SMA + JCMT Survey of Massive Star-forming cores in Cygnus-X

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Outline

• Background

• Surveys of Cygnus-X cores

• **JCMT+SMA**: existing data, and observations to be proposed

• Summary
In the context of high-mass star formation

Big Questions in high-mass star formation:

- initial conditions?
- earliest stages?
- collapse/fragment governed by G/T/B/R?
- further mass grow process?
  - How to break great barriers (radiation, ionization)?
  - disks accretion (collimated jets and outflows)?
  - competitive accretion / merging?

\[ \gtrsim 10^4 M_\odot \text{ clouds} \rightarrow 10^3 M_\odot \text{ clumps} \rightarrow \sim 1 - 10 \text{ pc} \rightarrow \sim 0.1 \text{ pc} \ (10'' \text{ for D } \sim 2 \text{ kpc}) \rightarrow \text{ massive (} 10^2 M_\odot \text{) cores?} \rightarrow \text{ Jeans-mass or super Jeans-mass (} \sim 1 - 10 M_\odot \text{) seeds?} \rightarrow \sim 0.01 \text{ pc and smaller} \]

Interferometers (SMA, JVLA, CARMA, ALMA) + JCMT
Why Cygnus X?

One of the richest molecular cloud and HII region complexes located at a distance $<2 \text{ kpc}$ ($\sim1.4 \text{ kpc}$, Rygl+2012);

The molecular cloud complex: mass $\sim 10^6 \, M_\odot$; size $\sim$ a few 100 pc;

Already Mapped by various IR to mm telescopes (e.g., Spitzer, Herschel, JCMT, IRAM 30m).
MAMBO 1.2mm survey: discovered 129 cores (~0.1pc); 42 massive (>30 $M_{\odot}$)

(Motte+ 2007; also see followups by Schneider+ 2010; Bontemps+ 2010; Csengeri+ 2010; 2011; Duarte-Cabral+ 2013, 2014)
Herschel 250µm

SCUBA2 850µm (credit to M. Thompson)

survey targets

W75N

DR21(OH)

100 pc

IRDC G79.43

AFGL2591
The SMA is a pathfinding instrument comprised of eight 6-meter antennas on Mauna Kea, HI, designed for high spatial and spectral resolution imaging in submillimeter atmospheric windows. The SMA is now being used to study Solar System bodies, protoplanetary disks, star forming regions, evolved star envelopes, the Galactic Center, nearby galaxies, and ultraluminous galaxies at cosmological distances.

The SMA is a collaborative project of the Smithsonian Astrophysical Observatory, part of the Harvard-Smithsonian Center for Astrophysics, and the Academia Sinica Institute of Astronomy and Astrophysics (Taiwan).

**survey strategies**

**JVL A (PI & archive)**
radio cont., NH$_3$

**SMA (PI & archive)**
dust cont., CO, SiO, CH$_3$OH, CH$_3$CN, ...

**MYSO s, jets/outflows, Temp., Turbulence**

**core frag., kinematics, toroids/disks, outflows, chemistry, B field, ...**

**ALMA**
selected sources

**CARMA**
selected sources

**JCMT (PI & archive)**
dust cont., CO, ...

**clump frag., CO outflows, B field**
Preliminary results - CO outflows with the SMA
CO outflows: SMA + JCMT
SMA

velocity

SMA + JCMT
another example
Preliminary results - 1.3 mm continuum with the SMA
A joint analysis of SMA and JCMT continuum data focusing on the clump/core fragmentation is ongoing ...
Mapping the field on multi scales (cloud → clump → core → envelope/disk) is the key to a better understanding of the role of the field
 JCMT+SMA observations in the plan — B field

magnetic field on ~1pc scales — CSO dust polarization

JCMT & SMA dust polarization observations of CygX massive cores will reveal the importance of B fields with an unprecedented sample that the sources are at a single distance and the mass density, outflow, turbulence, and evolutionary stage information all already available from the existing observations.
JCMT+SMA observations in the plan — coldest gas
summary

- Our JCMT CO(2-1) observations successfully recovered large scale structures missing in the SMA data, and clearly improved the image quality;

- A joint analysis of clump and core fragmentation with the JCMT and SMA dust continuum observations is ongoing;

- We will pursue future JCMT + SMA observations, aimed at, e.g., mapping the dust polarization and distribution of coldest gas.