# Accretion and Wind Variability of T Tauri Stars Diagnosed through Hα Variations

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## T Tauri Stars

- Classical T Tauri Stars (CTTSs) are young (~2 Myr), roughly solar mass stars still surrounded by active accretion disks.
- They display strong variability in accretion and wind signatures.
- Studying CTTSs allows us to investigate the processes shaping circumstellar environments.

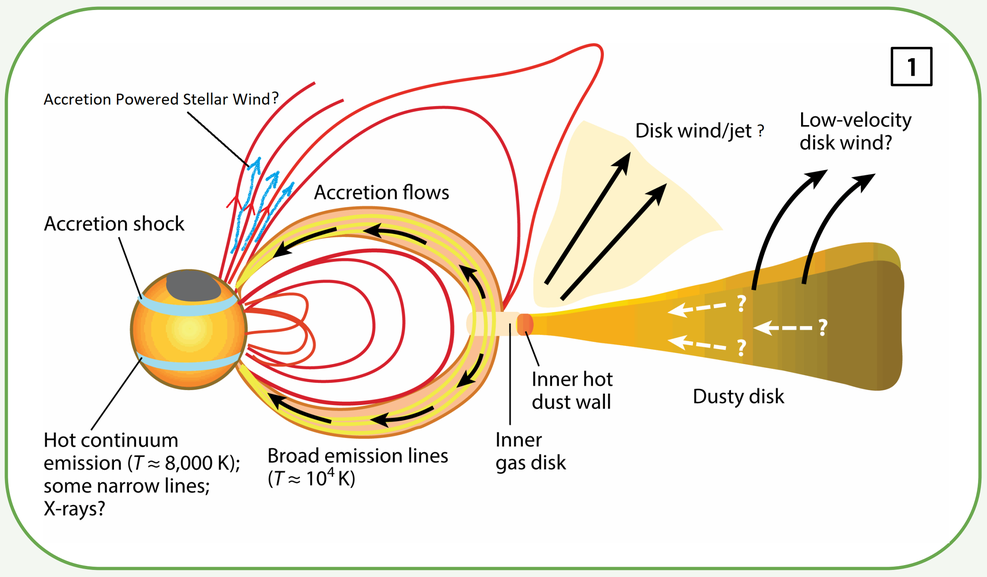



Fig 1. Schematic representation of a T Tauri star-disk system adapted from Hartmann et al. 2016[1].

We use high-resolution (R ≈ 60,000) spectra to analyze wind and accretion signatures in temporal variations in the H$\alpha$ emission line (6562.817 Å).

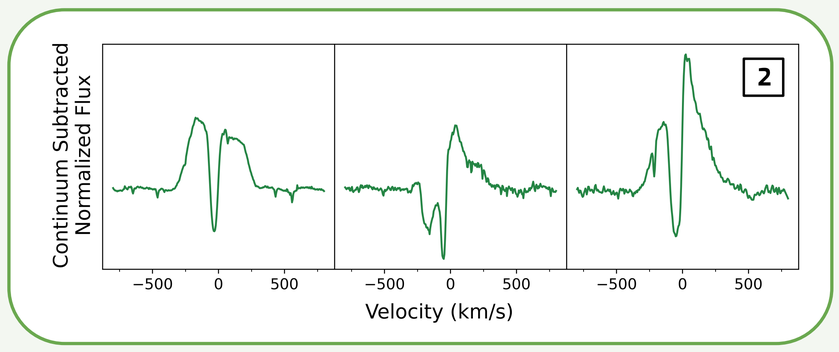
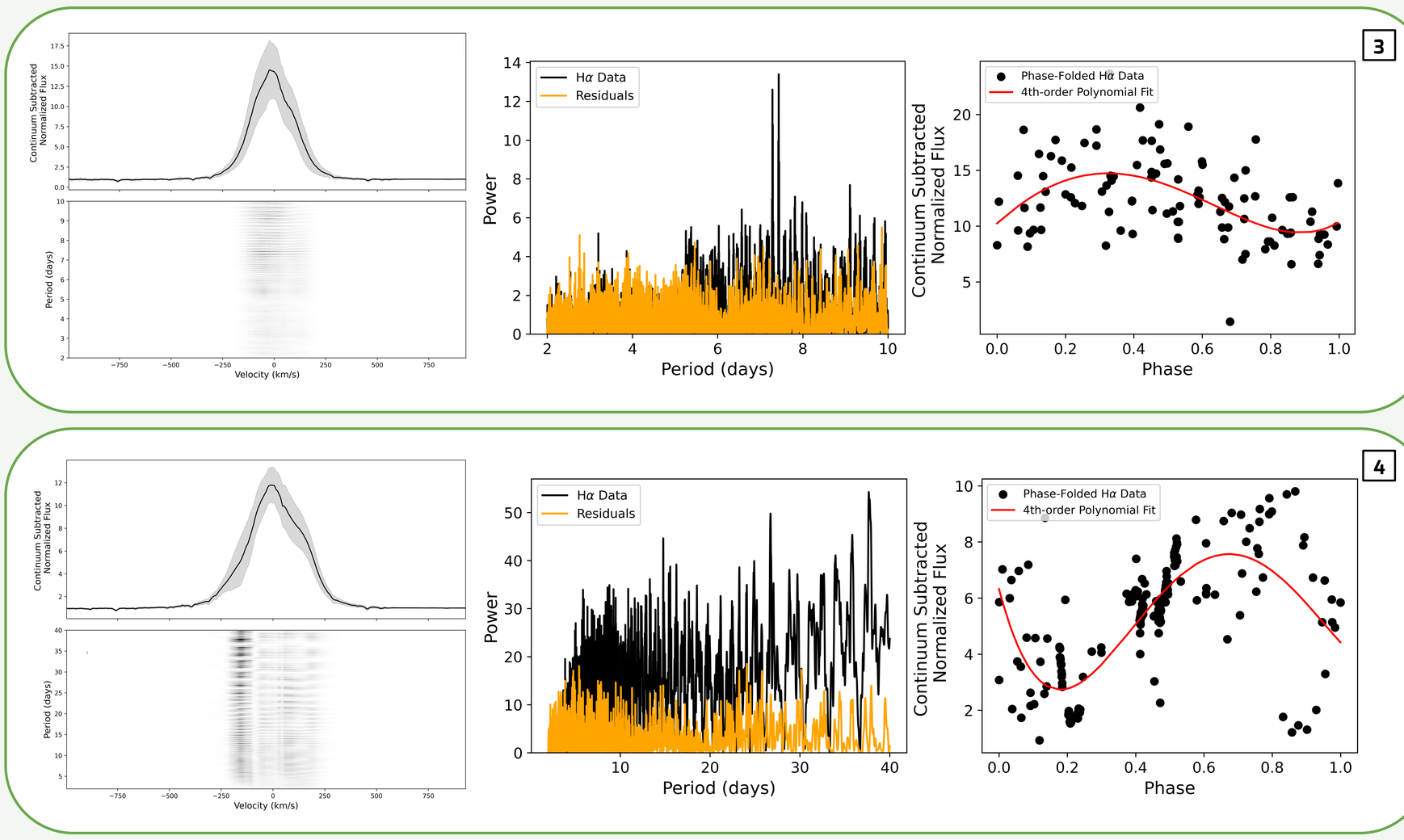



Fig 2. CTTS SU Aur over time. The variability in the H$\alpha$ emission line can happen on time-scales of days to weeks.

## Accretion and Wind Analysis




### Periodograms

We calculate 2D periodograms for all stars (11) in our sample. Here we show BP Tau (Fig 3) and CI Tau (Fig 4). For the velocity channel with the highest power, we

1. phase-fold the data at each of the candidate periods and fit a 4$^{th}$-order polynomial
2. compute the residuals between the observed data and the fit
3. calculate a 2D periodogram for the residuals

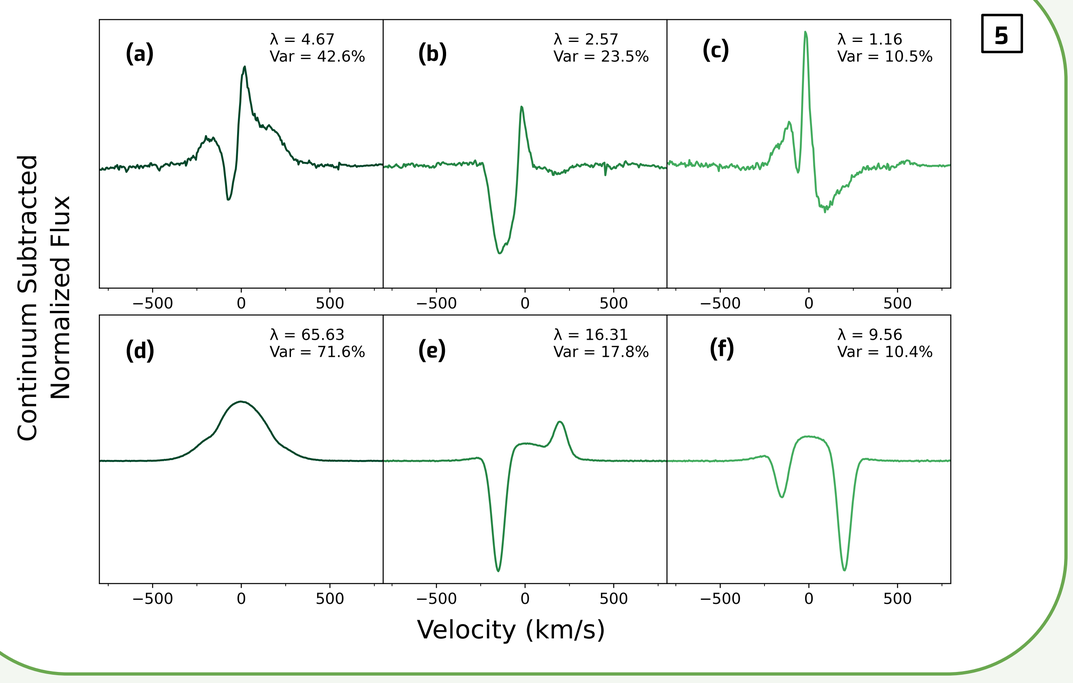
The period that produces the greatest reduction in periodogram power is taken to be the best-fit period.

We find a period of **~7.4 days for BP Tau**, attributed to stellar rotation, and a period of **~37 days for CI Tau**, linked to periodicity in the disk.

### Principal Component Analysis

Principal Component Analysis (PCA) identifies linear combinations of variables that account for the largest variance in the data[2]. It is useful for…

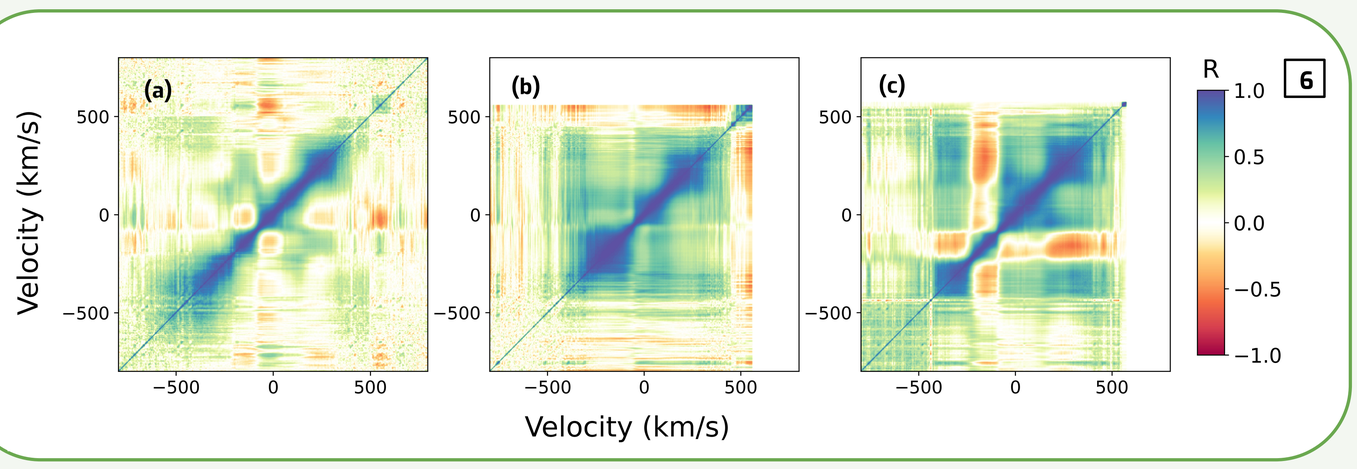
- analyzing variability that often arises from subtle features that may be obscured
- decomposing the data into components that represent distinct sources of variability
- isolating features to analyze temporal behavior and relationships




The results of PCA on synthetic data shows that the interpretation of the principal components can't be as literal as desired; the emergence of apparent relationships between the P-Cygni and inverse P-Cygni components reflects orthogonality instead of physical features.

Fig 5. Top row is the result from PCA on SU Aur. (a) Shows a component similar to the mean profile. (b) Shows hints of a P-Cygni component. (c) Shows hints of an inverse P-Cygni component. Bottom row is the result from PCA on synthetic data where the P-Cygni and inverse P-Cygni components are independent of each other but we see a relationship in (e) and (f).

### Correlation Matrices




For every velocity channel across the H$\alpha$ line profile, we calculate the correlation coefficient with every other velocity channel. The resulting matrix characterizes both the overall variability and localized velocity-dependent structure.

Fig 6. Correlation matrices for (a) RY Tau, (b) IQ Tau, and (c) CI Tau. The white space in (b) and (c) is due to wavelengths not being covered on the detector so we arbitrarily set the line profile values to 1. This means there is no variability and thus we cannot compute the correlation coefficient. We set the correlation coefficient value to 0.

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