4. MOLECULES IN EXTERNAL GALAXIES

Chairmen: F. Combes, N.Z. Scoville, J. Young
Editor: F. Combes

Supporting Commissions:

28, 34, 40

https://doi.org/10.1017/S1539299600008406 Published online by Cambridge University Press

THE MOLECULAR SPIRAL STRUCTURE IN M51 DERIVED FROM CO(J=2-1) LINE OBSERVATIONS

M. GUÉLIN, S. GARCIA-BURILLO, R. BLUNDELL, J. CERNICHARO, D. DESPOIS and H. STEPPE
IRAM, Domaine Universitaire, 38406 Saint Martin d'Hères, France and Avenida Divina Pastora 7, 18012 Granada, Spain

ABSTRACT. We present preliminary results of a high angular resolution-high sensitivity survey of CO($J = 2-1$) line emission in M51 made with the IRAM 30 m telescope.

1 Introduction

Since our Galaxy's spiral pattern is difficult to trace, the relation between molecular clouds and spiral structure must be studied in external systems. M51, with its "grand design" spiral pattern and favorable inclination, is well suited for this purpose. It is strong in CO, the most sensitive molecular probe, and close enough for its arms be resolved by the largest millimetre wave telescopes. Several surveys of the $J = 1-0$ emission in M51 have been reported in the literature (e.g. Rydbeck *et al.* 1985, Lo *et al.* 1987, Vogel *et al.* 1988, see also this Commission Meeting). They lack, however, angular resolution or sensitivity to resolve the interarm emission from the arm emission. We present here CO $J = 2-1$ line observations of the western half of M51, made with the IRAM 30-m telescope. This is the first survey of an external galaxy combining high angular resolution (HPBW = 12") with high sensitivity, thus allowing a thorough study of the interarm molecular gas.

2 Observations

The $J = 2-1$ ^{12}CO line emission was mapped over a 2'x3.5' area covering the western inner part of M51. Most of this area was fully sampled (6" spacings in **r.a.** and **dec.**) using the "basket-weaving" technique; the outer edges and southernmost part were half-sampled in declination. Good pointing and accurate calibration were ensured through frequent observation of nearby quasars and reference positions.

The IRAM 1.3 mm SIS receiver had an SSB noise temperature of 200-250 K over its 600 MHz-wide IF band. A 512x1MHz channel filterbank provided a velocity resolution of 1.3 kms^{-1}. Fig. 1 diplays the spectra observed in the central 100"x100" region, smoothed to a 13 kms^{-1} (10 MHz) resolution. Except for particular positions re-observed with longer integration times, they have a r.m.s. noise of $\simeq$15 mK. The spectra outside this central region have a r.m.s. of 20-30 mK. The velocity-integrated antenna temperature contours are presented in Fig. 2.

D. McNally (ed.), Highlights of Astronomy, Vol. 8, 575–577.

https://doi.org/10.1017/S1539299600008406 Published online by Cambridge University Press

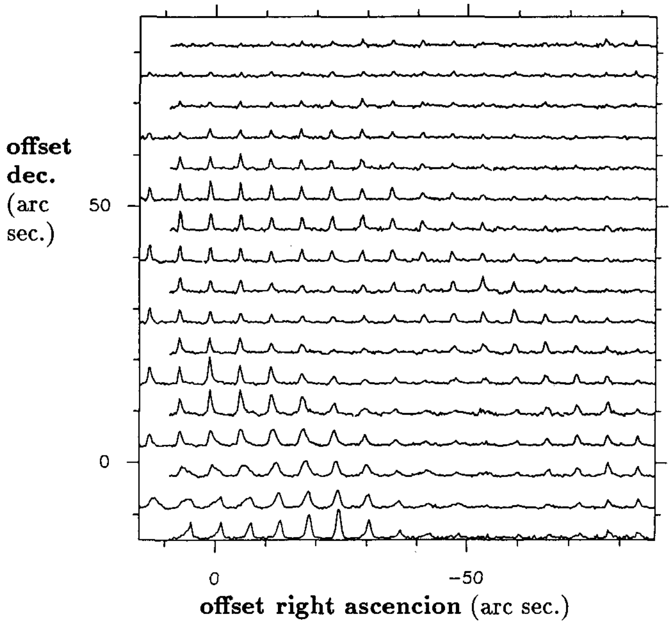

Figure 1: ^{12}CO (J=2-1) line profiles plotted against the offset from the nuclear continuum source (1950.0) right asc. = $13^h27^m46.1^s$ dec. = 47°27′14″. The velocity span for each spectrum is 300 kms^{-1}. The maximum antenna temperature, corrected for atmospheric absorption, is 0.7 K.

Less extensive observations, aimed at determining the $(J = 2-1)/(J = 1-0)$ and $^{12}CO/^{13}CO$ line intensity ratios, have also been made in the ^{13}CO $(J = 2-1)$ line and in the ^{12}CO and ^{13}CO $(J = 1-0)$ lines.

3 Results

The main results, from Fig. 1 and 2, are:

i) The CO arm-interarm contrast is large and highly variable. The arm-interarm velocity-integrated intensity ratio, observed with our 12" beam, is typically 3-6 for the arm at the centre of Fig. 1. It is only 2 at 90" west, 45" south of the galaxy's centre, and reaches 10-17 for the inner southwest arm (e.g. 10" west, 50" south of the centre);

ii) The CO arms are thick. Figs. 1 and 2 show that half of the CO emission in the western arm arises from a broad component (HPW$\simeq$20") which was missed by the interferometric study of Vogel et al. (1988). Actually, the $J = 2-1$ line brightness contours of Fig. 2 correlate closely with the 6 cm continuum emission contours observed with the VLA (van der Hulst 1988);

iii) CO is detected everywhere between the arms. Although weak, the interarm emission is not uniform and shows cloud complexes of small velocity dispersion (HPW$\simeq$6-20 kms^{-1}, vs 30-40 kms^{-1} in the arms);

iv) contrary to the finding of previous studies, there is plenty of CO at the centre of M51. The smaller peak temperature at the centre is compensated by a broader linewidth. The CO-derived rotation curve rises so steeply that the full span of velocities is almost reached in the central 12"-radius region;

v) the $^{12}CO(2-1)/(1-0)$ line brightness ratio, calculated after smoothing the $(J = 2-1)$ data to 21" and correcting for the different beam efficiencies, is found to decrease from the centre (aver. ratio: 1.2), to the interarm region ($\simeq$0.9) and to the arms ($\simeq$0.6).

https://doi.org/10.1017/S1539299600008406 Published online by Cambridge University Press

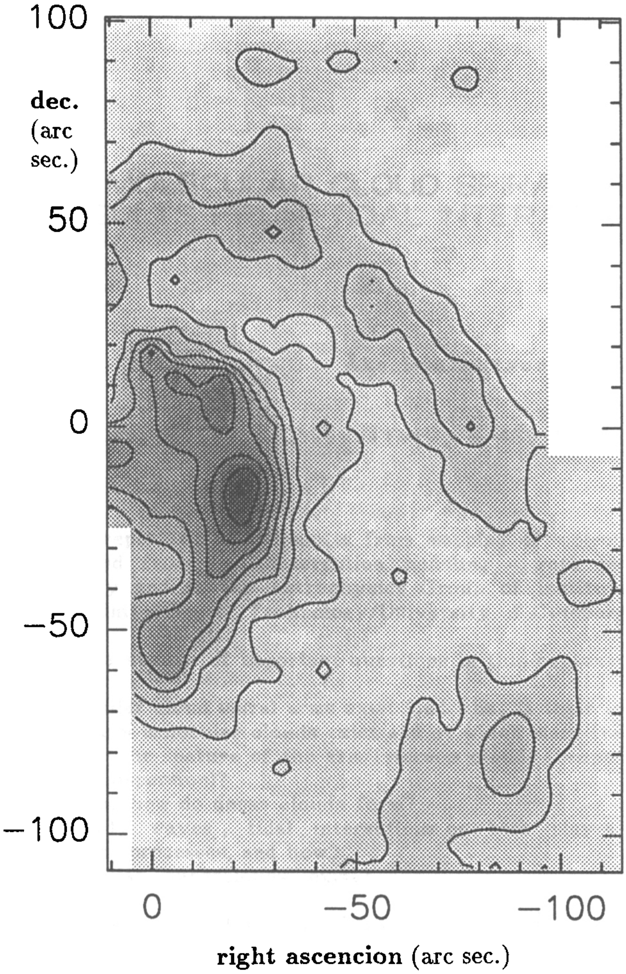

Figure 2: velocity-integrated antenna temperature contours of the $^{12}CO(J=2\text{-}1)$ line. First contour and contour step are 5 K·kms^{-1}. Abscissa and ordinate are offsets in **r.a.** and **dec.** from the nuclear continuum source.

A detailed analysis of the ^{12}CO (2−1) and (1−0) line profiles, as well as of complementary ^{13}CO data, is under way. It should help to understand the fate of the molecular clouds streaming across spiral arms.

References

Lo, K.Y., Ball, R., Masson, C.R., Phillips, T.G., Scott, S., and Woody, P.D. 1987, *Astrophys. J.* **317**, L63

Rydbeck, G., Hjalmarson, A., and Rydbeck, O.E.H. 1985, *Astron. Astrophys.* **144**, 282

van der Hulst, Kennicutt, R.C., Crane, P.C., and Rots, A.H. 1988. *Astron. Astrophys.* **195**, 38

Vogel, N.S., Kulkarni, S.R., and Scoville, N.Z. 1988, *Nature***334**, 402