Physical Conditions and Kinematics of the Filamentary Structure in OMC1

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We have studied the structure and kinematics of the dense molecular gas in the Orion Molecular Cloud 1 (OMC1) region with the N_2H^+ 3-2 line. The 6’ x 9’ regions surrounding the Orion KL has been mapped with the Submillimeter Array (SMA) and the Submillimeter Telescope (SMT). The SMA data are combined with the SMT data to recover the spatially extended emission. Using the N_2H^+ 3-2 and 1-0 data, we derive the physical conditions of the dense gas in OMC1 by conducting non-LTE analysis. We also examine the gas kinematics inside the filaments, and compare them with the filament/core formation models.

Introduction

Background

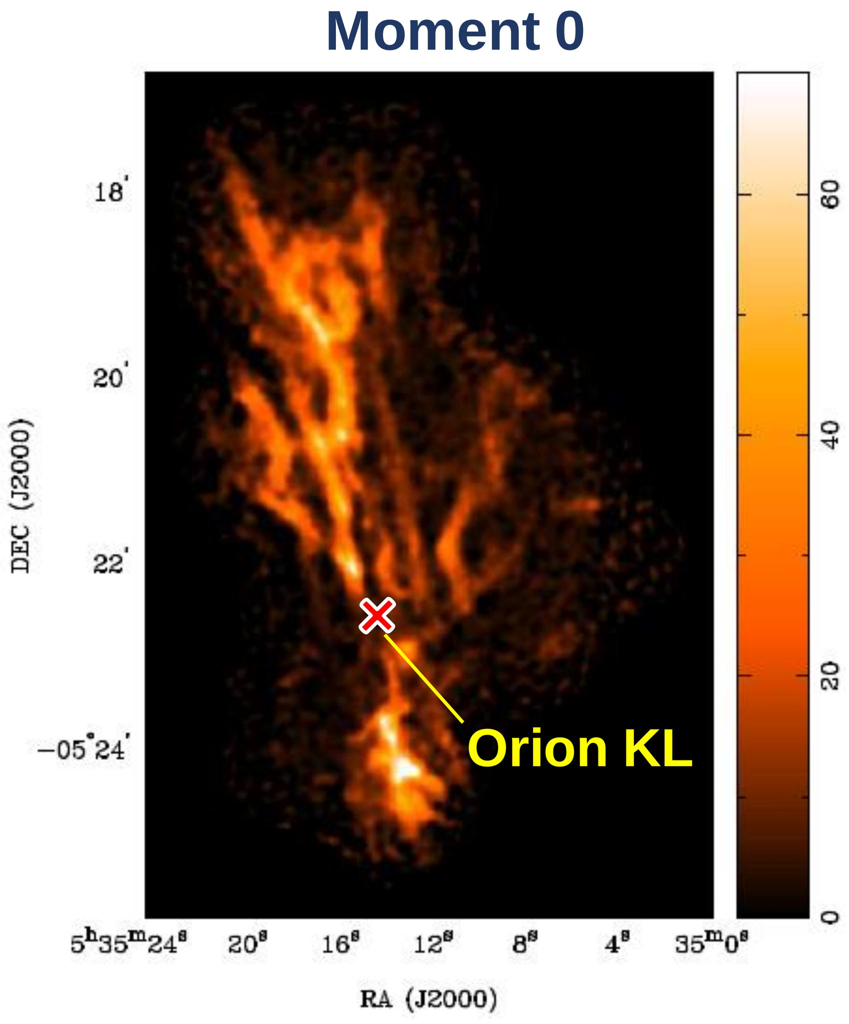
- Filaments have been commonly observed in star-forming clouds from parsec scale to sub-parsec scale
- Such structure may be important in star formation process, and may provide clues of the origin of star-forming regions

Observations

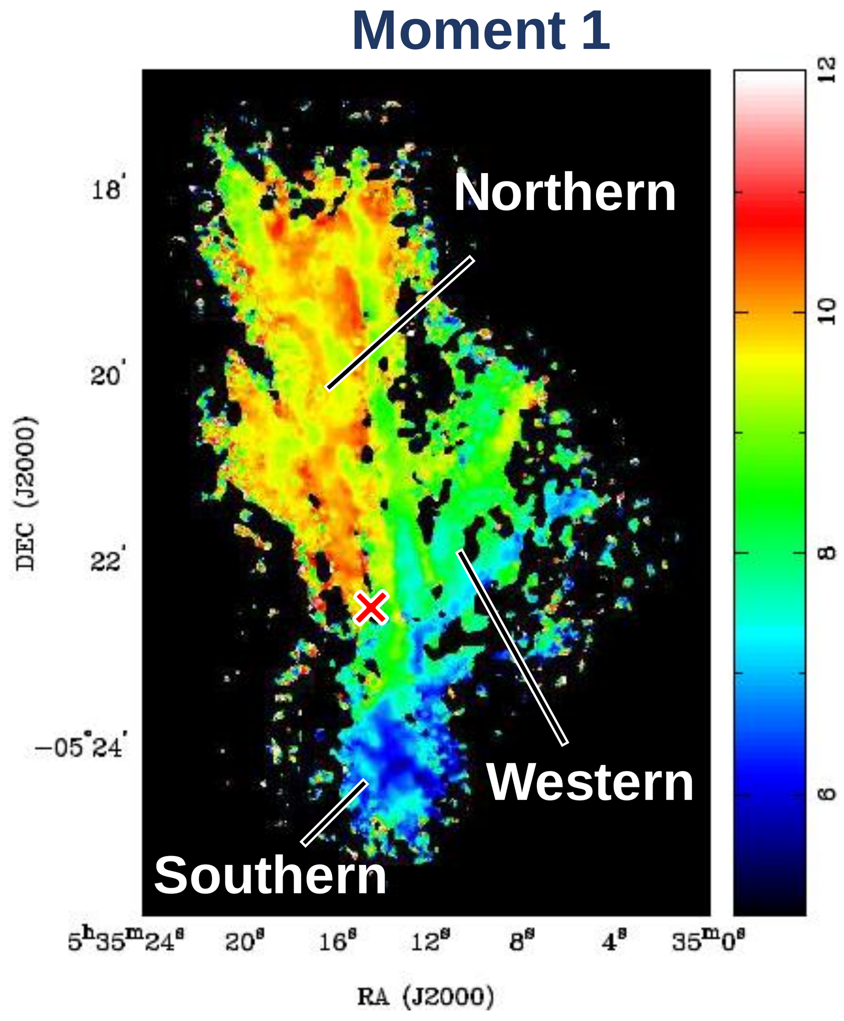
- **Source—Orion molecular cloud 1 (OMC1)**
  → distance: ~400 pc; nearest high-mass star-forming region
- **Line—N_2H^+ J=3-2**
  → critical density ~$10^6\ cm^{-3}$; abundant in cold regions (avoid Orion KL)
- **Telescopes—SMA** (144 pointing mosaic) **+ SMT** (OTF mapping)

Combined Results (SMA + SMT)

Moment 0



Moment 1

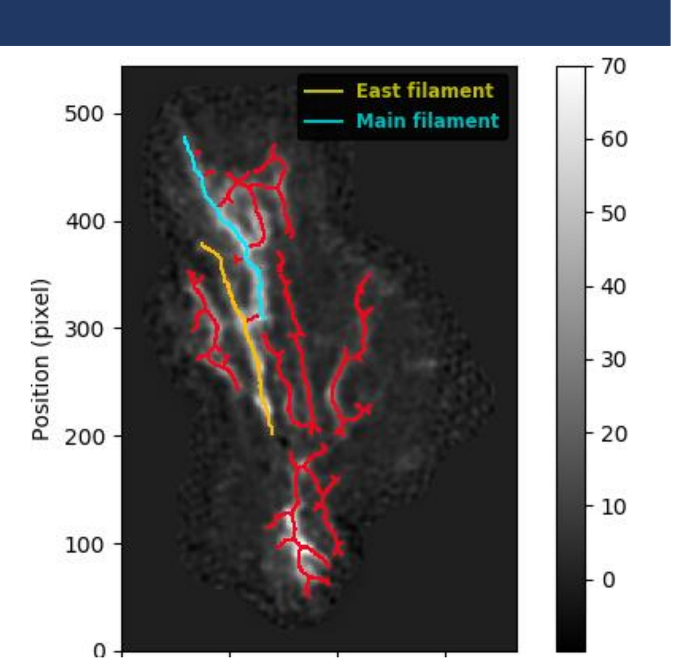


- Most emissions come from the filamentary structure having a typical FWHM of $0.02-0.03$ pc
- No significant emission at the Orion KL region due to the destruction of N_2H^+ molecules in active regions
- Clear velocity transitions at the boundaries of the Northern, Western, and Southern regions
- The three regions with different velocities converge at the Orion KL region → consistent with the MHD simulation of a **global collapsing** cloud (Peretto et al. 2013)

Structural Properties

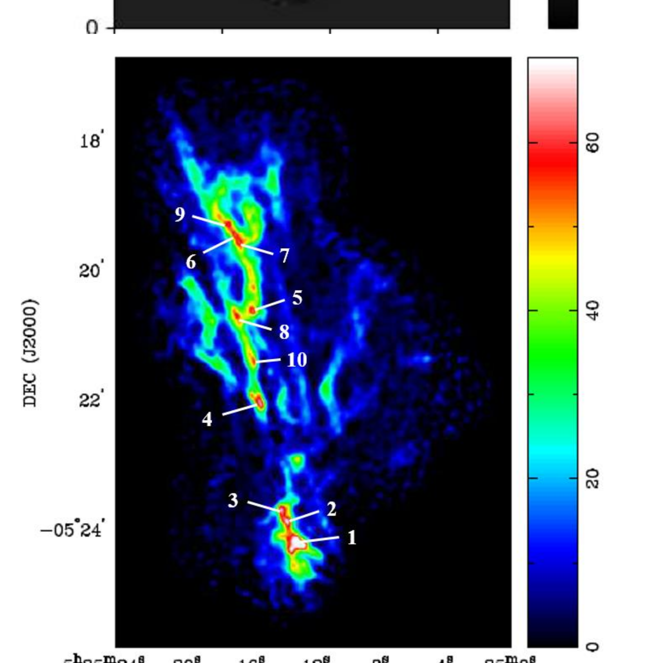
Filament Identification

- Using *FilFinder* Python package
- The main filament (blue) and the east filament (yellow) contain high-intensity clumpy cores → **core fragmentation**
- Line densities
  - Main filament: $94-102\ M_\odot\ pc^{-1}$
  - East filament: $78-85\ M_\odot\ pc^{-1}$



Core Identification

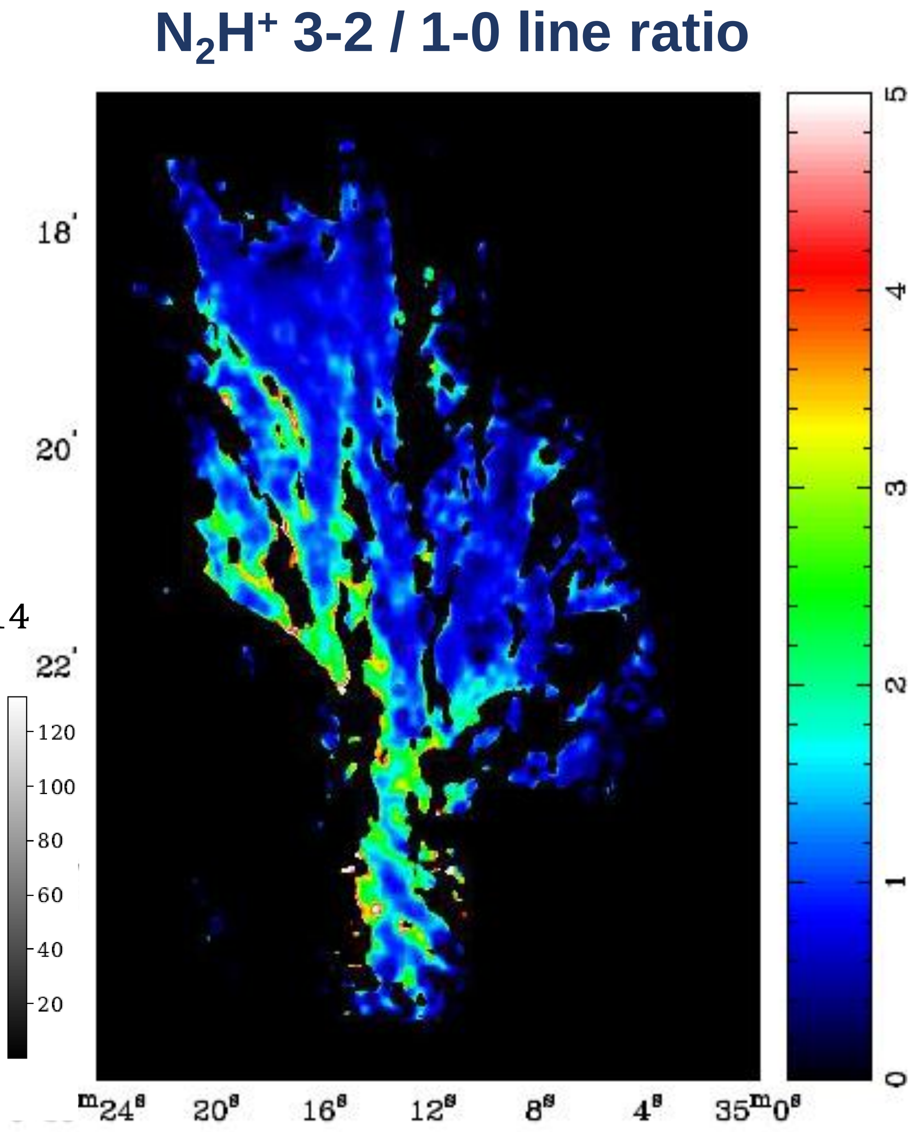
- Using 2-D *Clumpfind*
  → 10 cores identified
- Core masses in the filaments range from $0.1-3\ M_\odot$
  → consistent with the derived core masses in Teixeira et al. (2016) (using SMA 1.3mm continuum data)



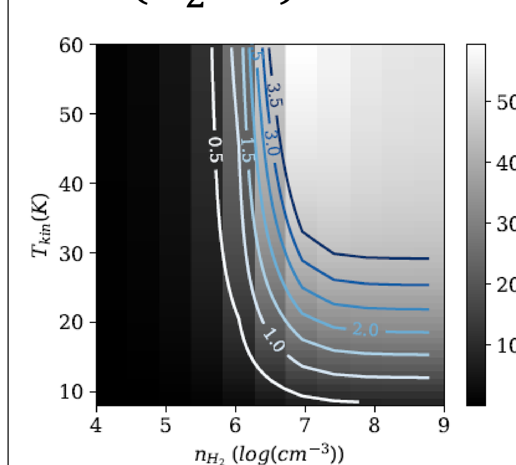
Physical Conditions

- The **eastern part** of OMC1 has higher intensity ratios
  → higher T_{kin} from the *RADEX* non-LTE model
- The **filament regions** have lower intensity ratios than the non-filament regions
  → high density (n, N) + low T_{kin}

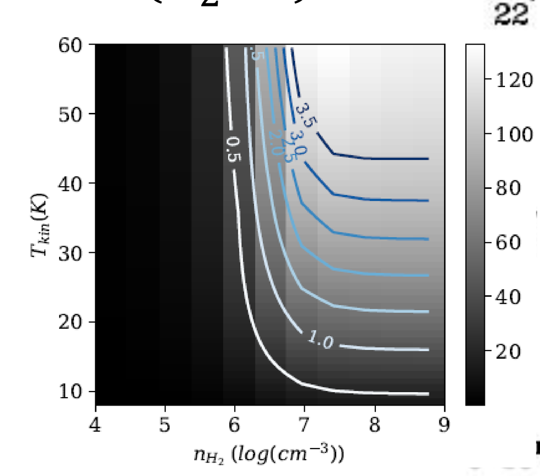
N_2H^+ 3-2 / 1-0 line ratio



$N(N_2H^+) = 10^{13.5}$



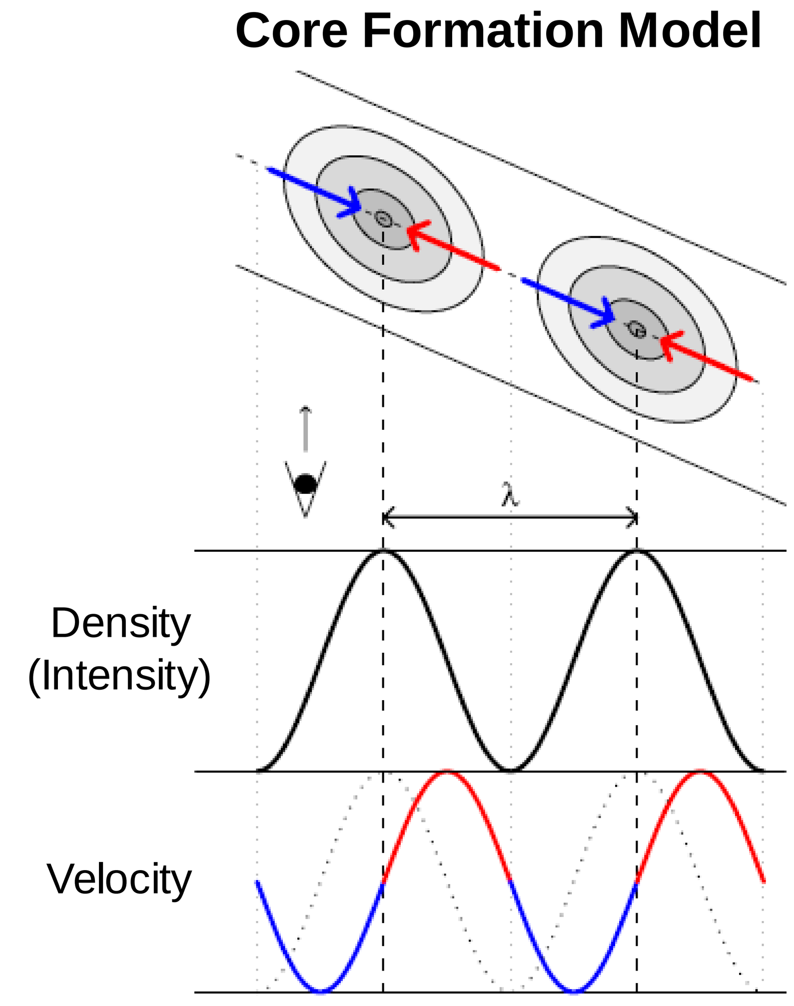
$N(N_2H^+) = 10^{14}$



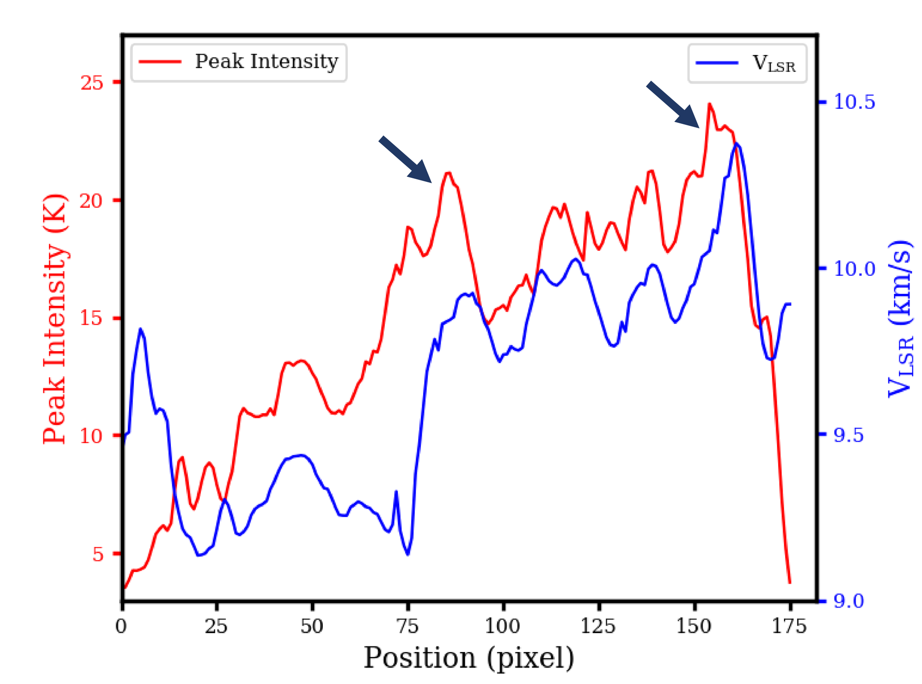
	Filament—Core Regions (> 50 K•km/s)	Filament—Low Intensity Regions (< 50 K•km/s)	Non-filament Regions
$n(H_2)\ (cm^{-3})$	3×10^7 10^7	3×10^6 10^7	10^6 3×10^6
$T_{kin}\ (K)$	19–23 or 18–20	17–22 or 13–16	>45 or 21–30
$N(N_2H^+)\ (cm^{-2})$	10^{14}	3×10^{13}	10^{13}
Typical Ratio	1 ± 0.3	1 ± 0.3	2.2 ± 0.4

Gas Kinematics

Core Formation Model



East Filament



- The **phase shift** between the intensity and velocity variations along the east filament is consistent with the core formation model

Conclusions

- The gas kinetic temperature in the eastern part of OMC1 is enhanced significantly to that of the remaining area, which is likely to be due to **external heating** from the high-mass stars in M42.
- The filaments have **higher densities** of ~10^7 cm^{-3} and **lower temperatures** of ~15–20 K than the non-filament regions. The lower temperatures could be explained by the shielding from the external heating due to the dense gas in the filaments.
- The east filament shows **core-forming gas motions**, which implies that it is in an earlier evolutionary phase than the main filament with star formation signature.

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