Spatially Resolved Silicate Features in T Tauri Binaries with MMT Mid-IR Adaptive Optics

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Introduction

• While Spitzer's unprecedented sensitivity has produced detailed studies of silicate emission from T Tauri stars (Furlan et al., 2006 and others), its limited angular resolution precludes resolving the silicate emission of binaries.

• Ground-based mid-infrared work can complement Spitzer by spatially resolving the brightest binaries.

• We use MMT's unique mid-IR adaptive optics system with MIRAC4 to resolve T Tau (0.68"/0.12" hierarchical triple) and XZ Tau (0.3" binary) in narrow-band silicate filters.

Future work with mid-IR AO

I. We are in the process of resolving a large population of binaries in the mid-infrared. This sample will be useful for determining how the silicate feature varies between binary components, and which stellar properties affect grain-growth in coeval pairs.

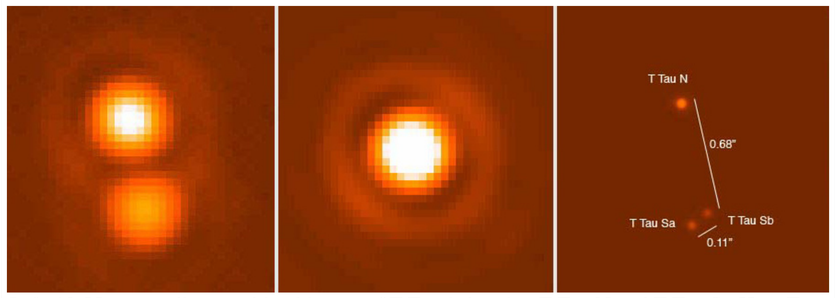
II. In our most recent telescope run, we used MIRAC4's grism mode to resolve XZ Tau with a low-resolution spectrograph. We are still working to reduce the data, but we should soon have resolved mid-IR AO spectra!

III. We are in the process of expanding our superresolution techniques to disks.

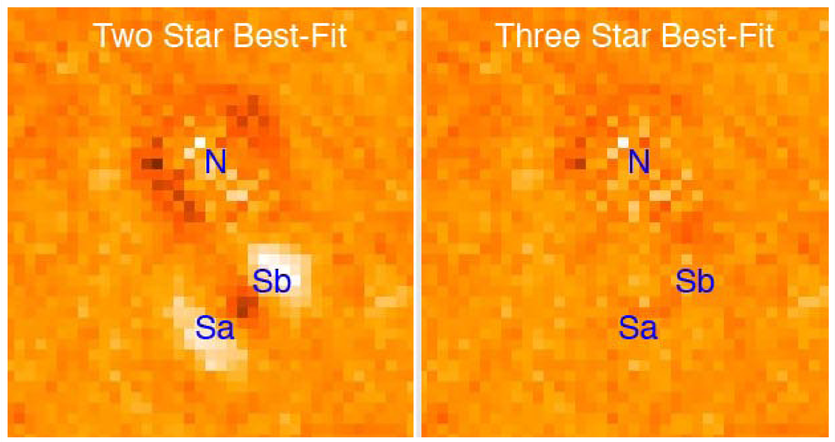
IV. All of this work will provide a valuable test-bed for JWST science.

T Tau

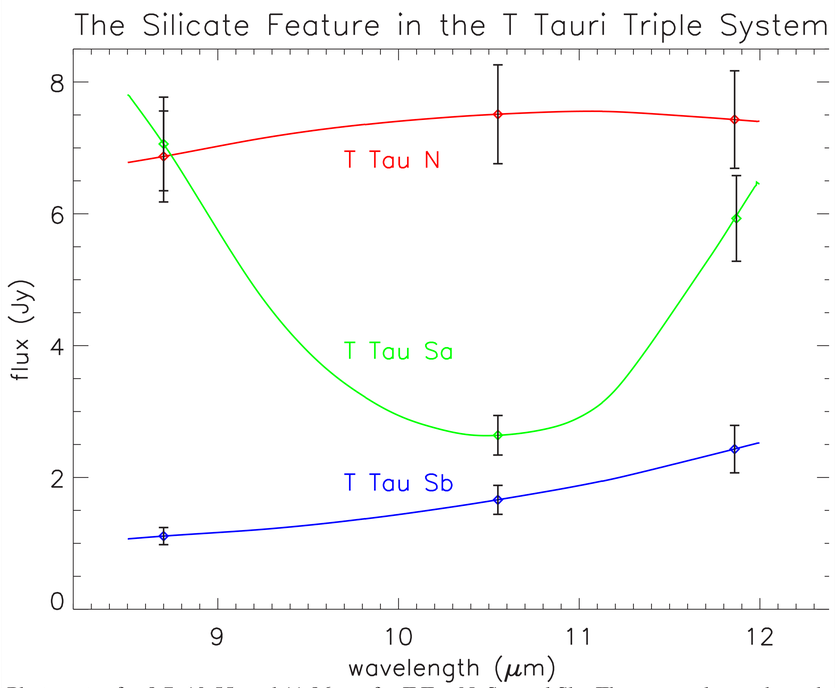
(Skemer et al., 2008, ApJ)



Left: 10.55 μm median combined image of T Tauri showing T Tau N and T Tau S. Here T Tau S appears to be unresolved. (For all three graphics, North is up and East is left. The images are 1.7" on a side). *Center:* 10.55 μm median combined image of Beta Gemini (the PSF used to deconvolve T Tau). *Right*: Schematic of the T Tauri system, with 10.55 μm photometry and astrometry as derived by our group.



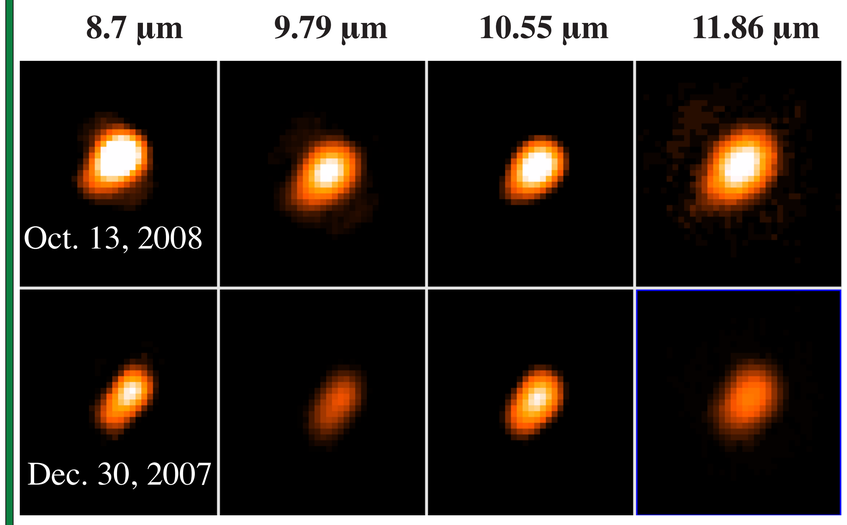
Levenberg-Marquardt best-fit residuals at 10.55 μm with two-star (left) and three-star models (right). The three-star fit has residuals at the photon noise floor.



Photometry for 8.7, 10.55, and 11.86 μm for T Tau N, Sa, and Sb. The curves drawn through the points are intended as a visual aid. T Tau Sa has a large absorption feature that is absent from the other stars, which indicates the presence of an edge-on protoplanetary disk. Since the other stars lack a similar feature, we infer that the disks in the T Tauri system are misaligned.

XZ Tau

(Skemer et al., 2009, in prep)



Images of XZ Tau taken ~1 year apart show dramatic changes in the system. The N-band variability of XZ Tau has been studied extensively with Spitzer (Leisenring and Bary, this conference). We are now able to constrain that variabilty to the North (primary) star. We also note that the system as a whole is currently brighter in the N-band then it has ever been. This could be the result of a dramatic accretion outburst.

Oct. 13, 2008

	8.7 μm	9.79 μm	10.55 μm	11.86 μm
Δmag	1.54	1.49	1.61	2.19
Total flux (Jy)	5.78	7.03	6.59	6.56
North flux (Jy)	4.65	5.61	5.37	5.79
South flux (Jy)	1.12	1.42	1.22	0.77

Dec. 30, 2007

	8.7 μm	9.79 μm	10.55 μm	11.86 μm
Δmag	0.69	0.48	0.56	0.52
Total flux (Jy)	2.66	2.55	2.48	2.45
North flux (Jy)	1.74	1.55	1.55	1.51
South flux (Jy)	0.92	1.00	0.93	0.94

Conclusions

• We have resolved the famous hierarchical triple system, T Tauri, and find evidence that one of its stars (T Tau Sb) has an edge-on disk, that is probably misaligned with the system's other disks.

• We have resolved the binary XZ Tau at two epochs and determined that its previously observed variability is dominated by one star (XZ Tau N).

• Spatially resolved spectra of XZ Tau and other binaries are coming soon!