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CO ($J = 2 \rightarrow 1$) IN-PLANE SURVEY OF THE 4^{TH} GALACTIC QUADRANT

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RESUMEN

Presentamos datos de CO($J = 2 \rightarrow 1$) cubriendo de 270° a 360° en longitud Galáctica a latitud $b = 0°$ (IV cuadrante). Los datos fueron obtenidos con el Very Small Telescope 2 (VST2), antena de 60 cm con un haz de 8.9 minutos de arco (FWHM) instalada por la Universidad de Tokio en la Silla, ESO Chile (Hasegawa et al. 1996). Los datos son analizados bajo un modelo axisimétrico similar al de Sakamoto et al. (1997) para $b = 0°$, y datos públicos de CO($J = 1 \rightarrow 0$) (Bronfman et al. 1989). La distribución del cociente $T_R^*(J = 2 \rightarrow 1)/T_R^*(J = 1 \rightarrow 0)$ se compara con la de regiones de formación de estrellas masivas de los catálogos de Bronfman et al. (1996) y Caswell & Haynes (1987).

ABSTRACT

We present CO($J = 2 \rightarrow 1$) data covering from 270° to 360° in Galactic longitude, at latitude $b = 0°$ (IV quadrant). These data were obtained with the VST2 (Very Small Telescope 2), a 60 cm antenna with a beam of 8.9 arcmin (FWHM) installed by the University of Tokyo at ESO La Silla, Chile (Hasegawa et al. 1996). The new data are analyzed under a similar axisymmmetric model from Sakamoto et al. (1997) for $b = 0°$, and using published CO($J = 1 \rightarrow 0$) data by Bronfman et al. (1989). The distribution of the $T_R^*(J = 2 \rightarrow 1)/T_R^*(J = 1 \rightarrow 0)$ ratio is compared to that of massive star forming regions from the catalogs of Bronfman et al. (1996) and Caswell & Haynes (1987).

Key Words: **GALAXY: STRUCTURE — ISM: CLOUDS — ISM: LINES**

1. INTRODUCTION

Distribution and mass of molecular interstellar component is important because dense molecular gas is closely connected to star formation and this makes it a good tracer of Galactic spiral arms. The best molecule to investigate this topic is CO, and nowadays there are complete surveys for the Galactic plane in CO($J = 1 \rightarrow 0$) transition. In addition, physical properties can be investigated using more transitions for the same molecule (multiline analysis). The first CO(2→1) survey of the Southern hemisphere was made using the 1.4m CAT telescope at ESO, by T. de Graauw et al. (1983), sampling essentially a grid with 30 arcmin spacing. In the same transition (CO $J = 2 \rightarrow 1$, ν=230.538 GHz, λ=1.3 mm) Tokyo's group is sampling the entire Milky Way with a dedicated twin VST radiotelescopes designed to obtain data, which can be directly compared with the Columbia-Chile survey of the CO($J = 1 \rightarrow 0$) emission. The first Galactic quadrant results were reported by Sakamoto et al. (1997) and this work is part of the on going IV Galactic quadrant survey.

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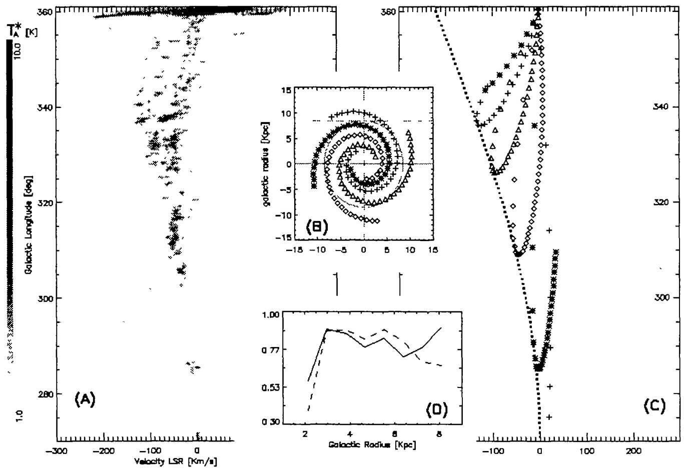

Fig. 1. Observed L-V diagram for the IV Galactic quadrant CO($J = 2 \rightarrow 1$) in (A); the best model fitting in real space (B) and its L-V diagram (C); finally $T_R^*(J = 2 \rightarrow 1)/T_R^*(J = 1 \rightarrow 0)$ (continuous line) and $[T_R^*(^{13}\mathrm{CO}_{J=1\rightarrow 0})/T_R^*(^{12}\mathrm{CO}_{J=1\rightarrow 0})] \times 5$ (dashed line), (D).

2. DATA, OBSERVATIONS AND RESULTS

The observations used here were collected during September-November 1997 using position switching technique. The resolution reached was 0.125° in Galactic longitude at latitude $b = 0°$. The integration time was 10 sec and was taken at least 10 times on every point. Bad baselines were discarded and a 0.25° K rms was reached. Only linear baselines were substracted from the data. The telescope was equipped with a cooled Schottky mixer frontend and an acusto-optical spectrometer (AOS) with 2048 channels and velocity coverage of 1200 km s^{-1} a velocity resolution of 2.0 km s^{-1}. The telescope has an offset Cassegrain Coudé optics with a beam efficiency of 0.91±0.03. Pointing of the telescope was checked toward bright stars using an optical telescope mounted on the subreflector stay and observing Orion KL and M17. Measured pointing errors were always better than 1′. Intensity calibration was made by standard chopper wheel technique.

- In the CO($J = 2 \rightarrow 1$) map (Fig. 1 A) the basic distributions of the $J = 1 \rightarrow 0$ to $J = 2 \rightarrow 1$ CO emissions are quite similar, except for the tendency of the $J = 2 \rightarrow 1$ to be weaker than $J = 1 \rightarrow 0$. However, CO($J = 2 \rightarrow 1$) emission is better tracer for spiral arms because of its relation with denser gas. Fig. 1(B) shows a density wave Galactic model with a pitch angle of 12°, fixing the best initial phase for each arm. Model plotted in L-V diagram using a flat rotation curve with $V_0 = 220$ km s^{-1} (small squares Fig. 1C).
- Axisymmetric model, Fig. 1(D): we observe a gradient in both ratios, $T_R^*(J = 2 \rightarrow 1)/T_R^*(J = 1 \rightarrow 0)$ (from 0.90 to 0.77) and $T_R(^{13}\mathrm{CO})/T_R(^{12}\mathrm{CO})$ (from 0.90 to 0.65) with Galactocentric distance, peaking at the 3-Kpc arm. In this analysis, we neglect the extreme data at 2 Kpc and 8 Kpc because of the big error bars. This result reinforces the thesis that the fraction of dense molecular gas increases toward the inner part of the Galaxy.
- Comparing $T_R^*(J = 2 \rightarrow 1)/T_R^*(J = 1 \rightarrow 0)$ and massive star forming regions: we observe strong relation betwen regions where $T_R^*(J = 2 \rightarrow 1)/T_R^*(J = 1 \rightarrow 0) \geq 1.0$ and selected HII and UC HII regions (all in the antenna beam, $b = 0.0° \pm 0.07°$) related with massive star formation.

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