DISKS IN HIGH-MASS STAR FORMATION

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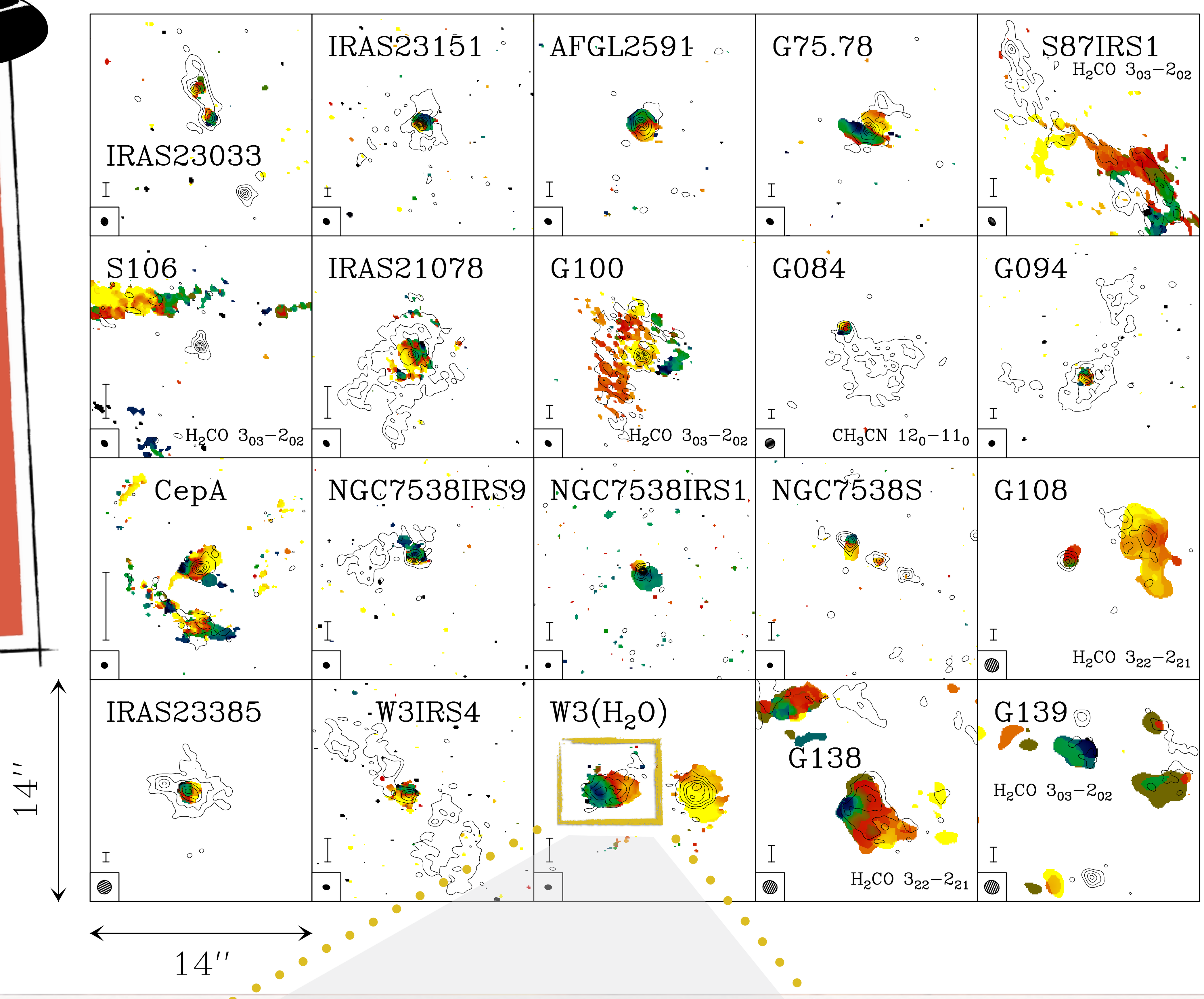
ABSTRACT

Among the unanswered questions in the field of high-mass star formation are those related to the existence of inner accretion disks and their characteristics. Using the NOrthern Extended Millimetre Array (NOEMA), the CORE large program aims to combine mm continuum and line observations at high spatial resolutions to directly study such rotating structures around high-mass clumps in the early phases of star formation, and characterize their properties. This poster presents an overview of the kinematics of the sample, as well as a case-study for one of the sources, W3(H_2O). We resolve two fragments at ~700 AU resolution, which are each in Keplerian rotation around ~10 M⊙ protostars. A stability analysis of the fargments show small Toomre Q values in the outskirts of the rotating structures, hinting at the possibility for further fragmentation of the cores via disk fragmentation.

Figure details

- colour: intensity-weighted peak velocity map in disk-tracing CH_3CN (12-11) k=3 line unless stated otherwise in the panel
- contours: 1.3 mm continuum
- beam sizes in bottom left corners
- bars in bottom left of each panel correspond to 3000 AU

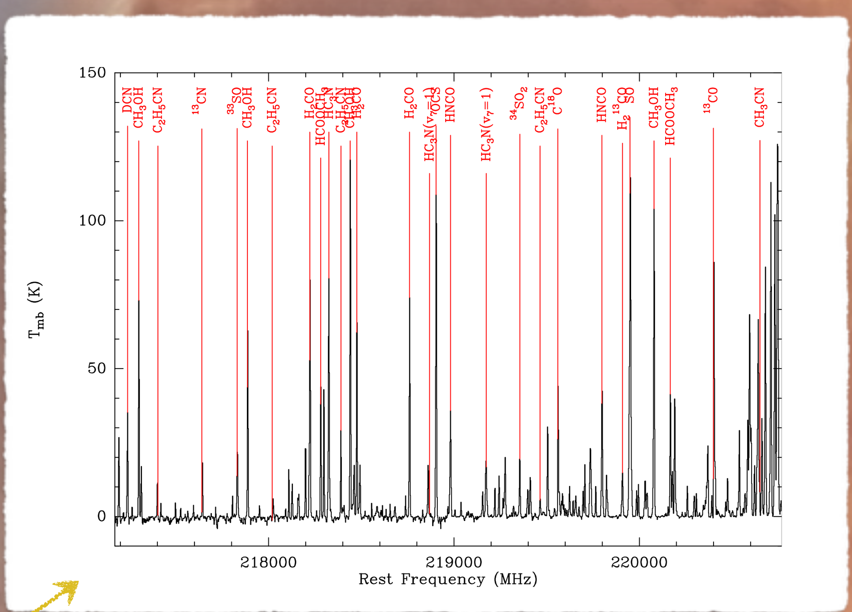
velocity gradient observed in most sources!



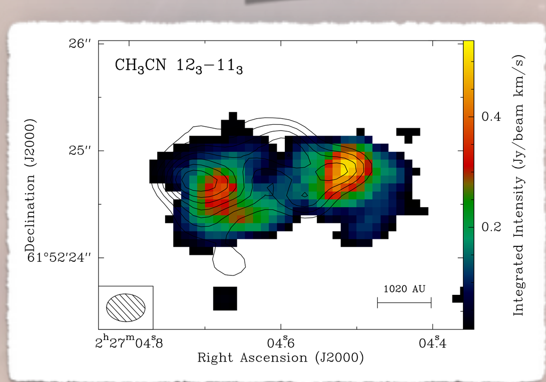
Focus on W3(H_2O)

- "Turner-Welch" object
- M ~ 30 M⊙
- L ~ 3×10^4 L⊙
- Distance ~ 2 kpc

Highly chemically rich



FRAGMENTATION



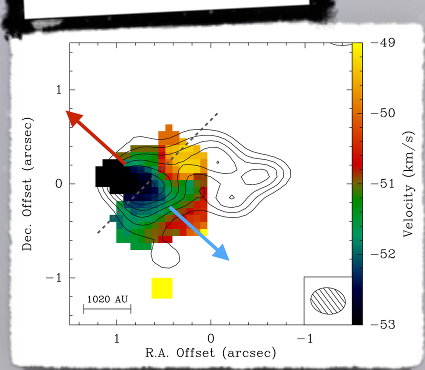
Imaging NOEMA data in the most extended configuration resolves structures on scales of ~700 AU

W3(H_2O) fragments into two sources on smaller scales

Above: integrated intensity map of CH_3CN (12-11) k=3 line with continuum contours

KINEMATICS

left fragment

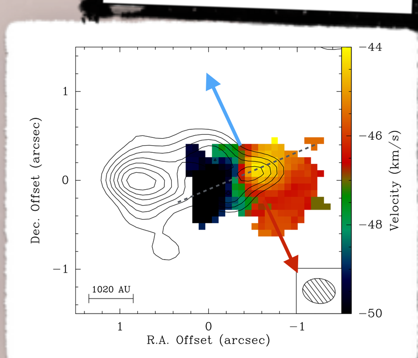


Right/Left: intensity-weighted peak velocity maps in CH_3CN (12-11) k=3, scaled for each fragment. The dashed lines highlight the directions of rotation.

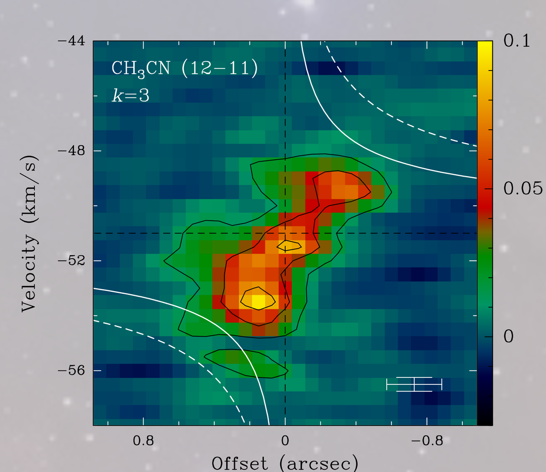
Clear velocity gradient across both fragments

Directions of rotation perpendicular to molecular outflows

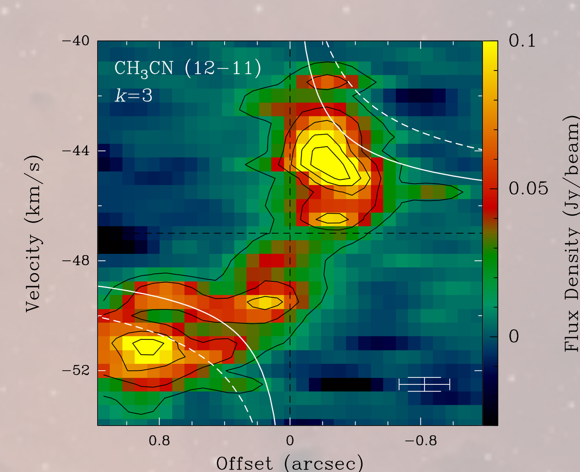
right fragment



Below: position-velocity (p-v) maps for cuts along the directions of rotation for CH_3CN (12-11) k=3 line. Solid and dashed white lines correspond to p-v curves of a disk in Keplerian rotation about a 10 and 25 M⊙ object, respectively.



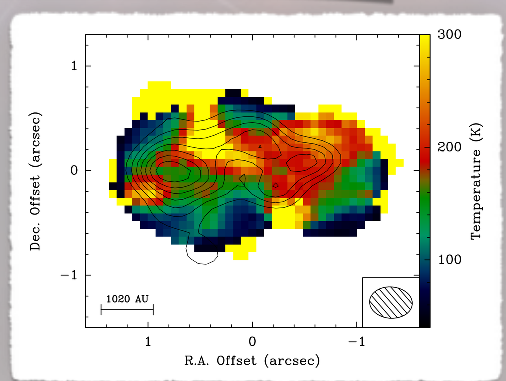
Each fragment almost in Keplerian motion around ~10 M⊙ protostar



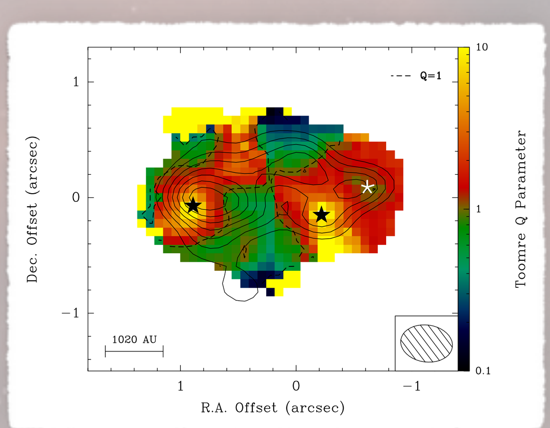
STABILITY

Right: Temperature map obtained from fitting CH_3CN (12-11) k=4,5, and 6 lines simultaneously under LTE conditions with XCLASS (Möller+ 2015).

Disk temperatures of ~100-300K



How stable are the rotating structures?



for a differentially rotating disk, the shear force can provide an additional stability, quantified via the Toomre Q parameter with Q<1 unstable (Toomre 1964)

$$Q = \frac{c_s \Omega}{\pi G \Sigma}$$

Ω: angular velocity of the disk; Σ: surface density of the disk

Above: Toomre Q map obtained by assuming the two disks are each in Keplerian rotation around 10 M⊙ protostars as depicted by black stars.

Two rotating cores assumed in Keplerian motion are mostly stable

The low Toomre Q values found on the right fragment coincide with a continuum peak as depicted by a white star, hinting at a possibility for fragmentation of this core into further sources via disk fragmentation.