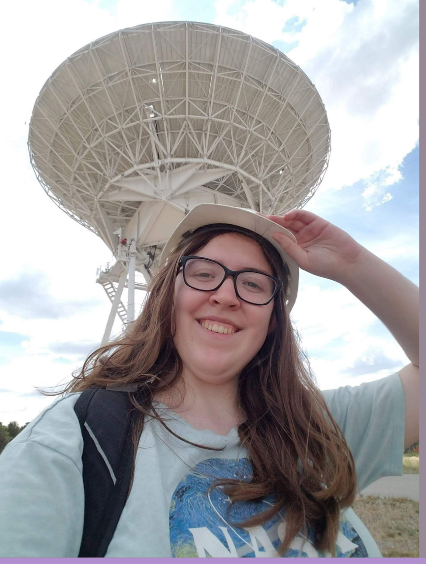

Evidence of a Cloud-Cloud Collision from Gas Overshooting the Galactic Center

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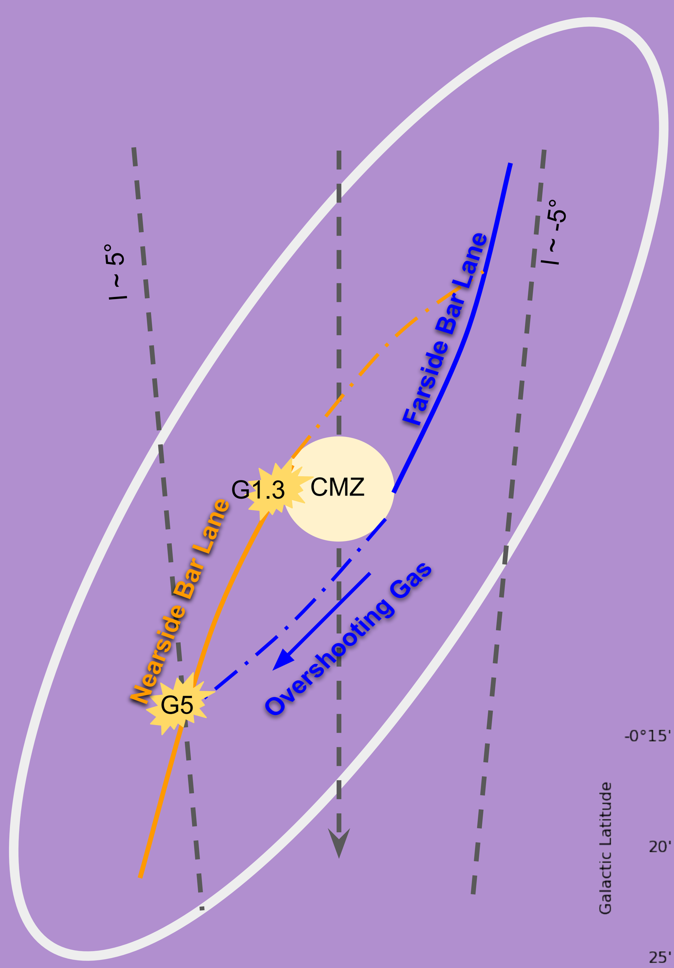
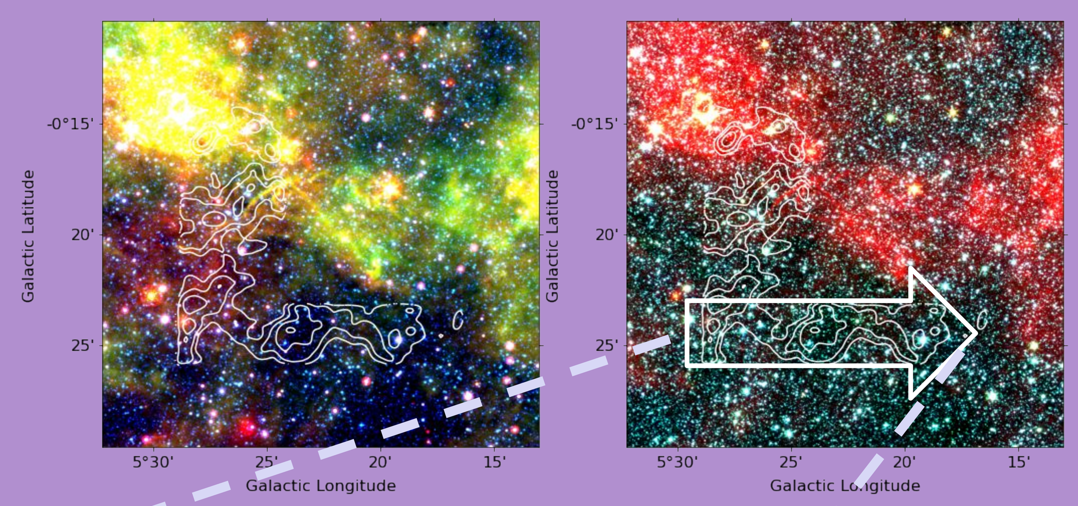
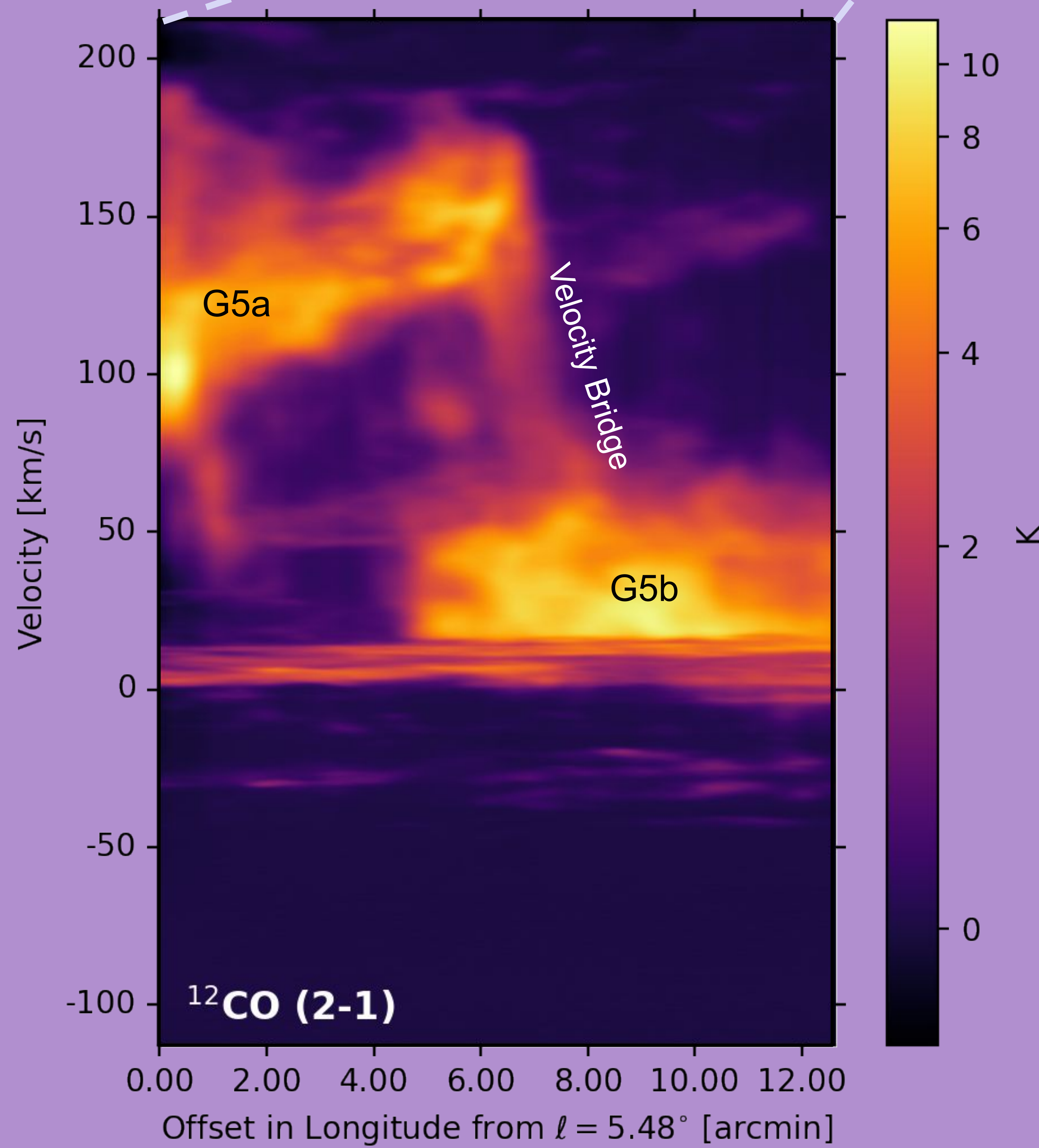
Bar Dynamics and the Movement of Gas and Dust Around the Galactic Center



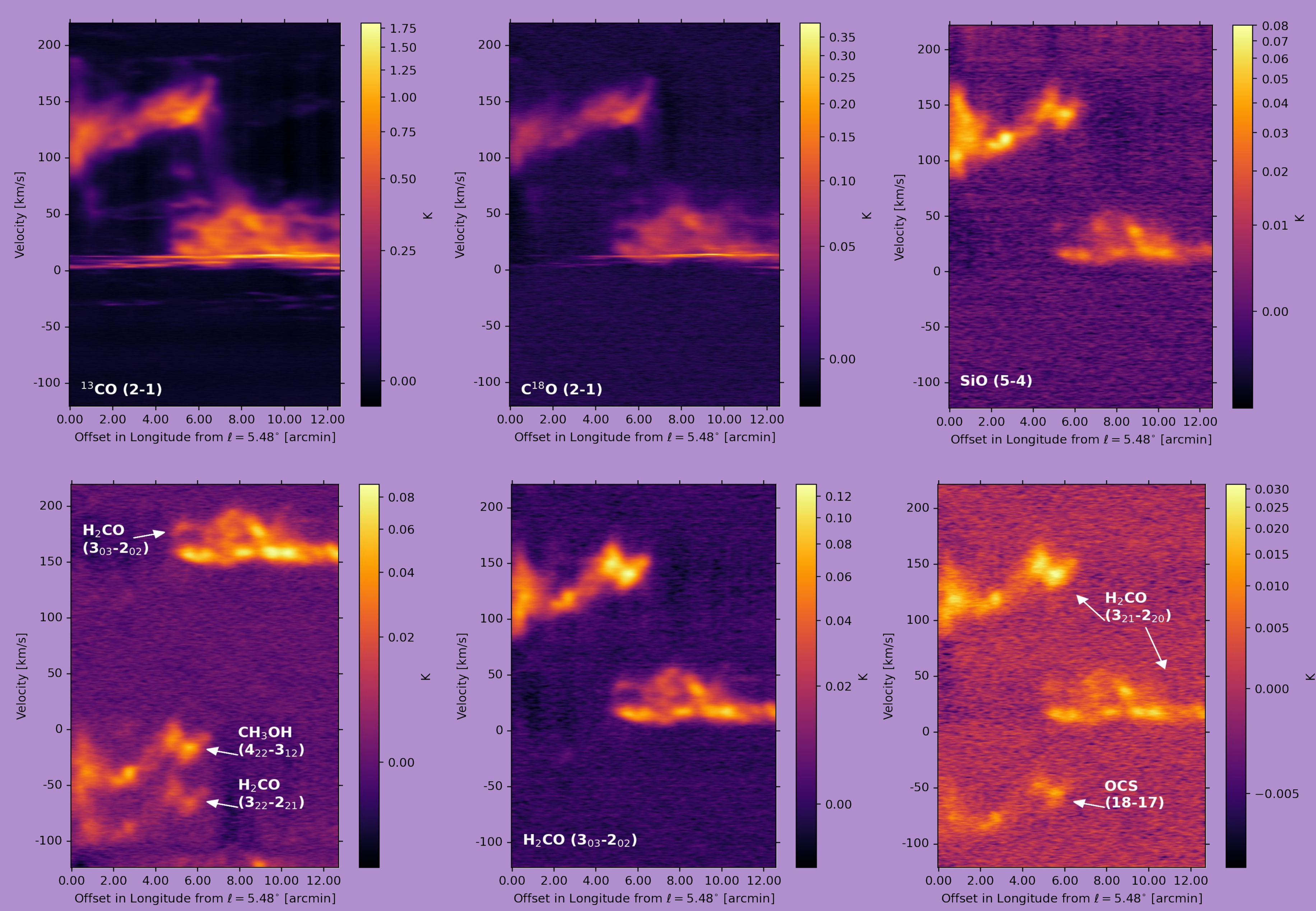
- The Milky Way Galaxy is a barred spiral galaxy, with a central gravitational bar potential.
- Bar lanes bring material into the Central Molecular Zone (CMZ) in the Galactic Center.
- The material flowing down the bar lanes collides with the CMZ at locations such as G1.3.
- However, some of this material overshoots the CMZ and collides with the bar lane on the opposite side of the Galaxy.
- The site of this collision is G5.

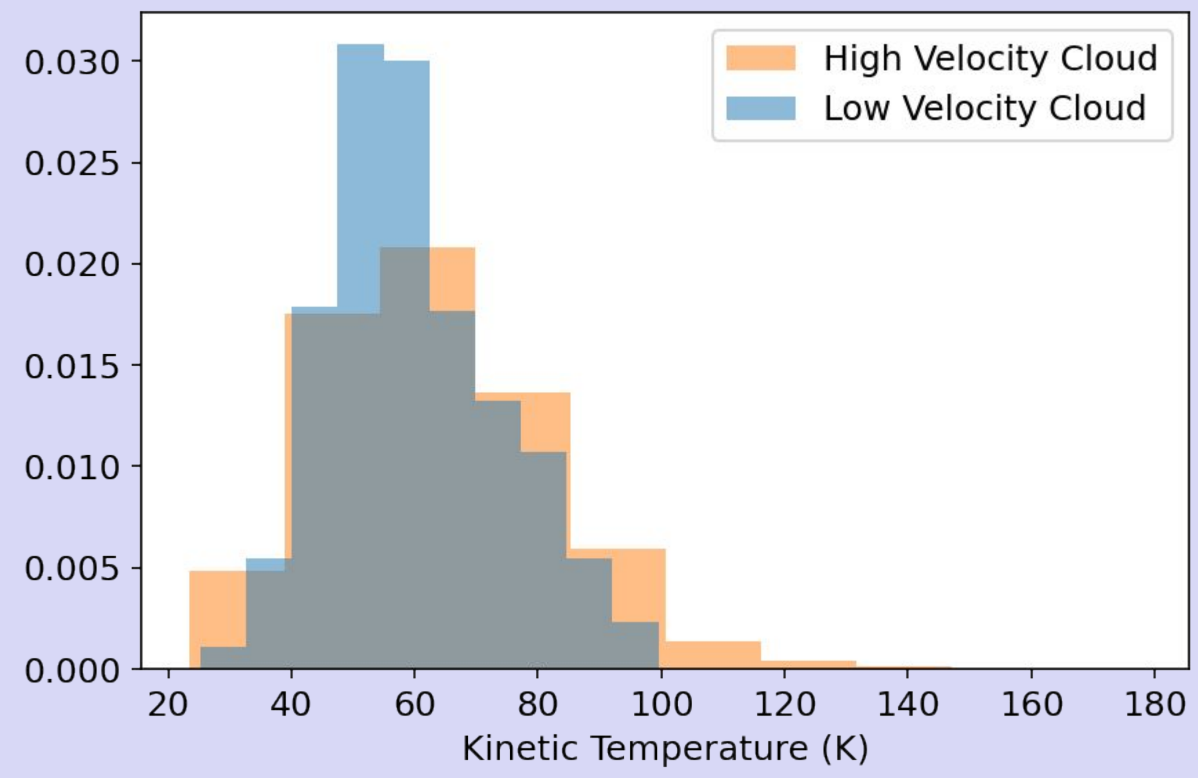




Direct Evidence of a Collision: Position-Velocity Diagram

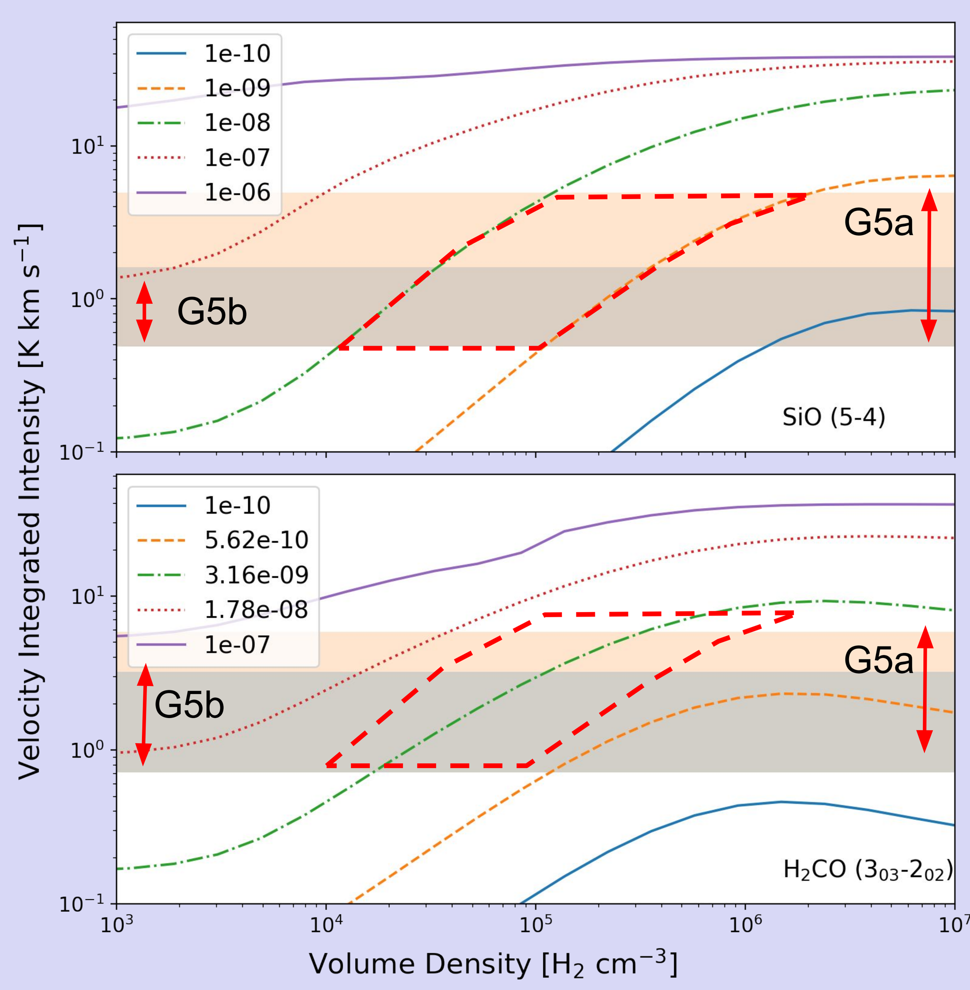
- The Velocity Bridge is direct evidence of a cloud-cloud collision.





Temperature

- The kinetic temperature was found using ratios of H_2CO (3_{21}-2_{20}) to H2CO (3_{03}-2_{02}), which were then put into a quadratic fit of the temperature-ratio relation found in Ginsburg et al. 2016.
- To find the temperature of the two clouds separately, integrated intensity maps were taken individually for the two clouds from 0 to 75 km s-1 and from 75 to 200 km s-1, and masked with a 5 sigma noise mask.
- The average temperature of the High-Velocity Cloud is **63 K.**
- The average temperature of the Low-Velocity Cloud is **60 K.**
- What is heating the cloud? There are no HII regions associated with G5.



Shocks

- SiO (5-4) was observed as a potential shock tracer.
- We do not think H_2CO is as good of a shock tracer as SiO, so the green line plot of them above shows where SiO might be enhanced.
- The H_2CO (3_{21}-2_{20}) was used with the other H_2CO line to find the formaldehyde temperatures.
- The expected abundance of
- Non-Local Thermal Equilibrium modeling was done for SiO (5-4) using Despotic (Krumholz 2014).
- Each line on the legend is for a different abundance of SiO to H_2.
- Typical ISM abundances of SiO are <10^{-8}. Shock enhancement is required to produce abundances >10^{-7}(Schilke et al. 1997).
- The abundance of SiO is above ambient (10^{-11}), but we do not see enhancement upstream, downstream, or in the collision region itself.
- SiO (5-4) may not be a good shock tracer, and in this case may do better at tracing dense gas.

Column Density Estimate and X-factor Incongruity

We measured the mass enclosed within one of the fields observed of G5.

X-Factor Mass Estimate

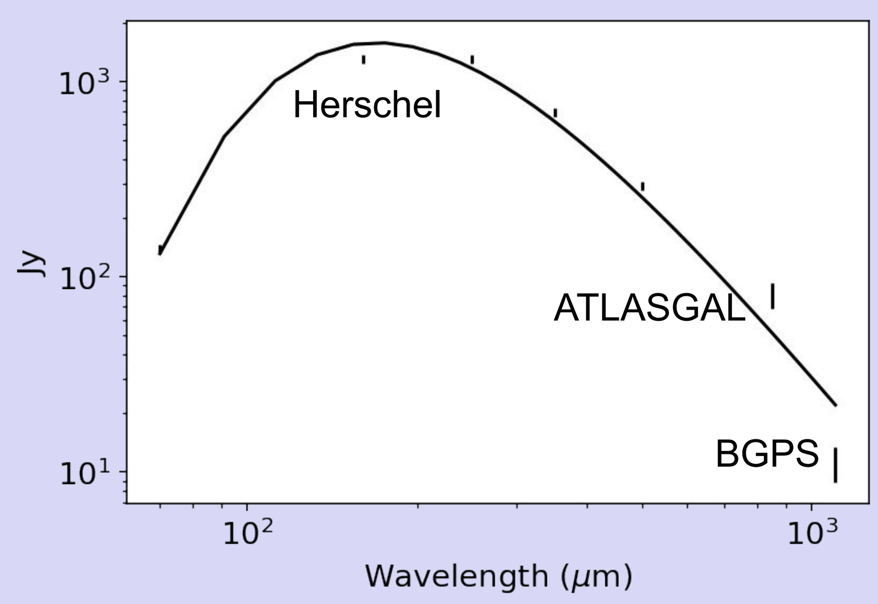
- We measured the column density of G5 by measuring the ^{12}CO integrated intensity and using the CO-to-H_2 X-factor, resulting in a column density of 6 x 10^{22} cm^{-2}.

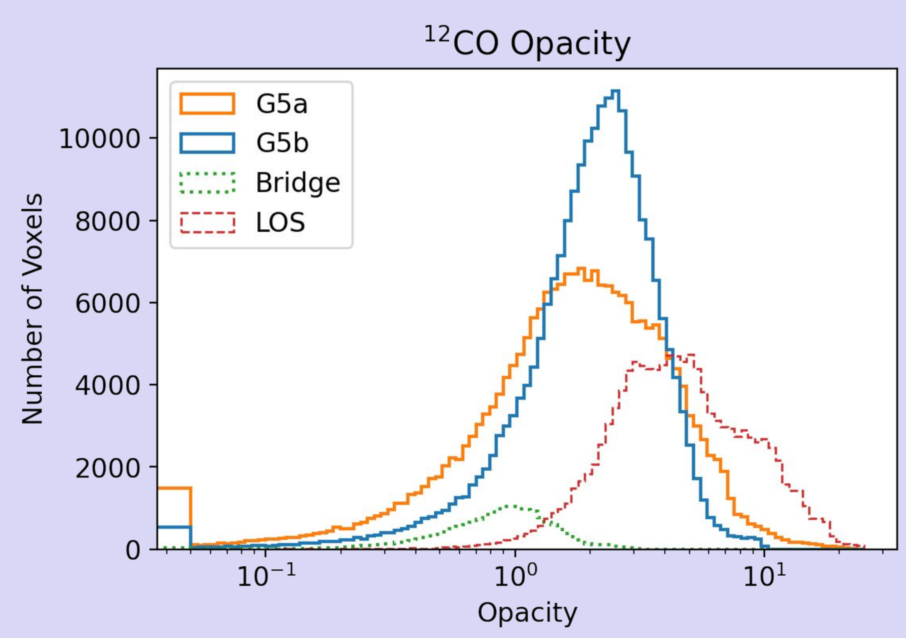
Dust Mass Estimate

- We created a Spectral Energy Distribution (SED) from Herschel, ATLASGAL, and BGPS data.
- Fitting the dust SED resulted in a column density of 0.4 x 10^{22} cm^{-2}.
- We also estimated a column density of 0.9 x 10^{22} cm^{-2} using PPMAP measurements.

CO LTE Mass Estimate

- We measured the column density of G5 by assuming local thermodynamic equilibrium conditions for CO and its isotopologues. We estimated the opacity of ^{12}CO to more accurately estimate the column density.
- Results were column densities of 0.5 x 10^{22} cm^{-2}.





The Galactic X-Factor Overestimates the Mass of G5

We observe strong observational evidence of gas overshooting the CMZ to collide with the bar lane on the opposite side of the Galaxy. We observe that the gas is warmer at this site than in the Galactic disk, and a lack of star formation in the cloud implies that it is heated through a mechanism such as shocks through the cloud collision or tidal shear stress as the cloud closely orbits the Galactic Center. We observe that the ^{12}CO opacity of G5 is lower than optically thick, and that the standard X-Factor overestimates the amount of mass in G5 by an order of magnitude.

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