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Large-Scale Molecular Gas Survey in ^{12}CO, ^{13}CO and C^{18}O (J = 2–1) with the Osaka 1.85m mm-submm Telescope

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Abstract. We have developed a new mm-submm telescope with a diameter of 1.85 m (hereafter, Osaka 1.85-m telescope) installed at the Nobeyama Radio Observatory. The scientific goal is to precisely reveal physical properties of molecular clouds in the Galaxy by obtaining a large-scale distribution of molecular gas, which also can be compared with large-scale observations in various wavelengths. The target frequency is ∼230 GHz; simultaneous observations in J = 2–1 lines of ^{12}CO, ^{13}CO and C^{18}O are achieved with a beam size (HPBW) of 2.7 arcmin. Here we present the progress of observations and the scientific results obtained by Osaka 1.85-m telescope. We note that these J = 2–1 data of the Galactic molecular clouds will be precious for the comparison with those of extra-galactic ones that will be obtained with the ALMA with the comparable spatial resolutions.

Keywords. ISM: clouds, stars: formation, radio lines: ISM

1. Telescope & Observations

The Osaka 1.85-m telescope is enclosed in a radome that prevents telescope structure distortion due to outdoor conditions. We have been observing molecular clouds along the Galactic plane by using the on-the-fly (OTF) mapping technique along the galactic coordinates. The technical details of the telescope and the performance are described in Onishi *et al.*(2013). The first scientific observations started from 2011 January. Currently, about 1500 square degrees have been covered including the galactic plane (l= 5°∼ 220° with $b \pm \sim 1°$) and star forming regions (Orion, Taurus, Cygnus OB7/X, Opuichus, Aquila and so on) (Fig. 1). The typical noise temperature (r.m.s.) is ∼0.45 K in T_{mb} with a velocity resolution of 0.3 km s^{-1}.

2. Scientific Results

2.1. *Orion Molecular Cloud*

We performed fully sampled ∼3′ resolution images of ^{12}CO (2–1), ^{13}CO (2–1), and C^{18}O (2–1) emission over the entire area of the Orion A and B giant molecular clouds. The data were compared with J = 1–0 of the ^{12}CO, ^{13}CO and C^{18}O data (e.g., Nagahama *et al.*1998) to derive the spatial distributions of the physical properties of the molecular gas. We explore the large velocity gradient formalism(e.g., Goldreich & Kwan 1974) to determine the gas density and temperature using line combinations of ^{12}CO (2–1), ^{13}CO (2–1), and ^{13}CO (1–0) assuming a uniform velocity gradient and abundance ratio of CO. The gas temperature is higher in the

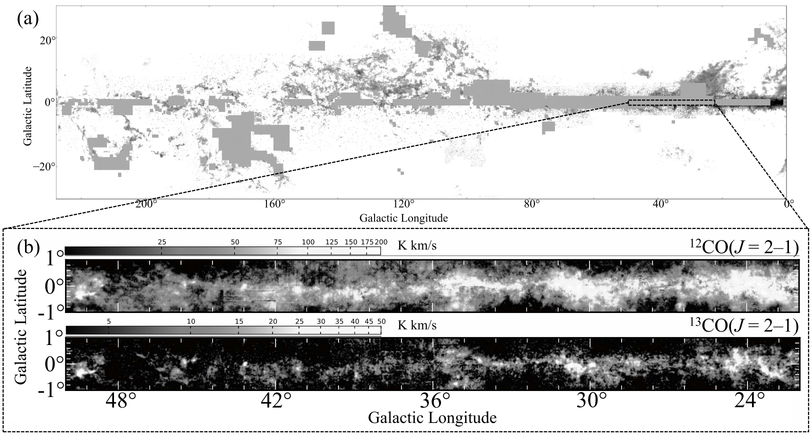

Figure 1. (a) Observed regions in the Milky Way with Osaka 1.85-m telescope are shown in gray squares. Gray scale image shows distributions of ^{12}CO (J = 1–0) (Dame *et al.*2001). (b) Examples of the maps toward the galactic plane with Osaka 1.85-m telescope.

area around the H II region with >100 K. The gas density is higher (> 2000 cm^{-3}) toward the cloud edge facing the H II region. These facts suggest the strong stellar wind and UV radiation from the surrounding massive stars are compressing and heating the molecular gas. Most of the results here are published as Nishimura *et al.*(2015).

2.2. *Survey of dense cores in Taurus*

We have observed the entire area of Taurus molecular cloud complex with Osaka 1.85-m telescope. It is the largest survey in Taurus in high-density gas(∼10^4 cm^{-3}) tracer of C^{18}O (2–1). We performed the virial analysis toward ∼40 C^{18}O (1–0) cores (e.g., Onishi *et al.*1998) to investigate their dynamical status. We then found that all of the cores with the C^{18}O (2–1) detection have virial ratios of >1. This indicates that these cores have higher density and are dynamically evolved compared with those without the C^{18}O (2–1) detection. We also identified some uncataloged compact cores as nearly point sources in C^{18}O (2–1). They were detected in low-column density ($< 3.5 \times 10^{21}$ cm^{-2}) environment judged from previous studies (e.g., ^{13}CO observations by Miznuno *et al.*1995). Their LTE masses are a few $M_\odot$, implying possible formation sites of very low-mass stars (or brown dwarfs) under the assumption of uniform star formation efficiency of ∼6 % (Onishi *et al.*1998).

References

Dame, T. M., Hartmann, D., & Thaddeus, P. 2001, *ApJ* 547, 792
Goldreich, P., & Kwan, J. 1974, *ApJ* 189, 441
Mizuno, A., Onishi, T., Yonekura Y., *et al.* 1995 *ApJ* (Letters) 445, 161
Nagahama, T., Mizuno, A., Ogawa, H., & Fukui, Y. 1998, *AJ* 116, 336
Nishimura, A., Tokuda, K., Kimura, K., *et al.* 2015 *ApJS* 216, 18
Onishi, T., Mizuno, A., Kawamura, A., Ogawa, H., & Fukui, Y. 1998, *ApJ* 502, 296
Onishi, T., Nishimura, A., Ota, Y., *et al.* 2013, *PASJ* 65, 78