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^{13}CO OBSERVATIONS OF 17 SMALL DARK CLOUDS

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ABSTRACT

We have carried out ^{13}CO $J = 1 \rightarrow 0$ line observations with spatial resolution of $2'$ toward 17 small globules selected from the catalogue of Clemens & Barvainis (1988) with a selection criterion of $|b| \geq 15$ degrees using the Nagoya 4-m radio telescope. Overall characteristics and physical parameters are presented and discussed by examining the ^{13}CO integrated intensity map for each of the globules.

Key Words : ISM — Globules: ISM — Clouds: Radio Lines — ISM

I. INTRODUCTION

Recent survey revealed that large fraction of globules posess embedded sources (Yun & Clemens 1990) indicating recent star formation activity. Because of their small sizes, simple geometrical shapes, and isolation, globules can be convenient objects for us to study the formation of an individual star. In spite of some early molecular line emission studies of globules, until very recently, Bok's hyphothesis that globules were undergoing gravitational collapse on their way to form stars remained untested.

Even though many previous investigators studied Bok globules in radio wavelength, there are very few mapping observations with only a few globules sampled. A fully 2-dimensional mapping of a globule is a fundamental database for the study of a density distribution inside a globule and degree of central condensation, which, in turn, can narrow down the constrains to examine gravitational collapse of a globule. For this purpose we have started to carry out mapping of a large sample of globules. In this report, we summarized the observations of ^{13}CO molecular line emission toward 17 small globules.

II. OBSERVATIONS

From the catalogue of Clemens & Barbianis (1988; hereafter CB), we have selected all objects whose absolute values of galactic latitudes are larger than 15 degrees. For the 17 selected objects, we carried out ^{13}CO ($J = 1 \rightarrow 0$) mapping observations with the 4-m radio telescope at Nagoya University in the period between 1995 January and April. The grid spacing was set to $2'$. The telescope has a beam size (HPBW) and a main beam efficiency of $2.7'$ and 0.7, respectively. The system temperature was about 200 to 300 K for the most of observing periods. Frequency resolution of the AOS is 25.5 kHz, corresponding to a velocity resolution of 0.07 km s^{-1} at 110 GHz. The standard chopper wheel method (Ulich & Haas 1976) was applied for determining the corrected antenna temperature, T_A^*. The resulting internal errors of T_A^* was less than 10% during the entire observing period. The radiation temperature, T_R^*, scale was also made by the observations of the standard sources, assuming the T_R^*'s of TMC-1, and L134 to be 4.5 K, and 5.5 K, respectively. The integration time was varied from 2 minutes to 8 minutes in order to retain an rms noise of ~0.15 K.

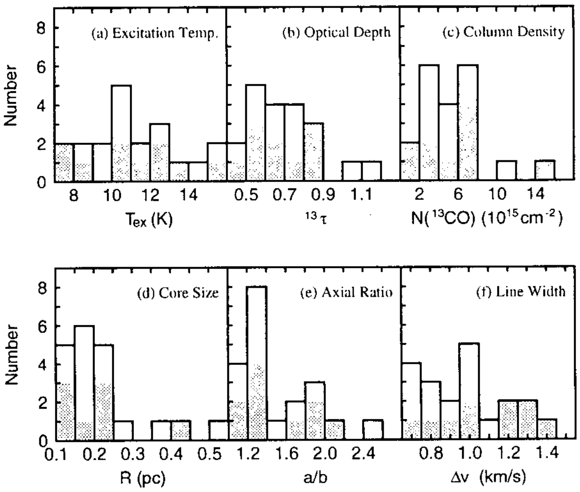

Fig. 1.— Histograms for the frequency distributions of T_{ex}, $^{13}\tau$, $N(^{13}\mathrm{CO})$ at the core, R, a/b, and Δv at the core, respectively. The gray bars represent for the cores with embedded *IRAS* sources.

III. RESULTS AND DISCUSSION

The line parameters at the peak position of the globules are listed in Table 1. By integrating the observed line emission profiles of each globule, we have obtained a map of the integrated intensity distribution for each of the globules. The maps will be published elsewhere. From the ^{13}CO integrated intensity distributions, we identified 20 cores among 17 globules. Most of the sample globules have single core, except for CB 68, CB 77, and CB 220. We found that a cometary shape accounted for the result of gravitational attraction by the galactic plane is obviously seen in three of the glob-

Table 1. Line Paremeters at the Peak Position

Object	$v_{\rm LSR}$ (km/s)	$T_{\rm A}^*$ (K)	$\int T_{\rm A}^* dv$ (K km/s)	Offset† (′)
CB19	6.4	3.46	3.15	(0,0)
CB20	5.7	4.36	3.46	(2,0)
CB28	8.9	4.52	4.98	(−2,0)
CB29	11.2	4.51	4.64	(0,0)
CB30	0.1	2.69	3.56	(2,−2)
CB31	−7.1	1.57	1.07	(2,0)
CB32	−5.0	1.72	1.61	(0,0)
CB63	2.5	3.24	2.55	(0,2)
CB64S	1.0	3.18	2.19	(0,0)
CB65	2.4	5.75	4.50	(−4,−2)
CB66	−0.2	3.16	1.98	(2,2)
CB67	4.8	4.49	3.54	(−2,2)
CB68	5.1	3.62	3.53	(0,0)
CB68NW	5.4	5.59	7.95	(−14,8)
CB77	−0.3	3.40	1.85	(0,0)
CB77NW	−0.3	2.54	1.46	(−8,18)
CB218	10.2	1.70	2.18	(0,4)
CB219	−1.8	1.77	0.91	(0,0)
CB220S1	3.0	2.72	2.58	(2,−12)
CB220S2	2.8	3.72	3.87	(2,−26)

† Offset is measured from the optical position of CB. Positive values toward north and east direction.

ules. The sample of globule cores observed in this study comprises two subsamples: 10 cores which have *IRAS* sources within one ^{13}CO map half-peak diameter of the ^{13}CO peak and another ten cores with no *IRAS* sources.

The line widths, Δv were estimated by the relation $\Delta v = \int T_{\rm A}^*(v)dv/T_{\rm A,max}^*$, (i.e. integrated intensity weighted line width). The excitation temperature, T_{ex} of each globule core was estimated from the peak intensity of ^{12}CO, and excitation temperatures of ^{12}CO and ^{13}CO were assumed to be equal. The peak optical depth $^{13}\tau$ and column density $N(^{13}{\rm CO})$ were estimated assuming that each globule core is in LTE. The H_2 column densities $N(H_2)$ of ^{13}CO cores were obtained from the column densities of ^{13}CO, assuming $N(H_2)/N(^{13}{\rm CO}) = 5 \times 10^5$ (Dickman 1978). The size of the major, a, and minor, b, axes of the 50% level of the maximum intensity were measured by assuming elliptical shape. The radius, R is given as the half of the geometric mean of a and b. To obtain the average H_2 density, $n(H_2)$, in the cores the $N(H_2)$ values were divided by the diameter of the cores.

The frequency distributions of the derived values of T_{ex}, $^{13}\tau$, $N(^{13}{\rm CO})$, R, a/b, and Δv for the 20 cores are shown in Figure 1, in which the gray bars represent for the cores with embedded *IRAS* sources. Mean axial ratio was found to be 1.5(±0.4), which confirms that small globules are almost rounded. A significant difference in Δv is likely to present between the groups of cores with embedded sources and starless cores as shown in Figure 1(f). This fact may imply that the condition of turbulent motion inside a globule might be quite different in nature between the two groups. Except for Δv, there is no significant difference between two groups in physical properties. A detailed comparison is required with larger sample size. A complete discussion on the physical properties of the globules observed in this study will be made in a subsequent paper.

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