CO(J=2→1) STUDY OF MOLECULAR CLOUDS IN THE SW ARM OF M31

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ABSTRACT

We present a map of a 3' x 3' section of the southwest arm of M31 in the CO(J=2→1) transition. We have detected emission in 25 positions out of 31 observed in a field centered at (−42.5', +7.5) (major axis, minor axis). The map is sampled at intervals of one beamwidth, with an angular resolution of 30" or 100 x 460 pc.

1. INTRODUCTION

M31, at a distance of 710 kpc (Welch et al. 1986), is one of the few spiral galaxies that is close enough for us to study individual GMC's with current millimeter telescopes. There are many similarities between M31 and the Milky Way, but tracers of current star formation are several times weaker in M31 (Hodge 1982; Walterbos and Schwering 1987). The goal of this study is to compare the molecular cloud ensemble with that of the Milky Way.

2. OBSERVATIONS AND RESULTS

Observations were carried out on the NRAO[1] 12m telescope, on Kitt Peak, AZ. The HPBW is 30" (100 pc at the distance of M31). Observations were carried out in a position switching mode. The velocity resolution was degraded to 3 MHz (3.9 km/s), and the typical rms noise level (T_R^*) is 20 mK.

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The spectra are shown in Figure 1. The region that we studied is part of the southwest arm, with the distance from the center of M31 ranging from 10 to 12 kpc. The arm, as defined by HII regions (Pellet et al., 1978), runs from the center left of the field to the upper right. Thus our map contains both arm and interarm regions.

The Figure shows that the stronger lines all appear in the part of the field containing the HII regions. Typical peaks in the arm regions are in the range 140 – 240 mK; typical peaks in the interarm region are 60 – 80 mK. Integrated intensities are 4 – 8 K–km/s on the arm and 2 – 4 K–km/s off the arm. (At the distance of M31, each K–km/s corresponds to a CO luminosity of 10^4K–km/s–pc^2.)

The CO line profiles in the arm region contain distnguishable, narrow components, whereas the lines away from the HII regions are both weaker and broader. The strongest lines are also systematically shifted to a more negative velocity. (This is true even when we correct for the effects of the rotation curve.) The narrow lines fall at a velocity of about –10 km/s with respect to the rest of the gas at the same location. If this arises from a shift in the rotational velocity, then it corresponds to an increase in orbital speed.

3. DISCUSSION

There is growing evidence (e.g. Kutner, Leous & Verter 1990), that the conversion from CO(J=2→1) luminosity to mass is approximately twice that for CO(J=1→0) luminosity, so we take $N(H_2)/I(2\to1) = 4 \times 10^{20} cm^{-2} (K\text{–}km/s)^{-1}$. This results in a peak surface density of 11 $M_\odot/pc^2$, and an average value (on the arm positions) of about 7 $M_\odot/pc^2$. For comparison, the average surface density around the tangent point of the Scutum Arm in our galaxy is 6 $M_\odot/pc^2$ (Kutner, Leous & Verter 1990). Furthermore, if we take the CO(J=2→1) maps of the GMCs in the Scutum Arm, and convolve them with a 100 pc beam, we find lines with a peak T_R^* of ~200 mK, and a FWHM of ~7 km/s. Thus, the narrow features in our M31 sample have the properties of Milky Way GMC's.

In contrast, it is harder to explain the weaker, broader lines at interarm positions as beam diluted GMC's (see Kutner, Verter & Rickard 1990). The more natural interpretation is that they arise from a number of lower mass clouds filling all or part of the allowed velocity space. For example, ~20 clouds with masses of $10^4 M_\odot$ per beam would reproduce the observed spectra. Thus, we have evidence for a change in the cloud ensemble from arm to interarm regions.

4. REFERENCES

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