Photometric and spectroscopic study of the mass accretion in the T Tauri system VW Cha

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Abstract

Young stellar objects are surrounded by a circumstellar disk, from which material is falling onto the stellar surface. According to the magnetospheric accretion model, the stellar magnetic field truncates the disk at the distance of a few stellar radii and channels the disk material onto the star. Although usually described with simple and static models, this accretion process is inherently time variable, therefore our aim is to characterize the accretion process in time and study the accretion diagnostic parameters.

Here, we present a complex study of **VW Cha**, a moderately accreting [1] low-mass T Tauri system [2], located at a distance of 194.5 pc.

Variability

- **Variability of young stars** is perhaps the most important source of information on the accretion process and on the behavior of the innermost region of the systems
- The observed variability may arise from different sources:
  - *Optical wavelengths*: **spots** on the stellar surface might cause periodic light variations, whereas the **variable accretion** results in more stochastic variability
  - *Near-infrared wavelengths*: we observe the innermost region of the circumstellar disk at the NIR wavelengths. These variations might be caused by **changes in the inner disk structure,** or by **changing irradiation** from the central star.

Observations

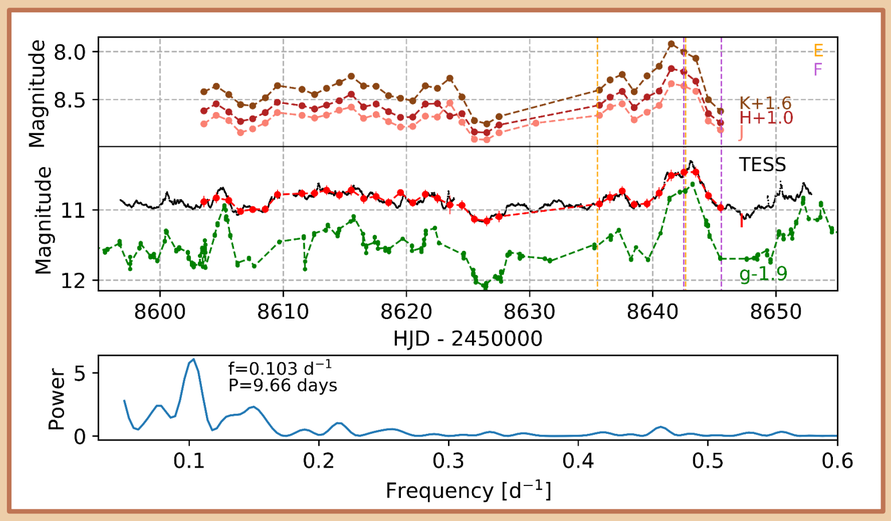
Photometry

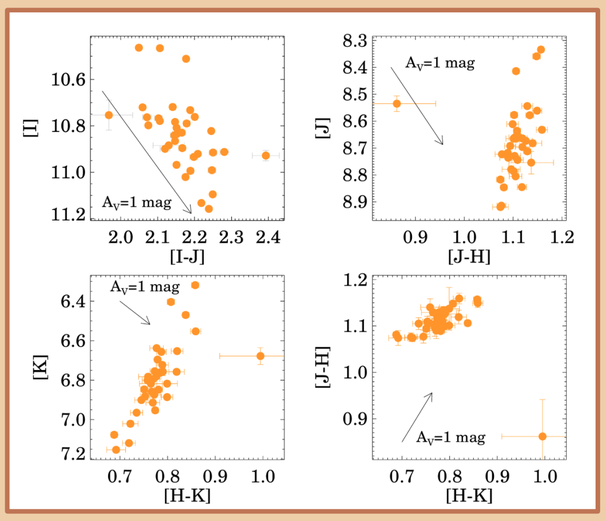
- **TESS Space Telescope**: VW Cha was covered by Sector 11 and 12, which provided a 54-days-long optical light curve with 30 min cadence
- **SMARTS Telescope:** contemporaneously with the TESS observing period, we obtained ground-based IJHK-band observations with nightly cadence

Spectroscopy

- **VLT/ESPRESSO (E):** we obtained two high-resolution (R=140 000) optical spectra contemporaneously with the TESS observing period
- **2.2m/FEROS (F):** we took two high-resolution (R=48 000) optical spectra contemporaneously with the TESS observing period

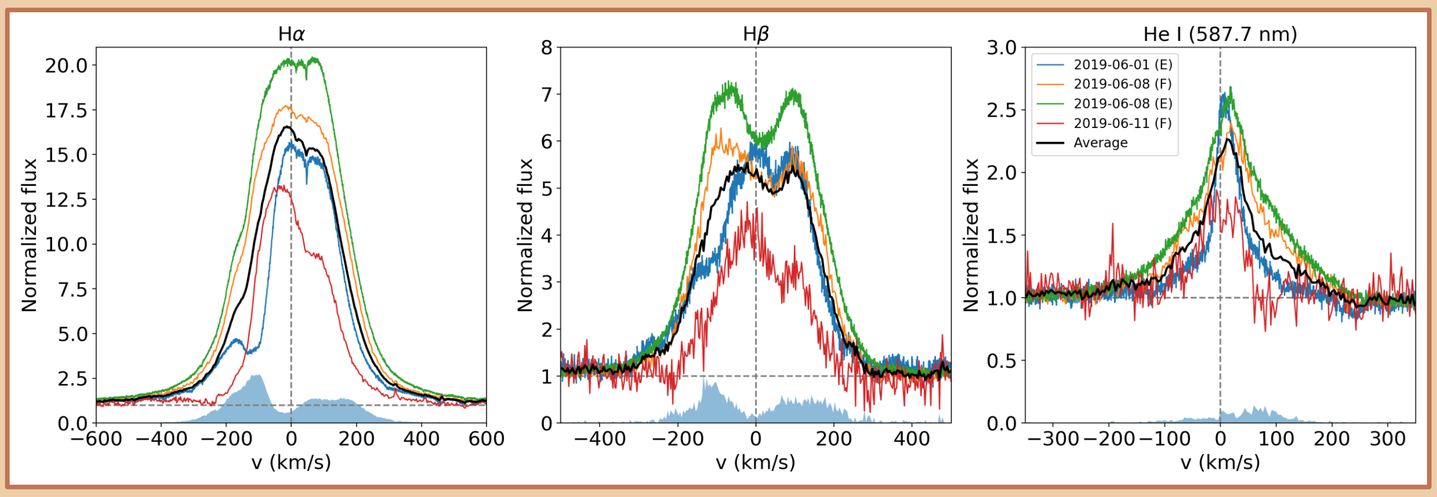
Photometry



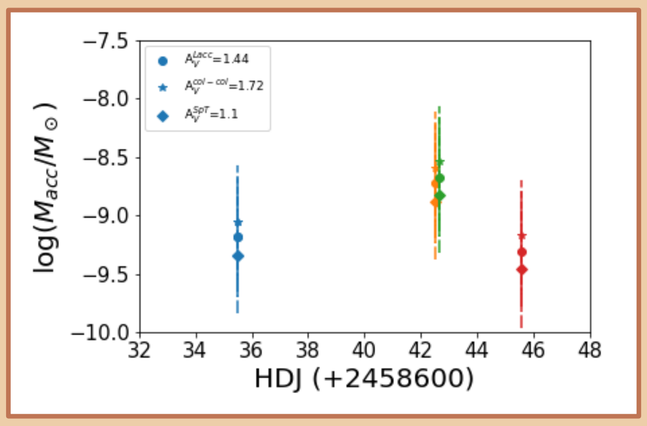


- The TESS light curve reveals **both periodic and stochastic variations** on hourly-daily timescales, with peak-to-peak amplitude of ~0.8 mag
- We carried out a **period analysis**, which resulted in a period at P=9.66 days (botttom panel). This periodic variation might arise from a **rotating spot** on the stellar surface and is consistent with the typical rotational period of T Tauri stars
- The additional **stochastic variations** might arise from **accretion fluctuation**
- The shape of the IJHK-band light curves follow the shape of the TESS light curve
- The NIR color-magnitude diagrams show that VW Cha **becomes redder as it brightens**
- The observed pattern may be **explained by disk models** [3], i.e. it may be caused by the changing accretion rate, or by changes in size of the disk's inner hole

Spectroscopy



- We obtained four spectra during the TESS observing period, covering **both brighter and dimmer** photometric states (see orange and purple vertical dashed lines over the light curves)
- Accretion tracers, such as Hα, Hβ and He I lines, show **strong amplitude variations** with higher amplitudes corresponding to the brighter states. This is consistent with the variability being caused by the **variable accretion**
- The Hα and Hβ lines also show significant **morphological variations**. As indicated by the variability amplitude on the figures by the blue shaded area, different parts of the lines show different level of variability. This suggests that **multiple physical processes**, such as accretion and stellar wind, are responsible for the variability of the lines.



- We determined the **accretion rate** using accretion tracer lines.
- The results show moderate accretion with log M_{acc}~-9 M_{sol}/yr. The variation of the accretion rate is consistent with the brightness changes at the optical wavelengths.

References

[1] Manara et al., 2016,A&A, Vol 585, A136
[2] Brandeker et al., 2001, ApJ, Vol. 561, L199-202
[3] Carpenter et al., 2001, AJ, Vol 121, Issue 6, p 3160-3190

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