The Evolution of Protoplanetary Disks in T Tauri Binary Systems

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Binaries are the most common outcome of star formation. However, the impact of binarity on the evolution of primordial circumstellar disks, which are the birthplaces of planets, is currently only little constrained by theory and observations. Consequently, star and planet formation in binary systems may be significantly different from that in single stars.

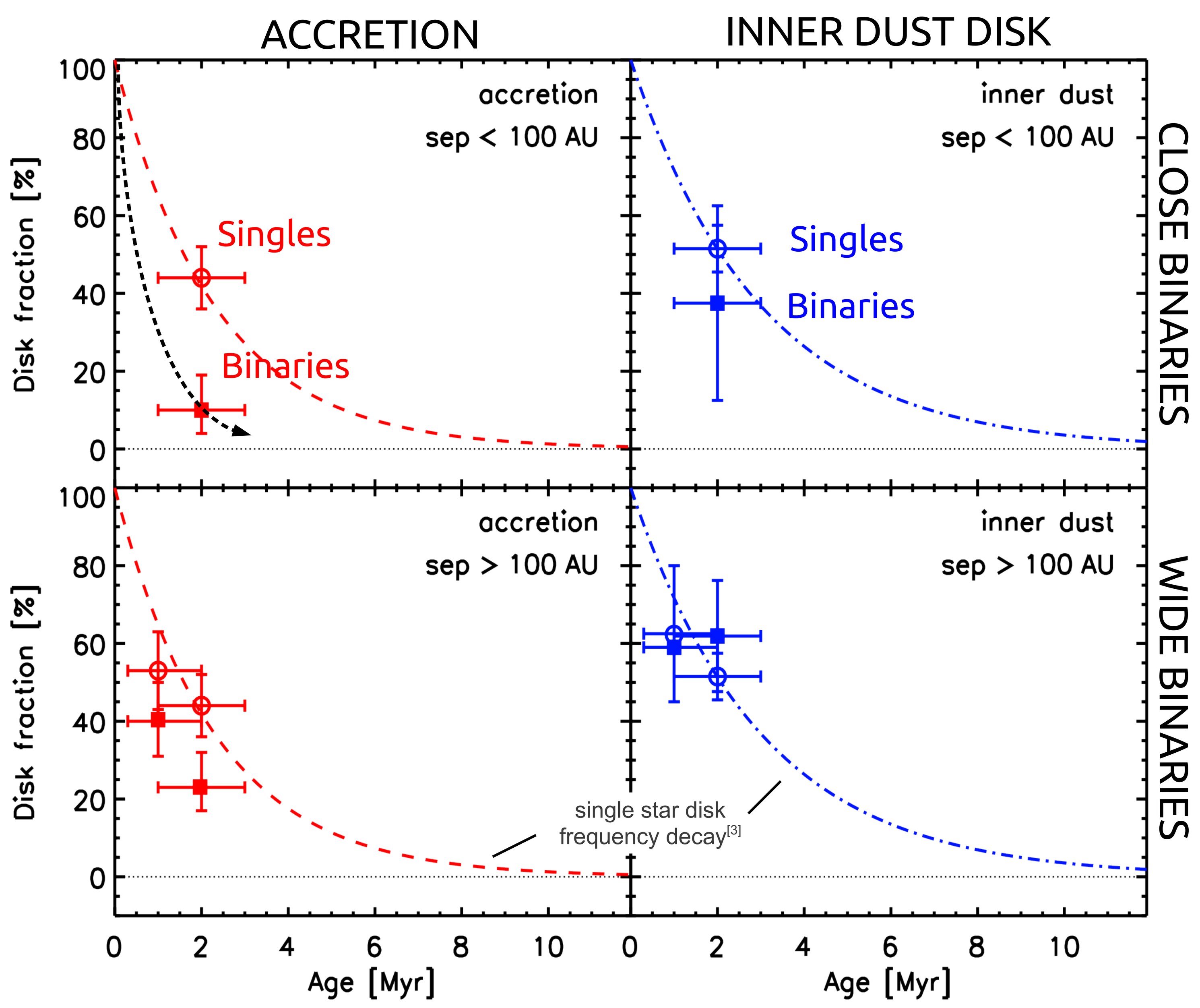
We present results from two of the largest coherent studies of the evolution of circumstellar disks around the components of binary stars to date[1,2]. 52 binaries were observed in the Orion Nebula Cluster (ONC) and Chamaeleon I (Cha I) star-forming regions with near-infrared photometry and spectroscopy. We quantify the presence of circumstellar accretion and dust disks around the individual components of low-mass binary stars with respect to their inferred stellar (e.g., mass, luminosity, T_{eff}), binary (binary separation, mass ratio), and cluster parameters (age, stellar density, presence of strong ionizing sources, star formation history).

DISK FREQUENCY DECAY AROUND BINARY COMPONENTS

Accretion disk frequency is reduced in close binaries

I

⇒ inner gas disks around the components of binaries evolve and disappear on a shorter timescale compared to single star disks



Hot dust around the individual components

II

of binaries survives almost as long as in singles

We observed 52 multiple stars in the ONC and Cha I star-forming regions with high-spatial resolution adaptive optics imaging and spectroscopy in several near-infrared bands. Brackett-γ emission was used as a tracer for accretion (i.e., inner gas disks) and NIR color excess as an indicator for the presence of hot dust in the inner disk.

The figure to the left shows the frequency of accretors and inner dust disks in the ONC (at 1Myr) and ChaI (at 2Myr) for wide and close binaries respectively. This is compared to single stars in the same clusters and to the decay of disks as a function of age[3].

The figure to the right shows the separation distributions of binaries with two or no accreting components, and mixed systems with an accreting primary or secondary. The statistics were compiled from our two surveys and additional data from the Taurus region [1,2,4,5].

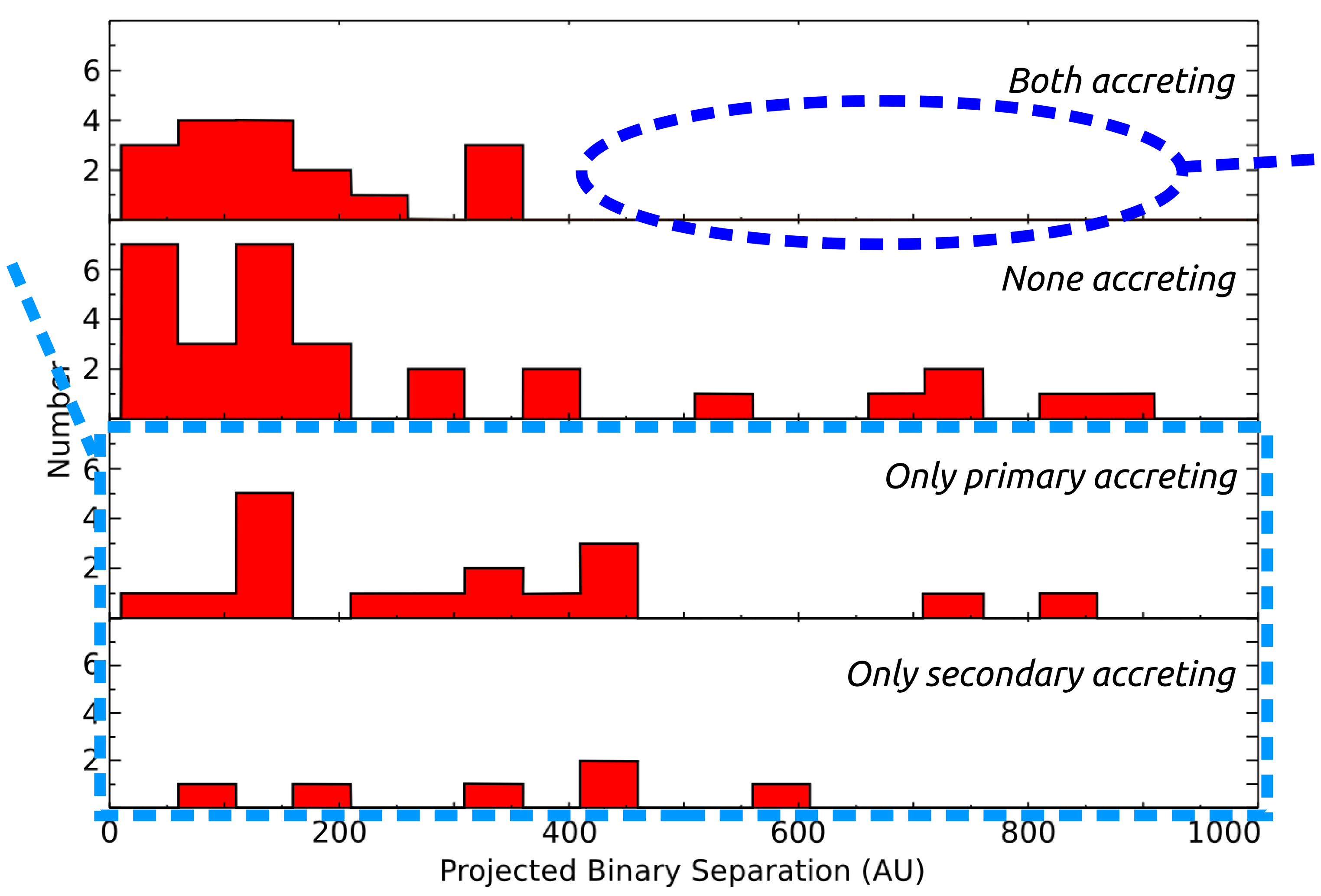
Additional analysis shows no difference between the mass accretion rates of binary components and those of single stars. Our data are consistent with previous findings that binary components are coeval.

PRIMARY VS. SECONDARY ACCRETION DISKS

Despite their equal age, Either binary component can be host to a longer-lived disk

III

⇒ Mass & separation are not the only parameters which determine disk properties



Where are the wide binaries with two accreting disks?

IV

⇒ Close systems synchronize their evolution more often

Possible reasons:

- Circumbinary reservoirs
- Angular momentum distribution

We conclude that stellar multiplicity has a significant impact on circumstellar disk evolution, in particular for binary separations <100 AU. The interplay of disk evolution and stellar multiplicity, however, is complex and requires further investigation since the number of binaries with available individual component disk information is currently small.

Future studies of disk evolution in binaries are underway – using recently acquired data – and more observations are planned. They will extend the present studies to reach better statistical significance in the currently studied clusters as well as target more star-forming regions. With a larger sample, evidences regarding, e.g., the planet formation potential of binaries may be addressed. For example, the intriguing parallel between a lower disk frequency around the components of close binaries and the absence of low-mass ($<1M_{Jup}$) hot Jupiters in the same type of system[6]. Or the fact that close to all planets in binaries were found to orbit the more massive stellar component. The former would be consistent with the formation of low-mass hot Jupiters in a slow process which requires more time than the disk lifetime in close binaries, while higher-mass gas giants form more rapidly. The latter would agree with a disk dispersal around the less massive binary component which is too rapid for the formation of most planets.

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