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H_2/CO CONVERSION FACTOR FOR M31 MOLECULAR CLOUDS

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1. Introduction

The conversion factor from the CO line intensity to column density of molecular hydrogen, $X = N_{H_2}/I_{CO}$, is one of the most important parameters in mm-wave study of galaxies and their molecular gas (e.g., Maloney 1990). Although the same value as that obtained for our Galactic clouds (e.g. Sanders et al. 1984; Bloemen et al. 1985) has been widely applied to galaxies, it is far from trivial that the conversion factor is universal among various types of galaxies. There have been few attempts to derive the value for galaxies, and the value is still controversial,if it is applicable to other galaxies or not: Approximately the same value as that for the Galaxy has been derived for M33 (Wilson and Scoville 1990, 1992), while an order of magnitude larger value is obtained for the LMC and SMC (Cohen et al. 1988; Rubin et al. 1991).

In order to obtain the conversion factor in nearby galaxies, in which individual molecular clouds can be resolved, we are conducting CO-line mapping of M31. In this paper we report a preliminary results from mapping of a north-eastern spiral arm of M31 in the $^{12}CO(J = 1 - 0)$ line emission using the NMA.

2. NMA CO Observations of M31

The $^{12}CO(J = 1 - 0)$-line observation was made in January-March 1990 using the NMA in the C/D configurations. We chose the field in the NE on the densest spiral arm at a galactocentric distance of 7 kpc. The field center was taken at RA=0h 42m 00m, Dec=41°11′ 06″ (1950), toward which a CO cloud complex has been observed (Ryden and Stark 1985; Combes et al. private communication). The final map had angular resolutin of 4.5 × 4.4 arcsec.

3. Molecular Clouds in M31 and the Conversion Factor

The CO map revealed a number of molecular clouds, which have sizes and velocity widths similar to local molecular clouds in our Galaxy (Fig. 1). From the size and velocity width, we estimate Virial masses of the clouds, and compare with their $^{12}CO(J = 1 - 0)$ luminosities. We then derive the conversion factor X from CO line intensity to H_2 mass of molecular clouds in M31. Table 1 summarizes the obtained values for five typical clouds detected in this observation. Averaging the values, we obtaine

$$X = N(H_2)/I_{CO} = (5.6 \pm 1.5) \times 10^{20} \ [\ H_2\ \ cm^{-2}/K\ \ km\ s^{-1}\ ].$$

This is larger than that for the Milky Way, 3.6×10^{20}, which has been derived with the same method as here (Sanders et al. 1984), but is smaller than that for the Magellanic Clouds.

Table 1. M31 H_2/CO Conversion Factor.

Cloud	$Q(H_2)^\dagger$	$L(CO)^\ddagger$	$X=Q/L^*$
A	6.54×10^{61}	1.22×10^{41}	5.36×10^{20}
B	1.55×10^{61}	2.01×10^{41}	7.77×10^{20}
C	3.86×10^{61}	0.74×10^{41}	5.22×10^{20}
D	5.35×10^{61}	1.44×10^{41}	3.72×10^{20}
E	9.51×10^{61}	1.63×10^{41}	5.83×10^{20}

† Q = Virial mass in Total number of H_2 molecules.
‡ $L = \int\int T_B dv dS$ in [K km s^{-1} cm^2] (CO luminosity).
* COnversion factor X in [H_2 cm^{-2}/K km s^{-1}]

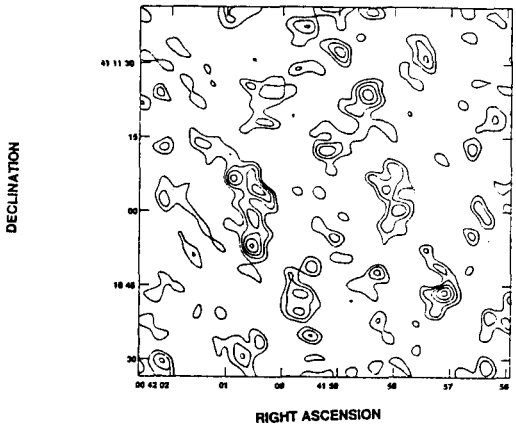

Fig. 1: Typical moleculer clouds in the spiral arm of M31.

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