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LARGE-SCALE [OIII] AND [CII] DISTRIBUTIONS OF THE LARGE MAGELLANIC CLOUD WITH FIS-FTS

A. Takahashi[1], A. Yasuda[1], H. Kaneda[1], M. Kawada[1], Y. Kiriyama[1], A. Mouri[1], T. Mori[1], Y. Okada[2], and H. Takahashi[3]
[1]Nagoya University, Furo-cho, Chikusa-ku, Nagoya, 464-8602, Japan
[2]I. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany
[3]Institute of Astronomy, Graduate School of science, University of Tokyo, Mitaka, Tokyo, 181-0015, Japan
E-mail: yasuda@u.phys.nagoya-u.ac.jp
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ABSTRACT

We present the results of far-infrared spectroscopic observations of the Large Magellanic Cloud (LMC) with FIS-FTS. We covered a large area across the LMC, including 30 Doradus (30 Dor) and N44 star-forming regions, by 191 pointings in total. As a result, we detect the [OIII] and [CII] line emission as well as far-infrared dust continuum emission throughout the LMC. We find that the [OIII] emission is widely distributed around 30 Dor. The observed size of the distribution is too large to be explained by massive stars in 30 Dor, which are assumed to be enshrouded by clouds with the constant gas density estimated from the [OIII] line intensities. Therefore the surrounding structure is likely to be highly clumpy. We also find a global correlation between the [OIII] and the far-infrared continuum emission, suggesting that the gas and dust are well mixed in the highly-ionized region where the dust survives in clumpy dense clouds shielded from energetic photons. Furthermore we find that the ratios of [CII]/CO are as high as 110,000 in 30 Dor, and 45,000 even on average, while they are typically 6,000 for star-forming regions in our Galaxy. The unusually high [CII]/CO is also consistent with the picture of clumpy small dense clouds.

Key words: galaxies: Magellanic Clouds; ISM: HII regions; ISM: lines and bands

1. INTRODUCTION

The Large Magellanic Cloud (LMC) is an irregular dwarf galaxy located at ∼ 50 kpc from the sun. 30 Doradus (30 Dor) in the LMC is one of the most famous and active massive star-forming regions. We present the results of far-infrared (FIR) spectroscopic observations of the LMC including 30 Dor with FIS-FTS.

2. OBSERVATION

We covered a large area across the LMC, including 30 Dor and N44 star-forming regions, by 191 pointings in total, as parallel observations in the LMC survey project. The data were taken in the low-resolution mode (R = 1.2 cm^{-1}) before 2006 December 25, and high-resolution mode (R = 0.18 cm^{-1}) afterwards.

3. RESULTS

The two fine-structure lines, [OIII] 88 μm and [CII] 158 μm, are detected from many of the observed areas. We find that the [OIII] emission is widely distributed, although the ionization potential of O^+ is as high as 35.1 eV. We also find that [OIII] and FIR continuum are correlated with each other (Fig. 1; Kawada et al., 2011, only for 30 Dor). Since the [OIII] line traces highly ionized regions and FIR continuum is emitted by cold dust, their correlation is rather unexpected. It suggests that the gas and dust are well mixed.

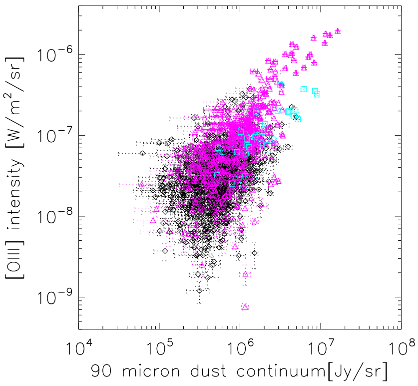

Fig. 1. Scatter plot between the [OIII] line intensity and the FIR continuum emission at 88 μm, both of which are obtained from FIS-FTS. The triangles, squares, and diamonds correspond to the regions around 30 Dor, N44, and others, respectively.

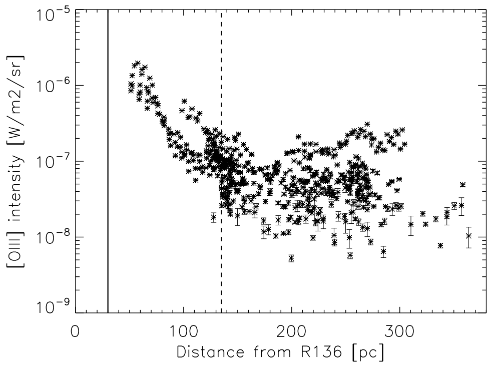

Fig. 2. Radial profile of the distribution of the [OIII] line emission plotted against the distance from R136. Strömgren radii of R136 for ambient gas densities of 100 cm^{-3} and 10 cm^{-3} are plotted by the solid and dotted lines, respectively.

4. DISCUSSION

Fig. 2 shows the radial profile of the distribution of the [OIII] emission plotted against the distance from the center of 30 Dor (R136). The plot shows the wide distribution of a highly ionized region around the central super cluster R136. The influence of R136 seems to reach $\sim 10'$, or 150 pc away from R136. We estimated the Strömgren radius of R136 for hydrogen gas. The results for ambient gas densities of 100 cm^{-3} and 10 cm^{-3} are plotted by the solid and dotted lines in Fig. 2, respectively. To explain the wide distribution of

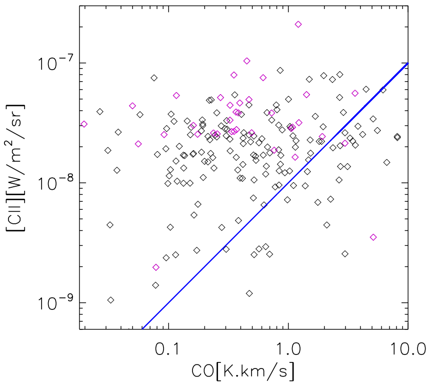

Fig. 3. Scatter plot between [CII] and CO (Fukui et al., 1999). The solid line shows the [CII]/CO ratio of 6,300, a typical value of star-forming regions in our Galaxy. The magenta and black triangles correspond to the regions around 30 Dor and others, respectively.

the [OIII] line, a reasonable density is 10 cm^{-3}. However, to explain the observed [OIII] line intensity, we require a density of 100 cm^{-3} based on a simple radiation transfer model. In addition, we find that the [CII]/CO ratios of $\sim$ 45,000 for the overall regions and 110,000 for the 30 Dor region are much higher than those of star-forming regions in our Galaxy ($\sim$ 6,300; Fig. 3).

The observational results cannot be explained by a usual plane parallel cloud model. We suggest a clumpy cloud model to explain above results. We estimate the cloud parameters satisfying the observation results. The cloud size and density are $\sim$ 3 pc and $\sim$ 500 cm^{-3}, respectively. The volume filling factor estimated from the extended [OIII] line emission is about 2%.

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