Observational Constraints on Accretion Disk Formation

D. Harsono[1,2], **J. K. Jørgensen**[3], **E. F. van Dishoeck**[1,4], **M. R. Hogerheijde**[1], **S. Bruderer**[4], **M. V. Persson**[1], **J. C. Mottram**[1]
(1) Leiden Observatory, The Netherlands; (2) SRON, Groningen, The Netherlands; (3) StarPlan, University of Copenhagen, Denmark; (4) MPE, Germany

Contact:
harsono@strw.leidenuniv.nl

Sterrewacht Leiden

Why:

Disks are important for star and planet formation, but **how and when they form** during the early stages of star formation is heavily debated.

What:

Identify and characterize **rotationally supported disks** near the end of the embedded stage of star formation (Class I).

How:

Spatially and spectrally resolved observations with IRAM PdBI to measure the size of embedded Keplerian disks with ^{13}CO and C^{18}O lines.

Infall

Rotation

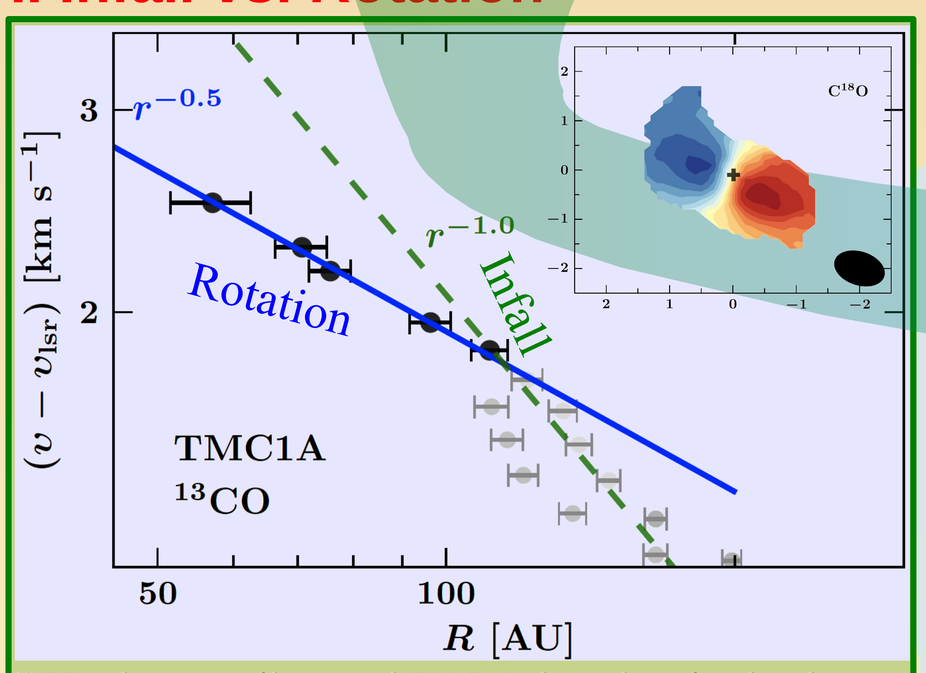
Conclusions:

I. Rotationally supported structures extend up to 100 AU, while infall motions dominate at scales > 100 AU.

II. The sizes of embedded disks derived from the continuum do not always correspond to the sizes of the rotationally supported disk.

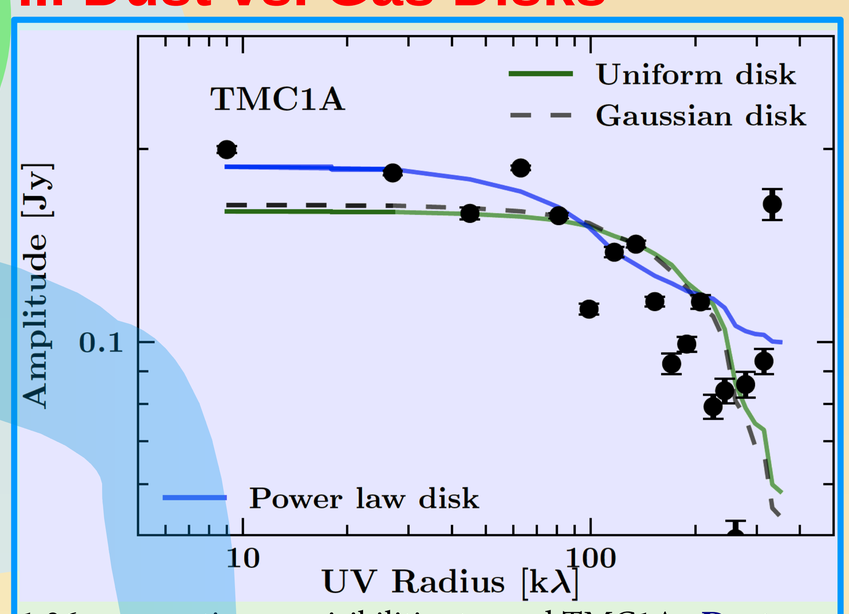
III. Keplerian disks grow rapidly near the end of the accretion phase when the stellar mass dominates the system mass.

I. Infall vs. Rotation



^{13}CO velocity profile toward TMC1A that is best fitted with a rotating structure ($\upsilon \propto r^{-0.5}$). Inset: C^{18}O moment 1 map within the inner 5" showing the blue and red-shifted rotating disk. **Rotation dominates the inner 100 AU radius**, while infalling structures dominate >100 AU scales[4].

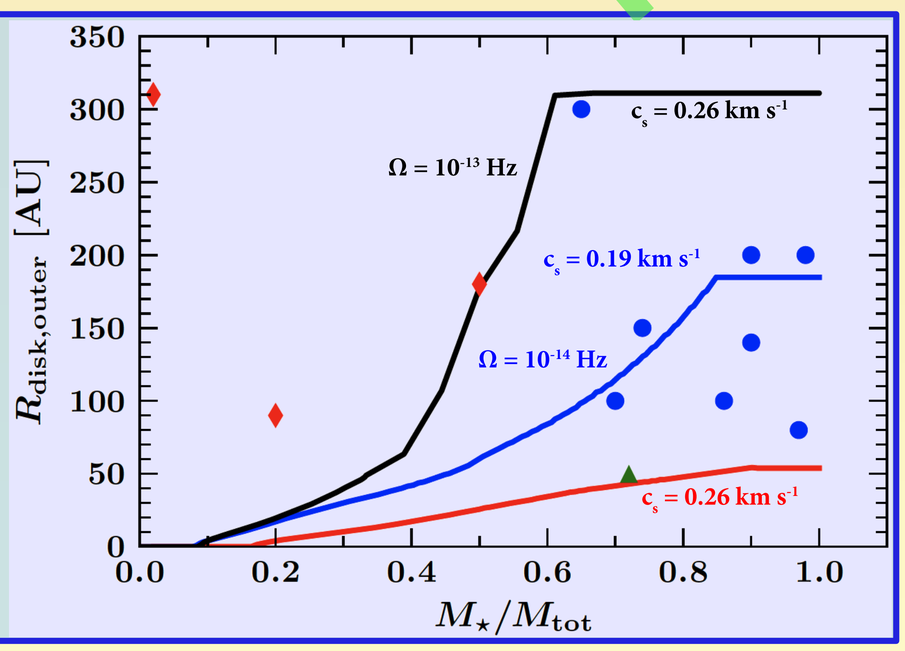
II. Dust vs. Gas Disks

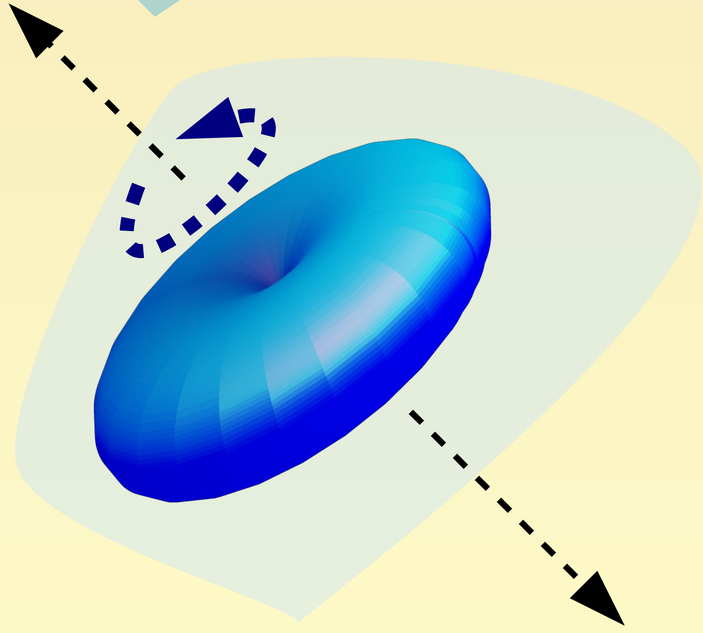


1.36 mm continuum visibilities toward TMC1A. **Dust disk sizes** are derived in the visibilities extending up to 130 AU for TMC1A and 350 AU for L1536, which **are larger than the size of the rotationally supported disks**.

III. Observed Embedded Disks

Observed disks[1,2,5,6,7] toward Class 0 (red diamonds) and Class I (blue circles) are compared to semi-analytical models[8]. A model with a rotation rate of 10^{-14} Hz and an outer envelope between 7000 and 10000 AU best describes the observed disk sizes. **The size of the Keplerian disk increases rapidly at the end of the main accretion phase.**





	TMC1A	TMC1	TMR1	L1536IRS
Keplerian Radius	80-100 AU	100	< 50	80
$M_\star$ [M$_o$]	0.45	0.4	...	0.8
$M_{\rm disk}$	0.075	0.024	0.011	0.034

Download here

The sample

Sources: TMC1A, TMC1, TMR1, L1536IRS

Distance: 140 pc; Disk Radii: 80-100 AU

Envelope Masses: 0.1 M$_o$

Disk Masses: 0.004-0.075 M$_o$

Acknowledgments. Based on observation carried out with the IRAM Plateau de Bure Interferometer. IRAM is supported by INSU/CNRS (France), MPG (Germany) and IGN (Spain). We thank IRAM staff, especially Chin-Shin Chang and Tessel van der Laan, for their help with the observations and reduction.

References:
1. Lommen, D., et al. 2008, A&A, 481, 141
2. Jørgensen, J. K. et al. 2009, A&A, 507, 861
3. Harsono, D. et al. 2013, A&A, 555, 45
4. Yen, H.-W. et al. 2013, ArXiv
5. Takakuwa, S. et al. 2012, ApJ 754, 52
6. Tobin, J. J. et al. 2012, Nature, 392, 83
7. Murillo, N. M. et al. submitted
8. Visser, R. et al. 2009, A&A, 395, 881