SMA Collaborations

Qizhou Zhang

- Partnership with ASIAA
  - Joint time allocation committee to review proposals
  - Contribute to general operating cost and technical support

- Collaboration with Nanjing University, China

- Potential collaboration with Purple Mountain Observatory, China on wSMA
Limited partnership with Nanjing University (2014 – 2022)

- Scientific Cooperation Agreement signed between SAO – NUSASS (Nanjing University School of Astronomy and Space Science) for a limited partnership that allows access of SMA observing time
- First agreement in Dec. 2014
- Extended in Nov. 2016
- Extended again in Nov. 2017 for period 2018 - 2022
Surveys of Clumps, Cores, and Condensations in Cygnus-X
Keping Qiu (NJU), Yue Cao (NJU), Yuwei Wang (NJU), Qizhou Zhang (CFA), Junhao Liu (NJU), Bo Hu (NJU)

Project Overview:
Cygnus-X is the most massive and active high-mass star-forming complex at a distance less than 3 kpc from the Sun (Motte et al. 2007-2017). We are performing comprehensive surveys of Clumps, Cores, and Condensations in Cygnus-X using SMA, PI. B. Qiu, dedicated to systematic study of the hierarchy of molecular cloud structures and high-mass star formation in the complex. The SMA survey, which is the central part of the project, has been conducted in the 1.3 mm wavelength with the Sub-compact, Compact, and Extended configurations. So far we have completed most of the SMA observations with more than 200 hours of observing time.

The scientific goals of this project are:
- to constrain the initial conditions of high-mass star formation by providing high-resolution molecular tracers from a large molecular cloud; here they fragment to form ~0.1 pc massive dense cores (MMDCs) and later become further collapsed and fragment into ~0.01 pc protostellar or protostellar condensates;
- to understand the star-formation process in a mass range similar to their low-mass counterpart through an unbiased survey of a large sample of outflows, rotational cores, and discs within a single molecular cloud complex.

**Remarks:**
- We are completing an SMA survey of the Cygnus-X complex, and the ongoing analysis provides these preliminary results:
  - We detect ~0.01 pc fragments toward more than 90% of the MDCs, and find that the fragmentation of the MDCs cannot be understood as thermal Jeans or turbulent fragmentation.
  - We detect high-velocity outflows in the SMA+JCMT CO maps in more than 90% of the MDCs; though most outflows are bipolar and/or collimated, only a few of them are associated with rotational structures seen in typical “disk-tracing” spectral lines, suggesting that pseudodisks around high-mass protostars are mostly smaller than 1000 AU.
  - We find that expanding HII regions, strong UV radiation, and stellar winds are very inefficient in triggering nearby high-mass star formation.
Cygnus-X survey

- Investigate cloud collapse and fragmentation → stellar cluster
- Explore chemical diversity and evolution in protostellar cores
- 47 pointings (including data from SMA archive), subcompact and extended configurations

1.3mm continuum (PI: Qiu)
Interest from PMO for 3mm-band RX

- Purple Mountain Observatory of Chinese Academy of Sciences expressed interest to build a set of 3mm-band guest receivers for the wSMA.
- Preliminary discussions between SMA – PMO since April 2018 about technical feasibility.
- PMO will hold meetings to gauge community interest in China.
- Small group (Paine, Radford, Oberg and Zhang) at CfA to explore its feasibility.
Atmospheric transmission at Maunakea
Why 3mm band?

- **Science drivers**
  - Access low-J molecular lines ($\text{N}_2\text{H}^+/$$\text{NH}_2\text{D}/\text{HCO}^+/$$\text{HCN}/\text{CO}$) to complement 230/345GHz RXs
  - Explore high-z universe via large areal surveys & spectral stacking (large BW compensates for small dishes)
  - Enable time sensitive observations in less optimal conditions

- Dual band operation through dichroic splitter
Excitation & H$_2$ mass in galaxies

Majority of molecular gas in the Milky Way/nearby galaxies are cold

Courtesy Petitpas
Hi-z galaxies

Observing freq $\sim z$

Courtesy Keating

Spilker+ 2014
Time domain astronomy

Black hole X-ray binary V404 Cyg

A 3mm band:

Enable time sensitive observations in less optimal conditions

Multi-frequency observations

Tetarenko+ 2017, Gurwell’s poster
- 3mm RX is one of the several ideas for the wSMA guest receiver slot
- We are at very early stage of a feasibility study, would love to hear Committee’s advise
Star formation in Cygnus-X

Why significant more active SF in DR 21(OH) than in northern filament??
Low J molecular lines are crucial

Three filaments in $^{13}\text{C}^+\text{O}$ and $\text{NH}_2\text{D}$

They intersect in DR 21(OH)
NGC 6334

Column density derived from ArTéMiS and Herschel 350 µm
Andre+ 2016

Russeil+ 2013

Zernickel+ 2013: HCO⁺ 3-2

July 17-18, 2018
NGC 6334 imaged with ACA

Storm+
ALMA Cycle 6 Stats: Time requests

12-m Array

- Band 6: 36%
- Band 7: 23%
- Band 9: 2%
- Band 10: 1%
- Band 8: 3%
- Band 4: 7%
- Band 5: 3%

7-m Array

- Band 6: 36%
- Band 7: 16%
- Band 8: 7%
- Band 9: 1%
- Band 10: <1%
- Band 3: 36%
- Band 4: 2%
- Band 5: 2%
Star formation in Cygnus-X

Why significant more active SF in DR 21(OH) than in northern filament??
Star formation in Cygnus-X

Hennemann et al. 2012