Physical Conditions and Kinematics in the Orion Molecular Cloud-1 Filaments

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Introduction

Background

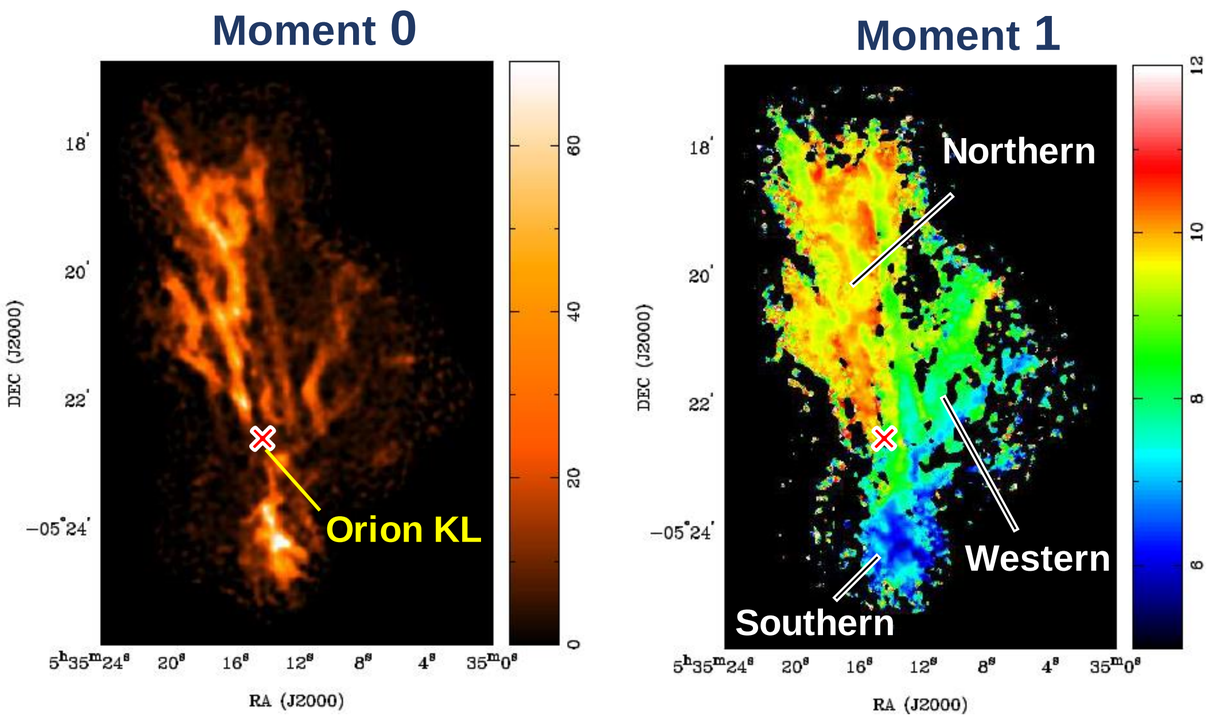
- Filaments have been commonly observed in star-forming clouds from parsec scale to sub-parsec scale
- Such structure may be important in star formation process, and may provide clues of the origin of star-forming regions

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**

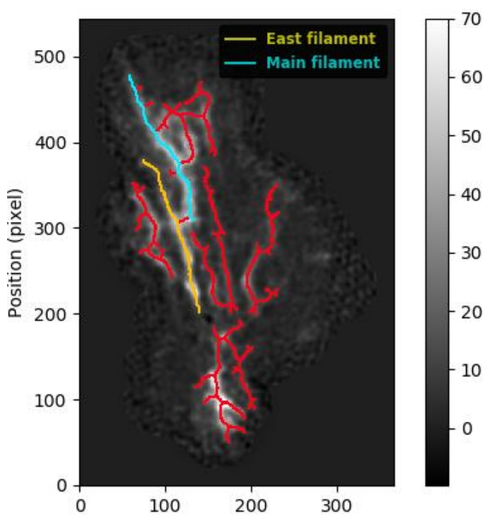


- Most emissions come from the filamentary structure having a typical FWHM of $0.02 - 0.03$ pc
- No significant emission at the Orion KL region due to the destruction of N_2H^+ molecules in active regions
- Clear velocity transitions at the boundaries of the Northern, Western, and Southern regions
- The three regions with different velocities converge at the Orion KL region → consistent with the MHD simulation of a **global collapsing** cloud [1]

Structural Properties

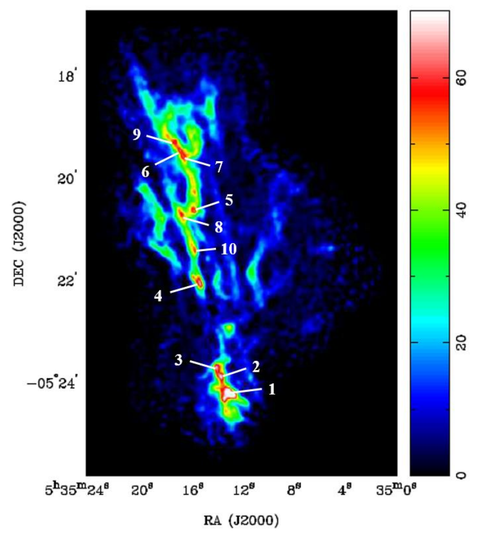
Filament Identification

- Using *FilFinder* package
- The main filament (blue) and the east filament (yellow) contain high-intensity clumpy cores → **core fragmentation**
- Line densities ($M_\odot/pc$)
  - Main filament: $90 - 100$
  - East filament: $50 - 60$



Core Identification

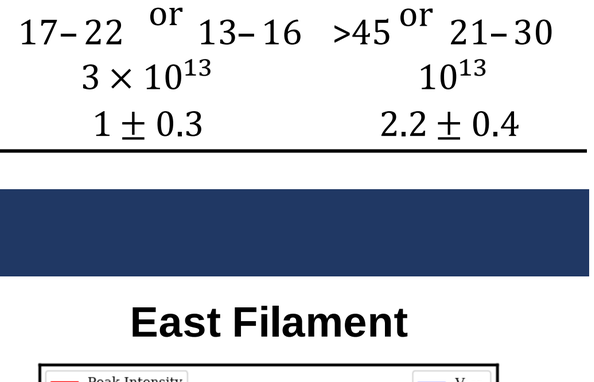
- Using 2-D *Clumpfind*
  → 10 cores identified
- Core masses in the filaments range from $0.1 - 3\ M_\odot$
  → consistent with the derived core masses in [2]
  (SMA 1.3mm continuum data)



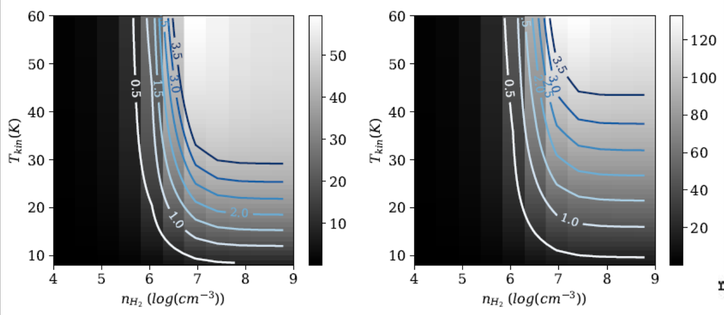
Physical Conditions

- 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 + low T_{kin}

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



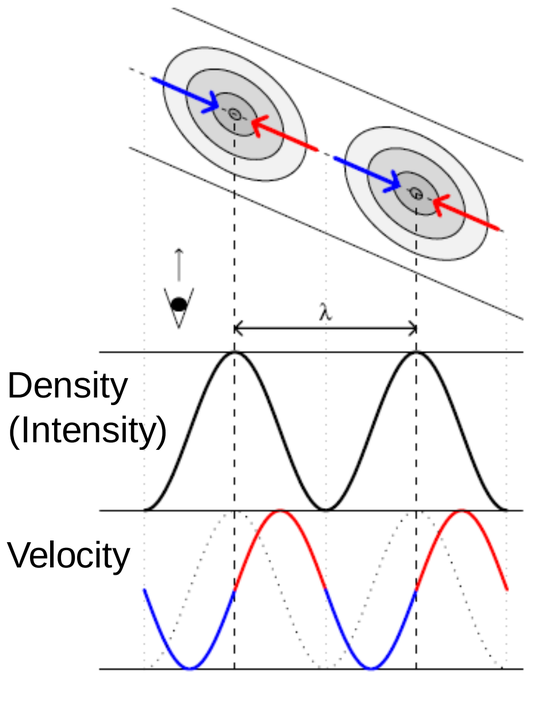
$N(N_2H^+) = 10^{13.5}$ | $N(N_2H^+) = 10^{14}$



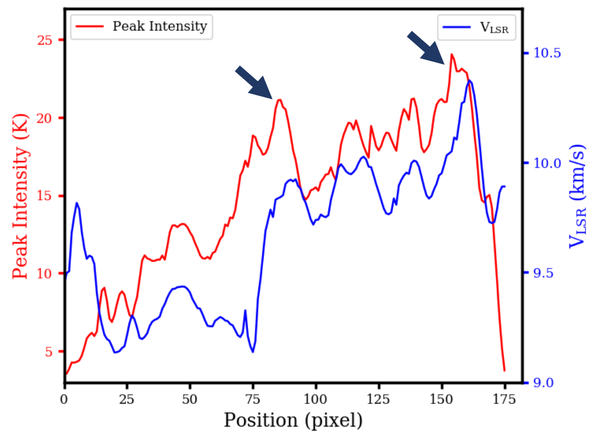
	Filament—Core Regions (> 50 K•km/s)	Filament—Low Intensity Regions (< 50 K•km/s)	Non-filament Regions
$\mathbf{n(H_2)}\ (cm^{-3})$	3×10^7 10^7	3×10^6 10^7	10^6 3×10^6
$\mathbf{T_{kin}}\ (K)$	$19-23$ or $18-20$	$17-22$ or $13-16$	>45 or $21-30$
$\mathbf{N(N_2H^+)}\ (cm^{-2})$	10^{14}	3×10^{13}	10^{13}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

Gas Kinematics

Core Formation Model [3]



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 and M43.
- 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.
- Kinematics of the east filament suggest that **core formation** is still ongoing in this region.

References

[1] Peretto et al., 2013, A&A, 555, A112
[2] Teixeira et al., 2016, A&A, 587, A47
[3] Hacar & Tafalla, 2011, A&A, 533, A34
[4] Hacar et al., 2018, A&A, 610, A77