The weak-line T Tauri star V410 Tau in the eyes of SPIRou and TESS

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In the past decades, many efforts have been done to better understand the planet/star formation, considering **young pre-main sequence stars called T Tauri stars.** Their magnetic topology as well as their surface have been mapped thanks to **Zeeman-Doppler Imaging (ZDI)**, a technique inspired from medical tomography. ZDI also allows one **to filter the stellar activity** from radial velocity measurements, by modeling the distorsions of the lines, in order to find signatures of a potential planet around the host star. However, most of the studies were done in the optical where the activity jitter is important.
Here we present results of a spectropolarimetric and photometric monitoring based on data collected with the **new near-infrared (NIR) spectropolarimeter SPIRou** recently installed at the Canada-France-Hawaii Telescope and the TESS space probe. Our study illustrates the **benefits of near-infrared (vs optical) observations**, to investigate the magnetic topologies of young stars and look for the potential presence of massive planets on close-in orbits through radial velocity measurements.

Zeeman-Doppler Imaging

- We applied Least-Square-Deconvolution (LSD) [3] on SPIRou data to finally used ZDI [1,2,4,6]. This allows us to reconstruct the logaritmic relative surface brightness map of the star as well as its magnetic topology.
- This is also the first time we combined high-resolution spectropolarimetry and high-precision photometry with ZDI.

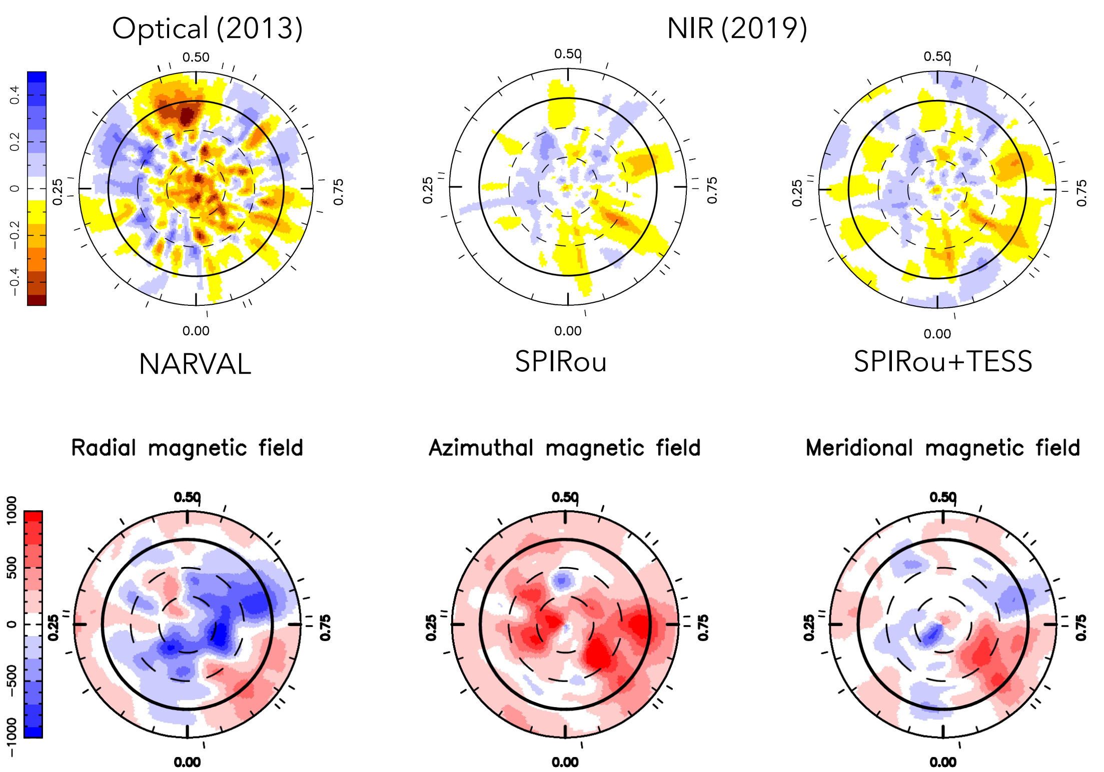


Fig. 1: *First row*: logarithmic relative surface brightness maps obtained from optical data (left), SPIRou data only (middle) and SPIRou and TESS data simultaneously (right). *Second row:* radial, azimuthal and meridional magnetic field components reconstructed from SPIRou data

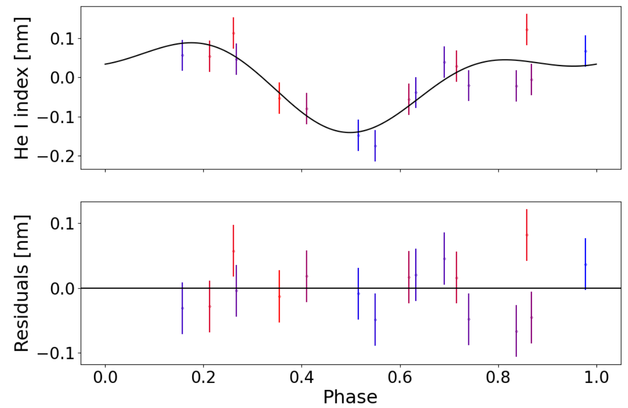
Stellar activity

Radial Velocity (RV)

- We use ZDI maps to deduce RV curves and filtered the stellar activity
- We compare this method with Gaussian Process Regression (GPR) [5]

Activity indexes

- We compute activity indexes from He I triplet (1083 nm), Paschen β and Brackett γ lines



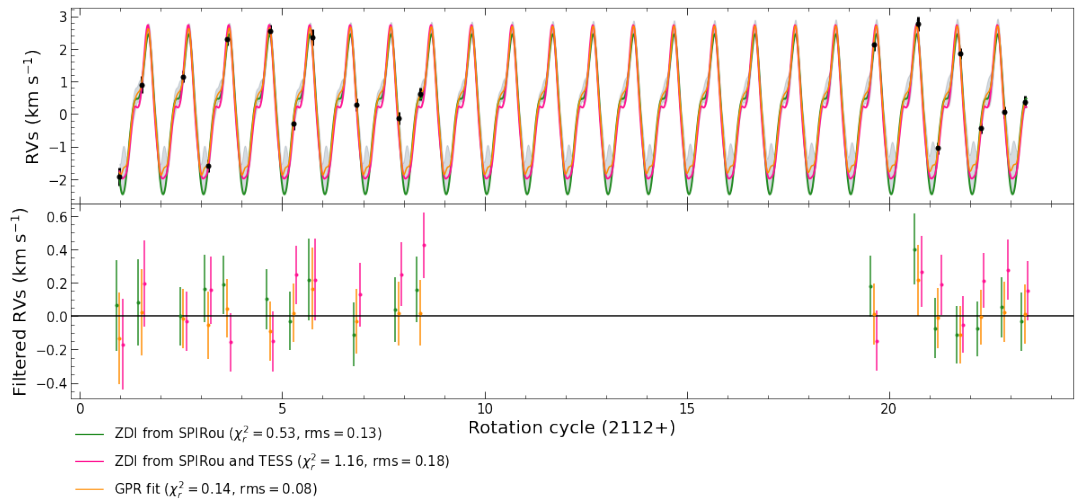


Fig. 2 : RVs of V410 Tau in 2019 November and December. *Top panel:* ZDI models (green and pink) and GPR (orange). *Bottom panel:* Filtered RVs.

Fig. 3 : Phase folded activity indexes (colored dots) derived from the He I triplet at 1083 nm with their fit in solid black line. Each color represents a rotation cycle. The bottom panel represents the residuals.

Conclusions

- **NIR maps are less contrasted** than the ones deduced from optical data and do not show any polar features
- Low latitudes spots were needed to fit the TESS light curve down to 1.3 mmag with ZDI
- **The magnetic topology is rather complex** with a strong azimuthal component despite the star being fully convective
- **High level of variability** shown by:
  - **Strong RV modulations but with smaller amplitude and dispersion than in the optical**
  - **Activity indexes**: modulation of the He I indexes with a stronger absorption at phase 0.5
- Confirms the results from [7] regarding the potential presence of a hot Jupiter

References

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