ALMA band 6 high-angular resolution observations of disks around M dwarfs in Taurus

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Large Double-ring disk around J04124068+2438157

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Introduction

A variety of substructures have been revealed by recent high-angular resolution ALMA observations (Andrews+2018; Long+2018). However, **most such observations target at Sun-like stars, little is known about substructures in disks around M dwarfs**. Correlations between disk substructures with the stellar mass will help reveal the physical causes of those properties.

Disks around M Dwarfs are expected to be smaller hence their substructures as well, which will need the most extended ALMA configurations to resolve.

Observations & Model

ALMA Band 6 observations toward six mid-M dwarfs (M3-M5) in Taurus:

- Beam size: ~40mas (C43-9/10)
- On-source time: ~ 15min
- Sensitivity: ~ 35mJy/beam

Visibility modeling:

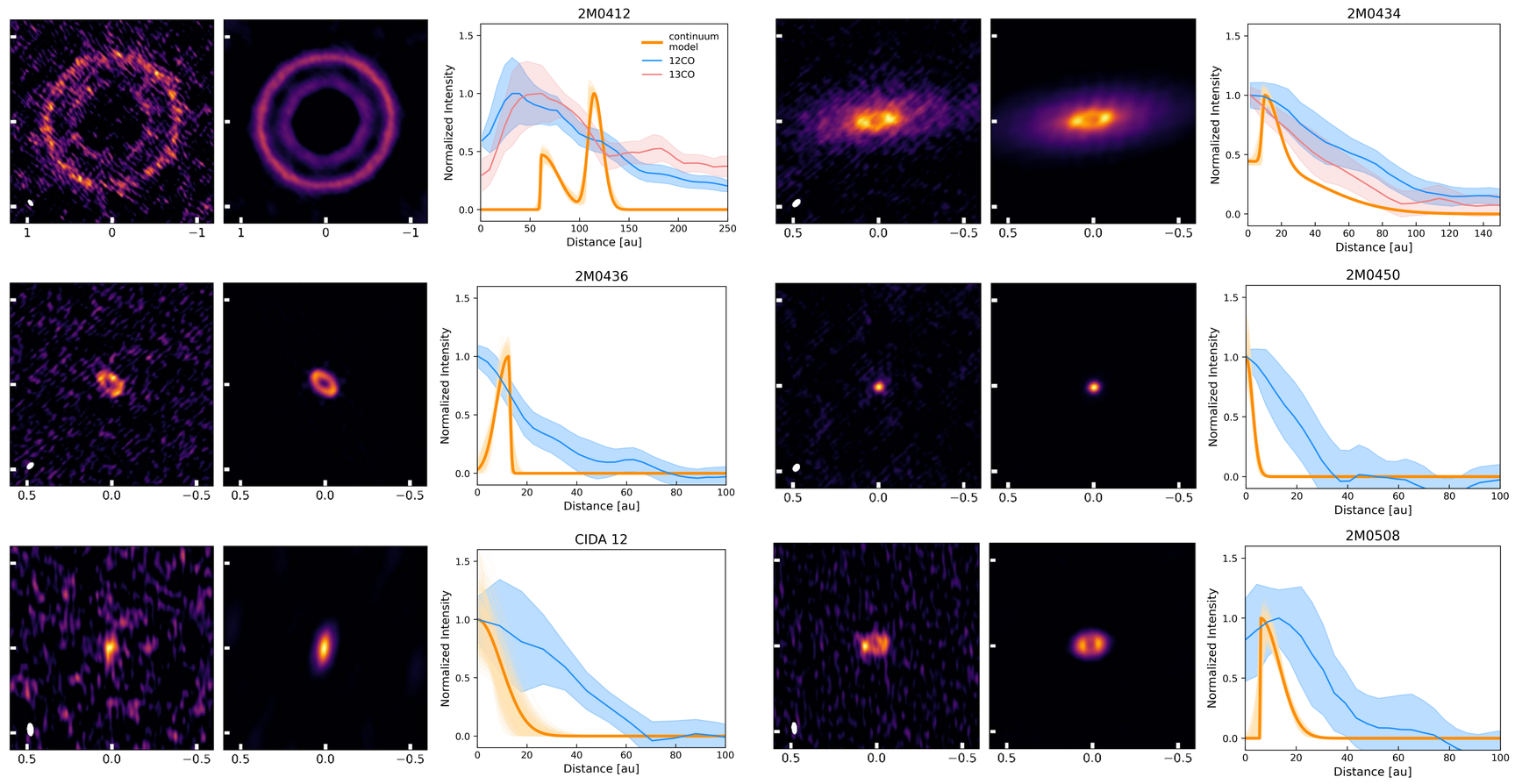
- Galario (Tazzari+2018) to convert model images into visibilities
- Smooth disks as Gaussians
- Rings as radially asymmetric Gaussian ring

Conclusions

- With high-angular resolution, substructures around M dwarfs seem to be common.
- 10 au cavities are the most common in our sample which may relate to photo-evaporation
- SEDs imply dust segregation

More ALMA observations of M-dwarf disks are needed!

Results

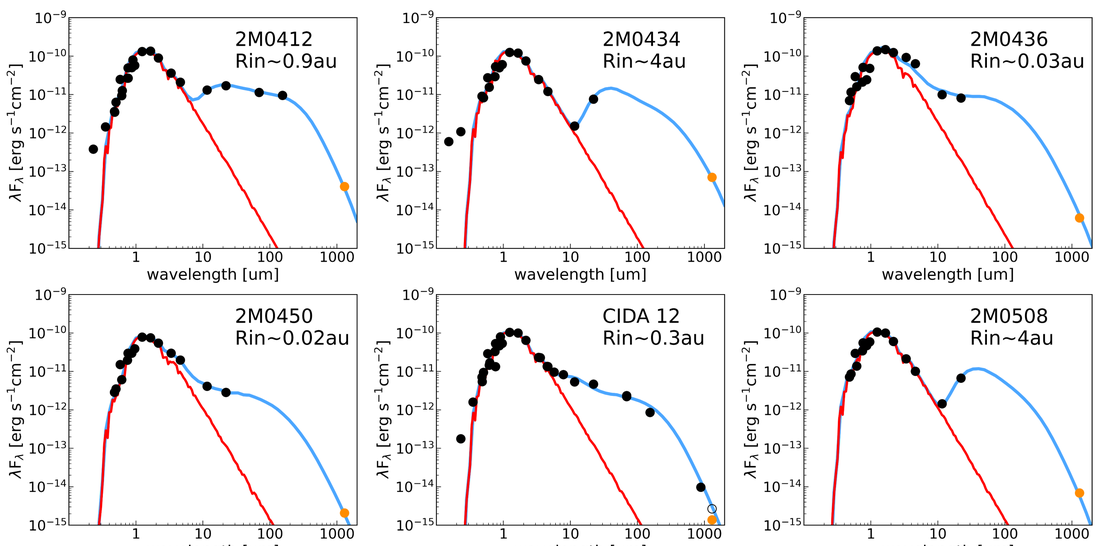


Dust emission

- Four disks have dust substructures detected which are all cavities and rings. The cavity sizes range from ~60 au to 7 au
- Most cavity sizes are around 10 au, matching expectations for photoevaporation (e.g., Owen+2017).
- Models favor an outer tail with sharp inner edge except for 2M0436. Possibly an unresolved inner disk emission in 2M0436 blends with the outer ring.
- $R_{90\%}$: 126.0, 81.2, 13.2, 5.1, 19.6, 20.4 au

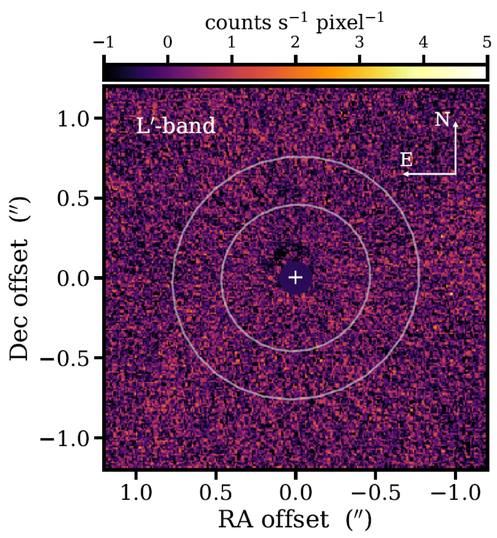
CO gas emission

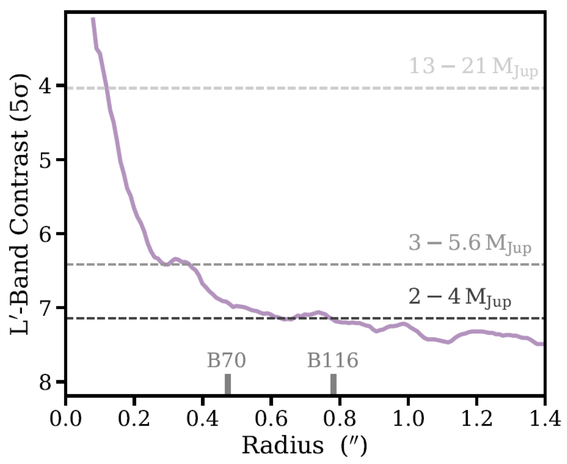
- 2M0412 shows a CO cavity size smaller than dust cavity which hints for dust segregation
- 2M0436 & 2M0450 show a gas-to-dust disk size ratio of ~5 which indicates more efficient dust radial drift in those disks. (Caveat that gas emission is likely not fully recovered)



Infrared SEDs of the six disks show evidence of cavities also present in small dust grains. Through radiative transfer modeling using RADMC-3D (Dullemond+2012), possible solutions show cavities for three disks structured in mm images and for one smooth disk.

Keck/NIRC2 observation of 2M0412





- No stellar companions beyond 10 au
- Contrast of 7.1 in the gap
- Upper limit on companion of 3.9 M_j for 4.7 Myr (or 2.1 M_j for 1.6 Myr) from BEX models