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Introduction: With near-infrared and millimeter interferometry we are studying the inner and outer disks of T Tauri stars, and with submillimeter imaging we are observing the disks of low mass stars and brown dwarfs.

Keck IR Interferometry (Inner Disks): The Keck interferometer provides exceptional angular resolution, and we are using this instrument to measure disk sizes at spatial scales less than 1AU. At these scales standard flared disk models predict small sizes unresolvable with the interferometer while more recent models predict a larger inner disk radius.

The observed targets cover a range of evolutionary states and both Solar-type and early-type objects. Only objects in the younger stages were spatially resolved, with squared visibilities ($V^2$) measured by the interferometer as significantly less than unity. The calibrated squared visibility is modeled as arising from an unresolved star and a resolved disk, modeled as a ring structure. As shown in Figure 1, the inner disk sizes suggested by the ring model are typically larger than the dust destruction radii.

Comparison of Observed and Predicted Sizes

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OVRO mm Interferometry (Outer Disks): By mapping Class I and Class II binary systems with millimeter interferometry, we are investigating the distribution and evolution of cool outer dust in young binary systems. Previous studies of Ophiuchus Class 0 binary systems revealed both circumprimary and circumsecondary disks.

The 3mm continuum data spatially resolve the binary pairs, and for both Class I and Class II Ophiuchus systems, the dust emission is dominated by the primary as shown in Figure 2. The circumprimary disks have masses comparable to the Minimum Mass Solar Nebula and show evidence for grain growth. Since massive secondary disks are absent at these stages, the potential for planet formation around secondaries may be significantly reduced. The association of the more massive disk with the primary is consistent with formation models, though the disk mass ratio limits are lower than expected from accretion simulations.

IRS 43

Figure 1: The best fit inner disk sizes are plotted as a function of the combined stellar and accretion luminosity. The inner radii expected for different dust sublimation temperatures are shown for comparison.

The inner disk sizes also have important implications for planet formation models. Theoretical models of planet migration require disk material between the star and the planet to provide a mechanism for angular momentum transfer to occur. Since radial velocity detected extrasolar planets have semi-major axes as small as 0.037 AU, the inner disk radius is expected to be comparable to this value. Interferometer measurements of the inner disk sizes, however, are larger. In a modified disk accretion model, the region interior to the dust sublimation radius is not evacuated, but retains gas that would allow planets to migrate to closer radii than the edge of the dust disk.

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Figure 2: The contours show the 3mm continuum map over the 2MASS image of the Class I source IRS 43. Only the brighter primary star has detectable dust emission.
Figure 2b: The same as Figure 2a except that the source is the Class II object SR 24.

In Taurus four Class I binaries were observed as a complementary sample to a study of Class II binaries that detected more massive circumprimary disks. The Taurus Class I binaries results are different from both the Ophiuchus binaries and the Taurus Class II binaries observed previously. Taurus class I secondary disks are dominant in three of four pairs. The difference may result from misidentification of the more massive component or it may be that small number statistics skewed the initial results. We are obtaining spectra to better characterize the Class I components and to determine which star has higher accretion.

CSO submm Imaging (Disks around Low Mass Objects): With the SHARCII camera operating at 350µm, we are conducted a survey of young (~2Myr) low mass star and brown dwarf members of Taurus in order to determine the frequency and masses of disks across the stellar/substellar boundary. A pilot study for this program was completed. For each of five spectral classes spanning low mass stars and brown dwarfs a target with no known companion and with the highest Hα equivalent width was observed so that the small initial sample satisfied common criteria.

The four stars all have detected submm disks, and the brown dwarf has a weak (2.5σ) possible detection, conservatively taken as an upper limit. For ease of comparison, the 350µm fluxes are scaled to 1.3mm (assuming a $\nu^2$ relation) and plotted on Figure 3 with previous results from millimeter observations. This preliminary result suggests a significant drop in disk flux from the bottom of the Main Sequence to the brown dwarf regime. The brown dwarf upper limit is more consistent with flat disk models than flared disks.


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