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Accretion dynamics in pre-main sequence binaries

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Abstract. Binary stars are a common outcome of star formation. Orbital resonances, especially in short-period systems, are capable of reshaping the distribution and flows of circumstellar material. Simulations of the binary-disk interaction predict a dynamically cleared gap around the central binary, accompanied by periodic "pulsed" accretion events that are driven by orbital motion. To place observational constraints on the binary-disk interaction, we have conducted a long-term monitoring program tracing the time-variable accretion behavior of 9 short-period binaries. In this proceeding we present two results from our campaign: 1) the detection of periodic pulsed accretion events in DQ Tau and TWA 3A, and 2) evidence that the TWA 3A primary is the dominant accretor in the system.

1. Introduction

Protostellar disks are integral to the formation of low-mass stars and planets. A paradigm for the star-disk interaction has been extensively developed in the case of single stars. However, most stars form in binary or higher-order systems where the distribution of disk material and mass flows are more complex. Short-period, pre-main sequence (pre-MS) binary stars can have up to three accretion disks: two circumstellar disks and a circumbinary disk separated by a dynamically cleared gap (Artymowicz & Lubow 1994).

2. Pulsed accretion

Theory suggests that mass may periodically flow in an accretion stream from a circumbinary disk, across the cleared gap, onto circumstellar disks or stellar surfaces (Muñoz & Lai 2016). For the near equal-mass, eccentric binaries considered in this proceeding, DQ Tau and TWA 3A (see Figure 1), simulations predict discrete accretion events near each periastron passage. Additional touch points for this theory include the amplitude and timing of variability, and whether one star in the system is preferentially fed. In the next two sections, we observationally test these predictions.

With time-series U-band observations from the LCO 1m network, we derive binary mass accretion rates for DQ Tau and TWA 3A. Both exhibit consistent enhanced accretion events near periastron passage, just as simulations

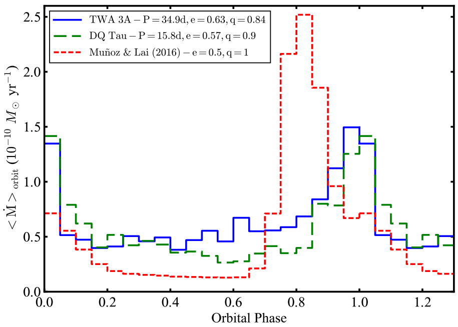

Fig. 1. Median accretion rate as a function of orbital phase for TWA 3A, DQ Tau, and a 2D, AMR, hydro simulation of binary accretion (Muñoz & Lai 2016).

would predict (Tofflemire et al. 2017a,b). Near periastron, the specific accretion rate can increase by a factor of ~3-10 from the quiescent value. Figure 1 compares their median accretion rate profiles to the results of a 2D hydro simulation of binary accretion.

3. Kinematics of accretion tracing emission lines

Over 3 consecutive TWA 3A orbital periods, we have obtained 14 SALT/HRS echelle spectra (R~30k). Figure 2 presents the accretion tracing emission line He I 5876Å where, due to its relatively narrow width, we can trace which star is predominantly accreting. The line centroid regularly falls at the primary's velocity suggesting it is the main receiver of circumbinary accretion streams.

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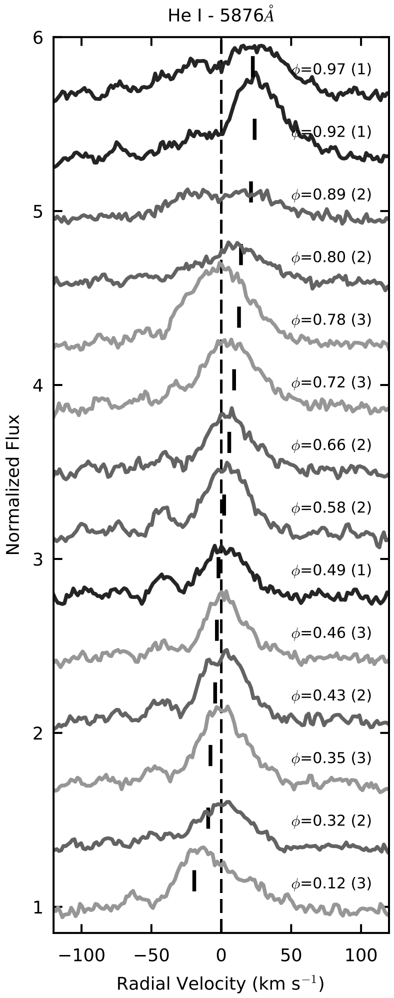

Fig. 2. TWA 3A – Velocity structure of the accretion tracing emission line He I 5876Å. The spectra are ordered by orbital phase from bottom to top, which is presented to the right of each line. Observations are not all from the same orbital cycle; the number in parenthesis and the color of each line denotes the orbital cycle. Short, vertical lines mark the primary velocity.

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