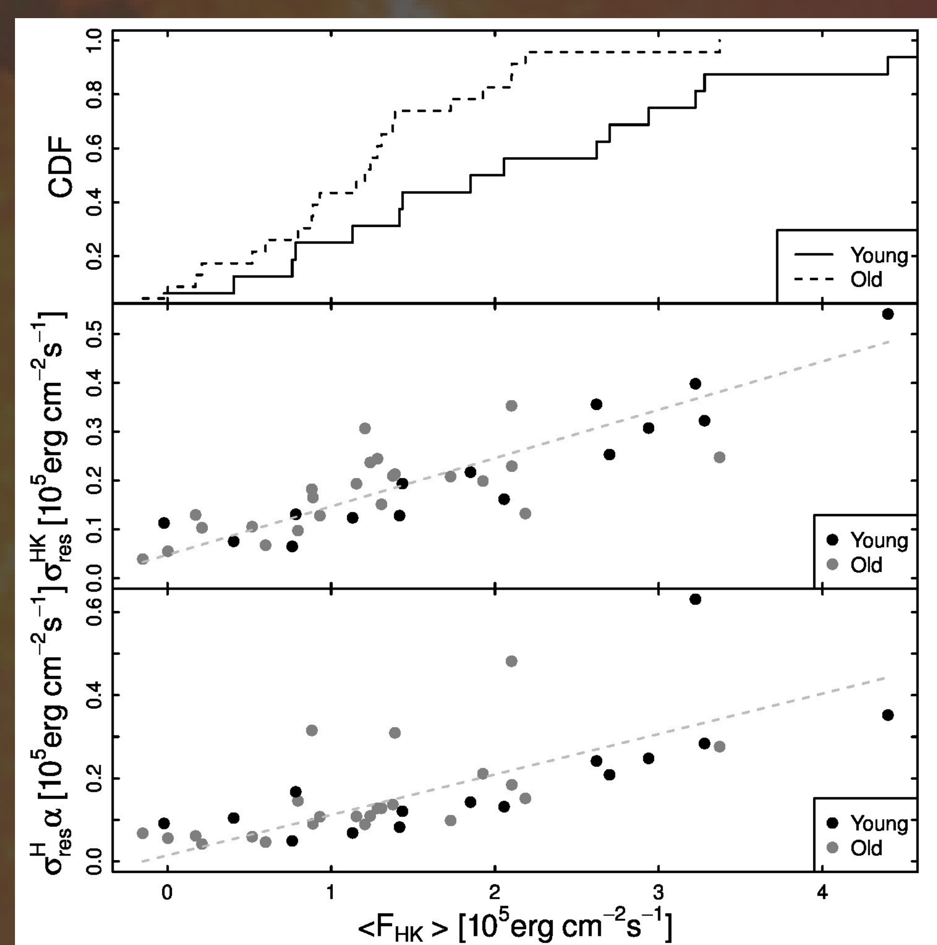
The stars follow loci with different trends in the Hα vs H&K diagram. We find evidence that the slope increases with decreasing effective temperature of the star. As shown by Meunier & Delfosse 2009 for the Sun, the slope increases with increasing contrast of filaments. We thus infer that the contrast of prominences on M dwarfs increases for cooler stars.





Analysis of variability

Variability vs. activity vs. age



Consistently with Maldonado et al 2016 (see poster), we find that younger M dwarfs tend to be more active.

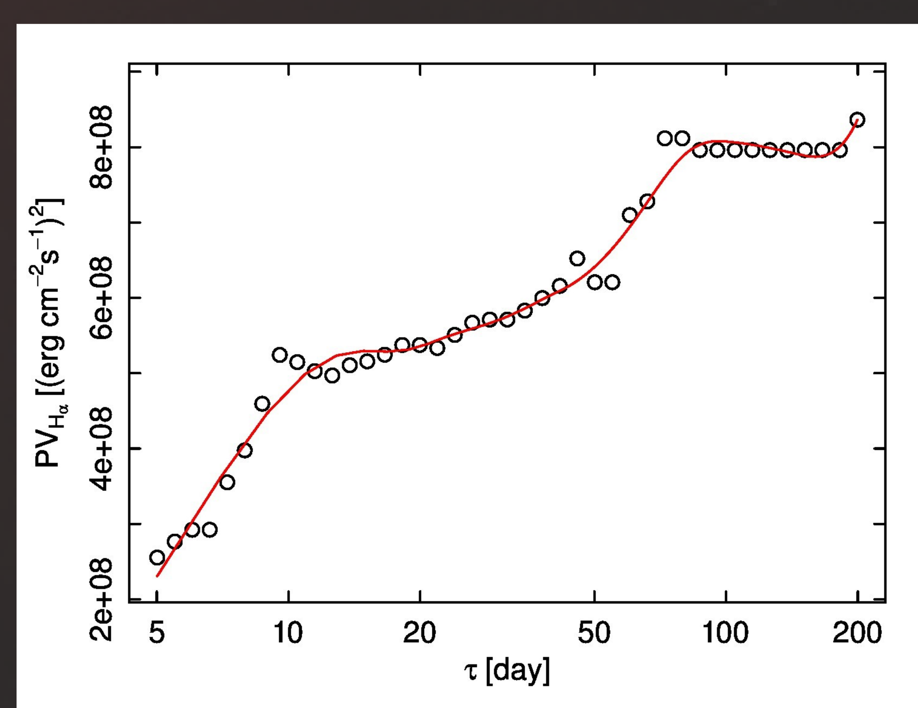
Moreover, the standard deviation of the H&K and Hα flux excess measurement for each star is ~10% of the H&K emission, i.e. variability linearly increases with the level of activity.

The linear best fits also suggest that even at null activity there is a residual variability of $\sim 0.5 \cdot 10^{-5}$ erg cm^{-2} s^{-1}.

Variability timescales

The Pooled Variance analysis (Donahue et al. 1997) is suited for time series containing multiple periodic signals with different amplitudes and phases, and is indicated to study the timescales of variability induced by stellar rotation and the life of Active Regions.

We compute the Pooled Variance of the H&K and Hα emission flux of the 8 stars in our sample with more than 90 observations, and we generally find two main periodicities, at 10-40 days and 50-60 days respectively.



We infer that the shorter periodicity corresponds to the stellar rotation period, consistently to a different time series analysis we are currently carrying on. The longer periodicity, which is a few stellar rotations, is likely due to the growth and decay of active regions.

Don't forget to visit the posters by Affer et al. and Maldonado et al. !

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