NRO M33 All Disk Survey of Giant Molecular Clouds (NRO MAGiC): HI to H_2 Transition

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We present the results of the Nobeyama Radio Observatory (NRO) M33 All Disk (30′ × 30′, or 7.3 kpc × 7.3 kpc) Survey of Giant Molecular Clouds (NRO MAGiC) based on ^{12}CO (J = 1−0) observations using the NRO 45-m telescope [1]. M33 is the best target to study the properties of the individual GMCs and their correlation with galactic structures such as spiral arms due to its proximity (~840 kpc) and small inclination angle. The spatial resolution of the resultant map is 19″.3 (= 81 pc) which is sufficient to identify each GMC.

We found clumpy structures with a typical spatial scale of ~100 pc, corresponding to GMCs, and no diffuse, smoothly distributed component of molecular gas at this sensitivity. The overall distribution of molecular gas roughly agrees with that of HI. However, closer inspection of the CO and HI maps suggests that not every CO emission is associated with local HI peaks, particularly in the inner portion of the disk (r < 2 kpc), although most of CO emission is located at the local HI peaks in the outer radii. We found that most uncovered GMCs are accompanied by massive star-forming regions, although the star formation rates (SFRs) vary widely from cloud to cloud.

We obtained a map of the molecular fraction, $f_{\rm mol} = \sum_{\rm H_2}/(\sum_{\rm H_I} + \sum_{\rm H_2})$, at a 100-pc resolution. This is the first $f_{\rm mol}$ map covering an entire galaxy with a GMC-scale resolution. We find that $f_{\rm mol}$ tends to be high near the center. The correlation between fmol and gas surface density shows two distinct sequences. The presence of two correlation sequences can be explained by differences in metallicity, i.e., higher (~2-fold) metallicity in the central region (r < 1.5 kpc) than in the outer parts. Alternatively, differences in scale height can also account for the two sequences, i.e., increased scale height toward the outer disk.

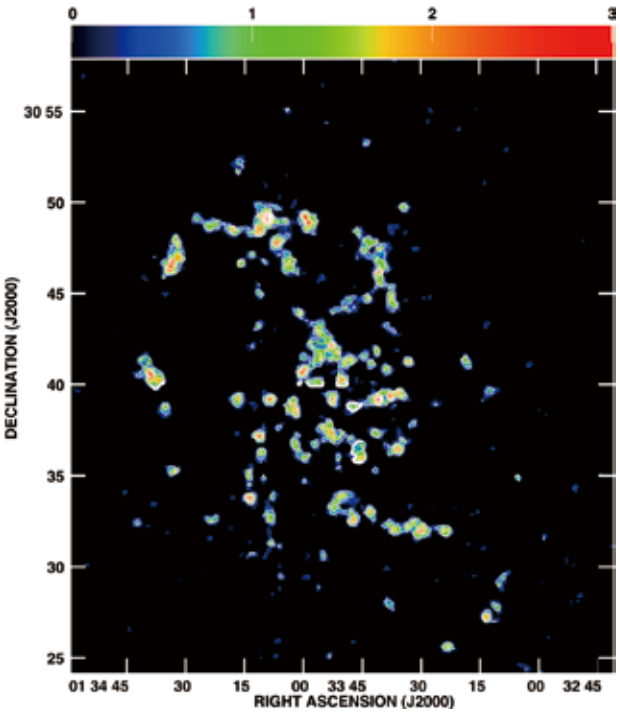

Figure 1: CO(1-0) total integrated intensity map.

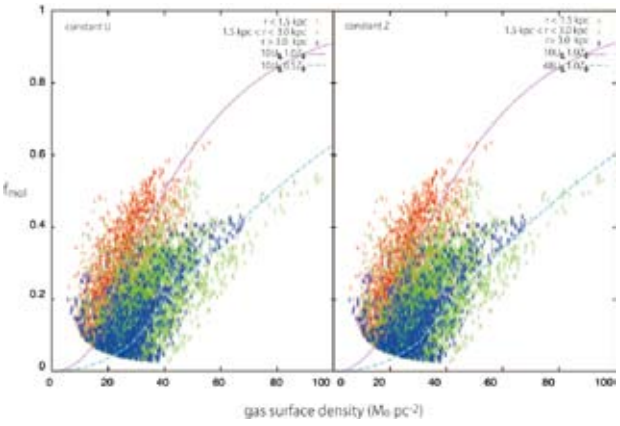

Figure 2: Correlation between gas surface density and $f_{\rm mol}$. Red, blue, and green points represent data with ranges of $r \leq$ 1.5 kpc, 1.5 kpc $\leq r \leq$ 3 kpc, and $r \geq$ 3 kpc. Pink dotted and cyan dashed lines indicate correlation for U = 10 U_0 at $Z = Z_0$ and Z = 0.5 Z_0 (left), and for Z = 1.0 Z_0 at U = 10 U_0 and U = 48 Z_0 (right), respectively.

Reference

[1] Tosaki, T., et al. : 2011, *PASJ*, **63**, 1171.