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^{12}CO(1-0) OBSERVATIONS OF BARRED GALAXIES WITH INTENSE FIR EMISSION

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RESUMEM. Se observó la línea ^{12}CO(1-0) con el nuevo radiotelescopio SEST de La Silla, Chile, en una muestra de galaxias espirales barreadas con intensa emisión en el infrarojo lejano, con el fin de estudiar la dinámica del gas molecular en relación al fenómeno de barras y al incremento de la actividad nuclear. La línea ^{12}CO(1-0) fué detectada en cinco de las seis galaxias observadas.

ABSTRACT. We have used the new 15 m SEST telescope at La Silla, Chile, to observe the ^{12}CO(1-0) emission from a sample of barred spiral galaxies with intense FIR emission, in order to study the molecular gas dynamics in relation to the bar phenomena and the enhanced nuclear activity. The ^{12}CO(1-0) line was detected in five of the six galaxies observed.

Key words: GALAXIES-BARRED — INTERSTELLAR-MOLECULES

. INTRODUCTION

Recent studies reveal that extreme cases of 'starburst' galaxies, in the absence : interaction, occur nearly always in barred spiral systems (e.g. Hawarden et al., 1986). On ıe other hand theoretical studies show that bars provide an efficient mechanism of transport : gas from the disc into the active starforming nuclear region (Combes and Gerin, 1987).

The rotation velocity of the bar with respect to the galaxy rotation, and the ynamics of the gas inside the bar would determine the kind of activity of the galaxies: ;tarbursts' or AGNs (Arsenault 1989).

On the other hand outflows of gas into the halo have been detected in some ılaxies with intense nuclear activity (NGC 1365, Edmunds et al., 1988; M82, Loiseau et al.,)89).

[. SAMPLE SELECTION AND OBSERVATIONS

We selected a sample of barred spiral galaxies with 100μm flux densities greater ıan 30 Jy from the IRAS catalogue (1985). The high FIR flux density is an indication of the lgh activity that we intend to correlate with the molecular gas inflow and, on the other ınd, it grants the detection of the line in view of the well established correlation between) and FIR apparent luminosities (e.g. Young at al., 1985). We selected galaxies south of ;clination -25° which canot be properly observed from the Northern Hemisphere. From this ımple we selected galaxies with inclination between 40° and 75°. In galaxies with larger ıclinations the emission from bars and spiral arms can be confused, whereas in nearly face-on ılaxies streaming motions cannot be detected.

The galaxies observed are N986, N1385, N4835, N6215, N6221 and N7582. Observations ;re done during 1988, July 17 to 21, with the new 15 m Swedish-ESO-Submillimeter Telescope

(SEST, Booth et al., 1989) at La Silla, Chile. At the frequency of the $^{12}CO(1-0)$ line ($\lambda 2.6$ mm) the half power beam width (HPBW) is 43 arcsec. A typical system temperature was 850 K including atmospheric noise and extinction. The backend was a wide-band AOS with 1700 channels spaced 690 kHz (1.8 km s^{-1} at $\lambda 2.6$ mm). Due to technical problems in this first public period of SEST observations, we could not observe all the points that we planned.

III. RESULTS

The CLASS package of programs was used to reduce the data. Straight line baselines were removed and the data were Hanning smoothed.

The derived parameters for the observed galaxies are listed in Table 1 and discussed individually below.

Table 1. Derived parameters of the observed galaxies.

NGC	Points Obs.	Vhel km s-1	ΔV km s^{-1}	Res km s^{-1}	T_A^* mK	σ mK	I_{CO} K km s^{-1}	N_{H2} H_2 cm^{-1}
0986	1	2004	100	7.2	18.	13.	1.5	6.0 10^{20}
1385	5	1484	102	7.2	49.	9.5	4.5	1.8 10^{21}
4835	4	2196	-	14.4	<18.	9.1	<1.8	<7.2 10^{20}
6215	1	1567	50	7.2	132.	19.	7.1	2.8 10^{21}
6221	9	1486	190	3.6	85.	14.	20.0	8.0 10^{21}
7582	7	1600	280	3.6	131.	15.	38.4	1.54 10^{22}

Notes to Table 1

- For NGC 4835 the value of V_{hel} is from Huchtmeier et al. (1983) as the galaxy was not detected.
- T_A^* is the peak temperature at the central position.
- I_{CO} is the intensity of the emission at the central position.
- Values of N_{H2} are calculated assuming a constant conversion factor of $N_{H2}/I_{CO} = (4\pm2)\ 10^{20}$ (H_2 cm^{-2}/K km s^{-1}).

NGC 986. In NGC 986, classified SB(r)ab (de Vaucouleurs et al., 1976; RC2), intense star formation is taking place at the ends of the bar where the spiral arms begin. We have obtained useable data for one point at the position of the optical nucleus.

NGC 1385. The nucleus of this SB(s)cd galaxy (RC2) is rich in stars of age comparable to or less than 100 Myr (Frogel, 1985), which implies a recent burst of star formation. We observed five points in a cross on a 40 arcsec grid, along the bar and perpendicular to it. The central profile, as for the other galaxies, is less noisy because it was observed often as a pointing accuracy check. The $^{12}CO(1-0)$ emission is stronger along the bar (p.a. 101°). The spectrum 40 arcsec to the west is the widest one, probably formed by more than one component.

NGC 4835. This strong IRAS source is classified as SAB(rs)bc in the RC2. We did not detect the $^{12}CO(1-0)$ line towards four points observed in this galaxy. In Table 1 upper limits are given.

NGC 6215. The central profile obtained for the SA(s)c (RC2) galaxy NGC 6215 presents a strong $^{12}CO(1-0)$ line. Being this galaxy non-barred, the enhancement of the line could be related to the interaction with NGC 6221 and NGC 6300, with which it forms a group. As NGC 6215 has an almost face-on inclination of 38°, the narrow profile width of 50 km s^{-1} is not surprising.

6221. This galaxy, classified as SB(s)c (RC2), belongs to a small group together with NGC ; and NGC 6300. It has a small bright nucleus with properties akin to both a weak Seyfert 2 an HII region (Boisson and Durret, 1986). It has also beeen identified with a fairly ong X-ray source (Marshall et al., 1979).

We observed nine points of a grid aligned with the bar (p.a. 118°). The profiles ig the bar, as in the case of NGC 1385, are wider than the ones outside the bar. The high ial-to-noise central profile shows at least two components. The profile 40 arcsec to the :, where there are prominent dust lanes, is stronger than the western one.

NGC 6221 is being mapped with better resolution in the ^{12}CO(2-1) transition with SEST telescope.

7582. This SB(s)ab (RC2) galaxy belongs to the Grus group and has a prominent bar which ears very dusty (Fig. 1b). This Seyfert 2 galaxy shows a high ionization region associated i non-thermal ionization and low excitation gas related to a starburst region. (Ward et , 1987). Hα observations show quite large deviations from axisymmetric flows along the bar a completely different nuclear velocity field (Morris et al., 1985).

As expected we detected significant ^{12}CO(1-0) emission along the bar out to a ance of 80 arcsec from the nucleus, in both directions (Fig. 1a). The rotation velocity of bar, with v_{rot}(max) ~150 km s^{-1} is in very good agreement with the Hα values of Morris et (1985). The two separate components in the centre show that the rotation curve becomes ontinuous in the central region. This is also consistent with the Hα data which show a rapidly rotating disc inside a ~5 arcsec radius. Moreover, OIII line observations ocate a bipolar outflow of highly ionized gas out of the plane of the galaxy.

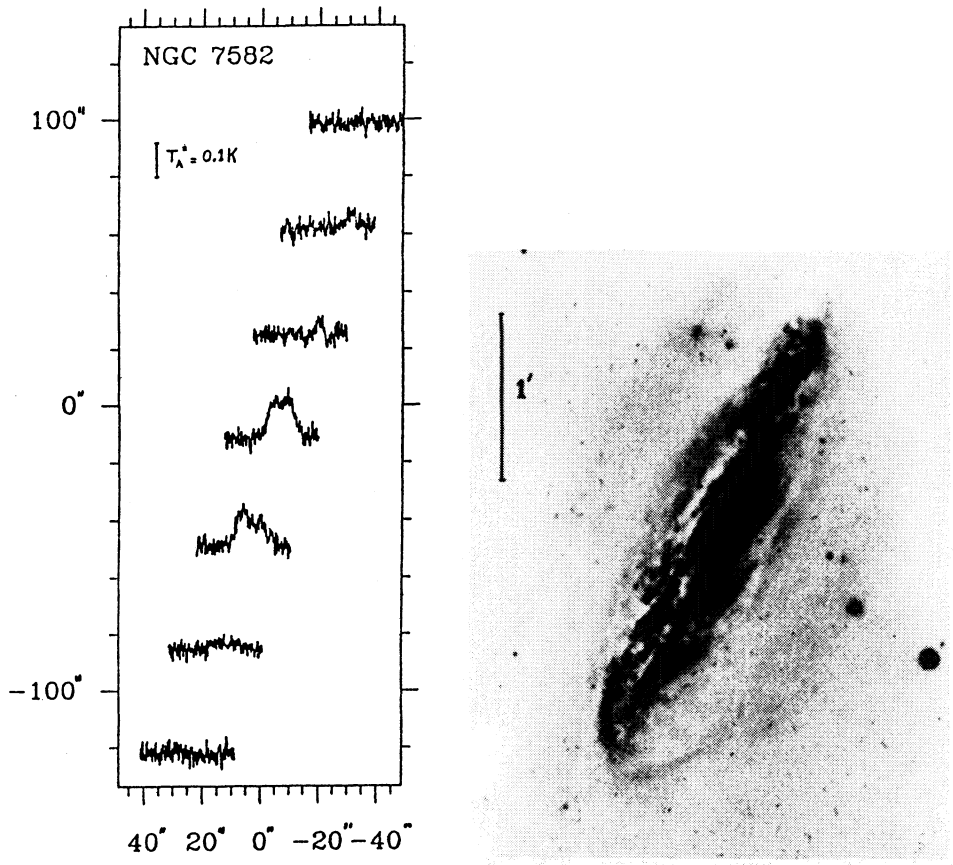

Fig. 1a) ^{12}CO(1-0) spectra along the bar of N7582. The velocity range is 1000 ≤ V_{hel} ≤ 2000 km s^{-1}. **b)** AAT prime focus unsharp masked plate of N7582 made by Morris et al. (1985) (Courtesy of the Royal Astronomical Society). North is to the top and East to the left.

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