Revising Circumstellar Disk Evolution – How Binaries Change the Picture

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Abstract. We combine new and previously published high-angular resolution near-infrared spectroscopic and photometric observations to measure the presence of accretion and hot circumstellar dust around the individual components of visual multiple stars and confirmed singles with separations between ∼20 and 800 AU in the Orion Nebula Cluster, Chamaeleon I, and Taurus star-forming regions. The data provide evidence for an accelerated disk dispersal in binaries – in particular of the less massive stellar component – at a mass accretion rate identical to that of single stars. Our findings have stringent implications on circumstellar diskparameters, which have been traditionally inferred from observations of "binary-contaminated" samples. For example, we find an increased single star accretor fraction, i.e., evidence for a longer single star disk lifetime, compared to previous surveys.

1. Introduction

Most stars form in binary systems The primary consequences for the T Tauri phase are the truncation, stirring, and irradiation of a circumstellar disk by the companion star. This environment is expected to result in a reduced disk lifetime and a predominance of circumprimary over circumsecondary material with possible implications for, e.g., planet formation around either component.

Previous binary observations have found that disk frequencies are indeed reduced (e.g., Kraus & Hillenbrand 2012; Cieza et al. 2009; Bouwman et al. 2006). As most do not resolve binaries into individual components, these studies do not provide information about whether the primary or secondary or both components are disk-bearing or about a correlation with the individual stellar component masses. This information is, however, vital to infer relative disk appearance, compute mass accretion ratesand find the true multiple star component disk lifetime as a function of binary separation and mass ratio.

2. The Current Study

We combine results of the stellar, accretion and hot inner disk properties of single stars and the individual components of 56 binaries in the Orion Nebula Cluster (Daemgen et al. 2012) and Chamaeleon I (Daemgen et al. 2013; Meyer & Daemgen 2014, *in prep.*) star-forming regions with a re-analysis of spatially resolved and unresolved literature data from the Taurus region (Kraus & Hillenbrand 2012; White & Ghez 2001; Hartigan & Kenyon 2003; McCabe et al. 2006). The binary component data are used to infer absolute and relative disk lifetimes, as well as mass accretion rates for single and binary star components.

3. Results

3.1 Revised disk lifetimes for binary components and single stars

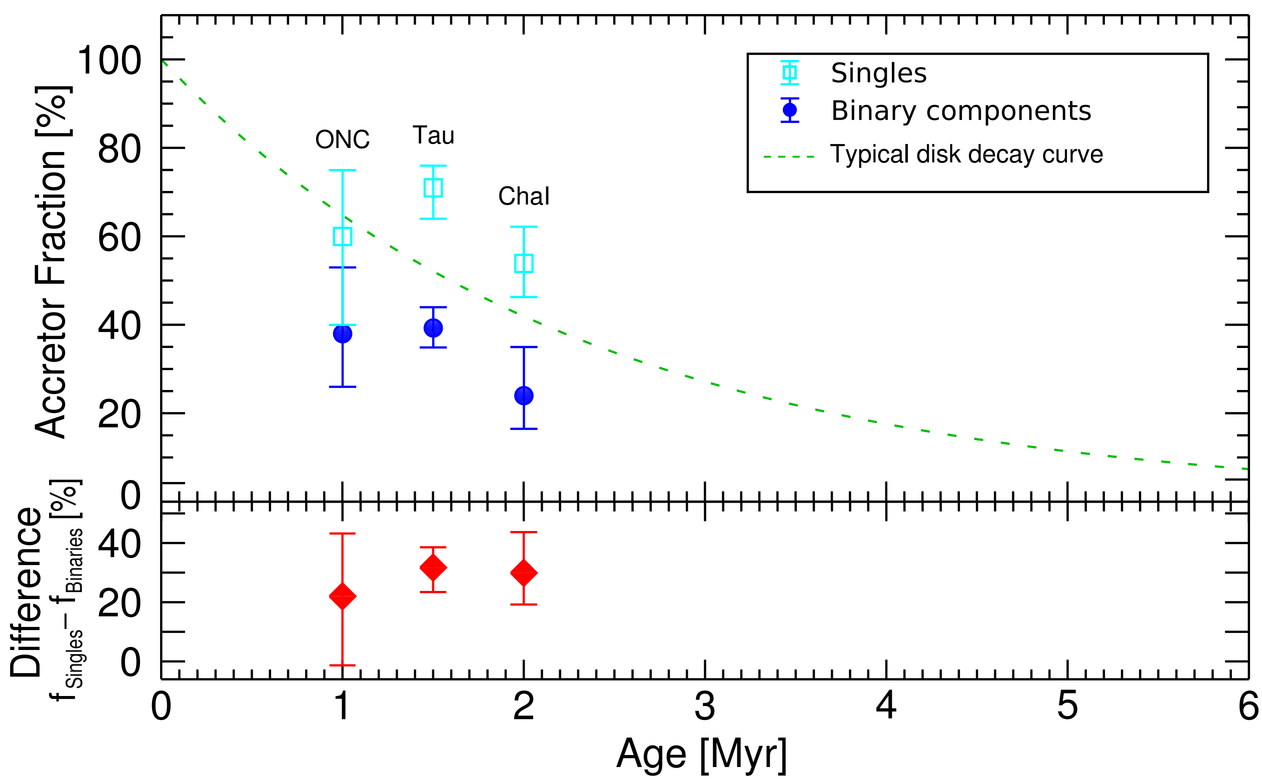

Figure .1: **Top panel:** Accretion disk frequency as a function of the age of the star forming region for singles and close binaries (sep ≈ 20–200 AU) respectively. The dashed line shows the accretion disk decay found by Fedele et al. (2010). References for the individual measurements in Sect. 2. **Bottom panel:** Difference between the single and binary fraction shown in the top panel.

Fig. .1 demonstrates a significantly reduced frequency of accretors among components of binary systems with separations $\leq$ 200 AU. The fraction of single stars with disks appears higher than found in previous surveys because contaminating binaries – with their lower disk frequency – have been removed from the single star samples (except Orion Nebula Cluster, ONC, Rebull et al. 2000; Robberto et al. 2004). We find that disk lifetimes of single stars might be up to ∼50% longer than previously assumed.

3.2 Mass accretion rates of binaries are the same as in singles

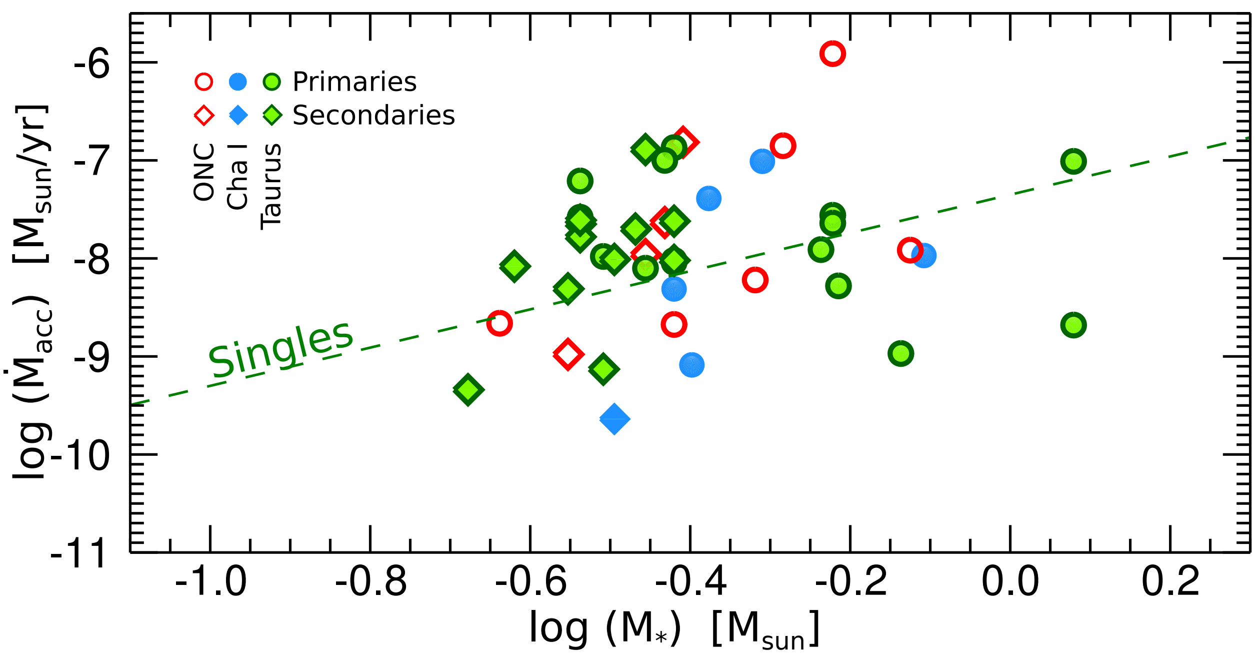

Figure .2: Mass accretion rates of the primaries and secondaries of binaries in the three targeted star-forming regions (Daemgen et al. 2012, 2013; Hartigan & Kenyon 2003). The single star correlation determined by Antoniucci et al. (2011) is shown with a dashed line.

Accretors in binary systems show similar mass accretion rates as single star accretors as well as no significant variation among the star-forming regions (Fig. .2). Together with the notion that binaries accrete, on average, for a shorter time (Sect. 3.1), this points to a smaller reservoir to accrete from (≡disk truncation) and/or a sudden shut-off of accretion induced by the presence of a binary companion.

3.3 Differential disk evolution as a function of separation

The separation distribution of binaries with two accreting components appears more peaked at the closest separations. This implies that close binaries in Orion, Chamaeleon I, and Taurus synchronize their disk evolution to a higher degree than wide binaries. This may be caused by feeding of disks from circumbinary reservoirs or point to angular momentum as one of the driving parameters for disk evolution. We find more accreting primaries than secondaries, in agreement with the more massive component accreting for a longer time than its companion.

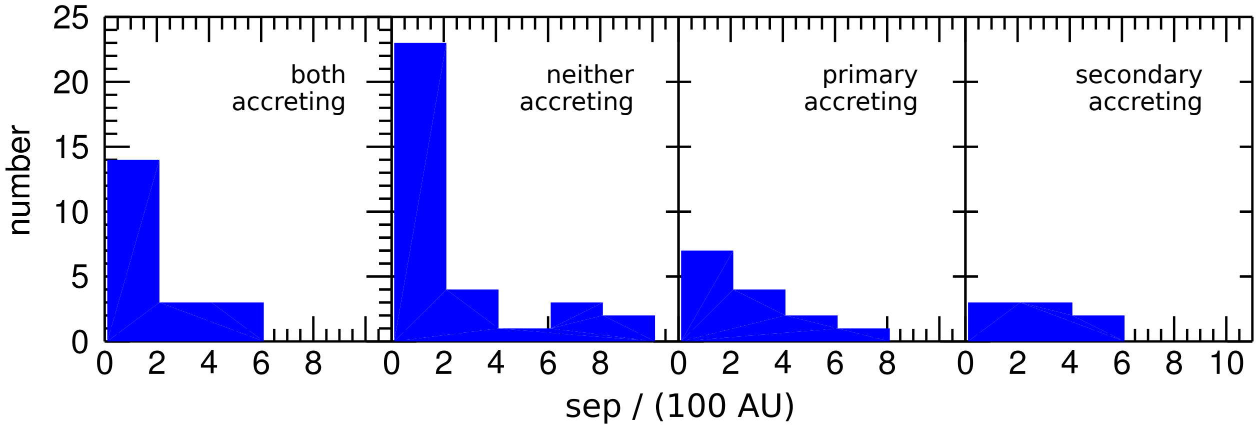

Figure .3: Number of binary star accretors per separation bin in four categories: Binaries with two accreting components, neither component accreting, or accretion found for either the more massive or less massive.

4. Outlook: Binary Disk Mass Evolution with ALMA

While the current study illuminates processes at the inner edge of the individual disks of young binaries, the distribution of the bulk of the mass – at cold temperatures and large radii from the star – remains largely unknown. We will investigate the correlation between the evolution of accretion/hot inner disks of binaries with the distribution of cold outer material by supplementing the current study with spatially resolved ALMA cycle 2 observations of a subset of our binary targets.

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