Probing accretion variability in CR Cha with TESS and high-resolution spectroscopy

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Abstract

Young stellar objects are still surrounded by a circumstellar disk, from which material is accreting onto the stellar surface. The mass accretion process is essential in the formation and evolution of Sun-like stars. Although usually described with simple and static models, the accretion is inherently time variable. The aim of our work is to characterize the geometry and variability of the accretion process over a wide range of timescales in several accretion tracers using high-cadence photometric and high-resolution spectroscopic data.

Here, we present a multi-epoch analysis of CR Cha, a low-mass young stellar object with the age of 1-3 Myr. CR Cha is an actively accreting K-type star which is located at a distance of 187 pc, and hosts a complex magnetic field [1].

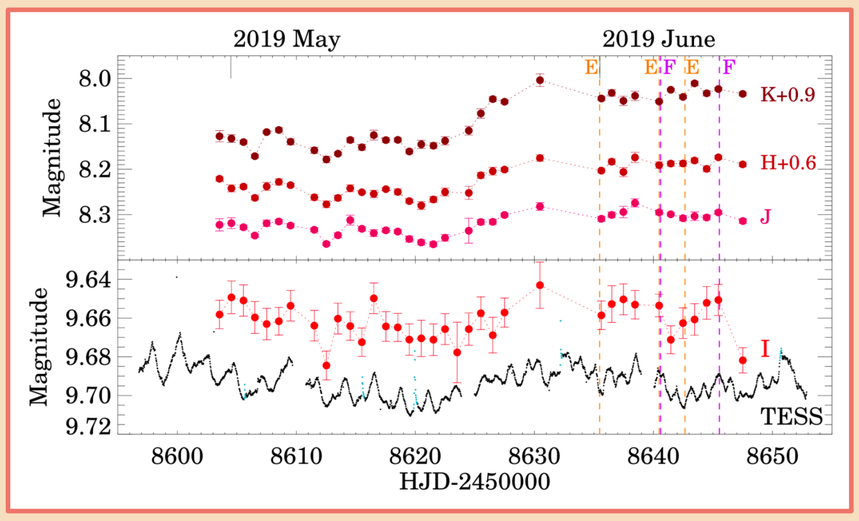
Variability

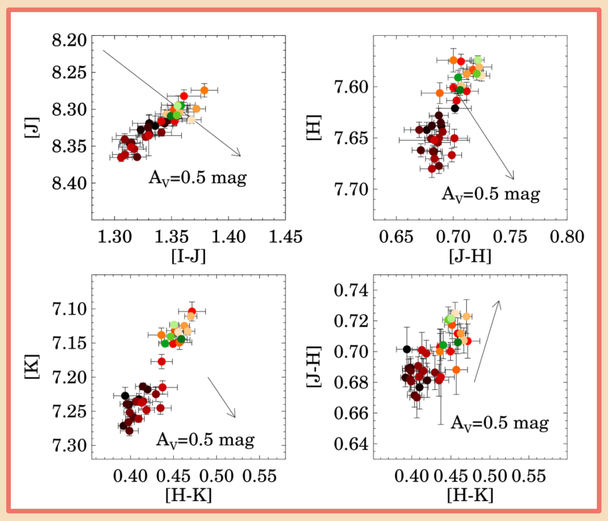
- The photometric and spectroscopic variability is a general characteristic of T Tauri stars.
- They might show **periodic variations** due to rotational modulation, at the same time, **irregular variations** can occur due to changes in the accretion rate, in the inner disk structure, in the stellar activity, or in the stellar wind.
- The variability may occur on **timescales from hours to years**, however, Costigan et al. 2014 [2] suggest that the dominant timescale of the variations is of the order of days.

Observations

- **2006 April 9-13:** *Spectropolarimetric* observations were obtained over five consecutive nights with the Anglo-Australian Telescope (AAT).
- **2018 March 3-9:** *Spectropolarimetric* observations were obtained over six nights with the HARPS instrument.
- **2019 May – August:** *Spectroscopic* observations were obtained with the VLT/ESPRESSO instrument (E) and the FEROS instrument (F).
- **2019 April – June:** Broad band *optical photometric* observations were taken with the TESS Space Telescope with 30-minutes cadence. In addition, we complemented the dataset with contemporaneous *I, J, H and K band* measurements obtained with the ground-based SMARTS telescope.

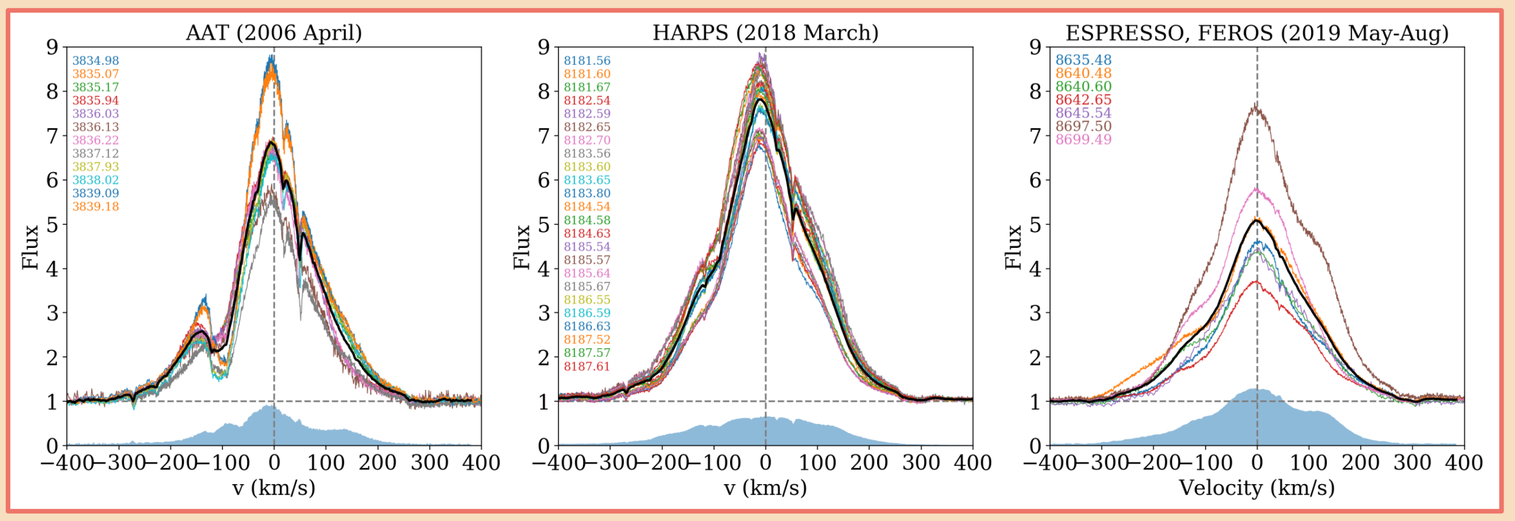
Photometry



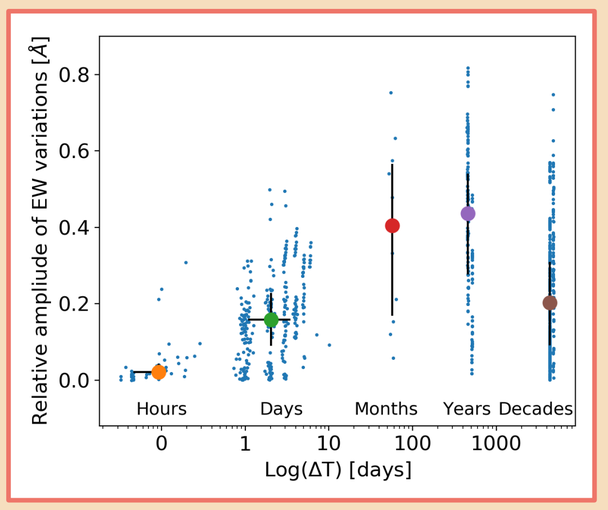


- The TESS light curve **reveals both periodic and stochastic variations** on timescales from weeks to hours, with peak-to-peak amplitude of ~0.05 mag.
- We carried out a period analysis, which resulted in a **P=2.31±0.03 days period**. This is consistent with the stellar rotation period [1, 3].
- The TESS light curve also shows **five flare-like events** with duration ranging from 3.8 to 7.2 hours.
- The shape of the I band light curve follows the variations seen in the TESS observations.
- The near-infrared **JHK band light curves indicate a brightening trend**.
- The colour-magnitude diagram shows that CR Cha becomes **redder as it brightens.**
- The observed pattern may be **explained by disk models** [4], i.e. it may be caused by the changing accretion rate, or by changes in the inner disk structure.

Spectroscopy



- The Hα line profiles show both **short term and long term variability**.
- The variance profiles, indicated with the blue shaded area, suggest that the **amplitude variations** of the central peak, likely due to accretion fluctuations, is the most significant on daily/hourly timescale.
- On monthly/yearly timescales, the shape of the line profile also changes besides the amplitude variations.
- We found significant **line profile variability** on yearly/decadal timescales, indicating that the different physical mechanisms responsible for the line profile changes are present to varying degree at different times.



- Our results show that the amlitude of the variations increases on timescales from hours to days/weeks, after which it saturates, which is in line with Costigan et al. 2014 [2].

References

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[4] Carpenter et al., 2001, AJ, Vol 121, Issue 6, p 3160-3190

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