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SMA observations towards massive clouds in the central molecular zone

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Abstract. Recently we conducted a mini-survey towards a sample of six massive clouds with surface density $>10^{24}$ cm^{-2} in the central molecular zone (CMZ) of the Milky Way, with the SMA at 280 GHz in the compact array and at 230 GHz in the compact/subcompact arrays. The data reveal compact dust continuum peaks, some of which are also associated with organic molecular lines and thermal SiO emission. The subcompact array data helps recover more structures, e.g. the regularly spaced, well-aligned continuum fragments in the 20 km s^{-1} cloud. Shock tracers such as SiO are found in all the clouds. Our observations suggest potential protostellar origin for some of the dust continuum peaks in these regions.

The inner 500 pc of our Galaxy, known as the central molecular zone (CMZ), is a star-forming environment with very extreme physical properties. Despite its large reservoir of dense gas that could form massive stars and clusters similar to the starbursts seen in galaxies, the CMZ appears to have an unusually low star formation rate. One possibility is that a deeply embedded protostellar population has been missed by existing observations.

Kauffmann *et al.* (2013) used the SMA 280 GHz dust continuum and N_2H^+ lines to map the dense gas in one of the CMZ clouds, G0.253+0.016, and found that despite its large mass measured by single-dish observations, little dense gas ($>10^5$ cm^{-3}) is present in the high angular resolution interferometric observations, which may explain the low level of star formation. We then expanded our observations to the other five clouds, including Sgr D, Sgr B1 off, 50 km s^{-1} cloud, 20 km s^{-1} cloud, and Sgr C, at 280 GHz with the SMA in its compact array. We are also in the process of surveying all the six clouds at 230 GHz in both the compact and subcompact arrays, to use the abundant molecular lines in this band to identify potential star forming sites.

1. Dust continuum peaks in the clouds

In the 280 GHz data, we found abundant dust continuum structures in all the clouds except G0.253+0.016, while N_2H^+ $J = ((3-2)$ emission which also traces dense gas is widely found. In the 230 GHz SMA observations, in addition to compact array data, we obtained sub-compact array data which provide shorter baselines, in order to recover extended flux. The continuum emission retrieved from the combination of the two arrays (Figure 1) shows more sub-structures than the 280 GHz data. For example, in the 20 km s^{-1} cloud, we found that five continuum peaks are regularly spaced and well-aligned, similar with the molecular core fragments found in Galactic surveys (e.g. Jackson *et al.* 2010). Based on the velocity of the dense gas tracer H_2CO, the five peaks present a

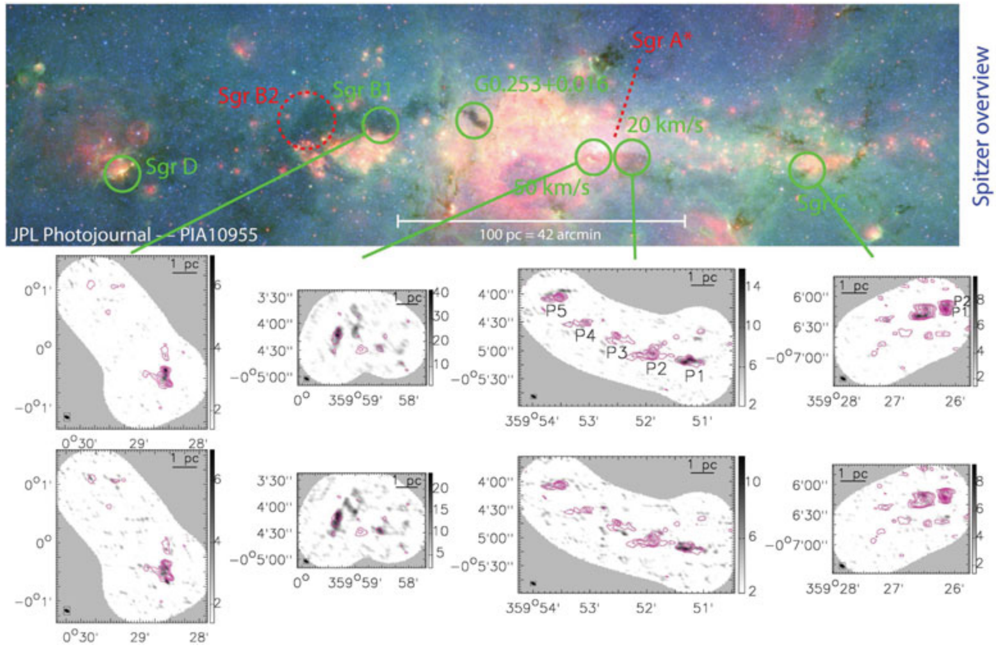

Figure 1. An overview of the CMZ and the 230 GHz SMA observations. **Upper panel:** *Spitzer* 3-color image of the CMZ (red: 24 μm; green: 8 μm; blue: 3.6 μm). The sources included in our surveys are marked by green circles. **Lower panels:** Combined compact/subcompact SMA 230 GHz data of four CMZ clouds, in galactic coordinates. The observation of other two clouds (Sgr D and G0.253+0.016) is in progress. The upper images show the integrated intensity (in unit of Jy/beam) of CH_3OH 8(-1,8)-7(0,7) transition line. The contours are the 230 GHz continuum, in increments of [3,6,9,15,25,35]*RMS, where RMS=5 mJy/beam. The lower images show the integrated intensity of SiO $J = (5-4)$ with identical contours. [A COLOR VERSION IS AVAILABLE ONLINE.]

velocity gradient from blueshifted to redshifted, from P1 to P5. If the cloud is on the near side of the CMZ, it may indicate an infalling trend along the filamentary structure towards Sgr A*.

2. Potential star forming sites

The dust continuum peaks in Sgr C (P1 and P2 in Figure 1) have been found to be protostellar in nature (Kendrew *et al.* 2013). Among the five dust continuum peaks in the 20 km s^{-1} cloud (see Figure 1), P2 seems to be a potential star forming site as well. Assuming a temperature of 30 K and an emissivity index of 1.5, the mass derived from the 230 GHz dust emission is $\sim$1300 $M_\odot$ at a distance of 8.4 kpc. P2 presents strong N_2H^+ emission, as well as spectral lines of shock tracers such as SiO and HNCO. Centimeter continuum emission (Betsy Mills, private communication) and water masers (Sjouwerman *et al.* 2002) have been found around this peak. After we analyze the kinematics using dense gas tracers, we will determine whether it is gravitationally bound. We plan to analyze the entire sample in the same manner and identify protostars in all six clouds.

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