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MAPPING STUDY OF MASSIVE CLOUD CORES

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ABSTRACT

Using 13.7 m telescope of Qinghai station of NAO, PMO at Delin Ha, 43 IRAS sources were mapped with ^{13}CO J=1-0 C^{18}O J=1-0 and CO J=1-0. Each source has one or more cores. The distances of these cores range from 1 pc to several pc, and the masses from $10^2 M_\odot$ to $10^5 M_\odot$. High velocity outflows were detected. The mass, momentum and energy of these massive cores are larger than those of the low mass ones. With radio, IRAS, MSX data, stellar source distribution were investigated, and sourceless cores that deviate from infrared sources were identified. They are potential high mass star formation sites.

Key words : massive star formation: sourceless cores: molecular lines observation

I. INTRODUCTION

To study the initial conditions of high mass star-formation is of a much more difficult work than the study for star-forming regions with low mass. First, high-mass young stellar objects evolve so rapidly that the nature of their very beginning stage changes too fast to be traced thus detected. Second, their clustering characteristic further brings difficulty to correctly locate and resolve the single object. And third, evidently, the number of the sample for massive star-forming sources is rather small.

Many efforts have been tried to probe the physical properties of early phase of high mass star formation. A number of surveys were carried out (Molinari et al. 1996, 2000, 2002; Sridharam et al. 2002; Beuther et al. 2002; Mueller et al. 2002; Shirley et al. 2003; Wu et al. 2005). Usually, millimeter and submillimeter continuum, such as 1.2 mm, 350 μ, and lines CS J=5-4, 7-6 are used to observe massive dense cores. Currently radio observations for such transitions at high frequency are restricted. Lower frequency transition of CO and its isotopes are as the general probes for molecular clouds to measure the basic parameters.

Recently we have mapped 43 sources with ^{13}CO J=1-0 C^{18}O J=1-0 and CO J=1-0, and more than 43 cores were obtained with their parameters calculated and derived. We've also analyzed the stellar contains of these cores with radio, IRAS and MSX data. Five sourceless cores were to our interest and thus focused on. The result has shown that CO and its isotopes could also be used as tracers for high mass star-formation sites.

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II. OBSERVATION

The lines referred were observed with the 13.7-m telescope at Qinghai station of Purple Mountain Observation, from January to October, 2004. The beam size at 112 GHz (^{13}CO J=1-0 transition)was $106'' \times 70''$ during first observing year. Later on, with an all-over adjustment of the system, the beam size then was improved and reached $50'' \times 50''$ in the following observing year. The pointing and tracking accuracy was better than $10''$. The frontend Superconductor–Insulator–Superconductor (SIS) Receiver observed ^{13}CO J=1-0 C^{18}O J=1-0 and CO J=1-0 lines simultaneously. The system temperature plus sky temperature of the atmosphere at zenith together was 250 K (single sideband). The acousto-optical spectrograph (AOS) has 1024 channels, and total bandwidth 145.43 MHz for ^{12}CO, 42.87 MHz for ^{13}CO and 43.3 MHz for C^{18}O, with spectral resolutions of 209 KHz, 78.7 KHz and 75.7 KHz for ^{12}CO, ^{13}CO and C^{18}O respectively. The antenna main beam efficiency is 42% at 112 GHz. The system noise level reached 0.26 K with the resolution of 209 KHz and an on-source integral time of 60 seconds. For mapping observations, the absolute position switch mode was used. The map size was usually $5' \times 5'$ with a step of $1'$. For sources with high-velocity wings, we have also identified the outflow features.

III. RESULTS AND DISCUSSION

43 sources had been observed until Oct. 2004. Lines of CO J=1-0 were analyzed. ^{13}CO J=1-0 lines were fitted with Gaussian function. C^{18}O J=1-0 lines usually had low signal to noise ratio and needed further observation for additional integration time. Here we reported the results from ^{13}CO J=1-0 of 34 sources that have been finished analyzing. So far the results showed that there were at least 23 cores in the analyzed 34

sources.

With radiation transfer equations (Sato et al. 1994), assuming the cloud is in local thermodynamic equilibrium:

$\tau(C^{13}O) = -\ln[1 - T_R^*(C^{13}O)/\{5.29[J(T_{ex}) - 0.164]\}]$

$N(C^{13}O) = 2.42 \times 10^{14}\tau(C^{13}O)\Delta V(C^{13}O)T_{ex}/[1 - exp(-5.29/T_{ex})]$

$J(T) = 1/[exp(5.29/T) - 1]$

The calculated parameters (Table 1) have shown that the focused objective sources include high mass star forming regions. And after stellar source analysis with radio and IRAS, MSX data, we have identified at least 5 sourceless cores (Fig. 1) and other stellar sources in different evolution stages(Fig. 2).

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TABLE 1.
CORE PARAMETERS

Source Name	D(kpc)	a(arcsec)	b(arcsec)	R (pc)	T_{ex}	$\Delta V_{FWHM13}(km\ s^{-1})$	τ_{13}	$N^{13}CO(10^{15}cm^{-2})$	$M_{cloud13}(10^3 M_\odot)$	$n_{H_2}(10^3 cm^{-3})$
00420+5530	5.0	240	150	2.3	22	1.9	0.38	14	8.9	0.90
05335+3609	15	300	150	7.8	19	4.0	0.46	31	223	0.57
06055+2039	2.4	300	420	2.1	44	3.9	0.49	130	41	9.0
06067+2138	2.0	180	180	0.88	19	2.4	0.72	23	2.1	3.7
06446+0029	6.0	240	90	1.5	18	2.2	0.18	4.9	1.8	0.47
19120+0917	4.1	180	120	1.5	14	3.6	0.67	18	3.5	1.7
19529+2704	3.4	120	180	1.4	24	2.6	0.35	25	6.7	2.6
	4.0	120	180	1.1	24	2.6	0.35	25	4.6	3.2
20100+3643	4.2	90	90	0.94	15	3.4	0.29	8.2	0.94	1.2
21074+4949	9.5	120	90	2.4	17	3.5	0.2	5.9	5.6	0.35
	9.8	120	90	2.5	17	3.5	0.2	5.9	5.9	0.34
22570+5912	5.0	120	180	1.8	35	3.3	0.33	54	24	4.4
23504+6012	4.0	150	240	1.6	23	2.6	0.33	18	6.8	1.6
S157	4.4	120	300	2.0	32	2.9	0.27	27	11	1.9
06436	5.0	184	95	1.48	10.8	4.3	0.40	11	1.0	2.17
00379+6248	1.6	100	50	0.28	14.1	2.8	0.50	15	0.047	15.9
01045+6505	1.0	80	38	0.14	8.8	2.1	0.22	2.1	0.0017	4.50
W3	4.0	150	112	1.28	50.8	3.3	0.25	100	6.9	23.8
02230+6202	4.2	216	294	2.56	17.1	2.5	0.27	11	2.9	1.19
02310+6133	4.0	124	68	0.92	9.5	2.7	0.54	7.8	0.26	2.50
04073+3800	0.5	266	146	0.24	18.4	1.6	0.59	16	0.045	18.2
19291+1713	5.1	228	164	2.36	13.4	4.1	0.16	6.4	1.5	0.77
19214+1424	3.5	408	182	3.6	40.1	12.6	0.34	340	180	26.7
06306+0437	1.8	180	126	0.64	18.4	3.1	0.28	15	0.27	6.82
19097+0847	4.2	218	102	0.46	10.9	4.8	0.47	15	1.5	2.91

Note: 1. Column 2 is the dynamical distance D calculated by the observed line center velocity of ^{12}CO;
2. Column 3-5 are major and minor angular size a and b which were taken from the contour at about half of the maximum, and the linear size R=$\sqrt{ab}/2$;
3. Column 6 is the excitation temperature calculated by the peak antenna temperature T_A^* of ^{12}CO.
4. Column 7-9 are listed δV_{FWHM13}, optical depth and the average column density of ^{13}CO within the core area, respectively.
5. The density of hydrogen molecules is listed in column 10 and the core mass in column 11.