Monitoring Long-term Variability of Optical Spectra and Extended Jets for Active T Tauri Stars

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Abstract

We present optical spectroscopic/spectrophotometric monitoring of four active T Tauri stars (DG Tau, RY Tau, XZ Tau, RW Aur A) at high spectral resolution (R > 10^4) and wide spectral coverage (~3700–10500Å) using CFHT-ESPaDOnS. The goal of the study is to investigate the correlation between time variable mass ejection seen in the jet/wind structure of the driving source and time variable mass accretion probed by optical emission lines. Through the observations for 10-20 years, this may allow us to constrain the understanding of the jet/wind launching mechanism, the location of the launching region, and the physical link with magnetospheric mass accretion. Our initial results in 2010-2012 have confirmed the presence of long-term time variability separates from the daily and monthly variability. This is so far consistent with the idea that these line profiles have a long-term variability (3-20 year) related to episodic mass ejection suggested by the structures in the extended flow components. We also investigate the correlations between equivalent widths and between luminosities for different lines. We find that these correlations are consistent with the present paradigm of steady magnetospheric mass accretion and emission line regions that are close to the star. Monitoring observations of extended flow components are also in progress using Gemini-NIFS.

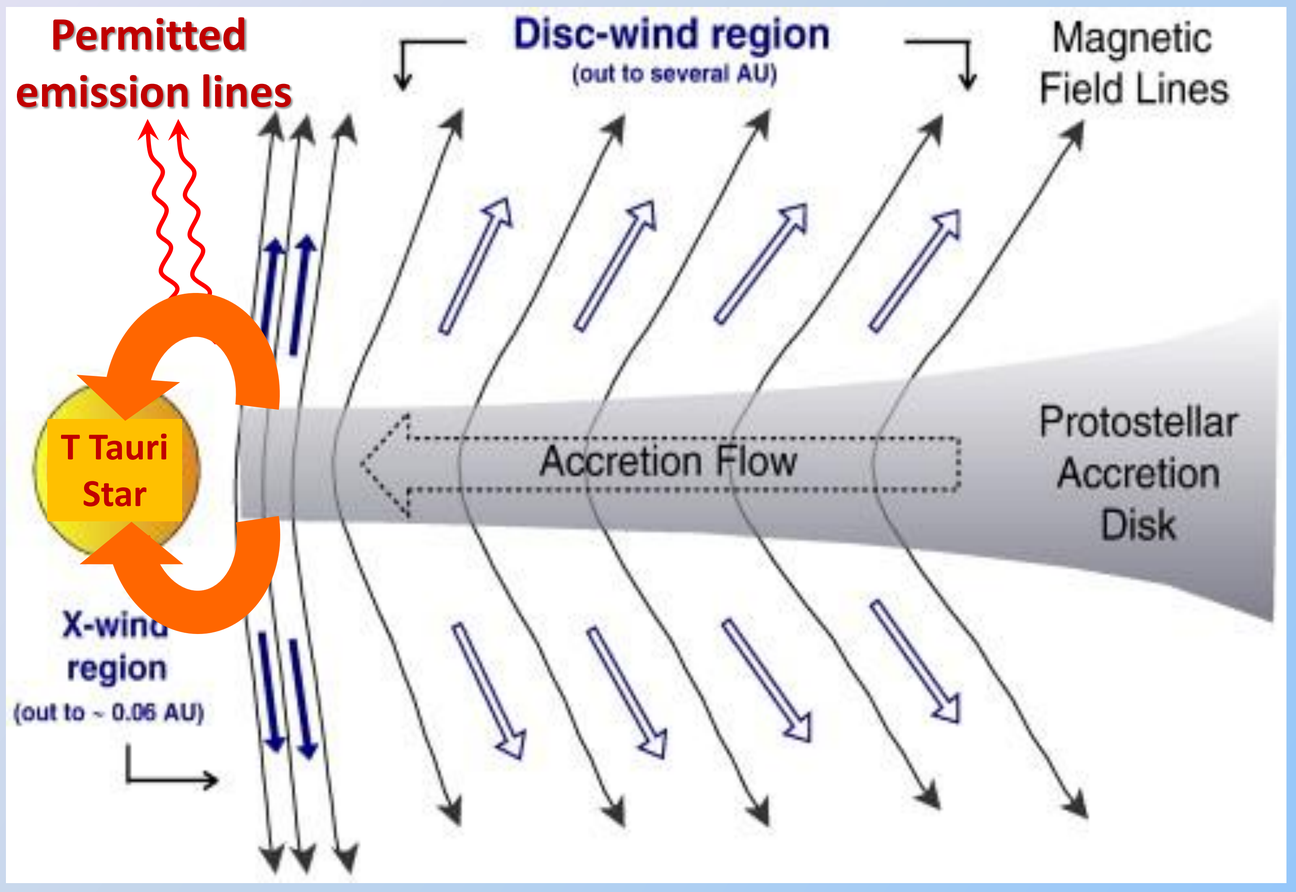

Fig. 1: A diagrammatic view of a T Tauri star and the protostellar disk (modified from Salmeron & Ireland 2012), which shows the jet launching region for disk-wind (out to several AU) and x-wind (within 0.1AU) models. However, observational studies for resolving the jet launching and flow acceleration region have been hampered by the limited angular resolutions of present telescopes. Here we adopt another approach by monitoring the features for mass ejection and accretion, including observing permitted emission lines of Hα and Paschen series, He I, Na D, O I, and Ca II triplets.

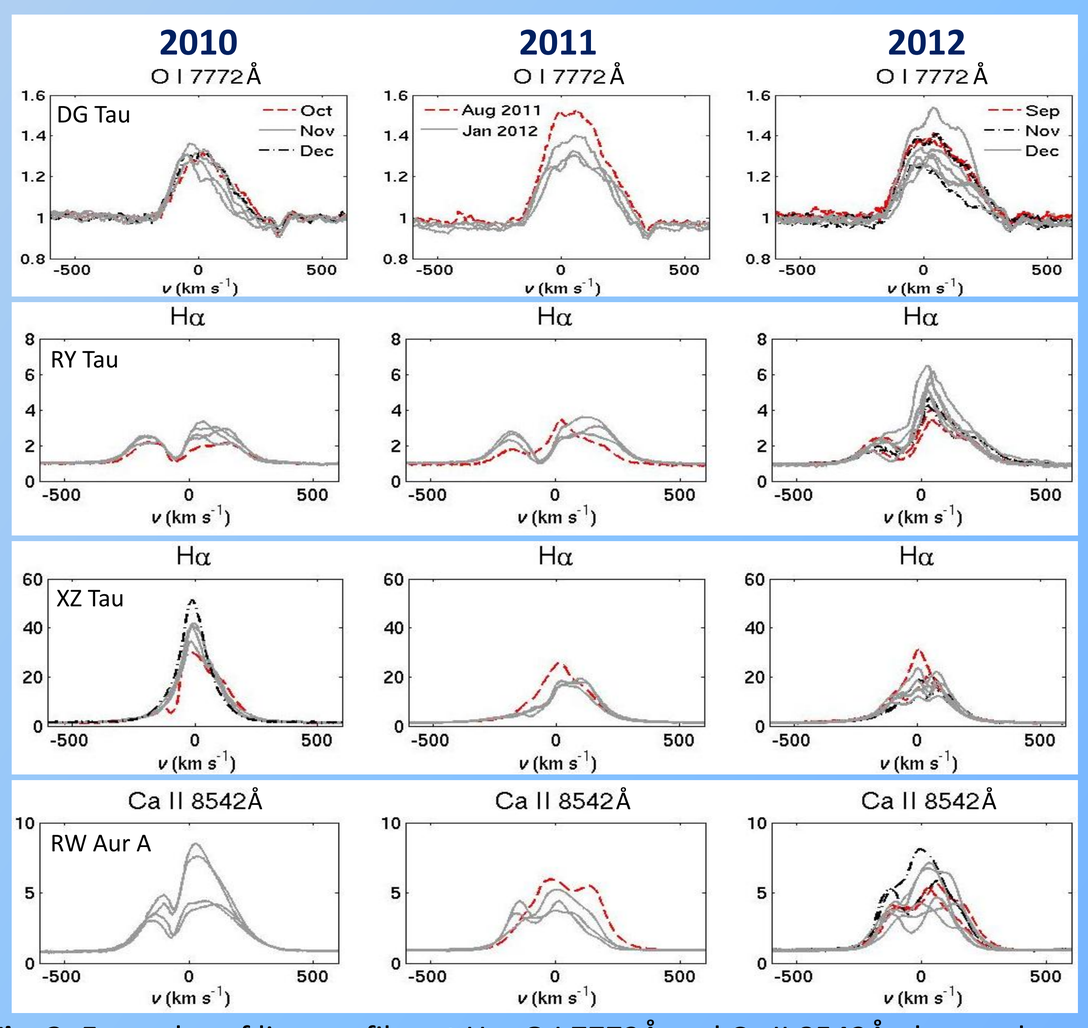

Fig. 2: Examples of line profiles at Hα, O I 7772Å and Ca II 8542Å observed using ESPaDOnS at CFHT from 2010-2012. The line profiles show long-term variations (> 1 yr) over short-term variations (<< 1yr) during our observations.

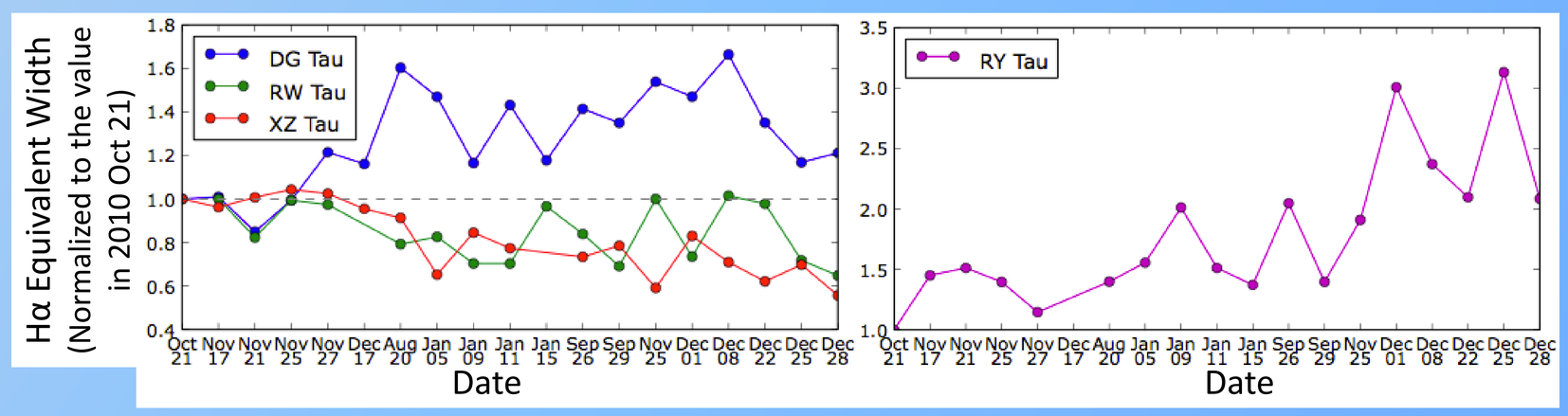

Fig. 3: (Right) Variations in the Hα equivalent widths for four target objects. Those in RY Tau and the other objects are shown separately to clearly show the long-term variation for the former.

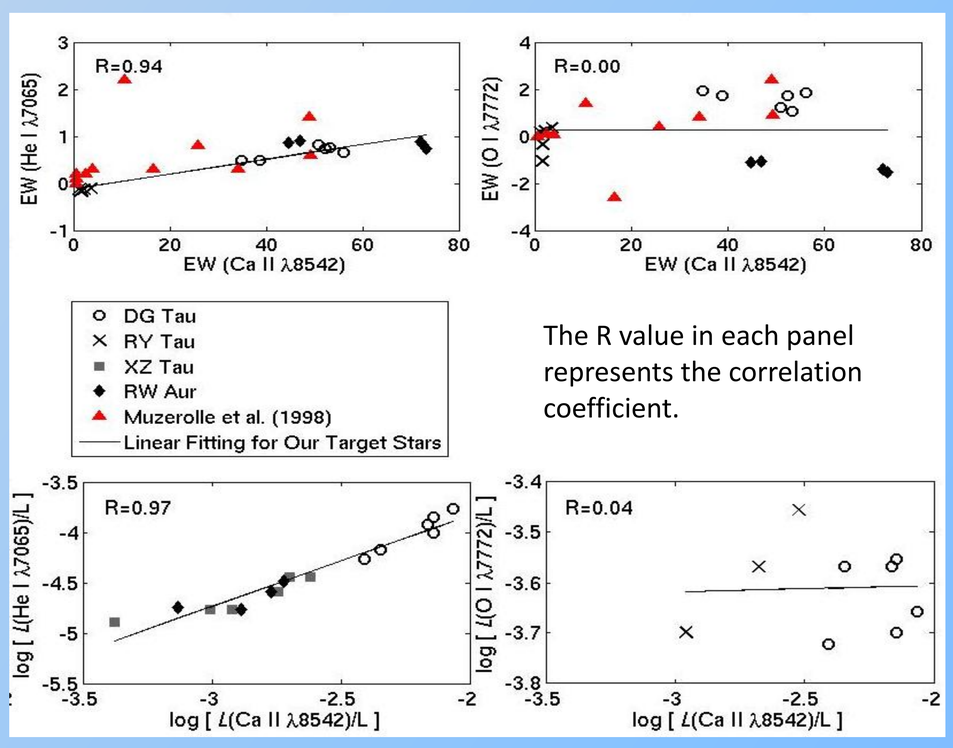

Fig. 4: Example correlations of equivalent widths and luminosities for the observation in 2010. **(Upper)** Correlations for equivalent widths between Ca II 8542 Å , He I 7065 Å and O I 7772 Å . **(Lower)** Same as the upper plots but for the extinction-corrected line luminosity. Only those with positive equivalent widths are used.

Data have not been released!

Fig. 5: Gemini-NIFS observations of the [Fe II] 1.64 μm emission in a blueshifted jet or wind in four active T Tauri stars at a ~0".1 resolution. The green cross shows the stellar position. Residuals of the continuum subtraction at the star are masked with a black ellipse. The length of the white arrow in each image shows the approximate proper motion per year suggested by the literature. The flow structures and proper motions in DG Tau, RY Tau, and RW Aur A suggests episodic mass ejection with intervals of a few years. The details can be seen in Beck et al. (in prep.) and White et al. (MNRAS, submitted).