# Activity of the young fast-rotating stars PZ Tel, HK Aqr, and LO Peg

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## Abstract

*Stellar activity has important implications for the evolution of planetary atmospheres [7, 6]. The first few hundred Myr of the evolution of Sun-like and cool stars is characterized by frequent flares and probably also frequent coronal mass ejection (CME) events [1]. Therefore, studying flares and CMEs on young stars is not only crucial for the understanding of stellar magnetic activity, but also for the evolution of planets and, consequently, habitability. We monitored three young, fast-rotating, and magnetically active stars with the following aims: 1) identifying and characterizing stellar flares in chromospheric lines, 2) searching for stellar eruptive prominences/CMEs via spectral line asymmetries and line shifts, 3) studying quiescent prominences over several rotations, 4) searching for prominence oscillations to infer the spatial scales and magnetic field strengths of these structures. Here we present preliminary results of this study.*

## 1. The target stars

We selected three nearby young fast rotating main-sequence stars. They have high levels of chromospheric and coronal activity, as reflected by their high X-ray luminosity $L_X$. The estimated daily number of strong ($E_X > 10^{32}$ erg) X-ray flares ranges from about ten to more than hundred [2]. On the Sun, such strong flares are tightly correlated with CMEs. Both PZ Tel and HK Aqr are known to have prominences which were discovered as absorption features moving across their rotationally broadened H$\alpha$ profiles [3, 4]. On the other hand, no such features have so far been observed on LO Peg, which is otherwise very active [5]. The selected stars are younger than those we monitored in a previous study [8].

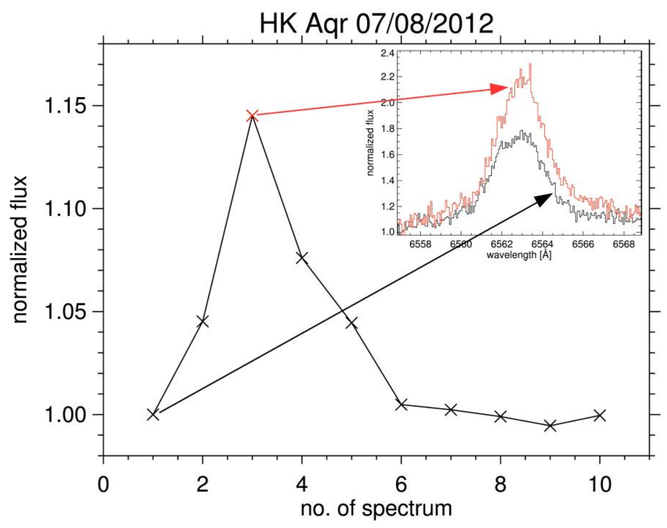
| star | spectral type | d (pc) | age (Myr) | $P_{rot}$ (d) | log $L_X$ (erg $s^{-1}$) | $N_{flare}$ ($d^{-1}$) |
|---|---|---|---|---|---|---|
| **PZ Tel** | K0V | 51 | 20 | 0.94 | 30.48 | 182 |
| **HK Aqr** | M0Ve | 22 | 200 | 0.43 | 29.26 | 13 |
| **LO Peg** | K5-7V | 25 | 50 | 0.42 | 29.70 | 33 |

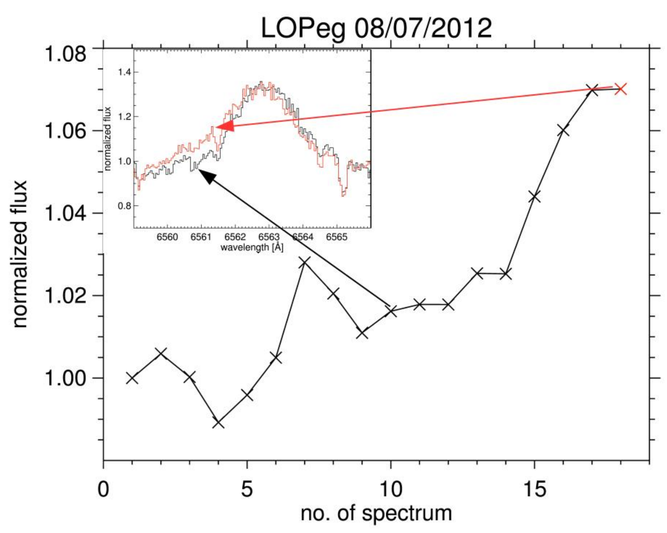
## 2. Observations

We obtained time series of optical spectra during six nights in August 2012 with the FEROS spectrograph installed at ESO's MPG/2.2m telescope in La Silla (PZ Tel, HK Aqr) and six nights in July 2012 with the Coude Echelle spectrograph installed at the 2m Alfred Jensch Telescope of the Thüringer Landessternwarte Tautenburg (LO Peg). The spectral range of the data (350-920 nm and 470-740 nm, respectively) covers various lines related to chromospheric activity (Balmer lines, Ca II H&K, Na I D1 D2 etc.). For LO Peg, we also obtained coordinated photometric observations with the 30cm astrograph (BMK) at Lustbühel Observatory, Graz. We are currently analyzing the data.

## 3. H$\alpha$ flares and profile shapes

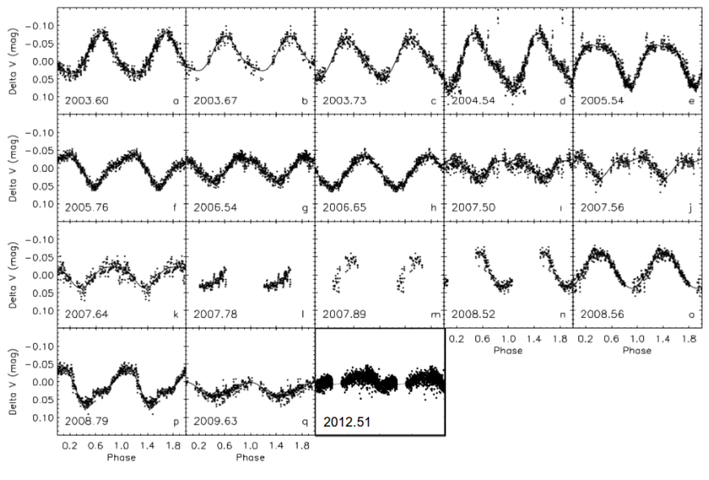
The two strongest H$\alpha$ flares seen in our data occurred on HK Aqr and LO Peg. Unfortunately, we only have data during the rise phase of the flare on LO Peg, as it happened at the end of the night. Below we show the two normalized H$\alpha$ lightcurves and include a comparison of the spectral line profiles during the pre-flare phase and during the flare peak. For HK Aqr, the peak emission is rather symmetric with slightly more flux in the red wing, whereas for LO Peg, we find a distinct blue wing enhancement. The flare of HK Aqr can also be seen in the dynamic spectrum of day 1 in section 5.



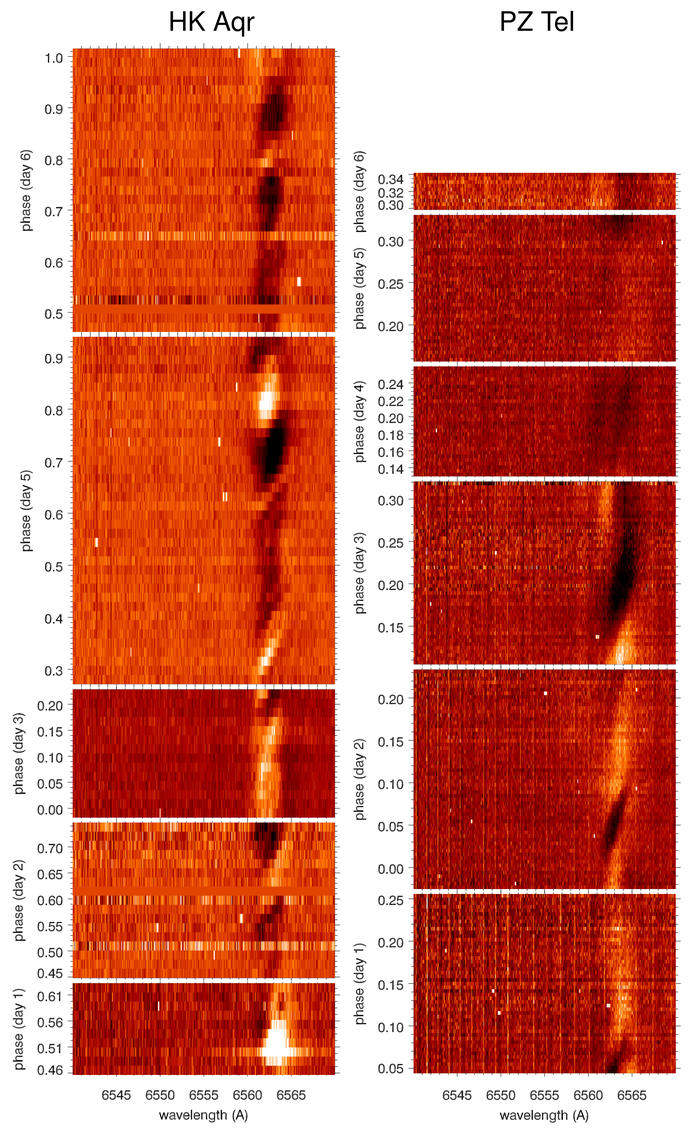

## 4. LO Peg photometry

Below we compare our photometry (last panel, epoch 2012.51) with a long-term time series from literature [9]. We clearly detected LO Peg's rotation and found that it was in a low-amplitude state, comparable to observations in 2007 and especially 2009.




## 5. Prominences

We show dynamic spectra (relative intensity as a function of wavelength and rotational phase) of the region around H$\alpha$ from HK Aqr and PZ Tel. One can clearly see the dark absorption features caused by prominences traveling from the blue to the red wing due to the star's rotation. Some stable systems can be seen over several rotations.




## 6. Future work

- ➤ Analysis of other chromospheric spectral lines
- ➤ Further analysis of line profile shapes to detect possible signatures of CMEs
- ➤ Determination of prominence parameters and search for possible oscillations

## References

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ACKNOWLEDGMENTS. P.O., M.L. and A.H. acknowledge the Austrian Science Fund (FWF): P22950-N16 for supporting this project. Based on observations made with ESO Telescopes at the La Silla Observatory under programme ID 089.D-0709.

FWF Der Wissenschaftsfonds.