Fragmentation of the Integral Shaped Filament as viewed by ALMA

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Kainulainen et al. (submitted; arXiv:1603.05688)

With:
Amelia Stutz, Thomas Stanke, Jorge Abreu-Vicente, Henrik Beuther, Thomas Henning, Katharine G. Johnston, Tom Megeath
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High line-mass filaments are:
($m_l > 100 \, \text{M}_\odot \, \text{pc}^{-1}; m_l^{\text{crit}} \sim 20 \, \text{M}_\odot \, \text{pc}^{-1}$)
+ **Important** for Galactic SF.
+ **Different** from low line-mass filaments ($m_l \sim 20 \, \text{M}_\odot \, \text{pc}^{-1}$).

(e.g., Stutz & Gould 2016),

The Orion A molecular cloud

*Herschel*-derived column density

Stutz & Kainulainen (2015)
“The Integral-Shaped Filament”

High line-mass filaments are: 
\( m_\parallel > 100 \, M_{\odot} \, pc^{-1}; \, m_\parallel^{\text{crit}} \approx 20 \, M_{\odot} \, pc^{-1} \)

+ **Important** for Galactic SF.
+ **Different** from low line-mass filaments \( (m_\parallel \approx 20 \, M_{\odot} \, pc^{-1}) \).

(e.g., Stutz & Gould 2016).

**Outstanding target:**  
the ISF in Orion A \( (d=450 \, pc) \)

1) **Resolve fragmentation** down to disk-scales.
2) A census of the **young stellar population** \( (\text{Spitzer} + \text{Herschel}) \).
ALMA Cycle 2 study of OMC-2
(PI: Kainulainen, Co-Is: Stutz, Stanke, Abreu Vicente, Beuther, Henning, Johnston, Megeath)

3 mm continuum emission
$FWHM = 3''$ (1 200 AU)
~130 mosaic points with ALMA
~40 mosaic points with ACA

Herschel-derived column density
Stutz & Kainulainen (2015)
3 mm continuum emission

ALMA

ACA

ALMA+ACA

rms (ALMA): 0.15 mJy beam$^{-1}$

recovered scales: \(\sim 1200-25000\) AU
3 mm continuum emission

ALMA

ACA

ALMA+ACA

rms (ALMA): 0.15 mJy beam$^{-1}$

recovered scales: $\sim$1200-25000 AU
Center part of the observed region
Contours in 3-sigma intervals
Identification of cores

+ GaussClumps (starlink/CUPID)
+ 40 dense cores, $M=0.2-3 \, M_{\text{SUN}}$

Center part of the observed region
Contours in 3-sigma intervals
ALMA+ACA
3 mm map

Number density
of dense cores
(40)

~55,000 AU = 0.3 pc

~30,000 AU = 0.15 pc

~1.6 pc
Two-point correlation function of the core separations

\[ \xi(r) \propto \frac{P_{DD}(r) - 2 P_{DR}(r) + P_R(r)}{P_{RR}} - 1 \]

\( P(r) = \) distribution of separations, \( r \)

D = observed data point
R = random data point

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Center part of the observed region
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Connection to the young stellar population?
Protostars and stars with disks

+ Spitzer Orion Survey (Megeath et al. 2012).
+ Herschel Orion Protostar Survey (HOPS; Furlan et al. 2016).

Center part of the observed region
Contours in 3-sigma intervals

Plusses: Protostars
Crosses: Stars with disks
Dense cores (40)

1.6 pc
Maternal grouping is **not (entirely) erased** during the protostar life-time (~0.5 Myr). It **is erased** during the life-time of stars with disks (~2 Myr).
Conclusions

**Fragmentation of the ISF:**

+ **Periodic fragmentation** to core groups (55 000 AU).
+ **Further fragmentation** below 20 000 AU, especially strong below 6 000 AU.

  → **Existing fragmentation models fail**; (e.g., Jeans 1902, Inutsuka & Miyama 1997, Fiege & Pudritz 2000; Fischera & Martin 2012); **need for multi-scale models.**

+ The grouping of the cores is erased in about the lifetime of stars with disks (~2 Myr).