• **SIO EMISSION FROM THE INNER PC OF SGR A**

- Star formation within the inner few pc
  - Signatures of ongoing star formation
- $^{13}$CO and H50α RRL observations
- Cloud Collapse Model

• **Conclusions**

Young Stellar Cluster Orbiting Sgr A*

- 90 WR/O stars
- Clockwise: 61 WR/O (blue)
- Counterclockwise: 29 WR/O (red)

$$Q = \frac{c_s \Omega}{\pi G \Sigma}$$

- Toomre instability
  $$Q_{\text{critical}} \sim 1$$
The Circumnuclear Molecular Ring (2-7pc)

FYZ et al. 2015
1. Water and Methanol Masers in the Molecular Ring

- The positions of water masers and collisionally excited methanol masers are drawn as crosses and circles on an HCN(1-0) map.

- The surrounding plots show the spectra of 13 water masers.
2. Molecular Ring’s Interior: SiO (5-4) Line Emission

- Detected 11 SiO peaks within 0.5pc
- Unbound by self-gravity $t_{\text{dyn}} < t_{\text{collapse}}$
- FWHM $\sim$ 150 km/s
- Blue-shifted velocity wings
- Non-circular radial velocities

- SiO is an excellent tracer of shocked gas in protostellar outflows
- SiO sources are YSO outflows
- $L$ and $\Delta V$ similar to Galactic YSOs
- Age $\sim 10^{4-5}$ years

Ionized gas orbiting Sgr A*
3. Infrared Excess Sources

- The distribution of YSO candidates is superimposed on a 7mm and 3.6 micron continuum image based on VLA and VLT observations (FYZ et al. 2015).
4. Star Formation near Sgr A*: Proplyd Candidates

- ~44 radio sources with cometary appearance
- Size scale ~500AU
- \([N\text{Ly} / d^2]_{(GC)} \sim [N\text{Ly} / d^2]_{(Orion)}\)
- Protostellar disk candidates
- Multiple sources of illumination
- The mini-spiral ionized gas orbiting Sgr A*
- ~100 OB stars within 5” of Sgr A*
- Resolution between ~50x100 mas

\(\text{FYZ et al. 2015}\)
ALMA DATA: $^{13}$CO (J=2-1)
BP1: Protostellar Outflows: ALMA DATA

$^{13}$CO (2-1) RGB
- Red SE lobe: 115-117 km/s
- Green Ridge: 113-114
- Blue NW lobe: 110-112 km/s

The Inner edge of the Molecular Ring
BP1: Protostellar Outflows: ALMA DATA

- $^{13}$CO (J=2-1) emission:
- Swept up material
• 13CO (2-1) Contours:
  • Redshifted: 96-100 km/s
  • Blueshifted 91-95 km/s
BP2: Protostellar Outflows: ALMA DATA

- $^{13}$CO (2-1) Contours:
- Redshifted: 96-100 km/s
- Blueshifted 91-95 km/s
BP8. Protostellar Outflows: ALMA DATA

- H50α RRL contours on 4.5 micron image
- Redshifted: -80 km/s
- Blueshifted -86 km/s
• 13CO (J=2-1) and SiO (5-4) emission
• Redshifted CO: 164-165 km/s
• Blueshifted CO: 162-163 km/s

PV diagram: Broad SiO (5-4)
\( v=146 \text{ km/s}, \Delta V=73 \text{ km/s} \)
• **13CO (2-1) Contours:**
  - Red: 13CO
  - Blue: 4.5 microns
  - A single lobe
  - Cross: YSO, IR excess
Protostellar Outflows: Physical Characteristics

$^{13}\text{CO}/^{12}\text{CO}=1/25$

$^{12}\text{CO}/\text{H}_2=10^{-4}$

Fraction of $^{13}\text{CO}$ in J-$2=0.2$

Momentum rate equivalent to $L/c$: 97, 160

Low mass star with outflow rate $10^{-7}$ Msol.

Dynamical time scale $\sim 2\times 10^4$ yrs

<table>
<thead>
<tr>
<th>Source</th>
<th>Red lobe mass (Msun)</th>
<th>Red lobe n$_H$ (cm$^{-3}$)</th>
<th>Blue lobe mass (Msun)</th>
<th>Blue lobe n$_H$ (cm$^{-3}$)</th>
<th>Mass to</th>
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<tr>
<td>&quot;BP1&quot;</td>
<td>0.194</td>
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<td>0.122</td>
<td>$2.14\times10^5$</td>
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<td>&quot;BP2&quot;</td>
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<td>&quot;BP3&quot;</td>
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<td>&quot;BP4&quot;</td>
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![Graph showing J=2 fraction vs T (K)]