Using (sub)millimeter interferometry to constrain circumstellar disk models

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To understand the process of planet formation we must turn to the environment of the early stages of this process – the disks of gas and dust found around young stars. In the recent years, the use of submillimeter interferometers has enabled us to investigate some of the main physical parameters of circumstellar disks in a way far better than can be done with other observational techniques.

We present some results from our resolved observations of circumstellar disks IM Lup and HD169142 with the Submillimeter Array* which illustrate how we can investigate disk inclination, mass, surface density exponent, disk outer radius and disk vertical structure and better constrain the existing models.

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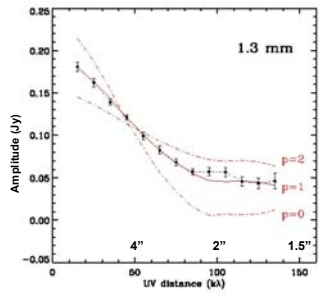
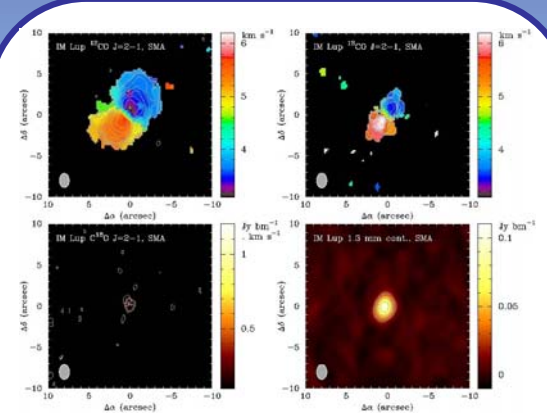
Visibility data of our 1.8" observations of 1.3mm dust continuum emission from the disk around T Tauri star IM Lup. We show the comparison of this data to three disk models (red lines) obtained by fitting the spectral energy distribution and 1.6μm and 0.6μm images (Pinte et al. in prep). The three models differ in the surface density exponent p, the parameter that describes the radial distribution of material in a disk: $\Sigma_{(R)} \sim R^{-p}$.

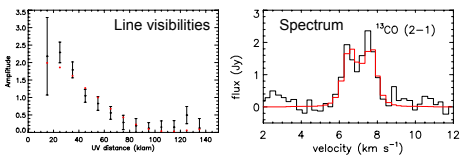


Interferometers are sensitive to the spatial scales of the emission smaller than 206kλ / uv-distance and can help discriminate between different values of p.



Disk around the T Tauri star IM Lup resolved in CO, ^{13}CO and C^{18}O J=2—1 emission and 1.3mm continuum emission with the SMA. This is the first gas rich disk in Lupus molecular cloud to be studied through resolved molecular line observations. The upper panels are velocity centroids of ^{12}CO and ^{13}CO showing a clear rotation pattern and extent of the emission at two sigma levels. These data indicate an inclination of 50 degrees from face-on and a very large outer radius of around 800AU. Lower panels show the integrated emission of C^{18}O, barely detected, and 1.3mm continuum map.

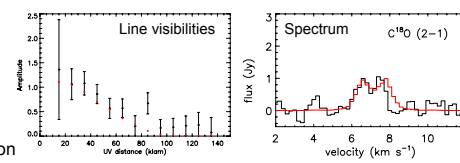
^{13}CO J=2—1 line



M_{13CO}=3.e-7 M_{sun}

Herbig Ae disk HD169142 was resolved at 1.4" using the SMA in ^{13}CO and C^{18}O J=2—1 lines. The visibilities were fit by a disk model from D'Alessio et al. (2005) database (T_{eff}=9000 K, A2 spec. type 10Myr old star) providing a measure of mass of ^{13}CO and C^{18}O gas in the disk, and an indication on total gas mass of 0.006-0.03 Msun. Fits to the visibilities are shown along with the observed and modeled line spectra (red). A comparison of the derived gas mass range with the dust mas $M_{dust} \geq$2e-4M_{sun} indicates that it is likely that the gas to dust mass ratio in this disk is less than 100:1.

C^{18}O J=2—1 line



M_{C18O}=4.e-8 M_{sun}

References

[1] Panić et al., A&A submitted;
[2] Panić et al., in prep.;
[3] Pinte et al., in prep.;
[4] D'Alessio et al., 2005, RevMexAA, 41, 61;