CO IN MILDLY ACTIVE GALAXIES

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The ratio between the intensities of the various CO line transitions, with the additional information about the isotope abundance, should enable us to probe the optical depth in the molecular clouds in galaxies. There are, of course, problems in interpretation as a result of the unknown structure of the clouds, their distribution and temperature. These problems become particularly important since most of the present data are derived in the vicinity of nuclei of galaxies.

Before the astrophysical interpretation can begin we must ensure that our data, which comes from various telescopes, many observers, and differing calibrating techniques, are really compatible. Since mm-telescopes are often used at the extreme end of their performance (aperture efficiencies of 25% and less) error beams are responsible for a large contribution to the received antenna temperature. The coupling of the antenna beam to a galaxy is often not considered. Interferometers lose a large part of the total flux due to incomplete coverage of the visibility plane.

The one galaxy which has been extensively studied by numerous observers is M82. It is considered to be the prototype of starburst activity. Fully sampled maps are available for the $^{12}CO(1-0)$, $^{12}C^{18}O(1-0)$, $^{12}CO(2-1)$, $^{13}CO(2-1)$ and $^{12}CO(3-2)$ lines as well as in some other molecules (e.g. HCN, CN, HCO^{+}) with sufficient angular resolution to probe the spatial distribution of optical thickness. A rotating molecular ring could be delineated in the nuclear area. Also recombination lines have been detected in the ring (Weliachew et al., 1984) suggesting partial ionization. The general conclusion, based on numerous observations (see Loiseau et al., 1990; Turner et al., 1990) is that considerable optically thin gas is seen in the nuclear area, possibly as a result of nuclear activity. Optical filaments indicate an aligned structure. An outflow from the nucleus in the direction of the minor axis has been observed (Bland and Tully, 1988). Measurements of both optical (Neininger et al., 1990) and radio (Reuter et al. (a), this volume) polarization suggest a dipolar magnetic field in the nucleus. Also the CO(3-2) line is intense in M82 (Tilanus et al., this volume), but the final result on CO(3-2)/(2-1) ratio needs further calibration checks. Based on the results described above Lesch et al. (1989) proposed a scenario for the generation of the dipole

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(poloidal) magnetic fields in the nucleus by currents flowing in the ring amplified by the dynamo action.

Another galaxy with mild nuclear activity is NGC 1808. Optical 'streamers' and radio polarization measurements suggest a magnetic field alignment in the direction of the minor axis. A rotating ring of CO and HI (Dahlem et al., this volume) is seen in the nucleus of this galaxy. The CO(2−1)/(1−0) ratios are the highest (1.3±0.2 with a 43" beam) after M82 (Dahlem et al., 1990). This is due to a disk-like (ring ?) CO(2−1) distribution in the nuclear area. An outflow is observed in the direction of the streamers.

The galaxy NGC 4945 is a southern edge-on spiral, with well-known nuclear activity, possibly barred. In the nucleus the peak CO(2−1)/(1−0) ratio is ~2.0. However, convolution to the 43" beam reduces the ratio to ~1.0±0.1 for the central area. The CO(2−1)/(1−0) ratio drops further in the spectra adjacent to the nucleus. In the disk of NGC 4945 the more usual value of ~0.7±0.1, typical for many nearby galaxies, is seen. Ring-like features have been suggested (Whiteoak et al., 1990) by the ^{12}CO(1−0) observations (see also Whiteoak et al., this volume).

The observations of CO and radio continuum of NGC 3628 again show the now familiar scenario. There is a magnetic field detected above and below the plane with mirror symmetry about the nucleus. The ^{12}CO(2−1) shows a number of rotating (ring-like ?) features. The ^{13}CO(2−1) data show a maximum in the nucleus, similar to M82, suggesting a concentration of optically thick material. Also the CO(2−1)/(1−0) ratios are lower, falling from 1.0 in the nucleus to 0.7 in the disk (Reuter et al. (b), this volume).

It is interesting to note that in spite of a dedicated search of both northern and southern galaxies not one object showed the parameters that are seen in M82. The galaxies described above all seem to have ring-like features in the nuclei. Also NGC 613, 1068, 1097, 4736, etc. all have nuclear rings. Galaxies with rings have the higher CO(2−1)/(1−0) ratios. Is this ratio an indicator of nuclear activity?

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