High resolution observational study of G345.50+0.35 massive star forming region

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Presentation Outline

Introduction

Methodology

Results

Conclusion

Overview of Massive Stars

- ❖Greater than **8 solar masses**
- ❖**Very luminous**
- ❖**Rare** compared to low-mass stars
- ❖Dense molecular clouds → **high dust extinction**

Difficult to observe during early formation

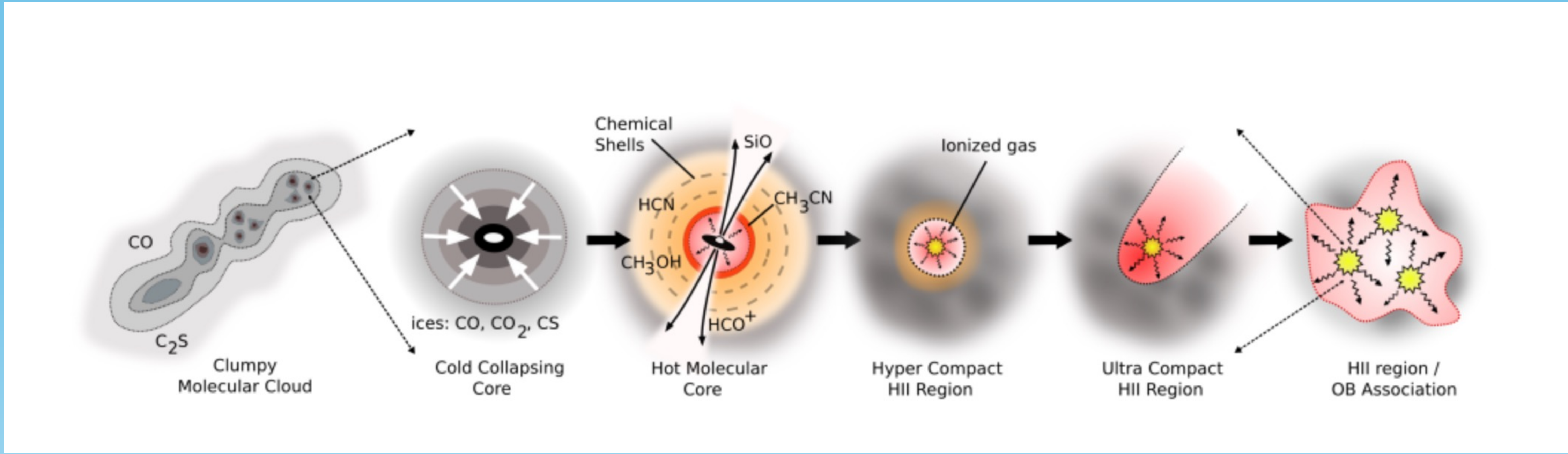


Image Credit: Urquhart J 2022

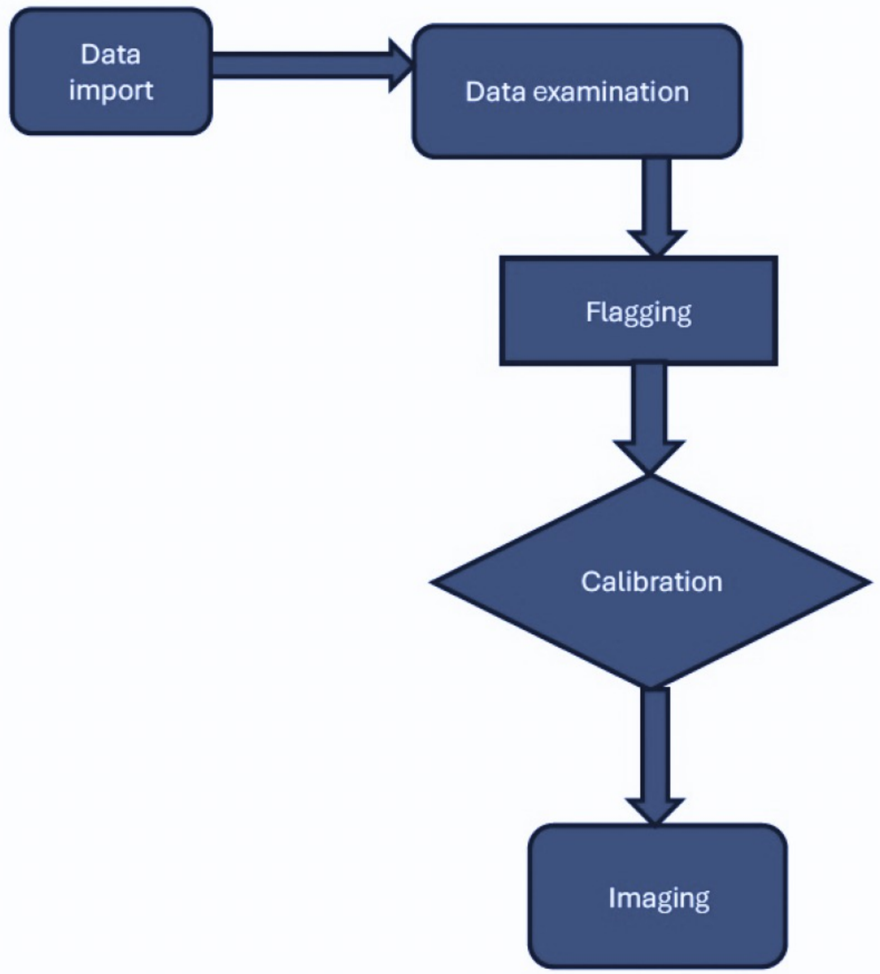
Previous Studies on G345.50+0.35

- It is also known as IRAS17008-4040
- Excited by B0-type stars (Garay et al., 2006)
- Massive star-forming region with candidate O-type protostar (Morales et al., 2009)
- Bright MIR source (IRAS 17008-4040 I) with an extended 4.5 μm emission
- Radio continuum emission (Seidu et al. in prep)
- G345.50M & G345.50S identified as disc candidates (Cesaroni et al., 2017)
- Core fragmentation (Dewangan et al., 2018)

Methodology

- ALMA (Band 6)
  - Datasets: 2013.1.00489.S & 2021.1.00311.S
  - Resolution: 0."2 and 0."5, with rms: 0.4 & 1.2 mJy/beam for the continuum emission
- MeerKAT (1.28 GHz)
  - Traces ionized gas
- ATLASGAL (870 μm)
- Spitzer (5.8 μm)
  - Mid-infrared morphology

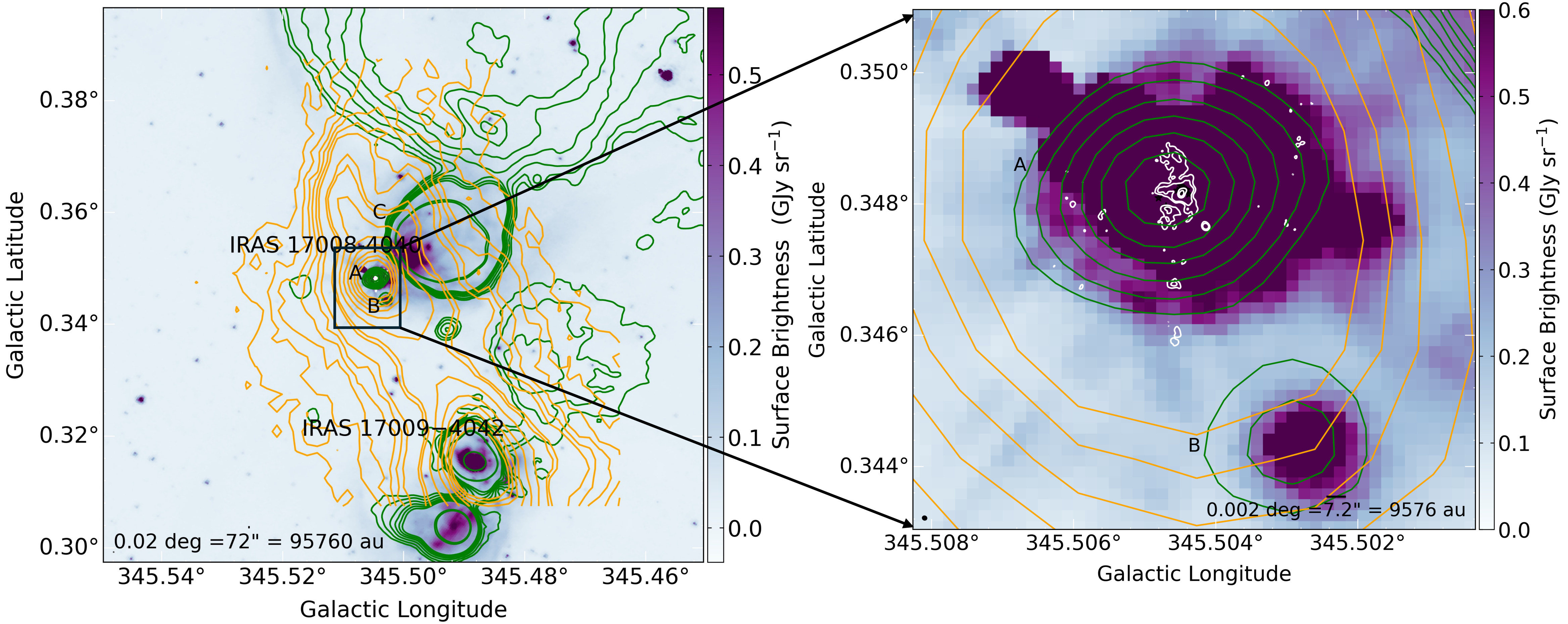
ALMA calibration steps



RESULTS

Free-free emission → ALMA bulk emission → ALMA emission at small scale

Composite image of G345.50+0.35 region



Derived Continuum Results (Radio Sources)

Table 4.1: Radio Continuum Parameters Derived from Two-Dimensional Gaussian Fitting

Name	Right ascension (h m s)	Declination (° ′ ″)	Peak Intensity (mJy beam^{-1})	Integrated Flux (mJy)	Deconvolved Core Size (″ × ″) [PA]°
A	17:04:22.988	-40:44:21.231	2.31 ± 0.53	2.8 ± 1.1	5.1 × 2.1 [112]
B	17:04:23.556	-40:44:35.222	0.95 ± 0.02	1.76 ± 0.05	7.93 × 6.82 [109]
C	17:04:20.118	-40:44:32.558	94.00 ± 6.70	585 ± 48	21.8 × 15.1 [23]

$$\left(\frac{N_{\rm Ly}}{\rm s^{-1}}\right) = 4.761 \times 10^{48} \times \left(\frac{S_\nu}{\rm Jy}\right)\left(\frac{T_e}{\rm K}\right)^{-0.45}\left(\frac{\nu}{\rm GHz}\right)^{0.1} \times \left(\frac{d}{pc}\right)^2$$

Ionizing Flux

•**Source A:** B2 Zero-Age Main Sequence (ZAMS) star

•**Source B:** B3 (III) star

•**Source C:** B0 (ZAMS) star

$$t_{\rm dyn} = \frac{4}{7}\frac{R_{\rm st}}{C_{\rm s}}\left[\left(\frac{R_f}{R_{\rm st}}\right)^{7/4} - 1\right]$$

Dynamical ages of the sources:

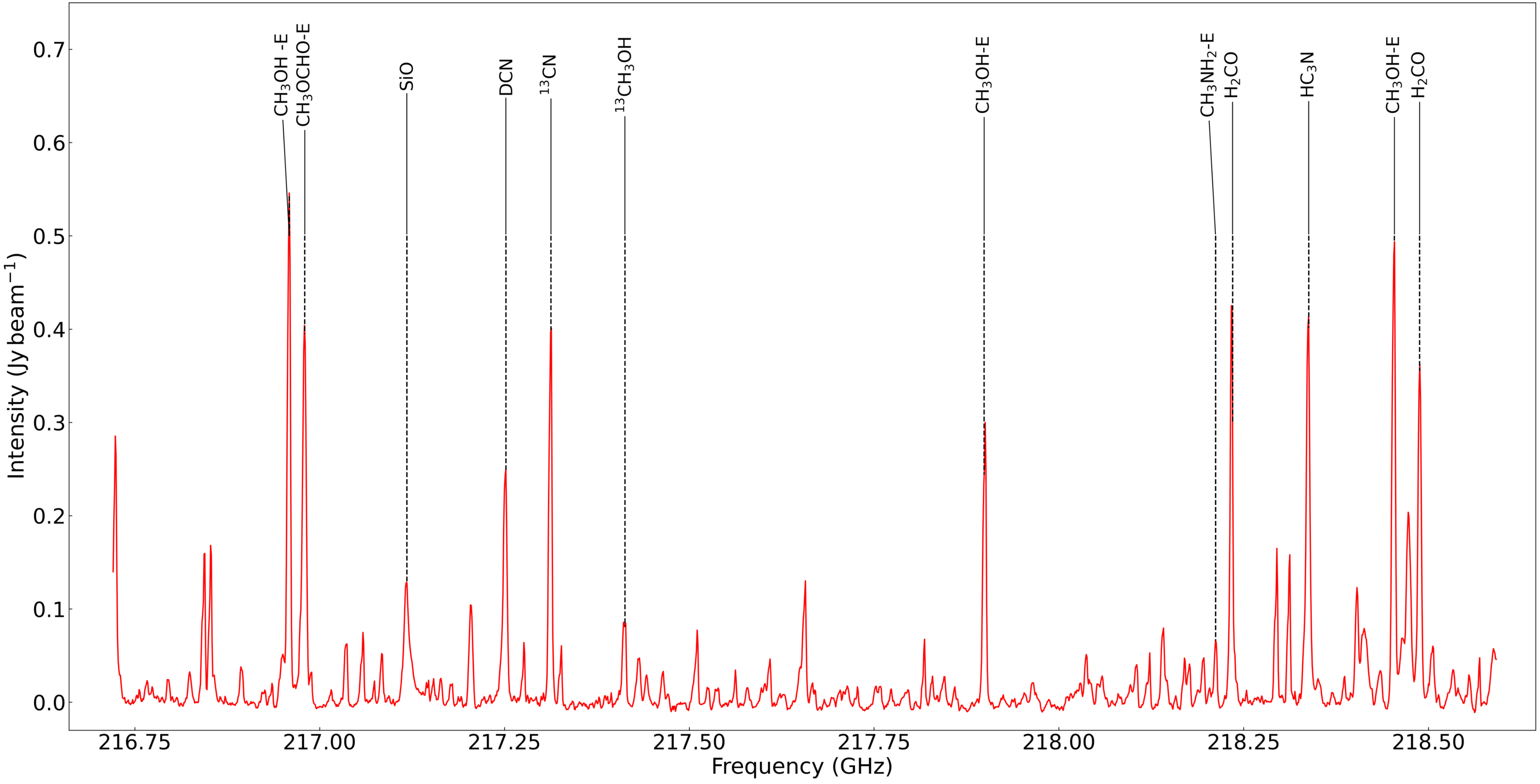
•Source A: **(3.55 ± 0.17) × 10^3 yr**

•Source B: **(1.49 ± 0.075) × 10^4 yr**

•Source C: **(2.80 ± 0.14) × 10^4 yr**

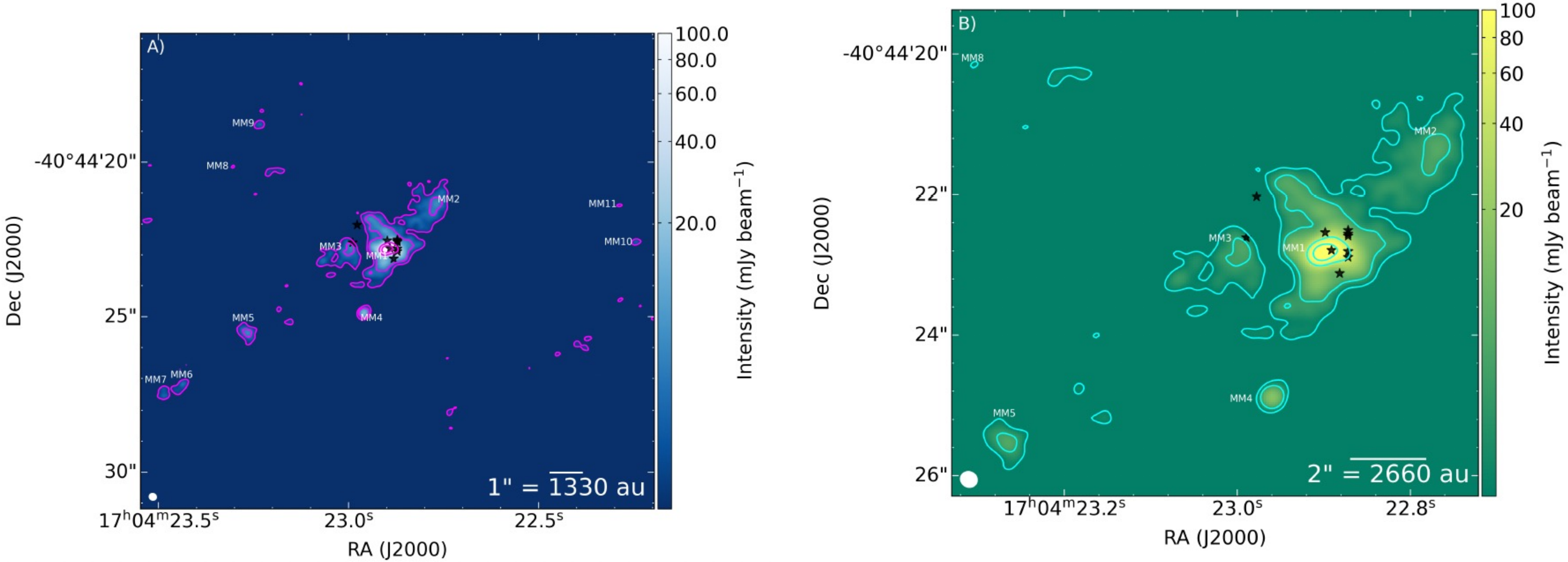
ALMA BULK EMISSION
0.”5 RESOLUTION

MOLECULAR LINES (0.”5 RESOLUTION)

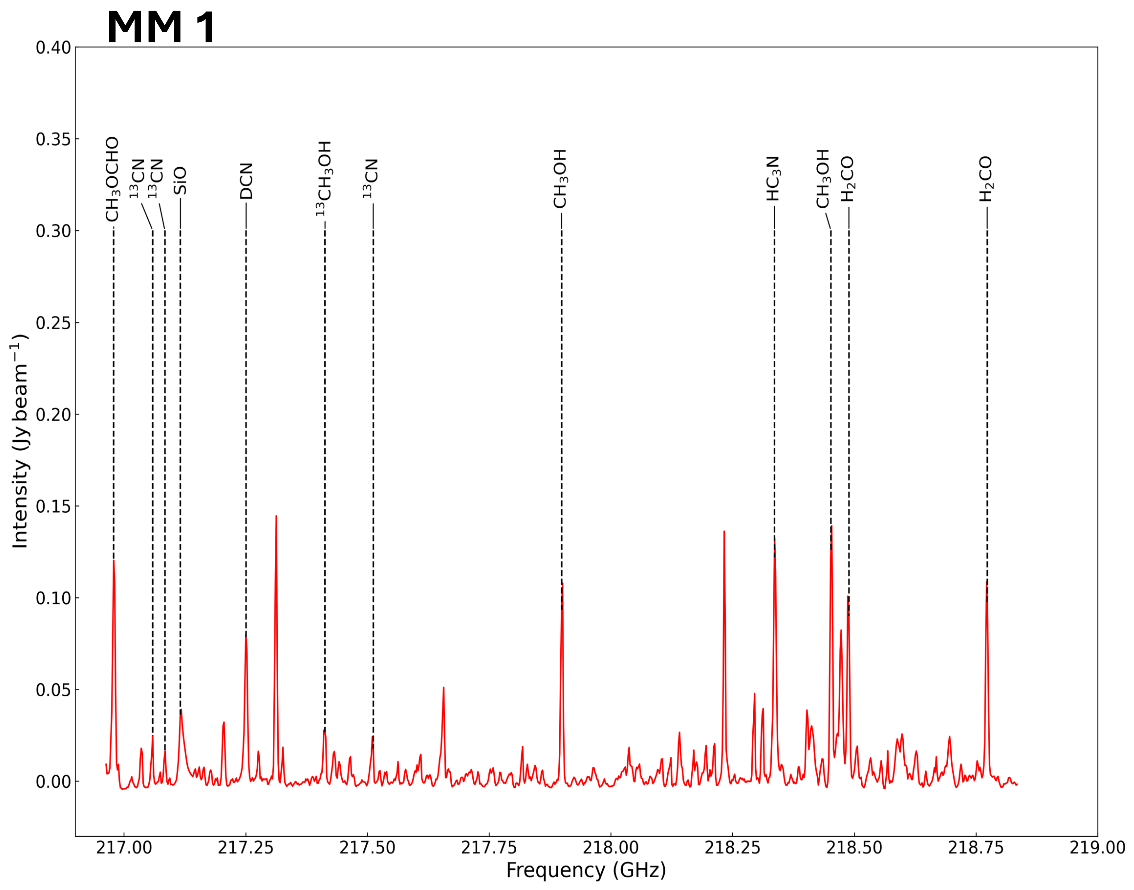


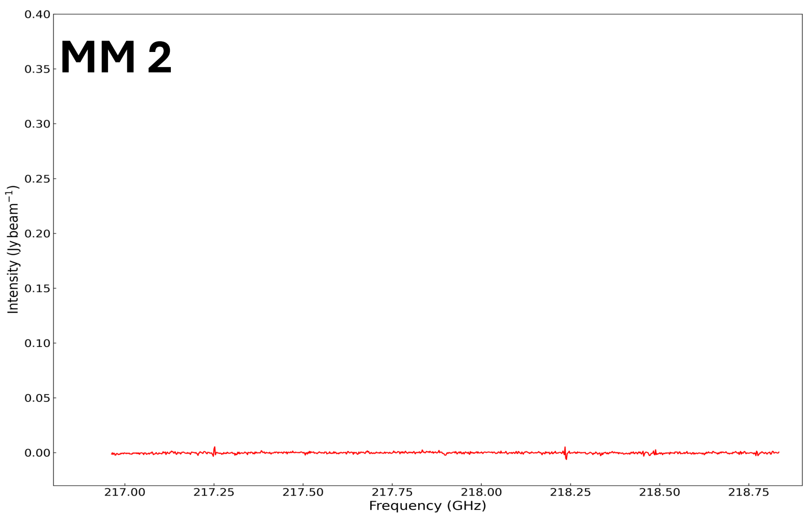
ALMA SMALL SCALE
0.”2 RESOLUTION

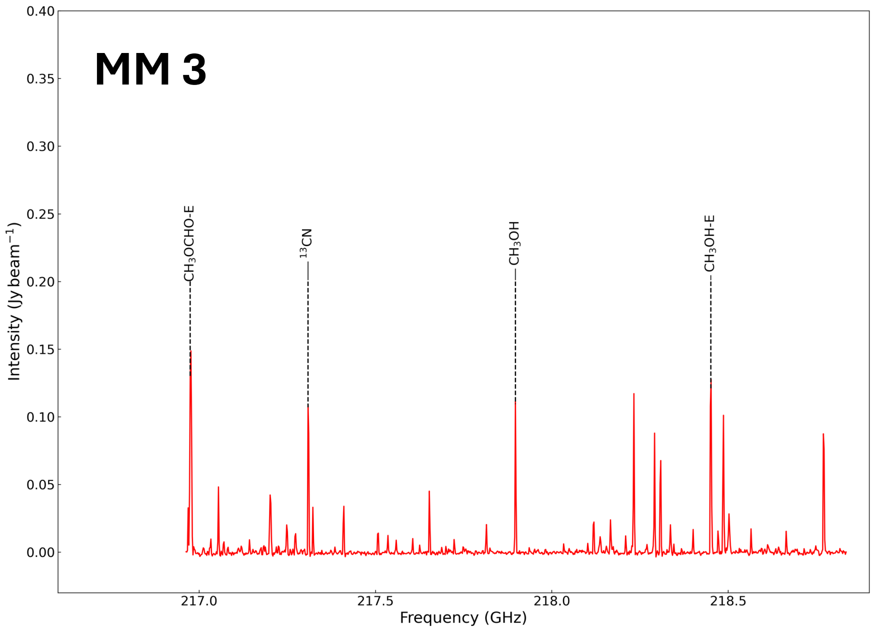
1.33 mm ALMA dust continuum image of G345.50+0.35

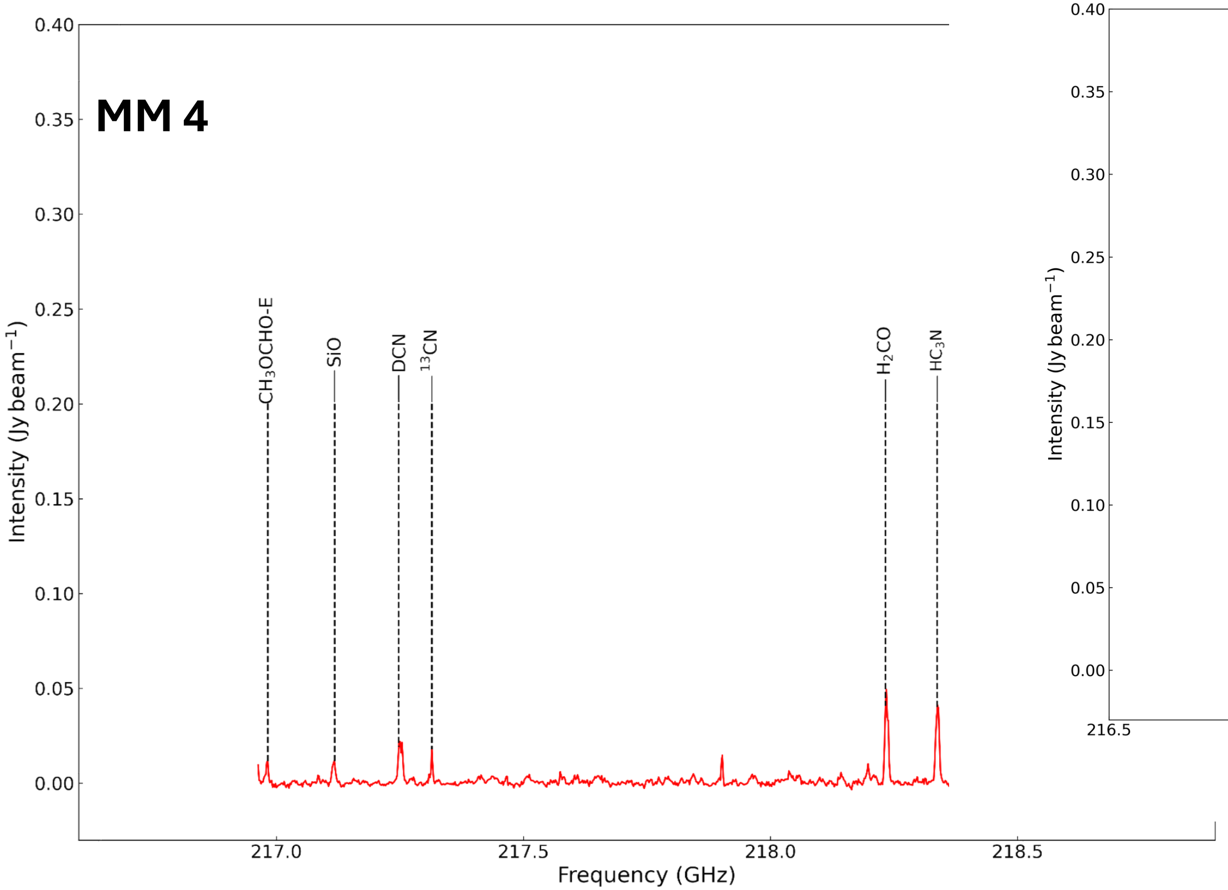


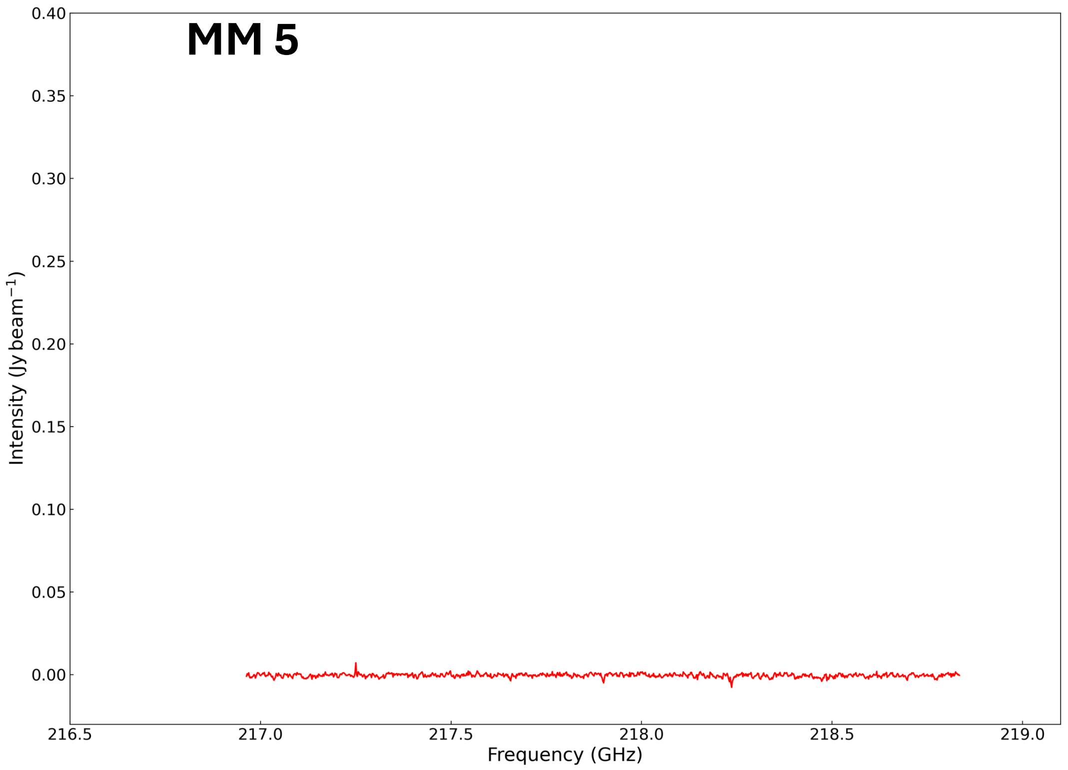
MOLECULAR LINES (0.”2 RESOLUTION)







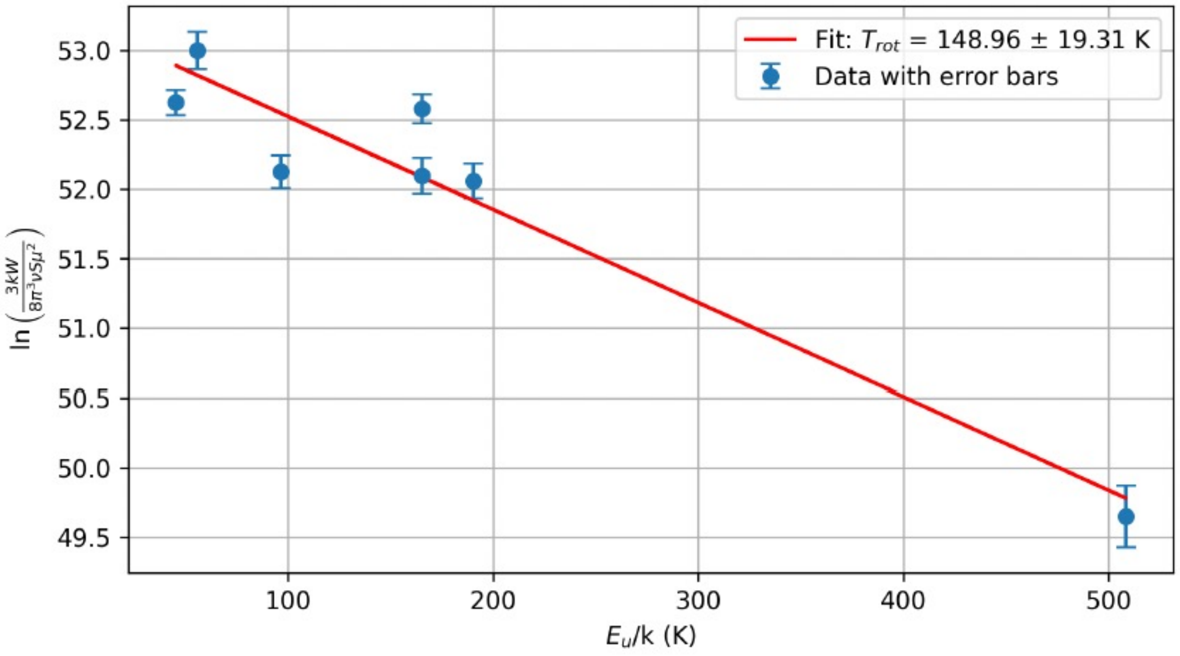

MM 4
Intensity (Jy beam^{-1})
Frequency (GHz)
CH_3OCHO-E
SiO
DCN
^{13}CN
H_2CO
HC_3N
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
217.0
217.5
218.0
218.5


MM 5
Intensity (Jy beam^{-1})
Frequency (GHz)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
216.5
217.0
217.5
218.0
218.5
219.0

DERIVED CONTINUUM RESULTS

Table 4.3: Physical Properties of the Various Cores

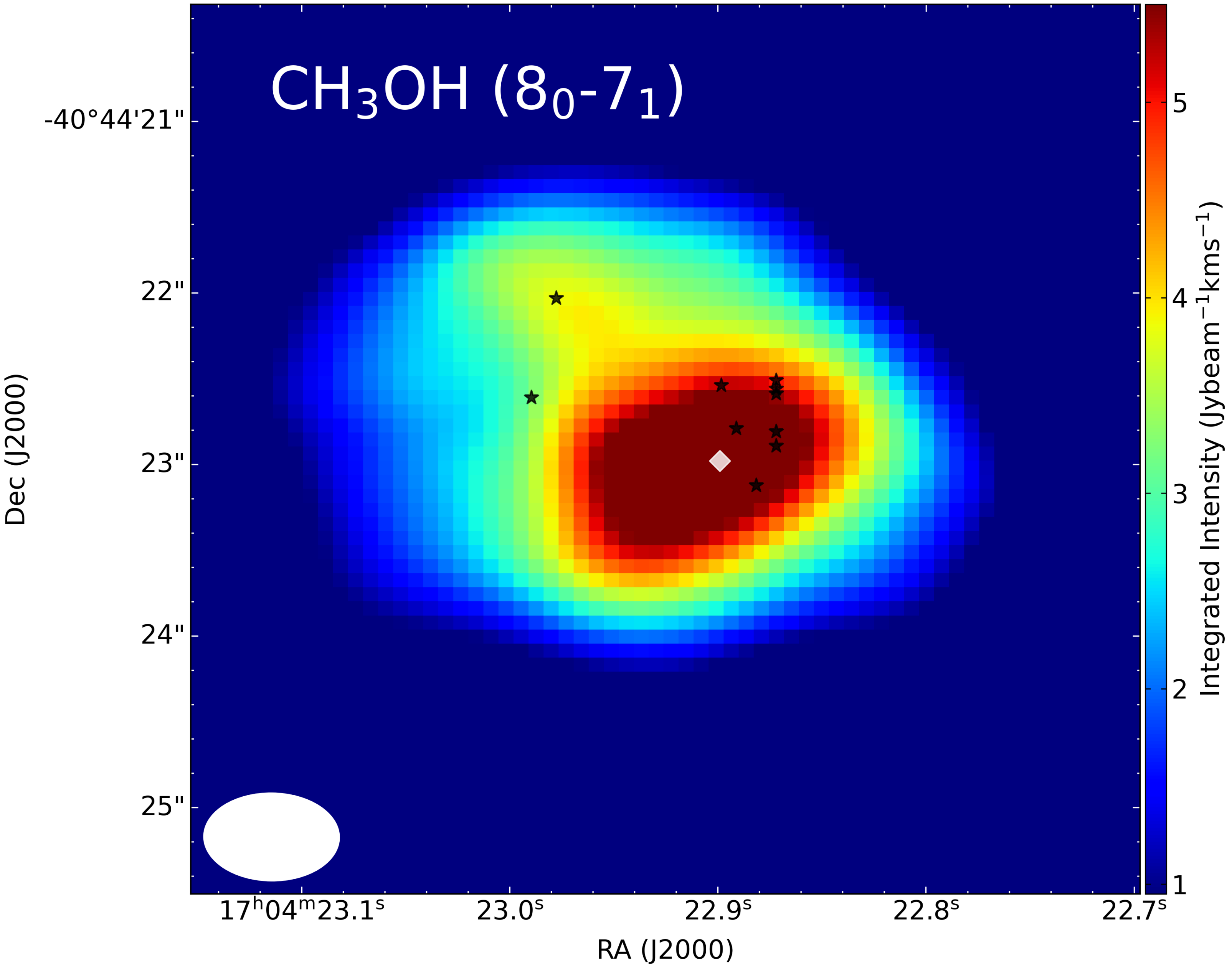
Name	Dust Temperature (K)	Core Mass ($M_\odot$)	Column Density (10^{24} cm^{-2})
MM1	100 - 148.96	10.0 - 7.0	164.00 - 110.00
MM2	20	3.64	3.92
MM3	100 - 148.96	0.24 - 0.16	3.05 - 2.04
MM4	100 - 148.96	0.55 - 0.37	8.62 - 5.79
MM5	20	1.33	33.20
MM6	20	0.30	11.90
MM7	20	0.53	5.46
MM8	20	1.40	14.80
MM9	20	0.40	8.31
MM10	20	0.32	7.64
MM11	20	0.37	5.39

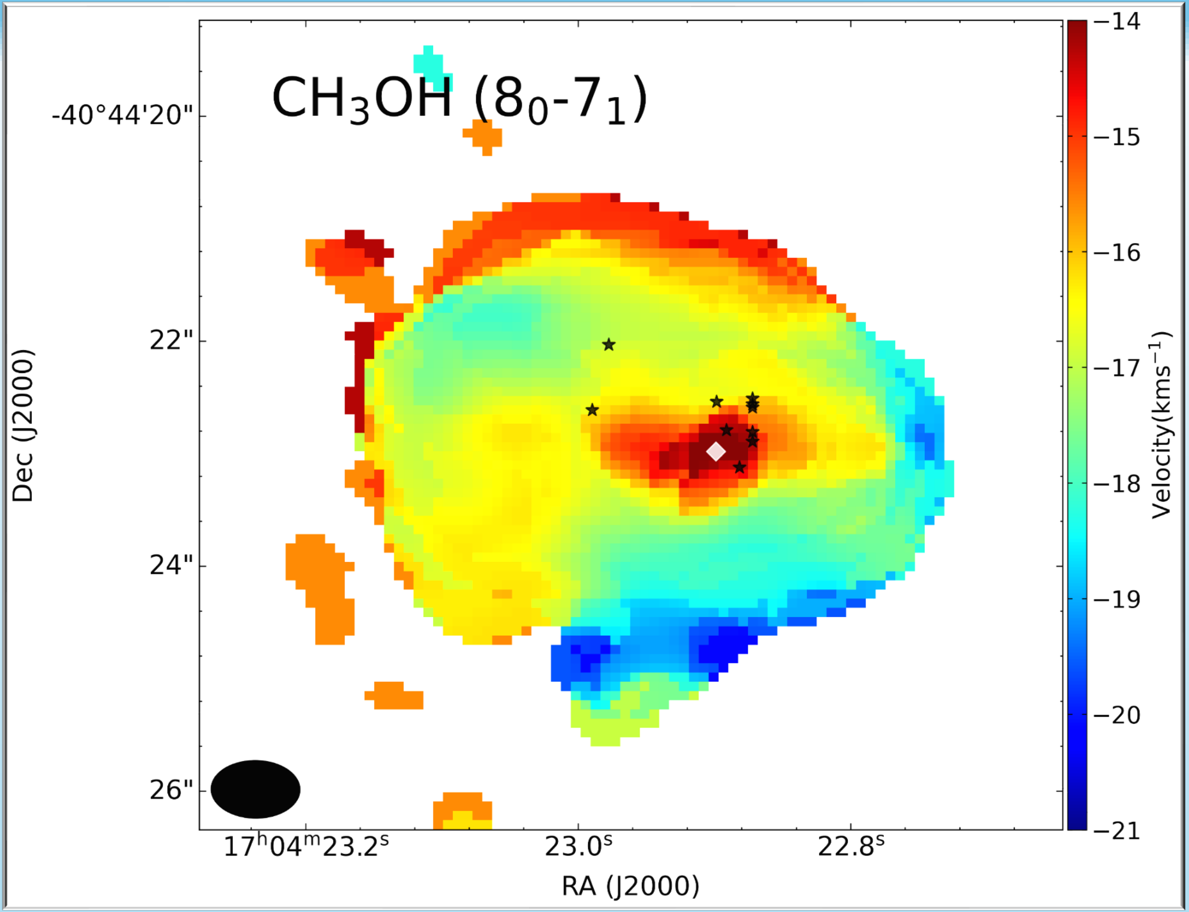


DEEPER INVESTIGATIONS

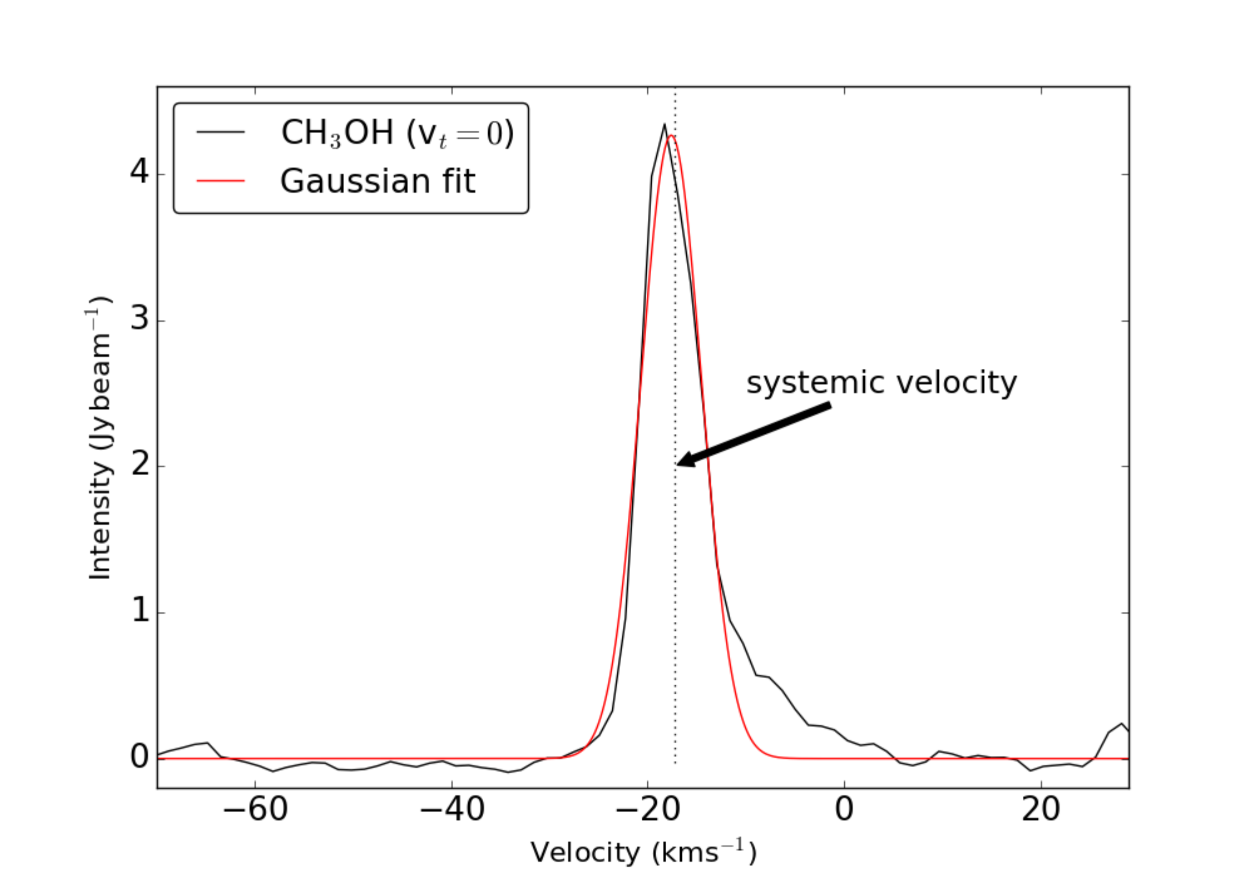
CH_3OH (8_0 - 7_1) Molecular Emission

- It exhibits a compact morphology





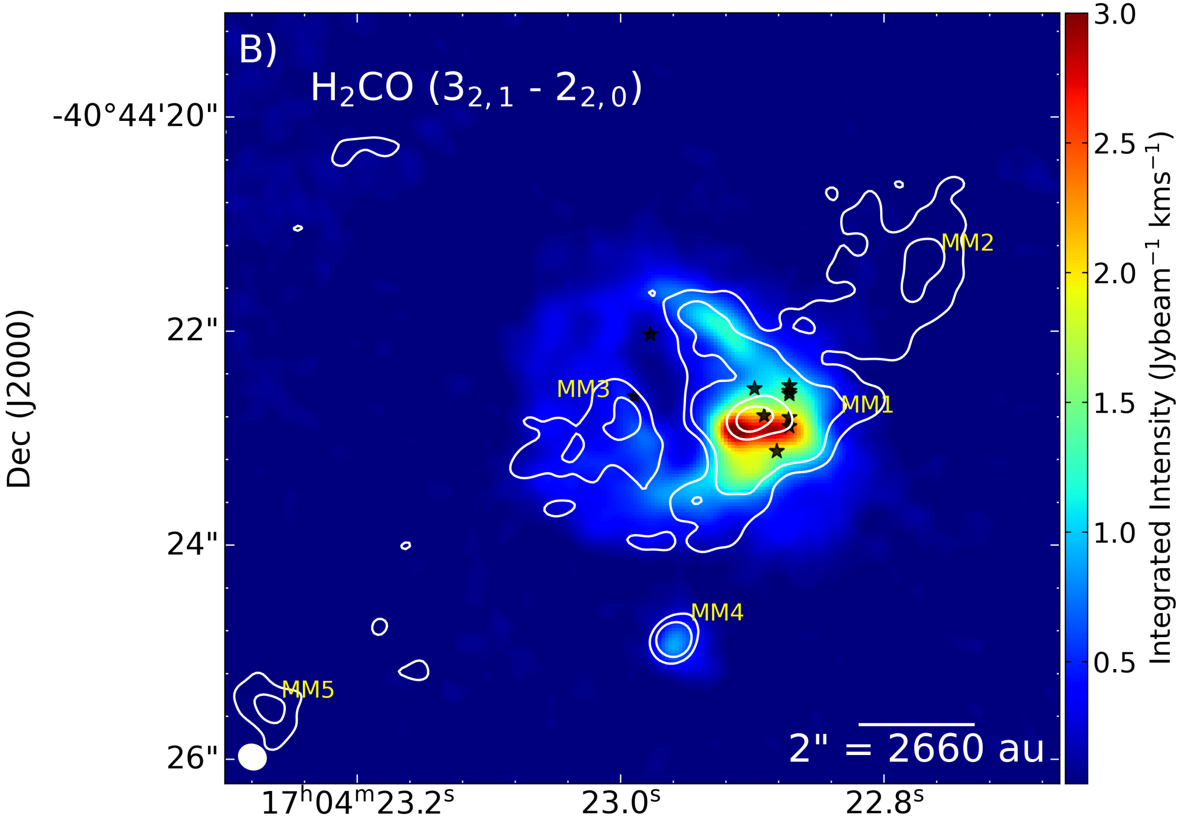
- The systemic velocity was determined by fitting a 2D Gaussian to CH_3OH (8_0 - 7_1) .
- The spectral profile shows optically thin emission.

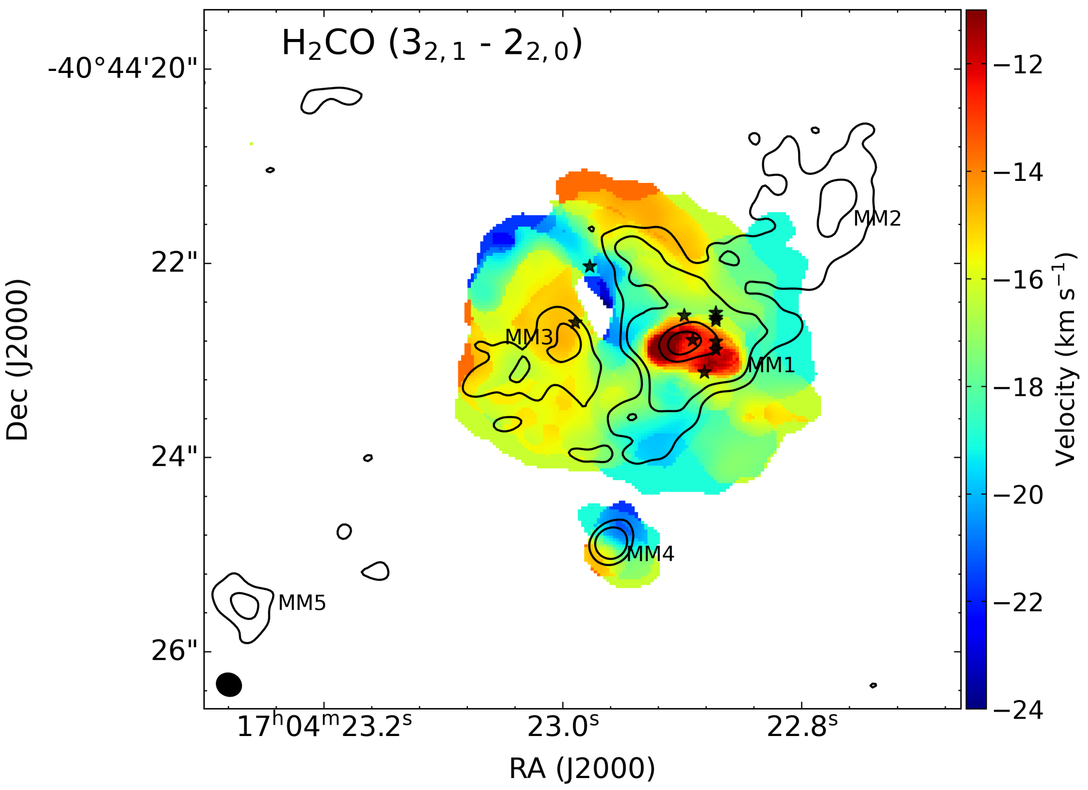


H_2CO ($3_{2\,1}$ - $2_{2\,0}$) Molecular Emission

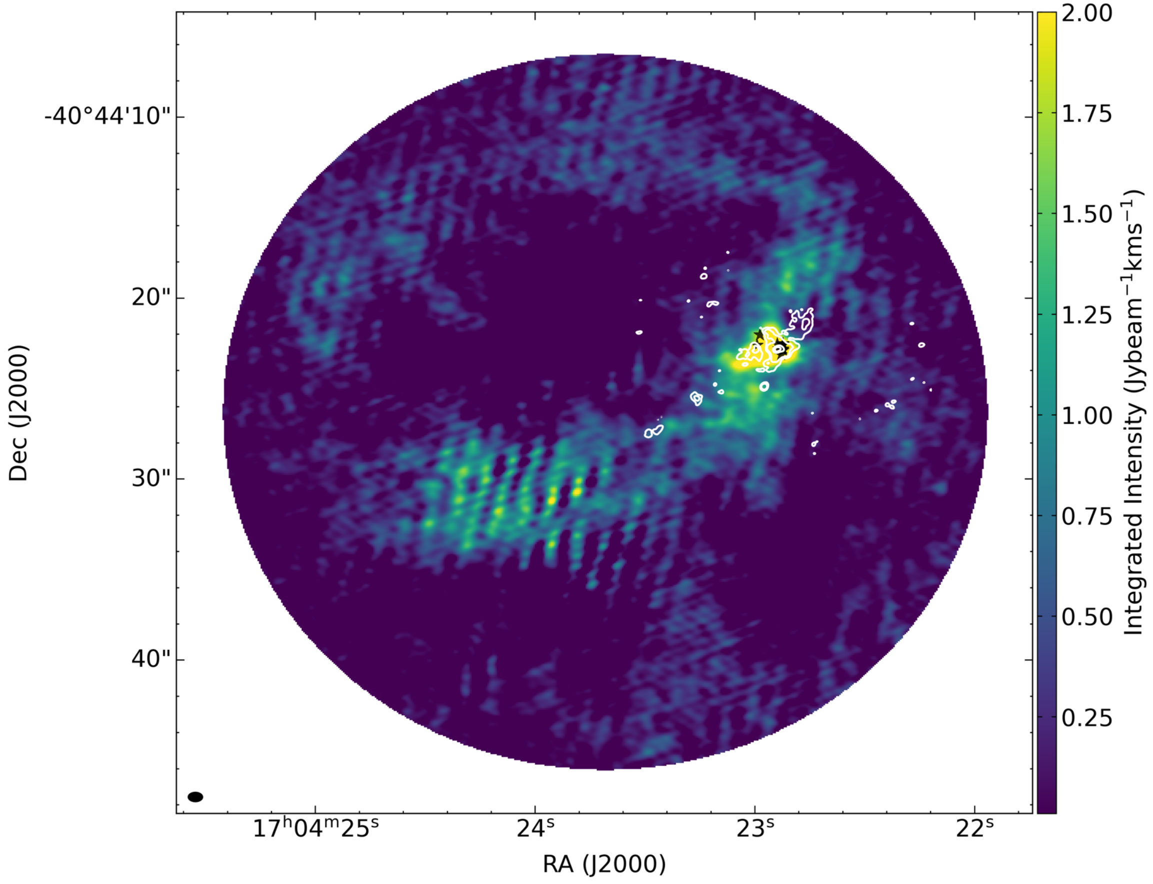
PRESENCE OF A DISK OR AN ENVELOPE

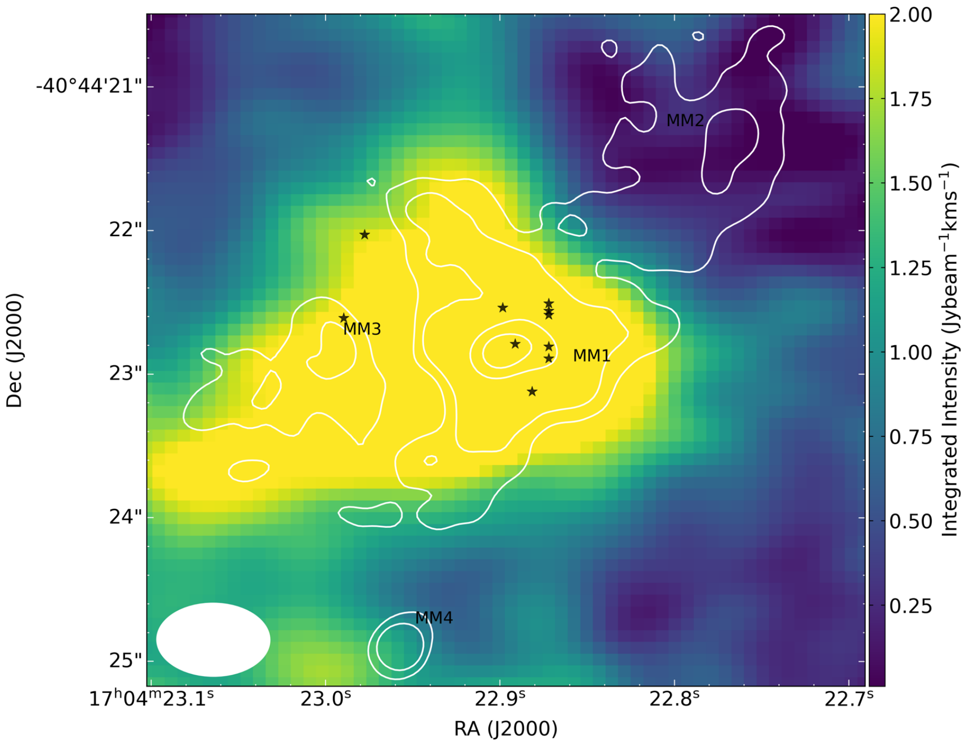
- MM1 1045 +- 94 au
- MM4 397 +- 35au

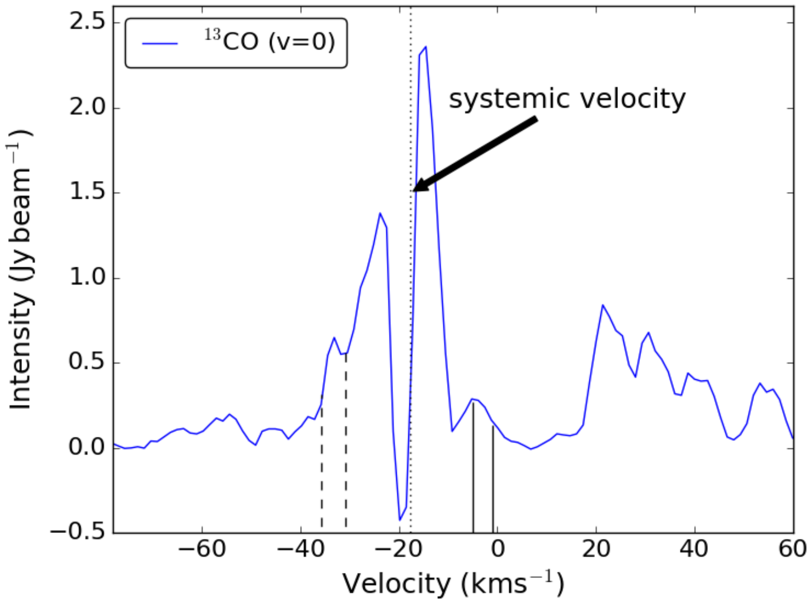


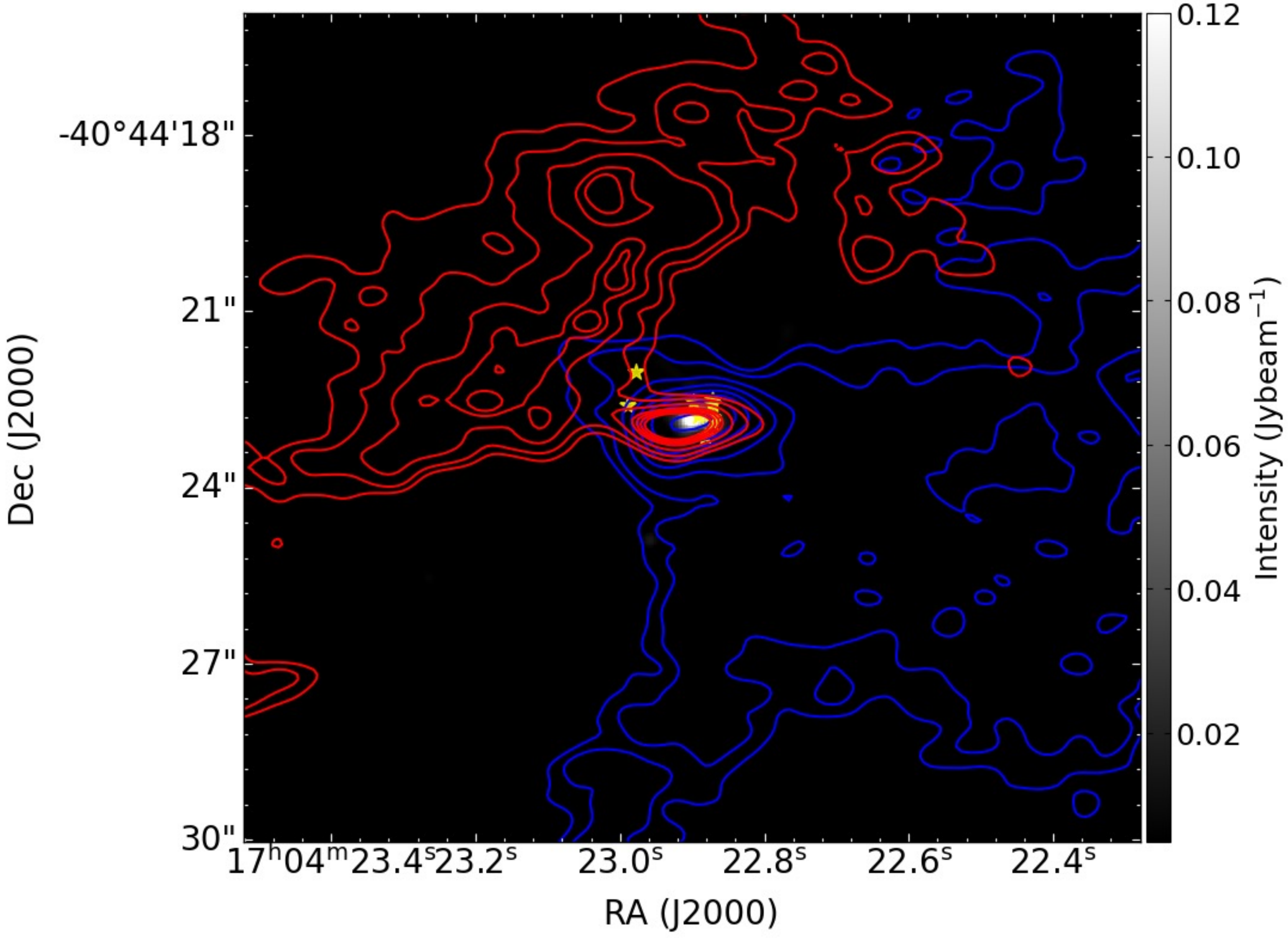


^{13}CO Molecular Emission









OUTFLOW PROPERTIES

- Dynamical timescale: $3 \pm 0.2\times 10^{3}$ yr.

- Outflow mass:$12.00 \pm 0.01\times 10^{-3}$ M⊙
- Momentum: $4.00 \pm 0.16\times 10^{-3}$ M⊙ km s^{-1}
- Energy: $2.96 \pm 0.001\times10^{43}$ ergs
- Mass outflow rate: $4.00 \pm 0.05\times10^{-6}$ M⊙ yr^{-1}
- Momentum flux: $1.32 \pm 0.8\times10^{-6}$ M⊙ km s^{-1} yr^{-1}
- Energy ejection rate: $3.09 \pm 0.02\times 10^{32}$ erg s^{-1}

Conclusions

- MeerKAT continuum maps reveal **three ionized sources (A, B, C)** with different dynamical ages → **Source C is more evolved** and may have triggered later star formation in A and B.
- ALMA continuum data (0.″2 resolution) detect a **cluster of 11 dense cores.**
- Molecular tracers (**H_2CO** , **^{13}CO**) show evidence of **rotation and large-scale outflows**.
- **MM1 is an actively accreting protostar**, driving feedback into its surroundings.
- Cavities in MM1 confirm **the presence of outflows**, supporting massive star formation models with **disk-mediated accretion.**


THANK YOU