Point Symmetric Clouds Around the GMZ

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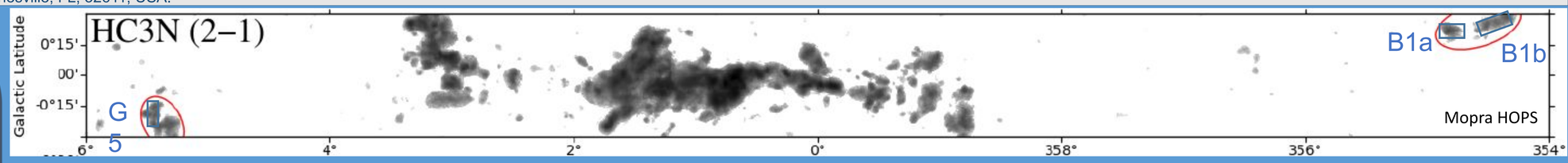


Introduction

There are two clouds, Bania 1 (l, b)=(-5.4, +0.4) and G5 (+5.4, -0.4) which are situated symmetric to Sgr A*. These clouds are outside of the Central Molecular Zone (CMZ), but not in the spiral arms of the galaxy either. They seem to be excited by some outside source and are nearly void of star forming regions. These two clouds may be evidence of Bar Potential Dynamics, which would provide data to understand and model the central galactic bar. By finding the properties of these clouds, we can figure out their function in the galaxy. These clouds are likely in the gas flows which feed the CMZ.

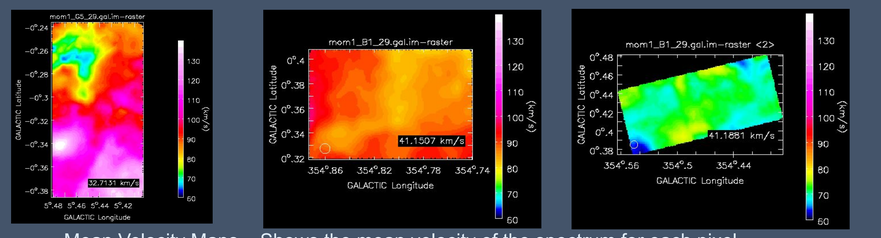
Questions:

1. Are the properties of these two clouds similar?
2. How do the properties of these clouds fit into the gas accretion scenario?

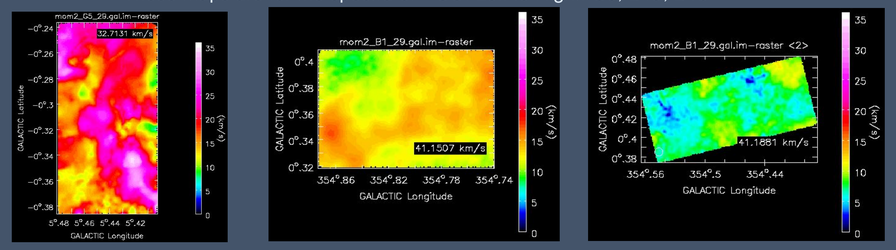
Abstract

We observed two clouds in the Galactic center, G5 at (l,b) = (+5.4, -0.4) and B1 (-5.4, 0.4) with ALMA and the ACA. These two molecular clouds, symmetric to Sgr A*, in earlier low resolution surveys have similar properties and differ galactic disk gas, but are outside of the CMZ. We aimed at these clouds to determine if they are also similar in gas properties, with measurements of the spectral lines ^{12}CO(2-1) (230.538 GHz), ^{13}CO(2-1) (220.368 GHz), and C^{18}O(2-1) (219.530 GHz) to observe the objects at a range of velocities, HC_3N (24-23) (218.295GHz) as an excitation tracer, H_2CO(303-202) (218.222GHz) and H_2CO(322-221) (218.730GHz) as temperature tracers, and SiO(5-4) (217.075GHz) as a shock tracer. Using formaldehyde line ratios, we found that these clouds are warm, around 50K. CO Isotopologue ratios were used to calculate the opacity of these clouds, which was around 1 to 4. These clouds are hot and low-opacity, unlike star-forming clouds in the spiral arms. The presence of the SiO (5-4) transition means that these clouds are undergoing shocks. A comparison with kinetic gas models of the galactic bar show that these clouds are likely not tracing exactly symmetric locations given the 3D orientation of the bar. G5 is likely a region where gas from a western x1 orbit which overshoots accretion onto an x2 orbit and collides with an eastern x1 orbit. B1 is likely gas along the tip of the western x1 orbit.

Kinematic Maps

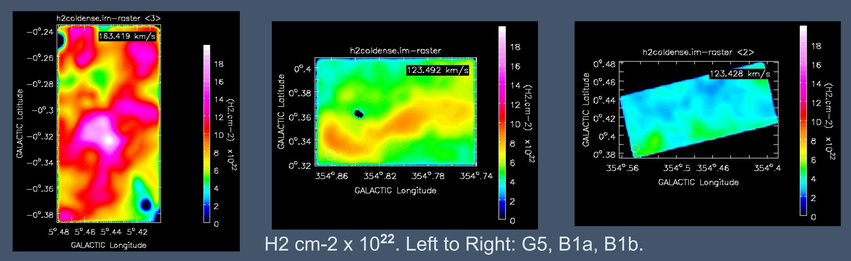


Mean Velocity Maps – Shows the mean velocity of the spectrum for each pixel. These maps are for the spectra of ^{13}CO. Left to Right: G5, B1a, B1b.



Velocity Dispersion Maps – Shows the width of the spectrum for each pixel and therefore how turbulent the gas is. These maps are for the spectra of ^{13}CO. Left to Right: G5, B1a, B1b.

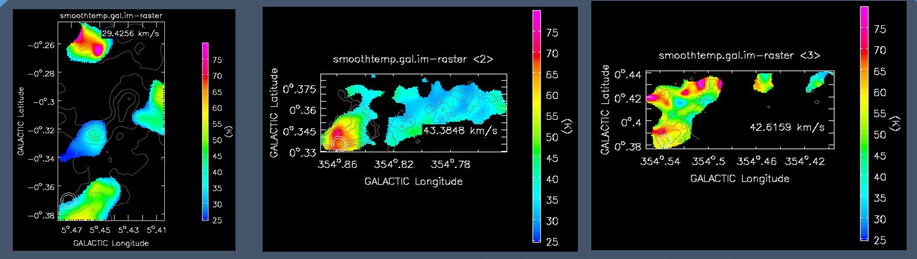
- G5 has components at many varying mean velocities compared to the relatively calmer B1 clouds.
- Velocity Dispersion maps show G5 is much more turbulent than the B1 clouds.
- Evidence that G5 is undergoing a collision with another cloud.



H2 cm-2 x 10^{22}. Left to Right: G5, B1a, B1b.

H_2 Column Density

- Shows how much molecular hydrogen gas there is in these clouds.
- Maps are based on ^{12}CO integrated maps times the standard factor X = 2e20 (cm-2/(K*km/s))



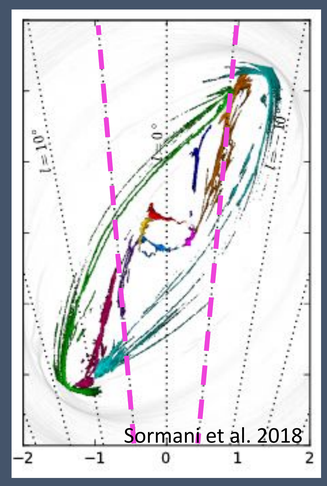
Kinetic temperature maps of the clouds in Kelvin. Left to Right: G5, B1a, B1b.

Temperature Maps

- Using a calculation based on Formaldehyde line ratios (Ginsburg et al. 2016) to find the kinetic temperatures of the clouds.
- Find temperatures using a fit based on the relationship between ratio of the H_2CO lines (3_{21}-2_{20}) and (3_{03}-2_{20})and the temperature.
- The temperatures of these clouds are around 35 to 80K, which are similar to the bulk of the galactic center.

Radiative Transfer

- Ratio maps of ^{12}CO integrated intensity maps compared to its less abundant isotopologues ^{13}CO and C^{18}O to constrain the CO opacities of the clouds.
- The opacities of these clouds vary from 1 to 4, meaning that they are translucent for CO.



Simulated top-down view of the Milky Way's central bar. Pink dashed lines show the line-of-sight of G5 and B1.

Conclusion

- A comparison with kinetic gas models of the galactic bar show that these clouds are likely not tracing exactly symmetric locations given the 3D orientation of the bar.
- G5 is likely a region where gas from a western x1 orbit which overshoots accretion onto an x2 orbit and collides with an eastern x1 orbit.
- B1 is likely gas along the tip of the western x1 orbit.

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