

1000 au-scale filamentary structures and cluster formation in Corona Australis revealed with ALMA

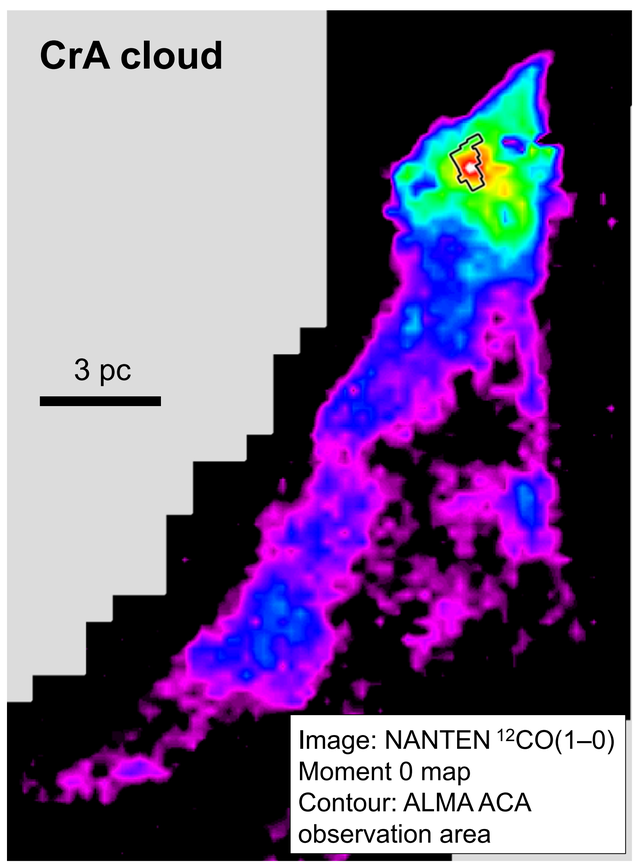
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Abstract: We focus on the Corona Australis (CrA) molecular cloud to solve the fragmentation process of molecular filaments to study how high stellar densities of cluster is achieved. The CrA cloud has a head-tail shape, and is known as the nearest (d=149 pc) low-mass cluster-forming region. We conducted a large mosaic survey at the head part of the cloud, which hosts the young R CrA cluster, using ALMA ACA. The ACA $C^{18}O$ data reveal a complex network of thin filaments. Within the observed area (0.4 pc^2), we identified ~100 filaments with typical widths of ~1300 au. Their typical line mass is a few $M_\odot$ pc^{-1}, significantly below the critical threshold for gravitational fragmentation. Thus, most filaments seem to be transient and unlikely to fragment gravitationally. However, higher resolution data by the ALMA 12m array show that the most massive filament (~9 $M_\odot$ pc^{-1}) contains four protostars with a typical spacing of ~1000 au along the filament crest. Even if gas within the filament is accumulated along its major axis, the total mass remains insufficient to form protostars. This result implies the necessity of continuous mass accretion onto the filament. The CrA cloud is located on the edges of two expanding HI shells. The morphology of the filaments is well reproduced by MHD simulations of colliding gas flows, supporting the scenario in which filament formation is driven by colliding gas flows from expanding HI shells. Moreover, Gaia DR3 data show that associated YSOs exhibit outward motion from the HI shell centers. Based on these results, we conclude that the filaments and active star formation in CrA are induced by external compression.

1. Introduction

- How molecular clouds fragment in cluster formation is not clear.
- Corona Australis (CrA) is low-mass cluster forming region at the distance of ~150 pc,

➢ CrA is the best site to study fragmentation in cluster formation.

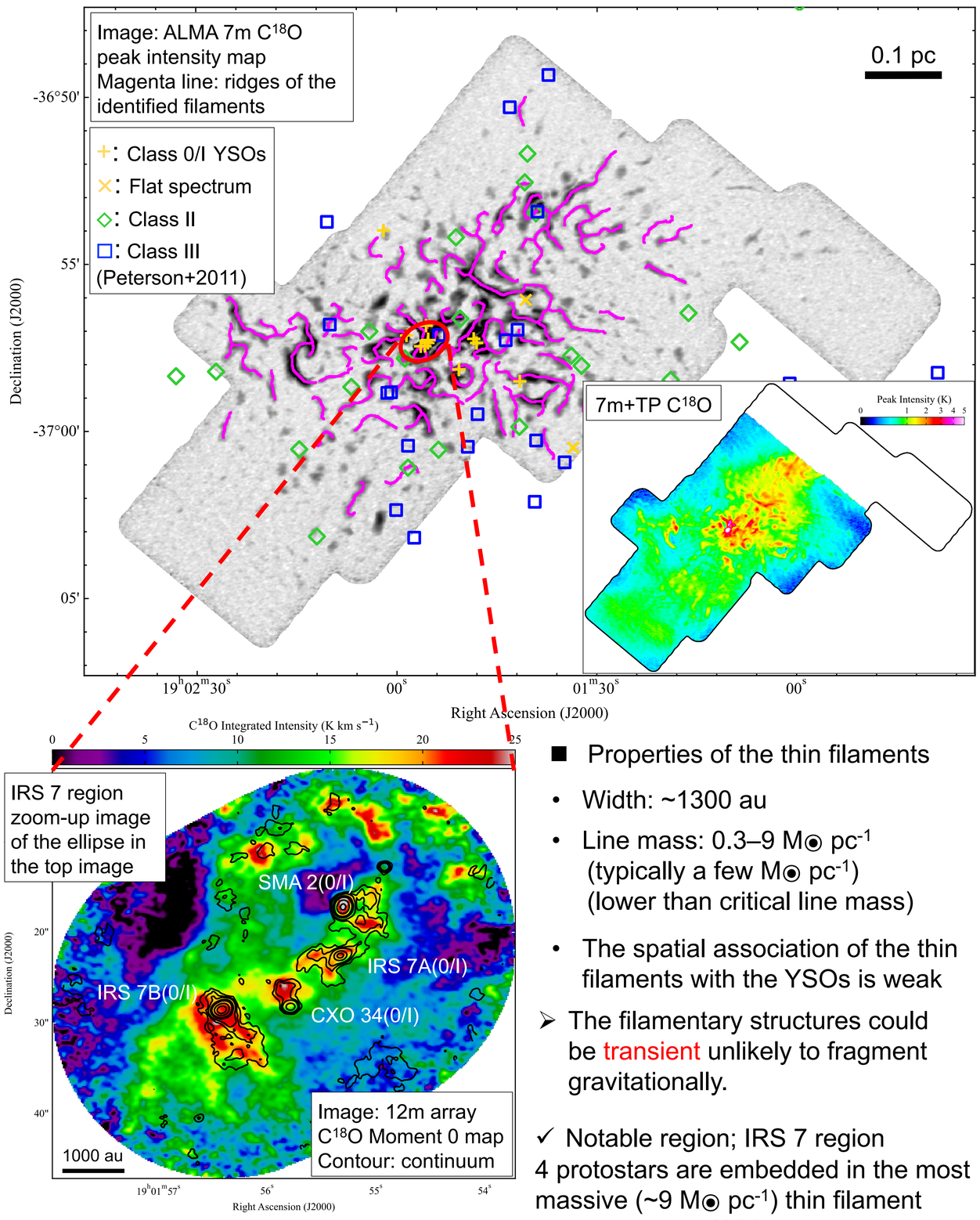


2. Observation

■ ALMA
- ACA: #2018.A.00056.S, Band 6
- 12m array: #2019.1.01792.S, Band 6
- FOV: 130 $arcmin^2$ (ACA), 0.5 $arcmin^2$ (12m array)
- Angular resolution: ACA: 7.”9 × 4.”9 (~870 au) 12m array: 1.”1 × 0.”85 (~150 au)
- SpW: ^{12}CO, ^{13}CO, $C^{18}O$(2–1), N_2D^+(3–2), SO(6_5–5_4), continuum

3. Results

101 thin filaments are identified from $C^{18}O$ data using *FilFinder* algorithm (Tachihara, Fukaya et al. 2024).

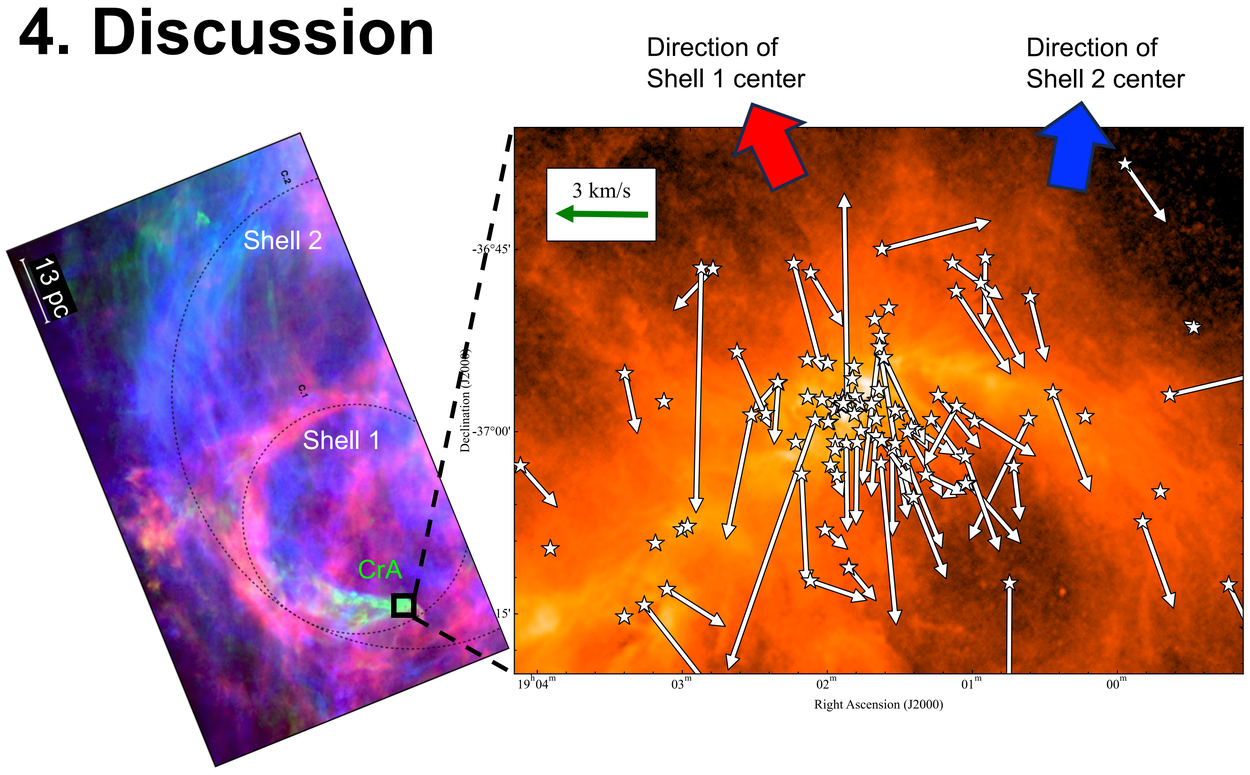


■ Properties of the thin filaments
- Width: ~1300 au
- Line mass: 0.3–9 $M_\odot$ pc^{-1} (typically a few $M_\odot$ pc^{-1}) (lower than critical line mass)
- The spatial association of the thin filaments with the YSOs is weak

➢ The filamentary structures could be transient unlikely to fragment gravitationally.

✓ Notable region; IRS 7 region
4 protostars are embedded in the most massive (~9 $M_\odot$ pc^{-1}) thin filament separated by ~1000 au each.

4. Discussion



(Left) HI gas distribution around the CrA cloud (taken from Bracco+2020). Red: HI at 7.4 km s^{-1}, Blue: HI at 3.3 km s^{-1}, Green: Dust emission obtained by Planck.
(Right) Gaia DR3 proper motion (relative to LSR) vectors of YSOs associated with the CrA cloud. The background image is H_2 column density map obtained by Herschel. The legend indicates the magnitude of the proper motion vector corresponding to 3 km s^{-1}. YSOs without arrows indicate that their proper motions have not been measured by Gaia.

4.1. Cluster formation in CrA

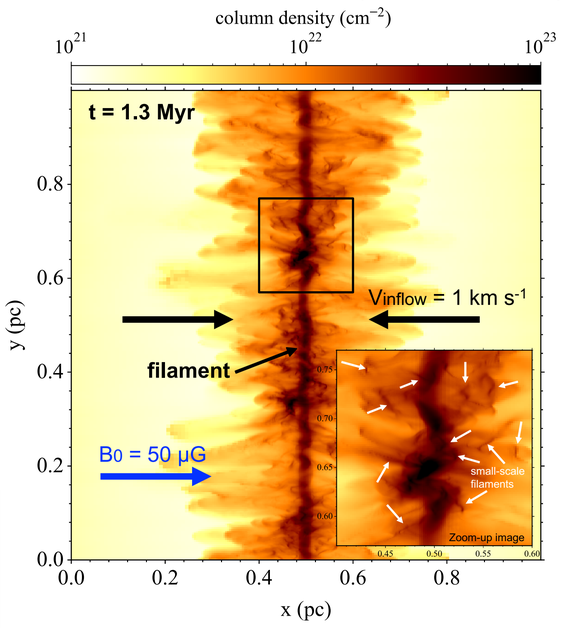
■ External compression by HI shells
- The CrA cloud is located on the edge where two HI shells overlap.
- Associated YSOs exhibit outward motion from the HI shell centers.

→Gas and stars are co-moving

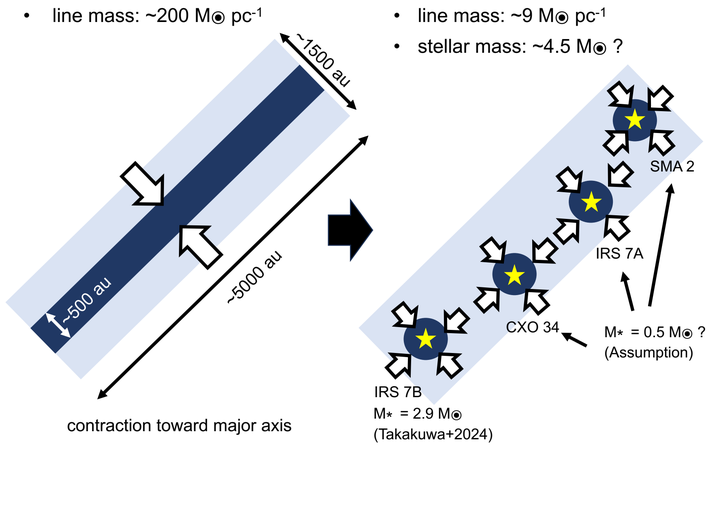
➢ Continuous or multiple gas flows from expanding HI shells compress the CrA cloud and induce active star formation.

4.2. Filament formation and fragmentation

■ MHD simulation result (Abe+2024, 2025)



■ Filament fragmentation at IRS 7 region



- High-resolution numerical MHD simulation of converging gas flow reproduces small-scale (width: ~1000 au) filaments, and they are transient (Abe+2024, 2025). →similar with thin filaments in CrA
- The converging gas flow, which is the initial condition of the simulation, corresponds to the HI gas flow in CrA.
- Abe+2025 propose that the line mass increases to ~100 $M_\odot$ pc^{-1} while the width of the filament center decreases.

➢ Observation results in the IRS 7 region are consistent with these results.

5. Conclusion

- 101 $C^{18}O$ filamentary structures are identified from ALMA ACA data.
- The most massive thin filament contains 4 protostars with a typical spacing of ~1000 au along the filament crest.
- Filament formation and low-mass cluster formation in the CrA cloud are induced by external compression from HI shells