The Galactic Center: Feeding and Feedback in a Normal Galactic Nucleus
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Interferometric 3mm spectral line and continuum survey of the central molecular zone

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Abstract. Because of its large angular extent, the central molecular zone (CMZ) has to date only been mapped in the mm with single dish telescopes, with resolution about 30″ (1.4 pc). We present the first interferometric maps of a 90×50 pc region of the CMZ, with spatial resolution of $\sim 10''$ (0.4 pc). We mapped ~ 0.25 square degrees of the CMZ with CARMA in 3mm continuum and the spectral lines SiO $J = (2-1)$, HCO^+ $J = (1-0)$, HCN $J = (1-0)$, N_2H^+ $J = (1-0)$, and CS $J = (2-1)$, covering roughly V_{LSR} = –200 to 200 km s^{-1} with spectral resolution $\Delta V \sim 2.5$ km s^{-1}. To recover the large scale structure resolved out by the interferometer, the continuum-subtracted spectral line images were combined with the Mopra 22-m telescope survey.

Keywords. Galaxy: center, ISM: clouds, radio lines: ISM

The central molecular zone (CMZ) is a region rich in molecular gas near the center of the Milky Way galaxy. About 400×80 pc in extent, the CMZ contains 3×10^7 $M_\odot$ of molecular gas with temperatures T $\sim$ 20-60 K, average densities exceeding $n(H_2) \sim 10^4$ cm^{-3}, and high turbulent velocities $\Delta V \sim$ 15-50 km s^{-1}. By comparison, typical giant

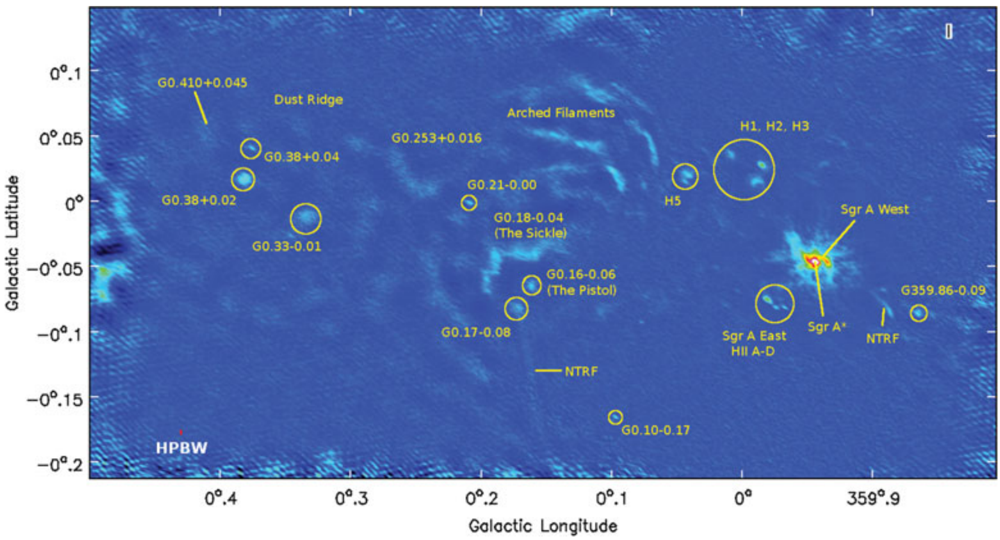

Figure 1. CARMA 3mm continuum map The spatial resolution is 13.4″ × 5.2″. The Arched Filaments, Sickle, Pistol are clearly visible, as are nonthermal radio filaments, several HII regions, and the clouds of the Dust Ridge. [A COLOR VERSION IS AVAILABLE ONLINE.]

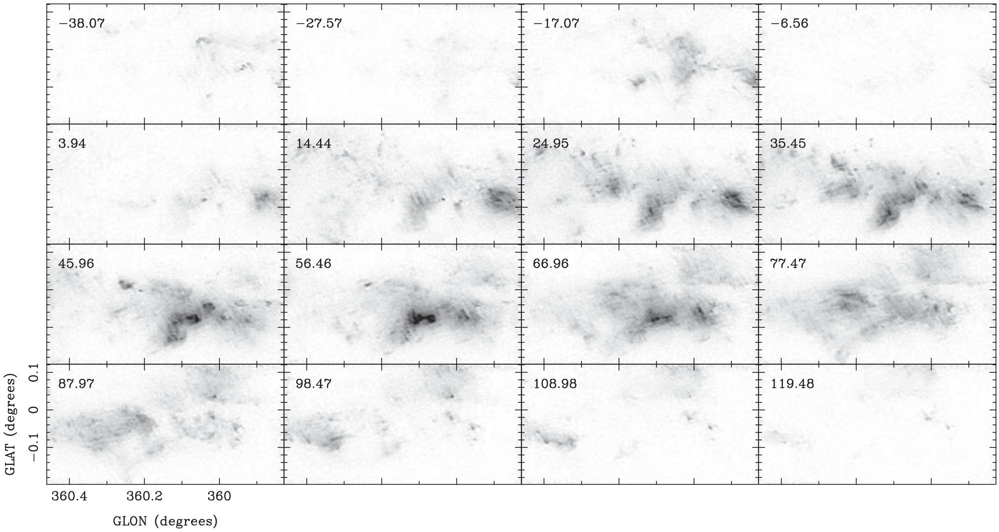

Figure 2. HCO^+ velocity channel maps of CARMA plus Mopra (HPBW=39″; Jones *et al.* 2012) data. Panels are 4-channel averages, with grayscale range 0.15 to 3 Jy/beam. The spatial resolution is 13.1″ × 5.9″. The Dust Ridge clouds are visible between V_{LSR} = 14 to 56 km s^{-1}.

Table 1. Properties of clouds in the Dust Ridge

Source	**FWHM Size (pc)**	**<I(HCO$^+$)> (Jy/bm km s^{-1})**	**N(H$_2$) (cm^{-2})**	**M(H$_2$) (M$_\odot$)**
G0.253 + 0.016 (cloud “a”)	7.3 × 2.3	17.1	$5.0\,10^{23}$	$5.9\,10^{5}$
G0.294 + 0.042	1.7 × 1.0	18.9	$5.5\,10^{23}$	$6.6\,10^{4}$
G0.331 + 0.037 (cloud “b”)	1.1 × 0.8	4.5	$1.3\,10^{23}$	$8.0\,10^{3}$
G0.375 + 0.040 (cloud “c”)	1.3 × 0.9	17.3	$5.0\,10^{23}$	$4.1\,10^{4}$
G0.410 + 0.045 (cloud “d”)	6.1 × 3.1	11.8	$3.4\,10^{23}$	$4.5\,10^{5}$

Note: Identifications in parentheses are from Immer *et al.* 2012.

molecular clouds have T ∼ 10-20 K, n(H$_2$) ∼ 10^3 cm^{-3} and ΔV ∼ 5 km s^{-1}. Despite its large reservoir of gas, the star formation rate in the CMZ is ten times lower than expected from predictions.

The physical characteristics of molecular gas in the CMZ are similar to those of infrared dark clouds (IRDCs). *Herschel* observations show low dust temperatures relative to the gas temperatures (Molinari *et al.* 2011). Our new 3mm survey identifies several of these IRDCs, in the chain of clouds forming the Dust Ridge (Lis & Carlstrom 1994; Immer *et al.* 2012) of molecular gas distributed between G0.253 + 0.016 and Sgr B2 (See Figures 1 and 2).

From the integrated HCO^+ intensity maps, we estimate sizes, column densities, and masses of the Dust Ridge clouds, assuming a kinetic temperature T = 50 K, fractional abundance X[HCO^+] = 2×10^{-10}, and optically thin and thermalized emission (Table 1). Our derived values are comparable to previous estimates (Lis *et al.* 2000; Immer *et al.* 2012; Longmore *et al.* 2012, 2013). G0.410 + 0.045, at the east end of the Dust Ridge has a comparable size and mass to G0.253 + 0.016, which is believed to be a progenitor of an Arches-like cluster (Longmore *et al.* 2012). Because of its similar properties, we suggest G0.410 + 0.045 is also likely to form a massive cluster.

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