A Very Compact Extremely High Velocity Flow at MMS 5 / OMC-3

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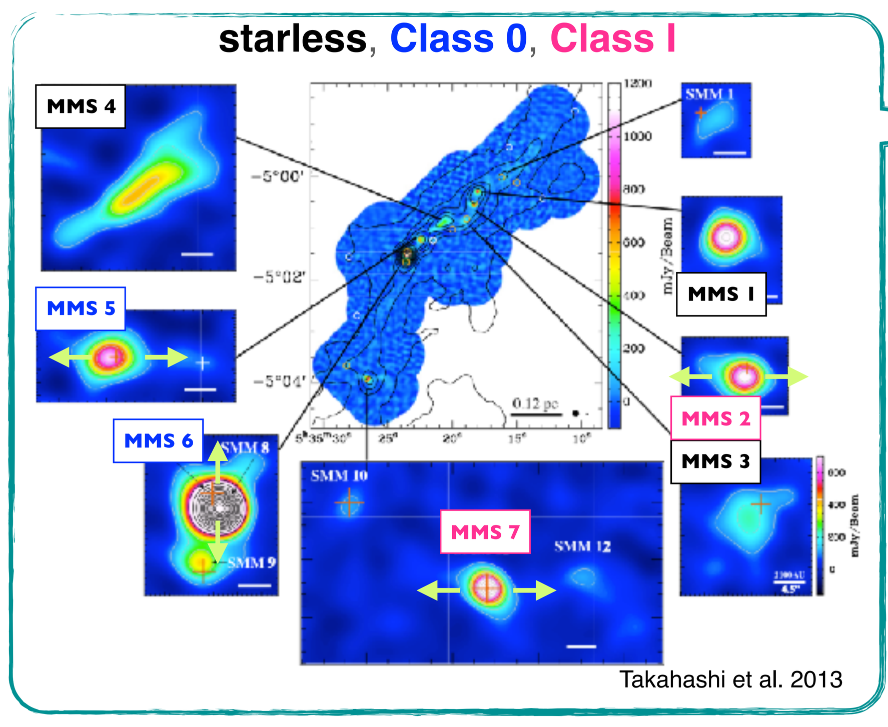
Target : MMS 5 / OMC-3

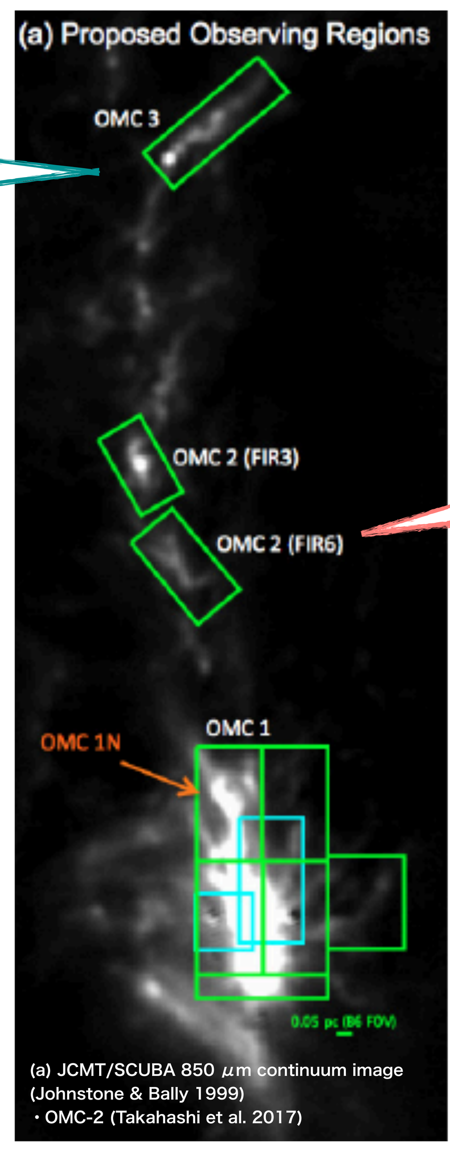
Observation

・Continuum 1.3mm and 2 Lines

spw	Frec [GHz]	Vel. Res [km/s]
CO J=2--1	230.538000	0.367
SiO J=5--4	217.104980	0.390

- CO : low resolution image (~1”) and high resolution image (~0.1”)
- SiO : high resolution image (~0.1”)





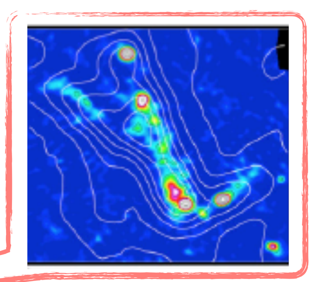
・Orion Molecular Cloud-3, 388 pc (Kounkel et al. 2017)

・RA=83.843625, dec=−5.020675 (CSO 9 and HOPS 88 by Lis et al. 1998 and Megeath et al. 2012; Furulan et al. 2016)

・Class 0

・a compact east-west bipolar outflow in the CO (1–0) emission (Takahashi et al. 2008)

Target : OMC-2



Observation

・Continuum 1.3mm and 2 Lines

spw	Frec [GHz]	Vel. Res [km/s]
CO J=2--1	230.538000	1.266
SiO J=5--4	217.104980	43.156

- low resolution image: ~1,300 AU (~3.5 arcsec) with ACA + ALMA 12m combined
- high resolution image: ~300 AU (~0.8 arcsec) with only ALMA 12m

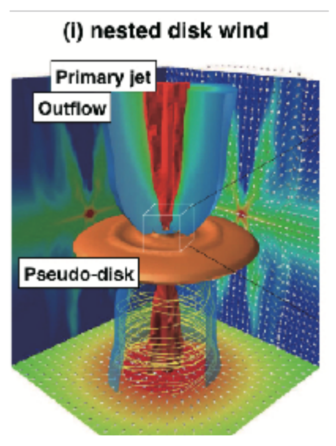
・The first extensive survey of the Orion ISF with ALMA that is optimized to mosaic the dust continuum and measure the fragmentation structure

・Orion Molecular Cloud-2, 388 pc (Kounkel et al. 2017)

Motivation

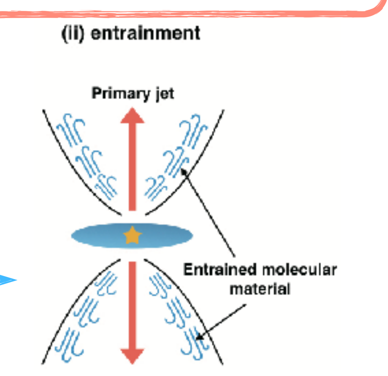
- The relation between the mass ejection and the accretion processes during the main accretion phase
- The driving mechanisms of molecular outflows and high-velocity jets

Driving mechanism: two scenarios

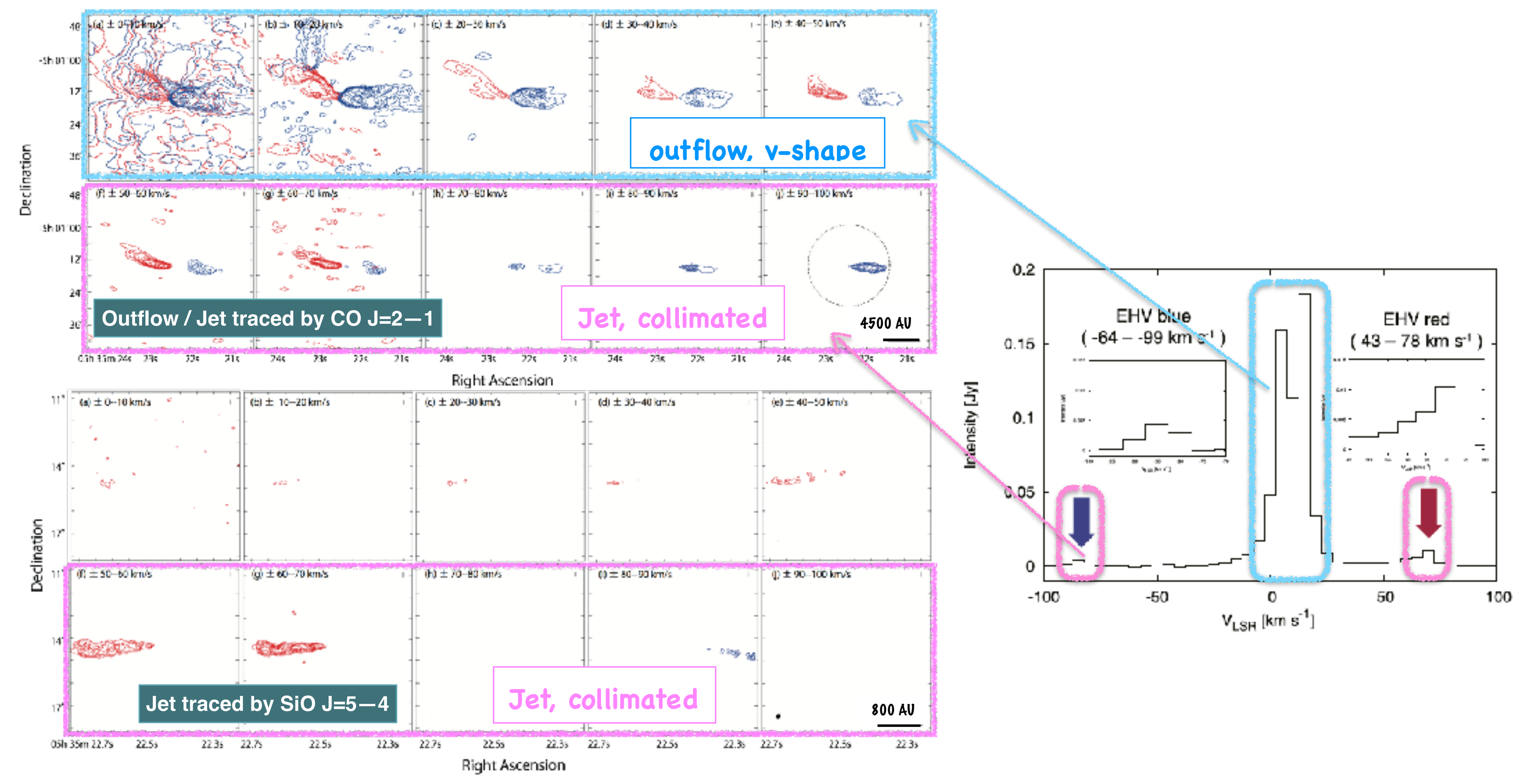


i) nested disk wind scenario (Magnetic Outflow)
--> Outflow flows are driven around the first core
--> Jet are driven second core (protostar) (Machida et al. 2014)
--> evolutionary difference between the low-velocity outflow and high-velocity jet

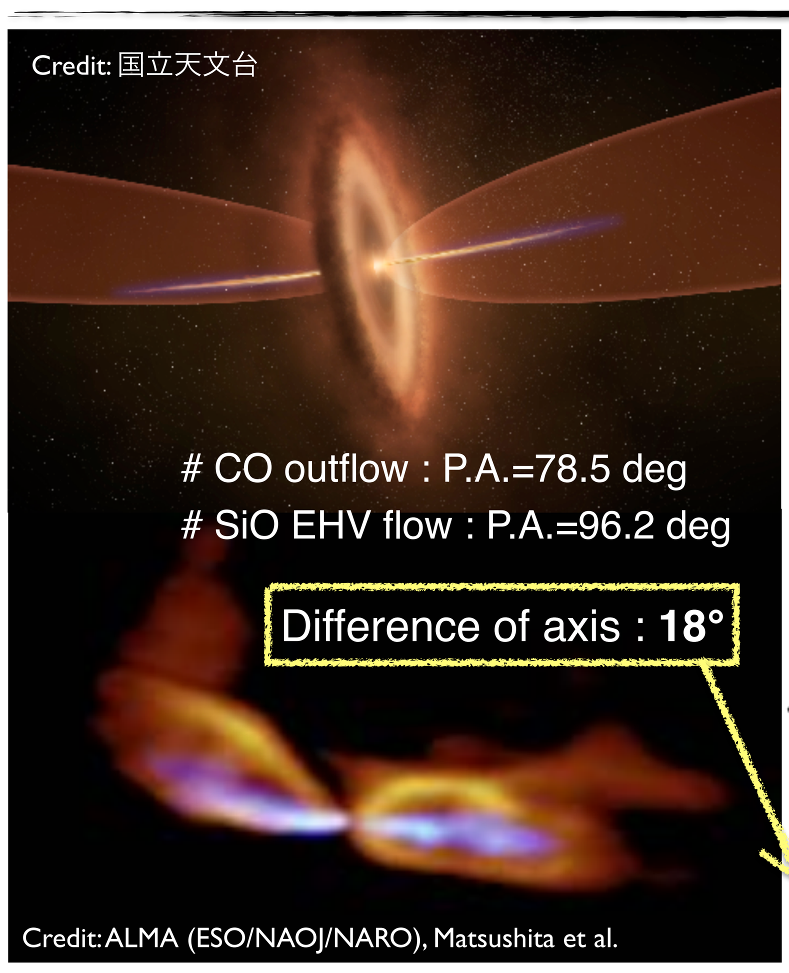
ii) entrainment scenario
--> the jet accelerates the entrained gas to the supersonic speed and creates the outflow (Arce et al. 2007)
--> both the outflow and jet have the same age



Q. What is EHV (Extremely High Velocity) Object ?
Ans. Detected both Outflow and Jet !



\# EHV objects are extremely rare, and only ~10 samples are currently known
\# ALL Class 0
\# low-mass, intermediate-mass, high-mass star



Parameter of Outflow / Jet

\# Jet size is shorter than outflow size

\# Dynamical timescale of Jet is smaller than that of outflow by a factor of ~ 3. (Mstsushita et al. 2019)

	L_{obs}[a] [AU]	L[b] [AU]	v_{obs}[c] [km s^{-1}]	v[d] [km s^{-1}]	t_{dyn}[e] [yr]
outflow (CO J=2–1)......	9,300	14,000	30	40	1,300
jet (CO J=2–1).........	7,000	11,000	70	90	470
jet (SiO J=5–4)........	1,600	2,500	70	90	110

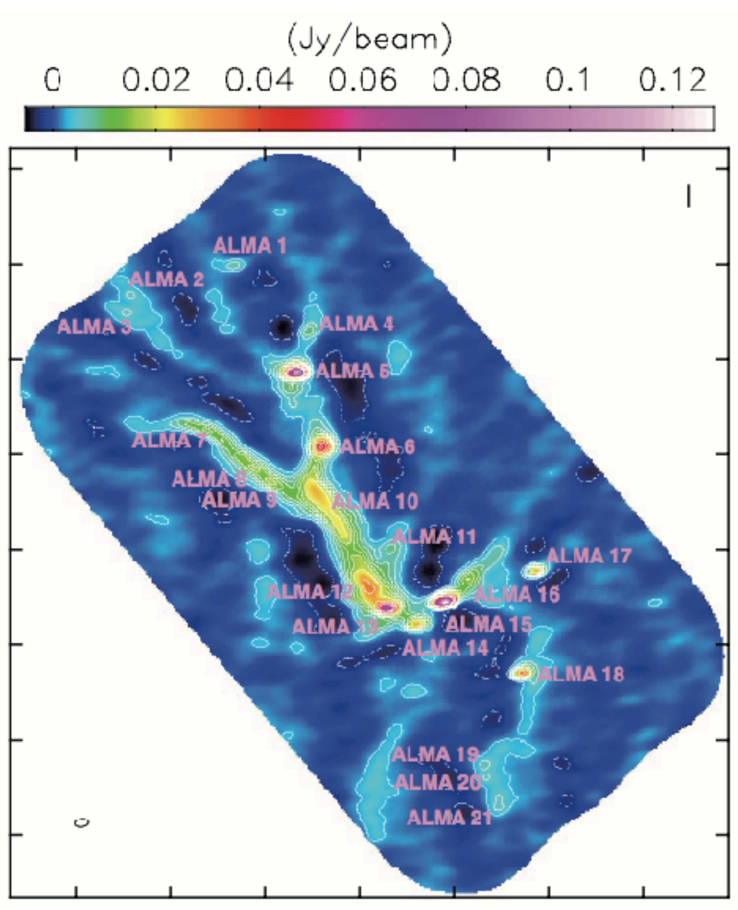
[a] Typical apparent size scale. [b] Intrinsic size scale assuming $i = 50°$.
[c] Typical observed line-of-sight velocity. [d] Intrinsic speed assuming $i = 50°$. [e] Dynamical timescale.

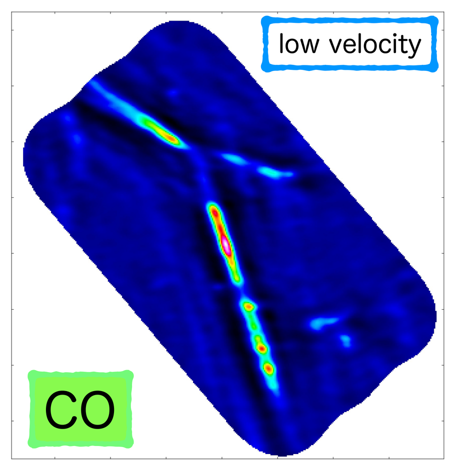
\# Evolutionary difference between the low-velocity outflow and high-velocity jet
\# Support the **nested disk wind scenario** ?

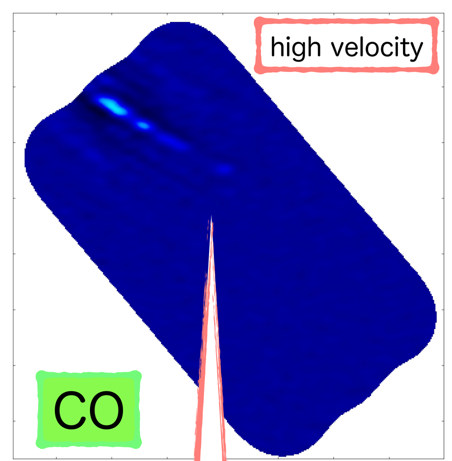
Different axis of Outflow / Jet

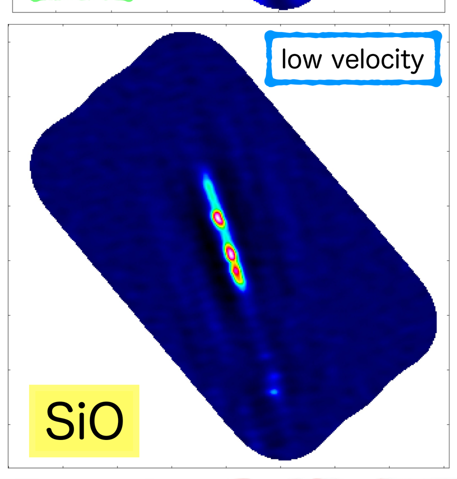
\# This difference between the jet and outflow axes could be explained by different launching radii.
\# Outflow traces the mass ejection history for the last ~10^3 yr, and the change of the outflow axis.
\# Jet traces only the mass ejection history around the protostar in the recent ~10^2 yr.

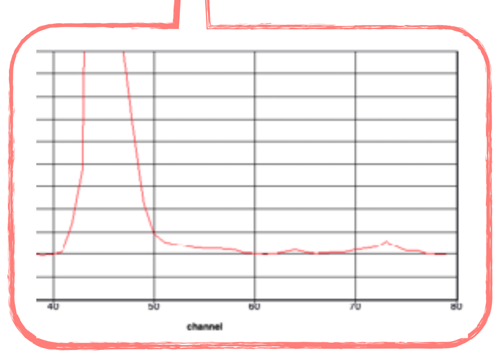
Continuum New Source and New Outflow and EHV Flow











- ALMA 5 : CO outflow and CO EHV flow
  >> low velocity : 10 - 40 km/s
  >> **high velocity : 50 - 90 km/s (new!)**
- ALMA 13 : CO and SiO outflow
- **ALMA 18 (new!)** : CO outflow

The core detected is detected over 10 sigma.
Comparison with previous observations such as HOPS objects
>> **10 objects are newly discovered in this ALMA observation**