The Effects of Binarity on Disks and Planet Formation

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Introduction

Binarity inhibits planet formation through disk truncation/dissipation, hastened accretion amd photoevaporation, and dynamical stirring. Binary systems seem to produce fewer, less massive, and different planets. However, without a statistically robust sample, it remains unclear how particular orbital parameters such as eccentricity or semi-major axis influence the presence and properties of planet-forming disks.

Methods

We employ the Keck II - NIRC2 telescope/instrument with adaptive optics (AO) and aperture mask interferometry (AMI) over multiple decades to measure orbits of solar system scale binaries. We use the Sydney NRM IDL code (M. Ireland et al.) with updated flat fielding, cosmic ray rejection, read noise mitigation, and correction of hot/bad pixels. We compare to *SAMpy* and literature values for validation. Then, we use *orbitize!* in python for an MCMC based orbit fit. We will apply these techniques to our sample of ~25 binaries within 25 AU and compare to disk-free in the Taurus region to measure disk presence against orbital parameters. With orbits, we will then extract information on the disk presence from IR or mm flux using a combination of Spitzer, ALMA, or SMA.

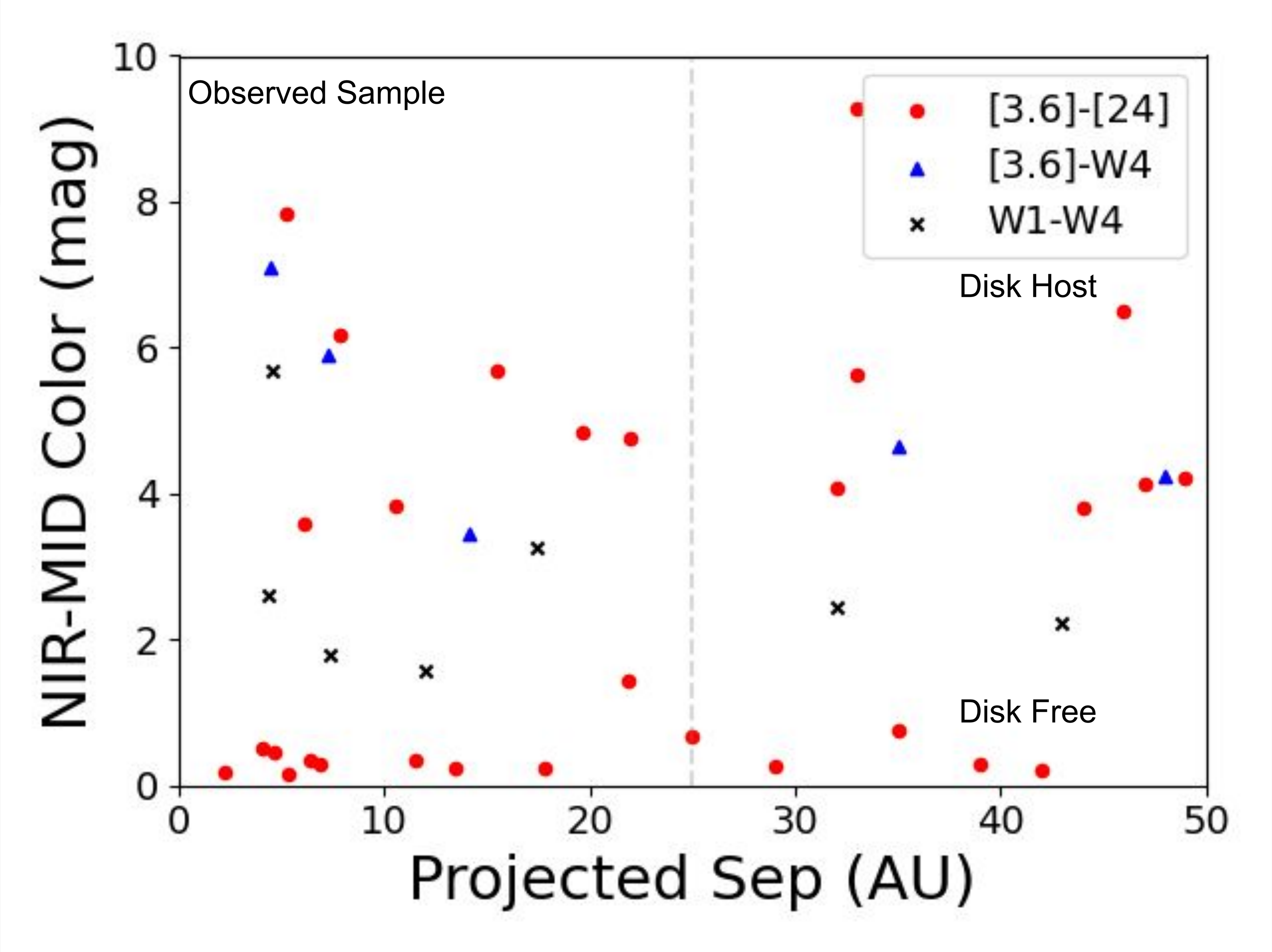

Figure 1 - NIR/MIR color vs projected separation for our sample of young (1-3 Myr) binaries in Taurus-Auriga. Targets at the top show IR excess, indicative of a disk, while those at the bottom do not. Left of the dashed line at 25 AU is our orbit fitting sample.

Early Results

Fig. 1 shows NIR/MIR colors of our sample compared with their projected separation. The points at the bottom are those with no disk, and those above show an excess indicative of a disk. *Fig. 2* shows our orbital fit for *SR 20*, and *Fig. 3* shows the same for *CoKu Tau 4*, where the black line is the highest log-likelihood orbit and the gray lines are 100 random posterior samples. Two points for *SR 20* are taken from Ghez et al. (1995), and one is discrepant due to poor observing conditions, and we found it to minimally affect the fit (within 1σ). We find tight constraints on semi-major axis within σ ~ 0.3 AU as well as eccentricity within σ ~ 0.03.

Future Work

In the coming year, we will analyze the orbits of ~25 systems as here to form a complete sample of the Taurus star forming region. We fit only below 25 AU because at that range (assuming circular orbit of identical solar mass stars) the orbital period is ~90 yr, and it becomes impractical to fit orbits with a maximum of ~30 years baseline. Then, we will collect infrared photometry data to establish the existence and properties of the protoplanetary disks. Finally, with a full sample of orbital and disk properties, we will measure the demographics of disks in binary systems to establish how binarity affects planet formation.

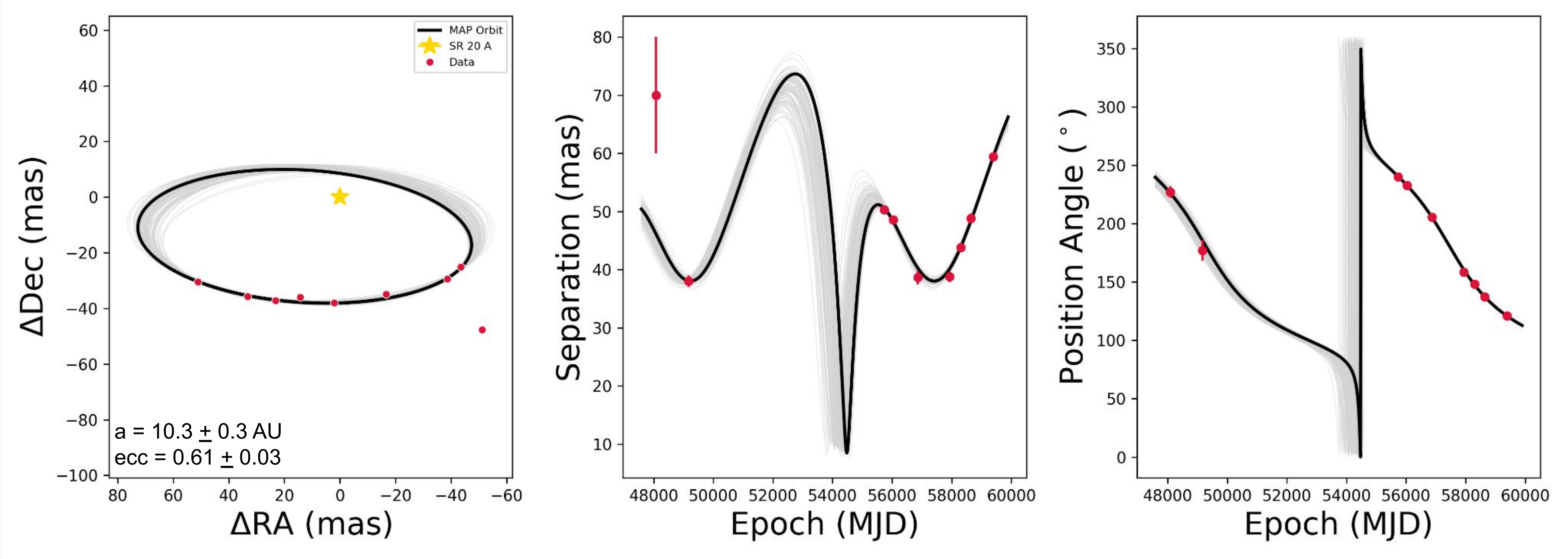

Figure 2 - Orbital fit results for SR 20. The black line shows the highest log likelihood solution, and the gray lines are 100 randomly sampled orbits to show uncertainty. Comparison of this orbit to the resolved disk properties in progress by Taylor Kutra (in prep)."

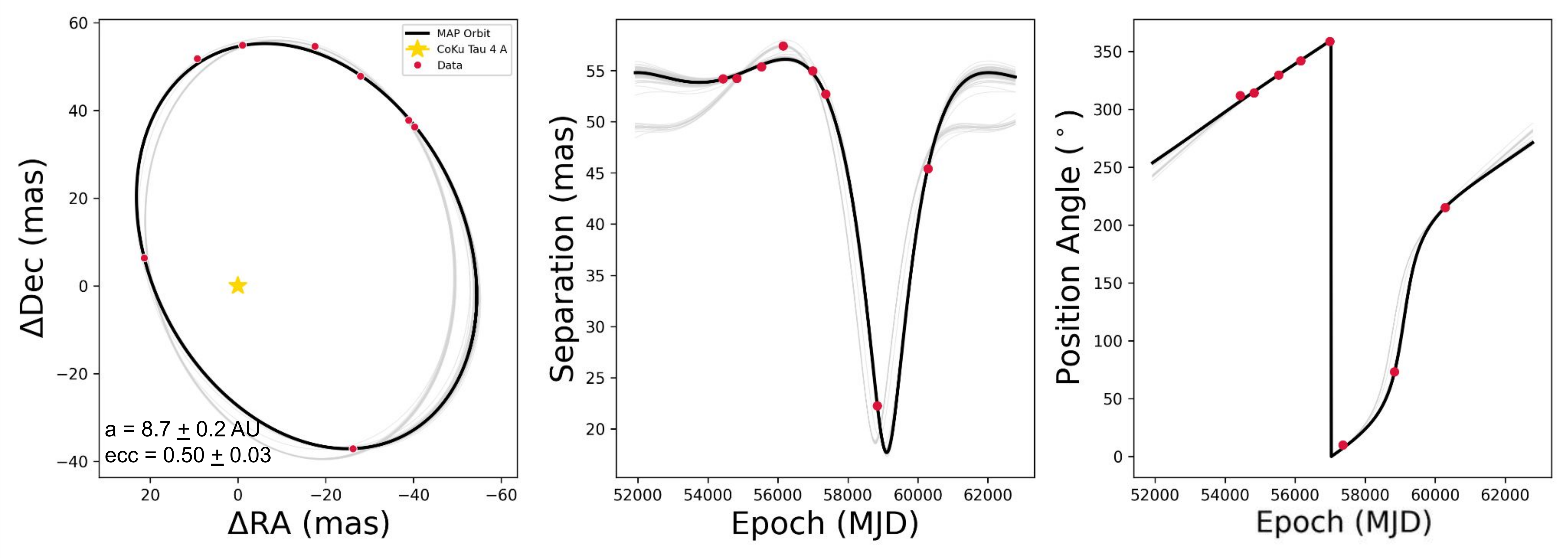

Figure 3 - Orbital fit results for CoKu Tau 4 following format of Figure 2. CoKu Tau 4 lacks inner circumstellar disks and only features a circumbinary disk. Its orbit resembles other binaries like SR 20, so the explanation for the different disk geometry is still unclear.