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GALACTIC ANTICENTER CO SURVEY: I. $L = 178°$ TO $186°$, $B = 3°.5$ TO $6°.0$

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ABSTRACT

We have mapped 17 deg^2 region toward Galactic anticenter in ^{12}CO $J = 1 - 0$ using the 3 mm SIS receiver on the 14 m telescope at Taeduk Radio Astronomy Observatory (TRAO). The region mapped in this paper is the first target of the Galactic AntiCenter CO Survey Project (GACCOS) and was selected comparing with IRAS Sky Survey Atlas (ISSA) images at 100 μm. Molecular emission of the target area is found to be very extended and is well matching with the FIR emission boundary. There are several pieces of clouds, and as some of spectra show several peaks, there seem to be several clouds overlapped in some directions. The Velocity of Local Standard of Rest (V_{LSR}) of the CO emission of the mapped region ranges from -20 to $+10$ km/s. It is also found that the two cloudlets located around $l = 180°$ have $V_{LSR} = -20$ km/s, which is very abnormal. The peak antenna temperature of 13 K arises near the H II Region S241.

Key Words : Interstellar medium: molecules: clouds

I. INTRODUCTION

Since the carbon monoxide 2.7 mm line was detected about 25 years, surveying the Galactic plane had been a hot topic as the distribution and large scale dynamics of molecular gas (and determination of galactic rotation curve), formation and evolution mechanism of stars etc. can be derived. For the last twenty years, there had been several CO surveys toward the Galactic plane, (Clemens 1986; Dame *et al.* 1987). However, in contrast to the relatively well studied inner Galaxy region, where the molecular mass is largely confined to the Molecular Ring, the molecular gas toward the Galactic Anticenter region has seldom been attempted as the determination of kinematic distance is very difficult and the distribution of the molecular gas is relatively weak. Columbia Survey (Dame *et al.* 1987) virtually covered the whole Galactic plane, but its resolution of 0.5 degree was very coarse, and study of the region toward Galactic Anticenter has not been reported. Only small part of the region was discussed in Huang's dissertation (1986), mainly focusing on the SNR Simiez 147. Our first target region toward the Galactic Anticenter is selected as its dust emission is apparently isolated from the background. We present the observational results of the first target region of the Galactic AntiCenter CO Survey Project (GACCOS).

II. OBSERVATIONS

We have mapped 17 deg^2 region of the Galactic Anticenter region $(l, b) = (178° \sim 186°, 3°.5 \sim 6°)$ in ^{12}CO $J = 1-0$ ($\sim$ 7,000 spectra) using the 3mm SIS receiver on the Taeduk Radio Astronomy Observatory (TRAO) 14 m telescope. The SIS receiver was just developed at TRAO in 1995 summer. The beam size is 47″ and the sampling rate is 3′. We used 250 kHz and 1 MHz filterbanks, which cover the velocity ranges of 170 and 650 km s^{-1} , respectively. All observations were made by position switching between observed positions and reference positions which were carefully selected for free of CO emission. All antenna temperatures are corrected ($\eta_{fss} = 0.63$) and presented in T_R^* (Kutner and Ulich 1981). The average rms of the spectra is $\sim$ 0.25 K in T_R^*.

III. RESULTS AND DISCUSSION

CO emission of the target area is found to be very extended. Figure 1 shows the CO emission integrated over all velocities, $\int T_R^* dv$. It is found that most of CO emission are apparently blended one another in spatial-velocity cube with some exceptions: Many of spectra show several peaks, which implies that several clouds are blended together toward some directions. However, there are several pieces of isolated clouds scattered in small scale. Velocity of Local Standard of Rest (V_{LSR}) of the emission in the CO emission of the mapped region ranges from -20 to $+10$ km s^{-1} . A couple of cloudlets with abnormal velocities ($V_{LSR} = -20$ km s^{-1}) toward $l = 180°$ and $b = 5°$ to $6°$ are identified. Their velocities of -20 km s^{-1} are very exceptional in this direction, and the more detailed study on these cloudlets may clarify their physical and dynamical status. In fact, we are going to observe these objects in high resolution in the several transition lines of molecules. The deep CCD observations in several optical bands of *BVRI* will provide a reliable distance estimate.

The peak temperature of 13.2 K in T_R^* arises around the position of H II region S241, $(l, b) = (180°.8, 4°.0)$. Several other peaks also arise around the hot IRAS point sources, some of which are found to be bipolar outflows, confirming that star forming activities are clearly going on. However, the peaks are not really as bright as those of in local GMCs containing H II re-

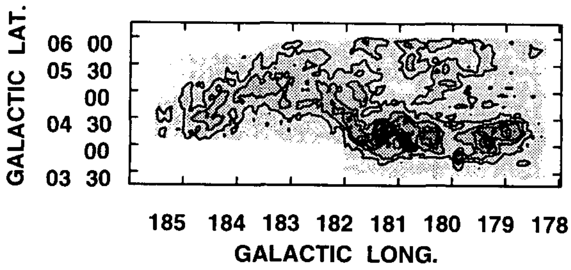

Fig. 1.— The CO integrated intensity map.

gions. This may be an effect of beam dilution in part, if the distance of the H II region S241 is accepted as 4.7 kpc (Moffat, FitzGerald, and Jackson 1979). The case for beam dilution is supported by the fact that the brightest lines in each peak are very localized. According to Moffat, FitzGerald, and Jackson (1979), the central star of S241 is O9 star, however, on the wisp of nebulocity there seems to be another OB star, distance of which is over 10 kpc from the sun, though this should be confirmed. On POSS plate there are two more H II regions with some nebulocities. both ot them are very small comparing with S241 and the CO emission toward these H II regions and associated regions are not remarkably bright enough.
The linewidths of the CO emission of the clouds(ΔV = 2 to 3 km s^{-1}) which can be isolated are generally narrower than those of local GMCs ($\Delta V \gtrsim 5$ km s^{-1}). This fact implies that the major part of CO emission comes from dark clouds, which normally do not have large bulk motion. Intriguingly, the CO emission matchs well with the FIR emission boundary at 100 μm, which implies that there are less foreground and background stray dust emission, and the dust emission is all correlated with molecular clouds associated. FIR emission and ^{12}CO integrated intensity relationship, I_{CO}/I_{100} is $\sim$ 0.5 (K km s^{-1})/(MJy ster^{-1}), and is very close to those of normal dark clouds.

The large-scale mapping toward anticenter region will be a unique data base in the transition of ^{12}CO $J = 1-0$, which is one of our major goal, and the results of this study combining with existing H I data (Weaver and Williams 1973), continuum data, and IRAS data are expected to yield substantial information on molecular gas in the outer Galaxy and on physical status of those clouds. Visual extinction can be determined by star counts for the whole region. It is useful to investigate the gas and dust properties of the cloud. The visual extinction to ^{13}CO column density ratio will be determined and compared with those found in the local molecular clouds. We will attempt to estimate the gas to dust ratio using the CO data and the far-infrared data from the IRAS survey. Systematic comparison of the molecular clouds in the anticenter region with the Inner Galaxy molecular clouds will clarify the environmental effects on those clouds statistically.

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