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Dissertation Summary

The Large-Scale Distribution and Properties of Carbon Monoxide in a Sample of Nearby Spiral Galaxies

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Galaxies are defined by a cumulative history of converting of gas into stars, and molecular gas (H_2) is the fuel for this star formation. Because H_2 cannot be observed directly, we observe the "tracer" CO and derive the H_2 mass indirectly via a "conversion" factor.

To move beyond global correlations and the limitations of undersampled, limited-coverage maps, this study has used the NRAO[1] 12 m telescope and its "on-the-fly" observing mode to efficiently and reliably map cold CO emission over very large areas in five spiral galaxies. The galaxies were selected based on previous CO detections, large angular size, low inclination, and morphology to form an illustrative sample ranging from big to small, starburst to nonstarburst, and actively interacting to passively quiescent. CO was mapped in roughly $15' \times 15'$ regions covering the optical disks of the selected galaxies.

This experiment has the following major results: (1) We now have large-scale, fully sampled maps of CO in IC 342, M83, NGC 1097, NGC 4736, and NGC 6946 (Fig. 1). The first large-scale, total neutral gas (H_2 + H I) surface density maps Σ_{gas} of these galaxies are now available. (2) The CO maps confirm the correlation with the optical disks in overall extent and gross morphology, although significant morphological differences exist. Interarm molecular gas is common in the sample. In the case of NGC 1097, interarm regions in the grand-design pattern, which are devoid of H I, have significant tracts of CO. Outlying patches of CO in NGC 4736 may be the last remnants of a dissolving bar. (3) Widespread high r_{12} [CO(2–1)/CO(1–0)] was found in two of the galaxies, indicating that large-scale optically thin CO may be present. This is significantly different from the large-scale properties of Milky Way molecular gas. (4) In comparisons between CO, neutral gas, and star formation tracers, the best correlation in overall morphology and the uniformity of the ratio from galaxy to galaxy (at least for the later galaxy types) is between Σ_{gas} and nonthermal continuum. (5) Two alternative theories for the large-scale formation of molecular gas in galactic disks were examined using the data. Toomre's Q parameter was evaluated for the disks of these galaxies in order to see if this gas instability theory could predict molecular cloud formation. No correlation was found; the gas disks are found to be subcritical (stable). Alternatively, there is a correlation between the total midplane gas partial pressure P_{ISM} and the fraction of neutral gas disk that is molecular, as predicted by theory. However, the scatter in this incomplete evaluation of P_{ISM} is large, and the quantities required to improve the evaluation are not currently available.

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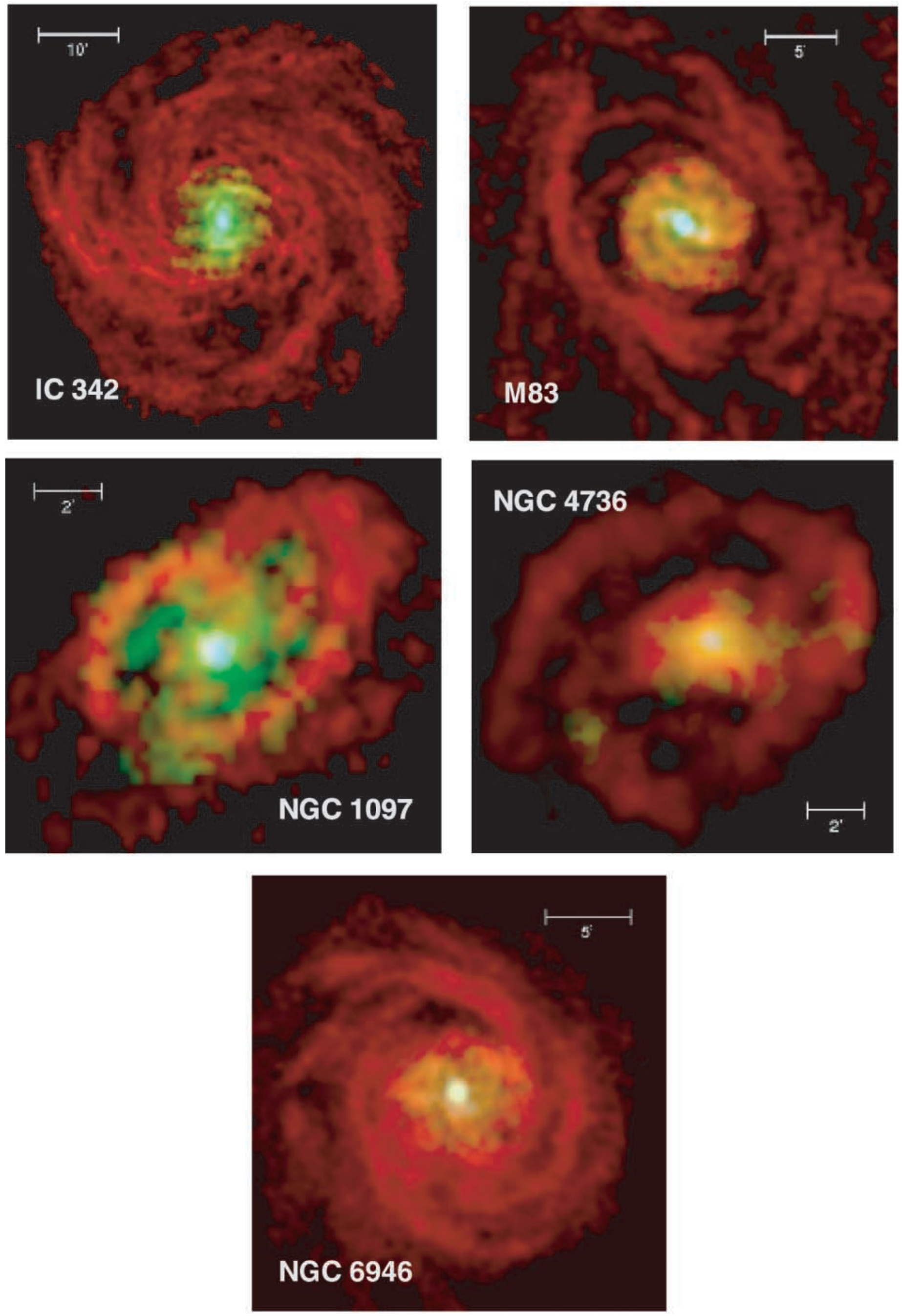

FIG. 1.—Molecular and atomic gas in five galaxies. CO is in green, H I is in red, and a blue channel has been added for the nuclear CO emission. CO and H I at nearly equivalent column densities show up in orange. The H I maps are from the following sources and used with permission of the authors: for M83: J. M. van der Hulst (2002, private communication); for NGC 1097: M. P. Ondrechen, J. M. van der Hulst, & E. Hummel (1989, ApJ, 342, 39); for NGC 4736: R. Braun (1995, A&AS, 114, 409); for NGC 6946: L. J. Tacconi & J. S. Young (1986, ApJ, 308, 600); and for IC 342: L. P. Crosthwaite, J. L. Turner, & P. T. P. Ho (2000, AJ, 119, 1720).