The Multi-Messenger Astrophysics of the Galactic Centre
Proceedings IAU Symposium No. 322, 2016
R.M. Crocker, S.N. Longmore & G.V. Bicknell, eds.

doi:10.1017/S1743921316011984

ALMA view of the Galactic Center 50km/s molecular cloud

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We have observed the Galactic Center 50km/s molecular cloud (50MC) with ALMA to search for filamentary structures. In the CS $J = 2-1$ emission line channel maps, we succeeded in identifying 27 molecular cloud filaments using the DisPerSE algorithm. This is the first attempt of filament-finding in the Galactic Center Region. These molecular cloud filaments strongly suggest that the molecular cloud filaments are also ubiquitous in the molecular clouds of the Galactic Center Region.

Keywords. Galaxy: center, ISM: clouds, ISM: structure

1. Introduction

In molecular clouds of the Galactic Disk Region(GDR), a number of filamentary structures have been found by Herschel survey observations (Pilbratt *et al.* 2010). It has been revealed that the molecular clouds ubiquitously exist as filamentary structures in the GDR with or without star formation. The widths of these filamentary structures are always ~ 0.1 pc even though the column densities vary by 1 or more orders of magnitude ($\sim 10^{20-23}\mathrm{cm}^{-2}$) (Pilbratt *et al.* 2011). Prestellar dense cores and deeply embedded protostars exist along with the filamentary structures of which column densities are more than $\sim 10^{22}\mathrm{cm}^{-2}$. In contrast, the non-star-forming filaments have much lower column densities which are up to $\sim 10^{21}\mathrm{cm}^{-2}$ (André *et al.* 2011). Thus, the column densities of the filamentary structures in the molecular clouds are closely related to the star formation in the GDR.

The Central Molecular Zone (CMZ) is a molecular cloud complex in the Galactic Center(GC) region inner 300 pc region. In the CMZ, the molecular gas is very dense and warm and its velocity dispersion is very large compared to the GDR. Filamentary structures have not been found in the CMZ except for G0.253+0.016(Rathborne *et al.* 2015) and have never been identified. Therefore, we observed the GC 50km/s molecular cloud (50MC) to search for filaments.

Table 1. Physical parameters of the 50MC and the GDR.

region	Width (pc)	Column Density N ($\times 10^{22}$ cm^{-2})	Line Mass $M_{\rm line}$ ($M_\odot$ pc^{-1})	Critical Line Mass $M_{\rm crit,line}$[1] ($M_\odot$ pc^{-1})
50MC	$0.150-0.384$ (ave.$=0.268\pm0.060$)	$2.32-21.1$ (ave.$=9.97\pm5.19$)	$103-1430$ (ave.$=529\pm285$)	~ 100 (assuming 50K)
GDR	0.10 ± 0.03	$\sim 0.1-10$	$\sim 10-100$	~ 20

Notes:
[1] $M_{\rm crit,line} = \frac{2c_s^2}{G}$ where c_s and G are the sound velocity and the gravitational constant, respectively.

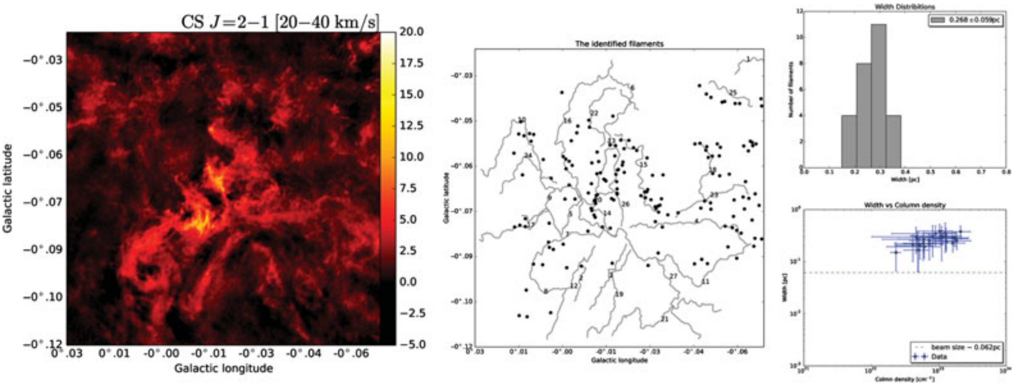

Figure 1. [left]The 50 km s^{-1} molecular cloud in an integrated intensity map of CS $J = 2-1$. The integrated velocity range is $V_{\rm LSR} = 20 - 40$ km s^{-1}. The synthesized beam size is $1.78'' \times 1.26''$. [middle]The location of the filaments identified using the DisPerSE algorithm in all velocity range. Gray thick lines show the central axes of the MCFs and black filled circles show the molecular cloud cores. [upper right]The histogram of the widths of the filaments. [lower right]The relation between the widths and column densities of the filaments. The dashed line shows the synthesized beam size in CS $J = 2-1$.

2. Filament Identification in the 50MC

We observed the 50MC located at $(l, b) = (0.018'', -0.072'')$ in ALMA cycle 1(2012.1.00080. S,PI M.Tsuboi). The whole of the 50MC was covered with mosaic observations. Many emission lines are included (CS $J = 2-1$, C^{34}S $J = 2-1$, H^{13}CO^{+} $J = 1-0$ and so on). The angular resolution is $\sim 1.5''$ (~ 0.06 pc) improved by a factor of 10 compared to those of the previous works. The integrated intensity map of the CS $J = 2-1$ emission line is shown in Fig. 1(left). In the map, the 50MC is clearly resolved into fine structures down to the size of ~ 0.1 pc. In addition, many filamentary structures can be discerned in the 50MC. The existence of a number of filaments in the 50MC strongly suggests that the filamentary structures are also ubiquitous in the molecular clouds in the GC region. We corrected the CS intensity maps for the optical depth effect using the comparison between the emission line intensities of CS $J = 2-1$ and C^{34}S $J = 2-1$ for the following analysis.

We identified the filamentary structures as molecular cloud filaments (MCF) using the DisPerSE algorithm. Finally, we found 27 MCFs shown in Fig.1(middle). We estimated the widths in FWHM of the MCFs using the Gaussian fitting. The distribution of the widths is shown in Fig.1(upper right) and the mean width of the MCFs in the 50MC (0.30 ± 0.06 pc) is larger than that in the Galactic disk region (0.10 ± 0.03 pc). In addition, the H_2 column densities and line masses of the MCFs were estimated. The relation between the column density and the width is shown in Fig.1(lower right). The width range is as narrow as ~ 0.2 pc independently of the large variation of the column density. The width, column density, line mass and critical line mass of the MCFs in the CMZ and the GDR are summarized in the Table.1.

In addition, almost all MCFs in the 50MC are supercritical filaments ($M_{\rm line} > M_{\rm crit,line}$) and 89 cores (56.0 %) among the 159 dense cores identified H^{13}CO^{+} J $= 1-0$ are located on the MCFs shown in Fig.1(middle). The high mass star formation is expected on the MCFs in the 50MC.

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Rathborne, J. M., Longmore, S. N., Jackson, J. M., *et al.* 2015, *Apj*, 802, 125

https://doi.org/10.1017/S1743921316011984 Published online by Cambridge University Press